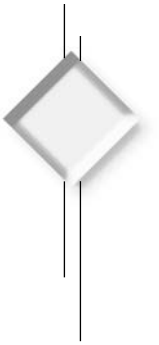
# BREAST IMAGING COMPANION



THIRD EDITION

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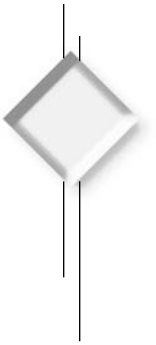

THIRD EDITION

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*I dedicate the third edition of this book to*

*The memory of my mother Gilda Paniza Cardeñosa (1923–2003).*
*Her unwavering determination to give me every possible opportunity against*
*significant odds, brought unique adventures spanning continents and cultures*
*and now a cache of memories few can rival. She was tenacious in her beliefs that*
*there is nothing like the American Dream,*
*and the unalienable rights afforded citizens in this country,*
*and that it could be ours,*
*if we remained true to ourselves and worked hard. She was right.*
*We made it beyond our wildest imagination; she was quite a lady.*

*My father Ricardo Cardeñosa Barriga*

*and*

*Dr. Regina O'Brien*

# CONTENTS

# PREFACE

Why another edition of the *Breast Imaging Companion*? Why an increase in the number of text pages and images, and yet an ongoing struggle to decide what to include and emphasize and what should wait for another book?

For an introductory breast imaging text, are more images and text better, or is struggling to select one or two images as representative of entities and processes that may have marked variability the preferred option, so as not to "confuse" or "overwhelm" the reader? I do not know the answer to this; however, I have opted to include as many images as possible with the firm conviction that this is the most helpful to residents, experienced breast imagers, technologists, and other breast health care providers. At this point, I can only hope that the resulting size of the book does not detract from the message or make this book less useful. As in previous editions, I have tried to pack in as much practical common-sense information as possible such that I even use some of the figure legends to introduce material. Imaging modalities, approaches to patient care, and our knowledge of breast diseases have continued to expand rapidly, dictating the need for expanding the text. To illustrate the concepts, I have added images and replaced many of the images used in previous editions, and I assure the reader that these are new images and not repeats from my other books.

The breast imaging story is truly remarkable. Amid controversy, ongoing skepticism, critical shortages in breast imagers, and the "lost leader" albatross that continually subverts many of our efforts, this specialty pushes forward with far-reaching contributions to the care and management of patients with breast cancer. It is always helpful to acknowledge where we have been and what has been accomplished, and from this to gather the strength and foresight to overcome the challenges we face.

When confronted with technical and quality issues in mammography, the American College of Radiology stepped forward and took a leadership role in proposing, developing, and implementing the first-of-its-kind voluntary accreditation program for mammographic facilities. This heralded the passage of the Mammography Quality Standards Act in 1992. These efforts resulted in marked improvements in the quality of the mammographic studies and established basic continuing medical education requirements for technologists, physicists, and interpreting physicians. Additional voluntary accreditation programs in breast ultrasound, stereotactically and ultrasound-guided breast biopsies, and, more recently, breast magnetic resonance imaging have since been developed.

Clinically, much has already been accomplished. As a direct result of our ability to diagnosis ductal carcinoma in situ, as well as stage 0 and stage 1 disease routinely, sustained decreases in breast cancer mortality have been reported. The highest quality images, however, are only as good as the interpretative ability of the radiologists evaluating the images and our ability to integrate imaging, clinical, and pathology findings. Therein lies the ongoing challenge we face, and this validates the main reason for updating and expanding the *Companion*. The continued development of clinical breast imagers whose focus on patient care integrates the ability to interpret a variety of images and undertake interventional procedures with the clinical skills and in-depth knowledge of breast pathology is the ongoing challenge in furthering our efforts against this disease. As the specialty advances, we must continue our commitment to quality and integrated interpretations, with a renewed focus on quality patient care. As stated in earlier editions, it is my ardent hope that through this effort I can contribute to and further the specialty of breast imaging and the training of radiologists. Breast imaging is undoubtedly a most rewarding specialty where, with compassion and empathy, you can make an otherwise difficult time easier for patients and ultimately you can save lives, many lives.

# ACKNOWLEDGMENTS

I am indebted to the radiology residents in the Department of Radiology at the Virginia Commonwealth University. Their commitment to learning clinical breast imaging and their focus on patient care afford an invaluable impetus for me to continue learning and finding better ways to teach breast imaging. They probably don't know what a lifeline they provide.

I would like to thank Drs. Ann S. Fulcher and Mary Ann Turner, Chair and Vice Chair of the Department of Radiology at the Virginia Commonwealth University (VCU). They have embraced my concepts for a world-class clinical breast imaging service and have provided an unwavering commitment to the section and me professionally and personally. At the institutional level, I must also extend my sincere appreciation to John F. Duval, Chief Executive Officer, Medical College of Virginia Hospitals; VCU Health System Administration; Darrell J. Johnson, Vice President of Professional Services; Sherry Elliot, Vice Chair of Operations, Department of Radiology; and Ronald Miller, Director, Department of Radiology. I am energized and humbled by their ongoing support and patience.

In the Section of Breast Imaging, I am honored to work side-by-side with two talented and dedicated professionals, Joanne Cousins, RTR(M); and Lynda Giardini, RTR(M)(BS), manager and supervisor for the section. Their technical expertise and knowledge are unrivaled, their integrity is exemplary, their work ethic is indefatigable, and they are unwilling to settle for mediocrity. I feel incredibly fortunate to work with them.

To the technologists in the Section of Breast Imaging—Mildred Ayala, Jill Brishke, Dealia Clark, Fareeda Connor, Margaret Drake, Constance Mountcasel, Wanda Shrewsbury, Amy Silva, Nadeen White, and Audra Young—and the staff in the Section—Trudy Abdul, Jennifer Campbell, Tami Freeman, Joyce Jackson, Linda Johnson, Anthony MacLauren, Marcell Patron, Rena Phillips, Raleigh Poindexter, Sheron Saxton, and Sharius Stephens—I extend my deepest gratitude for their patience and willingness to undergo significant changes in the last 2 years and for their commitment to our patients. Nancy Cooper, my secretary, also deserves much praise for her patience and due diligence in taking care of me and all section issues.

On a personal note I must again thank Kathleen M. Connelly, MBA. She continues to be an invaluable unpaid editor who not only reads what I write, with an inordinate amount of patience and understanding for my obsessive

attention to detail, but is also willing to engage in polemics regarding semantics, wording, sentence structure, and how best to teach. I would also like to thank Amy Davis and Leigh Kuhnly, whom I miss, but even from a distance, they continue to provide support and inspiration.

At Lippincott Williams & Wilkins, Lisa McAllister has again been incredibly supportive, gracious, and patient with my passionately held commitment that more images and text were needed to improve this book. She is incredibly kind, loyal, and delicate with her authors, and for this I am most appreciative. As with the Teaching File, Kerry Barrett and Louise Bierig have been instrumental, and I am fortunate to have had them as part of this project as well. I very much value their oversight, editorial suggestions, and support.

Lastly, my thanks to all the others at Lippincott Williams & Wilkins including Rosanne Hallowell, Benjamin Rivera, Angela Panetta, Risa Clow, and Larry Didona, and Karen Ettinger at Aptara, Inc. for all of their hard work and commitment to this project.

*Gilda Cardeñosa, MD*

CHAPTER 1

# BREAST CANCER: AN OVERVIEW

## BREAST CANCER FACTS

### KEY FACTS

- Excluding skin cancers, breast cancer is the most frequently diagnosed malignancy (~26% of all cancers detected). There is a 1 in 8 lifetime probability of developing breast cancer.
- In 2007, 178,480 new invasive and 62,030 in situ breast cancers are expected among women in the United States; 2,030 new breast cancers among men.
- Second leading cause of cancer mortality (15% of all cancer deaths) in women. In 2007, 40,460 women are expected to die of breast cancer; 450 deaths are expected from breast cancer among men.
- As a result primarily of early breast cancer detection (although some have suggested that it is due to improved treatment), the age-adjusted rate of death from breast cancer was 24% lower in 2003 than it was in 1989.
- Relevant risk factors:

  Patient sex: higher incidence among women.

  Patient age: incidence increases with advancing age.

  Incidence rates for all races are substantially higher for women age 50 and older (375 per 100,000) compared with women under age 50 (42.5 per 100,000).

  However, because women under the age of 50 represent 73% of the female population, 23% of all breast cancers are diagnosed in women under the age of 50.

  Personal history of breast cancer.

  Prior breast biopsy with certain benign diagnoses: proliferative changes with atypia; atypical ductal hyperplasia, lobular neoplasia (atypical lobular hyperplasia and lobular carcinoma in situ), juvenile papillomatosis.

Family history of breast cancer involving a first-degree relative—particularly if the cancer is bilateral or diagnosed in pre-menopausal relative.

BRCA1 and BRCA2 gene mutations—found in approximately 40% of familial breast cancers; represent 5% to 20% of the total percentage of breast and ovarian cancers.

History of chest wall exposure to high dose radiation (e.g., prior treatment of lymphoma).

- Other factors implicated with breast cancer risk:

  Early menarche and establishment of regular menstrual cycles.

  Late menopause.

  Bilateral oophorectomy before age 40 may decrease breast cancer risk by 50%. Women with natural menopause before age 45 have half the risk of breast cancer compared to women who undergo menopause after age 55.

  Late first-term pregnancy.

  Nulliparity.

  Postmenopausal obesity.

  Hormone replacement therapy.

- Breast cancer mortality rates declined an average of 2.3% per year between 1990 and 2002 among women of all races and ages.

  The breast cancer related death rate among black women is 37% higher than among white women.

- Utilization of screening mammography has been increasing.

  White women over age 40 reporting a mammogram in the previous 2 years increased from 30% in 1987 to 71% in 2003.

  For the same time period, usage of mammography among black women increased from 24% to 70%.

## PROGNOSTIC FACTORS

### KEY FACTS

- Status of axillary lymph nodes is the most important prognostic factor.

  Clinical, ultrasound, computed tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography (PET) assessments of axillary nodal status are not reliable.

  Histologic evaluation of axillary lymph nodes following axillary lymph node dissection (ALND) is more accurate than clinical evaluations; however, methods used to section lymph nodes can be associated with false negative rates as high as 30%.

- Sentinel lymph node biopsies (SLNB).

  Being used with increasing frequency to assess the status of the axillary lymph nodes, replacing ALND.

  The sentinel lymph node is postulated to be the first node draining a tumor and that the histologic status of this lymph node accurately predicts the status of the regional (axillary) lymphatic basin.

Methods to identify the sentinel lymph node are still in evolution but include use of a radioisotope alone or in combination with a blue dye (Lymphazurin blue); optimal results are obtained when a combination (radioisotope and blue dye) is used.

If a radioisotope is used, lymphoscintigraphy can be used preoperatively to assess the pattern of lymphatic drainage and may provide information regarding the status of internal mammary lymph nodes; alternatively, a handheld gamma probe is used intraoperatively to identify the "hot spot" in the axilla at the time of surgery.

Injection of radioisotope or blue dye can be done peritumoral, intradermal, periareolar or intratumoral; volume and timing of injection vary.

Liberman reported technical success rate, sensitivity and accuracy of 88%, 93%, and 97%, respectively, for SLNB.

Use of SLNB in women with ductal carcinoma in situ (DCIS) remains controversial. Indicated in patients with DCIS and microinvasive disease. Probably indicated in patients in whom, because of the size or imaging features of the DCIS, invasion is suspected preoperatively; alternatively, the SLNB is done as a second procedure in patients with DCIS found to have invasive disease at the time of the lumpectomy.

More meticulous evaluations of the excised lymph node including serial sectioning of the entire lymph node (as opposed to sample sections through several lymph nodes) and immunohistochemical staining have led to the observation of isolated tumor cells and micrometastatic disease the prognostic significance of which remains to be established.

Determining the presence of micrometastatic disease should be based on routine hematoxylin and eosin stained histological sections; immunohistochemical evaluation of excised sentinel lymph nodes is not encouraged at this time.

- ALNDs.

  Level I and II dissections will detect 99% of node positive patients.

  Indicated when the sentinel lymph node is not identified, or if metastatic disease is suspected clinically or is known to be present by virtue of a positive SLNB or an imaging guided biopsy or FNA of an axillary lymph node.

  Morbidity associated with ALNDs include: seromas, lymphedema particularly when combined with radiation therapy, neuropathies, restriction of shoulder movement, and injury or thrombosis of the axillary vein.

  Lymphangiosarcoma (Stewart-Treves syndrome) is a rare complication of long-standing lymphedema.
- Tumor size correlates with metastasis and prognosis.

  There is a 3% to 22% likelihood of metastatic disease in the axilla in patients with a tumor less than 1 cm in size.
- Lymphovascular space involvement (~15% of patients with invasive ductal carcinomas), particularly in lymph node negative patients.
- Extensive tumor necrosis; 50% of patients with necrotic tumors have aneuploid, estrogen, and progesterone receptor negative tumors with axillary nodal metastases at the time of presentation.

- Extracapsular tumor extension in involved axillary lymph nodes; considered by some as an indication for axillary irradiation.
- Histologic grading of tumors is not part of staging system because it does not accurately predict prognosis (significant observer variability).
- Estrogen receptors (ERs).

  Should be assessed for all breast cancers including DCIS.

  Prognostic and therapeutic implications.

  Weak predictor of recurrences and breast cancer related mortality.

  Higher and quicker recurrence rates and mortality in women with ER negative tumors.
- Progesterone receptors (PgRs).

  Should be assessed for all breast cancers.

  Prognostic and therapeutic implications.

  Weak predictor of recurrences and breast cancer related mortality.

  In patients with stage I disease, PgR status is not correlated with disease free survival.

  Useful in patients with stage II disease receiving adjuvant chemotherapy.

  Patients with ER, PgR positive tumors have longer disease free survival rates compared with patients having ER, PgR-negative tumors or ER-positive, PgR negative lesions.
- DNA flow cytometry.

  Analyzes tumor ploidy.

  Recurrences may be higher among women with aneuploid tumors.

  ER negative tumors more likely to be aneuploid.
- p53.

  p53 tumor suppressor protein, gene located on chromosome 17p.

  Monitors and preserves genomic integrity interrupting the cell cycle if DNA damage is present.

  Cells lacking p53 become unstable and lose ability to maintain correct number of chromosomes.

  20% to 25% of patients with breast cancer show p53 mutations (80% are missense mutations).

  p53 mutations correlate with aneuploid, ER negative, high-grade tumors that overexpress erbB2.

  Associated with poor prognosis.
- HER2/neu (c-erbB-2).

  Gene on long arm (q) of chromosome 17; overexpressed in approximately 20% of breast cancers.

  Human epiderminal growth factor receptor 2 (HER2).

  Overexpression frequently associated with high nuclear grade DCIS with central necrosis (comedo type).

  Overexpression is a poor prognostic indicator.

  May predict poor response to cyclophosphamide, methotrexate and 5-fluorouracil (CMF).

  Associated with altered p53 expression.

Trastuzumab (Herceptin) is a monoclonal antibody, FDA approved for the treatment of metastatic tumors overexpressing HER2/neu protein.

- E-Cadherin.
  Gene on chromosome 16q.
  Mutations and loss of expression in lobular carcinomas.

## Risk Marker Lesions

### Key Facts

- Relative risk (RR) is the rate of cancer in women with a given condition or diagnosis divided by the rate of cancer in the reference population.
  The reference population should be defined, because this alters the calculated RR.
  Additional factors that affect RR are the patient's age at the time of biopsy and the number of follow up years.
- No increased risk.
  No proliferative disease.
  Apocrine change.
  Duct ectasia.
  Mild epithelial hyperplasia.
- Slightly increased RR (1.5 to 2×).
  Proliferative disease without atypia.
  Papilloma.
  Sclerosing adenosis.
- Moderately increased RR (4 to 5×).
  Proliferative disease with atypia.
  Atypical ductal hyperplasia.
  Atypical lobular hyperplasia.
- High RR (8 to 10×).
  Atypical ductal hyperplasia and a positive family history (first-degree relative).
  Lobular neoplasia (lobular carcinoma in situ).
  Well differentiated DCIS.
- Complex fibroadenomas (see Chapter 13).
  RR of 2.17× in women with noncomplex fibroadenomas.
  RR of 3.10× in women with complex fibroadenomas.
  RR of 3.72× in women with complex fibroadenomas and a positive family history.
  RR of 3.88× in women with complex fibroadenomas and benign proliferative changes in the surrounding stroma.

- Radial scars (see Chapter 12).

  RR of 1.8× in women with radial scars compared to those without radial scars.

  RR of 3× in women with proliferative disease (no atypia) and radial scars compared to 1.5× in women with proliferative disease and no radial scar.

  RR of 5.8× in women with atypical ductal hyperplasia and radial scars compared to 3.8× for those with atypical ductal hyperplasia and no radial scar.
- Lesions suggested by some investigators as possibly associated with an increased breast cancer risk, but currently lack of epidemiological studies to prove or disprove contention.

  Multiple peripheral papillomas.

  Juvenile papillomatosis.

  Mucocelelike lesions.

  Columnar alterations with prominent apical snouts and secretions (CAPSS) with atypia.

## GENETICS

### KEY FACTS

- Sporadic breast cancer.

  Breast cancer with no identifiable inherited risk.

  No family history of breast cancer through two generations (offspring, siblings, parents, aunts, uncles, and both sets of grandparents).
- Familial breast cancer.

  Family history including one or more first- or second-degree relatives.
- Hereditary breast cancer.

  Early age of onset.

  Bilateral breast cancer.

  Multiple primaries.

  5% to 10% of breast cancer cases in the United States.

  BRCA1 and BRCA2 are two known "breast cancer genes."
- BRCA1

  Gene on long arm of chromosome 17 (17q), autosomal dominant.

  Large nuclear protein involved in transcription, development, cell cycling, and response to DNA damage.

  85% lifetime risk of developing breast cancer (20% risk by age 40, 51% by age 50, and 85% by age 70).

  40% to 50% risk of developing ovarian cancer by age 70.

  Breast cancers developing in BRCA1 positive patients are usually infiltrating ductal (some with features of medullary carcinoma), high grade, aneuploid, estrogen and progesterone receptor negative and p53 positive lesions.

- BRCA2
  Gene on chromosome 13q, autosomal dominant.
  Proteins participating in cellular response to DNA damage.
  There is an 85% lifetime risk of developing breast cancer, but a later age of onset as compared with BRCA1 (28% by age 50, 84% by age 70).
  Ovarian cancer in 0.4% of patients by age 50 and 27% by age 70.
  Male breast cancer; 6% lifetime risk of developing breast cancer.
  Association with pancreatic and prostate cancer.
- Genetic disorders associated with increased risk of breast cancer.
  Li-Fraumeni (SBLA) syndrome.
  Cowden's disease.
  Peutz Jeghers.
  Muir Torre.
  Ataxia-telangiectasia.

## CHEMOPREVENTION

### KEY FACTS

- Selective estrogen receptor modulators (SERMs) may reduce the risk of developing breast cancer.
  Tamoxifen (Nolvadex).
  Raloxifene (Evista).
  Potential side effects: blood clots, stroke, and endometrial cancer.
- Aromatase inhibitors.
  Decrease estrogen levels in postmenopausal women by preventing the conversion of androgen into estrogen; they lower the amount of estrogen produced outside of the ovaries.
  Anastrazole (Arimidex), exemestane (Aromasin), letrozole (Femara) approved for use in postmenopausal women with hormone receptor positive tumors.
  Potential side effects: osteopenia and osteoporosis.
- National Surgical Adjuvant Breast and Bowel Project (NSABP) cancer prevention trial P-1.
  To study the possible value of tamoxifen in breast cancer prevention.
  Trial included women over age 60, 35- to 59-year-old women with a 5-year risk of developing cancer equal to that of a 60-year-old woman as predicted by the Gail model, and any woman over age 35 with the diagnosis of LCIS (no group had a relative risk less than 4).
  Reductions in the risk of invasive and noninvasive breast cancers, 47% and 50%, respectively, for the women taking tamoxifen reported after a mean follow-up of 47.7 months.
  Risk reductions among women with LCIS and atypical ductal hyperplasia, 56% and 86%, respectively.
  Benefit observed in women of all ages.

Effect noted for ER positive tumors; rate of ER negative tumors in tamoxifen group did not differ from rate in placebo group.

Reduced incidence of osteoporotic fractures in the tamoxifen treated group.

Study confirmed association between tamoxifen and endometrial cancers in women over age 50.

Deep vein thrombosis and pulmonary emboli in women aged 50 and older.

Tamoxifen is approved for use in pre- and postmenopausal women whose breast cancer risk is elevated based on the Gail model of risk assessment.

- NSABP Study of tamoxifen and raloxifene (STAR) P-2 Trial.

  Raloxifene as effective as tamoxifen in reducing the risk of invasive breast cancer; higher risk of noninvasive cancers with raloxifene, but not statistically significant.

  Raloxifene associated with lower risk of thromboembolic events and cataracts.

  Both drugs have similar risk of other cancers, fractures, ischemic heart disease, and stroke.

## National Surgical Adjuvant Breast and Bowel Project (NSABP)

### Key Facts

- Cooperative clinical trials funded largely by the National Cancer Institute using randomized clinical trials to systematically evaluate various local and systemic therapies for breast cancer.

  Main trials outlined in the subsequent text provided data for many of the treatment options currently used for patients diagnosed with breast cancer. Other trials looking at different treatment options are ongoing, but are beyond the scope of this book.

  Headquarters of NSABP in Pittsburgh, PA.

  200 member institutions include university centers, comprehensive cancer centers, and nonuniversity, community based clinical practices.

- NSABP B-04 trial: radical versus total mastectomy.

  No significant differences in long-term outcome in clinically node negative patients randomized to radical mastectomy compared with those patients randomized to total mastectomy with or without nodal radiation therapy.

  No significant differences in long-term outcome in clinically node positive patients randomized to radical mastectomy compared to those randomized to total mastectomy with nodal radiation therapy.

- NSABP B-06 trial: total mastectomy versus lumpectomy w/without XRT.

  No significant differences in overall survival (OS), disease free survival (DFS), or distant disease free survival for patients with tumors measuring 4 cm or less randomized to total mastectomy compared to those randomized to lumpectomy and axillary lymph node dissection with or without breast radiation.

Incidence of ipsilateral breast tumor recurrence (IBRT) in 14.3% of patients who had lumpectomy and XRT compared to 39.2% in women treated with lumpectomy alone.

- NSABP B-17 trial: surgical treatment in women with DCIS.

  Lumpectomy alone compared to lumpectomy and XRT for patients with localized DCIS.

  XRT decreases the rate of noninvasive and invasive IBTR (14.6% to 8% for noninvasive and 16.8% to 7.7% for invasive).

  Presence of moderate to marked comedo necrosis is a significant independent predictor for IBTR.

- NSABP B-21 trial: adjuvant therapy in node negative patients.

  Patients undergoing lumpectomy and axillary dissection with node negative tumors measuring 1 cm or less randomized to tamoxifen alone, breast radiation and tamoxifen for 5 years, or radiation and placebo for 5 years.

  Incidence IBTR over an 8-year period was 16.5%, 9.3%, and 2.8% in patients treated with tamoxifen alone, radiation and placebo, and radiation and tamoxifen, respectively.

  Contralateral breast cancer noted to be decreased in women treated with tamoxifen.

- NSABP B-24 trial: tamoxifen use in women with DCIS.

  Patients undergoing lumpectomy and radiation therapy for localized DCIS randomized to either tamoxifen or placebo for 5 years.

  Tamoxifen improved DFS compared to placebo.

- NSABP B-13 trial: adjuvant therapy in node negative, ER negative tumors.

  Randomized node negative patients with ER negative tumors to surgery alone or surgery followed by 12 months of adjuvant chemotherapy with methotrexate and sequentially administered 5-FU followed by leucovorin.

  Benefits in DFS and OS reported in all women receiving MF.

- NSABP B-19 trial: adjuvant therapy in node negative, ER negative tumors.

  Randomized node negative patients with ER negative tumors to surgery alone or surgery followed by adjuvant chemotherapy with methotrexate and sequentially administered 5-FU (MF) or cyclophosphamide, methotrexate, fluorouracil (CMF).

  Statistically significant DFS and OS advantage with CMF compared to MF particularly in women under the age of 50. Small but not significant benefit in women 50 or older.

- NSABP B-18 trial: preoperative versus postoperative use of adjuvant chemotherapy.

  After breast cancer diagnosis with FNA or core needle biopsy patients randomized to surgery (lumpectomy and axillary node dissection or modified radical mastectomy) followed by 4 cycles of Adriamycin (doxorubicin) and cyclophosphamide (AC) or 4 cycles of AC followed by surgery.

  In the group receiving preoperative chemotherapy:

  36% of patients had a complete clinical response; 43% had a partial clinical response; 17% stable disease; 3% progressive disease.

9% of patients had a complete pathological response (e.g., no tumor present pathologically at time of surgery).

4% of patients had only noninvasive tumor in surgical specimen.

16% of patients had axillary downstaging (43% of patients receiving preoperative chemotherapy found to have nodal involvement compared with 59% in women undergoing surgery first).

These patients more likely to undergo lumpectomy.

No difference in DFS, OS, or distant disease free survival between two treatment groups.

Patients with a complete pathological response had significant improvements in DFS and OS compared to those patients found to have residual invasive carcinoma at the time of surgery.

- NSABP B-22 and NSABP-25: postoperative adjuvant therapy in patients with node positive cancer, effect of intensification and increased cumulative doses of AC.

  No benefit from dose intensification.

  No benefit from increasing the total dose of cyclophosphamide in the AC combination.
- NSABP B-28 trial: evaluation of postoperative paclitaxel (Taxol) following standard AC chemotherapy in node positive patients.

  Preliminary data suggest improvement in DFS, but no significant difference in OS between group receiving AC followed by Paclitaxel and the group randomized to AC only.

## Breast Cancer Staging (TNM Classification)

### Key Facts

- Primary tumor.

| | |
|---|---|
| TX: | Primary tumor cannot be assessed. |
| T0: | No evidence of primary tumor. |
| Tis | Carcinoma in situ. |
| | Tis (DCIS)—Ductal carcinoma in situ. |
| | Tis (LCIS)—Lobular carcinoma in situ. |
| | Tis (Paget's)—Paget's disease of the nipple with no tumor. |
| T1 | Tumor 2 cm or less in greatest dimension. |
| | T1mic—microinvasion 0.1 cm or less in greatest dimension. |
| | T1a—tumor >0.1 cm, but not more than 0.5 cm in greatest dimension. |
| | T1b—tumor >0.5 cm, but not more than 1 cm in greatest dimension. |
| | T1c—tumor >1 cm, but not more than 2 cm in greatest dimension. |
| T2 | Tumor >2 cm, but not more than 5 cm in greatest dimension. |
| T3 | Tumor >5 cm in greatest dimension. |

| | |
|---|---|
| T4 | Tumor of any size with direct extension to chest wall or skin.<br>T4a—extension to chest wall not including pectoral muscle.<br>T4b—edema or ulceration of breast skin or satellite skin nodules confined to same breast.<br>T4c—both T4a and T4b.<br>T4d—inflammatory carcinoma. |

- Regional lymph nodes (pathologic -pN).

| | |
|---|---|
| pNX | Regional lymph nodes cannot be assessed (previously excised or not removed for pathological evaluation). |
| pN0 | No regional lymph node metastasis histologically, no additional examination for isolated tumor cells (ITC). |
| pN0(i−) | No regional lymph node metastasis histologically, negative immunohistochemical (IHC). |
| pN0(i+) | No regional lymph node metastasis histologically, positive IHC, no IHC >0.2 mm. |
| pN0(mol−) | No regional lymph node metastasis histologically, negative molecular findings (RT-PCR). |
| pN0(mol+) | No regional lymph node metastasis histologically, positive molecular findings (RT-PCR). |
| pN1 | Metastasis in 1 to 3 axillary lymph nodes and/or in internal mammary nodes with microscopic disease detected by sentinel lymph node dissection, but none clinically apparent. |
| pN1mi | Micrometastasis (>0.2 mm, none <2 mm). |

## Breast Cancer Staging

### Key Facts

| | | | | |
|---|---|---|---|---|
| STAGE 0 | Tis | N0 | M0 | |
| STAGE I | T1 | N0 | M0 | |
| STAGE IIA | | T0 | N1 | M0 |
| | | T1 | N1 | M0 |
| | | T2 | N0 | M0 |
| STAGE IIB | | T2 | N1 | M0 |
| | | T3 | N0 | M0 |
| STAGE IIIA | | T0 | N2 | M0 |
| | | T1 | N2 | M0 |
| | | T2 | N2 | M0 |
| | | T3 | N1 | M0 |
| | | T3 | N2 | M0 |
| STAGE IIIB | | T4 | N0 | M0 |
| | | T4 | N1 | M0 |
| | | T4 | N2 | M0 |
| STAGE IIIC | | anyT | N3 | M0 |
| STAGE IV | | anyT | anyN | M1 |

(From: American Joint Committee on Cancer (AJCC). *Cancer Staging Manual.* 6th ed. New York: Springer; 2002.)

## SUGGESTED READINGS

Ahmedin J, Siegel R, Ward E, et al. Cancer statistics, 2007. *CA Cancer J Clin*. 2007;57: 43–66.

Bland KI, Copeland III EM. *The Breast*. 3rd ed. Philadelphia: WB Saunders; 2004.

Dupont WD, Page DL, Parl FF, et al. Long-term risk of breast cancer in women with fibroadenoma. *N Engl J Med*. 1994;331:10–15.

Fisher B, Costantino JP, Wickerham DL, et al. Tamoxifen for prevention of breast cancer: report of the National Surgical Adjuvant Breast and Bowel Project P-1 Study. *J Natl Cancer Inst*. 1998;90:1371–1388.

Harris JR, Lippman ME, Morrow M, et al. *Diseases of the Breast*. 3rd ed. Philadelphia: Lippincott Williams and Wilkins; 2004.

Jacobs TW, Byrne C, Colditz G, et al. Radial scars in benign breast-biopsy specimens and the risk of breast cancer. *N Engl J Med*. 1999;340:430–436.

Klauber-DeMore N, Tan LK, Liberman L, et al. Sentinel lymph node biopsy: is it indicated in patients with high-risk ductal carcinoma in situ and ductal carcinoma in situ with microinvasion? *Ann Surg Oncol*. 2000;7:636–642.

Liberman L. Pathologic analysis of sentinel lymph nodes in breast carcinomas. *Cancer*. 2000;88:971–977.

Liberman L, Cody HS 3rd, Hill AD, et al. Sentinel lymph node biopsy after percutaneous diagnosis of nonpalpable breast cancer. *Radiology*. 1999;211:835–844.

McTierney A, Gilligan MA, Redmond C. Assessing individual risk for breast cancer: risky business. *J Clin Epidemiol*. 1997;50:547–556.

Page DL, Dupont WD. Premalignant conditions and markers of elevated risk in the breast and their management. *Surg Clin North Am*. 1990;70:831–851.

Ries L, et al. *SEER Cancer Statistics Review, 1975-2003*. Bethesda: National Cancer Institute; 2006.

Smigal C, Jemal A, Ward E, et al. Trends in breast cancer by race and ethnicity: update 2006. *CA Cancer J Clin*. 2006;56:168–183.

Vogel VG, Constantino JP, Wickerham DL, et al. Effects of tamoxifen vs raloxifene on the risk of developing invasive breast cancer and other disease outcomes. *JAMA*. 2006;295:2727–2741.

Wickerham DL, Costantino JP, Mamounas EP, et al. The landmark surgical trials of the National Surgical Adjuvant Breast and Bowel Project. *World J Surg*. 2006;30:1138–1146.

CHAPTER 2

# REGULATORY ISSUES

## MAMMOGRAPHY QUALITY STANDARDS ACT OF 1992: BACKGROUND

### KEY FACTS

- Hearings by Senate Committee on Labor and Human Resources in 1992.
  Wide range of problems with mammography in the United States.
  Poor quality equipment.
  Lack of quality assurance procedures.
  Poorly trained technologists and interpreting physicians.
  Lack of facility inspection or consistent government oversight.
- On October 27, 1992, Congress passed The Mammography Quality Standards Act (MQSA) to establish quality standards for mammography.
  Legislation signed December 12, 1993, authorized for 5 years.
  Reauthorized on October 8, 1998.
- MQSA regulates mammographic modalities.
  Defined as technologies for radiography of the breast (e.g., film screen, digital mammography).
  Spot compression, magnification and implant evaluation are considered techniques used with a mammographic modality not separate mammographic modalities.
  Stereotactic biopsy, needle localization, and ductography are procedures currently exempt from the definition of mammographic modality and not regulated under MQSA.
  Ultrasound, magnetic resonance imaging, and nuclear medicine studies are nonradiographic procedures and not regulated under MQSA.
- Effective October 1, 1994, all mammography facilities (except those of the Department of Veterans Affairs) must be accredited, certified (2 different processes) and inspected.

Accreditation has to occur before certification.

An approved accrediting body does accreditation every 3 years.

American College of Radiology, Mammography Accreditation Program.

State of Iowa (limited to facilities in Iowa).

State of Arkansas (limited to facilities in Arkansas).

State of Texas (limited to facilities in Texas).

The Food and Drug Administration (FDA) or an approved certifying state provides certification. Certifying states can only certify facilities within their state borders; the FDA does not certify facilities in approved certifying states. Certifying states:

State of Illinois.

State of Iowa.

State of South Carolina.

Inspections occur on site annually by the FDA-trained and certified federal or state inspectors on behalf of The Department Health and Human Services (HSS) annually.

- Authority for approving accreditation bodies and certifying facilities delegated to the FDA.
- Federal Register publications.

  December 21, 1993: MQSA interim rules.

  September 30, 1994: Amendments.

  April 3, 1996: MQSA proposed final regulations.

  October 28, 1997: Final regulations.

  Final MQSA regulations in effect as of April 28, 1999.

## MQSA: Requirements

### Key Facts

- Accreditation of mammography facilities.

  Undertaken by private nonprofit organizations or state agencies meeting FDA standards for accrediting bodies and approved by the FDA.

  Accrediting bodies must pass annual FDA reviews.

  Accreditation process must include clinical image evaluation for each mammography unit.
- Annual physics review of mammographic facilities by a qualified medical physicist.
- Annual on site inspection of all mammography facilities.

  FDA certified federal or state inspectors.

  When state inspectors are used for MQSA inspections, state inspection programs must be audited by direct federal inspection of a sample number of state inspected facilities. (Federal audit inspections may be done jointly with the state inspection or separately).
- Initial and continuing qualifications standards for:

Interpreting physicians.
Radiologic technologists.
Medical physicists.
Mammography facility inspectors.

- Eligibility to certify adequacy of training and experience of mammography personnel.
- Quality standards.
  Mammographic equipment and practices.
  QA/QC program.
- Standards governing.
  Record keeping.
  Mammography reports.
  Patient and physician notification.
- Advisory committee.
  National Mammography Quality Assurance Advisory Committee (NMQAAC) to advice FDA on appropriate quality standards and accreditation bodies.

## MQSA: Inspections

### Key Facts

- All mammography facilities undergo annual inspections by MQSA inspectors. Review component.
  QA/QC program: procedures and documentation.
  Personnel qualification records.
  Medical physicist's survey reports (last 2 years).
  Medical audit and outcome analysis records.
  Mammography reports and films on randomly selected patients.
  Procedures for communicating exam results to patients and referring physicians.
  Display of FDA certificate in each patient waiting area.
- Evaluation of equipment during annual MQSA inspections.
  Unit designed specifically for mammography.
  Availability of required image receptors, moving grids and compression paddles.
  Collimation assessment (alignment of x-ray field/image receptor and image receptor/compression device).
  Reproducibility of exposure.
  Beam quality and half-value layer (HVL) measurement dose calculation for craniocaudal view.
  Phantom image quality.
  Display of focal spot and target material used, after exposures.
  Processor evaluation.
  Darkroom fog.

- Verbal notice given to facility at least 5 working days before inspection.
  Date for inspection selected with facility.
  Confirmation in writing follows verbal notice.
  Fees for the annual MQSA inspection are based on the number of units in a given facility.
  $1749 for the first unit.
  $204 for each additional unit.
  $991 if a follow-up inspection is needed.
  $509 assessed by FDA on facilities operating in approved certifying states (independent of the fees charged by the state certifying body).
  Facility is billed after inspection; fees due in 30 days.
  Fees for facilities in certifying states may differ from those listed previously for the FDA.
- Level 1 noncompliance (requires immediate action to remedy; re-inspections and sanctions if corrective action is not taken).
  Failure to meet key MQSA requirement such that the quality of the mammography done at a facility may be compromised.
  Program for high-quality mammography not fully instituted.
  Unqualified personnel.
  Nondedicated mammography equipment.
  Radiation dose of 400 mrad/exposure or more.
- Level 2 noncompliance (written response with corrective action required within 30 days of inspection).
  All key MQSA requirements are met, but facility fails to meet a significant mammography quality item.
  Medical audit system lacking.
  Radiation dose of 300 to 400 mrad/exposure.
  Phantom image fails minimum criteria.
- Level 3 noncompliance (corrective action before next inspection).
  Facility meets all major MQSA requirements; minor problem(s).
  Minor equipment problem(s).
  All QC tests not completed.
- Reinspection to determine if corrective actions for noncompliance have been implemented.
  Level 1 noncompliance.
  Failure of facility to respond as required by FDA.
- Additional mammography review (AMR).
  Undertaken when FDA believes mammography quality may have been compromised and may represent a serious risk to human health.
  Facility provides clinical images and relevant information specified by FDA for review by accreditation body or other entity specified by FDA.
  FDA may require that the facility notify patients and referring physicians if it is determined that a serious risk to human health may have existed.

## MQSA: Personnel Qualifications

### Key Facts

- In evaluating education and experience requirements count back appropriate number of months from the date of the inspection or the end of the full calendar quarter immediately preceding the inspection or any date between the inspection and the end of the previous full calendar quarter.
- Mammography facilities are responsible for ensuring that personnel providing mammography services meet applicable MQSA requirements.
- Records for personnel who leave a facility should be kept until after the next annual inspection.

## Interpreting Physicians

- Physician qualified as interpreting physician under the interim regulation prior to April 28, 1999.
- If after April 28, 1999:

  Valid state license to practice medicine.

  Board Certification in Diagnostic Radiology by an FDA approved body (American Board of Radiology, American Osteopathic Board of Radiology or the Royal College of Physicians and Surgeons of Canada) OR 3 months of formal training in mammography.

  60 hours of category I continuing medical education (CME) in mammography with at least 15 obtained in the 3 years immediately prior to qualifying as an interpreting physician.

  240 mammograms interpreted under direct supervision in the 6 months prior to qualifying as an interpreting physician OR, if the physician becomes board certified at the first allowable time, the 6-month period can be anytime in the last 2 years of the residency program.
- Continuing requirements.

  Maintain a valid state license to practice medicine.

  960 interpretations per 24 months.

  15 category I CME credits in a 36-month period; 6 of the 15 CME hours must be in each mammographic modality.

  8 hours of training in each mammographic modality before independent use.
- Re-establishing qualifications.

  Interpret 240 mammograms under direct supervision or enough studies to bring total to 960 mammograms per 24 months whichever is less.

  Interpretations should be done in the 6 months immediately preceding independent reading.

  Bring continuing education credits to 15 hours category I CME per 36 months.
- Participation in quality assurance activities is required of all interpreting physicians. For example, follow procedures for corrective action if poor

quality images are submitted for interpretation and participation in medical outcomes and audit program.

## Radiologic Technologists

- Qualified as a radiologic technologist under the interim regulations prior to April 28, 1999, or completed 40 contact hours of specific training in mammography in the topics specified in the regulations, including performance of 25 examinations under direct supervision.

  State license or certification from an FDA-approved body (American Registry of Radiologic Technologists or the American Registry of Clinical Radiography Technologists).

  8 hours of training in each mammographic modality used.
- Continuing requirements.

  Maintain a valid state license or general certification.

  200 mammography examinations per 24 months.

  15 CEUs per 36 months [at least 6 continuing education units (CEUs) in each mammographic modality used].

  8 hours of training in each mammographic modality used before independent use.
- Re-establishing qualifications.

  25 mammography examinations done under direct supervision.

  Continuing education credits up to 15 CEUs in 36 months.

## Medical Physicists

- Initial requirements.

  State licensed or certified by FDA approved body.

  Master's or higher degree in a physical science with no less than 20 semester hours of physics.

  20 contact hours of specialized training in conducting mammography facility surveys.

  Experience conducting surveys of at least 1 mammography facility and a total of at least 10 mammography units.
- Alternative initial qualifications.

  Qualified as a medical physicist under the interim regulations and maintained active status of any licensure, approval, or certification required under interim regulations.

  Prior to April 28, 1999, have:

  Bachelor or higher degree in a physical science with no less than 10 semester hours in physics.

  40 contact hours of documented specialized training in conducting surveys of mammography facilities.

  Experience conducting surveys of at least 1 mammography facility and a total of at least 20 mammography units (met after fulfilling degree requirement).

- Continuing education.
  15 CEUs per 36 months.
  Two facilities and 6 units per 24 months.
  Maintain valid state license, state approval or certification.
- Re-establishing qualifications.
  Bring total number of supervised surveys to 2 facilities and 6 units per 24 months under direct supervision.
  Bring continuing education credits to 15 CEUs per 36 months.
- Because the FDA expects that facilities should be able to call on the services of the medical physicist throughout the year, facilities must be able to identify their qualified medical physicist at the time of MQSA inspections.

## MQSA: Reporting of Results

### Key Facts

- Information required in mammography reports.
  Name of patient and unique patient identifier (e.g., medical record number).
  Date of study.
  Interpreting physician.
  Assessment (negative, benign, probably benign, suspicious, highly suggestive of malignancy, known biopsy proven malignancy, incomplete, need additional imaging evaluation, incomplete need prior films for comparison).
  Recommendations to health care provider.
  Clinical questions raised by health care provider should be addressed even if assessment is negative or benign.
- Written report to referring health care provider within 30 days of study.
- To patient if there is no referring health care provider (e.g., self-referred patients).
- Suspicious or highly suspicious results communicated directly to referring health care provider and patient as soon as possible (ideally within 3 to 5 days).
- Summary report in lay language to all patients within 30 days of study.
  Self-referred women receive both the mammography report and a summary report in lay language.
- Facility must keep medical records and films for 5 years, 10 years if no additional mammograms are done on a patient at that facility, or longer if required by state or local law.
- Original films must be transferred (temporarily or permanently) as requested by patient or patient's representative.
- Federal law on this issue supersedes any conflicting state or local requirements.
  Costs for transferring or copying films can be passed on if done at the request of the patient or, if state law mandates that the facility retain copies.
  Any fee charged, however, cannot exceed documented cost incurred by the facility.

Cost of originals or copies made by the facility for its own benefit cannot be charged.

- Self-referred patients.

  Have no health care provider.

  Decline a health care provider.

  Or provider declines responsibility for their care.
- Facilities accepting self-referred patients must send mammography report and a lay summary of findings to the patient and have a system in place for referring patients to a health care provider when clinically indicated.
- Self-requesting patients.

  Schedule mammography on their own initiative, but name a health care provider who accepts responsibility for their clinical breast care.

  Accept a health care provider offered by facility.

  Treated as referred patients (mammography report to health care provider, lay summary to patient).
- Consumer complaint mechanism.

  Written system for collecting and resolving consumer complaints.

  Complaints not resolved by facility referred to accrediting body.

  Complaints not resolved by accrediting body referred to FDA.

  Events that could adversely affect clinical outcomes are considered serious complaints.

  Poor image quality.

  Missed cancers.

  Personnel not meeting FDA qualifications.

  Failure to send reports or lay summaries within 30 days.

  Records of serious complaints must be kept by the facility for at least 3 years.

## MQSA: Equipment Standards

### Key Facts

- Equipment used must be designed specifically for mammography; requirements for film screen and full field digital mammography (FFDM) are outlined subsequently.
- Tube image receptor assembly (screen film and FFDM).

  Must be capable of being fixed in position with no unintended motion after position is fixed.

  No unintended motion if there is an interruption in power (e.g., a power failure).
- Film screen systems should provide 18 × 24 cm and 24 × 30 cm image receptors and matching 18 × 24 cm and 24 × 30 cm moving grid mechanisms.
- Beam limitation and light fields (film screen and FFDM).

  X-ray field should extend to, or beyond, the chest wall edge of the image receptor (collimator should allow for complete coverage of the image receptor at the chest wall edge).

Film screen and FFDM systems (except Fisher) with a light beam passing through the x-ray beam limiting device must provide illumination of not less than 160 lux (15 foot candles) at 100 cm or maximum source image receptor distance whichever is less.

- Systems used for magnification (film screen and FFDM).

  1.4× to 2× magnification capability.

  Capable of operating with the grid removed.
- Compression devices (film screen and FFDM).

  For each image receptor size.

  Flat and parallel to the breast support table (except Fisher FFDM).

  Do not deflect from parallel by more than 1 cm at any point (except Fisher FFDM).

  Chest wall edge straight and parallel to the chest wall edge of the image receptor.

  If not designed to be flat and parallel, must meet manufacturer's design and maintenance requirements.

  Compression paddles for special purposes (e.g., spot compression) may be provided.
- Technique factor selection and display.

  Manual selection of mAs (film screen and FFDM).

  Technique factors (e.g., kV, mA and exposure time or mAs) indicated before exposure (film screen and FFDM).

  With automatic exposure control (AEC), system should indicate kVp and mAs used (film screen and FFDM).

  For film screen systems AEC mode is operable in all modes used clinically (e.g., grid versus nongrid; various target filter combinations).

  Flexible positioning of the detector for placement under target tissue (film screen).

  Size and positioning of detector indicated on x-ray input surface of the compression paddle (film screen).

  Position selected should be indicated clearly (film screen).

  Optical density can be varied from zero setting (film screen).
- Display of selected focal spot and target material (film screen and FFDM).
- X-ray film and intensifying screens designed for mammography (film screen).

  Film used should be matched to the screen's spectral output as specified by manufacturer.

  Chemical solutions used for processing should be capable of developing the film equivalent to the minimum requirements specified by film manufacturer.
- A hot light and film masking devices available for use by the interpreting physician (film screen and FFDM for hardcopy comparison).
- Compression (film screen and FFDM).

  Initial power driven compression with hands-free controls.

  Fine adjustment control.

Operable from both sides of the patient.

Force for initial power drive between 111 N (25 lb) and 209 N (47 lb).

AEC to maintain film optical density within 0.15 of mean optical density.

Focal spot evaluation using system resolution only.

Radiation output from 513 mR/sec to 800 mR/sec.

- Facilities with FFDM systems.

  Access to laser film printer.

  A qualified medical physicist must test printer.

  Facilities must be able to provide hardcopy films of final interpretation quality to medical institutions, physicians, health care providers, patients, or patient's representative.

  It is recommended that only those monitors and printers cleared for FFDM use by FDA's Office of Device Evaluation (ODE) be used.

- Infection control.

  Procedures for cleaning and disinfecting mammography equipment after contact with potentially infectious materials (e.g., blood or other body fluid).

  Compliance with federal, state, and local regulations.

  Compliance with equipment manufacturer's recommendations.

## Quality Assurance Under MQSA

### Key Facts

- Under MQSA facilities are required to establish and maintain a quality assurance program.

  Some of the requirements outlined subsequently differ from what is required by the American College of Radiology Mammography Accreditation Program (see Chapter 3) or state accreditation programs.

- Responsible individuals.

  Lead interpreting physician: ensures that the quality assurance program of a facility complies with MQSA.

  Interpreting physicians: must meet the qualifications required for interpreting physicians under MQSA, follow procedures for corrective action of poor quality images and participate in the medical outcomes program of their facility.

  Medical physicist: do surveys, mammography equipment evaluations, and oversee the quality assurance practices of mammography related equipment.

  Quality control technologist: responsible for the tasks not assigned to the lead interpreting physician or medical physicist.

- Quality assurance records are kept until the next annual inspection or until the test has been done two additional times at the required frequency (whichever is longer).

  Employee qualifications.

  Mammography techniques and procedures.

Quality control (data monitoring, problems identified through data analysis, corrective actions taken, and effectiveness of the corrective actions).

Safety and protection.

- Daily quality control tests.

  Processor quality control using the mammography film used by the facility done before any clinical images are processed.

  Base plus fog within ±0.03 of established operating levels.

  Mid density within ±0.15 of establish operating levels.

  Density difference within ±0.15 of established operating levels.

  Weekly quality control tests.

  Image quality evaluation using an FDA approved phantom.

  Film optical density of at least 1.20 at the center of the phantom image.

  Film optical density shall not change by more than ±0.20 from established operating levels.

  Phantom image must achieve at least the minimum score established by the accreditation body and accepted by FDA (e.g., 4 largest fibers, 3 largest speck groups, and 3 largest masses).

  Density difference between background and the added test object shall not vary more than 0.05 from established operating levels.

- Quarterly quality control tests.

  Fixer retention: no more than 5 micrograms of residual fixer per square cm.

  Repeat analysis: if the repeat rate changes by more than 2% from previously established rates, determine reasons for change.

- Semiannual.

  Darkroom fog: darkroom safelight on; mammography film used by the facility for clinical images with a mid density of no less than 1.2; film, emulsion side up, exposed to darkroom conditions for 2 minutes; optical density related to darkroom fog cannot exceed 0.05.

- Screen film contact.
- Compression: maximum force for initial power drive between 111 N (25 lb) and 209 N (47 lb).
- Annual tests (Details on specific requirements are beyond the scope of this book, please refer to Federal Register, October 27, 1997).

  Automatic exposure control.

  kVp accuracy and reproducibility.

  Focal spot condition.

  Breast entrance air kerma and AEC reproducibility.

  Dosimetry.

  X-ray field/light field/image receptor/compression paddle alignment.

  Uniformity of speed screen.

  System artifacts.

  Radiation output.

- For FFDM, FDA requires facilities to comply with QC program as recommended by the image receptor manufacturer.

Also applies to review workstations (monitors) and laser printers.

- Medical audit of outcomes.

  Follow-up on all positive mammographic assessments (suspicious and highly suspicious findings; additional imaging evaluation needed) and correlation of pathologic and mammographic findings.

  Data for each interpreting physician and for facility as a whole.

  Done at least every 12 months.

## MQSA and Full Field Digital Mammography

### Key Facts

- FDA has approved ACR to accredit the following full field digital mammography (FFDM) units:

  General Electric Senographe 2000D, DS and Essential.

  Fisher Senoscan.

  Lorad/Hologic Selenia.

  Siemens Mammomat Novation DR.

  Fuji FCRm (computed radiography).

- Facilities with any other FFDM manufacturer or model must apply and be approved by the FDA for an extension of certificate to include use of FFDM.
- If a mammography unit is used for both film screen and computed radiography, the unit must be accredited as 2 separate units (image quality, QC, and personnel qualifications are different).

## American College of Radiology, Mammography Accreditation Program: Background

### Key Facts

- Oldest and largest mammography accreditation program in the United States.
- 1985: Nationwide Evaluation of X-ray Trends (NEXT 85).

  Radiation dose and image quality at 232 US mammography sites.

  Wide variation in image quality and radiation dose.
- 1986: Galkin et al. survey 26 mammography sites in Philadelphia area.

  10-fold range in average glandular dose.

  Site to site variation in image quality.

  Wide variations in film processor performance over 15-day period in 41% of the facilities.
- Concurrently, American Cancer Society (ACS) through National Breast Cancer Awareness Screening Programs wants to encourage mammographic screening nationally.

How to assure high quality mammograms at low radiation doses?

American College of Radiology approached by ACS about accreditation program.

- 1986: ACR designs and pilots mammography equipment testing program.
- August 1987: accreditation of sites by ACR starts.

  Voluntary program.
- Goals of ACR accreditation program.

  Establish quality standards for mammography.

  Mechanism for mammography sites to compare themselves with nationwide standards.

  Collection and dissemination of data on mammography practices.

  Encourage quality assurance.

  Reproducible, high quality images at low radiation dose to patient.

## Mammography Accreditation Program

### Key Facts

- ACR accredits mammography units (FDA certifies facilities).

  All units in a facility must be accredited to receive 3-year certification from FDA.

  Although there are several other accrediting bodies, ACR accredits over 90% of mammography facilities.

  As of November 3, 2006: 13,542 units accredited in 8844 facilities.

  Currently 90% of units pass accreditation on the first attempt compared with the 70% pass rate in 1994.

  Reasons for failure on the first attempt at accreditation:

  70% clinical image quality deficiency.

  23% phantom image quality deficiency.

  5.5% clinical and phantom image quality deficiency.

  Less than 1% did not meet 300-mrad dose limit.
- Facilities seeking accreditation complete entry application.

  If facility fulfills criteria, ACR (or other accreditation body) notifies the FDA so that a 6-month provisional certificate is issued enabling the facility to do mammography pending completion of the accreditation process.

  Full accreditation application is sent to the facility.
- For accreditation, facilities submit:

  A completed form providing information on equipment, personnel qualifications, and phantom image for image quality and dose evaluations using an approved breast phantom and thermo luminescent dosimeter.

  Two normal mammograms (fatty and dense breasts).

  Processor quality control for 30-day period.

  Fee ($1,325.00 for first unit and $1,175.00 for each additional unit).

- Clinical and phantom images need to be taken within 30 days of each other and during the time period covered by the processor quality control chart submitted.
- The clinical images submitted should represent a facility's best work and be interpreted as negative.

  Craniocaudal (CC) and mediolateral oblique (MLO) views of a patient with fatty tissue.

  CC and MLO views of a patient with dense tissue.

  Submit original films (no copies).
- Using a 1 to 5 scale, images fail if a 1 or 2 is assigned to any of the quality parameters evaluated. Clinical images are scored independently by at least 2 reviewers.

  Images are reviewed for positioning, compression, exposure, contrast, sharpness, noise, artifacts, and exam identification.

  If the review is split (e.g., 1 pass, 1 fail), the images are submitted to a senior reviewer for arbitration.
- Phantom image reviewed by at least two medical physicists.
- Average glandular dose may not exceed 300 mGy (mrad) per view.
- Final review with assessments and recommendations issued by ACR, successful facilities receive 3-year accreditation with decal for each unit.

  FDA is notified by the ACR so that a 3-year certificate can be issued.

  Facility included on American Cancer Society referral list of approved mammography facilities.
- Units failing two consecutive attempts at accreditation should be taken out of service until a corrective action plan is submitted by the facility.
- Annual update package.

  Quality control documentation.

  Medical physicist's survey for each unit.

  Application data update (e.g., changes in personnel and equipment).
- On-site surveys required.

  At least 5% of the facilities accredited (minimum of 5 facilities but not more than 50 facilities are required).

  50% of the facilities visited are selected randomly; others based on problems identified through state or FDA inspections, serious consumer complaints or history of noncompliance.

  A radiologist, medical physicist, and an ACR staff person make up the survey team.

  QA/QC records, personnel qualifications, images, mammography reports, and audit program (information) are reviewed and equipment is tested.

  Serve to verify and validate the information provided by the facility.

  Intended as an educational experience.
- Random clinical image reviews required.

  At least 3% of the facilities accredited (can count facilities selected randomly for on site visits).

  Facilities are selected randomly.

- The ACR also has accreditation programs for stereotactic breast biopsy, diagnostic breast ultrasound, ultrasound guided breast biopsy, and magnetic resonance imaging of the breast (beyond the scope of discussion in this text).

## SUGGESTED READINGS

American College of Radiology. *ACR Standard for the Performance of Breast Ultrasound Examination*. Reston: American College of Radiology; 1998.

American College of Radiology. *ACR Standard for the Performance of Ultrasound Guided Percutaneous Breast Interventional Procedures*. Reston: American College of Radiology; 1996.

American College of Radiology. *ACR Standard for Continuing Medical Education*. Reston: American College of Radiology; 1996.

American College of Radiology. *ACR Standard for Performance of Stereotactically Guided Breast Interventional Procedures*. Reston: American College of Radiology; 1996.

American College of Radiology. *ACR Standard for Communication: Diagnostic Radiology*. Reston: American College of Radiology; 1999.

Destouet JM, Bassett LW, Yaffe MJ, et. al. The ACR's mammography accreditation program: ten years of experience since MQSA. *J Am Coll Radiol*. 2005;2:585–594.

US Department of Health and Human Resources, Food and Drug Administration. *Guidance for Industry and Compliance. MQSA Policy Statements in a Question and Answer Format*. Washington: US Government Printing Office; June 2, 1998.

US Department of Health and Human Resources, Food and Drug Administration. Quality mammography standards; final rule. *Federal Register*. 1997 Oct 28:62:55852–55993.

US Department of Health and Human Resources, Food and Drug Administration. 21 CFR parts 16 and 900.

US Department of Health and Human Services. *Small Entity Compliance Guide. An Overview of the Final Regulations Implementing the Mammography Quality Standards Act of 1992*. Washington: US Government Printing Office; 1997.

CHAPTER 3

# QUALITY CONTROL

## General Comments

### Key Facts

- Quality control (QC) in mammography is important; it is a daily, ongoing process assessed on a film-by-film basis.
- Every step in the imaging chain is tested routinely so that potential problems are detected, identified, and corrected before they affect clinical image quality.

  Each mammography unit has to have an identification number that appears on the films.

  Each screen has to have an identification number that is marked with an opaque, permanent marker; the identification number should also be on the outside of the cassette.
- An appropriate combination of mammographic film, processor, processing chemistry, developer temperature, and processing cycle should be selected.

  Intensifying screens should be matched spectrally to the film's sensitivity.

  The film used for processor QC should be of the same type of film used for clinical images.

  If more than one type of film is used, the fastest film should be used for processor QC.
- Follow recommendations specified by the film manufacturer for processor, chemistry, developer temperature, immersion time, and replenishment rates.
- The National Council on Radiation Protection and Measurements (Report #99) recommends:

  Storing photographic materials at temperatures less than 24°C (range 15°C to 21°C), away from exposure to chemical fumes or radiation.

  Storing open film packages in areas with 40% to 60% humidity.

Standing film on edge when storing (pressure can damage film).

Not allowing liquid photochemicals to freeze.

- Only digital thermometers are used in mammographic film processors (mercury containing thermometers should never be used in processor).

  Accuracy to at least ±0.5°F.

  Clinical fever thermometers have an accuracy better than ±0.5°F over a 90° to 100° range; must be reset after each reading (e.g., they are not continuous reading thermometers).

  When measuring the temperature of developer and fixer solutions the thermometer is placed in the same location (nongear side of the processor) each time.

  Clean thermometer between measuring developer and fixer and before storage.

  Compare measured temperature to reading from the built-in thermometer.

  If discrepancy between thermometers is more than 0.5°F, the calibration of both thermometers should be checked.

- Sensitometer.

  Twenty-one steps; single-sided exposure.

  Emission spectrum should be similar to that of the intensifying screens used clinically.

- Densitometer.

  Check for consistency using the densitometer calibration strip that comes with the densitometer.

  Determine low, medium, and high optical density test areas (with optical density read by densitometer when new or in good calibration).

  If current reading differs more than 0.05 from original readings, densitometer should be checked.

  Densitometer should be "zeroed" as specified by the manufacturer prior to measuring optical densities.

- Sensitometric strips should be processed and read with a densitometer immediately after exposure.

  Data are plotted to determine if the processor is operating properly **before any clinical images are processed.**

  Preexposed sensitometric strips undergo latent image changes.

  As latent image decays, film optical density changes.

- Control charts.

  Plot data immediately: film density, optical density difference, exposure time or mAs, number of visible objects seen on phantom image, date, and initials of individual doing the test.

  Provide easy means of reviewing data.

  Allow for detection of trends (three points moving in the same direction either upward or downward) so that corrective action is taken before control limits are reached or exceeded.

  When a data point reaches or exceeds limits, repeat the test.

If the repeat measurement also reaches or exceeds limits, corrective action is indicated immediately.

Circle out-of-control data points on the control chart.

Document the cause of the problem and the corrective action taken.

- At the start of a QC program, operating levels and control limits need to be established.

  If control limits are exceeded repeatedly, QC procedures need to be improved or equipment needs to be repaired or replaced.

  Operating levels need to be re-established when:

  The film manufacturer makes a change to a film currently in use and recommends that the processor QC be re-established.

  The film volume changes.

  The brand or type of chemicals used is changed.

  The film brand or type is changed.

  The replenishment rates change.

  The development time changes.

  There is a change in the setting of the specific gravity automixer.

  A different sensitometer or densitometer is used.

  The film processor is changed.

  New x-ray equipment is installed.

  The film is running out so that a crossover cannot be done correctly.

- Phototimer technique chart.

  Used to overcome suboptimal phototimer performance (inconsistent image optical density).

  A list of kilovolt peak (kVp) and density-control settings used to obtain consistent film optical densities with exposure times between 0.5 and 2 seconds (chart developed by technologist in consultation with the physicist).

  Use of technique charts improves image contrast and minimizes motion blur on units with suboptimal phototimer performance.

  Post on mammographic unit adjacent to control panel.

  Should be followed by every technologist using equipment.

  Technique charts cannot be used to overcome a deficient AEC system.

  Provide information on obtaining appropriate optical densities when using a manual technique in imaging women with implants.

## Film Labeling

### Key Facts

- As important medical documents, the labeling of mammography films must be standardized.
- Except for view and laterality, labels are placed away from the image of the breast.

- Under MQSA, a permanent identification label, with the following information easily discernable, is required on all mammographic studies (film screen and full field digital mammography):
  Patient name.
  Unique patient identification number.
  Date of study.
  Radiopaque laterality and projection markers, placed closest to axilla.
  Facility name.
  Facility location (minimum: city, state, and zip code).
  Technologist identification.
  Cassette/screen identification number.
  Mammography unit identification number (if more than one unit in the facility).
- A flash card patient ID system is strongly recommended.
  Most permanent (compared to stick on labels).
  Reproduces on copy films.
  Should fit squarely in designated space.
  Not acceptable if the information is illegible, does not fit, is lopsided, or cut-off.
- Separate date stickers that can be read with overhead lights are recommended, because they facilitate sorting through mammographic studies.
- Troubleshooting suboptimal films requires knowledge of the technical factors used in obtaining the exposure, so it is also recommended that the technical factors used for an exposure appear on the film.
  Target-filter.
  kVp.
  Exposure time.
  Compression force.
  Compressed breast thickness.
  Degree of obliquity.

## QC Tests (Technologists)

### Key Facts

- Daily.
  Darkroom cleanliness.
  Processor QC.
- Weekly.
  Screen cleanliness.
  Viewboxes and viewing conditions.
  Phantom images.
- Monthly.
  Visual checklist.

- Quarterly.
  Repeat analysis.
  Analysis of fixer retention in films.
- Semiannually.
  Darkroom fog.
  Screen-film contact.
  Compression.
- Under MQSA, if any QC test fails, the source of the problem must be identified.
  Immediate corrective action (before any clinical images are done) is required for failures in processor QC, phantom images, darkroom fog, screen film contact, and compression.
  Corrective action within 30 days is required for failures in repeat analysis and analysis of fixer retention in film.
- The reader is encouraged strongly to consult the American College of Radiology's *Mammography Quality Control Manual* (American College of Radiology, Reston, VA, 1999) for additional details on QC; familiarity with these concepts is critical in troubleshooting technically suboptimal films.

## Darkroom Cleanliness

### Key Facts

- Objective.
  Minimize film artifact.
- Frequency.
  Daily, before any films are processed for the day.
- Equipment.
  Mop and pail, lint free towels and antistatic cleaning solution.
- Procedure.
  Turn processor and water on and clear countertops.
  Wipe processor feed tray and countertops with lint-free, clean, damp (antistatic solution) towel.
  Damp-mop darkroom floor.
  Wipe or vacuum overhead vents and safelights weekly before cleaning feed tray and countertops.
- Darkroom: general principles.
  Dust and dirt must be minimized: no smoking, drinking, or eating.
  Counter for loading and unloading cassettes should be clear of any objects (collect dust).
  No overlying shelves (dust settles and collects on items placed on shelves above counters).
  Darkroom ceiling should be made of solid material, tiles collect dust.
  Heating and air conditioning ducts should not be placed over countertops.

Electrostatic air cleaners can be used to reduce dust and dirt.

Humidity should be kept between 40% and 60% to minimize static; materials that reduce static electricity should be used for countertops and static systems to provide a continuous flow of iodinized air (reduce static) should also be used.

Ultraviolet lights are available to demonstrate some types of dust and dirt.

## Processor QC (Operating Levels)

### Key Facts

- Objective.

  To establish operating levels for the processor.
- Frequency.

  Initiation of QC program.

  When significant changes in imaging procedures occur.
- Equipment.

  Sensitometer for single emulsion film: Twenty-one steps in 0.15 optical density increments; spectral characteristics of sensitometer light source should match those of light source being used to expose films (e.g., green, if green emitting screens are used).

  Densitometer, fresh box of control film, control chart, clinical digital thermometer accurate to at least ±0.5°F (do not use mercury thermometer).
- Procedure.

  Fresh box of film and reserve this box of film for QC; note emulsion number on control chart.

  Drain chemicals from processor, flush tanks, and roller racks with water.

  Drain replenisher tanks and refill with fresh replenisher.

  Fill fixer tank with fixer solution.

  Flush developer tank again with water.

  Fill developer tank half full with developer, add specified amount of starter solution then add sufficient developer to fill the developer tank.

  Set the temperature of the solutions (developer, fixer, and water) as specified by the manufacturer. Dryer temperature should not exceed the film manufacturer's recommendations.

  Set developer and fixer replenishment rates as specified by film manufacturer.

  After developer temperature has stabilized, check temperature.

  Evaluate darkroom environment and do a darkroom fog test.

  Using the sensitometer, expose and process sensitometric strips each day for 5 consecutive days at the same time each day.

  As outlined subsequently, sensitometric strips should be processed in a consistent manner.

  Using densitometer, read and record densities for each step (measure at center of each step); should also measure an area of processed film, not exposed.

Calculate a 5-day average for each step.

Identify the step with average density closest to, but not less than, 1.20, designate as mid-density (MD) step (speed point, speed index, speed step).

Identify the step closest to 2.20 and the step closest to, but not less than, 0.45: the difference between these steps is designated the density difference (DD).

The average density of the 5 (days) unexposed areas is designated base-plus-fog (B + F).

Record MD, DD, and B + F and the respective upper and lower control limits on the control chart.

- Indications for reestablishing operating levels for processor include changes in:

  Film in use, film volume or film brand or type.

  Brand or types of chemicals used.

  Replenishment rates.

  Development time.

  Setting on specific gravity automixer.

  Sensitometer or densitometer.

  Film processor.

  Running out of QC film prior to crossover being done.

## PROCESSOR QC (DAILY)

### KEY FACTS

- Objective.

  To ensure dependable film quality through consistent film processing.
- Frequency.

  At the start of each workday before processing any patient films.
- Procedure.

  Expose and process sensitometric strip.

  Process strips consistently each day.

  Stabilized developer temperature (as specified by manufacturer).

  Less-exposed end of strip into processor first.

  Process on same side of processor feed tray (right versus left) each time.

  Consistent emulsion orientation, for single emulsion film (i.e., emulsion side up).

  Time between exposure and processing should be approximately the same each day (to avoid latent image changes).

  QC on densitometer, sensitometer and thermometer as recommended by manufacturers.

  Read density for MD, DD, and B + F steps and plot on chart.

  Determine if any point exceeds control limits.

  If any data point exceeds control limits, expose and process a second strip to be sure proper procedure is followed.

Circle out-of-control points, determine and correct cause of problem, repeat test, and note the cause of the problem in the "remarks" section of control chart.

If trends develop (three or more points moving in one direction), institute corrective action before obtaining an out-of-control data point.

- Caveats.

  Sensitometric strips need to be processed within an hour of being exposed and evaluated before any clinical films are processed.

  Use calibrated densitometer for reading strip; visual comparison is not adequate.

  Developer temperature should be within ±0.5°F of temperature specified by manufacturer.

  QC needs to be done on sensitometer, densitometer, and thermometer to ensure proper calibration as specified by the manufacturers.

  Mercury containing thermometers should never be used in the processor.

- Performance.

  MD and DD should be within ±0.10 of operating levels; if outside ±0.10 but within ±0.15, the test should be repeated; if value is confirmed, process clinical images but monitor processor closely.

  If MD and DD exceed ±0.15, identify and correct problem before processing any mammograms.

  B + F should be within ±0.03; if B + F exceeds ±0.03, identify and correct problem before processing any mammograms.

  Corrective actions need to be noted in control chart.

  Processor QC controls are retained for 1 year.

  Sensitometric films are retained for the last full month's QC chart.

## Processor QC (Control Film Crossover)

### Key Facts

- Objective.

  When a new box of processor QC film is needed, new operating levels are established to take into account slight variations in the characteristics of the film between old and new film boxes.

  Film is produced in batches; slight variations in film characteristics may be seen between batches.

  Film aging and storage can affect sensitometric characteristics.

- Frequency.

  When new box of film is opened for QC purposes.

- Procedure.

  With at least five sheets of film remaining in old QC box, select a new box of film for processor QC.

Processor should have seasoned chemistry operating within the ±0.10 control limits.

At the same time of day when processor QC is normally done, expose and immediately process five sensitometric strips each from the old and new film boxes.

Determine an average for the steps previously designated as MD, DD, and B + F on the five films from the old and new boxes of film.

Determine differences in the average values between the new and old boxes of film.

To establish new operating levels, adjust old operating levels for MD, DD, and B + F by the difference in averages (if the difference between new and old is positive, the new operating level is increased; if the difference between new and old is negative, the new operating level is decreased).

Record new operating levels and control limits on a new control chart.

Record emulsion number for new box of QC film on control chart.

Record date of crossover procedure in the remarks section of the QC chart.

## Screen Cleanliness

### Key Facts

- Objective.

  To assure that mammographic screens and cassettes are free of dust and dirt particles.
- Frequency.

  Done at least weekly.

  Depending on usage, screens and cassettes may need to be cleaned more often.

  If any artifact is detected (cassettes are numbered so that repeating artifact can be tracked to a given cassette and corrective action can be taken immediately).
- Equipment.

  Screen cleaner (screen manufacturer), lint free wipes, Camel's hair (or antistatic) brush, canned air (compressed air needs to be "clean" air, no moisture oils).
- Procedure.

  Select clean location and check screens for dirt, dust, and other marks under a bright light.

  Clean screens using procedures and materials recommended by manufacturer.

  After cleaning with liquid cleaners, allow vertically oriented and partially opened cassettes to air-dry.

  Inspect screen and cassette cover.

  Wait at least 15 minutes (or as recommended by manufacturer) after loading cassette and before using (for good film-screen contact to develop).
- Performance.

  Review clinical images for minus density artifacts on an ongoing basis.

# Phantom Images

## Key Facts

- Objective.

  To check that x-ray imaging system and film processor(s) are operating optimally with respect to film density, contrast (density difference), uniformity, and image quality.
- Frequency.

  Initial: after equipment calibration and with seasoned chemistry in processor.

  At least weekly.

  After servicing any equipment or with changes in film or screen type.
- Equipment.

  Mammographic phantom (equivalent to a 4.2 cm thick compressed breast with 50% glandular and 50% adipose tissue); contains six fibers (diameters of 1.56, 1.12, 0.89, 0.75, 0.54, and 0.4 mm), five speck groups (diameters of 0.54, 0.4, 0.32, 0.24, and 0.16 mm) and five masses (decreasing diameter and thickness of 2.00, 1.00, 0.75, 0.50, and 0.25 mm); Radiation Measurement, Inc. RMI-156 or Nuclear Associates 18-220 can be used for American College of Radiology mammography accreditation.

  Consistent placement so that disc does not obscure phantom details or cast a shadow on any portion of AEC detector (disc can be attached to phantom permanently using Superglue); 4 mm thick and 1 cm diameter acrylic disc on phantom.

  Use same cassette each time to eliminate inconsistencies resulting from cassette or screen variability.

  Film type used clinically.

  Appropriate masking when reviewing phantom images.

  Magnifying lens: 2× or higher.

  Densitometer.

  Phantom control chart.
- Procedure.

  Load cassette with film from bin used for patient images, wait enough time for good screen-film contact to occur.

  Cassette in cassette holder.

  Phantom on cassette holder: center left to right and align edge of phantom with chest wall side of image receptor.

  Compression device in contact with phantom but no compression is applied.

  Phototimer under center of wax insert (consistency in phototimer).

  Technical factors for exposure should be those currently in clinical use for a 4.2 cm compressed breast of average density.

  Plot mAs on control chart.

  Record density-control setting on control chart.

  Process film in processor used for mammographic films always using the same emulsion orientation.

  Measure background film optical density at the geometric center of the phantom.

Establish DD by determining the difference between the film optical density measured inside the disc and directly adjacent to the disc, to its right or left, perpendicular to the anode-cathode axis.

Plot background optical density and density difference on the control chart.

The same person should view phantom films at the same time each day using the same viewbox, viewing conditions and magnifying lens used to review clinical images.

- Data analysis and interpretation.

  Each object type (fiber, speck group, mass) is scored separately.

  Count from the largest object in a type down until reaching a score of 0 or 0.5.

  Count each fiber as a point if the full length of the fiber is visible and the location and orientation of the fiber is correct; count a fiber as 0.5 point if more than half, but not all, of the fiber is visible.

  Evaluate the background; if a fiber-like artifact (as apparent or more apparent than the "real" fibers) is seen anywhere in the wax insert area of the image, but not in an apparent location or orientation, deduct the "artifactual" fiber from the last real half or whole fiber scored.

  Record final score.

  Start with the largest speck group, and using a large field-of-view magnifying lens (2× or more) count each group as 1 point if four or more of the six specks in the group are visible in the proper location; count a speck group as 0.5 point if two or three of the six specks are visible in the proper location.

  Evaluate the background; if speck-like artifacts (as apparent or more apparent than the "real" specks) are seen anywhere in the wrong location anywhere on the wax insert of the image, deduct them one for one from the individual specks counted in the last whole or half-speck group scored and adjust the score of the last group accordingly.

  Record the final score.

  Count each mass as 1 point if a minus density object is seen in the correct location and it appears circular against the background (i.e., more than three-fourths of the perimeter is visible); count as 0.5 point if a minus density object is visible in the correct location but does not have a generally circular appearance.

  Record score before artifact deduction.

  Evaluate the background, if a mass-like artifact (as apparent or more apparent than the real masses) is seen in the wrong location in the area of the wax insert, deduct the artifactual mass from only the last whole or half mass scored.

  Record final score.

  With a magnifying lens examine the image for nonuniform areas, dirt or dust artifacts, grid lines or artifacts, processing artifacts, or any other artifacts.

  Circle artifacts or grid lines on film.

  Compare film to original and previous films.

  Investigate artifact sources or grid lines.

- Performance.

  A minimum of the four largest fibers, three largest speck groups and three largest masses must be visible.

  Number of test objects in each group should not decrease by more than one half.

Operating levels for background optical density should be at least 1.40 ± 0.20; background film optical density should never be less than 1.20.

When using the 4.0 mm acrylic disc, the operating level for DD should be at least 0.40 ± 0.05.

For a given density control setting, mAs should not change by more than ±15%.

All mammography units and processors at a given facility should produce similar film optical densities.

If results do not meet requirements, the source of the problem needs to be identified and corrective action taken before any clinical images are done.

Retain phantom images for the last full year; retain original phantom images until it is necessary to establish a new baseline.

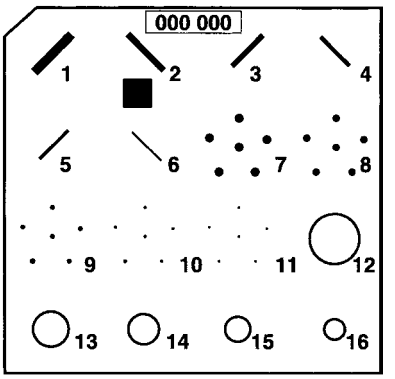



**FIGURE 3-1** Illustration of details in RMI 156 phantom. Nylon fibers (1–6): 1.56 mm, 1.12 mm, 0.89 mm, 0.75 mm, 0.64 mm, and 0.40 mm. Simulated microcalcifications (7–11): 0.54 mm, 0.40 mm, 0.32 mm, 0.24 mm, and 0.16 mm. Tumor-like mass (12–16): 2.00 mm, 1.00 mm, 0.75 mm, 0.50 mm, and 0.25 mm.

## Viewboxes and Viewing Conditions

### Key Facts

- Objective.
  Optimization of viewing conditions (luminance of viewboxes, ambient room illumination, and light falling on viewboxes may affect interpretation).
- Frequency.
  Weekly.
- Equipment.
  Window cleaner and towels.
- Procedure.
  Viewbox surface is cleaned making sure all marks are removed.
  Inspect viewboxes for luminance uniformity.
  Assure masking equipment functions properly.
  There should be no sources of bright light or reflection from viewbox surface in reading room.
- Precautions and caveats.
  Minimize direct or reflected light from windows, other viewboxes, or source of bright light on mammography viewboxes.

Lighting in the mammography interpretation room should be low level and diffuse.

Luminance of mammography viewboxes should be at least 3,000 candela/$m^2$ (compared to 1,500 candela/$m^2$ of viewboxes in general radiography).

Brightness of fluorescent bulbs decreases with time (10% in 2000 hours) so tubes should be replaced every 18 to 24 months.

To assure uniformity in color and luminance, if one bulb needs replacing (i.e., flickering or burned out), all tubes should be replaced at the same time; replacement tubes should be of the same type and color.

## Visual Checklist

### Key Facts

- Objective.

  To assure that the x-ray system indicator lights, displays, mechanical locks, and detents work properly and that the mechanical rigidity and stability of equipment is optimal.
- Frequency.

  Monthly and after service or maintenance.
- Equipment.

  Checklist.
- Procedure.

  Review items on visual checklist, rotate C-arm, date, and initial.
- Performance.

  All items in checklist should pass; if not, immediate corrective action is indicated.

## Repeat Analysis

### Key Facts

- Objective.

  To determine the number and causes of repeat mammograms.

  Data help identify ways to improve efficiency, reduce costs, and patient exposures.
- Frequency.

  Initially then at least quarterly.

  If possible at least 250 patients are needed for repeat rates to be meaningful; greater numbers of patients yields more meaningful data.
- Equipment.

  All rejected films.

  Data for repeated images placed in the patient's film jacket (i.e., not in rejected film bin).

  Means to count total number of films used during the test period and for sorting films during analysis.

  Data sheet.

- Procedure.

  Dispose all rejected films.

  Inventory the film supply so that the number of films used during the test period can be established.

  Collect all rejected films for the length of time needed to radiograph a minimum of 250 consecutive patients; more reliable data can be obtained if films are collected on a larger number of patients.

  Sort rejected films into categories (positioning, motion, light films, black films, static/artifacts, fog, incorrect patient ID, double exposure, mechanical, miscellaneous, good films/no apparent reason, clear film, wire localization, QC).

  Determine overall percentage of repeated films by dividing total number of repeated films (do not include wire localization, and QC films) by the total number of films exposed during the analysis period and multiply by 100.

  Determine the overall percentage of rejected films by dividing total number of rejected films (include all categories) by the total number of films exposed during the analysis period and multiply by 100.

  Determine the percentage of repeats in each category by dividing the number of repeats in that category by total number of repeated films (do not include clear film, wire localization, and QC films) and multiply by 100.

- Caveats.

  Any film repeated should be included (not just rejected films), even if the films are placed in the patient's jacket.

  Technologists should not alter their procedures or criteria for accepting films during the repeat analysis period.

- Performance.

  Overall repeat rate should be 2% but rate lower than 5% is adequate (based on at least 250 patients).

  Percentage for each category should be similar.

  If the repeat rate exceeds 5%, or if the repeat or reject rate changes from the previously measured rate by more than ±2%, investigate the changes and take corrective action if necessary.

  Corrective actions should be recorded.

  Effectiveness of corrective actions needs to be assessed by doing another repeat analysis after corrective actions are implemented.

  Corrective actions need to be taken within 30 days of test date.

## Analysis of Fixer Retention in Film

### Key Facts

- Objective.

  Evaluation of processed film to determine amount of residual fixer.

  Retention of fixer indicates insufficient washing of film and degrades image stability (as fixer is oxidized, film turns brown over time).

- Frequency.
  Quarterly.
- Equipment.
  Hypo estimator and residual hypo test solution.
- Procedure.
  Process one sheet of unexposed film.
  Place one drop of residual hypo solution on emulsion side of film and let stand for 2 minutes and then blot excess solution.
  Place film on white paper and compare the stain with a hypo estimator strip immediately after blotting excess test solution.
- Performance.
  Residual hypo should be 0.05 g per $m^2$ or less.
  If stain indicates a greater amount of hypo, repeat test.
  If the results are confirmed, corrective action is necessary.
  Water level in water tank, wash water flow and fixer replenishment rates should be checked; service may be required.

## Darkroom Fog

### Key Facts

- Objective.
  To assure that light sources in and out of the darkroom and darkroom safelights do not fog film.
- Frequency.
  Initially and then semiannually.
  When filters or bulbs are changed (filters fade with time; use bulbs of wattage specified by film manufacturer; if bulbs of higher wattage than recommended are used, filters may fade more quickly).
- Equipment.
  Phantom, mammography unit, densitometer, film from a new box (not from film bin), opaque card, and timer.
- Procedure.
  Filters, bulb wattage, and distance from safelight to film handling areas as specified by manufacturer.
  Turn all lights off in darkroom and adjust your eyes for 5 minutes.
  Check for obvious light leaks around the door, processor, and ceiling; light leaks may come from one direction only, so move around cautiously.
  Correct any light leaks.
  In total darkness, load a film in the cassette.
  Place cassette in mammography unit cassette holder.
  Center phantom on cassette holder with edge of phantom aligned with chest wall side of image receptor.
  Bring compression paddle down in contact with the phantom.

Use phototimer position used in generating phantom images (under center of wax insert).

Expose using technical factors used clinically for a 4.2-cm compressed breast.

In total darkness, remove exposed film, emulsion side up on countertop.

Use opaque card to cover half of phantom image (card perpendicular to chest wall edge of film).

Turn all safelights on for 2 minutes and then process film.

With densitometer, measure unfogged portion (covered by card) of phantom image away from test objects, close to the edge separating fogged and unfogged portions of film.

Measure the density of the fogged portion of the image immediately adjacent to the area measured in the unfogged portion.

Subtract density of unfogged portion of phantom image from the density of the fogged portion.

Record the optical density difference on monthly, quarterly, and semiannual checklist.

- Performance.

  Determine cause and take corrective action if fog greater than 0.05.
- Sources of fog.

  Incorrect, faded, or cracked filters; incorrect safelight housing; incorrect bulb type or wattage; inappropriate safelight location (too close to film handling area); processor or timer indicator lights; light leaks around door, processor, passbox, and ceiling.

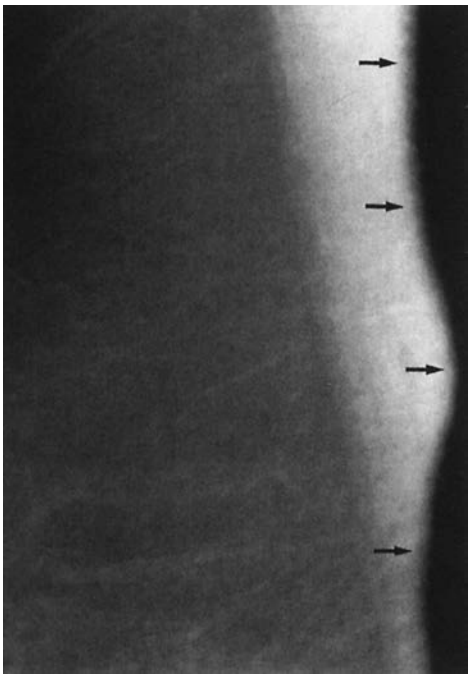


**FIGURE 3-2** Film fog (*arrows*).

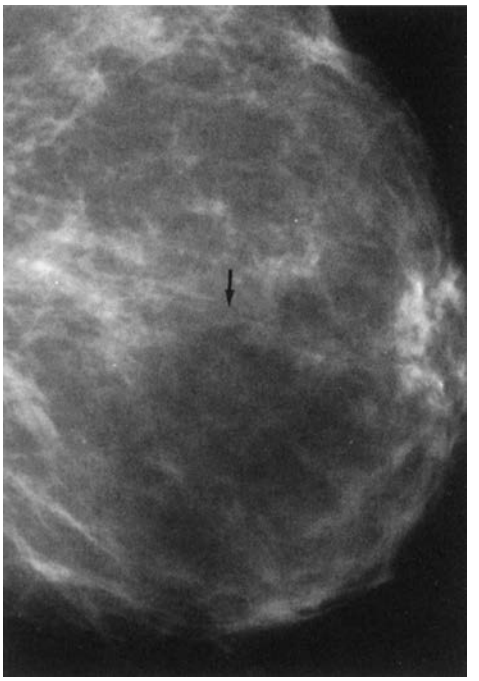


**FIGURE 3-3** Film fog (*arrow*) resulting from a cracked safelight filter.

## Screen-Film Contact

### Key Facts

- Objective.

  Assure optimal contact between film and screen.

  Resolution of mammography film higher than that of conventional film (16 to 10 cycles/mm compared to 4 to 8 cycles/mm) so image sharpness can be affected significantly if there is poor film-screen contact.

- Frequency.

  Initially, for new screens, semiannually on all cassettes and when reduced image sharpness is suspected.

- Equipment.

  Cooper screens (40 mesh or 40 wires per inch), acrylic sheets to provide 4-cm thickness, film, densitometer (aperture 2.0 mm in diameter or greater), screens, and cassettes.

- Procedure.

  Clean screens and cassettes and air-dry cassettes for at least 15 minutes.

  Load film in cassettes (cassettes should have unique identifier number seen on images taken) and wait 15 minutes (or period specified by cassette manufacturer) to allow entrapped air to escape.

  Place cassette on top of cassette holder (no grid).

  Place cooper screen on top of cassette.

  Place acrylic sheet(s) (used to assure exposure time will be at least 0.5 second) on top of compression device.

  Move compression paddle (with acrylic sheets) as close to the x-ray tube as possible (effectively reducing scatter radiation).

  Select manual technique (25 to 28 kVp) for film density between 0.70 to 0.80 in image measured over mesh near chest-wall edge.

  Expose and process film.

  Standing 3 feet away, view films on viewbox; check for darker areas in mesh image.

  Clean the screens and interior of cassettes that do not pass initial test and repeat previous steps.

  Cassettes that pass with retesting can be used clinically.

  For cassettes that do not pass retest, place the original and retest film aligned and side-by-side on viewbox and compare location of poor contact areas.

- Performance.

  Areas of poor contact larger than 1 cm, not eliminated by recleaning the cassette and remaining in the same location after retesting, are not acceptable and cassette should be replaced.

  Multiple areas less than 1 cm are acceptable.

## Compression

### Key Facts

- Objective.
  To assure adequate compression in manual and powered modes.
  To assure that too much compression cannot be applied.
- Frequency.
  Initially and then semiannually.
- Equipment.
  Flat, analog-type bathroom scale and towels.
- Procedure.
  Towel on cassette holder for protection.
  Scale on towel, center the scale directly under the compression paddle.
  Place one or more towels on top of scale.
  Allow power drive to operate compression until it stops automatically.
  Read and record compression force on monthly, quarterly and semiannual checklists.
  Release compression.
  Now use manual drive until compression paddle stops.
  Read and record compression force on monthly, quarterly and semiannual checklists.
- Performance.
  Force of at least 25 lb (111 N).
  The maximum compression force for the initial power drive must be between 25 lb (111 N) and 45 lb (200 N).

## QC Tests (Physicists)

### Key Facts

- All tests should be done at least once annually.
- Mammography unit assembly evaluation.
- Collimation assessment.
  X-ray field needs to align with light field.
  Collimation allows for coverage of image receptor by x-ray but does not allow significant radiation beyond edges of image receptor (cannot exceed by more than 2% of the source-to-image distance [SID]).
  Chest wall edge of compression paddle aligns with chest wall edge of film.
  Compression paddle edge must not extend beyond image receptor by more than 1% of SID or appear on image.
  Corrective actions need to be taken within 30 days of test date.

- System resolution.
  Evaluation of limiting resolution from geometric blurring (focal spot) and screen-film combination.
  In contact mode at least 13 line pair per mm with bars parallel to anode-cathode axis.
  In contact mode at least 11 line pair per mm with bars perpendicular to anode-cathode axis.
  The limiting resolution in magnification mode must be no lower than this.
  Under MQSA, facilities should evaluate focal spot condition by determining system resolution.
  Corrective actions need to be taken within 30 days of test date.
- kVp accuracy and reproducibility.
  kVp should be ±5% of indicated kVp and reproducible (coefficient of variation of 0.02).
  Corrective actions need to be taken within 30 days of test date.
- Beam quality assessment (half value layer, HVL, measurement).
  HVL with compression paddle in place equal to or greater than kVp/100 + 0.03 (mm of aluminum).
- Automatic exposure control (AEC) system performance assessment.
  To maintain consistent image optical density as breast thickness and imaging modes change.
  MQSA requires that the AEC maintain film optical density within ±0.15 of the mean optical density when thickness of a homogeneous material is varied over a range of 2 to 6 cm, and kVp is varied appropriately for such thickness over the kVp range used clinically in the facility.
  The optical density of the film in the center of the phantom image shall not be less than 1.20.
  Corrective actions need to be taken within 30 days of the test date.
- Uniformity of screen speed.
  All cassettes need to be tested and difference between maximum and minimum optical densities shall not exceed 0.30.
  Corrective actions need to be taken within 30 days of test date.
- Breast entrance exposure, average glandular dose, and AEC reproducibility.
  Maximum allowable coefficient of variation for exposure and mAs (or time) in the AEC reproducibility test is 0.05.
  Average glandular dose to an average (4.2 cm compressed) breast must not exceed 3 mGy (0.3 rad) per view for screen-film image receptors.
  Radiation output of the mammography system should not be less than 7.0 mGy air kerma per second (800 mR/sec) over a 3-second period of time when operating at 28 kVp in the standard mammography (Mo/Mo) mode at a clinically used SID.
- Image quality evaluation.
  At a minimum the four largest fibers, three largest speck groups, and three largest masses should be seen.
  The number of test objects seen in each group type should not decrease by more than one half.

Background density should never be less than 1.20; operating level for phantom background optical density should be at least 1.40 ± 0.20.

Density difference due to the 4.0-mm acrylic disc should be at least 0.40 ± 0.05.

- Artifact evaluation.
- Viewbox luminance (≥3,000 cd/$m^2$) and room illuminance (≤50 lux).

## SUGGESTED READINGS

American College of Radiology's *Mammography Quality Control Manual*. Reston, VA: American College of Radiology; 1999.

Hendrick RE. Quality assurance in mammography. *Radiol Clin N Am.* 1992;30:243–255.

CHAPTER 4

# TECHNICAL CONSIDERATIONS

## EQUIPMENT

### KEY FACTS

- X-ray spectrum.
  Bremsstrahlung, characteristic emission, target materials, filtration.
  Target materials.
  Molybdenum: 17.4 and 19.6 keV.
  Rhodium: 20.2 and 22.7 keV.
  Tungsten.
- Filtration.
  Molybdenum (0.03 mm): 20.0 keV K-edge.
  Rhodium: 23.2 keV K-edge.
  Beryllium window used: does not absorb low keV photons needed in mammography.
- Heel effect.
  X-ray beam intensity on anode side less than on cathode side.
  Cathode side directed at base of breast (thicker portion of breast requires higher intensity).
- Collimation.
  To image receptor size allowing x-ray beam on chest wall side, to extend to or beyond the edges of the image receptor by no more than 2% of the source-to-image distance (SID).
- Focal spot.
  In conjunction with SID affects sharpness and resolution.
  Area on anode struck by electrons is the actual focal spot.
  X-ray beam projected toward the patient and film is the effective focal spot.
  For routine mammography: 0.3 mm or smaller.
  For magnification: 0.15 mm or smaller.

Focal spot condition is to be evaluated using the system resolution only; resolution should be 11 line pairs/mm when a bar pattern is placed within 1 cm of the chest wall edge, 4.5 cm above the image receptor and the bars are perpendicular to the anode cathode axis of x-ray tube (13 lp/mm if bars are oriented parallel to anode-cathode axis of x-ray tube).

- SID.

  Distance from the focal spot to the film; at least 55 cm for routine images and 60 cm for magnification; 50 to 80 cm; average: 60 to 65 cm.

  Smallest focal spot with largest SID and minimum patient exposure is desirable.
- Object-to-film distance should be as small as possible for routine mammography.

  Magnification with increasing geometric blur (penumbra effect) is obtained as the breast is raised away from the film; a small focal spot is needed to overcome penumbra effect.
- Generator.

  High frequency or constant potential generators provide high-voltage waveform and a homogeneous x-ray beam.

## CONTRAST

### KEY FACTS

- Because of the need to maximize subtle contrast differences between normal glandular tissue and developing breast cancers, high-contrast images are critical in mammography.

  Depending on the energy of the x-ray beam, tissue types (e.g., fat, glandular tissue, breast cancer, muscle) absorb different amounts of radiation. The linear attenuation coefficient ($\mu$) is used to quantify the amount of radiation absorbed by a centimeter of tissue at different keVs.

  X-ray beams of lower photon energy (20 keV) are used in mammography because the linear attenuation coefficients of fat, glandular tissue, and breast cancers are more distinct compared to the linear attenuation coefficients of these tissues when higher photon energy is used.
- Subject contrast.

  Independent of film contrast.

  Reflects radiation absorption differences (tissue thickness, density and atomic number).

  Varies depending on radiation quality (target material, kV, filtration).

  Need to minimize scatter radiation (use of compression and grids, selected kV, collimation).
- Film contrast.

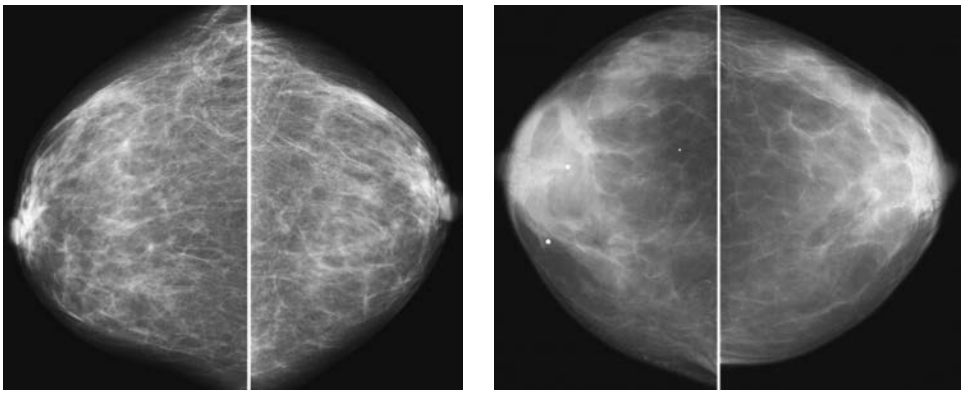
  Subject contrast.

  Scatter radiation (compression, grid).

  Film and screen type.

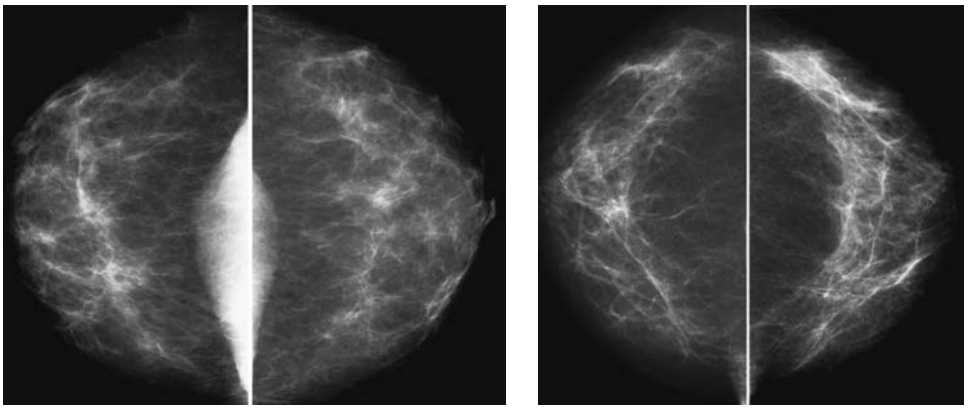
  Processing (darkroom conditions, processor developer temperature, time).

  Photographic density.



**A** **B**

**FIGURE 4-1** Low-contrast images. **(A)** Right and left craniocaudal (CC) views. **(B)** Different patient. Right and left CC views. Gray images with visualization of subcutaneous tissue. Notice gray appearance of fatty tissue. In these patients, glandular tissue is fairly well exposed. Contrast is related to film type, processing environment, kV used for exposure (as kV is increased, contrast decreases), film loaded correctly in cassettes (e.g., emulsion side of film on screen), adequacy of exposure (often under exposed images are low in contrast), optical density settings, scatter radiation and subject contrast.



**A** **B**

**FIGURE 4-2** High-contrast images. **(A)** Right and left CC views. **(B)** Different patient. Right and left CC views. Subcutaneous tissue is burned out and fat is nearly black in appearance. Glandular tissue is well exposed. High-contrast images, such as these, are optimal.

# Technical Factors

## Key Facts

- High-quality mammographic images are critical if we expect to detect early cancers reliably. High quality requires evaluation of images on a film-by-film basis for positioning, exposure of glandular tissue, contrast, adequacy of compression, resolution, noise, artifacts, and film labeling.
- Knowledge of the technical factors used to expose an image is needed to troubleshoot suboptimal images effectively.

  Range available in most units: 22 to 23 to 40 kVp in 1-kVp increments.

  Energy of photons (driving force): x-ray beam wavelength, penetrating power.

  Use as low a kVp as needed to penetrate (expose) glandular tissue adequately. As kVp is increased, however, image contrast decreases.

  Well-exposed glandular tissue permits visualization of trabecula, small tubular structures and vessels. Adequate exposure of the glandular tissue burns out skin and subcutaneous tissues in most women.

  As kVp is lowered, the penetrating power of the x-ray beam decreases, and scatter radiation increases, resulting in higher radiation doses.

  kVp must be within ±5% of selected or indicated kVp: test at the lowest kVp measurable with kVp test device, and at the most common and highest kVp's used clinically.
- mA output.

  mA controls beam intensity.

  Increasing mA output enables reduction in exposure times. As exposure time is reduced, the likelihood of patient motion is decreased.

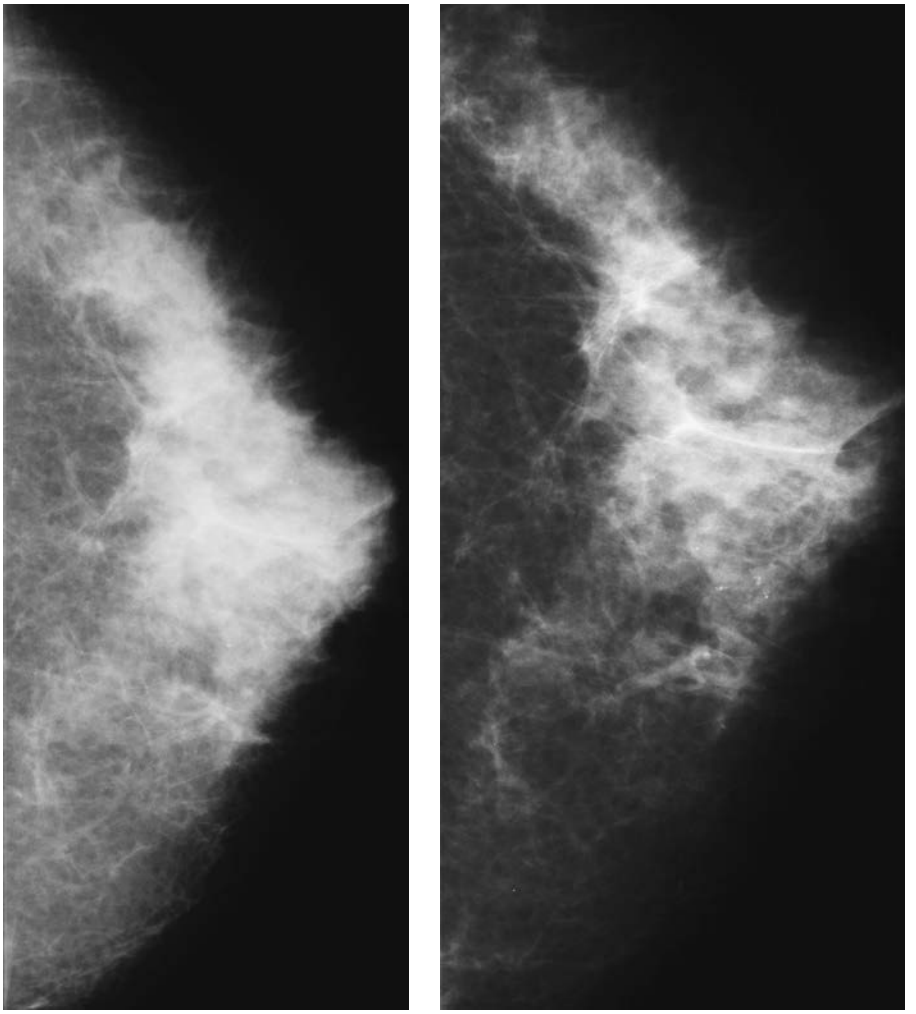
  mA output of smaller focal spot is less than that for the larger focal spot.

  Radiation output at 28 kVp with Mo/Mo must be ≥7.0 mGy (800 mR/sec) at any source to image distance the system is designed to operate. Need to maintain this rate when averaged over 3 seconds.
- mAs and density setting.

  As mAs is increased, optical density is increased (darker film).

  With changes in the density setting, mA remains constant, exposure time changes.

  Each step in density setting changes mAs by 12% to 15% (approximate 0.15 change in film optical density).
- Film optical density in areas of glandular tissue should be 1.3 to 1.5; optical densities below 1 (and should not be below 0.7) affect ability to detect low-contrast lesions.



**A** **B**

**FIGURE 4-3** **(A)** Left craniocaudal (CC) view. How would you dictate this study? Do you conclude with a disclaimer about dense tissue limiting our evaluation? Can we do better? Inadequate exposure of dense glandular tissue is a problem: the ability to detect microcalcifications and small spiculated or round masses may be eliminated. Assuming correct placement of photocell under the dense tissue, to penetrate dense tissue, and depending on mAs read out, we can increase kV (if maximum allowable mAs has been reached increasing kV is the only option even though as we increase kV, contrast may decrease) or decrease tissue thickness (e.g., increase compression). Fine trabecular detail should be visible through dense tissue. In this patient, depending on mAs, we can increase kV (more energy for photons to penetrate) or do anterior compression views (decreasing thickness). Under exposed images are also often characterized by low contrast. **(B)** Repeat left CC view demonstrates what can be done if adjustments are made to technical factors used for exposure and compression is maximized. The glandular tissue is now well exposed so that fat is seen intermingled with the tissue and the trabecula and vessels are visible and several clusters of calcification are now apparent. Also note improvement in contrast.

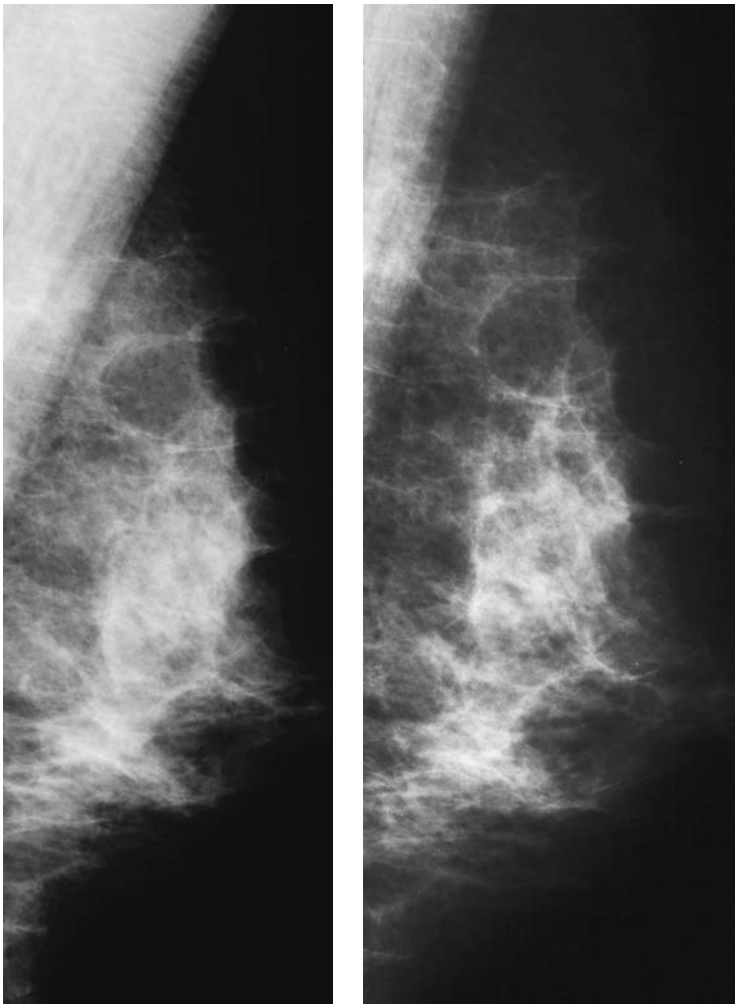


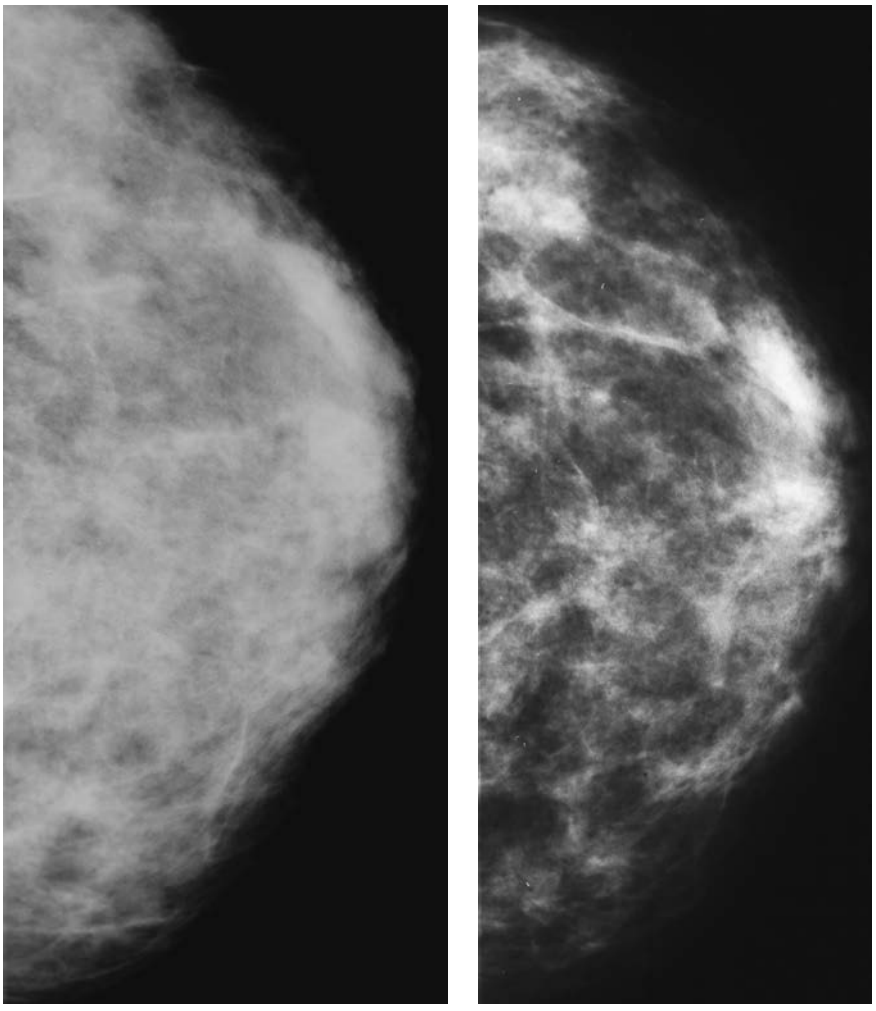

**FIGURE 4-4 (A)** Left mediolateral oblique (MLO) view. Underexposed images like this should be repeated. In determining how to correct this image technical factors need to be known (e.g., kV, mAs, amount of compression, photocell positioning). Underexposed images are also usually low in contrast. Rather than hide behind a disclaimer relative to how the density of the tissue can obscure a lesion, we need to determine what went wrong and how to improve the image. **(B)** Repeat MLO view demonstrates a well-exposed, high-contrast image. Fatty tissue is now seen intermingled with the glandular tissue and the trabecular pattern is visible.

## Automatic Exposure Control

### Key Facts

- AECs control length of exposure needed to obtain desired film optical density; AEC terminates exposure at a specified back-up time or mAs; this avoids tube overload.
- AEC needs to be operable for grid and non-grid technique and with various target-filter combinations.

- With kVp selected, adjustments in mAs compensate for breast thickness and differences in tissue types. Manual adjustment is accomplished with changes in the density setting.
- AEC is adjusted for film/screen combination, processing, and cassettes in use.
- The position of the AEC can be varied. Exposure reflects AEC positioning. If the AEC is placed close to the chest wall (retroglandular fat), anterior dense tissue may be underexposed; if positioned anteriorly, retroglandular fat may be overexposed.
- Size and possible positions of AEC detector are indicated on the compression paddle.
- Over 2 to 6 cm, optical density must be maintained within ±0.15 of mean. With various modes and over 2 to 8 cm, optimal density should be maintained within ±0.30 of mean optical density.



A B

**FIGURE 4-5** **(A)** Left craniocaudal (CC) view done with inappropriate photocell positioning. Underexposed, low-contrast image. Unacceptable. **(B)** Repeat left CC view with photocell positioned under glandular tissue. Glandular tissue is now well exposed and image is high in contrast.

# GRIDS

## KEY FACTS

- Scatter radiation is detrimental to image quality and results in significant loss of contrast.

  If no grid is used, scatter radiation can constitute 40% to 85% of primary beam intensity.
- Grids are used to absorb scatter radiation.
- Reciprocating grid.

  Sizes: 18 × 24 cm and 24 × 30 cm sizes to match standard cassette sizes.

  Moves from right to left.

  Detachable: no grid is used with magnification technique (scatter radiation dissipated in air gap used for magnification technique).
- Grid ratio.

  Ratio of lead strip height to distance between strips: 3.5:1 to 5:1 and 30 to 50 lines/cm.
- Bucky ratio.

  Ratio of incident radiation on grid to transmitted radiation.

  Quantifies the increases in patient exposure resulting from grid use.

  Should be less than 2.5 for all exposures.

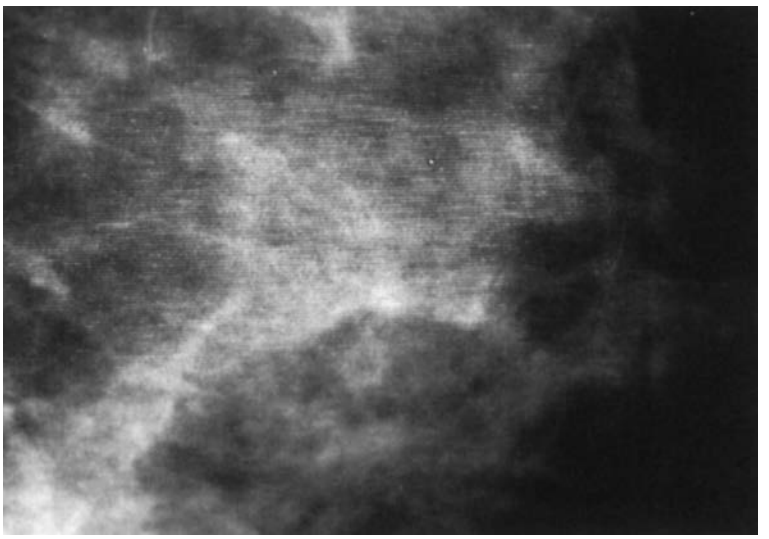


**FIGURE 4-6** Grid lines.

## COMPRESSION

### KEY FACTS

- Purposes.

  Higher image contrast: lower kVp can be used for adequate exposure (need less energy [lower kVp] to penetrate tissue adequately).

  Decrease tissue thickness and scatter radiation (affecting subject contrast).

  Reduce geometric unsharpness: as breast is thinned out, structures are brought closer to film.

  Reduce motion unsharpness from shorter exposure times and breast immobilization.

  Radiation dose reduction.

  More homogeneous breast thickness: reduce over penetration of thinner anterior tissue and under penetration of thicker breast base.

  Improved visualization of potential lesions by minimizing superimposition of tissues.
- Compression paddle.

  Transparent.

  Rigid enough to maintain parallel compression.

  Inner edge of paddle should align with image receptor; otherwise the paddle will project on image.

  Lip along chest wall should be 2 to 4 cm high at close to a 90-degree angle. This prevents posterior and axillary tissue (fatty) from overlapping on the breast being imaged and reinforces the paddle.

  A sloping contoured compression paddle (American Mammographics, Chattanooga, TN) is now available that adjusts to accommodate and optimally compress the breast: paddle tilts downward from thicker breast base to thinner, but often denser, anterior subareolar tissue.
- Compression mechanism.

  Powered by electric motor, pneumatic or hydraulic device.

  Controlled by foot pedal (technologist's hands free for breast positioning).

  Manual back up to facilitate small adjustments just before taking image.

  Post exposure release at console: technologist can release compression as soon as image is taken.
- Compression thickness and force displayed on unit (accurate to within 0.5 cm of thickness and 5% of force).

## IMAGE BLUR

### KEY FACTS

- Geometric blur.

  Focal spot size (can be seen when magnification views are done with large 0.3 mm focal spot as opposed to 0.1 mm focal spot).

Focal spot-object distance.

Object-image receptor distance.

- Motion blur.

  Breast immobilization, need adequate compression.

  Exposure time (should not exceed 2 seconds).

  Equipment motion.

- Image-receptor blur.

  Single emulsion film, single screen.

  Phosphor distance.

  Phosphor particle size.

  Screen thickness: thicker (faster) screens associated with greater amount of blur.

  Screen-film contact (after loading the cassette with film, 15 minutes should elapse before an exposure, which allows the film to settle so there is good film/screen contact).

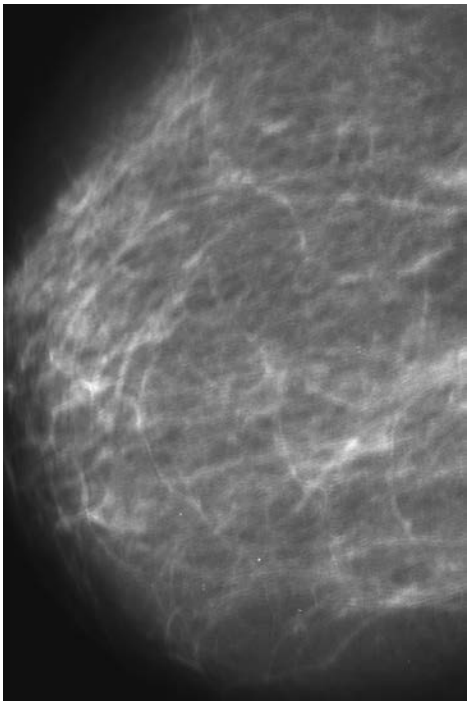
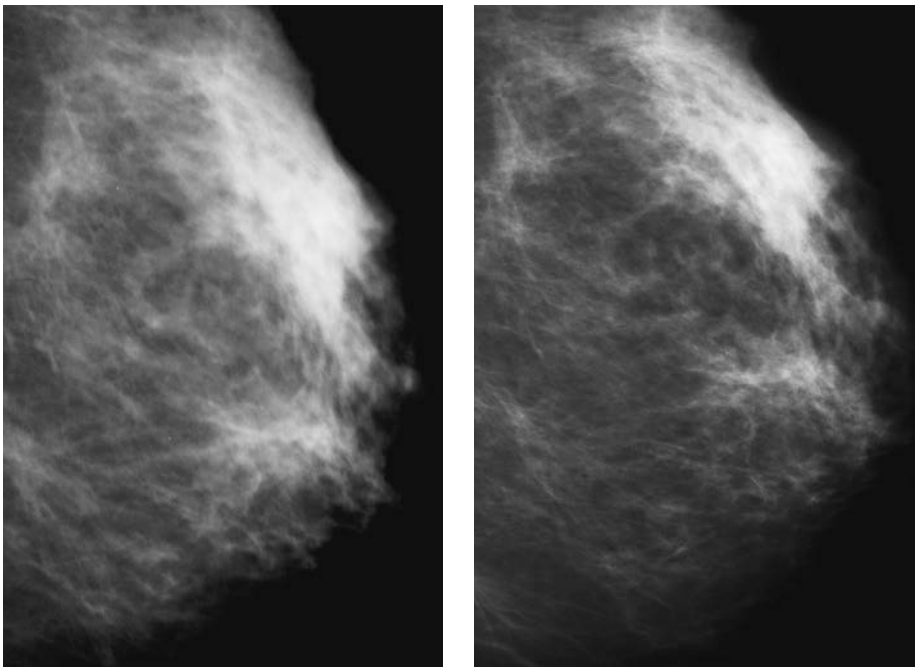
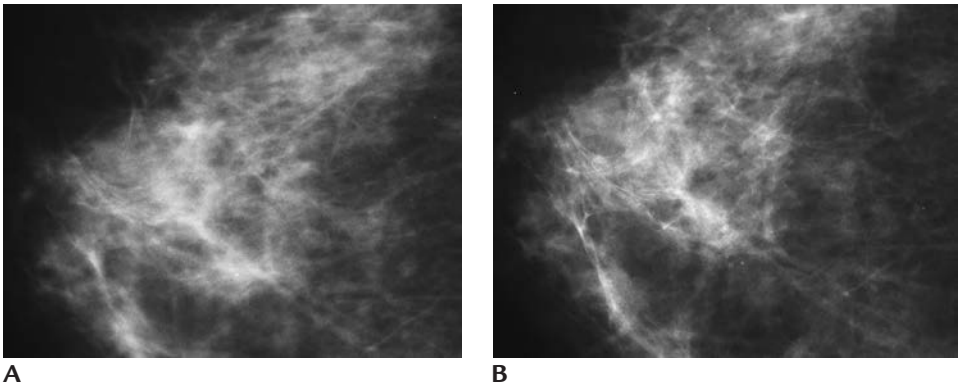


**FIGURE 4-7** Significant motion (*blur*) is present precluding adequate evaluation.



**A** **B**

**FIGURE 4-8** Motion (*blur*). **(A)** Initial mediolateral oblique (MLO) view demonstrates blurring of trabecular pattern. Also notice apparent low contrast appearance of image. Blur is perceived as a loss of contrast. **(B)** Repeat MLO view, demonstrates sharp trabecular pattern. High-contrast image.



**A** **B**

**FIGURE 4-9** Motion. **(A)** Photographically coned down image demonstrates blurring of trabecular pattern and vessels. Specifically evaluate images for blurring; it may be subtle and focal. **(B)** Repeat image with no motion demonstrates sharp trabecula and vessel walls. Scattered calcifications are now appreciated. Calcifications and small spiculated masses can be "tomogramed" off the field of view by motion (*image blurring*). If there is any blurring, repeat images should be obtained.

# Cassettes, Screens, and Film

## Key Facts

- Cassettes.

  Easy to use, durable, thin, lightweight with low radiation absorption.

  Film/screen contact should be maximized.

  Numbered (radiopaque) for identification (useful when troubleshooting artifacts).
- Screens.

  Reduce patient exposure (intensify x-rays).

  Phosphor layer coated on support base.

  Phosphor converts x-ray beam energy to visible light: film more sensitive to visible light than to x-rays.
- Single-emulsion film.

  Film base: transparent plastic with gelatin layers on both sides of film base.

  Emulsion (contains light-sensitive silver halide crystals; magenta dye-sensitizing film to green light; and chemicals for stability, low fog and fast processing); same amount of emulsion as on double emulsion film but it is all on one side of film base.

  Antiabrasive layer over emulsion to protect emulsion.

  On backside, antihalation layer helps prevent scatter and film curling during processing.
- Emulsion side of film should be in contact with screen.

  Manufacturers have notched film so that the technologist can place film in cassette correctly by feeling for the notches (also used to distinguish between different film types).
- Characteristics of film are described by the characteristic curve (H & D curve).

  Optical density plotted on the y-coordinate; log relative exposure plotted on the x-coordinate.

  The slope of the characteristic curve defines film contrast; toe region of the curve corresponds to the glandular tissue (light or whitest areas on the film); the shoulder represents low-density or fatty tissue (darkest areas on film).

  High-contrast film is used in mammography (steepest curves); low-latitude film: narrow range of exposures produce optimally exposed images.

  Curve depends on processing environment.

  Shape of curve is independent of x-ray quality (kV, mA); these factors change the position of the curve along the x-axis.

  Curve is used to compare different film types or same film with different processing environments and to monitor daily processing conditions.

  System speed: faster film/screen combinations require less exposure to produce desired film optical density.
- Reciprocity law failure.

  When film is exposed directly to x-rays, exposure is the product of intensity and time (exposure = intensity $\times$ time).

When film is exposed to light (e.g., when intensifying screen is used), reciprocity law may fail when long exposure times are used.

## PROCESSING

### KEY FACTS

- Film processing is often the weakest link in producing high-quality mammographic images; requires ongoing attention.
- Developer: latent image is developed.

  Developer temperature is specified by manufacturer (often 95°F) and should remain constant.

  Time in developer: in 90-second processing, 19 to 23 seconds; can be extended to 45 seconds to improve development of latent image with some film types (extended developing processing time) but may increase noise; need to work with film type and manufacturer.

  Chemical activity of solutions (specific gravity).

  Agitation.
- Fixer: image is fixed, unexposed and undeveloped silver halide is removed from film.
- Wash: removes chemicals.

  May use a water filter.

  Algaecides (depending on water supply).
- Dryer.
- Solutions need to be replenished. Replenishment rates depend on number of films being passed through processor.
- Solutions need to be replaced. Follow specifications of manufacturer.
- Under processing of film results in loss of contrast and increases in patient dose.

  Low developer temperatures.

  Inadequate development time or agitation of developer.

  Developer not optimized for film type, over diluted, under replenished, contaminated, or changed too frequently.

## ARTIFACTS

### KEY FACTS

- X-ray equipment.

  Filter (corrosion, damaged, wrong filter).

  Compression paddle (lip of paddle).

  Image receptor holder (textured, paint, motion).

  Grid (uneven motion, grid hesitation, very short exposure time, grid not plugged in, stationary grid, edge of grid on chest wall).

- Patient.
  Deodorant.
  Hair, hair products.
  Jewelry.
  Tattoo.
  Body part projecting on images (ear lobe, chin, gown, arm).
- Cassette/film/screen.
  Film scratches, nail dents (crimp).
  Finger pressure (fingerprints).
  Moisture.
  Screen scratches.
  Film loaded in cassette upside down (e.g., emulsion side away from screen).
  Upside down cassette (in bucky).
  Static (more common with daylight load systems).
  Foreign object on screen (dust, lint, small objects) affects film screen contact.

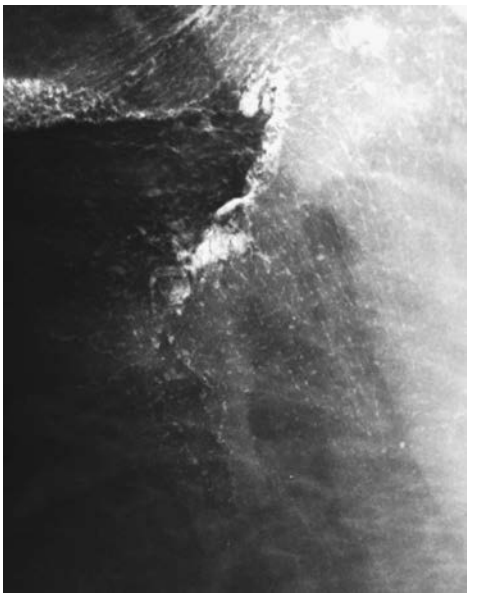
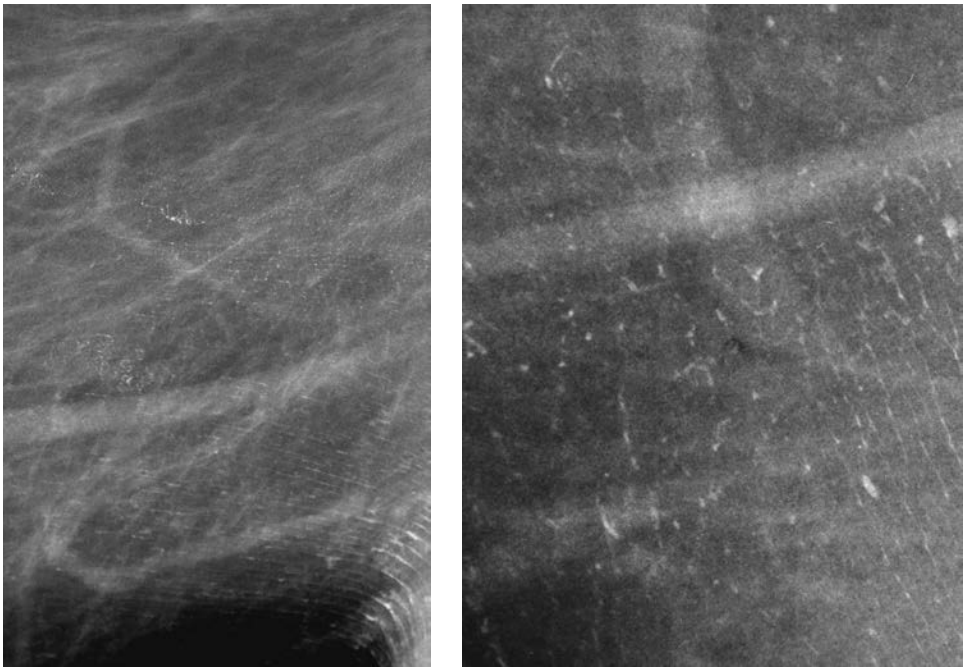


**FIGURE 4-10** Deodorant. High-density material in axillary region simulates calcifications. Women should be asked to not apply deodorant prior to their mammogram. Although less than ideal, the patient can be asked to wipe the deodorant off at the time of her study.



**A** **B**

**FIGURE 4-11** Desitin. **(A)** High-density material in inframammary fold region. **(B)** Linear high-density material with linear distribution mimics calcifications. Patient is asked is wipe deodorant or other products applied to the breasts or axilla off before images are done.

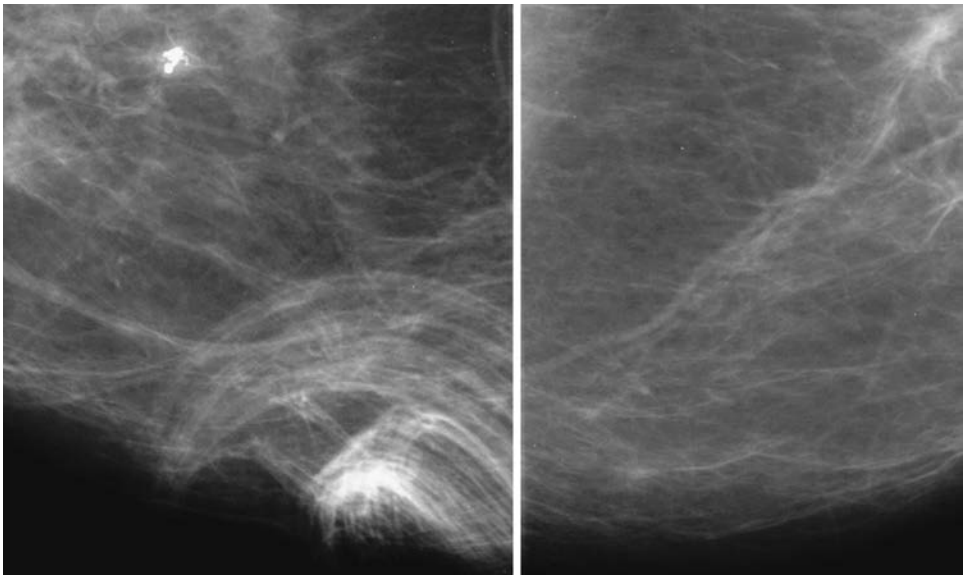


**FIGURE 4-12** Hair. High-density linear swirls medially on the right craniocaudal view. A mass with coarse calcification (e.g., calcifying fibroadenoma) is also noted on the right.

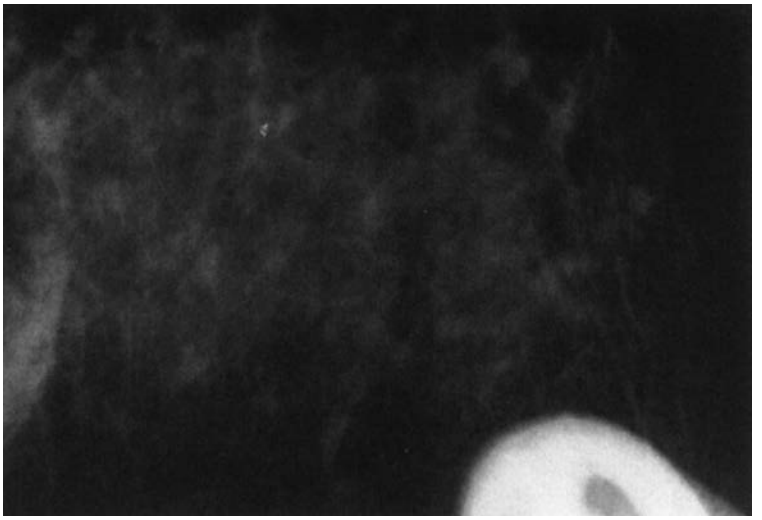


**FIGURE 4-13** Patient's nose projecting on image.

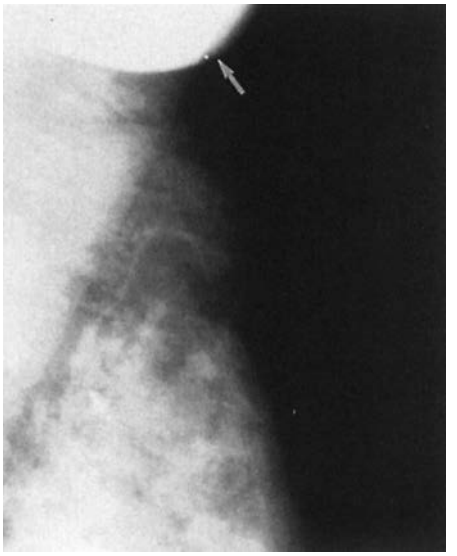
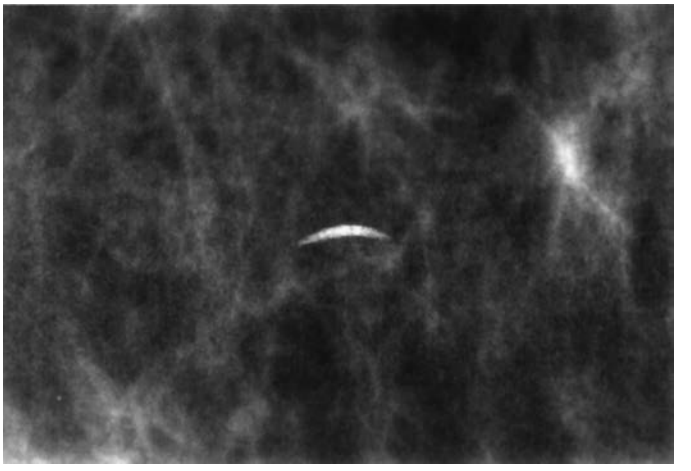
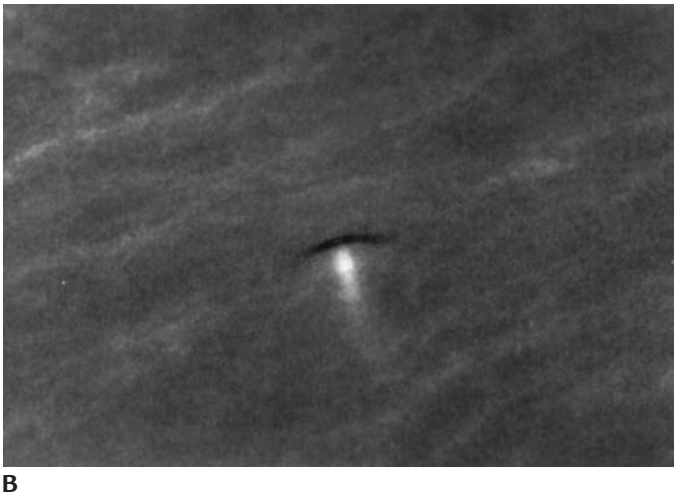


**FIGURE 4-14** Chin (*arrow*). At this location, you can sometimes see portions of the arm. If the arm interposes itself between the compression paddle and image receptor, compression may be limited and soft tissue artifact is seen.



**A**



**B**

**C**

**FIGURE 4-15** **(A)** Nail film crimp. Minus artifact. Before exposure. On inspection film is bent at this point. **(B)** Nail film crimp. Plus artifact. After exposure. On inspection film is bent at this point. **(C)** Fingerprints (*arrows*). Minus artifact (before exposure). Fingerprints can simulate microcalcifications.

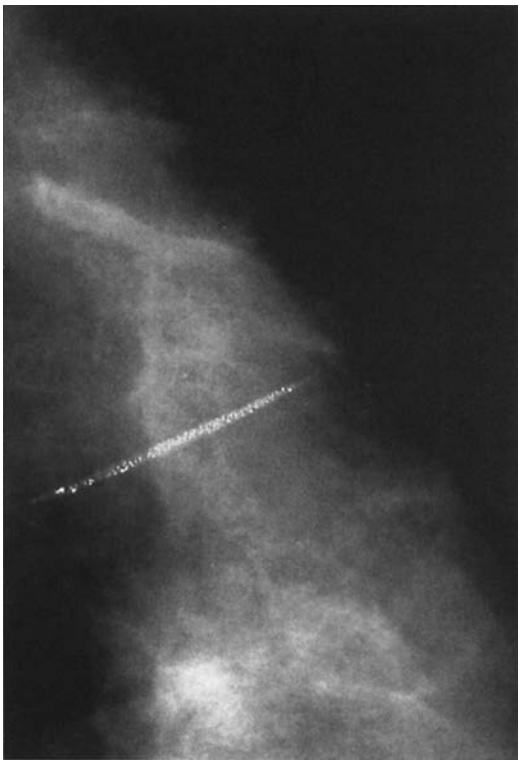


**FIGURE 4-16** Nail polish. In our facility the technologists cannot wear nail polish.

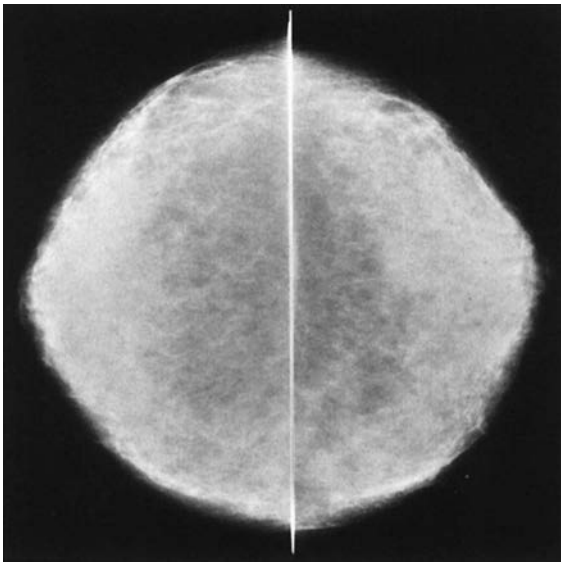
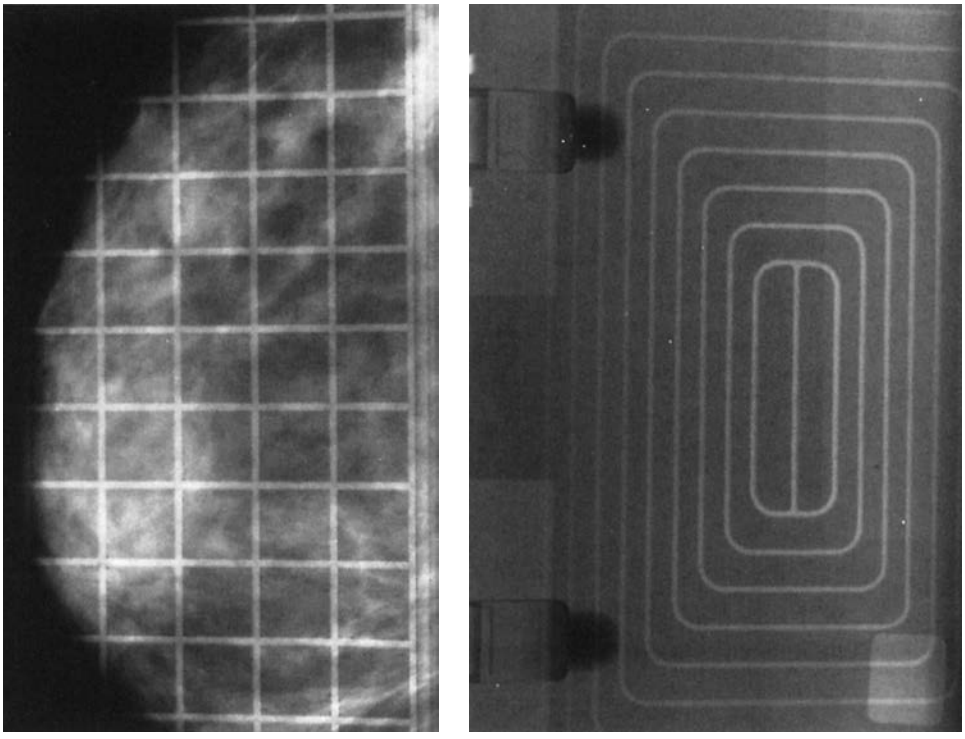


**FIGURE 4-17** Incorrect film loading. Underexposed, low-contrast, low-resolution imaging resulting from loading the film with the emulsion side away from the screen. The emulsion side of the film should be in contact with the screen.



**A** **B**

**FIGURE 4-18** **(A,B)** Upside down cassette (different cassette types).

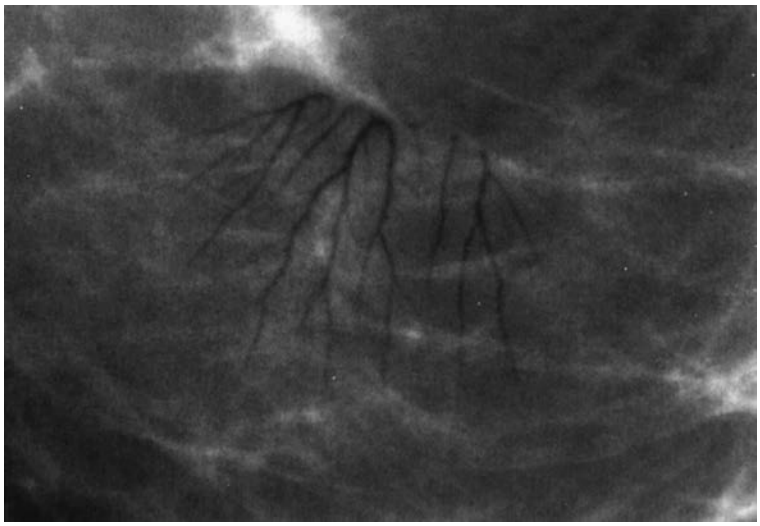


**FIGURE 4-19** Static: focal fog (mammographic "lighting").

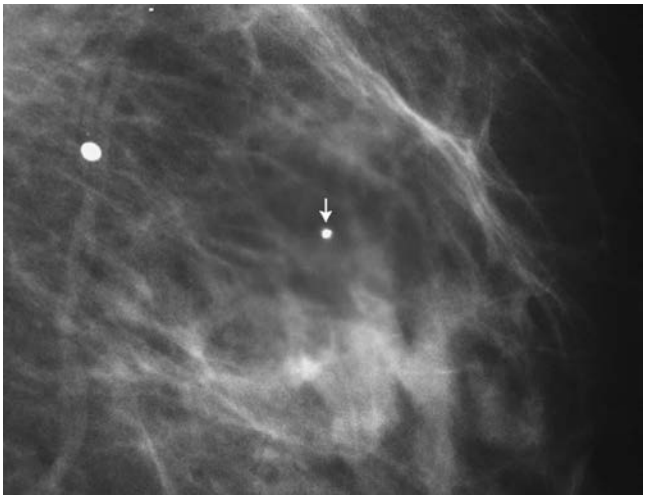


**FIGURE 4-20** Poor film screen contact. An object on the screen (*arrow*) precludes close apposition between screen and film. The object can generally be seen (as in this case) as an artifact and if the image is examined closely, blurring is seen surrounding the artifact. The blurring reflects poor film/screen contact. The film is actually lifted away from the screen by the artifact.

## Processor Artifacts

### Key Facts

- Processor: need to know:
  Plus or minus density artifact.
  Orientation of artifact (parallel, perpendicular or random) with respect to direction of film travel.
  Emulsion orientation (emulsion side up or down).
  Position of film on feed tray (right or left side of the processor).
  Sensitometry.
- Plus density (dark): pressure or handling after exposure.
- Minus density (light): pressure or handling before exposure.
- Processor: parallel to direction of film travel.
  Entrance roller marks: plus density, evenly spaced.
  Guide shoe marks: plus or minus density, evenly spaced, leading or trailing edge of film.
  Delay streaks: plus density, randomly spaced.
- Processor: perpendicular to direction of film travel.
  Stub lines or hesitation lines: plus density, 1⅝ inch from leading edge.
  Chatter: plus density, evenly spaced.
  Slap lines: plus density, broad line 2⅛ to 2¼ inch from trailing film edge.
  Pi lines.

- Random artifacts.
  Drying patterns and water spots: seen in reflected light, mottled bands or spots.
  Wet pressure marks: plus density, resemble noise/quantum mottle.
  Runback: plus density, trailing edge of film.
  Flame pattern.
  Pickoff: minus density, small, emulsion removed down to film base.

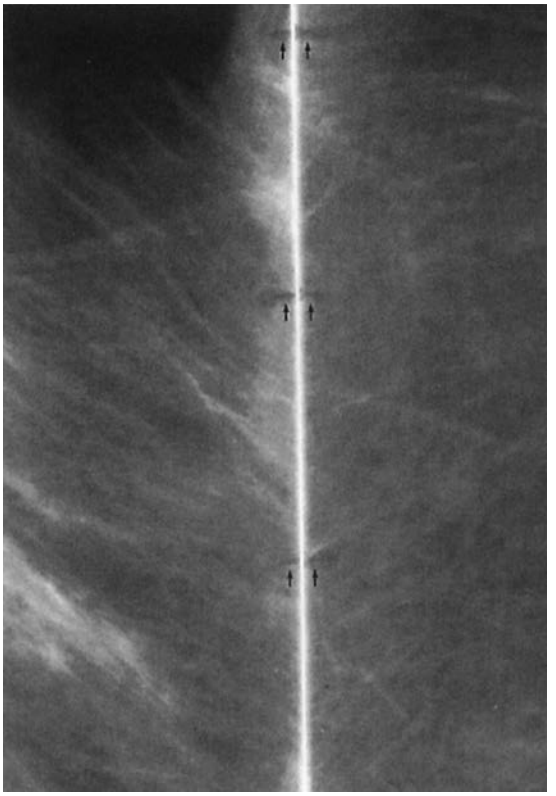


**FIGURE 4-21** Guide shoe marks (*arrows*). Plus density artifact evenly spaced.

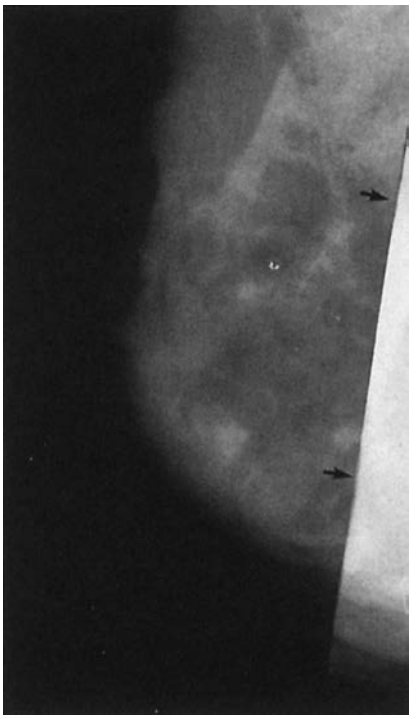


**FIGURE 4-22** Overlap of films during processing due to impatience. The first film is not completely into the processor before the second film is fed in (*arrows*).

## Digital Mammography

### Key Facts

- Units ($300,000 to $500,000) and associated components needed (work stations, monitors, archival systems and amount of storage space) are costly.
- Image acquisition, display and storage are independent of each other.
- Spatial resolution needed still being investigated. Current systems produce images with pixel sizes ranging from 50 to 100 μm. As compared with film-screen (20 lp/mm), resolution for full field digital systems ranges from 5 to 10 lp/mm.
- Image acquisition devices.

  Conversion of absorbed x-ray to light photons by fluorescent screen (e.g., cesium iodine). Light produced is measured pixel by pixel (e.g., using amorphous silicon diodes or charged coupled devices), electronic signal from each pixel is amplified and sent to analog to digital converter for storage of signal; indirect digital detector.

  Amorphous selenium plate stores charge created by ionization of absorbed x-rays; charge is read by either scanning the plate with laser beam or using a silicon diode array in contact with the plate; direct digital detector.

  Computed radiography uses photo-stimulable phosphor. Absorbed x-rays, promote electrons in phosphor plate to higher levels. Higher energy (blue) light is emitted in proportion to x-ray exposure as a laser scans phosphor plate and electrons are released.

- Image display.
  Hard copy: films printed by laser imagers having 40-μm spot size; facilities must have FDA-approved laser printer in order to satisfy MQSA requirement that hard copy films of digital studies be available to patients as needed.
  Soft copy: high resolution 2K × 2.5K (5 Mpixel) monitors.
  More development is needed to make workstations more user friendly.
- Image storage.
  Storage requirements for mammography are significant (40 to 240 Mbytes per 4 views).
  Expensive.
  Optical disks—picture archiving and communication system (PACS).
  CD-ROMS.
- To use new modality, initial 8 hours of training in modality plus 6 hours of continuing medical education every 3 years.
- Benefits of digital systems.
  Image acquisition times.
  Increased imaging contrast and wider display latitude.
  Ability to manipulate contrast and latitude of selected areas or entire image after exposure.
  Detector noise is decreased.
  Telemammography.
  Computer aided detection (although CAD can be used with analog studies also, films have to be digitized).
- Digital systems permit additional methods of evaluation.
  Dual energy subtraction mammography (subtraction of digital images acquired using two different energy spectra).
  Tomosynthesis (e.g., tomographic images of breast).
  Contrast enhanced digital mammography.
- Digital Mammographic Imaging Screening Trial (DMIST).
  American College of Radiology Imaging Network (ACRIN) funded by National Cancer Center (NCI) sponsored study to evaluate the diagnostic accuracy of digital mammography compared with film screen mammography.
  Digital and film screen mammography had similar screening accuracy for entire study population.
  Digital mammography may be better in screening women under age 50 and those with dense tissue regardless of age.
  False positive studies same for digital and film screen mammography.

## SUGGESTED READINGS

Bassett LW. Quality determinants of mammography: clinical image evaluation. *RSNA Categorical Course in Breast Imaging Syllabus*. 1995;57–67.

Eklund GW, Cardenosa G, Parsons W. Assessing adequacy of mammographic image quality. *Radiology*. 1994;190:297–307.

Haus AG, Jaskulski SM. *The Basics of Film Processing in Medical Imaging*. Madison: Medical Physics Publishing; 1997.

Hendrick RE, Berns EA. Optimizing techniques in screen-film mammography. *Radiol Clin NA*. 2000;38:701–718.

National Council on Radiation Protection. *A Guide to Mammography and Other Breast Imaging Procedures* (NRCP Report #149). Bethesda: National Council on Radiation Protection and measurements; 2004.

Pisano ED, Gatsonis C, Hendrick E, et al. Diagnostic performance of digital versus film screen mammography for breast cancer screening—the results of the American College of Radiology Imaging Network (ACRIN) digital mammography imaging screening trial (DMIST). *N Engl J Med*. 2005;17:1773–1783.

Pisano ED, Yaffe MJ, Kuzmiak CM. *Digital Mammography*. Philadephia: Lippincott Williams and Wilkins; 2004.

Sprawls P, Kitts EL. Optimum processing of mammographic film. *RadioGraphics*. 1996;16:349–354.

Wentz G. *Mammography for Radiologic Technologists*. 2nd ed. McGraw Hill; 1997.

Widmer JH, Lillie RF, Jaskulski SM, et al. *Identifying and Correcting Processing Artifacts*. Rochester, NY: Technical and Scientific monograph #4. Eastman Kodak Company; 1994.

Yaffe MJ, Hendrick RE, Feig SA, et al. Recommended specifications for new mammography equipment: report of the ACR-CDC focus group on mammography equipment. *Radiology*. 1995;197:19–26.

CHAPTER 5

# SCREENING MAMMOGRAPHY

## General Comments

### Key Facts

- Breast cancer is a heterogeneous disease.
- Breast cancer causes are unknown, so prevention is not currently an option.
- As a result primarily of early breast cancer detection (although some have suggested that it is due to improved treatment), the age-adjusted rate of death from breast cancer was 24% lower in 2003 than it was in 1989.
- There is debate as to whether breast cancer is systemic from the beginning or is localized to the breast for variable time periods before becoming systemic.
- If cancer is systemic from inception, early detection through mammographic screening would have little benefit. However, if localized to the breast for variable periods, early detection might represent the only effective way of dealing with this disease.

  Data from the two-county Swedish screening trial supports the contention that breast cancer is localized to the breast for a variable period of time prior to the development of systemic disease.

  Under these circumstances, the time to diagnosis becomes critical; the earlier breast cancer is detected, the less likely it is to have become systemic.

  Regardless of tumor grade and nodal status, patients diagnosed with breast cancers less than 1 cm in size have a 20-year survival rate of approximately 87% (Tabar L, Two-County Swedish trial).

  Patients with node-negative breast cancers less than 1.5 cm in size have a 20-year survival rate of approximately 83.8% (Tabar L, Two-County Swedish trial).
- Although prevention of breast cancer is not currently an option, early breast cancer detection impacts overall breast cancer mortality rates significantly. Also, there are more available treatment options when cancer is detected early.

  We must screen a sufficiently large portion of the population to see effects.

  We must screen at appropriate intervals.

- Even with the use of mammography (the best method for detecting early breast cancers reliably), breast cancers will be missed:

  If the threshold for intervention is high, we wait until a lesion is obviously cancer before recommending a biopsy.

  If the screening intervals are too long.

  It is generally accepted that breast cancers grow more quickly in premenopausal women, so annual screening mammography is recommended in all women starting at age 40.

  Tumor sojourn time, defined as the time taken for cancers to go from mammographic preclinical to clinical detectability, is 1.7 years in premenopausal women compared with more than 3.3 years in postmenopausal women.
- Breast cancer is now most commonly diagnosed through mammographic screening. (Previously, most breast cancers were diagnosed by patients during breast self examination).

## Screening Trials

### Key Facts

- Issues to consider in proving screening efficacy:

  Survival by itself is insufficient to establish an alteration in the natural history (or mortality) of breast cancer.

  Randomized controlled trials with mortality as the end point are needed to overcome biases:

  Lead time bias: breast cancers can be detected at an earlier date through screening; however, this does not change the time to death.

  Length bias: there are a disproportionate number of slower growing tumors (better prognosis) diagnosed through screening.

  Selection bias: self-selected patients (volunteers) may have better outcomes regardless of screening (patients with increased awareness and more likely to be compliant with treatment and follow ups).

  Over diagnosis bias: lesions detected through screening are of questionable significance (e.g., well differentiated invasive ductal carcinoma; low nuclear grade ductal carcinoma in situ) with respect to overall patient mortality.
- Randomized controlled trials needed to prove efficacy of screening.

  Trials must enroll enough women to have sufficient statistical power to prove a benefit from screening (e.g., enough women have to die of breast cancer in the control group to prove that the deaths do not occur in the study group). The smaller the difference (benefit) one is trying to prove, the larger the number of women needed to prove that difference.

  Randomization into control and studies groups should be blinded.

  Technology, interpretation, and management of findings should be optimal and standardized.

Seven randomized controlled trials of women starting at age 40 have shown 19% to 32% reductions in breast cancer mortality in women invited to undergo screening compared to the control group not invited to screening.

The Canadian National Breast Screening Study is the only trial that failed to show a benefit for mammographic screening in 50- to 59-year-old women. Significant flaws and issues, however, have been raised with respect to how this trial was conducted.

When considering the results of randomized control trials, it is important to recognize that for the study group, women are invited to undergo screening. Some may choose to not accept the invitation to screening mammography (e.g., compliance is not 100%). These women are still counted as having had screening mammography.

Likewise in the control group, although women are not invited to screening mammography, they can have a mammogram independently of the study, and even though a cancer may be detected through the mammogram, they are counted as not having had mammography (crossover).

Sufficient follow up to see benefit is needed; in 40- to 49-year-old women 10 to 15 years of follow up are needed before screening benefit is seen.

It is generally accepted that screening mammography in women over the age of 50 is beneficial (e.g., less women die of breast cancer in the screened population). How logical is it to think that mammography does not work in women under the age of 50? What is magical about 50? What happens to breast tissue when it is 50 years old?

Although there is some loss of breast tissue perimenopausally, one cannot predict patient age based on parenchymal patterns: young women may have fatty breasts; older women may have dense tissue.

## SCREENING RECOMMENDATIONS

### KEY FACTS

- American Cancer Society (ACS) screening guidelines for the early detection of breast cancer.

  Yearly mammograms are recommended starting at age 40.

    Women should be educated with respect to benefits, limitations, and possible harm associated with screening.

  A clinical breast exam should be part of a periodic health exam about every 3 years for women in their 20s and 30s and every year for women 40 and older.

  Screening with magnetic resonance imaging as an adjunct to mammography is recommended for women with an approximately 20% to 25% or greater lifetime risk of breast cancer including women with a strong family history or breast or ovarian cancer and women treated with chest radiation for Hodgkin's disease.

Women at increased risk (e.g., family history, genetic tendency, past breast cancer, atypical ductal hyperplasia) should talk with their doctors about the benefits and limitations of starting mammography screening earlier, having additional tests (i.e., breast ultrasound and MRI), or having more frequent exams.

Cessation of annual screening is not age related but a function of comorbidity.

- The ACS no longer recommends a baseline study between ages 35 and 40.
- The ACS no longer recommends monthly breast self examination (BSE) starting at age 20.

  Women should be told of possible benefits, limitations, and harms associated with BSE. It is up to the patient herself if she wants to do BSE regularly, occasionally or not at all.
- If a woman is in a high-risk category, screening can be started 10 years earlier (age 30) unless the mother's breast cancer occurred at an early age (before age 40), in which case we start 10 years before the age of detection (e.g., if cancer was detected at age 37 in her mother, we start screening the daughter at age 27). However, we usually don't start screening below age 25.

## Screening Views: General Comments

### Key Facts

- Breast cancer size at the time of diagnosis is an important prognostic factor. Regardless of tumor grade and nodal status, patients with breast cancers less than 1 cm in size have a 20-year survival rate of approximately 87% (Tabar L, Two-County Swedish trial).
- High-quality mammography can demonstrate invasive lesions 10 mm or smaller in size as well as noninvasive breast cancer (ductal carcinoma in situ) commonly presenting with microcalcifications routinely.
- Breast positioning during mammographic studies is critical. Exclusion of breast tissue from the field of view may eliminate the opportunity to diagnose an early, potentially curable breast cancer.
- The inferior and lateral margins of the breast are mobile; the upper and medial portions of the breast are fixed in position. During mammographic positioning, natural breast mobility should be used to maximize the amount of tissue included in the images (to minimize breast tissue exclusion).
- Posterior nipple line (PNL).

  If positioning on the mediolateral oblique (MLO) view is optimal (thick muscle at axilla, convex muscle border to nipple level), draw a line along the anterior margin of the pectoral muscle, drop a perpendicular line from the nipple to the muscle, and measure. This is the posterior nipple line (PNL) that can be used to approximate the amount of tissue present. Measuring the PNL is of limited usefulness if positioning on the MLO view is suboptimal.

On the craniocaudal (CC) view, measure from the nipple back to the edge of the film regardless of whether you see pectoral muscle or not. The PNL measurement on the CC view should be within 1 cm of the measurement obtained on the respective MLO view. If it is not within 1 cm, tissue has been excluded on the CC view.

- In some women, additional views (e.g., exaggerated CCs) may be needed to image all breast tissue in two projections. In addition to positioning, mammographic images must be evaluated for appropriate compression, exposure, contrast, sharpness, noise, artifacts, and film labeling.
- Depending on breast size, 18 × 24 cm (8 × 10 in) or 24 × 30 cm (10 × 12 in) cassettes are available for film screen studies. Women with large breasts may require more than two views of each breast to image all breast tissue. For the MLO views, you may need to image the upper portion of the breast in one view and the lower portion in a second view. Do whatever it takes to ensure all breast tissue is imaged in two different projections.
- For women with small breasts or the male breast, narrow compression paddles (approximately half the width of the regular compression paddles) are available for optimal positioning.

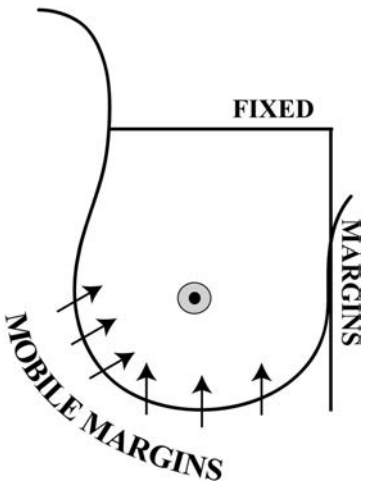



**FIGURE 5-1** The superior and medial portions of the breasts are fixed and have little inherent mobility. The inferior and lateral margins of the breasts are mobile. Exclusion of superior and medial tissue is minimized when natural breast mobility is used during position for the routine views. As the mobile portions of the breast are mobilized toward the fixed margins, the distance traveled by the compression paddle over fixed tissue is minimized. This reduces the likelihood of excluding tissue and, as skin stretching is lessened, some of the discomfort associated with compression is diminished.

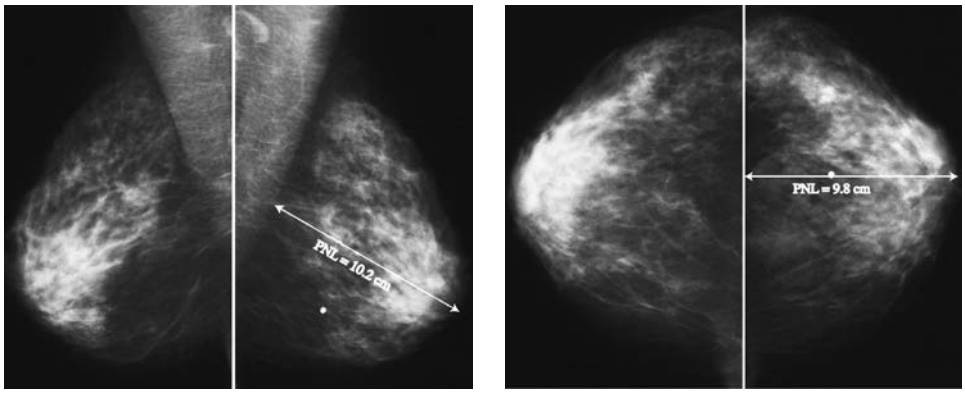



**FIGURE 5-2** Posterior nipple line (PNL). **(A)** Mediolateral oblique (MLO) and **(B)** craniocaudal (CC) views. In evaluating positioning on CC views, the presence of pectoral muscle or cleavage assures that a maximal amount of posteromedial tissue has been included on the image. If pectoral muscle or cleavage is not seen on the CC view(s), the PNL can be measured to assure posterior tissue has not been excluded on the CC view. In this patient, pectoral muscle or cleavage is not seen on the left. The PNL line on the well-positioned left MLO view measures 10.2 cm. On the left CC view, it measures 9.8 cm. The measurements are within 1 cm of each other such that no significant amount of posterior tissue has been excluded on the CC view. Incidentally noted are axillary lymph nodes bilaterally and a benign coarse calcification in the left breast.

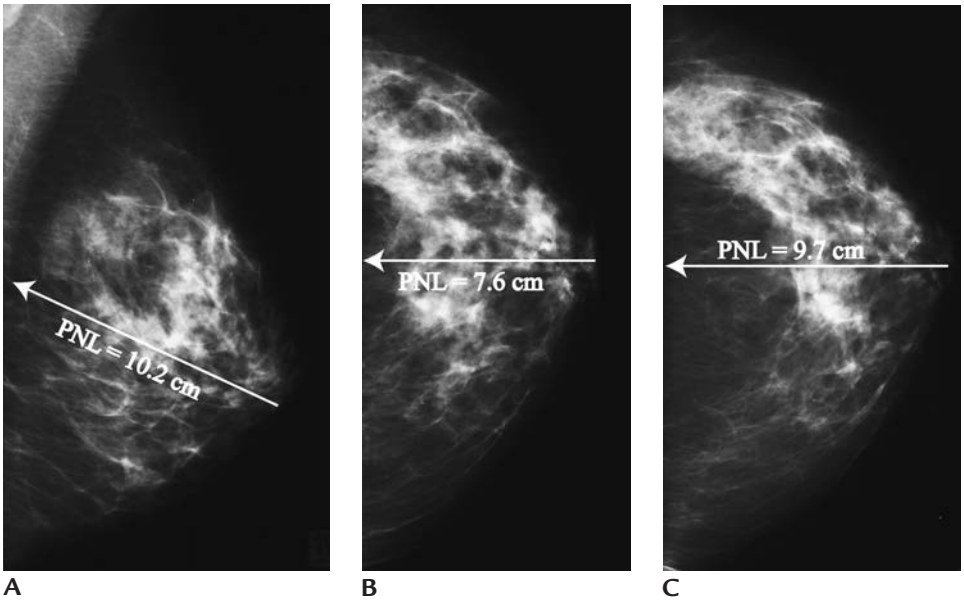



**FIGURE 5-3** Posterior nipple line (PNL). **(A)** Left MLO and **(B)** craniocaudal (CC) view. No pectoral muscle or cleavage is seen on the CC view. Only a small amount of retroglandular fat is imaged on the CC view. The PNL measurement on the CC view (7.6 cm) is not within 1 cm of the measurement on the MLO (10.2 cm) view. The CC view needs to be repeated because a significant amount of posterior tissue is excluded from the image. **(C)** Repeat left CC view. More posterior tissue and retroglandular fat is included on this image and the PNL (9.7 cm) is now within 1 cm of that measured on the MLO.

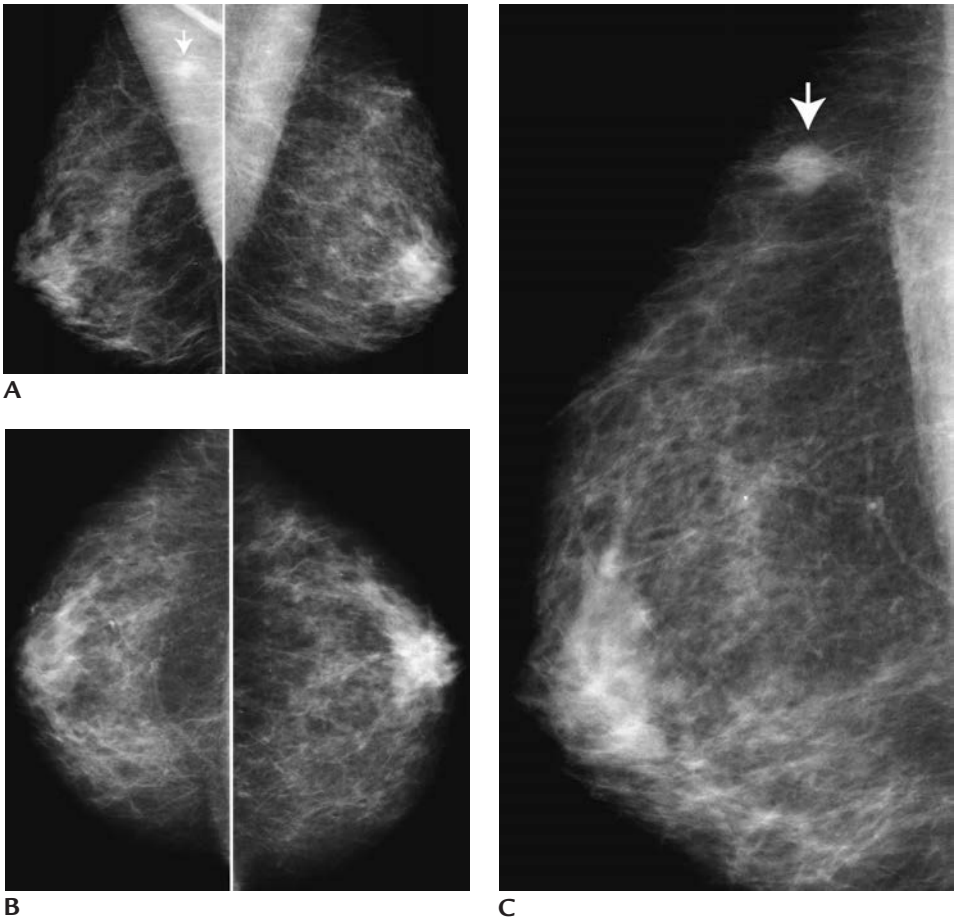



**FIGURE 5-4** Lesion exclusion. **(A)** Screening study, MLO views. A possible mass *(arrow)* is noted superimposed on the right pectoral muscle. **(B)** Craniocaudal (CC) views. No abnormality is apparent. **(C)** Exaggerated craniocaudal view (XCCL) view. Mass *(arrow)* is now imaged laterally in the right breast. This mass was excluded from the field of view on the routine CC view and subtle on the MLO view. With the XCCL, it is readily apparent and now imaged in two projections. Every effort should be made to see all breast tissue in two projections.

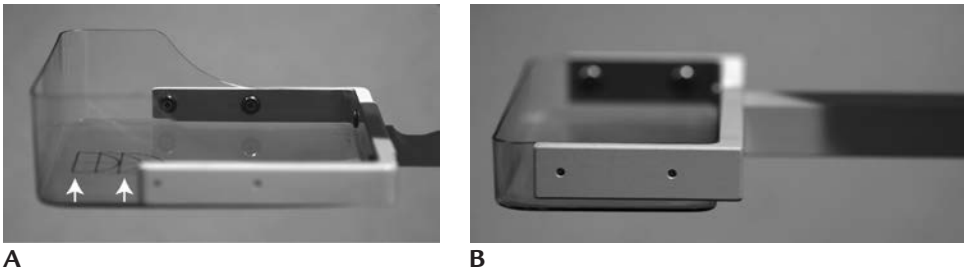



**FIGURE 5-5** Compression paddles. **(A)** Full sized compression paddle used for routine mammographic views. Marks *(arrows)* centrally on the paddle are used by technologist to determine photocell positioning when phototiming images. To obtain adequate exposure, the photocell should be placed under the glandular tissue. For analog images, full compression paddles are available in two sizes that match the two available cassette sizes. **(B)** A narrow paddle (half the width of the full sized compression paddle) is helpful in imaging small breasted female patients, women with implants, and male patients.

# MLO Views

## Key Facts

- Natural breast mobility.

  The lateral portion of the breast is mobile; the medial portion is fixed.

  The goal is to mobilize the lateral portion of the breast as much as possible to minimize tissue exclusion and skin stretching of upper inner quadrant tissue.
- Pectoral muscle relaxation.

  Mobilization of the breast and underlying pectoral muscle medially, and outward pull of the breast tissue, is easier if the pectoral muscle is relaxed.

  Because the pectoral muscle inserts on the upper portion of the humerus, the humeral head should be inwardly rotated with the arm down behind the film holder or resting on top of the film holder.
- Patient specific angle of obliquity.

  The angle depends on pectoral muscle orientation: when maximizing the outward pull of a skin appendage (e.g., the breast), it is best to pull parallel to the underlying muscle fibers.

  Depending on a woman's body habitus, pectoral muscles have variable angles of obliquity. Short, stocky women have more horizontally oriented pectoral muscles; tall, thin women have more vertically oriented pectoral muscles.

  A small portion of the upper abdomen should be included as breast tissue, can extend to the inframammary fold (IMF) and below.
- The technologist should work from behind the patient. This allows the technologist to keep the patient from backing out of the unit even slightly.

  From behind the patient, the technologist can also keep one hand on the patient's shoulder making sure the humeral head is rotated inwardly and the arm is either on the film holder or down behind the film holder.

  The technologist uses her other hand to lift the breast up and out as compression is applied with the foot pedal.

  The hand on the humeral head can also be used to pull upper skin (just inferior to clavicle) thereby minimizing skin fold development.

  After breast positioning, there should be no gaps between the patient and the film holder at the axilla, posterolateral margin of the breast or at the IMF.

  An air pocket will be focally apparent if the breast is not flush with the bucky.

  Skin folds sometimes develop up against the bucky. The image may need to be repeated if there is inadequate penetration through a skin fold, the fold is large and compromises compression, or if there is associated blur.
- Pectoral muscle should be seen to the level of the nipple.
- If the pectoral muscle is relaxed appropriately, mobilized medially, and maintained medially during exposure, the pectoral muscle edge will have a convex contour.

- If the pectoral muscle edge is concave, parallel to the edge of the film or triangular, the breast is not positioned optimally. The right angle of obliquity was not selected; the muscle was not relaxed adequately, mobilized medially or, if mobilized, not maintained medially mobilized; or the patient backed out of the unit slightly.
- The pectoralis minor muscle is seen in a small number of women as a triangular density superimposed on the upper most portion of the pectoralis major muscle.

  In women with Poland's syndrome, pectoral muscle is not seen on the MLO view and breast size may be asymmetric (small breast on affected side).

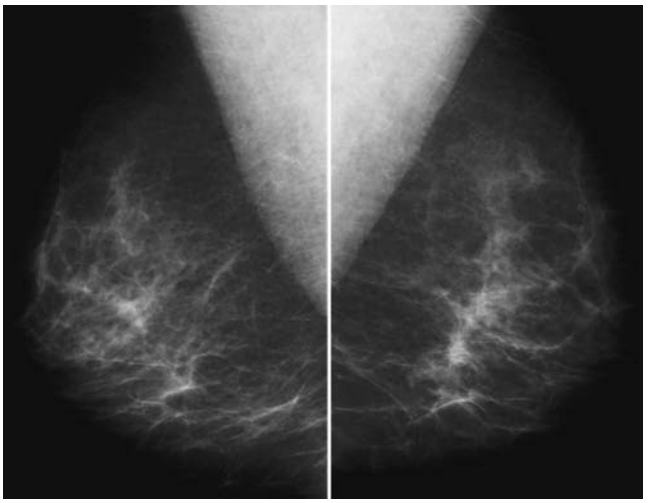
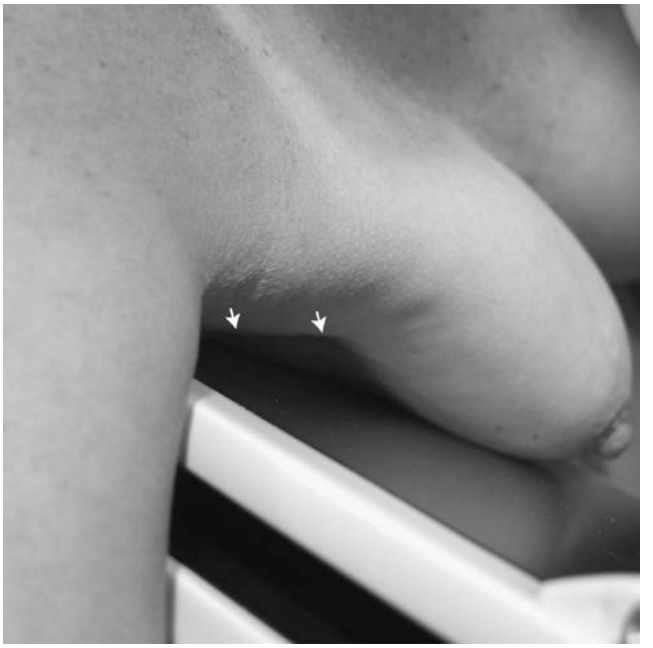


**FIGURE 5-6** MLO view. Pectoral muscle is wide in the axilla, extends to the level of the nipple, and has a convex anterior margin. The breast is lifted up and breast tissue is pulled out and well compressed. The images are well exposed and high in contrast.



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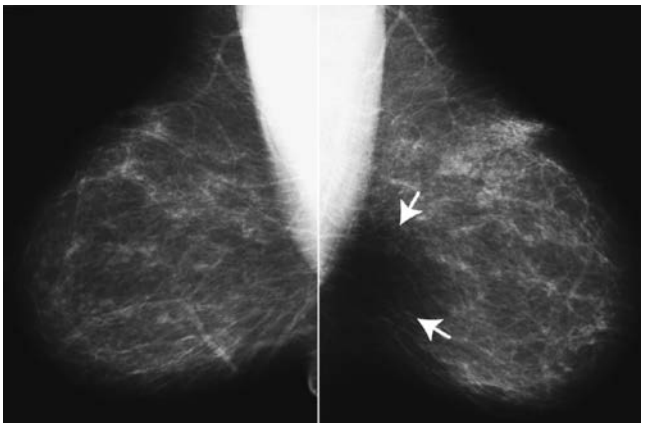


B

**FIGURE 5-7** Air pockets. **(A)** In positioning patients, it is important to place the breast evenly against the bucky otherwise air pockets *(arrows)* may develop limiting compression and leading to an uneven exposure. Note that the patient's arm is relaxed behind the bucky and that the humeral head is inwardly rotated so that that the pectoral muscle remains relaxed. **(B)** Markedly lucent area *(arrows)* just above the inframammary fold (IMF) reflecting the presence of an air pocket. This is an uneven exposure. In some patients, air pockets are seen more superiorly associated with the pectoral muscle.

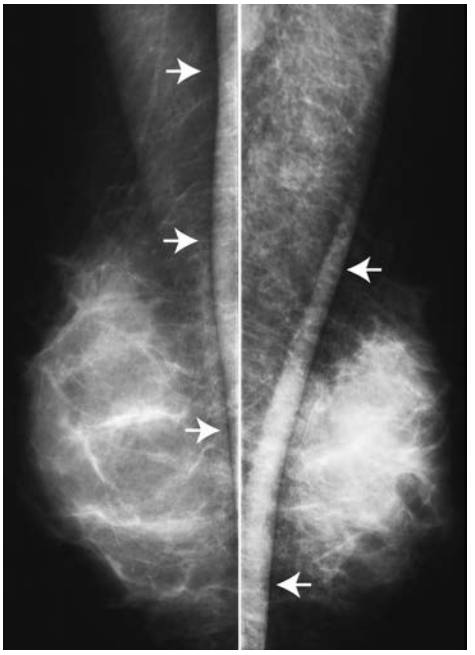
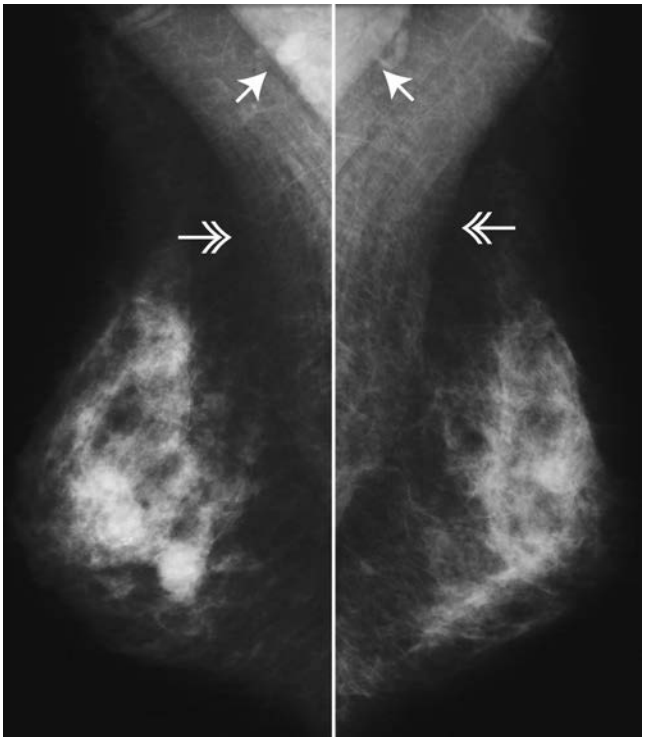
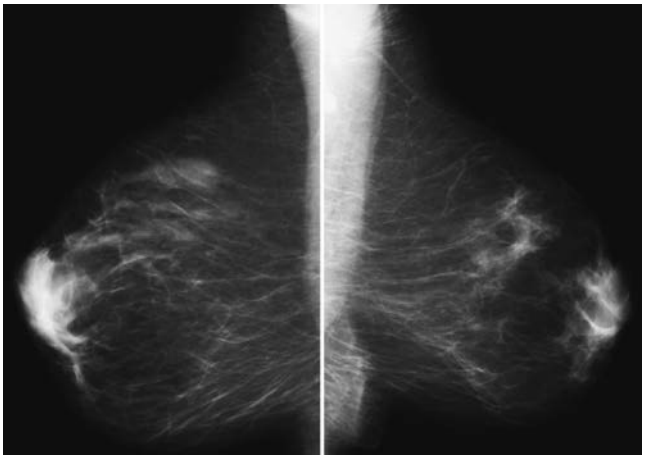


**FIGURE 5-8** Skin folds. MLO views demonstrating skin folds bilaterally *(arrows)*. As the breast is being positioned, skin folds can develop against the bucky and therefore not readily apparent to the technologist. Air (sharp radiolucency) outlines the edge of skin folds. When these are small, well penetrated and compression has not been compromised it is not critical to repeat the image. Specifically, look for blurring in the tissue adjacent to the fold to make sure compression is adequate. Given the size of the folds and the lack of good compression particularly on the left, these images were repeated (not shown).



**A**

**FIGURE 5-9** MLO views. **(A)** Concave pectoral muscles *(doubled headed arrows)*. The pectoralis minor muscles (*arrows*) are apparent in this patient as triangular densities superimposed on the upper posterior most aspect of the pectoral major muscles. Lymph nodes are noted scattered in the axilla bilaterally.



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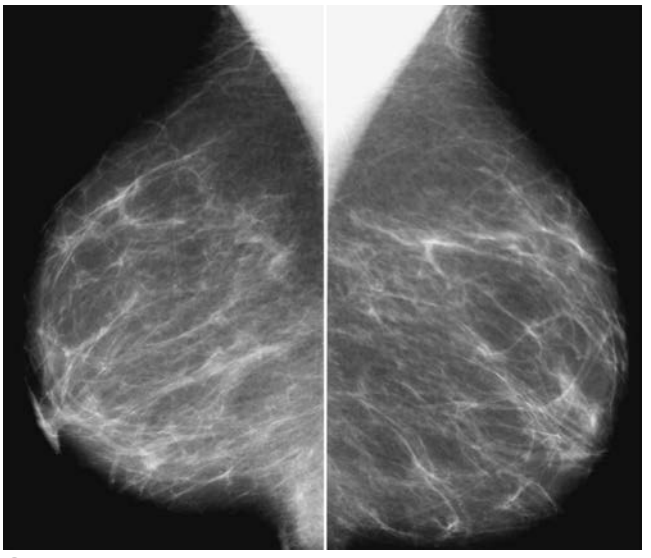
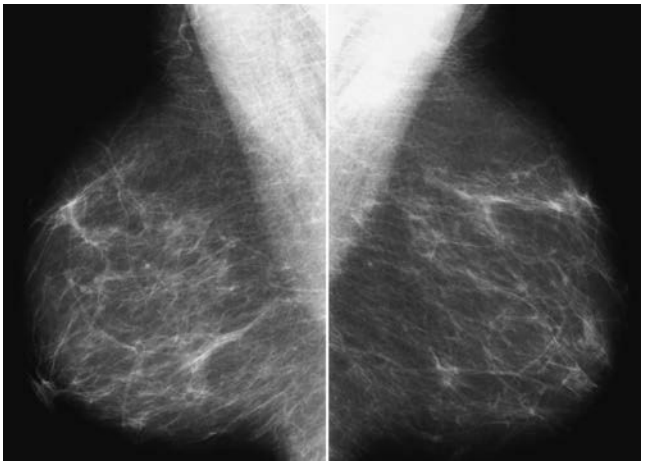


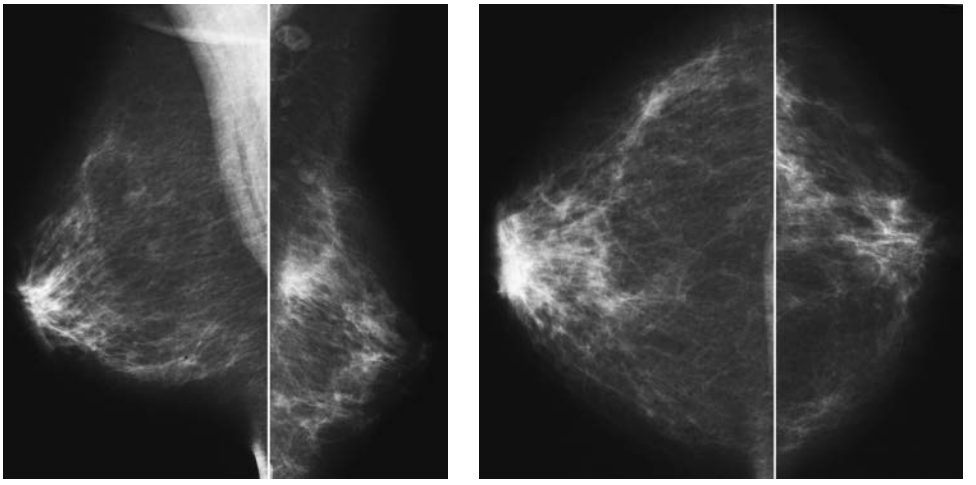
C

**FIGURE 5-9** (*Continued*) **(B)** Pectoral muscles extend to the level of the nipple; however, they are parallel to the edge of the film and not wide at the axilla, particularly on the right. Angle of obliquity, muscle relaxation, and mobilization were done; however, this appearance for the pectoral muscles suggests that the patient backed out of the unit slightly as compression was being applied. **(C)** Triangular shaped pectoral muscles bilaterally.



**D**

**FIGURE 5-9** (*Continued*) **(D)** Repeat MLO images on patient shown in **(C)**. The muscles are now wide in the axilla, have a convex anterior margin, and extend to the level of the nipple. The IMF is open. More posterior tissue is also imaged bilaterally. A focus on pectoral muscle relaxation and a different angle of obliquity were used on the second set of images.



**A** **B**

**FIGURE 5-10** Poland's syndrome. **(A)** MLO and **(B)** craniocaudal views. The left breast is smaller than the right and there is absence of the pectoralis major muscle on the left. Axillary and intramammary lymph nodes are noted superiorly on the left.

# CC Views

## Key Facts

- Natural breast mobility.

  The IMF is identified and the breast is lifted to the extent of its natural mobility.

  Breast mobility is variable. In some women, it is several centimeters but in others it may be less than 1 cm.

  After breast mobilization, the film holder is moved to the elevated IMF position and back to the chest wall. Care should be taken not to go above the elevated IMF position, because this may exclude inferior, posterior lesions.

  If care is not exercised as the breast is lifted, a skin fold develops inferiorly at the IMF. This skin fold can simulate the appearance of the pectoral muscle. Trapped air creates a lucency at the edge of the skin fold.
- Every millimeter the breast is mobilized upwardly is a millimeter less that the compression paddle must come down over fixed (not inherently mobile) upper tissue, thereby minimizing the possibility of tissue exclusion and skin stretching. Much of the associated discomfort with mammography is probably related to skin stretching as compression is applied rather than to compression itself.
- Outward pull.

  As the breast is mobilized superiorly, tissue is also pulled out away from the body as much as possible.

  The technologist should work from the medial side of the patient.
- The contralateral breast should be lifted and placed on the corner of the bucky. If the technologist is not careful, the contralateral breast can be an impediment to the film holder going back all the way to the chest wall. By interposing itself between the film holder and the chest wall, the contralateral breast can lead to the exclusion of medial/posterior tissue.
- The medial half of the breast must be included on CC views; at the same time, as much lateral tissue as possible should be imaged. As the compression paddle is coming down, the medial half of the breast is stabilized while the lateral portion of the breast is pulled in ("lateral tug").
- The lateral tug is usually enough to bring lateral tissue into view on routine CC views so that retroglandular fat is seen posterior to lateral tissue. In approximately 10% of women, tissue will extend to the edge of the film laterally even after the lateral pull. Exaggerated CC views laterally (uni- or bilateral) are needed in these women to image lateral tissue. The presence of lateral and posterior tissue can be confirmed on the MLO view (tissue superimposed on pectoral muscle superiorly and posteriorly).
- After the lateral tug, in many patients a skin fold develops in the most posterior portion of the breast laterally. This is an indication that the "lateral tug" was attempted. The technologist can eliminate some of these skin folds by interposing her index finger between the compression paddle and the breast and then rolling her finger out, along with the skin fold, from under the paddle posteriorly.

- After breast positioning, there should be no gaps between the patient and the film holder (e.g., at cleavage or posterolaterally).
- Pectoral muscle should be seen in approximately 30% to 40% of CC views. When seen, it ensures that posterior tissue has not been excluded.
- If pectoral muscle is not seen, look for cleavage. This ensures that, at least medially, no tissue has been excluded. If no pectoral muscle or cleavage are seen be sure to measure the posterior nipple line.
- In some women a triangular, round or wedge shaped density may be seen medially on CC views.

  This represents either the sternal attachment of an otherwise atrophied pectoral muscle or the sternalis muscle. The sternalis muscle usually has a round, mass like appearance and is an uncommon variant in chest wall musculature (muscle extending from infraclavicular region to the caudal aspect of the sternum). It is commonly unilateral.

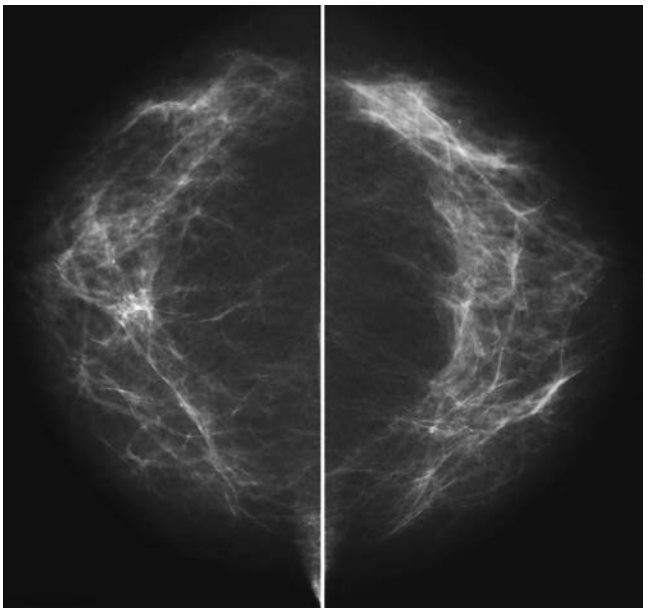


**FIGURE 5-11** Craniocaudal (CC) views. Retroglandular fat is seen laterally and although no pectoral muscle or cleavage is seen the posterior nipple line on these CC views is within 1 cm of that on the MLO views (for corresponding MLO views, see Fig. 5–6).

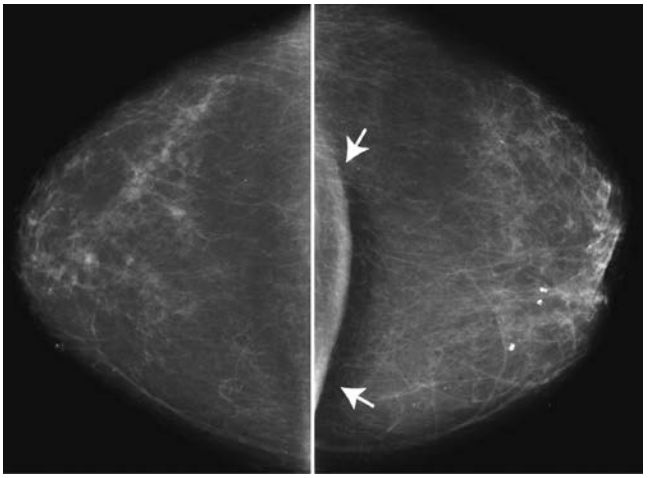
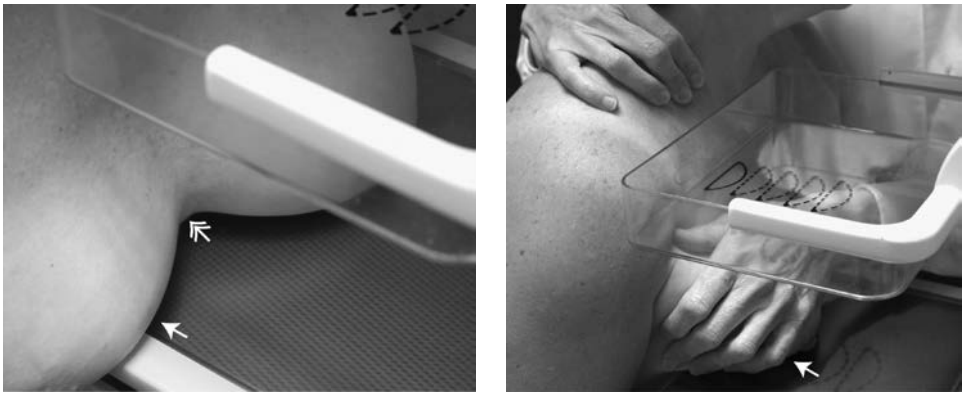


**FIGURE 5-12** Skin fold. As tissue is lifted, a skin fold (*arrows*) can develop at the IMF. The appearance can simulate pectoral muscle. Outlined by air (lucency), the edge of the fold is sharp and helps distinguish it from the pectoralis major muscle. Because the skin fold develops inferiorly against the bucky, it is not visible to the technologist during positioning.



**A** **B**

**FIGURE 5-13** Positioning, craniocaudal (CC) views. **(A)** After the breast is lifted and pulled out, consider the position of the contralateral breast. If it is left pendulous, it can impede the bucky from going back to the chest wall, so it should be lifted and placed at the edge of the bucky (*arrow*). This then helps position the bucky against the chest wall and so that any gap at the cleavage (double headed arrow) is eliminated. **(B)** As compression is applied, the lateral aspect of the breast should be pulled in (*arrow*). In some women, this lateral tug can add a significant amount of lateral tissue to the image without giving up any medial tissue.

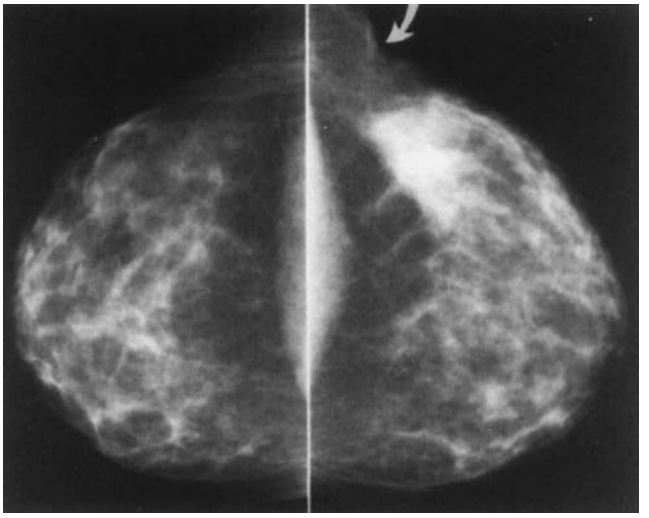
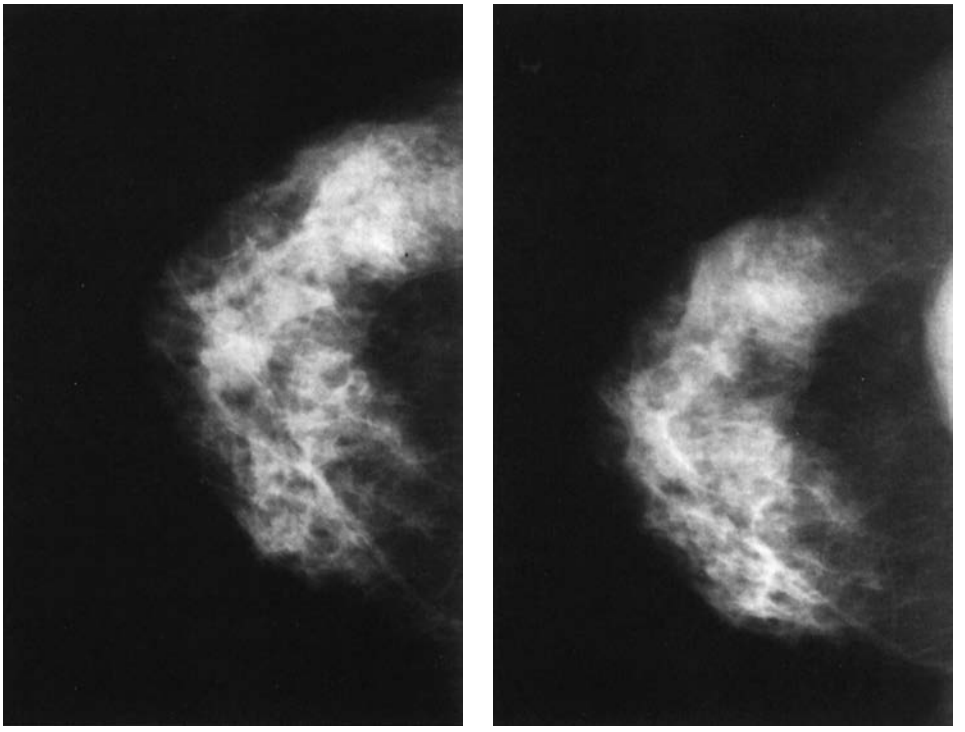


**FIGURE 5-14** Right and left craniocaudal (CC) views. Pectoral muscle is present bilaterally and retroglandular fat is seen laterally. Skin fold *(arrow)* on the left laterally arises from the technologist doing a lateral pull to include as much lateral tissue as possible on the craniocaudal view.



**A** **B**

**FIGURE 5-15** Effect of positioning and lateral pull. **(A)** Right craniocaudal (CC) view. No pectoral muscle is seen and there is tissue extending to the edge of the film laterally. Is positioning optimal? **(B)** Right CC view with attention to positioning and lateral tissue pull. More tissue is included in the image. Pectoral muscle is present. Retroglandular fat is imaged laterally.

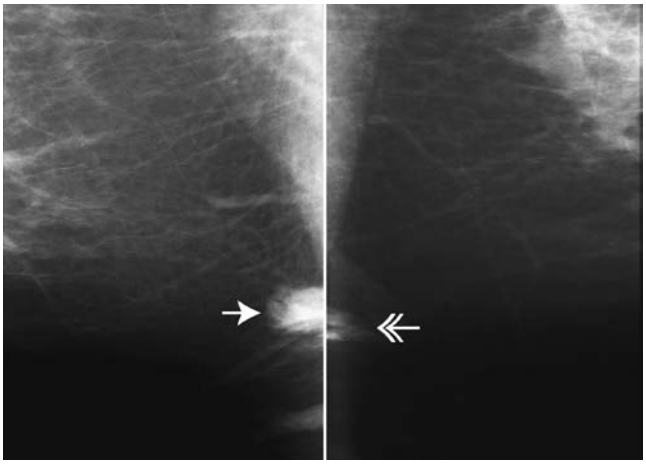


**FIGURE 5-16** Sternalis muscle. Bilateral round soft tissue density *(arrows)* medially right larger than left seen separate from the pectoral muscle, consistent with the sternalis muscle. No abnormality is identifiable on the oblique views (not shown).

## Exaggerated Craniocaudal (XCCL) Views

### Key Facts

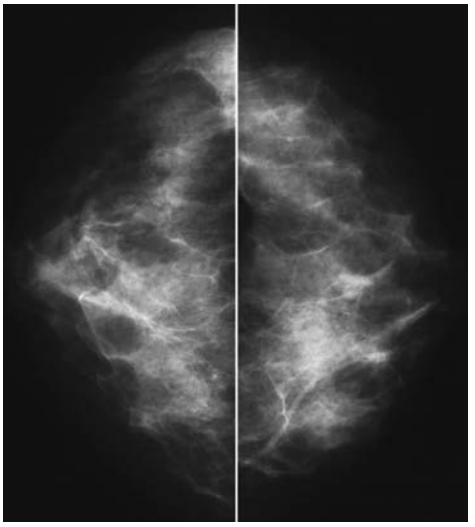
- In approximately 10% of women, XCCL views (uni- or bilateral) are done as part of the screening study to evaluate lateral tissue (prominent axillary tail of Spence).
- Indications

  As part of the screening study: on CC views, tissue extends to the edge of the film laterally; on MLO views, a prominent tail of Spence is confirmed by seeing tissue extending superiorly, superimposed on pectoral muscle.

  To evaluate lateral lesions; may be combined with spot compression paddle.
- This view is not accomplished by placing the film holder laterally, but rather by asking the patient to rotate so that the film holder can be placed at the mid-axillary line.
- For most women, the x-ray tube needs to be angled slightly so that the compression paddle doesn't come down on the humeral head. The tube is not angled more than what is needed to clear the humeral head (5° maximum). If the tube is angled more, a shallow oblique rather than a CC view is obtained. Also, the patient should not be leaned back.
- A small amount of pectoral muscle is seen in properly positioned XCCL views. The shape of the pectoral muscle is helpful in assessing if the tube was angled excessively or the patient was leaned back (e.g., if image is a shallow oblique).

  On an optimal XCCL, the amount of pectoral muscle imaged is small and the margin is often parallel to the edge of the film.

  If a large amount of the pectoral muscle is imaged displaying a bulging, convex contour, the image is more likely to be a shallow oblique and not an XCCL.



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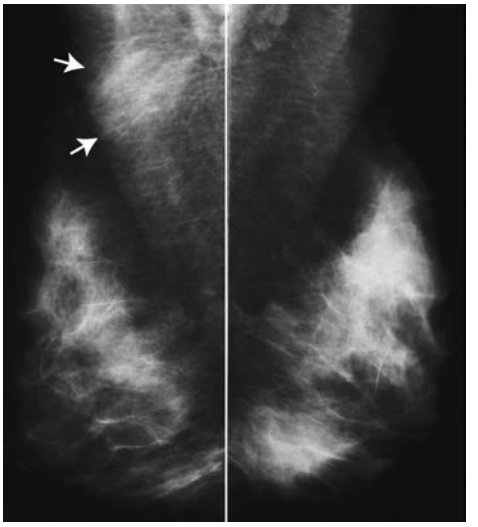

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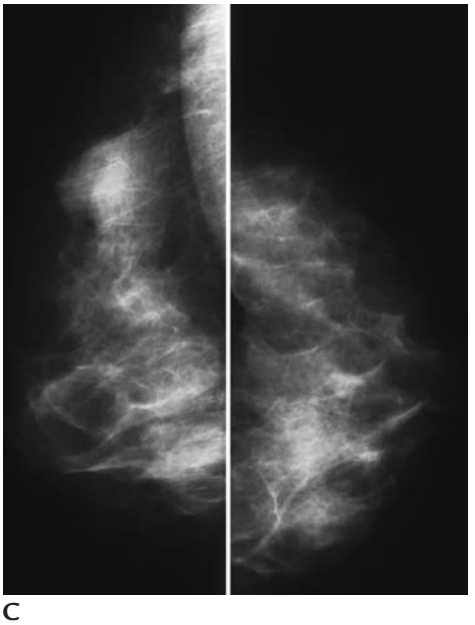
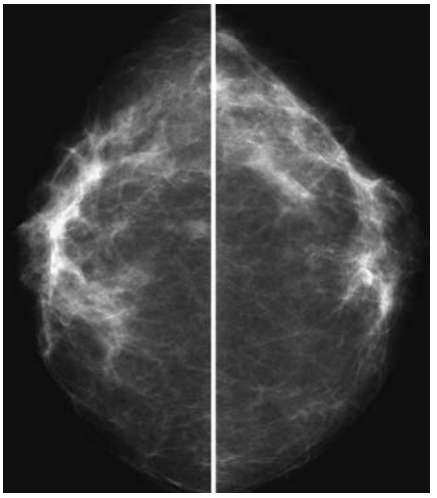


C

**FIGURE 5-17** **(A)** Craniocaudal (CC) views. Glandular tissue extends to the edge of the film bilaterally. To confirm the presence of lateral tissue, review the MLO views. **(B)** MLO views. Glandular tissue *(arrows)* superiorly, superimposed on the pectoral muscle on the right confirms the need for a right exaggerated craniocaudal (XCCL) view. **(C)** Right exaggerated craniocaudal view. Tissue extending laterally is now evaluated in two projections. In assessing positioning on XCCL views, you should not only see retroglandular fat laterally but also a small amount of pectoral as shown in this patient.



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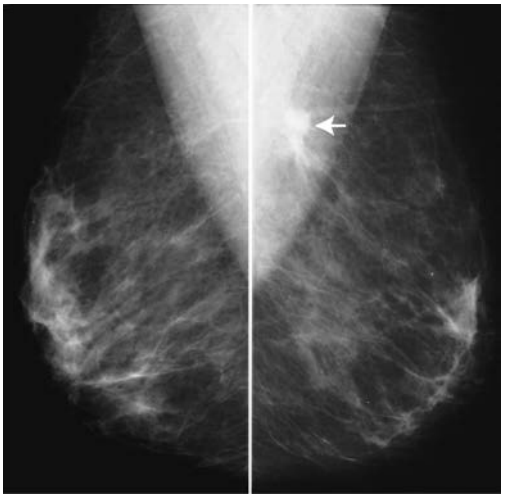

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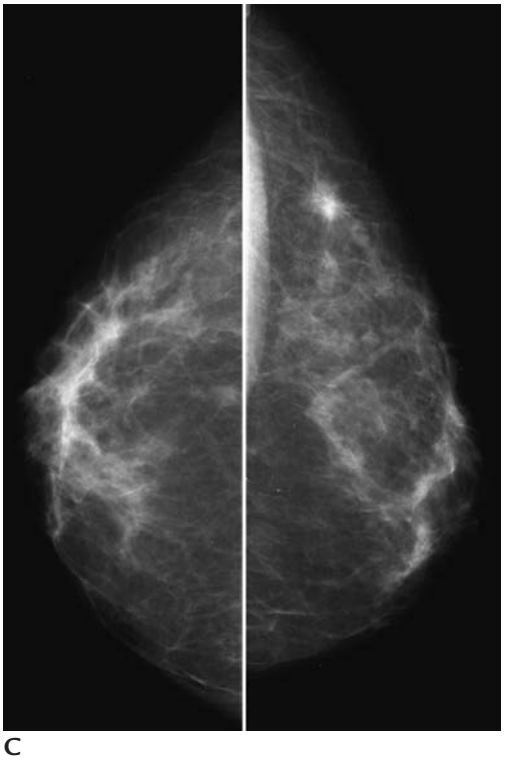


C

**FIGURE 5-18** Invasive ductal carcinoma. **(A)** Craniocaudal (CC) views. Tissue is seen extending to the edge of the CC view on the left. **(B)** MLO views. A potential mass *(arrow)* is seen superimposed on the left pectoral muscle. **(C)** Left exaggerated craniocaudal (XCCL) view. A mass with spiculated margins is imaged laterally in the left breast corresponding to the finding seen on the MLO view. The mass is now imaged in two projections thereby establishing its exact location in the breast. In assessing positioning on XCCL views, you should not only see retroglandular fat laterally but also a small amount of pectoral as shown in this patient.

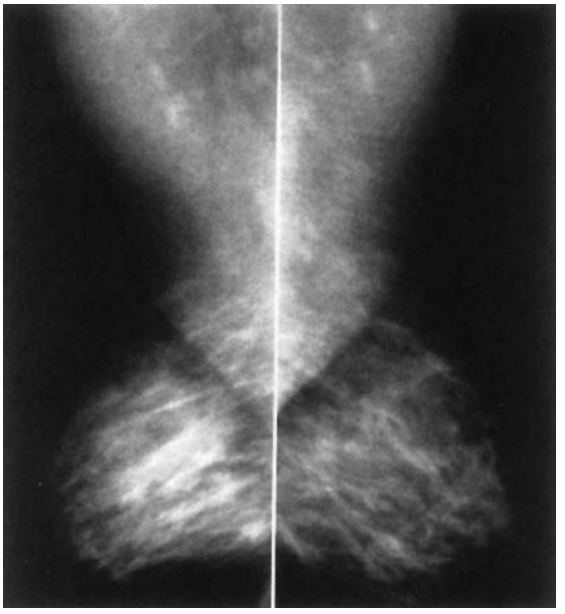
## Breast Compression and Anterior Compression Views

### Key Facts

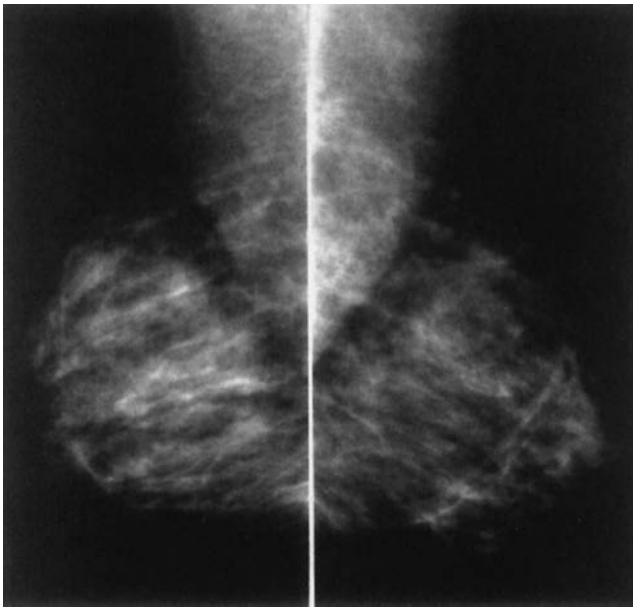
- Ideally the breast is compressed until taut.
- Some women experience significant discomfort during compression. Compression should not be forced on patients: it is better to have suboptimal compression than an angry patient who leaves after an unpleasant experience and never returns to your facility or never has a mammogram at any facility again.
- Women with cyclical tenderness may benefit from scheduling 1 or 2 days after menstruation. If a patient presents during a period of maximal tenderness offering to reschedule the appointment is usually appreciated.
- The technologist should work with the patient by explaining the importance of compression and educating the patient on how long compression lasts. Let the patient know she is in control of the examination and of how much compression is applied: compression will be stopped when the breast is taut or at any point prior to that if the patient says so.
- Even when the patient tolerates compression, the base of the breast (thickest part of the breast), the pectoral muscle, or the abdomen may limit compression of the anterior portion of the breasts.

  Whenever there is suboptimal compression blur may degrade the images.
- Blur related to suboptimal compression can be focal. Evaluate the subareolar area, the edge of the pectoral muscles and the trabecular pattern just above the IMF. Do the structures look sharp? If there are calcifications or vessels do they look sharp? Like subtle findings, blur will go undetected unless you specifically evaluate the mammogram for its presence.
- If you suspect blur (motion) get additional views. You may want to use the spot compression paddle in the area of perceived blur.
- When anterior compression is compromised by a particularly thick breast base, prominent pectoral muscles or too much abdomen in the field of view on the MLO view or, if anterior tissues are exposed inadequately, obtain anterior compression views.

  Anterior compression views are obtained by moving the compression paddle forward away from the base of the breast or the pectoral muscle. A spot compression paddle may be used if the area to be evaluated is small.



A



B

**FIGURE 5-19** **(A)** Right and left MLO views. Strikingly prominent pectoral muscles. The anterior tissue is undercompressed. Underexposure of tissue on the right. **(B)** Anterior compression, right and left MLO views. Moving forward off the pectoral muscles so that compression of anterior tissue is optimized. In this patient, pectoral muscle is still seen (pectoral muscle is not always seen with anterior compression views.) Although illustrated here with MLO views, this can also occur on craniocaudal views.

## Imaging Women with Implants

### Key Facts

- Four views of each breast are done.

  Two CC views, one with the implant in the field of view and one with the implant displaced as much out of the field as possible.

  Two MLO views, one with the implant in the field of view and one with the implant displaced as much out of the field as possible.

  If there is significant encapsulation, displaced views may be difficult to do. A 90° lateral view can be added in women with encapsulation to increase the amount of tissue imaged.
- Implant in the field of view.

  These views are done prior to any significant implant manipulation. Implant status is checked before proceeding with implant displaced views.

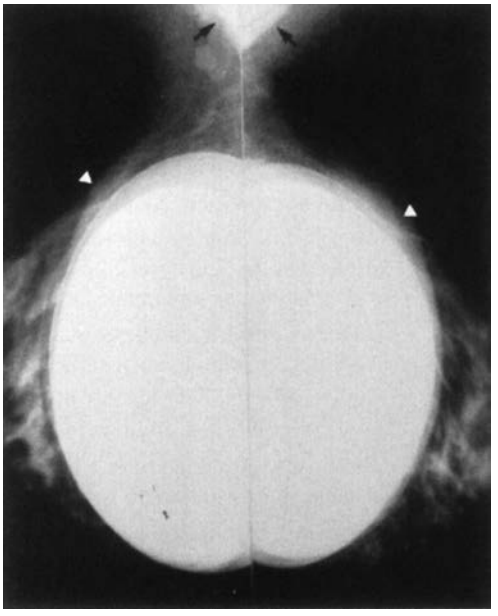
  The breast is positioned as in women without implants.

  For these views, breast tissue is never compressed adequately because the implants are the limiting factor to compression. Not only is the tissue not spread out as compression is applied, it is pushed out and trapped between the implant and the skin. As a result, only enough compression to immobilize the breast (minimal compression) is applied for these views.
- Implant displaced views (ID).

  Anterior and lateral tissue is pulled out away from the implant while the implant is pushed back up against the chest wall.

  Compression is applied over tissue. The implant is not compressed because it has been pushed back against the chest wall.

  There is better tissue visualization in patients with subpectoral implants.
- If these principles are followed, the likelihood of a mammogram related implant rupture is virtually nonexistent.



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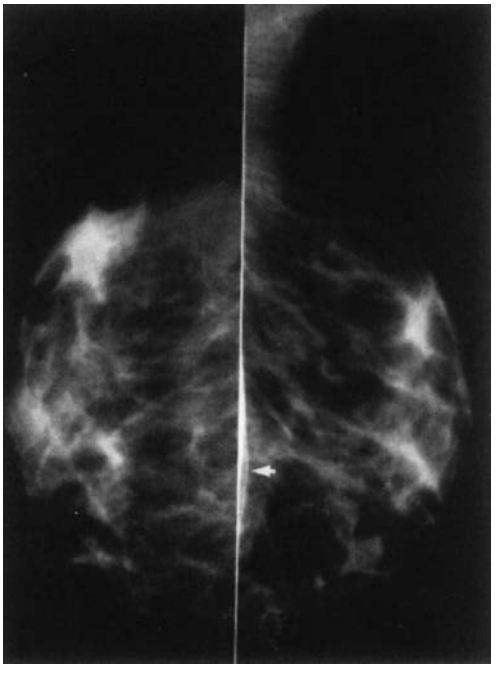
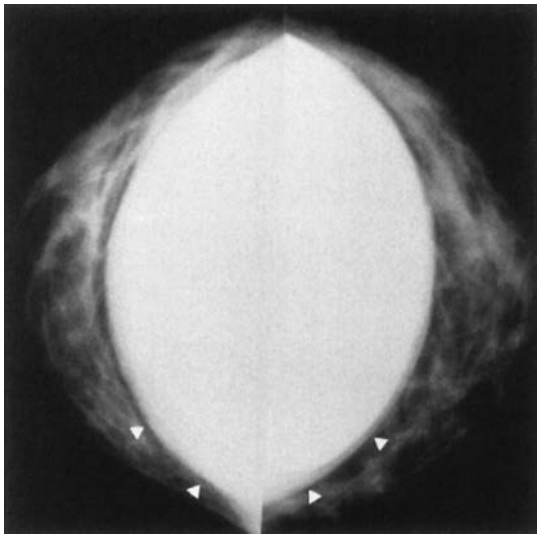


B

**FIGURE 5-20 (A)** Right and left MLO views. Subpectoral, double-lumen implant in the field of view. Pectoral muscle over implants *(arrowheads*). Pectoral minor muscles (*arrows*). (**B**) Right and left MLO, implant-displaced views. Compressed tissue can now be evaluated. A small amount of implant is seen on the left (*arrow*).



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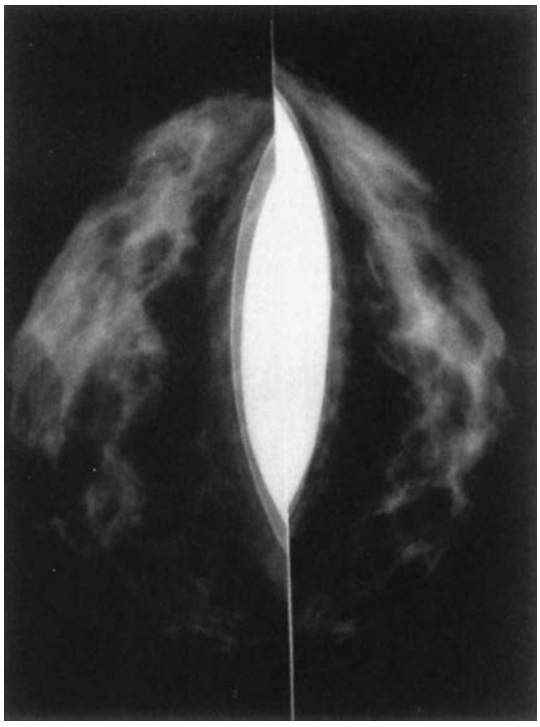


**D**

**FIGURE 5-20** (*Continued*) **(C)** Right and left craniocaudal (CC) views. Subpectoral, double-lumen implant in the field of view. Pectoral muscle overlying implants (*arrowheads*). **(D)** Right and left CC, implant-displaced views.

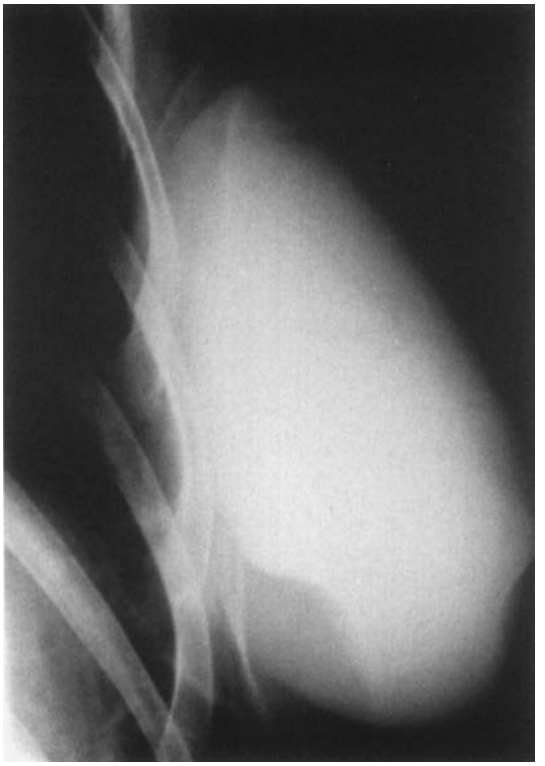


**FIGURE 5-21** Chest wall view. The posterior aspect of implants is not seen with routine or implant-displaced views (see Fig. 5-20). The chest wall view can be done to evaluate the posterior portion of implants. This is done using an aluminum filter, no compression, and 38 to 42 kV.

## Approach to Screening Mammography

### Key Facts

- By definition screening mammography is done in asymptomatic women.
- Two views of each breast are obtained. At the discretion of the technologist exaggerated craniocaudal views or anterior compression views are obtained as part of the screening study.
- Reviewing screening mammograms is about perception: is there potentially a lesion?

  If a potential lesion is identified, the patient is called back for additional diagnostic evaluation.
- It is strongly recommended that screening studies be prehung with comparisons and interpreted in batches.

  Limit distractions (e.g., telephone, interpreting other nonmammographic studies).

  Focus attention on films (e.g., minimize paperwork).

  Although in some communities there is a push for online interpretation of screening mammograms, this is not an efficient use of radiologist or

technologist time nor is it cost-effective and may lead to diagnostic errors.

Online interpretation of screening studies may also preclude establishing accurate data, such as a true call back rate.

- Review images in a consistent manner every time, using high luminance view boxes (3500 NIT) with a mechanism to mask out extraneous light.
- The only light in the reading room should come through the mammographic images. Extraneous light causes constriction of pupils, decreasing sensitivity to available light. With no ambient light, observer's eyes become more efficient at gathering light coming through images.

  It takes approximately 30 minutes for our vision to adjust to low ambient light.
- CC views back to back; MLO views back to back; comparison studies (see later) over current CC and MLO views.
- Images should be evaluated for technical factors. Do not settle for suboptimal quality. If you find yourself making excuses for the images, don't interpret—repeat!

  Positioning: Has all breast tissue been evaluated in two projections?

  Is compression adequate? Is there motion or blur?

  Has good contrast been achieved?

  Is the tissue adequately exposed?

  Are there artifacts? Have the films been labeled appropriately?
- Images should be viewed at a distance and close-up with a magnification lens; it is also helpful to send your brain specifically looking for motion, diffuse changes, microcalcifications, masses, and distortion. Otherwise findings may not be appreciated.
- Specifically evaluate:

  Subareolar area.

  Retroglandular area on CC and MLO views.

  Medial aspect of breasts on CC views.

  Superior cone of tissue on MLO views.

  Glandular tissue-subcutaneous fat junctions.
- You may want to evaluate the mammogram in parts, in a systematic, consistent manner. Areas not being evaluated can be masked; evaluate lateral, mid, and medial portions on CC views and upper, mid, and inferior portions on MLO views. This approach focuses your attention on smaller segments of the breasts. Commercially available viewers can facilitate this process; these can come with built in magnification.
- Comparison studies.

  Consider looking at studies that precede the current study by 2 or more years.

  Subtle changes may not be readily apparent from 1 year to the next, but become apparent when comparison is made to the earliest studies available.

  If awaiting prior films for comparison, dictate an interim report on the screening images rather than setting the study aside for dictation until prior films become available.

Document attempts to obtain prior films (outside facility, referring physician office, and patient contacts).

If prior films do not become available after 2 to 3 weeks, proceed as though the patient had no prior films.

- Do not be seduced by stability. If you see malignant calcifications, a spiculated mass, or distortion (with no history of surgery or trauma or ongoing infection) today, recommend a biopsy, even if the lesion(s) has been stable for 1 or several years (and word your report cautiously).
- If there is an obvious lesion (clinical or mammographic), look away from it. Make sure you evaluate the remaining breast tissue and the contralateral breast before evaluating the obvious lesion. Do not let yourself be distracted!
- Benefits of double reading screening mammograms under discussion.

  Two readers evaluate the screening studies independently.

  May increase the number of screen-detected cancers (6% to 15% increase in cancer detection reported with double reading without increases in call back or biopsy recommendation rates).

  Further studies are needed because some suggest that the reported increases in cancer detection are associated with a decrease in the sensitivity of the first reader.

  Double reading may not be feasible in many practice settings and may be precedent setting for double reading of other radiologic studies.

  Alternatively, computed aided detection (CAD) can be used.
- CAD.

  Marks are placed on images by a neural-network to direct the attention of the interpreting radiologist to possible masses and calcifications.

  Ultimately, the interpreting radiologist makes the decision concerning the significance of any area marked on the mammogram.

  Analog films need to be digitized. Digitally acquired images processed directly.

  CAD-marked images should be retained.

  This reportedly adds a 20% increase in cancer detection. Sensitivity for calcifications is higher than for masses. Areas of architectural distortion marked less than 50% of the time.

  No recognition for areas of developing asymmetry.
- Importance of radiologist training in mammography reported by Linver and associates.

  12 general radiologists, 2-year period, 38,633 mammograms.

  11 group members attend 17 dedicated mammography courses.

  50% increase in the number of breast cancers diagnosed during the second year (6.5% volume increase).

  Sensitivity increased from 80% to 87% with no change in positive predictive value (32%).

  Median tumor size and node positivity decreased.

  50% increase in the use of spot compression, magnification, and sonography.

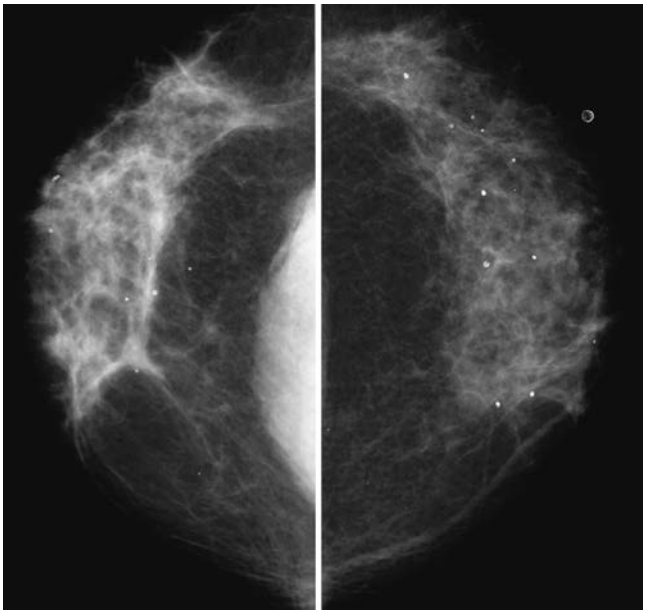
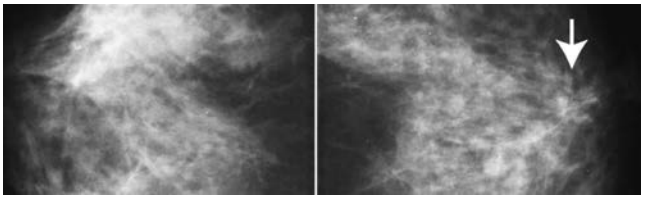


**FIGURE 5-22** Invasive lobular carcinoma. Shrinking breast. The right breast is smaller than the left, the trabecular markings are more prominent and the overall density of the parenchyma is increased. Diffuse changes can be difficult to perceive unless you are specifically looking for them.



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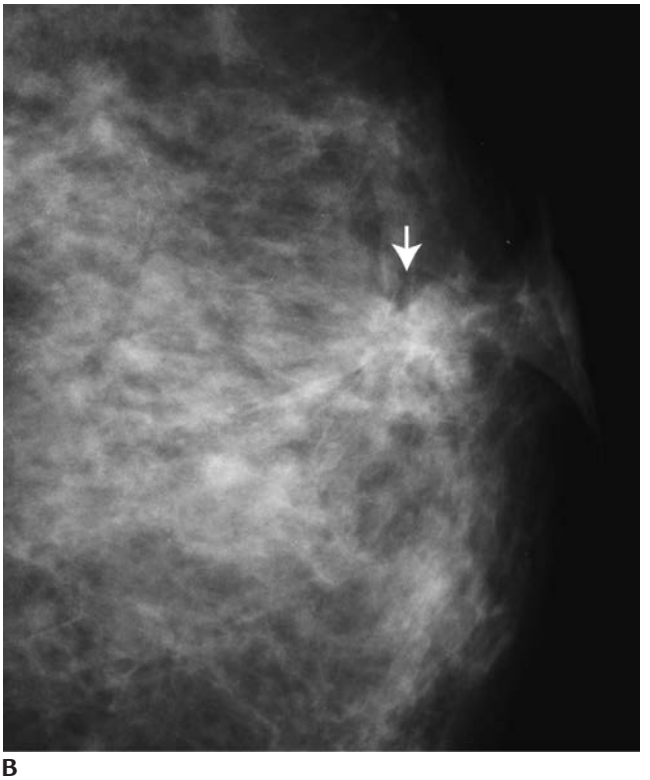
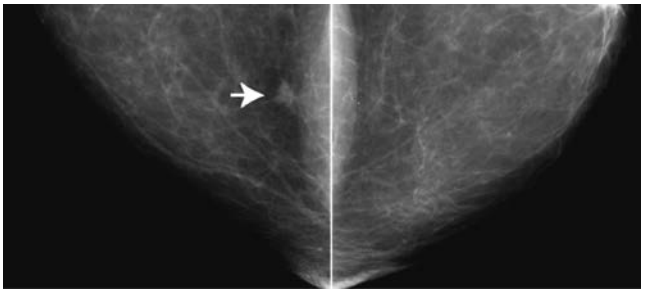


B

**FIGURE 5-23** Invasive ductal carcinoma with lobular features, left subareolar area. **(A)** Craniocaudal views. Split the images in thirds so that your attention is focused on smaller amounts of tissue and specifically evaluate the subareolar area. It is the second most common location for breast cancers to develop and, because of the convergence of the ducts, the possible superimposition of the nipple and potentially compromised compression, this area can be hard to evaluate. Increased density and possible distortion *(arrow)* is noted in the left subareolar area. The patient has no history of surgery or trauma at this site. She is called back for additional evaluation. **(B)** Mass with spiculated margins and associated distortion *(arrow)* is confirmed on the spot compression views. Biopsy is indicated.



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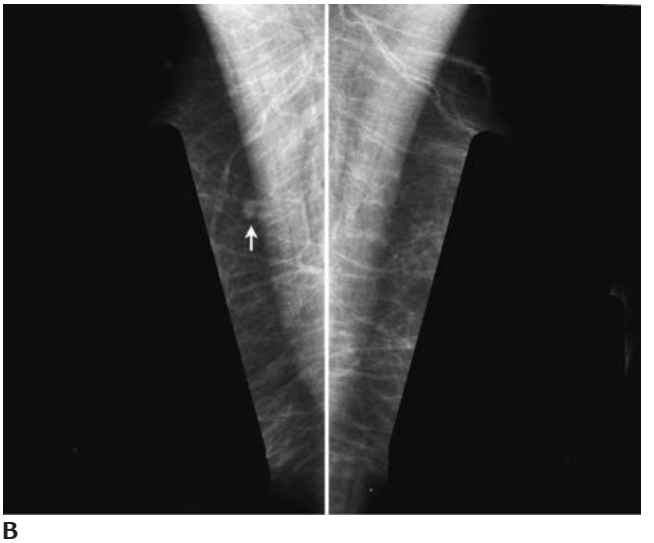
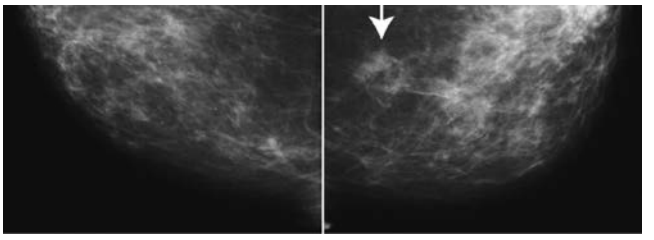


**B**

**FIGURE 5-24** Invasive ductal carcinoma. **(A)** Craniocaudal (CC) views. Split the images in thirds so that your attention is focused on smaller amounts of tissue and specifically evaluate the medial aspect of the breasts on the CC views. A mass *(arrow)* is present postero-medially on the right. **(B)** MLO views. A mass *(arrow)* is noted just anterior to the right pectoral muscle. It's location on the MLO view (e.g., distance from nipple) and approximated size correlates with the finding on the right CC view medially. The strip of tissue (commonly fatty) between glandular tissue and pectoral muscle should be specifically evaluated on MLO views. Detected areas of parenchymal asymmetry or possible masses are evaluated by comparing with prior studies to assess change and, if needed, calling the patient back for additional evaluation.



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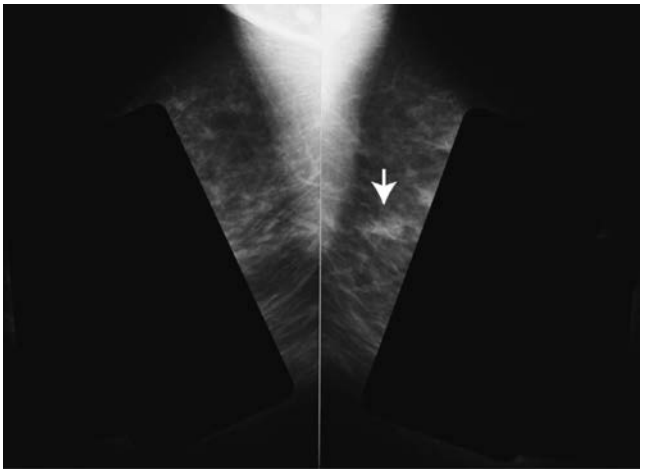
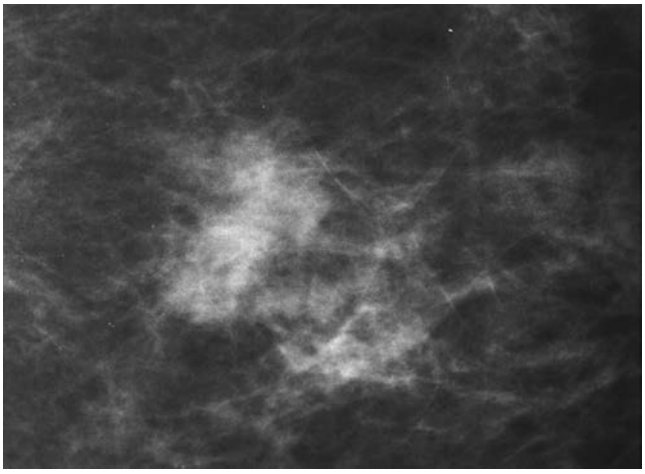


B

**FIGURE 5-25** Invasive ductal carcinoma. **(A)** Craniocaudal (CC) views. Split the images in thirds so that your attention is focused on smaller amounts of tissue and specifically evaluate the medial aspect of the breasts on the CC views. Parenchymal asymmetry *(arrow)* is present posteromedially on the left. If no prior films are available for comparison or this represents a change, with what degree of certainty can you say this is normal? Review the MLO view. Do you see a potential abnormality correlating to the finding seen on the CC view, keeping in mind that size and location should be about the same between CC and MLO views? **(B)** MLO views. Parenchymal asymmetry *(arrow)* is identified in the strip of tissue between pectoral muscle and glandular tissue. Its location and size matches that for the potential finding on the CC view. The patient is called back for additional views.



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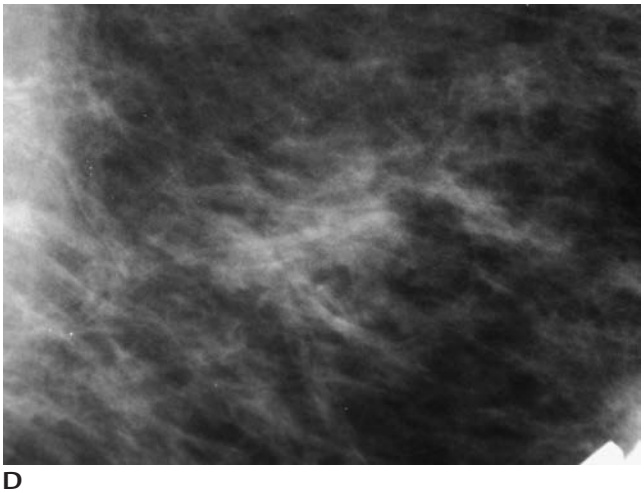


**D**

**FIGURE 5-25** (*Continued*) **(C)** Spot compression view, CC projection. **(D)** Spot compression view, MLO projection. The spot compression views confirm the presence of an irregular mass with indistinct margins requiring biopsy.

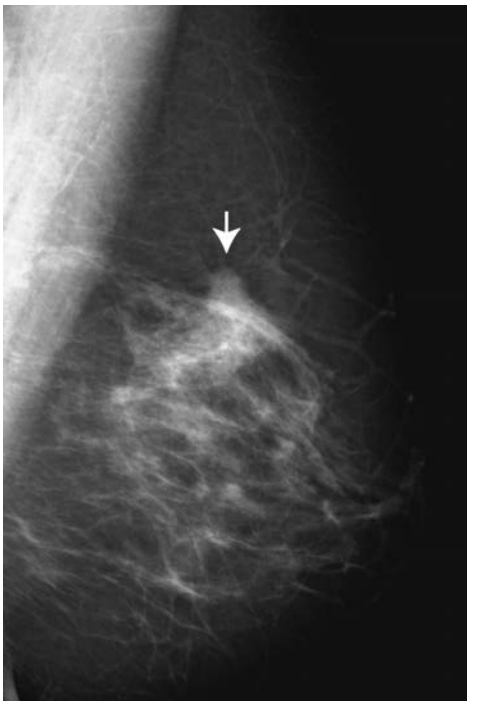
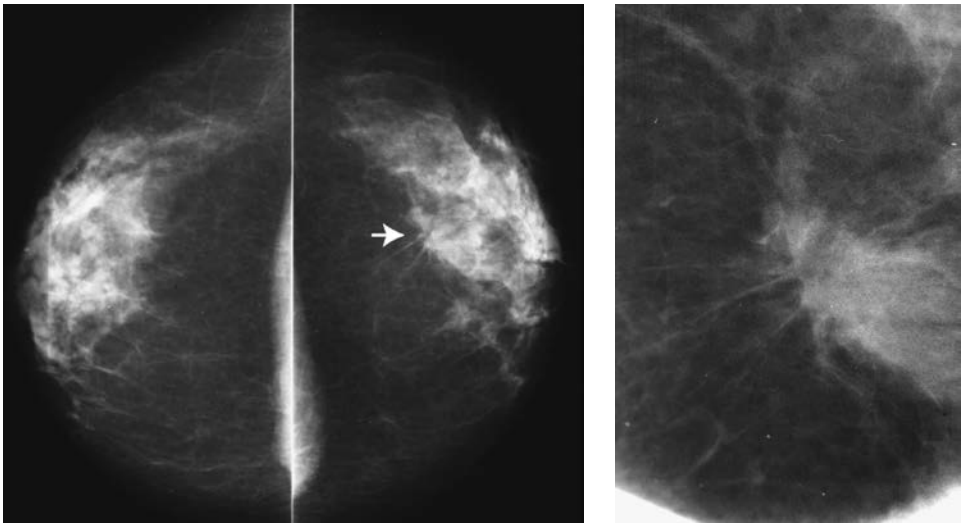


**FIGURE 5-26** Invasive ductal carcinoma. Left MLO view. The superior cone of tissue on MLO views has a distinctive scalloped appearance in many patients. When the tissue in this area develops a round contour *(arrow)* as in this patient, additional evaluation is indicated particularly if this represents a change from prior studies. Spot compression views (not shown) confirm the presence of a mass requiring biopsy.



**A** **B**

**FIGURE 5-27** Invasive lobular carcinoma. **(A)** Craniocaudal (CC) views. Evaluate the glandular tissue-fat interfaces for bulging contours or straight lines. In this patient a potential mass *(arrow)* is identified on the routine views. **(B)** The spot compression view confirms the presence of a mass with spiculated margins requiring biopsy.

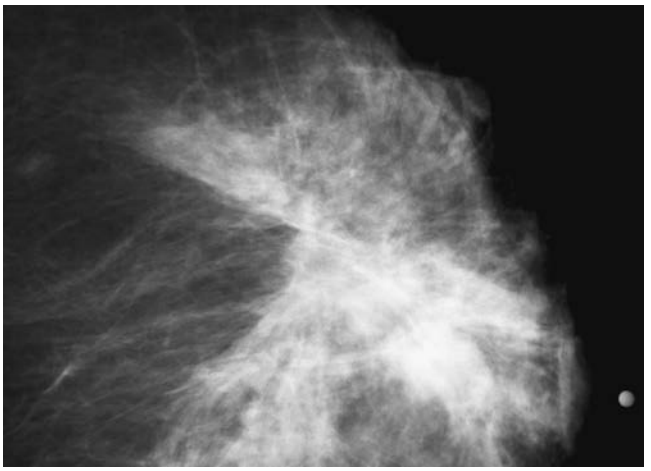


**FIGURE 5-28** Invasive ductal carcinoma with lobular features. "Tent" sign. Tissue is drawn in at the glandular tissue–fat interface on the craniocaudal view.

## LOOKING FOR...

### KEY FACTS

- Screening views are for detection of potential abnormalities, not characterization or diagnosis.

  Decision algorithm on screening studies is simple. Is the study normal or possibly abnormal, indicating the need for additional studies? Do not try to characterize potential lesions on screening mammograms.

  What appears to be a lesion can turn out to be superimposed tissue on additional views and what appears as an inconsequential area of asymmetry can turn out to be a lesion highly suspicious for malignancy. Why make decisions and recommendations with inadequate and incomplete information?

  The only assessment categories we use on screening studies are 1, 2, and 0 (negative; benign and assessment is incomplete; need additional imaging evaluation or prior films).
- Evaluate images.

  Normal breast tissue is scalloped.

  Straight lines should not be seen unless there is a history of surgery or trauma.

  Bulging contours from tissue into fatty areas (glandular-fat interfaces).

  Developing densities or masses compared with previous studies.

  Areas of parenchymal asymmetry.

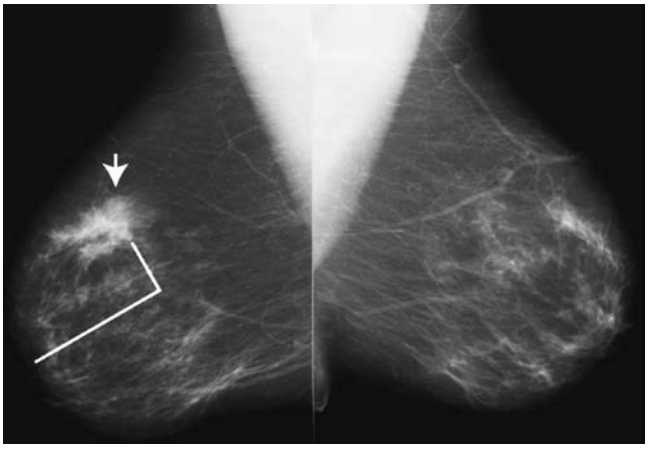
    Focal parenchymal asymmetry.

    Global parenchymal asymmetry.
- When considering additional views on screening studies is the area of potential concern on CC and MLO views the same, or are two different areas being looked at? Evaluate distance from the nipple.

  Is the size of the area of potential concern on CC and MLO views approximately the same? If there is a significant discrepancy in size between CC

and MLO views, or if a large area seen in one view has no corresponding abnormality on the other view, this is unlikely to represent to a lesion.

- Indications for diagnostic studies.
  Mass(es): screen detected or palpable.
  Microcalcifications: usually screen detected.
  Architectural distortion: usually screen detected; sometimes palpable.
  Parenchymal asymmetry: usually screen detected; sometimes palpable.
  Palpable abnormality described by patient or referring physician.
  Focal tenderness.
  Spontaneous nipple discharge.
  Miscellaneous.
- Be particularly careful with:
  A neodensity in a postmenopausal woman (particularly if not on estrogen).
  Solid masses that are increasing in size.
  Increasing size or density at a postoperative site after the first 6 months after surgery (it is also worth knowing the histology of the original biopsy).



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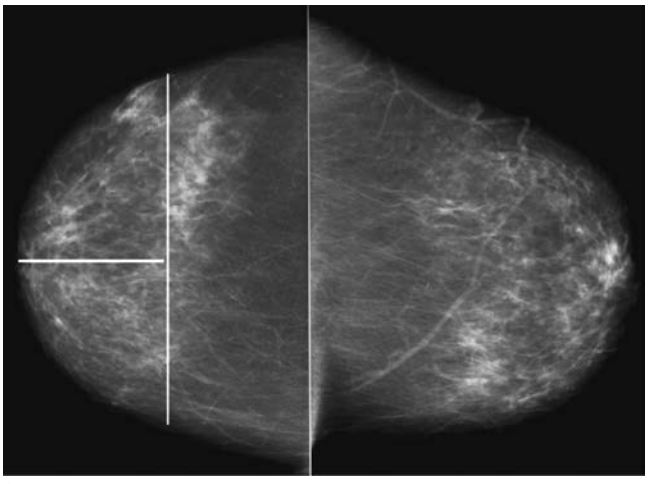


**B**

**FIGURE 5-29** Superimposition. **(A)** MLO views. A potential mass *(arrow)* is imaged in the superior cone of tissue on the right MLO. When evaluating potential abnormalities on the screening views, consider the size of the area in question (particularly if the area is larger than 1 cm in size) and its location in the breast relative to the nipple. With the exception of some invasive lobular carcinomas, most breast cancers are three-dimensional. The size of a cancer on the MLO view should approximate the size of the lesion on the craniocaudal (CC) view. Also, the distance from the nipple to the lesion should be about the same on the two images. Superimposition of normal tissue should be considered if there is a significant size discrepancy or if the distance from the nipple doesn't match on CC and MLO views. **(B)** Craniocaudal views. When measuring back from the nipple to the expected location of the lesion, no comparably sized area is seen on the CC view.

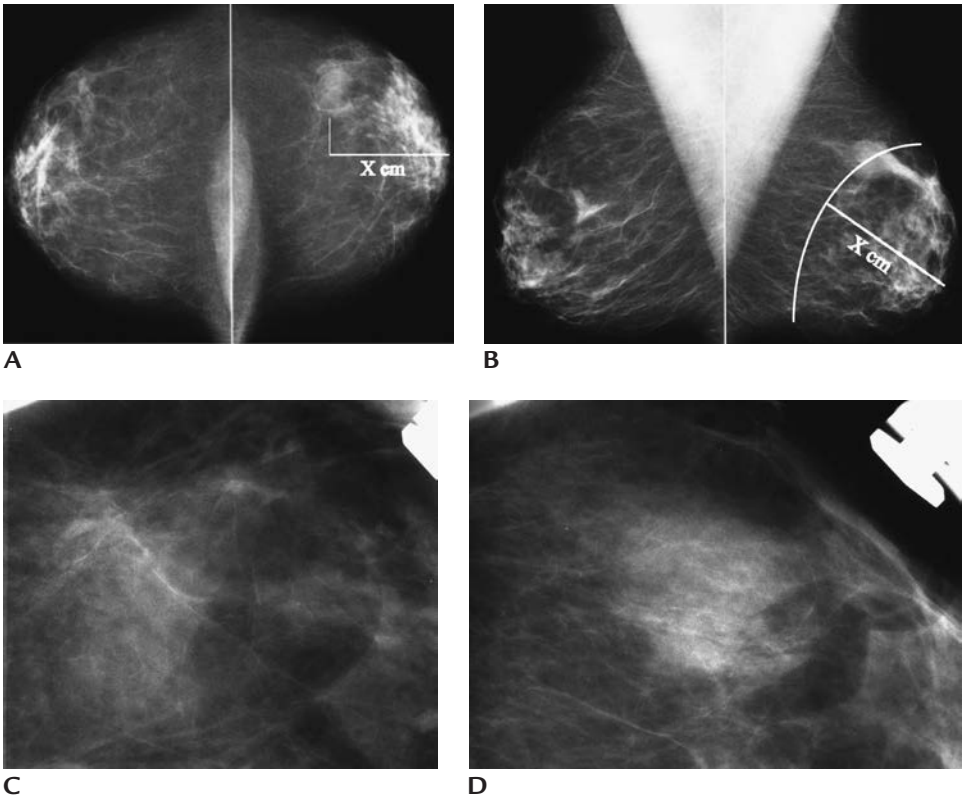
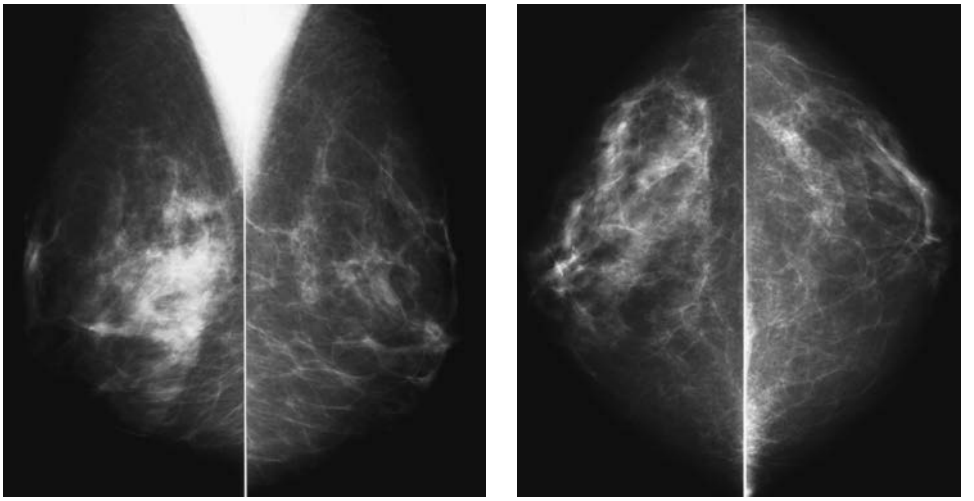



**FIGURE 5-30** Focal parenchymal asymmetry. **(A)** Craniocaudal views. Parenchymal asymmetry is noted laterally in the left breast. **(B)** MLO views. Comparable rounded area of asymmetry is noted corresponding in size and location to area seen on the craniocaudal view. Review of prior films is helpful. If there are no prior films available, or this represents a new finding, the patient is called back for additional views. **(C)** Spot compression view, CC projection and **(D)** spot compression view, MLO projection. Although a rounded area of tissue is seen on the MLO spot, no abnormality is apparent on the CC spot compression view. On physical examination, normal tissue is palpated throughout the upper outer quadrant of the left breast and normal tissue is imaged in this quadrant sonographically.



**A** **B**

**FIGURE 5-31** Global parenchymal asymmetry. **(A)** MLO and **(B)** craniocaudal views. Global parenchymal asymmetry is noted involving the right breast. This patient has no history of surgery and her physical examination is normal.

## SUGGESTED READINGS

American College of Radiology. *ACR Practice Guideline for the Performance of Diagnostic Mammography*. Reston, VA: American College of Radiology; 2006.

American College of Radiology. *ACR Practice Guideline for the Performance of Screening Mammography.* Reston, VA: American College of Radiology; 2006.

Bassett LW. Quality determinants of mammography: Clinical image evaluation. In: *RSNA Categorical Course in Breast Imaging Syllabus*. 1995; 57–67.

Bassett LW, Hirbawi IA, DeBruhl N, et al. Mammographic positioning: evaluation from the view box. *Radiology.* 1993;188:803–806.

Bird RE. Screening mammography: Approach to interpretation and value of double reading. In: *RSNA Categorical Course in Breast Imaging Syllabus*. 1995; 73–76.

Bradley FM, Hoover HC, Hulka CA, et al. The sternalis muscle: an unusual normal finding seen on mammography. *AJR Am J Roentgenol.* 1996;166:33–36.

Cardenosa G, Eklund GW. Screening mammography in women 40 to 49 years old [Commentary]. *AJR Am J Roentgenol.* 1995;164:1104–1106.

Eklund GW, Cardenosa G, Parsons W. Assessing adequacy of mammographic image quality. *Radiology.* 1994;190:297–307.

Eklund GW, Cardenosa G. The art of mammographic positioning. *Radiol Clin North Am.* 1992;30:21–53.

Eklund GW, Busby RC, Miller SH, et al. Improved imaging of the augmented breast. *AJR Am J Roentgenol.* 1988;151:469–473.

Kopans DB, Feig SA. The Canadian National Breast Screening Study: a critical review. *AJR Am J Roentgenol.* 1993;161:755–760.

Leitch AM, Dodd FD, Constanza M, et al. American Cancer Society guidelines of the early detection of breast cancer: Update 1997. *CA Cancer J Clin.* 1997;47:150–153.

Linver MN, Paster SB, Rosenberg RD, et al. Improvement in mammography interpretation skills in a community radiology practice after dedicated teaching courses: 2-year medical audit of 38,633 cases. *Radiology.* 1992;184:39–43.

Meyer JE, Stomper PC, Lee RR. Pectoralis muscles simulating a breast mass. *AJR Am J Roentgenol.* 1989;152:481–482.

Moskowitz M. Breast cancer: age specific growth rates and screening strategies. *Radiology.* 1986;161:37–41.

Ries L, Harkins D, Krapdio M, et al. *SEER cancer statistics review, 1975–2003*. Bethesda: National Cancer Institute; 2006.

Samuels TH, Haider MA, Kirkbride P. Poland's syndrome: a mammographic presentation. *AJR Am J Roentgenol.* 1996;166:347–348.

Smith RA, Mettlin CJ, Davis KJ, et al. American Cancer Society Guidelines for the early detection of cancer. *CA Cancer J Clin*. 2000;50:34–49.

Tabar L, Duffy SW, Warren Burhenne L. New Swedish breast cancer detection results for women aged 40–49. *Cancer.* 1993;72[Suppl]:1437–1448.

Tabar L, Fagerberg G, Duffy SW, et al. Update of the Swedish two-county program of mammographic screening for breast cancer. *Radiol Clin North Am*. 1992;30:187–210.

Tabar L, Fagerberg G, Day NE, et al. Breast cancer treatment and natural history: new insights from result of screening. *Lancet*. 1992;1:412–414.

Tabar L, Dean PB. *Teaching Atlas of Mammography*. 3rd ed. New York: Thieme Verlag; 2001.

Tabar L, Tot T, Dean PB. *Breast Cancer: The Art and Science of Early Detection with Mammography.* New York: Thieme; 2005.

CHAPTER 6

# DIAGNOSTIC MAMMOGRAPHY AND PROBLEM SOLVING

## General Comments

### Key Facts

- If possible, screening and diagnostic mammography should be separated temporally and spatially.

  In order to maximize efficiency, cost effectiveness, and data collection, the screening process should be streamlined. Two views (rarely three) of each breast are done, checked for technical quality by the technologist, and the patient is told to expect her results in writing within the next week. The studies are prehung and interpreted in batches. Many times these studies are done with no radiologist on site.

  Although we have imaging algorithms for diagnostic patients, a radiologist is always available to direct the workup and discuss results with these patients at the time of their visit. Every effort is made (including biopsies) to complete the needed work up with one patient visit.
- The diagnostic patient population is composed primarily of two patient groups: women with potentially abnormal screening mammograms called back for additional evaluation or those presenting with breast related symptoms. Patients who have had a lumpectomy and radiation therapy are also done as diagnostics for the first 7 years following their lumpectomy.
- In women 30 years of age or older presenting with a focal finding (e.g., "lump," focal tenderness), a metallic BB is placed at the site of concern and craniocaudal and mediolateral oblique views are done bilaterally, as is a spot tangential view of the area of clinical concern. Depending on the findings in these initial images, additional mammographic views and an ultrasound may be done.

  In women younger than 30 years of age, or women who are pregnant or lactating, and who present with clinical symptoms, correlative physical

examination and ultrasound are our starting points. If there is any question of an underlying malignancy, a complete mammogram is done.

Although metallic BBs are used to mark areas of clinical concern, every effort should be made to ensure that the BB is in the right area and that the lesion has not been excluded from the field of view during positioning. This is particularly applicable to lesions close to the chest wall.

- Young girls (8 to 12 years old) presenting with a subareolar mass.

  Usually represents breast bud development.

  May be asymmetric, but eventually becomes symmetric.

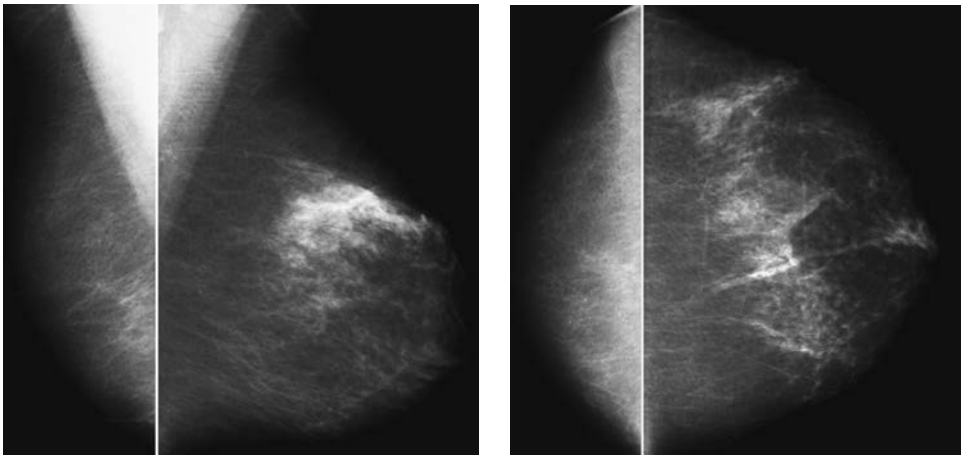
  Failure of breast development results if biopsy is undertaken at this time (effectively the breast bud is removed at the time of surgery).
- Diagnostic mammography is about workup, analysis, and decision-making.
- When evaluating patients in the diagnostic setting, it important to not have your attention so focused on the clinical finding that you do not evaluate the rest of the affected breast and the contralateral side. It may be that the presenting symptom is a benign finding and a clinically occult cancer is identified in the contralateral breast.
- Patients identified mammographically or clinically with a potential breast lesion are evaluated by whatever methods are indicated to establish an accurate diagnosis.
- Physical examination, additional mammographic images, breast ultrasound, breast MRI, ductography, cyst aspiration and pneumocystography, imaging guided fine needle aspiration, or needle biopsy are the methods most commonly used for evaluation.
- In women with potentially abnormal screening mammograms, additional mammographic images and breast ultrasound are most helpful in establishing the presence and characteristics of a lesion and determining the extent of the lesion.
- Even in women with obviously malignant lesions on screening mammograms, additional evaluation is helpful in demonstrating unsuspected satellite lesions and the extent of lesions. These issues can affect management decisions.

  Breast conserving therapy may not be appropriate if the primary lesion is extensive or there are multiple lesions in two or more quadrants (e.g., multicentric disease).

  Having the patient return permits direct communication between radiologist and patient concerning the findings and a biopsy can be done during that visit so that a histologic diagnosis can be established expeditiously.

  Bracketing may be indicated to localize calcifications in a segmental or regional distribution.
- Correlation is a critical component of the diagnostic setting. Does what you see mammographically correlate with the "lump" described by the patient? Does what you see on ultrasound correlate to the mammographic finding? Does what you see on magnetic resonance imaging correlate with a finding on ultrasound? Is what the pathologist describes on a core biopsy congruent with the imaging features of the lesion you biopsied?

- Additional imaging facilitates decision-making, provides justification for recommendations, and increases our confidence in the recommendations.
- For diagnostic evaluations, whatever is needed to make an accurate diagnosis is done during the patient's visit (including imaging guided biopsy).
- A radiologist directs all diagnostic evaluations and communicates with the patients regarding findings and recommendations directly. Communication of results should not be delegated to the technologist.



**A** **B**

**FIGURE 6-1** No breast development following breast bud removal. **(A)** Mediolateral oblique and **(B)** craniocaudal views in patient who had a "tumor" removed at age 8. A "lump" centered in the subareolar area of one or both breasts in young girls most commonly represents the breast bud. If this is surgical excised, no breast development occurs.

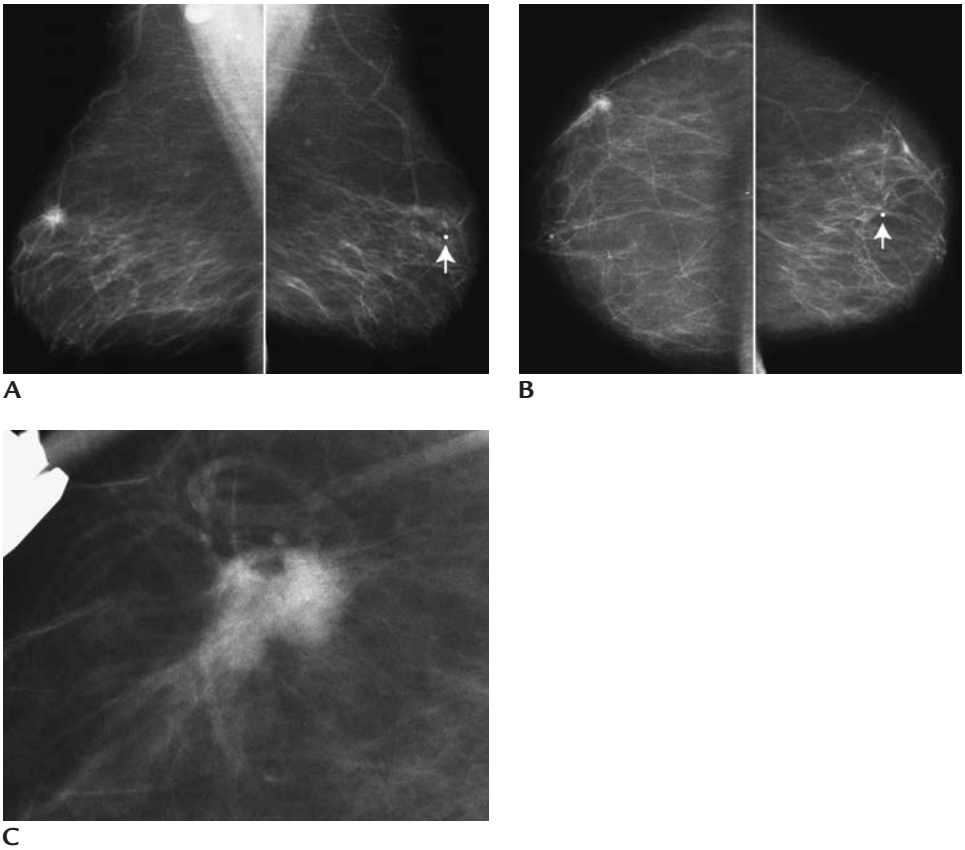



**FIGURE 6-2** Well-differentiated invasive ductal carcinoma with associated ductal carcinoma in situ, low nuclear grade cribriform type. **(A)** Mediolateral oblique and **(B)** craniocaudal views in a patient presenting with a "lump" in the left breast. A metallic BB (*arrows*) is used to mark the site of the clinical finding. Fatty tissue is imaged on the spot tangential view (not shown) of the clinical finding. Because the area of concern is included on the images and fatty is imaged at this site no further evaluation of the left breast is undertaken. Be careful in these situation (or when there is an obvious benign or malignant lesion) to not have your attention focused to the exclusion of evaluating the mammogram completely. Look away from the obvious and make sure you evaluate the rest of the breast and the contralateral side. A clinically occult, mammographically apparent mass is present in the right breast. **(C)** A spot compression view confirms the presence of a mass with spiculated margins and some associated amorphous calcifications in the upper outer quadrant of the right breast. Core biopsy is done to confirm expected histological diagnosis.

## Spot Compression Views

### Key Facts

- Indications.

  To establish or confirm the presence of a lesion: is this a lesion or is it normal superimposed tissue?

  To evaluate masses more accurately (superimposed tissue obscuring the margins of mass may be displaced).

  To evaluate the subareolar area, particularly if the anterior portion of the breast is not well compressed.

  To evaluate areas of the breast that may otherwise be difficult to reach and include on routine views or with possible lesions partially seen at the edge of any one view (e.g., lesions that are in the upper inner quadrant posteriorly or superiorly or lesions in the axillary tail).

  To obtain better exposure of a particularly dense area of tissue or to overcome focal blur (e.g., motion).
- As a general rule, spot compression views are the starting point when it is unclear if a lesion is present.
- If a potential lesion is seen in only one of the two screening views, start by evaluating the area of concern in the projection in which it is originally seen. If a lesion is confirmed with spots, then characterize and localize it in a second projection (e.g., using 90° lateral or spot-rolled views for triangulation).
- Focal compression is applied. Small paddles permit a greater degree of compression, help spread tissue out, and bring the area of radiographic concern closer to the film improving resolution and overall image quality.

  Positioning the area of concern under the central aspect of the small spot paddle is more of a challenge for the technologist particularly in the patients with larger breasts.

  Effective techniques can be employed (e.g., referencing the lesion back to the nipple with measurements) so that the paddle is positioned accurately in most patients.

  In more challenging situations, marking the position of the compression paddle on the initial images can help direct the re-positioning of the paddle if additional views are needed.
- Applying focal compression on both sides of the breast (double spot compression) may improve image quality and lesion resolution.
- Assessing image quality:

  Well-exposed, high-contrast images.

  Be sure that the area being evaluated is in the field of view. Sometimes lesions are compressed or squeezed out from under the spot compression paddle.

  Avoid motion and blurring.

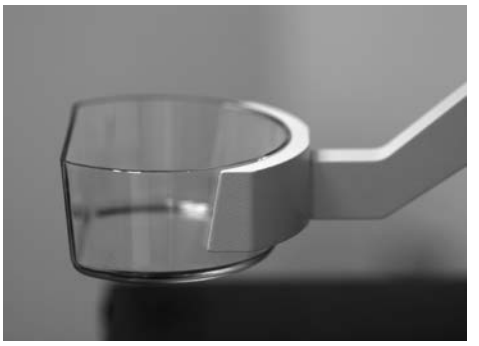
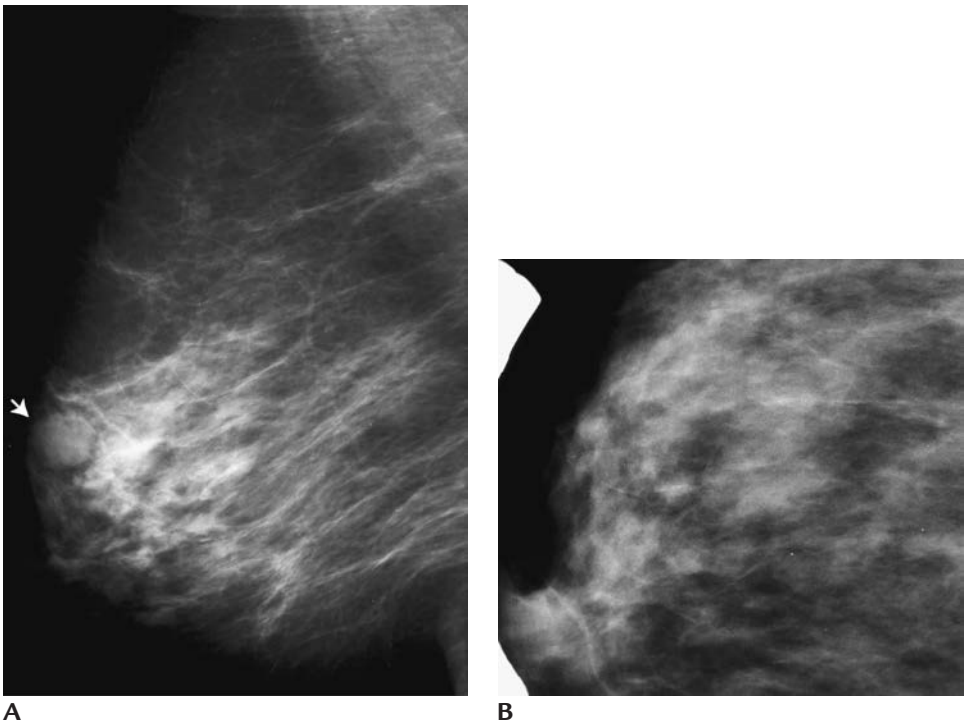
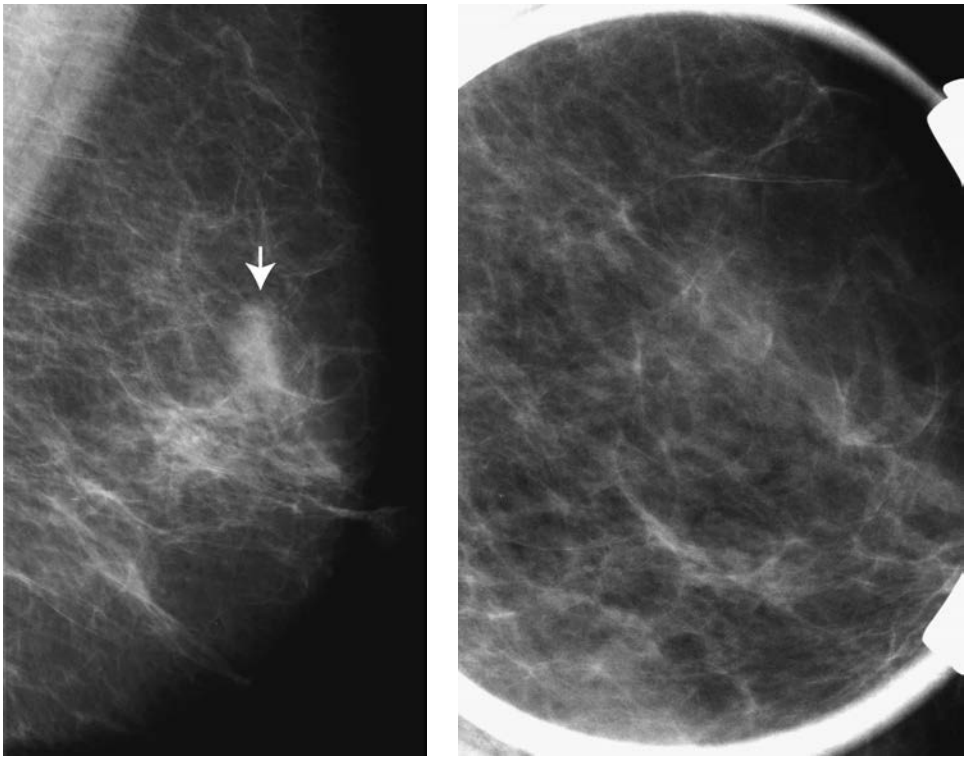


**FIGURE 6-3** Spot compression paddle used in my practice for all diagnostic evaluations (e.g., spot, tangential, rolled, magnification, cleavage).



**A** **B**

**FIGURE 6-4** Superimposition. **(A)** Right mediolateral oblique view with possible mass (*arrow*) medially on the subareolar area. Although no abnormality is apparent in the craniocaudal view (not shown), the patient is asked to return for spot compression views. **(B)** On the spot compression view, a lesion is effectively excluded. Superimposed glandular tissue accounts for density seen on the CC view. When reviewing spot compression views, ascertain that the area of concern has not be pushed out of the field of view with compression.



**A** **B**

**FIGURE 6-5** Superimposition. **(A)** Left mediolateral oblique view with an irregular density (*arrow*) superiorly. With what degree of certainty can you say this is or is not a lesion? Why not bring the patient back and get additional information? **(B)** Spot compression view demonstrates normal tissue. A significant lesion is excluded. Superimposed glandular tissue accounts for density seen on the MLO.

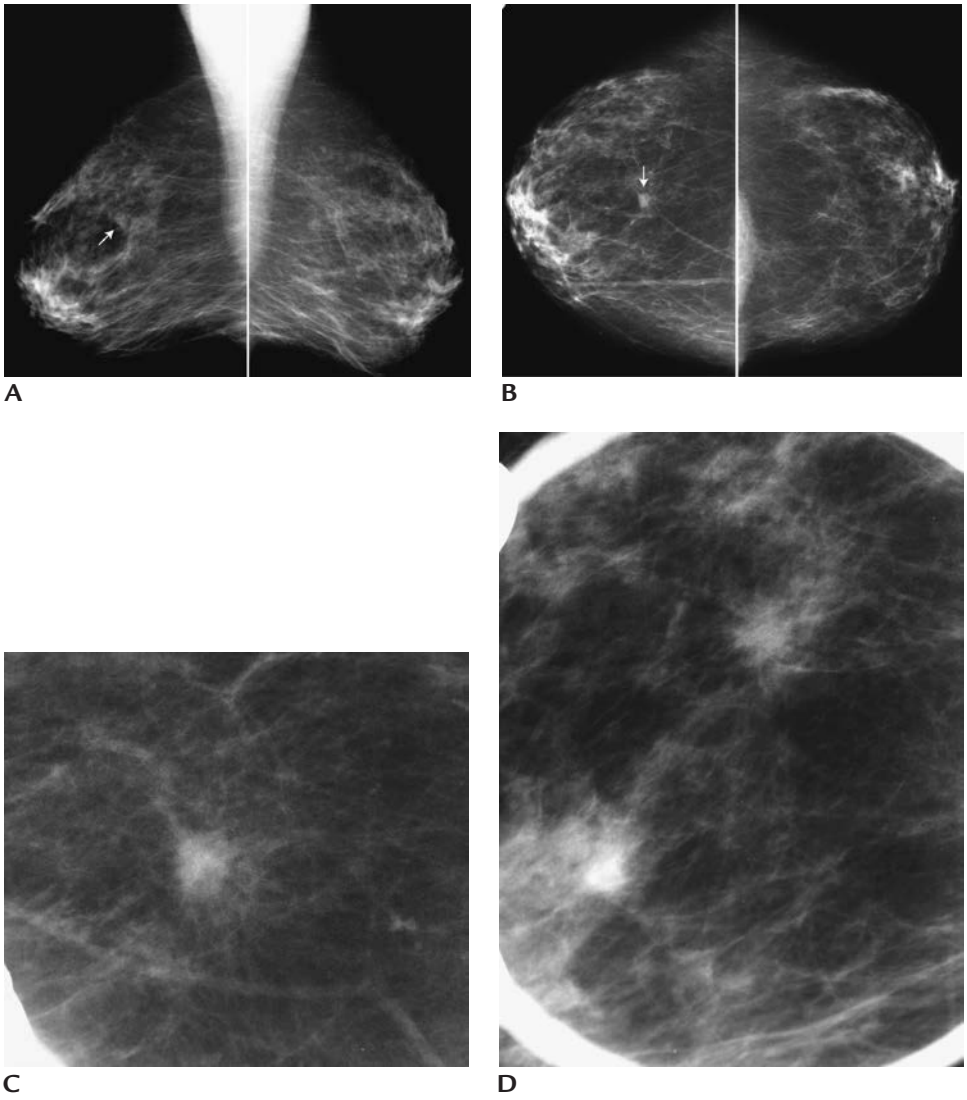



**FIGURE 6-6** Invasive lobular carcinoma. **(A)** Screening study, mediolateral oblique and **(B)** craniocaudal views. A possible mass (*arrows*) is present in the right breast. This is better seen on the craniocaudal view compared with the oblique view. The patient is called back for additional evaluation. **(C)** Craniocaudal and **(D)** mediolateral oblique spot compression views confirm a mass with irregular and spiculated margins. If the patient has no history or surgery or trauma to this site, biopsy is indicated.

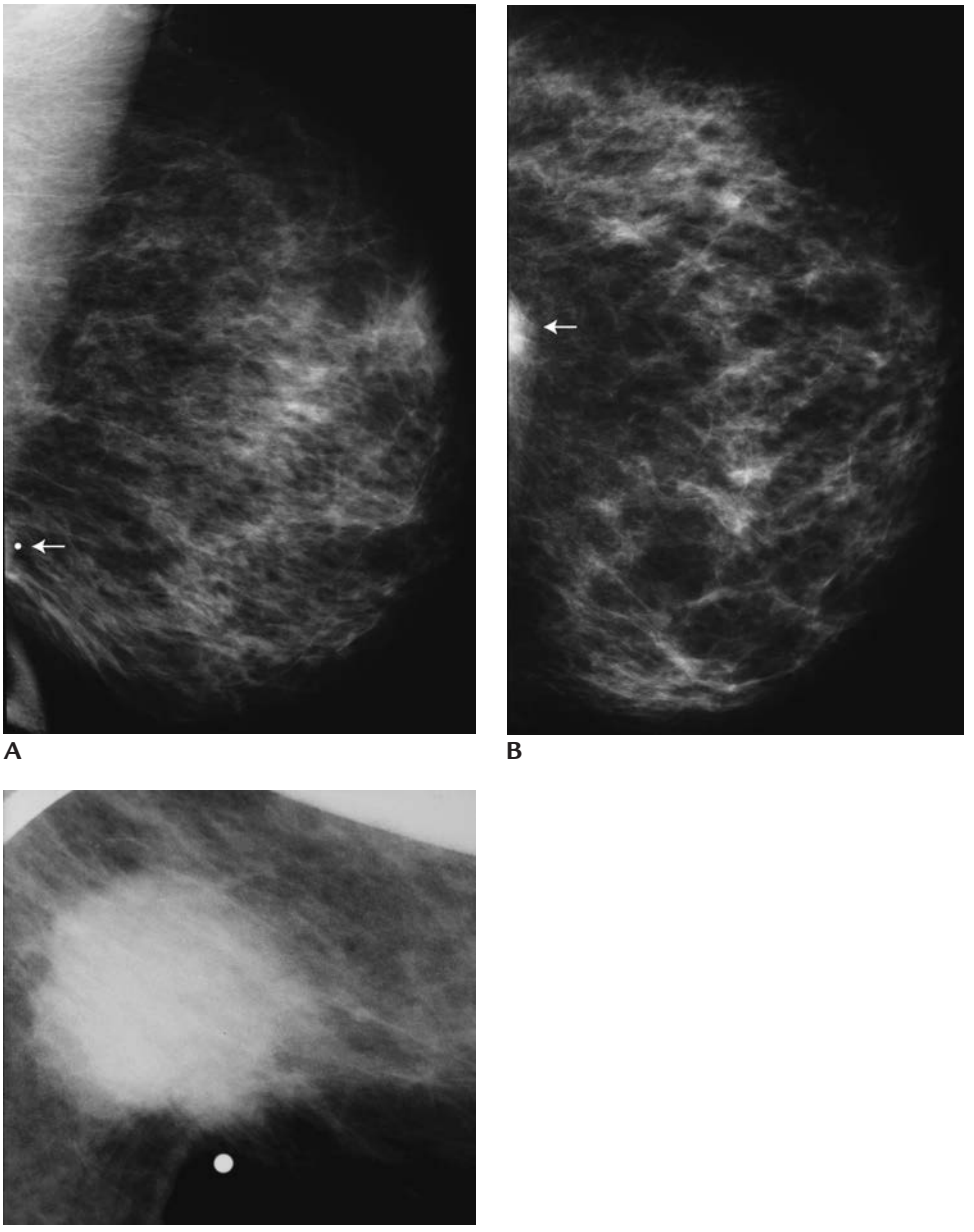


**FIGURE 6-7** Poorly differentiated invasive ductal carcinoma. **(A)** Left mediolateral oblique and **(B)** craniocaudal view in a patient presenting with a palpable mass (*arrows*). Metallic BB seen on the oblique view but not on the craniocaudal view is used to mark the area of clinical concern. **(C)** Spot compression view of the palpable finding demonstrates a round dense mass with indistinct margins. As in this patient, when a lesion is completely or partially excluded on the routine views, using a spot compression paddle sometimes permits the inclusion of more tissue on the image. Ultrasound is also helpful in evaluating tissue and lesions that may be difficult to image mammographically.

## Micro-Focus Double Spot Compression Magnification Views

### Key Facts

- Indications.

  When there is a mass on the screening studies, magnification views provide additional information on margins, possible satellite lesions, and the presence of associated microcalcifications.

  With calcifications, magnification views provide more detailed morphologic information. Additional calcifications in a given cluster may become apparent and additional unsuspected clusters of calcifications may be detected.

  Evaluation of asymmetric tissue or areas of distortion.
- As a general rule, magnification is the starting point when a lesion is present on the screening views and the next step is lesion characterization.
- Magnification views can be done using a full paddle or the spot compression paddle. We prefer to use (double) spot compression (see the subsequent text) for all of our magnification views so that compression is maximized over the area of radiographic concern and the tissue is thinned out as much as possible.
- For magnification, an air gap technique is used. As the breast is moved away from the film holder, magnification is obtained; increasing amounts of magnification are obtained as the object to film distance is increased.

  Magnification platforms of different heights are available; the maximal magnification is approximately 1.8×.

  To counter the effect of increased blurring at edges related to the penumbra effect, a small focal spot (0.1 mm) is needed.

  The use of a small focal spot increases the exposure time. Therefore, as a general rule, the kVp used for magnification views is increased by 2 over that used for nonmagnification images.
- No grid is used. Scatter radiation is dissipated in the air gap.
- Carbon top magnification stands absorb radiation; a Lexan (polymer) top can be used to decrease the amount of radiation absorbed by the magnification stand by almost 20%.

  Image quality can be improved as exposure times are shortened (reduces likelihood of patient motion).

  The Lexan stands provide a built-in spot compression device that, when combined with a spot compression paddle, leads to double spot compression further improving image quality.
- Assessing image quality.

  Well-exposed, high-contrast images.

  No motion (a recurring problem with magnification views because of the relatively longer exposure times).

  Area of concern imaged in two projections.
- Labeling of magnification images.

  M preceded by laterality followed by view.

  RMCC = right magnification craniocaudal view; RMMLO = right magnification mediolateral oblique view.


**FIGURE 6-8** Magnification stand made of Lexan comes with built in spot compression. If this is combined with a spot compression paddle, the tissue being evaluated is focally compressed in the two directions (e.g., double spot compression). Compared with the carbon top magnification stands, this type of stand absorbs 20% less radiation so that the exposure can be shortened. Improved compression from the use of the double compression in conjunction with the Lexan top can minimize the likelihood of blurring (e.g., motion).

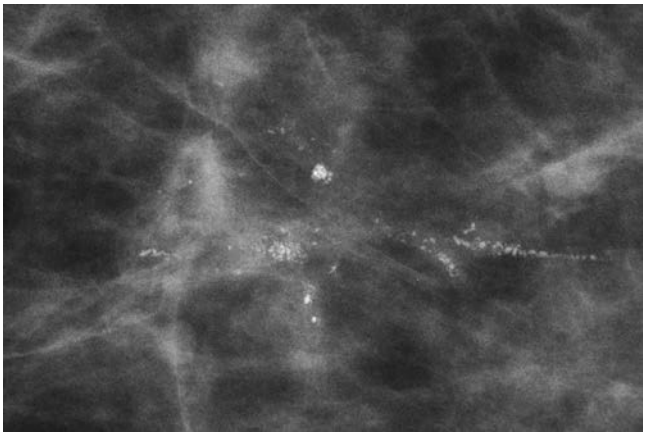


**FIGURE 6-9** Ductal carcinoma in situ, high nuclear grade with comedo necrosis. Double spot compression magnification (1.8×) view. Linear calcifications with irregular margins and clefts demonstrating linear orientation. Also noted are round and punctate calcifications.

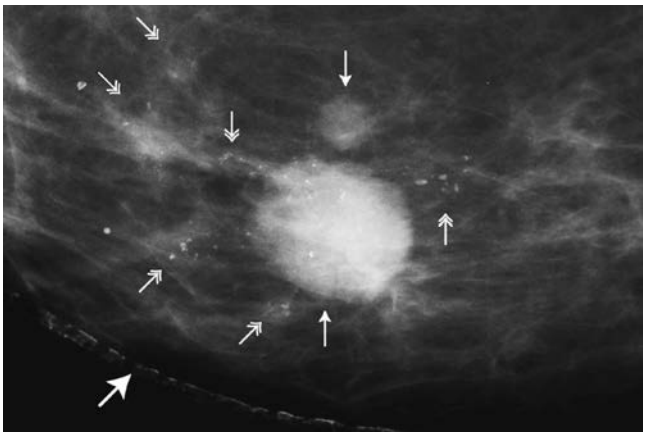


**FIGURE 6-10** Poorly differentiated invasive ductal carcinoma multifocal with associated intermediate grade ductal carcinoma in situ, solid and cribriform types with central necrosis associated with, and extending away from, the invasive disease. Magnification (1.8×) view demonstrating two adjacent round masses (*arrows*) with indistinct margins and associated pleomorphic calcifications (*double headed arrows*) in the larger mass and extending anteriorly and posteriorly away from the invasive disease. Additional views can be helpful in characterizing the nature and extent of the disease. Arterial calcification (*thick arrow*) is incidentally noted.

## Tangential Views (TAN)

### Key Facts

- Indications.

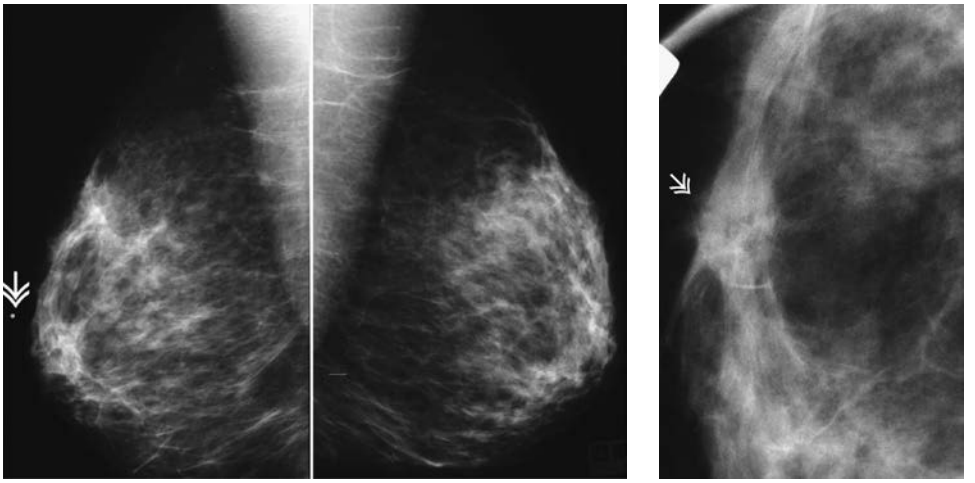
  To demonstrate the dermal location of lesions (usually calcifications; masses are visible on inspection of the skin).

  In dense breast tissue, this view may improve detection and evaluation of palpable masses. Contrast can be obtained by partially or completely surrounding the palpable area with subcutaneous, predominantly fatty tissue. In addition to the routine views of the breast, we obtain a spot tangential view of the "lump" in all patients describing a focal finding.

  In patients treated with lumpectomy and radiation therapy, spot tangential views can be used to separate skin changes from possible underlying postlumpectomy changes (skin often projects on lumpectomy site) (Fig. 15–13).
- On any two views of the breast only a small amount of skin is in tangent to the x-ray beam.

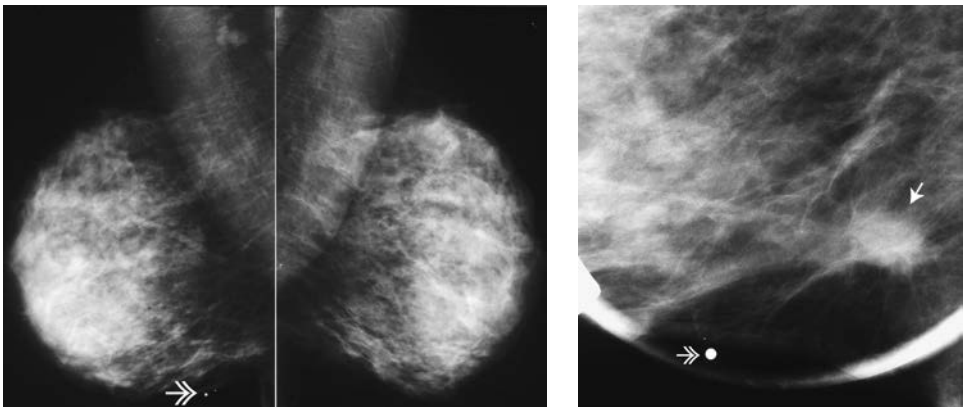
  Most skin is superimposed on the breast parenchyma.

  Skin lesions project and can simulate breast lesions.
- A metallic BB is placed on the area of skin thought to contain calcifications or over the area of clinical concern in symptomatic patients. This area is placed in tangent to the x-ray beam. A spot compression paddle is used for these images.



**A** **B**

**FIGURE 6-11** Invasive ductal carcinoma. **(A)** Mediolateral oblique views. Metallic BB (*double headed arrow*) used to mark location of palpable finding. No abnormality is apparent on the routine views (craniocaudal views not shown). **(B)** Spot tangential view demonstrates a mass with indistinct and spiculated margins corresponding to the palpable finding. In addition to the routine full paddle views of the breasts, we obtain spot tangential views of focal findings. As in this patient, if the lesion is partially or completely outlined by fat, it becomes more readily apparent on the spot tangential view compared with the routine views.



**A** **B**

**FIGURE 6-12** Invasive ductal carcinoma. **(A)** Mediolateral oblique views. Metallic BB (*double headed arrow*) used to mark location of palpable finding. Although there is a subtle asymmetry just above the inframammary fold it cannot be characterized with confidence on the routine views. **(B)** Spot tangential view demonstrates a mass with spiculated margins (*arrow*) requiring biopsy. The metallic BB (*double headed arrow*) is used to indicate approximate location of clinical finding.

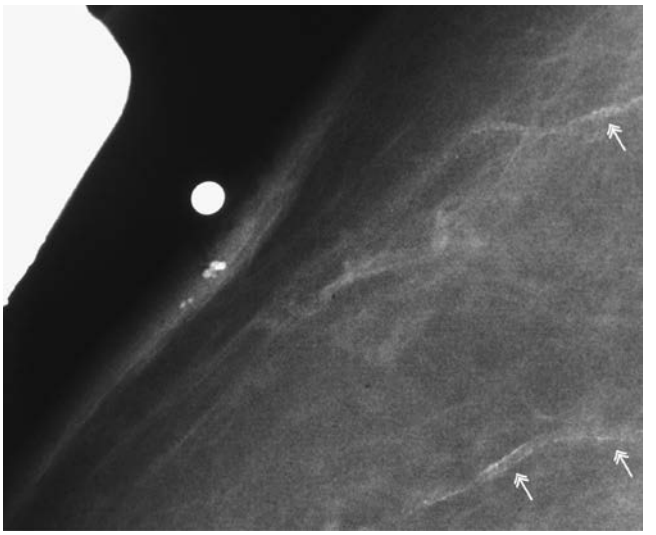


**FIGURE 6-13** Skin calcifications. Spot tangential view done to establish the skin location for a cluster of calcifications superimposed on breast tissue on the routine mammographic views. A metallic BB is placed on the skin surface thought to contain the calcifications and a spot tangential view of the BB is done to demonstrate the location of the calcifications. Arterial calcifications (*double headed arrow*) are incidentally noted.

## Rolled Spot Compression Views (Change of Angle Views)

### Key Facts

- Indications.
  To help establish the presence of a lesion.
  To approximate the location of a lesion.
  To move a lesion away from surrounding tissue for better evaluation.
- Most breast cancers are three-dimensional. As tissue is rolled or tube angle is changed, breast cancers usually remain apparent (invasive lobular carcinoma is the one exception). In contrast, normal breast tissue usually changes significantly in appearance as tissue is rolled or tube angle is changed.
- Rolled views can be done in any projection (e.g., CC, MLO, 90° lateral), and tissue can be rolled in any direction desired.
- If a mass is adjacent to and partially obscured by surrounding tissue, consider taking the lesion and rolling it into fatty tissue (away from the tissue that is potentially obscuring the lesion margins). This may make the lesion more conspicuous.
- As a rule, several rolled views are obtained rolling the tissue in different direction and projections.
  The views must be reviewed thoroughly and with great care before saying there is no lesion.

- We usually use a spot compression paddle for our rolled views. However, any view of the breast represents a change of angle or rolled view because, unless the extra views are done without releasing compression, it is hard to reproduce breast positioning on any two views.
- Labeling of rolled views: rolled lateral (RL), rolled medial (RM), rolled superior (RS), and rolled inferior (RI), preceded by projection RCCRM = right craniocaudal view, upper tissue rolled medially.

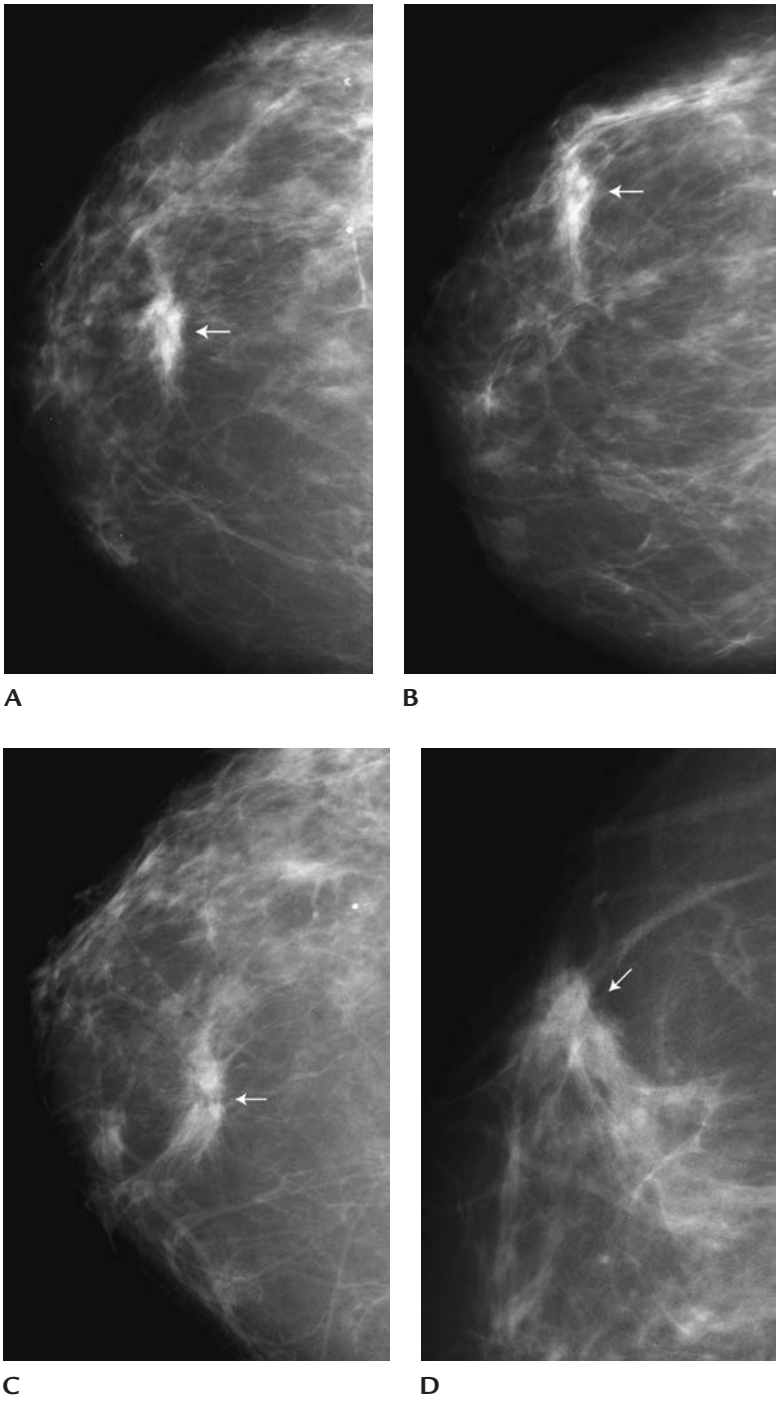



**FIGURE 6-14** Invasive lobular carcinoma. **(A)** Right craniocaudal view. An irregular mass with spiculated margins (*arrow*) is identified in the right breast. **(B)** When superior tissue is rolled laterally, the mass (*arrow*) moves laterally. **(C)** When superior tissue is rolled medially, the mass (*arrow*) moves medially. The rolled views help establish the location of this mass to the superior aspect of the right breast. **(D)** Spot compression view in the orthogonal projection (e.g., lateral) confirms that the mass (*arrow*) is located superiorly in the right breast. It is now imaged in orthogonal views.

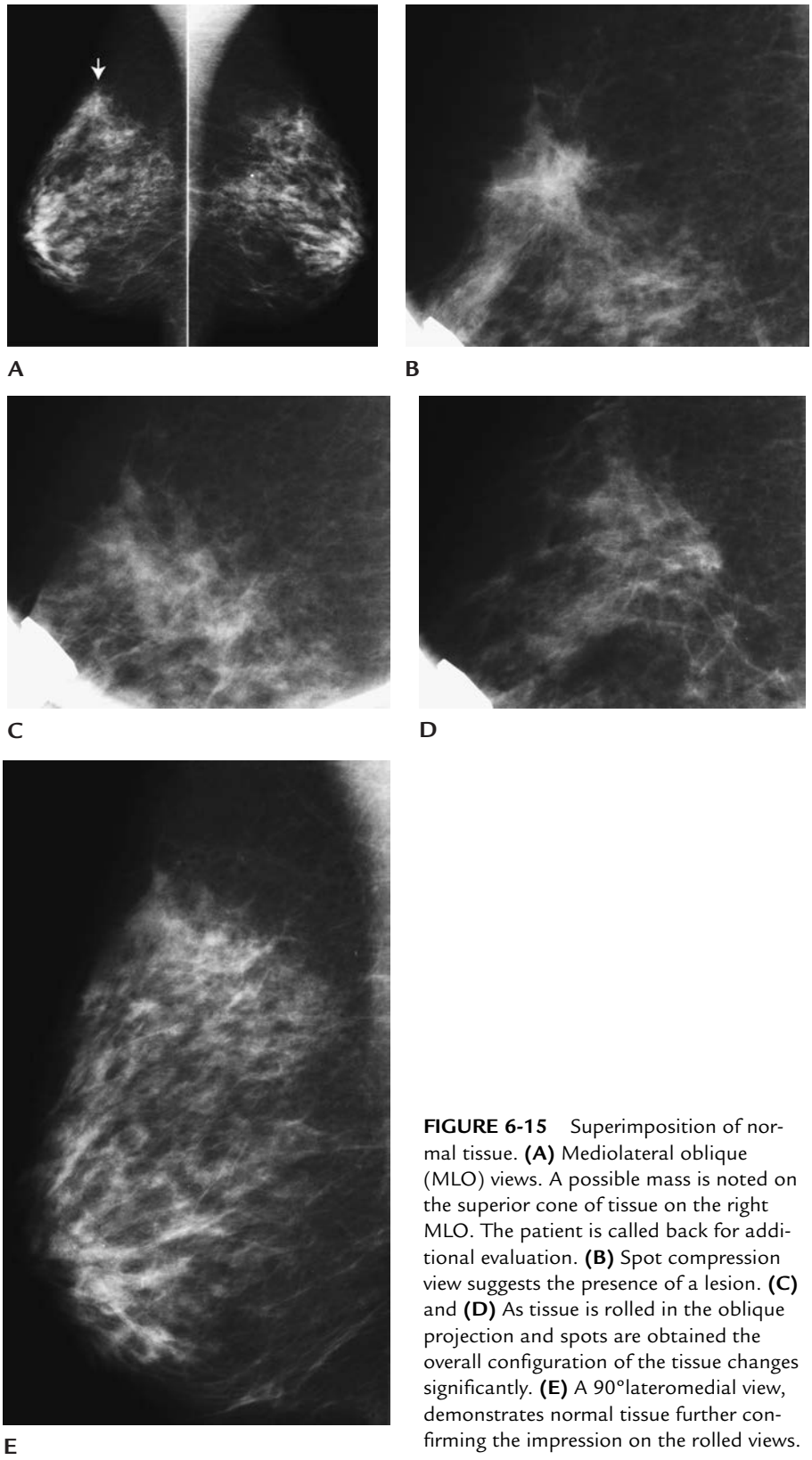


**FIGURE 6-15** Superimposition of normal tissue. **(A)** Mediolateral oblique (MLO) views. A possible mass is noted on the superior cone of tissue on the right MLO. The patient is called back for additional evaluation. **(B)** Spot compression view suggests the presence of a lesion. **(C)** and **(D)** As tissue is rolled in the oblique projection and spots are obtained the overall configuration of the tissue changes significantly. **(E)** A 90°lateromedial view, demonstrates normal tissue further confirming the impression on the rolled views.

## Mediolateral Views (ML)

### Key Facts

- A true 90° lateral view of the breast.

  Because tissue is not being pulled away from the body parallel to the underlying muscle fibers, some tissue is probably excluded from the field of view.
- The direction of the x-ray beam is defined by the name of the view. In this case, the x-ray beam enters the medial portion of the breast, traverses the breast, and exits on the lateral side onto the film.
- This is not a routine screening view, but rather a trouble-shooting view.
- Indications

  Evaluation of lateral lesions: the lateral portion of the breast will be closest to the film, thereby maximizing resolution.

  In the triangulation of lesions seen on the CC view but not identified with certainty on the MLO view (or seen on MLO view but not identified with certainty on the CC view).

  For preoperative needle localization and, in conjunction with the CC view, for determining the shortest distance from the skin to the lesion.
- As a change of angle view relative to the MLO, it provides another projection that is useful in evaluating lesions.

## Lateromedial Views (LM)

### Key Facts

- A true 90° lateral view of the breast.

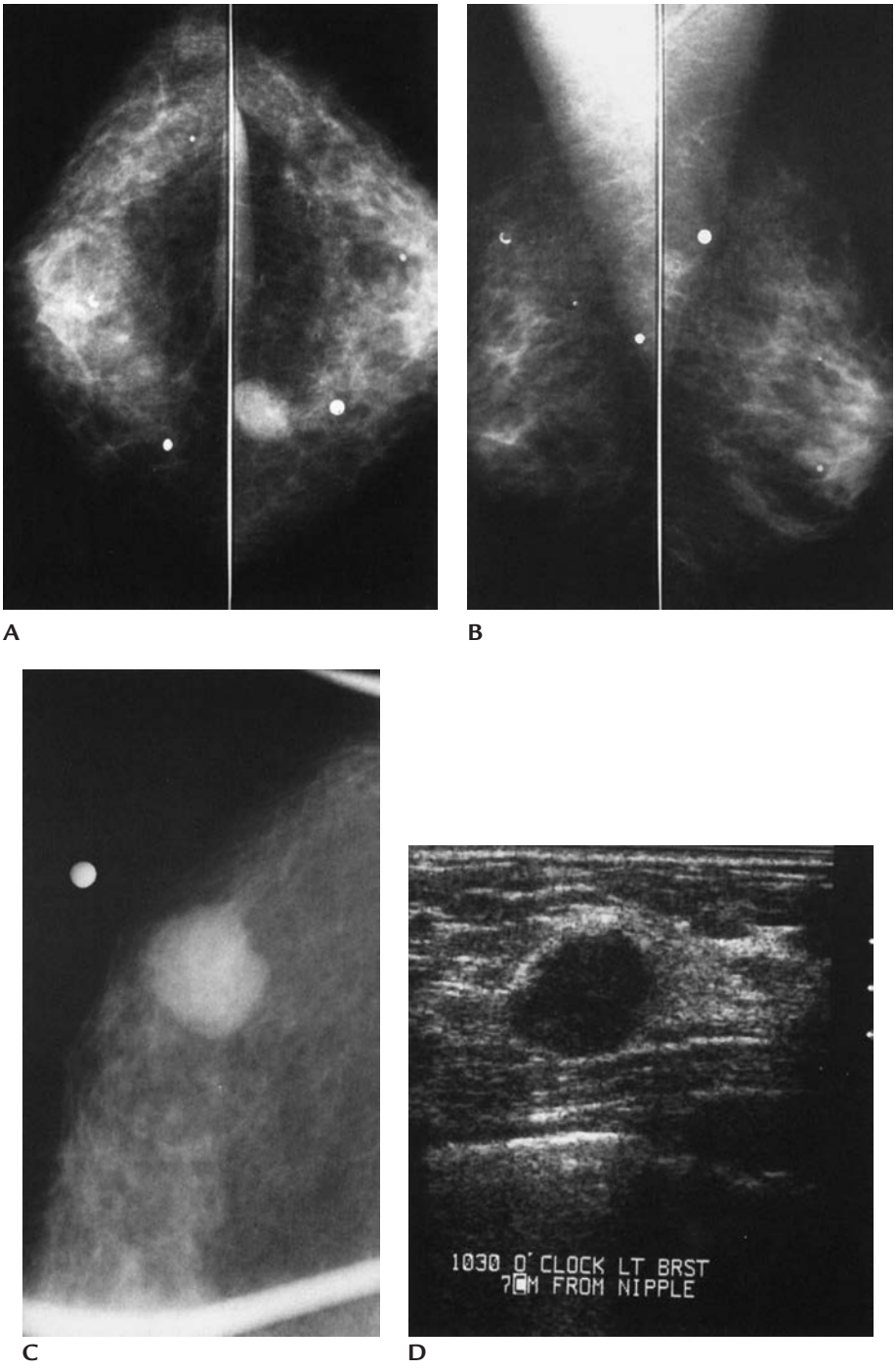
  Because tissue is not being pulled away from the body parallel to the underlying muscle fibers, some tissue is probably excluded from the field of view.
- For this view the x-ray beam enters the breast on the lateral side (compression paddle on the lateral portion of the breast) and exits on the medial side (bucky and film on medial side) onto the film.
- This is not a routine screening view, but rather a troubleshooting view.
- Indications.

  Evaluation of medial lesion: the medial portion of the breast is closest to the film thereby maximizing resolution.

  If there is any question that medial tissue (or lesions) has been excluded on the MLO view; the film holder is placed up against the sternum, (the patient is asked to extend her neck and rest her chin on top of the bucky), maximizing visualization of the medial tissue.

  In the triangulation of lesions seen on the CC view but not identified with certainty on the MLO view (or seen on the MLO view but not identified with certainty on the CC view).

  For preoperative needle localization and, in conjunction with the CC view, to determine the shortest skin-to-lesion distance.
- As a change of angle view relative to the MLO, it provides another projection that is useful in evaluating lesions.




**A** **B**

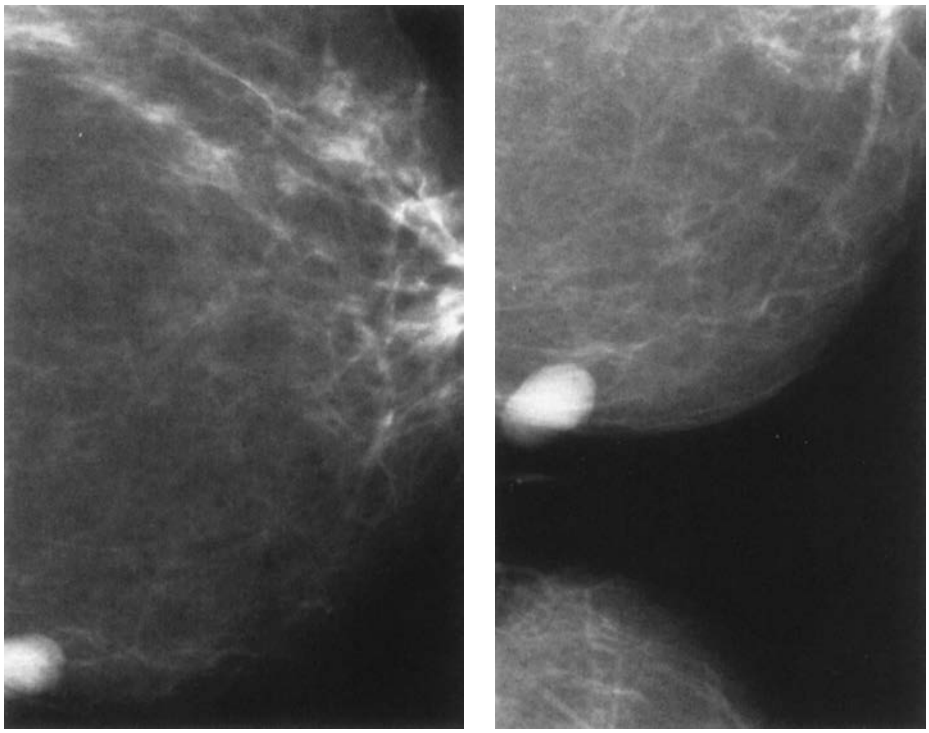
**C** **D**

**FIGURE 6-16** Infiltrating ductal carcinoma. **(A)** Craniocaudal views. Metallic BB is marking a palpable abnormality. The round mass medially corresponds to the palpable mass. **(B)** Mediolateral oblique views. Metallic BB is seen, however, the mass is excluded from the field of view. **(C)** A 90° lateromedial spot compression view. With the film holder against the sternum, inclusion of medial tissue is maximized on 90° lateromedial views round mass with partially ill-defined margins (anteriorly). **(D)** Solid, hypoechoic mass. Assessment category 4, suspicious abnormality; biopsy is recommended.

# Cleavage Views (CV)

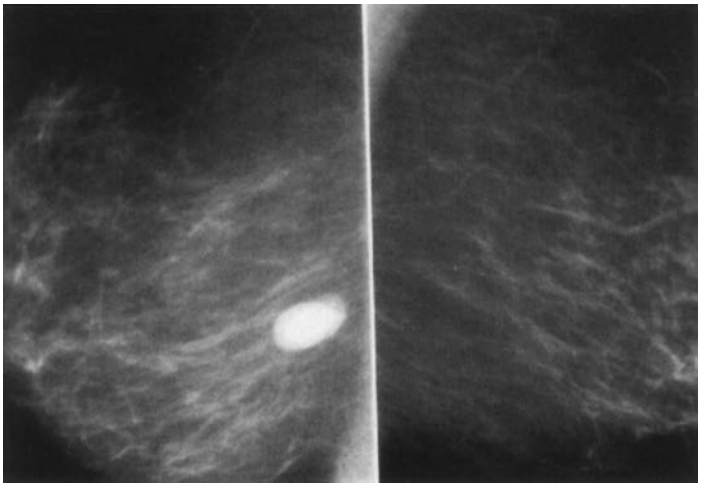
## Key Facts

- Indication.
  Evaluation of medial, posterior tissue.
- Both breasts are lifted and placed on the film holder.
- If phototiming is used, the breasts should be offset so that the cleavage is not directly over the photocell; otherwise, air is phototimed.
- If the breast is not offset, a manual technique can be used.



A B

**FIGURE 6-17** Fibroadenoma. **(A)** Left craniocaudal view. Partial visualization of a mass medially. Portion seen on this view is well circumscribed. What can be done to visualize the lesion completely in two projections? **(B)** Cleavage view. The mass is seen in its entirely and characterized as oval and well circumscribed. Breasts are offset so that tissue is placed over the phototimer (rather than the cleavage—air).



**C**

**FIGURE 6-17** (*Continued*) **(C)** Left 90° lateromedial and mediolateral oblique (MLO) views back to back. Mass is seen on the 90° lateromedial view, but not the MLO. Medial lesions are best evaluated on lateromedial views because medial tissue is placed against the bucky. Solid mass on ultrasound (not shown). In the absence of prior film for comparison, this lesion can be followed (category 3, probably benign lesion; short-term follow-up is recommended.)

## Caudocranial Views (FB From Below)

### Key Facts

- Indications.
  Evaluation of superior lesions, the film (bucky) is placed over superior tissue.
  Kyphotic patients, male breast.
  Needle localization when lesion is closest to inferior portion of the breast (fenestrated compression paddle is placed over inferior tissue).
- Compression is applied from below, superior tissue up against film.
- Awkward positioning for the patient: the tube, rotated 180°, will be between the patient's legs (legs straddle tube).

## Lateromedial Oblique Views (LMO)

### Key Facts

- Indications.
  Evaluation of medial lesions (medial tissue closest to film).
  Patients with kyphosis, pectus excavatum, pectus carinatum, and/or a prominent pacemaker.
  Patients who recently underwent median sternotomy.
- True reverse oblique: x-ray beam travels from lower outer quadrant to upper inner quadrant.

- Patient-specific angle is established as for routine MLO. The bucky is then placed just inferior to clavicle and humeral head.
- Pectoral muscle should be relaxed.

## Superolateral to Inferomedial Oblique (SIO) Views

### Key Facts

- X-ray beam travels from upper outer to lower inner quadrant.
- Limited usefulness.

## Benign Characteristics

### Key Facts

- Radiolucent masses (e.g., oil cysts, lipomas, galactoceles).
- Fat containing masses (e.g., lymph nodes, fibroadenolipomas, galactoceles, fat necrosis, postoperative, or posttraumatic fluid collections).
- Vascular, dystrophic, "popcorn," rim or eggshell, lucent centered, rodlike, skin, round, punctate and suture type calcifications, milk of calcium and calcified parasites.

## Probably Benign Lesions

### Key Facts

- The usefulness of the "probably benign lesion" concept and short-term follow-up, requires:
  - Ease of lesion classification.
  - An ability to detect changes in the lesion on follow-up studies.
  - If the lesion is a cancer, it should not be upstaged when the change is detected.
  - Lesions with an inherently low likelihood of malignancy.
  - Data in support of the concept provided independently by Sickles and Varas.
- It is recommended strongly that lesions not be put into the probably benign category without appropriate workups:
  - Provide appropriate baseline for follow-up.
  - Masses that appear well circumscribed on screening studies may have small spiculations and irregular margins on magnification views.
  - Calcifications that appear benign on screening studies may have pleomorphic features on magnification views.
  - Ultrasound is undertaken on well-circumscribed masses. If the mass is a simple cyst, a 6-month follow-up is not appropriate. Annual mammography is recommended.

Some of the lesions are characterized as benign after additional imaging obviating the need for follow-up.

- It is recommended strongly that only those lesions fulfilling the criteria for probably benign lesions be placed in this category.

  Rosen et al. described 51 cancers among 178 lesions assigned to the probably benign category (45% clustered calcifications, 24% asymmetric density, 24% masses, and 4% architectural distortion).

  None of the 51 cancers fulfilled the published criteria for probably benign lesion; 92% of lesions had already demonstrated progression.
- This classification should be not be abused or used to short-circuit workups and decision-making.

  Used in under 8% of all mammograms.

  Need to exclude obviously benign lesions (e.g., fat containing lesions, milk of calcium, cysts).

  If the lesion is present on previous studies with no interval change, a 6-month follow-up adds no additional information and is not indicated. Annual mammography is recommended.

  If the lesion has increased in size compared to prior studies, and is solid on ultrasound, 6-month follow-up is not appropriate. A biopsy is indicated.
- Probably benign lesions, and the data in support of follow-up, are defined mammographically (no comparable study has been done for ultrasound).

  Localized findings.

  Multiple findings.
- Localized findings.

  Cluster of small, round or oval calcifications.

  Nonpalpable, noncalcified, solid, round or oval, predominantly well-circumscribed masses (may have gentle lobulation); margins must be seen completely (e.g., not obscured by surrounding breast tissue); regardless of the size of the mass or age of the patient.

  Nonpalpable, focal asymmetry with concave margins and interspersed fat.

  Asymptomatic (no nipple discharge), single dilated duct.
- Multiple (three or more), similar findings, distributed randomly often bilaterally circumscribed masses round or oval, small calcifications in tight clusters (or scattered individually throughout both breasts).

  If after additional views (spot compression, spot magnification) a lesion meets the previously described criteria, periodic mammographic follow-up can be undertaken. It is not necessary to biopsy these lesions unless the patient is extremely anxious and follow-up will affect quality of life, the patient is unlikely to return for follow-up (poor compliance), or if the patient is pregnant or planning pregnancy.

  The likelihood of malignancy for probably benign lesions as reported by Sickles is low:

  For solid circumscribed mass: 1.4%.

  For focal asymmetric density: 0.6%.

  For localized microcalcifications: 0.4%.

  For multiple solid circumscribed masses: 0.3%.

For generalized microcalcifications: 0.2%.

For miscellaneous: 0%.

- Probably benign masses that are actually malignant can be detected with changes on follow-up studies.

  Prognostically, size, nodal status, and the clinical course of these lesions when detected on follow-up studies are reportedly no different from that of malignancies diagnosed at the time of initial screening.

  The cancers that are identified are usually found on the 1-year follow-up exam.
- For probably benign lesions, a 6-month follow-up is recommended. This is the only additional study that is done.

  Bilateral mammography 6 months later is followed by annual mammography (e.g., only one additional, usually unilateral, study is done).

  Given the reported likelihood for breast cancer in women with localized or generalized microcalcifications, multiple solid circumscribed masses, and miscellaneous lesions, and because most cancers among probably benign lesions are identified at the 1-year follow-up, some advocate yearly follow-up only.

  3-month follow-ups should not be done on a routine basis. The evaluation of women with questionable postoperative changes or an inflammatory condition is the only indication for 3- or 4-month follow-ups. In these situations, rapid (benign) changes are expected.

  Short-term follow-ups are intended for probably benign lesions. If you are expecting a change in 3 months, you should probably be considering biopsy today!
- The concept of the probably benign lesion and the data supporting follow-up were described on the basis of mammographic features.

  There is no comparable definition or longitudinal data supporting follow-up of lesions characterized sonographically.

## Malignant Characteristics

### Key Facts

- Physical examination findings.

  Hard, gritty mass; little mobility.

  Tissue consistency difference (particularly if correlated with parenchymal asymmetry mammographically).

  Skin thickening, retraction (dimpling), stretching, erythema, and ulceration.

  Nipple retraction.

  No significant associated tenderness.
- Mammography.

  Mass with spiculated margins and no history of previous surgery, trauma, or mastitis at the site of the mass.

  Ill-defined, microlobulated mass with malignant-type microcalcifications.

  Skin thickening, retraction.

  Nipple retraction.

Architectural distortion with no history of previous surgery or trauma at the site of the distortion.

Linear, branching, casting type calcifications.

Linear or segmental distribution of linear and punctate calcifications.

- Ultrasound.

  Mass with marked hypoechogenicity.

  Mass with spiculated, angular or microlobulated margins.

  Spiculation.

  Taller than wide (e.g., vertically oriented)

  Shadowing.

  Branch pattern (tubular projections branching away from the nipple).

  Duct extension (tubular projection extending from the mass in the direction of the nipple).

  Microcalcifications (echogenic foci some of which may shadow).

## TRIANGULATION

### KEY FACTS

- If a potential lesion identified in one view warrants additional workup, it is first evaluated in the view in which it is seen. Spot compression and rolled views are done. If the abnormality persists, every effort is made to determine its location in the orthogonal projection.
- Evaluate the movement of an abnormality between MLO (the screening view is the starting point) and 90° lateral views to get a general idea of where the lesion is on the CC view.

  If the abnormality moves up from the MLO to the 90° lateral view, the lesion is in the medial half of the breast.

  If the abnormality moves down from the MLO to the 90° lateral view, the lesion is in the lateral half of the breast.

  If the abnormality doesn't shift much in position from the MLO to the 90° lateral view, the lesion is in the mid portion of the breast behind the nipple.
- Apply these same concepts if an abnormality is identified in the CC view, but its location is unclear on the MLO view.

  A lateral lesion on the CC view will move down from the MLO to the 90° lateral view.

  A medial lesion on the CC view will move up from the MLO to the 90° lateral view.

  A lesion in the mid portion of the breast will not shift between MLO and 90° lateral views.
- Sickles described a practical method for triangulating the location of lesions seen in one view.

  Using the nipple as the horizontal reference point, line up the 90° lateral, MLO, and CC views.

  Draw a line through the lesion on the two views in which the lesion is seen and extend it into the third view.

The lesion is along the course of the line on the third view.

By determining how far back from the nipple the lesion is, you can approximate the location of the lesion along the course of the line fairly accurately on the third view.

- Eklund has described a method that is useful in establishing the clock position of lesions.

  Knowing the expected clock position of a lesion seen mammographically is particularly useful when doing targeted ultrasound studies: there can be certainty that the lesion evaluated sonographically is the same lesion seen on the mammogram.

  On an MLO view not all tissue projecting above the nipple is truly above the nipple.

  The x-ray beam for an MLO view travels from the upper inner quadrant through the breast and out the lower outer quadrant.

  Some tissue in the upper inner quadrants projects below the level of the nipple on MLO views.

  Some tissue in the lower outer quadrants projects above the level of the nipple on MLO views.

  The posterior nipple line (PNL) on a lateral diagram of the breast describes the trajectory of the x-ray beam shown on a frontal diagram of the breast.

  If a lesion is 1 cm above the PNL on the MLO view it's location on a frontal diagram of the breast is defined by a line drawn 1 cm above the trajectory of the x-ray beam for the MLO view. By using the location of the abnormality on the CC view, one can more precisely determine where along the course of that line the lesion is to be found.

  If the lesion is 1 cm below the PNL on the MLO view, a line drawn 1 cm below the line defining the trajectory of the x-ray beam on an MLO in the frontal diagram approximates the location of the lesion. The location of the lesion on the CC view further defines the location of the lesion on the frontal view (e.g., is the lesion medial or lateral).

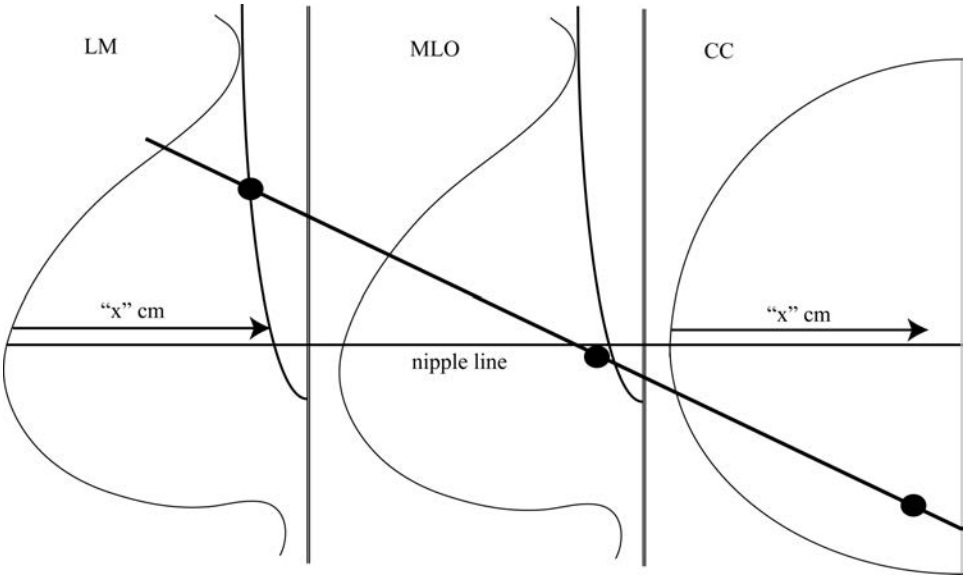



**FIGURE 6-18** Method for triangulation of lesions described by Sickles (1988). Lateral, oblique and craniocaudal views are lined up using the nipple as the horizontal reference point. If a lesion is seen on lateral and oblique views posteriorly, its approximate location on the craniocaudal view can be established by extending the line that connects the lesion on the views in which it is seen into the third view. The lesion is found alone the course of this line. Its location can be defined further by measuring its approximate location back (e.g., "x" cm) from the nipple.

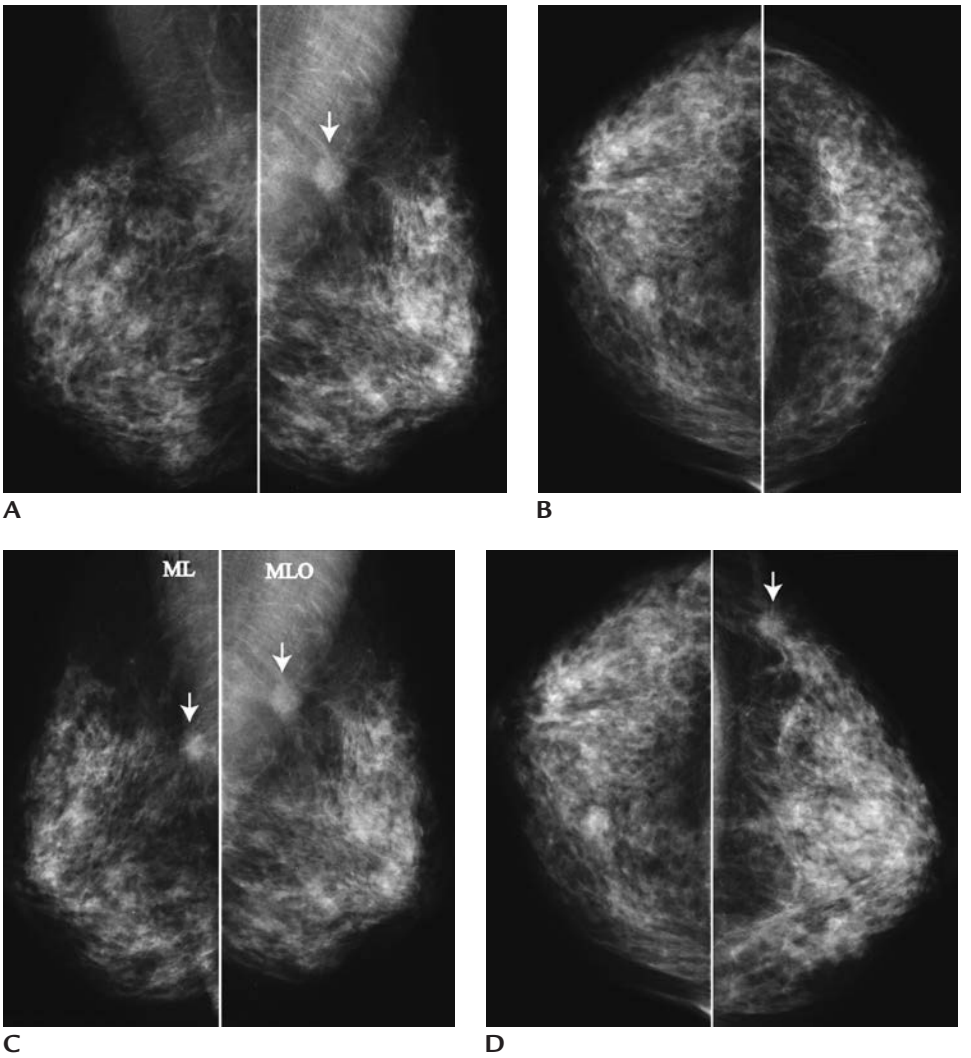
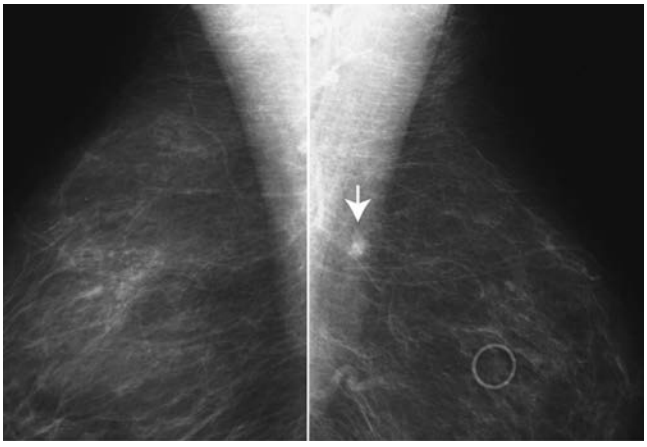



**FIGURE 6-19** Invasive ductal carcinoma. **(A)** Mediolateral oblique (MLO) and **(B)** craniocaudal (CC) views. A potential mass (*arrow*) is imaged superimposed on the pectoral muscle on the left mediolateral oblique view. No abnormality is identified in the CC view. Our approach to these patients is to spot the lesion in the projection in which it is seen. If the lesion persists on the spot compression views, rather than assume the lesion is lateral, central or medial in location, we obtain a 90° lateral view. **(C)** Left 90° lateral view back-to-back with MLO. Mass (*arrows*) moves down on the lateral view compared to the MLO so that the lesion is likely to be in the lateral aspect of the left breast. **(D)** Left craniocaudal view exaggerated laterally confirms the presence of the mass (*arrow*) in a lateral location.



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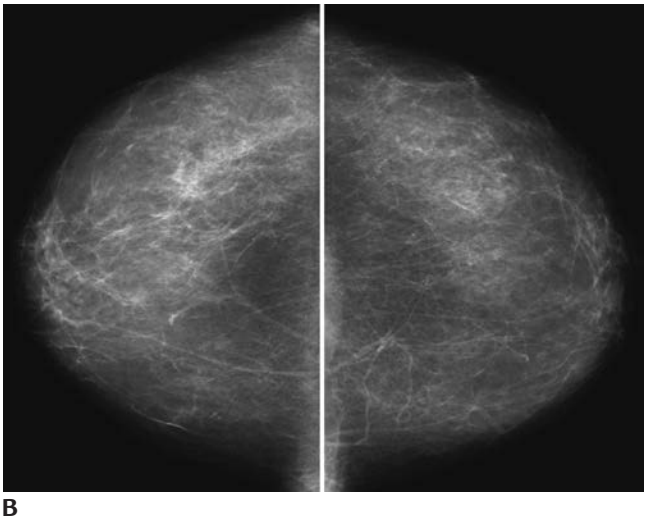
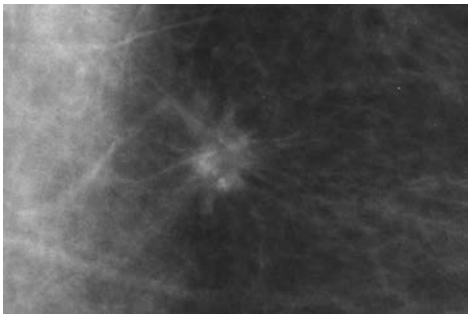


**B**

**FIGURE 6-20** Invasive ductal carcinoma. **(A)** Mediolateral oblique (MLO) and **(B)** craniocaudal (CC) views. A potential mass is imaged superimposed on the pectoral muscle on the left MLO view. No abnormality is seen in the CC view.



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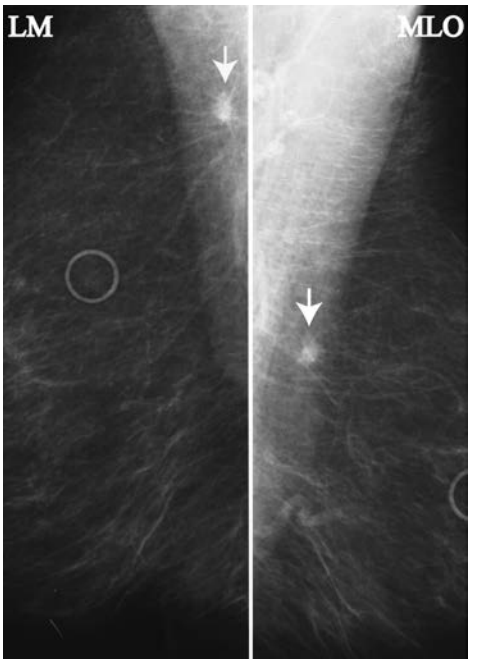


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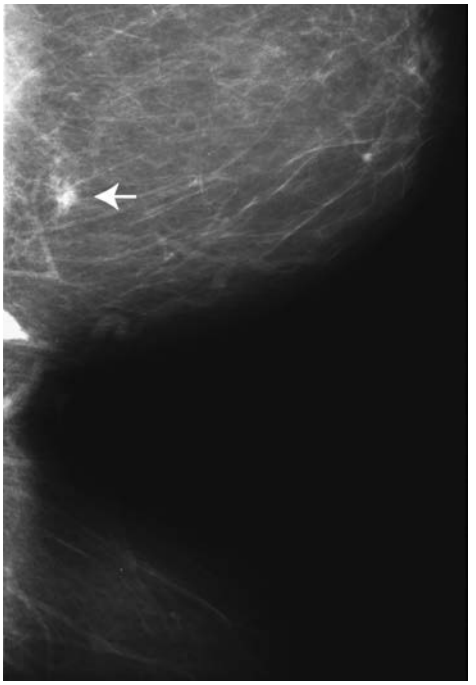

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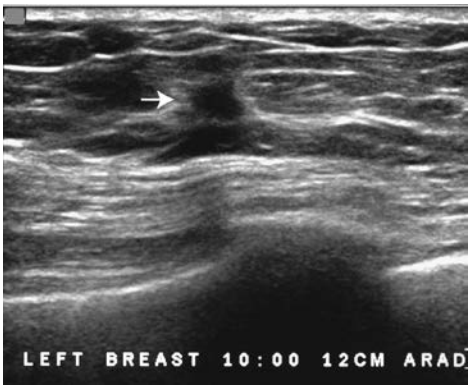



F

**FIGURE 6-20** (*Continued*) **(C)** Spot compression view in the mediolateral oblique projection confirms the presence of a mass with spiculated margins. Rather than assume the lesion is lateral, central or medial in location, we obtain a 90° lateral view so as to establish the location of the lesion in the craniocaudal view. **(D)** Left 90° lateral view back to back with MLO. The mass (*arrows*) moves up on the lateral view compared to its location on the MLO view consistent with a medial location for the lesion. A cleavage view is done to establish the location of the mass. **(E)** Cleavage view confirming the medial location of the mass (*arrow*). The breasts are offset so that tissue is placed over the phototimer (if the cleavage is placed over the phototimer, the image will be overexposed). **(F)** A hypoechoic mass with angular and spiculated margins is imaged in the upper inner quadrant of the left breast at the expected location of the mass imaged mammographically.

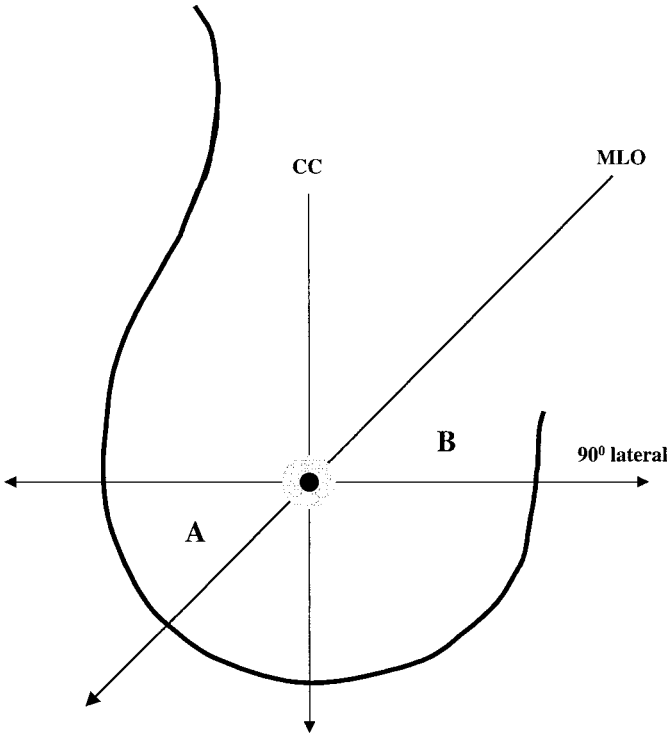



**FIGURE 6-21** Frontal diagram of the right breast. On craniocaudal (CC) and 90° lateral views of the breast, determining the location of tissue and lesions is straightforward. On CC views, medial tissue projects medially and lateral tissue projects laterally. On 90° lateral views, superior tissue projects above the nipple and inferior tissue projects below the nipple. On a mediolateral oblique view, however, some tissue in the lower outer quadrant projects superiorly or above the level of the nipple **(A)**, and some tissue in the upper inner quadrant projects inferiorly or below the level of the nipple **(B)**.

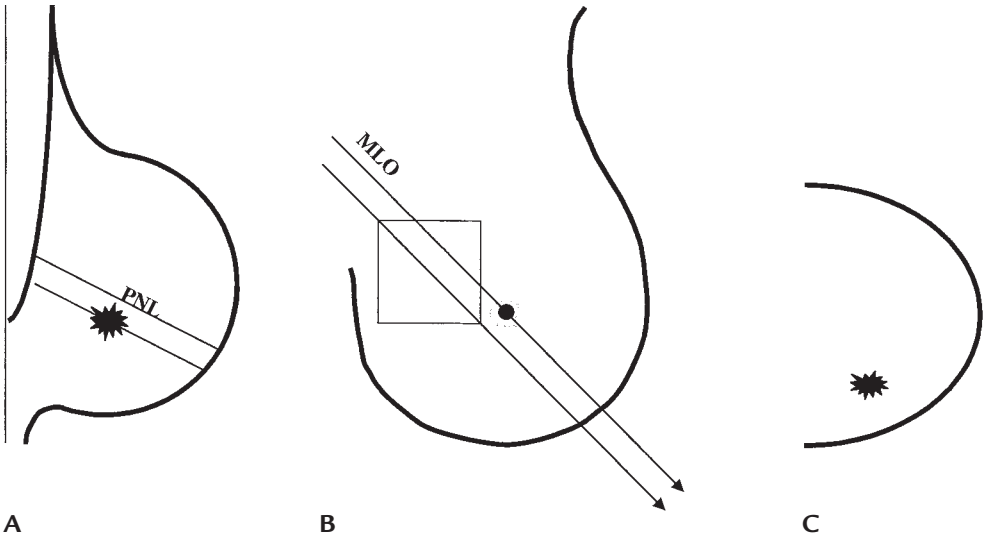



**FIGURE 6-22** Method for determining the clock position of lesions described by Eklund. **(A)** To establish the clock position of a lesion, draw the PNL on the left mediolateral oblique (MLO) view. Draw a second line that passes through the lesion and is parallel to the PNL. In this example the speculated mass is below the PNL. Determine the distance between these lines (approximately 5 mm). **(B)** On a frontal diagram of the left breast, draw a line from upper inner quadrant, through the nipple, and out through the outer quadrant. This line describes the PNL on the frontal diagram and the path of the x-ray beam for a 45° MLO view. Draw a second line 5 mm below and parallel to the line describing the path of the x-ray beam. The lesion is located somewhere along the course of this second line. **(C)** To approximate the location of the lesion further, review the left craniocaudal (CC) view. If the lesion is medial on the CC view, as in this example, the lesion is in the upper inner quadrant at approximately the 10 o'clock position (along the course of the line in the square). If the lesion is lateral on the CC views, the lesion would be in the outer quadrant at approximately the 5 o'clock positions. Although not all MLOs are done at 45°, this method is helpful in obtaining an approximate location for lesions.

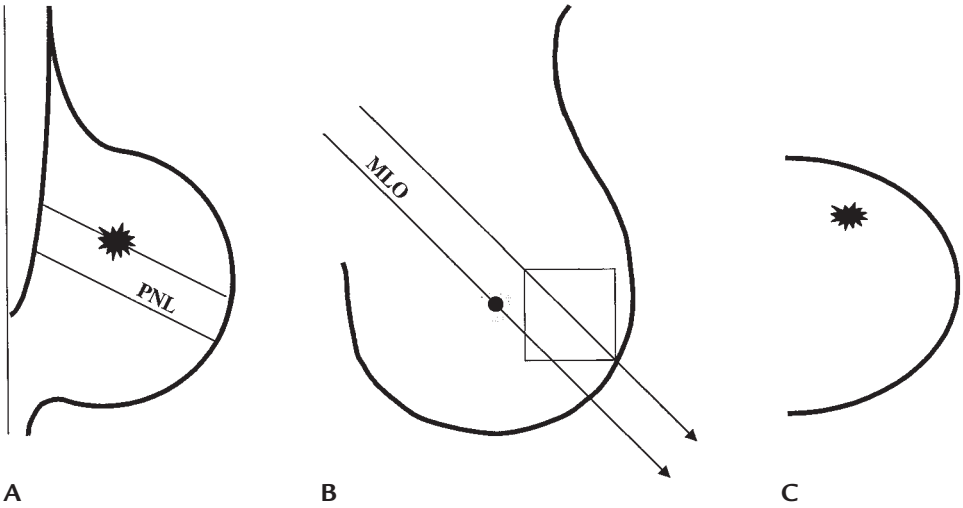



**FIGURE 6-23** **(A)** A spiculated mass is present on the left mediolateral oblique (MLO) view approximately 1 cm superior to the PNL. **(B)** On a frontal diagram of the left breast, a line is drawn 1 cm above, and parallel to the line drawn describing the trajectory of the x-ray beam on an MLO view. The lesion seen on the MLO view is somewhere along the course of this line. **(C)** To determine a more precise location for the mass, review the craniocaudal (CC) view. In this example the lesion is in the lateral aspect of the breast and as such it is at the 3 to 4 o'clock position (along the line in the square). The value of this method cannot be underestimated. It provides assurance that what is seen mammographically is evaluated sonographically, and it makes targeted ultrasound studies more efficient. Before undertaking an ultrasound, the approximate clock position of the lesion is determined, and the transducer is placed directly over the lesion in most patients.

## SUGGESTED READINGS

American College of Radiology. *ACR Practice Guideline for the Performance of Diagnostic Mammography*. Reston: American College of Radiology; 2006.

American College of Radiology. *ACR Practice Guideline for the Performance of Screening Mammography.* Reston: American College of Radiology; 2006.

Bassett LW. Quality determinants of mammography: clinical image evaluation. In: *RSNA Categorical Course in Breast Imaging Syllabus*. 1995:57–67.

Bassett LW, Hirbawi IA, DeBruhl N, et al. Mammographic positioning: evaluation from the view box. *Radiology.* 1993;188:803–806.

Brenner RJ. Surveillance mammography: is it defensible if you are wrong? *Applied Radiology*. 1996.

Eklund GW, Cardenosa G. The art of mammographic positioning. *Radiol Clin North Am*. 1992;30:21–53.

Eklund GW, Cardenosa G, Parsons W. Assessing adequacy of mammographic image quality. *Radiology*. 1994;190:297–307.

Eklund GW, Busby RC, Miller SH, et al. Improved imaging of the augmented breast. *AJR Am J Roentgenol.* 1988;151:469–473.

Eklund GW. Triangulation method. Personal communication.

Rosen EL, Baker JA, Soo MS. Malignant lesions initially subjected to short-term mammographic follow-up. *Radiology*. 2002;223:221–228.

Rubin E. Six-month follow-up: an alternative view. *Radiology*. 1999;213:15–18.
Sickles EA. Probably benign breast lesions: when should follow-up be recommended and what is the optimal follow-up protocol? *Radiology*. 1999;213:11–14.
Sickles EA. Management of probably benign breast lesions. *Rad Clinics NA*. 1995;33:1123–1130.
Sickles EA. Management of probably benign lesions. *RSNA Categorical Course in Breast Imaging Syllabus*. 1995:133–138.
Sickles EA. Nonpalpable, circumscribed, noncalcified solid breast masses: likelihood of malignancy based on lesion size and age of patient. *Radiology*. 1994;192:439–442.
Sickles EA. Periodic mammographic follow-up of probably benign lesions: results in 3,184 consecutive cases. *Radiology*. 1991;179:463–468.
Sickles EA. Practical solutions to common mammographic problems: tailoring the examination. *AJR Am J Roentgenol.* 1988;151:31–39.
Swann CA, Kopans DB, McCarthy KA. Localization of occult breast lesions: practical solutions to problems of triangulation. *Radiology*. 1987;163:557.
Varas X, Leborgne F, Leborgne JH. Nonpalpable, probably benign lesions: role of follow-up mammography. *Radiology*. 1992;184:409–414.

CHAPTER 7

# BREAST ULTRASOUND

## General Comments

### Key Facts

- Ultrasound is an adjunctive test, not a replacement for high-quality mammography.
- As systems improve, indications for breast ultrasound expand.

  Characterization of masses as cystic or solid.

  Characterization of solid masses as intermediate, low or high probability of malignancy.

  Evaluation of women with a palpable finding who, on spot compression views of the area of clinical concern, have normal appearing glandular tissue or a nonspecific finding mammographically.

  Evaluation of women presenting with a palpable mass during pregnancy, lactation, or under 30 years of age.

  In distinguishing mastitis from abscess formation.

  Evaluation of women with asymmetric tissue or developing densities on a mammogram.

  Evaluation of women with nipple discharge; intraductal lesions may be identified if the lesion is in a dilated duct close to the nipple. Ductography should be considered as the modality of choice in women presenting with spontaneous nipple discharge.

  Evaluation of women with calcifications having a high likelihood of malignancy to determine if the calcifications have an associated soft tissue component; the soft tissue component may reflect distended ductal carcinoma in situ containing ducts or invasive disease. Also, if the calcifications are seen sonographically, ultrasound guidance can be used to guide a needle biopsy and the preoperative wire localization.

  To evaluate women with unsuspected findings on magnetic resonance imaging.

To evaluate potential findings in areas that may be difficult to image mammographically (e.g., upper inner quadrant superiorly, tail of Spence).

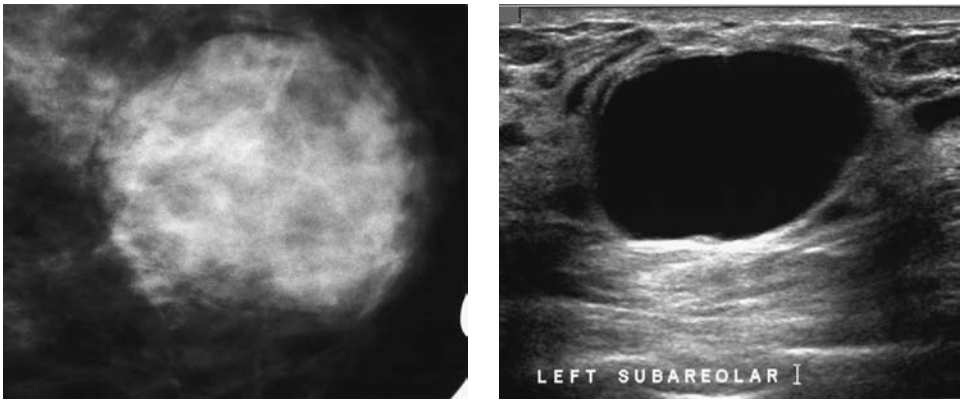
To guide interventional procedures (e.g., cyst aspirations, fine needle aspirations, abscess drainages, preoperative wire localizations, needle biopsies, and clip placement in patients undergoing neoadjuvant therapy).

- Potential application as a screening tool is under investigation.

  Although microcalcifications can be demonstrated on ultrasound (using the mammogram as a guide), the ability to reliably detect and characterize microcalcifications prospectively with ultrasound is limited; this, along with a high degree of operator dependence for optimal studies, limits the exclusive use of breast ultrasound for screening purposes.

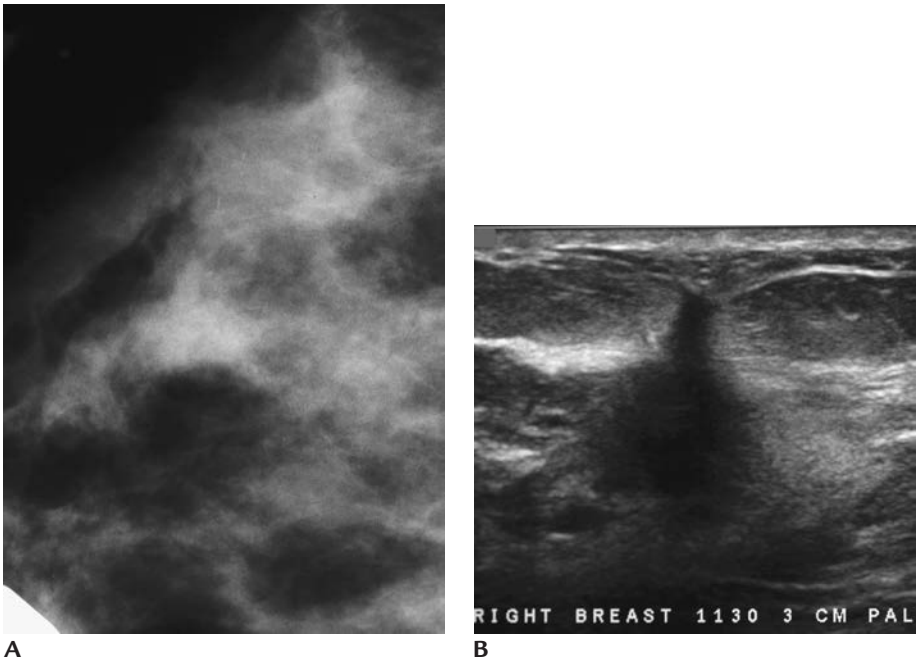
  Data is emerging in support of using mammography and ultrasound to screen high-risk women with dense tissue.

  Kolb and associates reported a 17% increase in cancer detection when using ultrasound for screening women with dense tissue. The tumors detected with ultrasound alone were comparable in size and stage to mammographically detected, clinically occult breast cancers.
- Breast ultrasound may seem simple, but it is not, and optimal technique and equipment are necessary. In many women, the distinction between normal tissue and a lesion is difficult. Experience and an understanding of breast anatomy and mammographic imaging are important for appropriate correlations.
- Radiologist involvement is critical. In our practice, the radiologists are responsible for all breast ultrasound. It is important to establish rapport with patients and correlate physical, mammographic magnetic resonance imaging, and ultrasound findings in order to minimize under- or overdiagnosis.
- Given the degree of operator dependence and potential for documenting "pseudolesions," we do not usually interpret outside ultrasounds. In our own practice, no images are taken until we are sure that a lesion is present. The images taken are limited to those required to document the characteristics of the lesion in orthogonal planes, establish maximum size, and justify the recommendation we are making to the patient and referring physician.



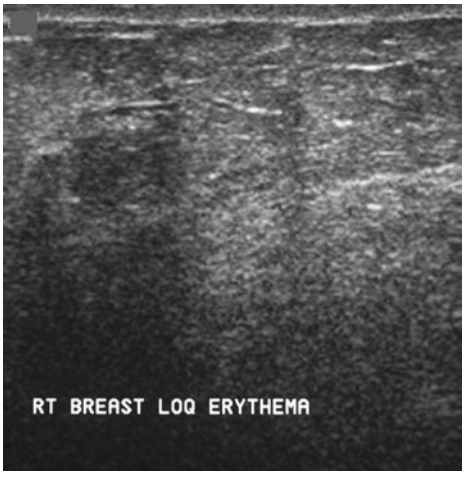

A B

**FIGURE 7-1** Cyst. **(A)** Spot compression view of the left breast demonstrating a round mass with partially indistinct and obscured margins. A halo is seen outlining portions of the margin suggesting a benign etiology. The internal matrix of this mass cannot be established on physical examination or mammography alone. **(B)** On ultrasound, an anechoic mass with well-circumscribed margins and posterior acoustic enhancement diagnostic of a cyst is seen corresponding to the mammographic finding. Unless the patient is symptomatic, this does not require further intervention or short-interval follow-up.




A B

**FIGURE 7-2** Invasive ductal carcinoma. **(A)** Spot tangential view taken at site of "lump" described by the patient in the right breast. Dense glandular tissue is imaged. No underlying mass or distortion is apparent. Correlative physical examination and ultrasound are indicated for further evaluation. **(B)** On physical examination, a hard mass is palpated in the upper outer quadrant of the right breast corresponding to the area of concern to the patient. Sonographically, an irregular, vertically oriented, hypoechoic mass with spiculated and angular margins as well as associated shadowing is imaged at the 11:30 o'clock position, 3 cm from the right nipple. An ultrasound guided biopsy is done. Ultrasound is helpful in evaluating areas of otherwise normal appearing dense glandular tissue as well as areas of tissue that may be excluded from the mammographic field of view.

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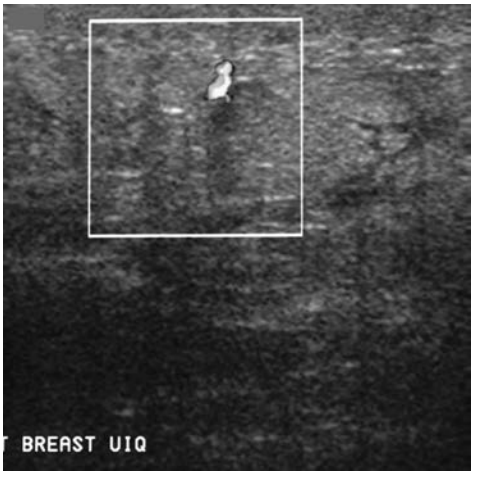
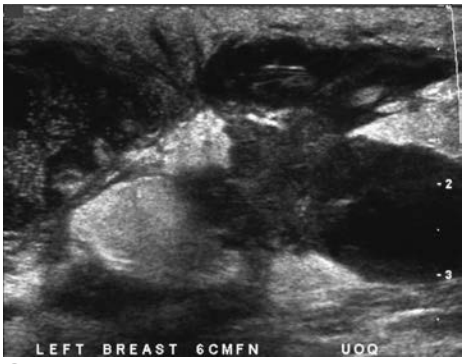
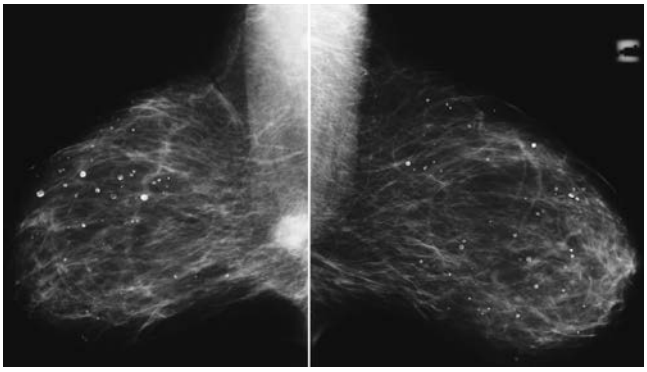



B




C

**FIGURE 7-3** **(A)** Mastitis. Diffusely increased echogenicity of tissue with loss of normal tissue planes. Cooper's ligaments are not apparent. This appearance is seen in women with edema, post-traumatic change or ongoing inflammatory changes. It is also characteristic of normal tissue in a lactational state. **(B)** Mastitis, different patient. Diffusely increased echogenicity of tissue with loss of normal tissue planes. In these patients, increased vascularity is often seen coursing through the tissue. Doppler used to identify vessel. **(C)** Multiloculated abscess. Interconnecting, complex cystic masses with extension to the skin and resulting marked skin thickening; in this patient, the associated skin involvement suggests imminent fistula formation.



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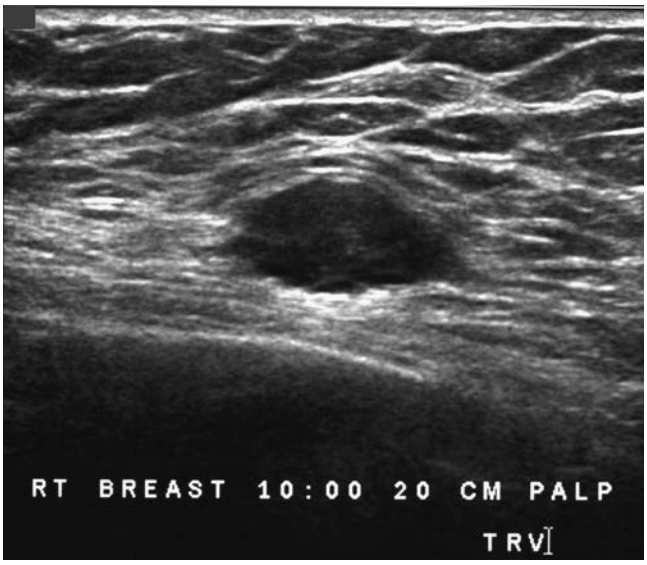
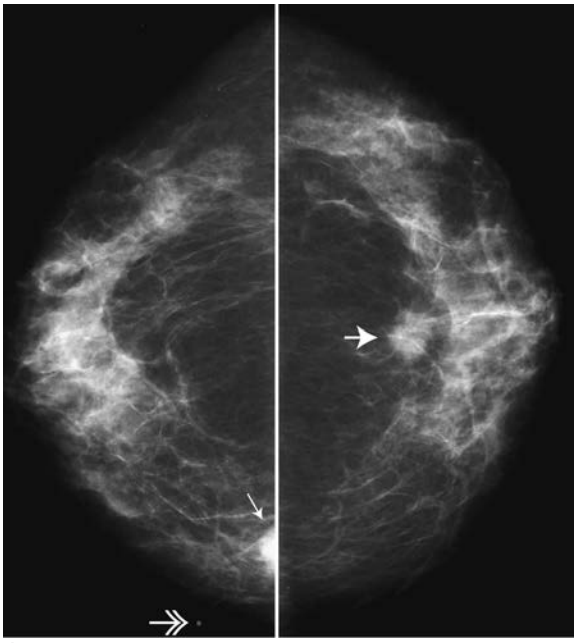



**B**

**FIGURE 7-4** Invasive ductal carcinoma, poorly differentiated. **(A)** A mass with indistinct margins is partially imaged superimposed on the lower most aspect of the right pectoral muscle. Multiple attempts to image the lesion in the craniocaudal projection were unsuccessful. Multiple lucent centered calcifications are present diffusely scattered bilaterally. **(B)** An oval hypoechoic mass with microlobulated and spiculated margins and some posterior acoustic enhancement is imaged corresponding to the mass seen mammographically. Although the patient reportedly had a normal physical examination prior to her screening mammogram, this mass is palpable, hard but movable. Ultrasound is helpful in evaluating areas that may otherwise be difficult to image mammographically.



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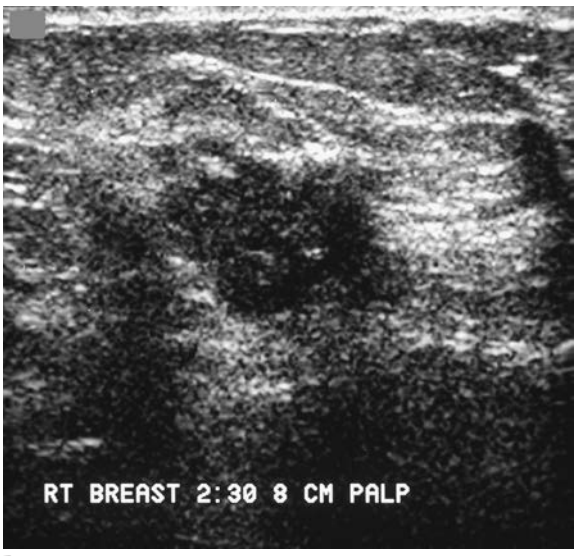



B

**FIGURE 7-5** Invasive ductal carcinoma, bilateral synchronous lesions. **(A)** Craniocaudal views in a patient presenting with a palpable mass in the right breast. Metallic BB (*double headed arrow*) used to mark area of clinical concern. A mass (*small arrow*) is partially seen posteromedially at the edge of the right craniocaudal view. Although multiple images were attempted, because of its location in the upper inner quadrant of the right breast, it could not be seen in entirety mammographically. A clinically occult spiculated mass (*larger arrow*) is noted in the left breast. Remember to not let yourself be distracted by the clinical finding; evaluate the mammogram completely before focusing in on obvious findings. **(B)** An irregular hypoechoic mass with indistinct, spiculated, and angular margins is imaged in the upper inner quadrant of the right breast. Ultrasound is helpful in evaluating areas that may otherwise be difficult to image mammographically (e.g., axillary tail, far posterolateral lesions, upper inner quadrant close to the chest wall).

## TECHNICAL CONSIDERATIONS

### KEY FACTS

- Between 7.5 MHz and 13.5 MHz dynamically focused, linear array transducers; depth of focus: 3 cm or less; unless a mass is large or deep in the breast, 5 MHz transducers are not used in breast imaging.
- Axial (longitudinal) resolution.

  Inversely proportional to wavelength; not affected by depth.

  Higher frequency transducers with shorter wavelengths have better axial resolution.
- Lateral resolution.

  Approximately equal to beam width; varies with depth.

  Scan line density (number of lines displayed per image frame) is adequate for most 7 MHz to 7.5 MHz transducers.

  Maximum line density (N) = c (speed of sound in cm/second)/(2 × D [maximum depth in cm to be displayed] × r [frame rate]).

  Fixed elevation plane focal length: electronic linear probes can be focused electronically along the long axis of the transducer; the focus of the shorter axis (elevation plane axis) is fixed. It should be 1 to 1.5 cm, but most transducers are focused at 3 to 4 cm. A stand off pad or a large amount of coupling gel should be used; otherwise, there is averaging from surrounding tissue.

  Long axis electronic focusing: focusing can be for receiving and transmitting. The number and depth of transmit focuses can vary. Many transducers do not have enough superficial transmit focal zones. Standoff pads can improve the electronic transmit-zone focusing.
- Contrast resolution.

  Related to transducer frequency and bandwidth.

  Higher frequencies and broader bandwidth improve contrast resolution.
- Because of poor near-field focus, phased and linear array transducers create artifactual echoes in cysts. If there is no built-in offset, offset pads should be used in evaluating the near field with these transducer types.
- Tissue harmonic imaging.

  Helps reduce near-field and side-lobe artifacts, increasing lesion conspicuity and eliminating artifactual echoes in cysts.

  Harmonics are multiples of the transmission frequency. The transmission frequency is the first harmonic. The second harmonic, twice the transmission frequency (2f), is what is used currently.
- Power.

  Sound intensity: voltage applied to transducer.

  Intensity decreases in tissue secondary to refraction, diffusion, and absorption. Power should be enough to penetrate through to the chest wall, but not more than that. The pectoral muscle and ribs should be visible.

# SCANNING

## KEY FACTS

- As with any imaging modality, optimizing quality and interpretative skills is critical in maximizing diagnostic accuracy with breast ultrasound. Baker et al. reported 60.5% noncompliance with at least one of the ACR's guidelines for performance of ultrasound examinations (transducer used, focal zone positioning, gain setting, field of view, lesion in perpendicular projections, maximal lesion dimensions, image labeling, and film labeling) in a review of 152 breast ultrasound studies from 86 different institutions.
- Patient positioning.

  Breast tissue should be thinned maximally for adequate penetration with a high-frequency transducer.

  Supine or contralateral posterior oblique most common starting position. Depending on breast size and lesion location, however, the degree of obliquity can be changed as needed to thin tissue maximally.

  Supine positioning facilitates evaluation of the medial quadrants.

  Ipsilateral arm is elevated comfortably (with hand under patient's head) to help thin and spread tissue.

  Positioning, however, can be changed as needed to evaluate a particular area or symptom in the breast (e.g., upright positioning is used if the patient describes lesion as only palpable or best palpated when she is upright).
- Transducer manipulation and positioning.

  The transducer should be moved slowly with one hand, as correlative physical examination is undertaken with the contralateral hand. The examiner's fingers can move back and forth at the leading edge of the transducer, correlating what is seen with what is felt (e.g., putting eyeballs at the tips of our fingers).

  If a potential lesion is identified, the transducer is moved back and forth and rotated at least 90° to ensure that what is being seen is not a fatty lobule in a cross-section.

  The ducts converge on the nipple in a radial fashion. In addition to scanning in transverse and sagittal orientations, radial and antiradial scanning can be used.
- Compression of tissue with the transducer.

  Thins tissue and helps eliminate critical angle shadowing (which can preclude evaluation of deeper tissue) from superficial Cooper's ligaments.

  To assess compressibility of lesion: benign lesions are more compressible than malignant.

  Too much compression may be counterproductive by causing patient discomfort, pushing lesions out of the scan plane or altering the focal zones so that superficial lesions might be missed.

  During procedures, compression with the transducer helps to stabilize the lesion as the needle is advanced.
- Although breast ultrasound may be targeted to the area of palpable or mammographic concern, a wider section of tissue surrounding the area of the lesion should be evaluated. Some advocate scanning the entire breast.

- In patients with a probable malignant lesion, scanning the entire breast may be helpful in identifying multifocal or multicentric disease. Scanning of the contralateral breast may be helpful in identifying synchronous lesions. The ipsilateral axilla and parasternal region (to assess for enlarged internal mammary lymph nodes) are also evaluated. If potentially abnormal lymph nodes are identified, fine needle aspiration or core biopsy can be done.
- Time Gain Compensation (TGC).

  Depending on depth, returning echoes need different degrees of amplification: time-gain-compensation (TGC). Rapid attenuation (dense tissue) requires a steeper TGC curve.

  In evaluating masses, this if often manipulated during the real time portion of the study.

  Fatty tissues should be medium gray from skin to pectoral muscle.

  Shallow curve for fatty tissue; steeper curve for glandular tissue.
- Number of zones and focal zone positioning.

  Placed at the depth of the lesion and to encompass.
- Field of view (FOV).

  An adequate amount of tissue should be seen surrounding the lesion to determine if there is associated shadowing or enhancement.

  FOV should be enough to see the pectoralis muscles, ribs, and pleural line.

  When doing biopsies, the FOV should enable visualization of the needle, particularly the tip and its relationship to the lesion and chest wall.
- Image labeling.

  Breast being imaged (e.g., right, left).

  Location of lesion (o'clock position, quadrant, or shown on a breast diagram).

  Distance from nipple or zone in the breast.

  Transducer orientation (e.g., radial and antiradial or transverse and sagittal/longitudinal).

  Orthogonal images of the lesion should be taken with and without measurements (e.g., calipers).

  If a lesion is palpable at the time of the study, consider annotating this on the image as well.
- Film labeling.

  Patient's first and last name.

  Unique patient identification number.

  Facility name and location.

  Date.

  Operator ID.

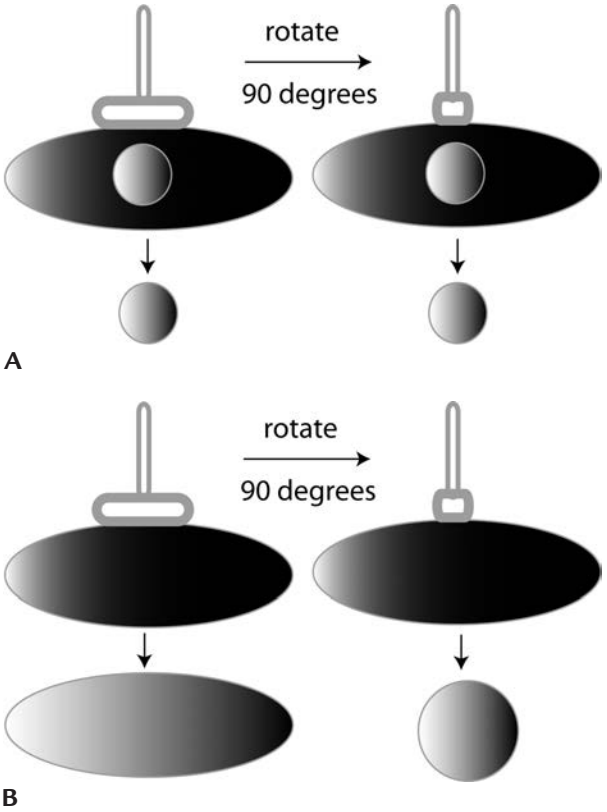
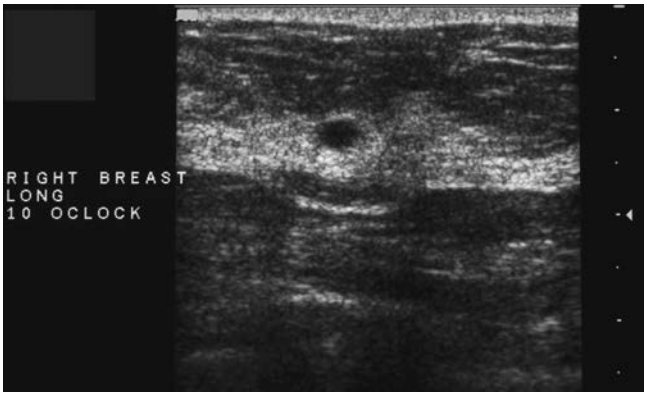
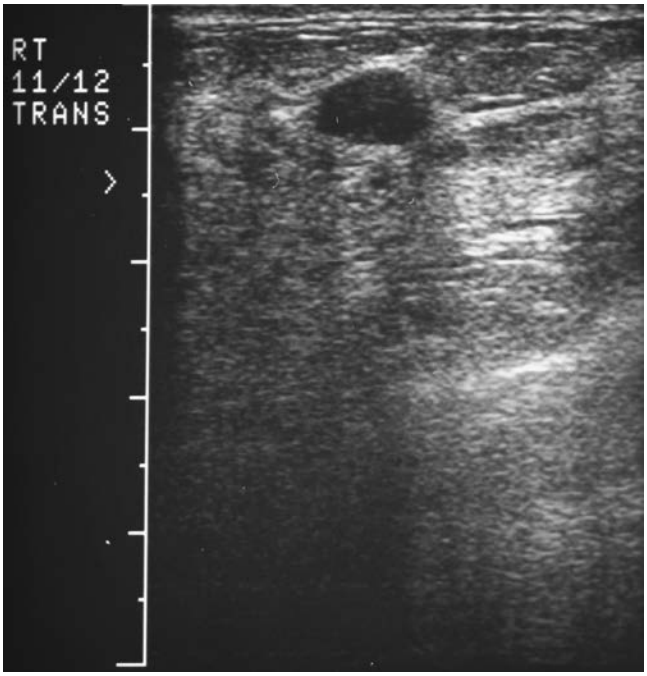



**FIGURE 7-6** **(A)** If a potential lesion is identified, it is important to rotate the transducer over the area. A true lesion remains discrete (oval, round, or irregular) as the transducer is rotated. **(B)** Oblong breast tissue bundles are intercalated within the skeleton provided by Cooper's ligaments. If a bundle is imaged in cross-section, it may appear masslike. However, as the transducer is rotated over this area, the pseudo mass elongates, becomes less apparent, and often fuses with the surrounding tissue.

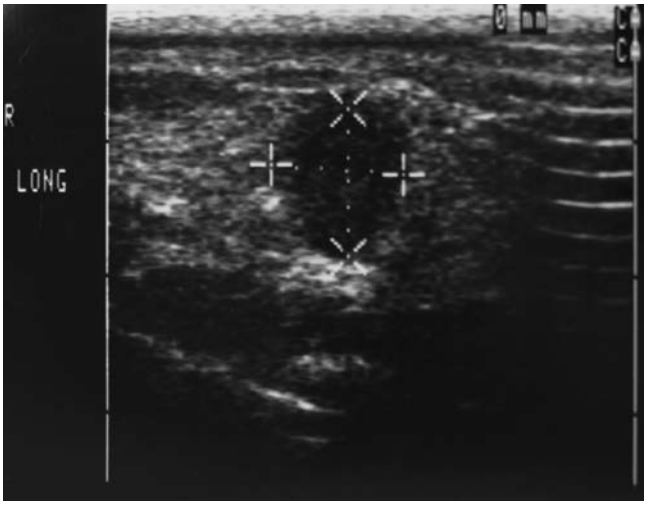



**A**




**B**

**FIGURE 7-7** **(A)** Note positioning of the focal zone (*arrowhead*) and labeling of the image. When using the single focal zone, placing it close to the lesion for maximum resolution is helpful. Depending on the size of lesion, multiple focal zones may be needed. The 10 o'clock position can encompass a significant amount of tissue in some patients; therefore, giving an approximate distance from the nipple (or describing a zone) can be helpful particularly if a follow-up ultrasound is recommended. **(B)** Note focal zone position, field of view and labeling of image.

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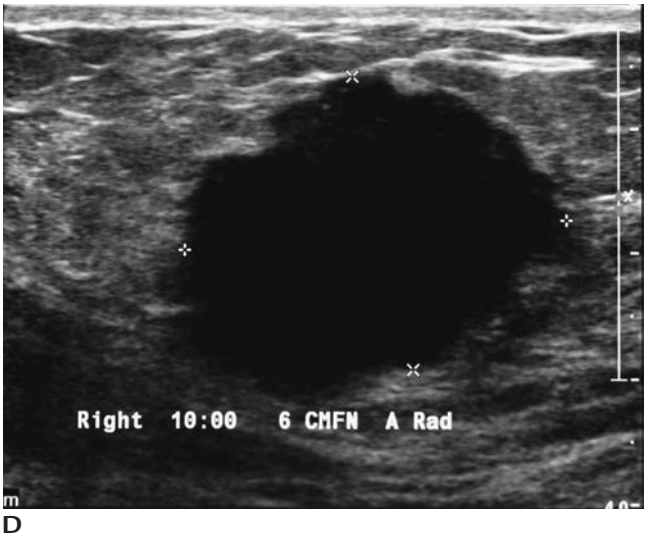



D

**FIGURE 7-7** (*Continued*) **(C)** Note overall image quality. No focal zones could be identified on this image. Also, other than stating which breast is being imaged (*R*) and the orientation of the transducer (*LONG*), there is no reference to the location of the lesion in the breast. **(D)** Note the field of view on this image. Ideally the field of view should reach the chest wall and you should be able to establish if there is associated shadowing or enhancement deep to the lesion. If a lesion is palpable, this should be annotated on the image (in addition to the location of the lesion and the scan plane).

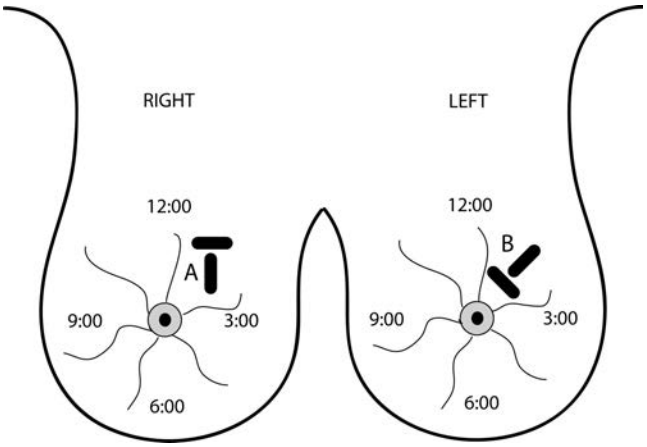



**FIGURE 7-8** Frontal diagram of the breasts illustrating the o'clock positions in the right and left breasts, the sagittal and transverse **(A)** or radial and antiradial **(B)** planes commonly used when scanning.

## NORMAL ANATOMY

### KEY FACTS

- Unlike fat elsewhere in the body, fat in the breast is hypoechoic relative to glandular tissue.

  In mammographically dense tissue, ultrasound is helpful because hypoechoic lesions are readily discernible from adjacent relatively hyperechoic glandular tissue.

  In mammographically fatty tissue, even lesions measuring 1 to 2 cm may not be apparent on ultrasound because the echo texture of the lesion may not be significantly different from that of the surrounding fat (e.g., the lesion is isoechoic with surrounding tissue).

  Subtle diffusely increased tissue echogenicity with loss of normal soft tissue planes can be seen normally in women who are lactating.

  Diffusely increased tissue echogenicity with loss of normal soft tissue planes (e.g., loss of visualization of Cooper's ligaments) may be difficult to establish; however, comparison with the contralateral side is helpful. This may be seen in patients post trauma (see Figure 15-61B), or those with an ongoing inflammatory condition or congestive heart failure and associated edema.
- Skin.

  With the stand off pad (placing the skin in the correct depth of focus for the transducer), the skin is characterized by a hypoechoic central area sandwiched between two echogenic bands measuring approximately 1 to 3 mm in width.

  Early in the development of sebaceous cysts, a hypoechoic mass may be imaged thickening the skin.

As the lesion enlarges, the echogenic deep dermal layer may be disrupted.

Skin thickening that may be associated with dilated subdermal lymphatics (interstitial fluid collections) and hyperemia may be seen with edema from any cause (e.g., postradiation therapy, congestive heart failure, inflammatory conditions, locally advanced breast cancer, inflammatory carcinoma).

- Nipple.

  Can generate significant shadowing; need to angle transducer to evaluate subareolar area.

  Can be made to simulate a solid mass.

- Ribs.

  Depending on how the transducer is held, and the orientation of the underlying ribs, these may be seen as linear hyperechoic bands with posterior acoustic shadowing or as oval, repeating hypoechoic masslike areas. A novice may mistake the latter for a lesion. In fact, ribs can serve as a good example for patients who want to see what a "tumor" looks like or how a tumor differs from a cyst.

- Pectoral muscles.

  Pectoralis major and minor muscles seen as one.

  Hypoechoic bands of variable widths with specular echoes overlying ribs; as the transducer is rotated, the specular echoes elongate to form thin parallel echogenic bands in the muscles.

  Thin hyperechoic line on surface of muscle represents the deep pectoral fascia overlying the pectoral muscles and separates muscle from overlying breast tissue.

- Ligaments.

  Hyperechoic bands of variable thickness crisscrossing breast tissue more readily apparent in the fatty breast.

  May generate areas of irregular shadowing; compression and transducer movements are needed to eliminate this shadowing (distinguishing it from a lesion).

- Lymph nodes.

  Well-circumscribed, hypoechoic mass with hyperechogenic focus (fatty hilum).

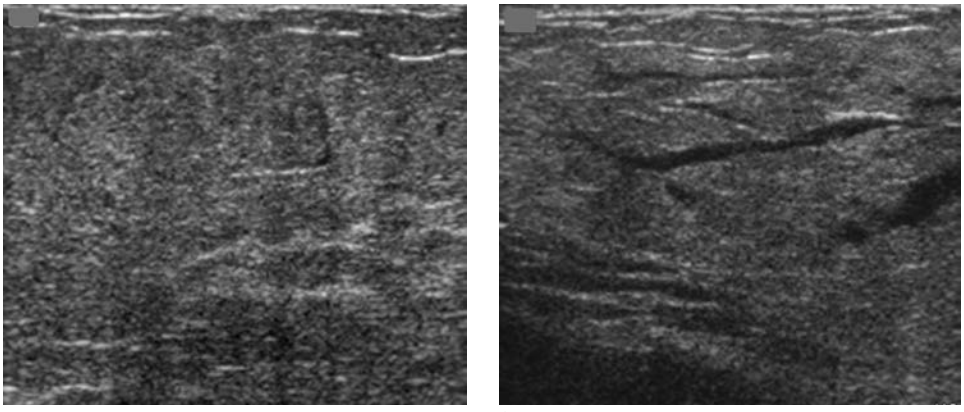
- Tissue.

  Bundles of fatty and glandular tissue interposed among fibrous bands (Cooper's ligaments).

  Depending on how the transducer is held, tissue bundles can be seen longitudinally or as potential masses when viewed in a cross-section (as the transducer is rotated 90°). When a potential lesion is seen, rotate the transducer over it. If it is a "pseudolesion," it will take on a longitudinal appearance and fuse with surrounding tissue. If it is a true lesion, it will maintain its rounded or oval shape, remaining distinct from surrounding tissue.

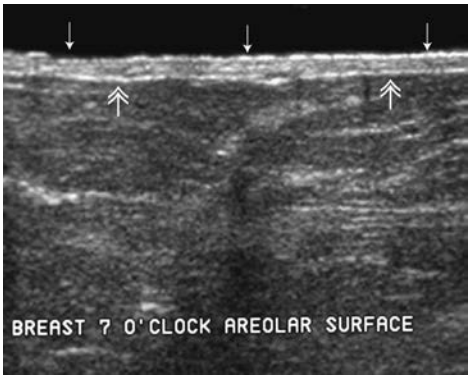
  May see ductal structures when imaging close to the nipple.

  If ducts are traced away from the nipple, they thin out and can sometimes be seen connecting to small hypoechoic masses (presumably acini).



**A** **B**

**FIGURE 7-9** **(A)** Homogeneously hyperechoic tissue in lactating patient. In these women, the demarcation of tissue bundles by Cooper's ligaments is either absent or less apparent. **(B)** Minimally dilated ducts coursing through homogeneously hyperechoic tissue in a woman who is lactating. The degree of ductal distension seen in these patients varies depending on when the last breast feeding or pumping occurred.

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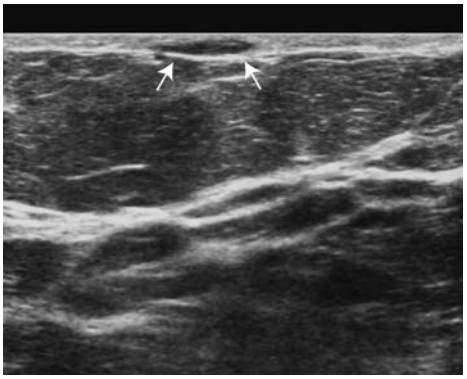

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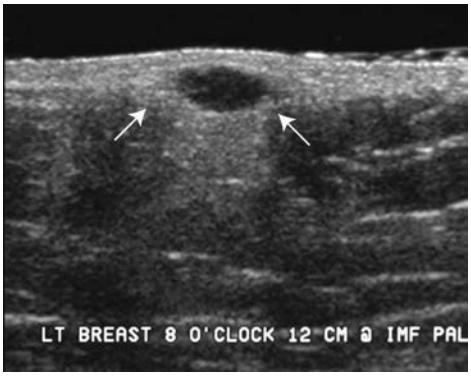
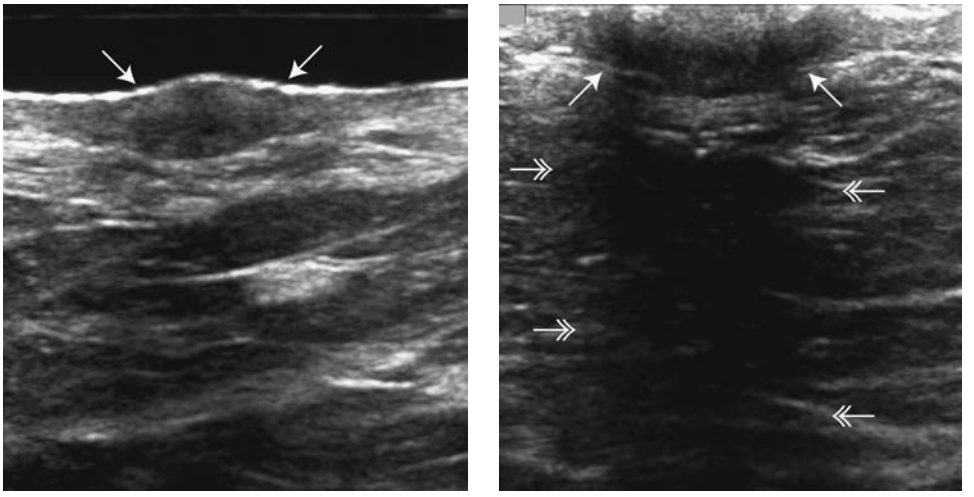


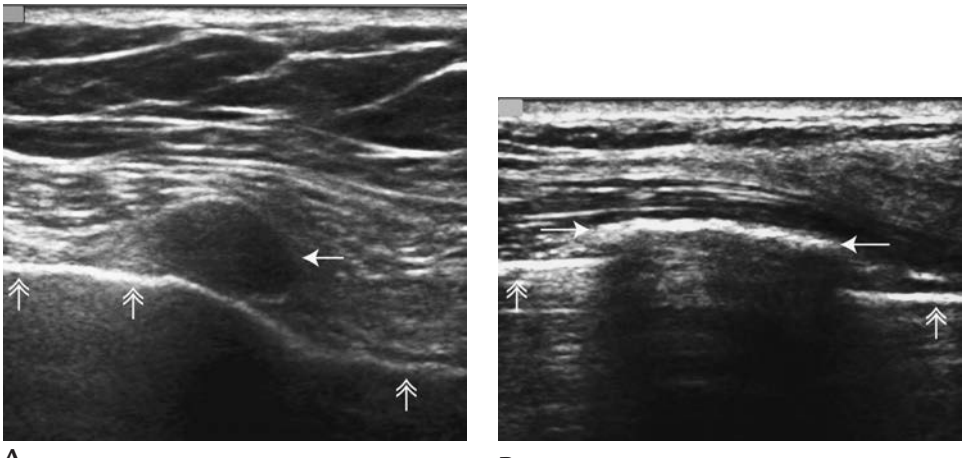

C

**FIGURE 7-10** **(A)** Normal skin is 1 to 2 mm thick and is characterized by a hypoechoic band sandwiched between two echogenic lines: the superficial (*arrows*) and deep (*double headed arrows*) dermal layers. **(B)** Patient presenting with discreet, superficial palpable mass. An oval hypoechoic mass (*arrows*) is imaged contained in the dermis consistent with a sebaceous cyst. At this time the deep dermal layer is intact. **(C)** Patient presenting with a discreet, raised, superficial mass. On physical examination, this moves with the skin. An oval hypoechoic mass arising in the dermis is imaged corresponding to the palpable finding. In this patient, the deep dermal layer is disrupted and the echogenicity of the tissue deep to the lesion is increased consistent with an ongoing inflammatory change (*arrows*). In all of these patients, a stand off pad is used for optimal evaluation of the skin and underlying subcutaneous tissue.



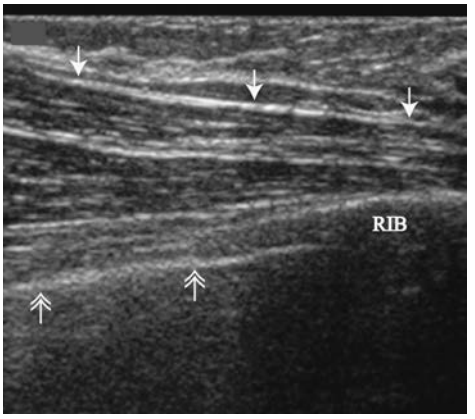
**A** **B**

**FIGURE 7-11** Nipple. **(A)** In some patients, the nipple can simulate a mass (*arrows*). **(B)** In other patients, the nipple (*arrows*) can produce a significant amount of shadowing (*double headed arrows*). Angling the transducer around the nipple may be needed to distinguishing this artifactual shadowing from a subareolar lesion.



**A** **B**

**FIGURE 7-12** Ribs. **(A)** In cross-section, ribs are imaged as repeating oval, circumscribed, hypoechoic masses (*arrow*) deep to the pectoral muscle. Pleura is seen as an echogenic line (*double headed arrows*) deep to the ribs. Pectoral muscle is imaged overlying the ribs. Bundles of predominantly fatty tissue are imaged demarcated by Cooper's ligaments (echogenic lines coursing through tissue). **(B)** When imaged longitudinally, the rib appears as an echogenic line (*arrows*) with associated shadowing. Pleura (*double headed arrows*) is seen as an echogenic line interrupted by the shadowing created by the rib. Pectoral muscle is imaged overlying the rib.

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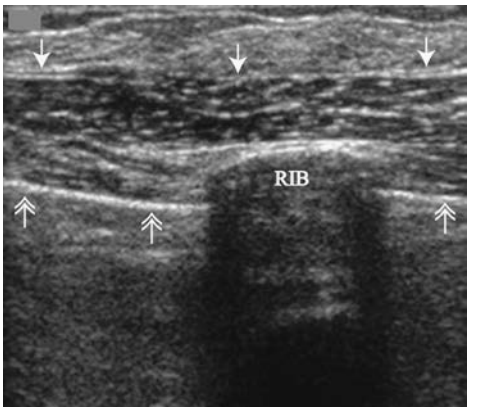
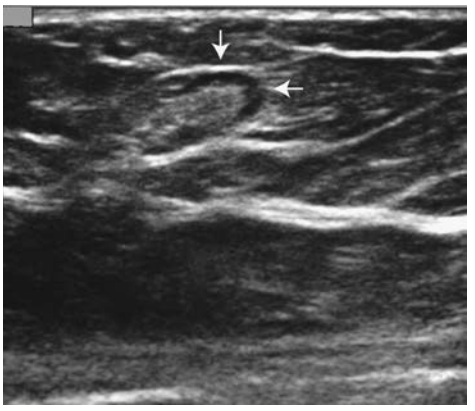



B

**FIGURE 7-13** Pectoral muscle. **(A)** The pectoral muscle is hypoechoic. In this orientation of the transducer, parallel echogenic striations are noted in the substance of the muscle. The deep pectoral fascia (*arrows*) serves to delineate the pectoral muscle from overlying breast tissue. A longitudinally oriented rib with associated shadowing is imaged. The pleura is seen as an echogenic line (*double headed arrows*) deep to the pectoral muscle. **(B)** The pectoral muscle is hypoechoic. As the transducer is rotated, the parallel linear striations become round and punctate foci of echogenicity in the substance of the muscle. The deep pectoral fascia (*arrows*) serves to delineate the pectoral muscle from overlying breast tissue. The rib is associated with shadowing that interrupts visualization of the pleura (*double headed arrows*).



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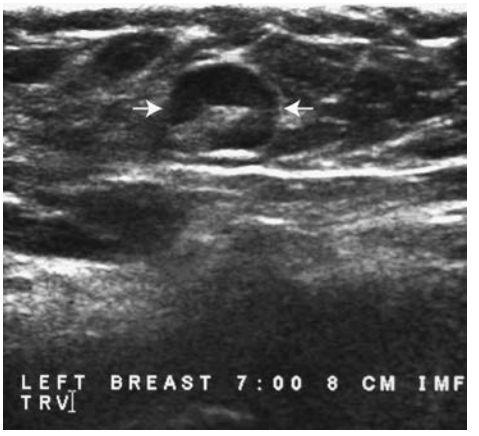
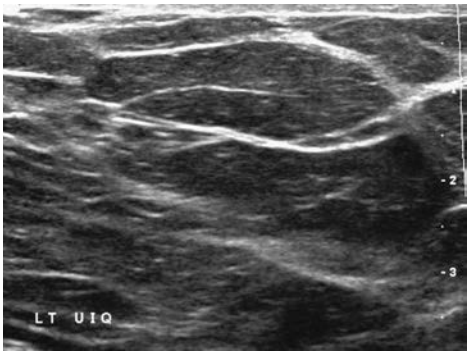
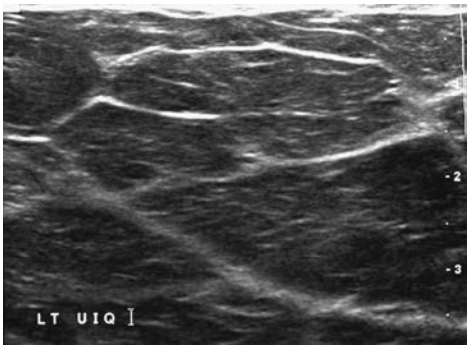



B

**FIGURE 7-14** Lymph nodes. **(A)** Oval mass (*arrows*) with circumscribed margins characterized by a hypoechoic cortex and a central oval area of hyperechogenicity. **(B)** Round hypoechoic mass (*arrows*) with circumscribed margins and an eccentric oval area of hyperechogenicity consistent with an intramammary lymph node. This is in the lower inner quadrant of the left breast. Although more common in the upper outer quadrants, intramammary lymph nodes can occur anywhere in the breast including, as in this patient, medially.




**A**




**B**

**FIGURE 7-15** Fatty tissue. **(A)** Bundles of hypoechoic tissue surrounded and delineated by echogenic Cooper's ligaments. **(B)** Bundles of fatty tissue delineated by Cooper's ligaments in a patient with predominantly fatty tissue mammographically.

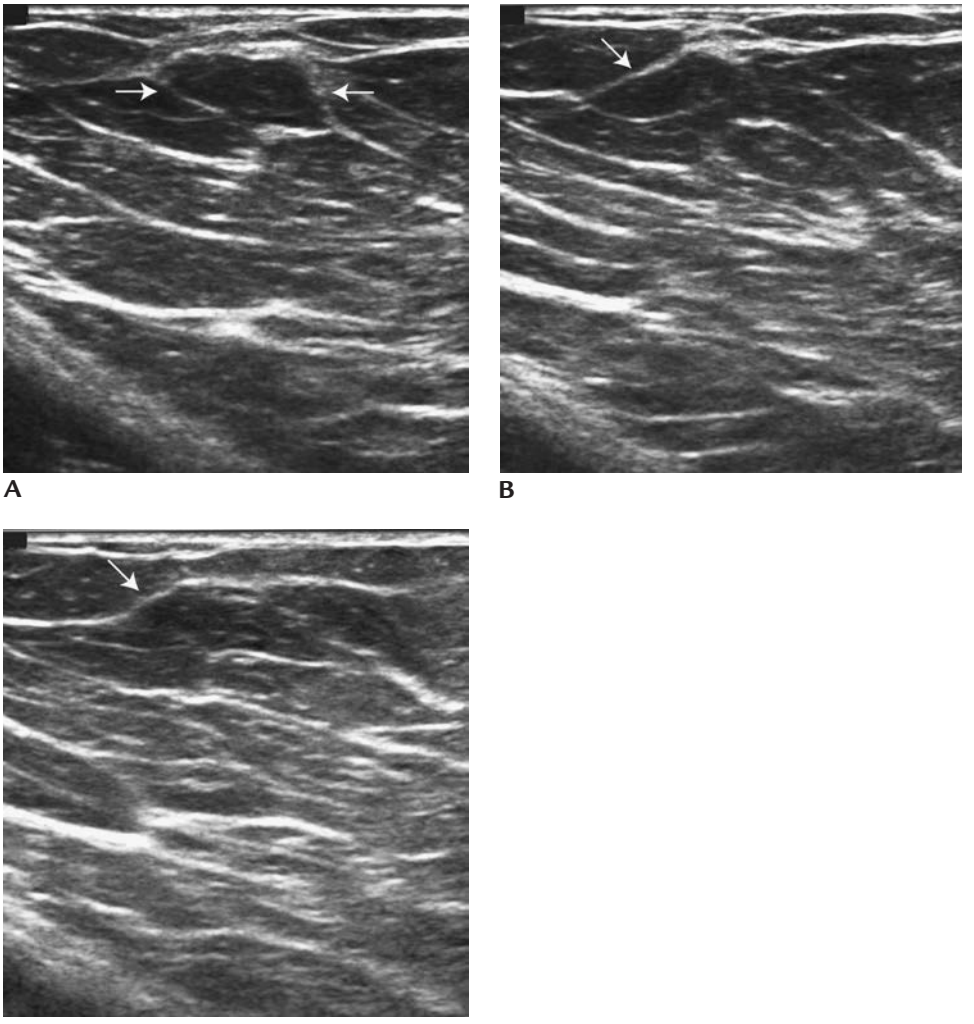
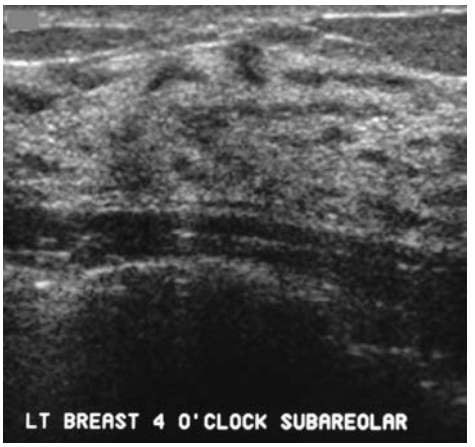


**FIGURE 7-16** Pseudolesion. **(A)** In a cross-section, a fatty tissue bundle delineated by a Cooper's ligament is imaged as an oval, masslike area (*arrows*). **(B)** As the transducer is slowly rotated over this area, the appearance of the tissue changes and the possible mass (*arrow*) starts to elongate becoming less well defined. **(C)** After a 90° rotation of the transducer over the area, a mass is no longer apparent (*arrow*). As the transducer is rotated, a true lesion will maintain its shape and appearance. In contrast, fatty lobulation will demonstrate significant changes in appearance.

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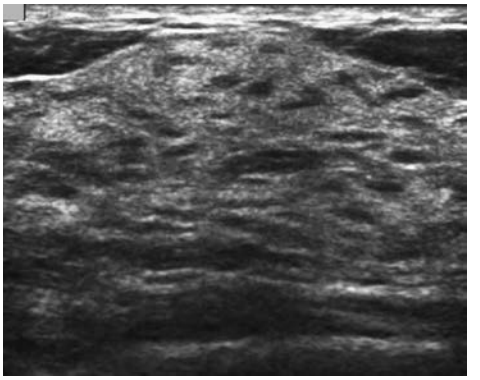


B

**FIGURE 7-17** Dense tissue. **(A)** Fibroglandular tissue is often characterized by the presence of round, oval, or elongated areas of hypoechogenicity in a more echogenic background. **(B)** A fibrous ridge of tissue extending subcutaneously flanked by two fatty lobules. In some patients, these ridges can be discreetly palpable.

## Benign Characteristics (Solid Masses)

### Key Facts

- Hyperechogenicity.
  Most hyperechoic masses are benign (rare exceptions).
  Tissue that is hyperechoic relative to subcutaneous fat is commonly fibrous tissue.
  In some patients fibrous ridges may be palpable.
  Areas of fibrocystic change (fibrocystic complex) are hyperechoic with small (<0.5 cm) hypoechoic or anechoic nodules; these may also be palpable.
  Lipoma.
- Circumscribed margins.
- Oval shape.
- Parallel orientation; long axis of lesion parallels skin (wider than tall; horizontal; sagittal and transverse dimension greater than anteroposterior dimension).
- Gentle bi- or trilobulation.
- Thin echogenic pseudocapsule.
  Slow growing lesions.
  Real-time scanning (in different directions, moving the transducer back and forth along different planes) is usually needed to document complete "pseudocapsule."

- Negative predictive value for sonographically benign classification of 99.5% reported by Stavros.

  Approximately 1.6% of malignant lesions were misclassified as benign.

  By excluding nodules with even one malignant-type finding, the reported sensitivity is 98.4%.

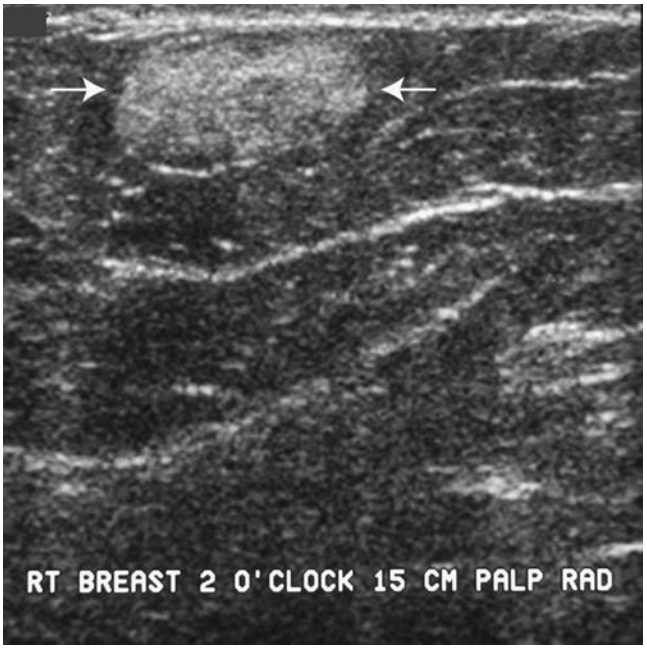



**FIGURE 7-18** Oval, hyperechoic mass (*arrows*) consistent with a benign finding.

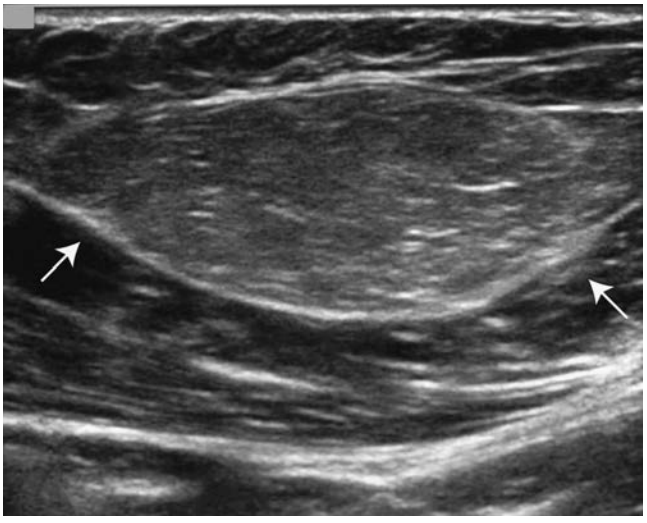


**FIGURE 7-19** Lipoma. Oval, circumscribed mass (*arrows*) with slightly increased echogenicity.

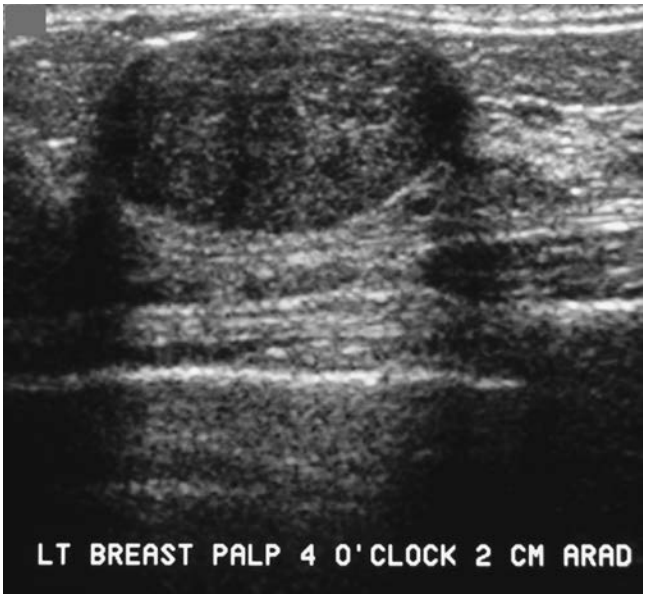



**FIGURE 7-20** Fibroadenoma. Oval, hypoechoic mass with circumscribed margins and associated posterior acoustic enhancement.

## Intermediate Characteristics (Solid Masses)

### Key Facts

- Isoechogenicity.
  Same echogenic as subcutaneous fat.
  If a palpable or mammographically detected mass is not readily apparent as a cyst sonographically presume it is solid (isoechoic).
- Mild hypoechogenicity.
- No posterior acoustic features (e.g., normal sound transmission).
- Enhanced transmission.
- Heterogeneous echo texture.
- Homogeneous echo texture.

## Malignant Characteristics (Solid Masses)

### Key Facts

- Marked hypoechogenicity.
  May be a particularly prominent feature of abnormal axillary lymph nodes and medullary carcinoma.
- Spiculation.
  Simulates spiculation seen mammographically.
  Hypoechogenic bands (may be thick or thin) radiating perpendicularly from mass.

Malignant characteristic with highest positive predictive value reported by Stavros.

- Orientation not parallel: taller than wide or vertical.
  At least a part of the nodule has a greater anteroposterior dimension than either sagittal or transverse.
  Round.
  Growth across normal tissue planes.
  Low sensitivity, high positive predictive value.
- Angular margins.
  Junction between mass and surrounding tissue.
  Angle may be acute, obtuse, or 90°.
  Reliable sign of malignancy.
- Shadowing.
  Less through transmission of sound than surrounding tissue.
  Present even if mild or incomplete (associated with only part of the mass).
- Microlobulation.
  Many small (1 to 2 mm) lobulations on surface of mass.
- Duct extension.
  Hypoechoic tubelike projection from mass directed radially toward the nipple.
- Branch pattern.
  Hypoechoic tubelike projections extending from a mass directed away from the nipple.
- Calcifications.
  High specular echoes that may be seen as an isolated finding or within a mass or dilated tubularlike structures (presumably ducts).
  May see associated shadowing.
- Enhancement.
  Although most commonly associated with benign lesions, enhancement may be seen with rapidly growing round tumors (poorly differentiated invasive ductal carcinoma not otherwise specified) and with mucinous and intracystic papillary carcinomas.
- Although malignant lesions commonly demonstrate a combination of malignant features, a biopsy is indicated even if only one malignant feature is seen in a mass.

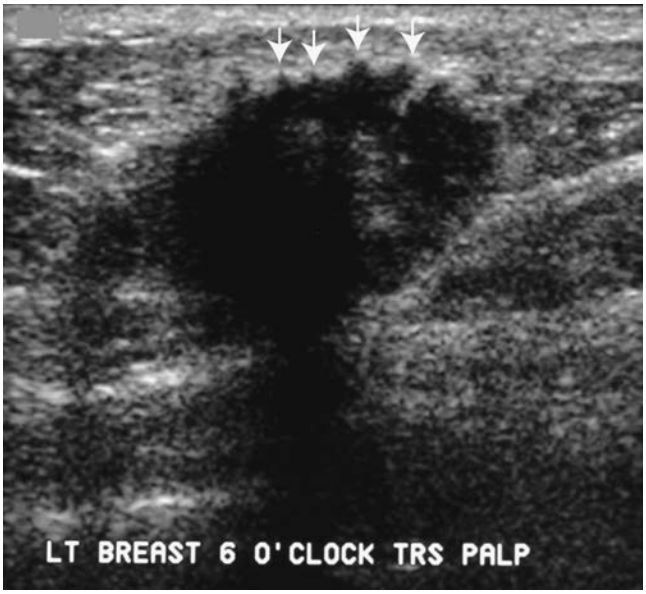



**FIGURE 7-21** Invasive ductal carcinoma. Mass, portions of which are markedly hypoechoic, demonstrates a focal area of intense shadowing. The margins demonstrate lobulation and spiculation (*arrows*). Malignant lesions usually exhibit several of the malignant characteristics (see Fig. 6-7 for mammogram).

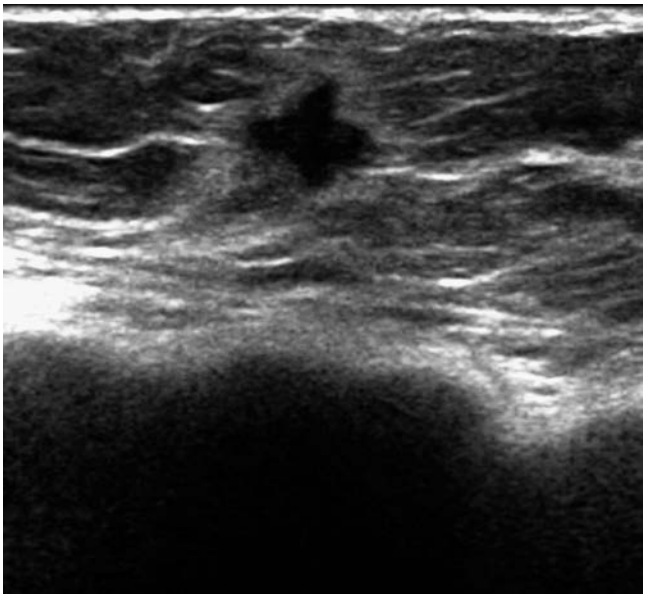


**FIGURE 7-22** Invasive ductal carcinoma. Irregular, vertically oriented mass with angular margins and a thick echogenic rim.

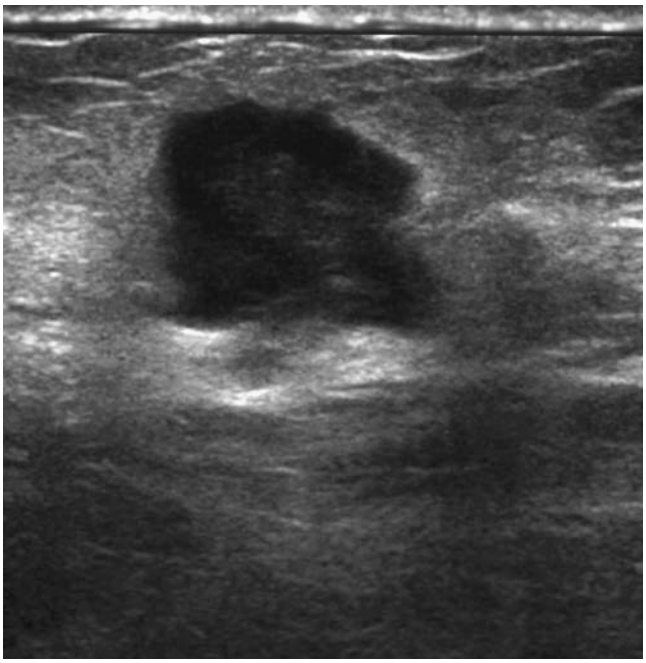


**FIGURE 7-23** Invasive ductal carcinoma. Irregular, vertically oriented hypoechoic mass with angular margins and posterior acoustic enhancement.

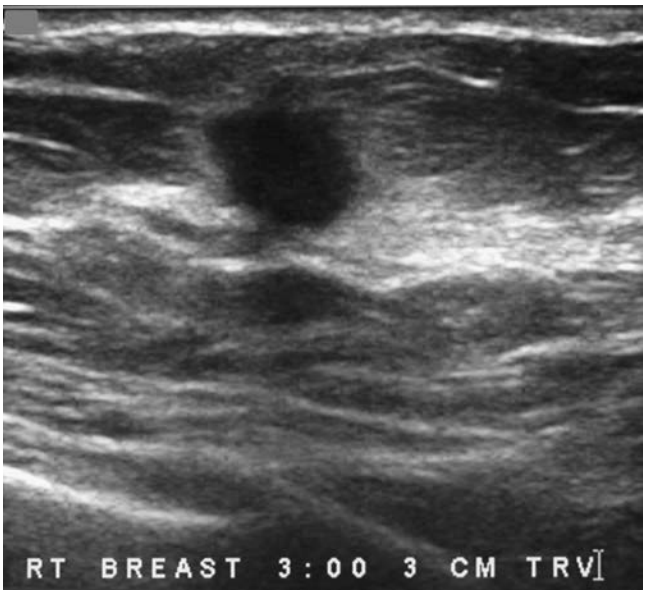



**FIGURE 7-24** Invasive ductal carcinoma. Hypoechoic mass with microlobulated margins and a thick echogenic rim.

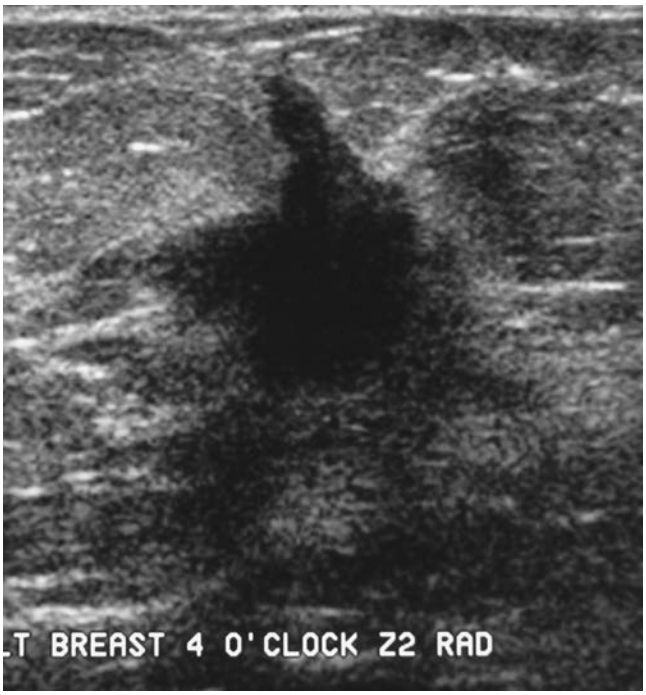



**FIGURE 7-25** Invasive ductal carcinoma. Irregular hypoechoic mass with indistinct and angular margins and associated posterior acoustic shadowing.

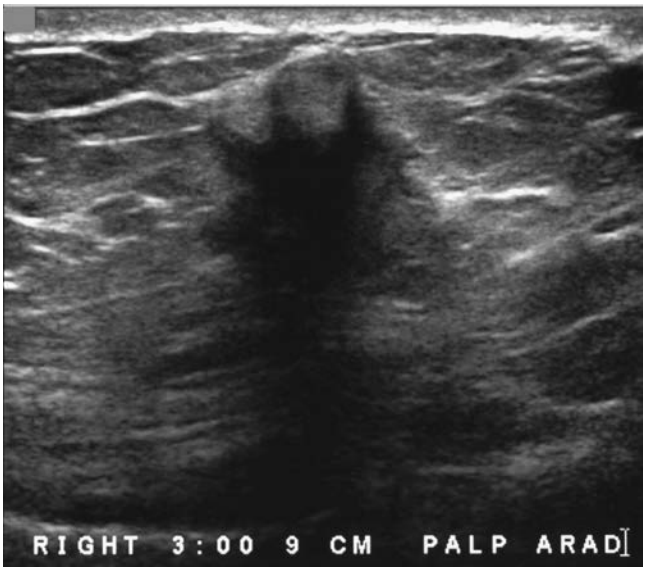



**FIGURE 7-26** Invasive lobular carcinoma. Irregular, vertically oriented mass with indistinct, spiculated, and angular margins, as well as associated shadowing. As in this patient, invasive lobular carcinoma is sometimes characterized by intense shadowing.

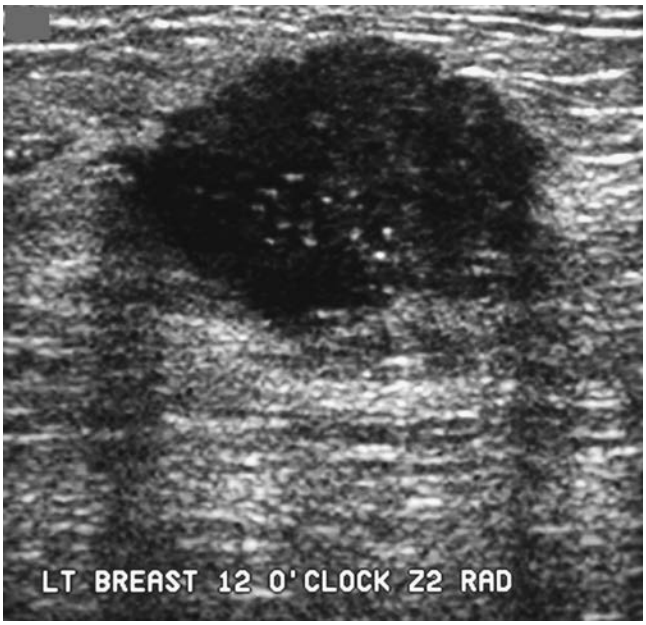



**FIGURE 7-27** Invasive ductal carcinoma with associated ductal carcinoma in situ (DCIS). Oval, hypoechoic mass with lobulated margins and some posterior acoustic enhancement. Multiple echogenic foci within the mass are consistent with calcifications reflecting the presence of associated DCIS.

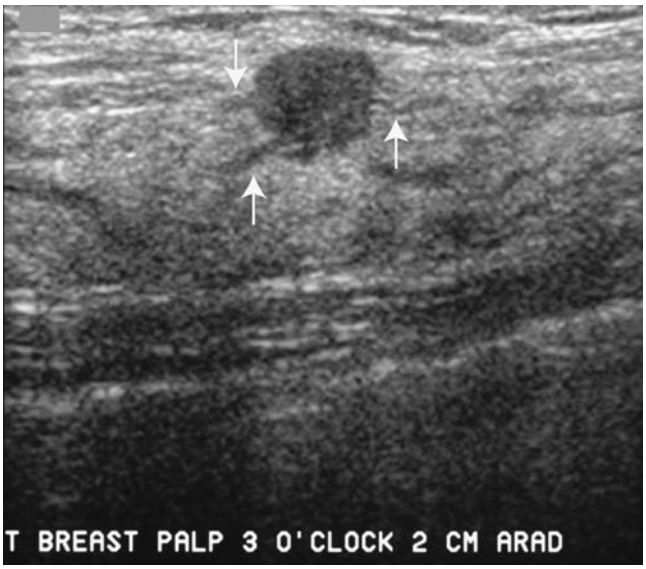
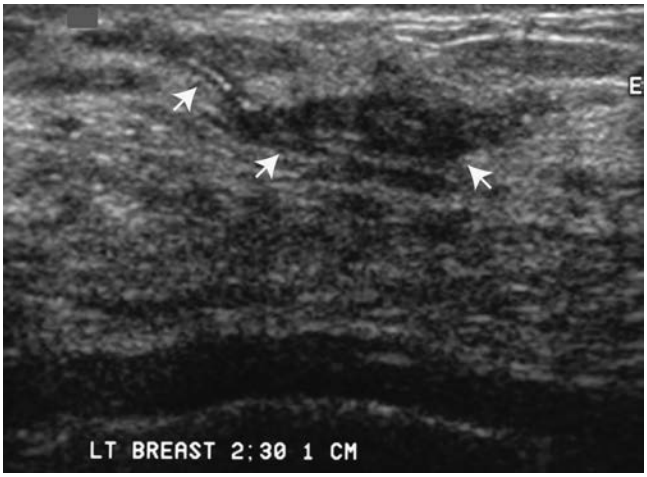



**FIGURE 7-28** Invasive ductal carcinoma. Round hypoechoic mass with circumscribed margins and posterior acoustic enhancement. Hypoechoic tubular processes (*arrows*) are present extending towards the nipple and away from the nipple consistent with duct extension and branch pattern, respectively.

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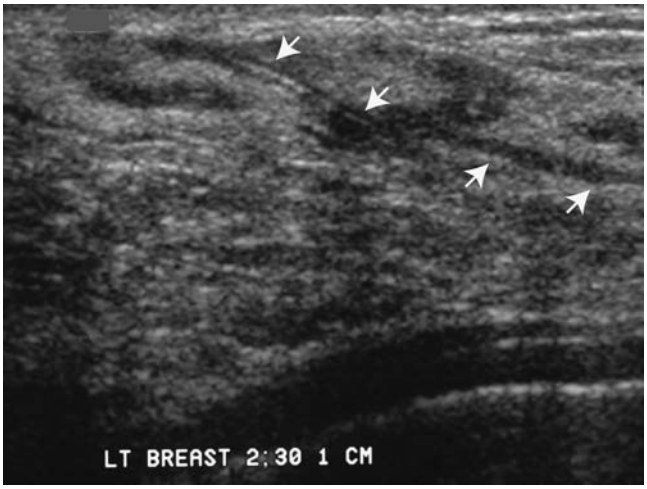



**B**

**FIGURE 7-29** Ductal carcinoma in situ. **(A,B)** Hypoechoic tubular structures (*arrows*) within which echogenic foci (e.g., calcifications) are present.

# American College of Radiology Ultrasound BI-Rads Lexicon

## Key Facts

- Mass.
  Seen in two different projections.
  Shape.
    Oval: elliptical (may have gentle undulations, macrolobulations).
    Round: anteroposterior and transverse diameters equal.
    Irregular (mass is not round or oval).
  Orientation: skin is reference point.
    Parallel: long axis of mass is parallel to skin ("wider than tall," horizontal).
    Not parallel: long axis not parallel to skin ("taller than wide," vertical, round).
  Margin.
    Circumscribed.
    Not circumscribed: indistinct, angular, microlobulated OR spiculated (more than one term may be used).
  Lesion boundary: transition between lesion and surrounding tissue.
    Abrupt interface.
    Echogenic halo.
  Echo pattern: relative to fat.
    Anechoic.
    Hyperechoic.
    Complex: mass contains both anechoic and echogenic components.
    Hypoechoic.
    Isoechoic.
  Posterior acoustic features.
    No posterior acoustic features.
    Enhancement.
    Shadowing.
    Combined pattern (enhancement and shadowing).
  Surrounding tissue (more than one may apply).
    Duct changes.
    Cooper's ligament changes.
    Edema.
    Architectural distortion.
    Skin thickening.
    Skin retraction/irregularity.
- Calcifications.
  Macrocalcifications ($\geq$0.5 mm in size).
  Microcalcifications out of mass ($<$0.5 mm in size, do not occupy entire acoustic beam and do not shadow).
  Microcalcifications in mass.

- Special cases.
  Clustered microcysts.
  Complicated cysts.
    Low level internal echoes.
    Fluid-fluid or fluid-debris levels.
  Mass in or on skin.
  Foreign body.
  Lymph nodes: intramammary.
  Lymph nodes: axillary.
- Vascularity.
  Not present or not assessed.
  Present in lesion.
  Present immediately adjacent to lesion.
  Diffusely increased vascularity in surrounding tissue.
- Assessment categories.
  Category 0: need additional imaging evaluation.
  Category 1: negative.
  Category 2: benign finding(s).
  Category 3: probably benign finding-short interval follow-up suggested.
  Category 4: suspicious abnormality, biopsy should be considered.
  Category 5: highly suggestive of malignancy, appropriate action should be taken.
  Category 6: known malignancy (biopsy proven): appropriate action should be taken.

## ULTRASOUND ARTIFACTS

### KEY FACTS

- Image distortion is related to variation in the speed of sound waves.
  Ultrasound units assume the speed of sound is the same in different tissue types. However, the speed of sound in fat is 1,450 m/sec and 1,540 m/sec in soft tissue.
  Therefore, traveling through fat takes longer than traveling through soft tissue. Increased transmission time means increased distance; the object appears deeper than it may actually be if different tissue types are crossed by the beam.
  If the speed is greater than 1,540 m/sec, then the object may appear foreshortened.
- Phantom images related to refraction.
  These are generated because of the assumption that the ultrasound beam travels in a straight line.
  If the beam is refracted and then strikes a reflecting object, the echo retraces its oblique path back to the transducer. However, the object is

displayed at an appropriate distance directly down from the transducer because it assumes that the beam traveled a straight line.

- Blurring related to finite beam width.

  The width of the ultrasound beam at a particular depth determines blurring. Objects smaller than the ultrasound beam appear larger. The size seen depends on the width of the beam at the depth of the lesion. The object is sharpest and most narrow (closest to its actual size) when the depth of the object is at the focal depth for the transducer; this is the narrowest point for the beam.

- Distorted images at interfaces are related to finite beam width.

  At an interface, two regions of a structure are at different depths. These echoes are treated as though arising from one position along central axis of beam.

  The image depicts echo sites directly behind one another when in fact they are not. The interface is therefore distorted.

- "Fill-in," partial volume effect is related to finite beam width.

  Echoes are detected from areas outside the central beam axis.

  This is why small cysts contained entirely in the beam width may not be seen at all or may contain internal echoes. The acoustic properties of cysts differ from those of adjacent tissue, and partial volume effect occurs.

- Reverberation.

  This is due to impedance mismatch between the transducer and the patient's skin. Part of the beam is reflected back into patient.

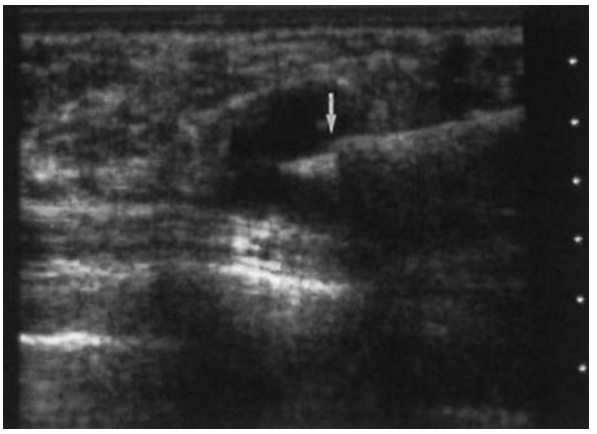
  There are two interfaces within the breast. Echoes from the two interfaces, displayed correctly, are followed by repeating artifactual echoes separated by equal distances (the distance between the interfaces) decreasing in amplitude.

  These reverberation artifacts can result in "filling in" of cysts and mirror images.

- Posterior acoustic enhancement and shadowing, although useful in evaluating lesions, can also be considered artifactual.

  It is assumed that the same TGC curve is applicable to all scan lines generating an image.

  However, this is not necessarily true when scanning through a cyst (i.e., nonattenuating compared with surrounding tissue) or when scanning through an infiltrating lobular carcinoma (lesions that can significantly attenuate the sound beam compared with surrounding tissue).



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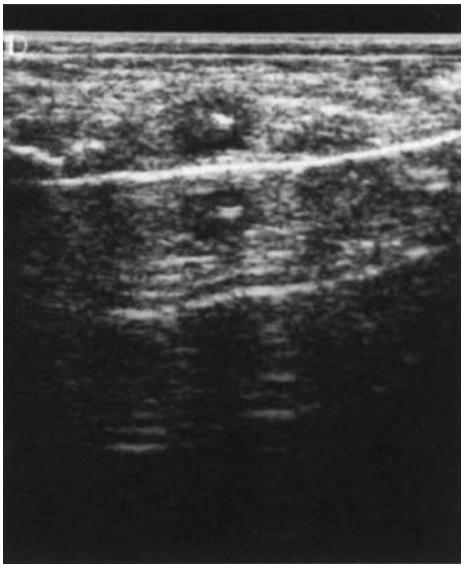


**B**

**FIGURE 7-30** Ultrasound artifacts. **(A)** Bayonet sign. Given differences in the speed of sound between tissue and cyst fluid the needle appears broken *(arrow)*. This confirms the presence of the needle within the fluid filled structure. If not seen, the needle may still be in the cyst; if seen, however, one is certain that the needle is in the cyst. **(B)** Mirror image artifact due to reverberation. Ultrasound of specimen. Appearance suggests two lesions.

## SUGGESTED READINGS

American College of Radiology. *ACR Practice Guidelines for the Performance of a Breast Ultrasound Examination*. Reston: American College of Radiology; 2006.

American College of Radiology. *Breast Imaging Reporting and Data System (BI-RADS)*. 4th ed. Reston: American College of Radiology, 2003.

Baker JA, Soo MS. Breast US: assessment of technical quality and image interpretation. *Radiology*. 2002;223:229–238.

Bassett LW, Kimme-Smith C. Breast sonography. *AJR Am J Roentgenol*. 1991;156: 449–455.

Goodsitt MM. Chapter 29: Ultrasound instrumentation and the A, B, M's of ultrasound. In: Taveras JM, Ferrucci JT, eds. *Radiology, Diagnosis-imaging-intervention*. Philadelphia: JB Lippincott; 1993.

Gordon PB, Gilks B. Sonographic appearance of normal intramammary lymph nodes. *J Ultrasound Med*. 1988;7:545–548.

Jackson VP. The role of US in breast imaging. *Radiology*. 1990;177:305–311.

Jokich PM, Monticciolo DL, Adler YT. Breast ultrasonography. *Radiol Clin North Am*. 1992;30:993–1009.

Kimme-Smith C, Rothchild PA, Bassett LW, et al. Ultrasound artifacts affecting the diagnosis of breast masses. *Ultrasound Med Biol*. 1988;14(suppl):203–210.

Kolb TM, Lichy J, Newhouse JH. Occult cancer in women with dense breasts: detection with screening US-diagnostic yield and tumor characteristics. *Radiology*. 1998;207:191–199.

Parikh JR, Cardenosa G, Coll D, et al. Chapter 30: Breast ultrasound. In: Taveras JM, Ferrucci JT, eds. *Radiology, Diagnosis-imaging-intervention*. Philadelphia: JB Lippincott; 1993.

Stavros AT. *Breast Ultrasound*. Philadelphia: Lippincott Williams & Wilkins; 2004.

Stavros AT, Thickman D, Rapp CL, et al. Solid breast nodules: use of sonography to distinguish benign and malignant lesions. *Radiology*. 1995;196:123–134.

Stavros AT, Dennis MA. *An introduction to breast ultrasound*. In: Parker SH, Jobe WE, eds. *Percutaneous Breast Biopsy*. New York: Raven Press; 1993:95–109.

Stavros AT, Dennis MA. The ultrasound of breast pathology. In: Parker SH, Jobe WE, eds. *Percutaneous Breast Biopsy*. New York: Raven Press; 1993:111–127.

Venta LA, Dudiak CM, Salomon CG, et al. Sonographic evaluation of the breast. *RadioGraphics*. 1994;14:29–50.

CHAPTER 8

# MAGNETIC RESONANCE IMAGING

## General Comments

### Key Facts

- Magnetic resonance imaging (MRI) is an adjunctive test, not a replacement for high-quality mammography and breast ultrasound.
- MR images are reviewed in conjunction with recent mammogram (and ultrasound, if patient has had one), relevant clinical/surgical history and breast pathology reports (if any).
- Current indications for breast MRI.

  Patients with new diagnosis of breast cancer.

  Extent of disease: multifocality, multicentricity in as many as 20% to 25% of patients. Detection of additional unsuspected disease may alter patient management. As the use of partial breast irradiation increases, the ability to detect the presence of multicentric disease becomes critical.

  Evaluation of contralateral breast: up to 6% of patients are identified with unsuspected cancer in the contralateral breast.

  Lymph nodes (intramammary, axillary, and internal mammary).

  Chest wall involvement.

  Response to neo-adjuvant therapy.

  Tumor size.

  Decreases or loss of previously demonstrated enhancement.

  Although changes may be seen, not always correlated with tumor regression.

  May help identify primary breast cancer in patients presenting with metastatic disease to the axilla and an otherwise undetected primary breast cancer.

  Assessment of residual disease in patients with positive margins following lumpectomy.

  In distinguishing scar tissue from a recurrence at the lumpectomy site.

Screening patients with a high risk of developing breast cancer (e.g., 20% to 25% lifetime risk of breast cancer, BRCA1, BRCA2 gene carriers, history of chest wall radiation).

Evaluation of silicone breast implant, however, clinical significance of implant rupture is controversial.

- Should have access to MR-guided biopsy (or wire localization) capabilities.

  Need to be able to biopsy or excise MR detected lesions, because some of these lesions are not found on ultrasound (e.g., "second look" ultrasound).

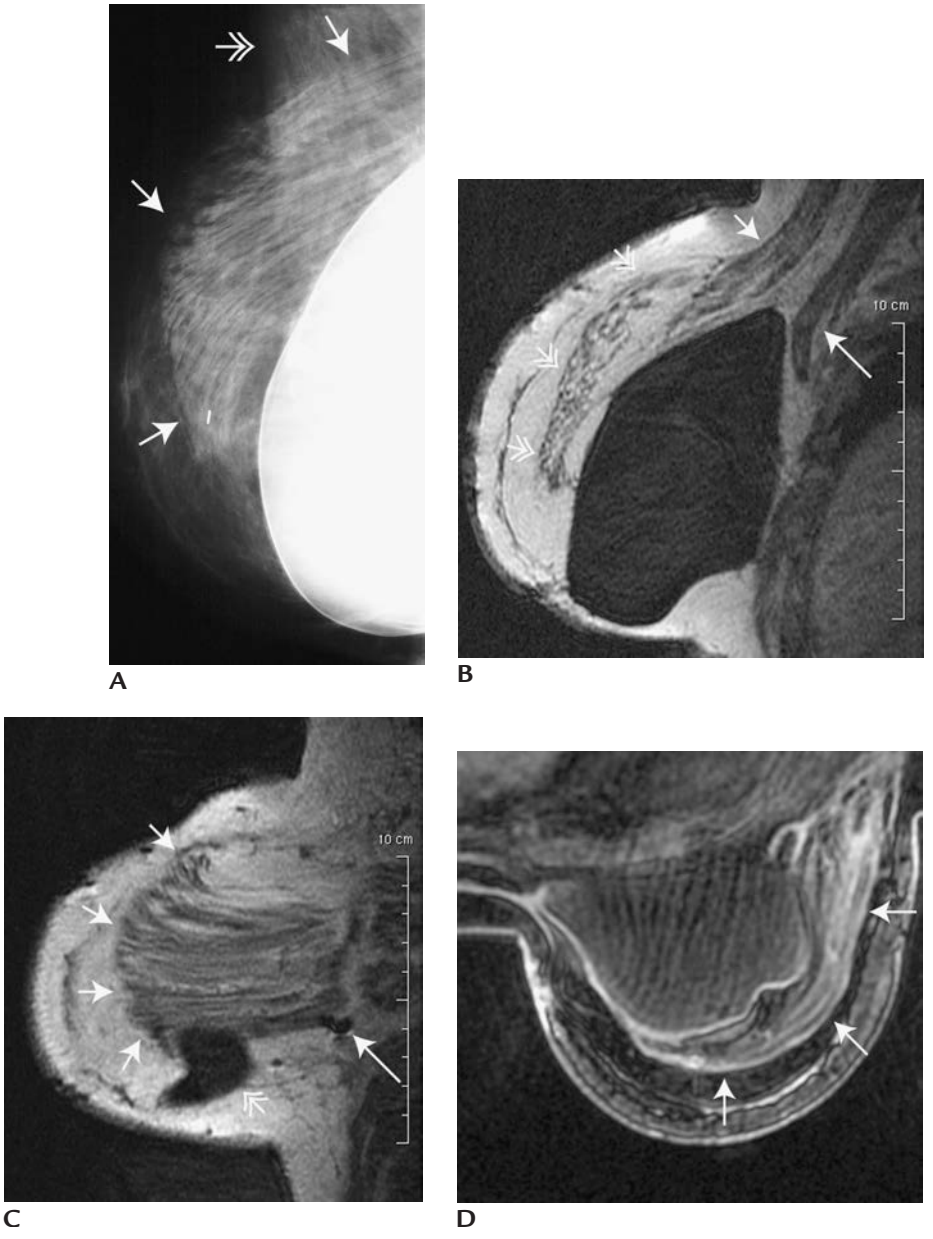



**FIGURE 8-1** Patient with history of right mastectomy with implant and latissimus dorsi flap reconstruction. **(A)** Mediolateral oblique view demonstrating saline implant and latissimus dorsi muscle flap (*arrows*) with characteristic fatty striations superolateral to the implant. Pectoral muscle (*double headed arrow*) is also imaged. **(B)** Sagittal T1-weighted image of right mastectomy site demonstrates implant between pectoralis major (*short arrow*) and minor (*longer arrow*) muscles. Latissimus dorsi muscle flap (*double headed arrows*) can be seen more anteriorly overlying implant. **(C)** Sagittal T1-weighted image of right mastectomy site more laterally demonstrates striations of latissimus dorsi muscle flap (*arrows*) and small portion of implant (*double headed arrow*) inferiorly. Bloom artifact (*long arrow*) from a metallic clip is also apparent. **(D)** Axial, T1-weighted image with fat suppression demonstrates latissimus dorsi muscle flap partially overlying implant laterally. In reviewing breast MRs, it is always helpful to have a recent mammogram (and breast ultrasounds, if any are available) and relevant clinical and surgical history, as well as any breast pathology reports.

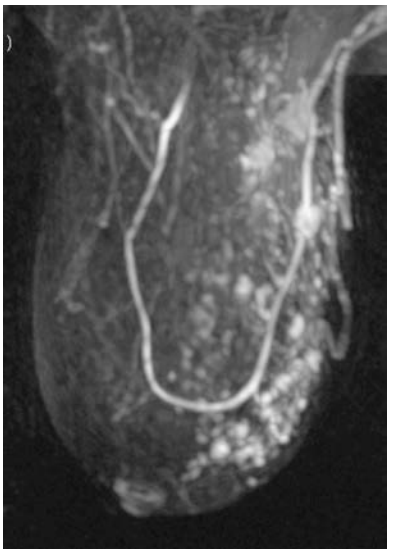
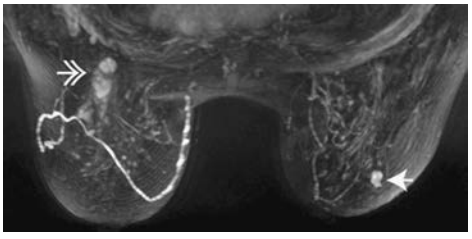
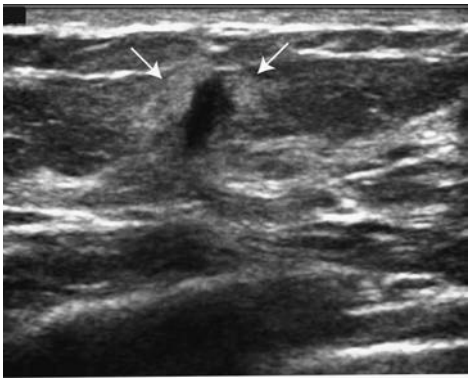


**FIGURE 8-2** Maximum intensity projection. Patient with two masses in the upper inner quadrant of the left breast. Dense tissue mammographically; two hypoechoic masses corresponding to the palpable findings and possibly a third in the subareolar area are identified with ultrasound. MRI demonstrates more extensive disease than suspected with many enhancing masses present in the medial quadrants of the left breast (e.g., multicentric disease). No abnormality is identified in the contralateral breast.



A



B

**FIGURE 8-3** Evaluation of patient with newly diagnosed invasive ductal carcinoma in the left breast. **(A)** Maximum intensity projection. Patient with known, biopsy proven, invasive ductal carcinoma in the left breast (*double headed arrow*). Enhancing mass (*arrow*) identified anteriorly in the right breast. **(B)** Markedly hypoechoic, vertically oriented mass (*arrows*) with echogenic rim identified with ultrasound at the expected location of the MR finding. Invasive ductal carcinoma on ultrasound-guided biopsy.

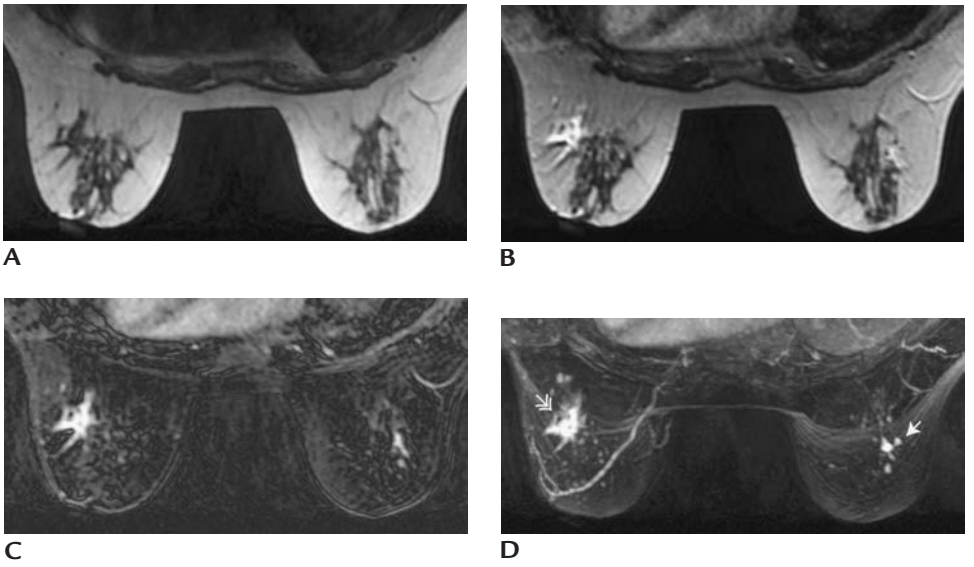



**FIGURE 8-4** Evaluation of patient with newly diagnosed invasive lobular carcinoma in the left breast. **(A)** T1-weighted, axial image pre-contrast. **(B)** T1-weighted image immediately following the contrast bolus; same slice as that shown in A. **(C)** Subtraction image at same slice as shown in A and B. **(D)** Maximum intensity projection. Irregular spiculated mass (*double headed arrow*) corresponding to the site of the patients known malignancy in the left breast. Multiple enhancing masses (multifocal) are present in the right breast (*arrow*). These could not be identified on ultrasound. MR guided biopsy yielded lobular carcinoma in situ. Four separate sites (largest measuring 1 cm) of invasive lobular carcinoma and extensive lobular carcinoma in situ are identified at the time of the lumpectomy on the right.

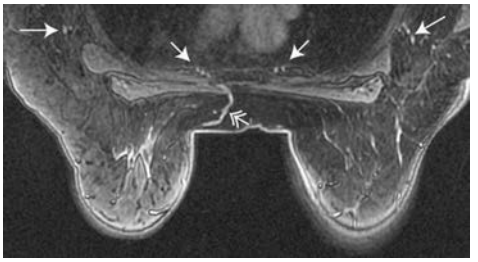


**FIGURE 8-5** Axial T1-weighted image, fat suppression, post-contrast. In this patient, normal appearing axillary lymph nodes are present bilaterally (*long arrows*). Normal right and left internal mammary artery and vein (*short arrows*) with no associated internal mammary adenopathy at this level. Branch (*double headed arrow*) of left internal mammary artery is seen.

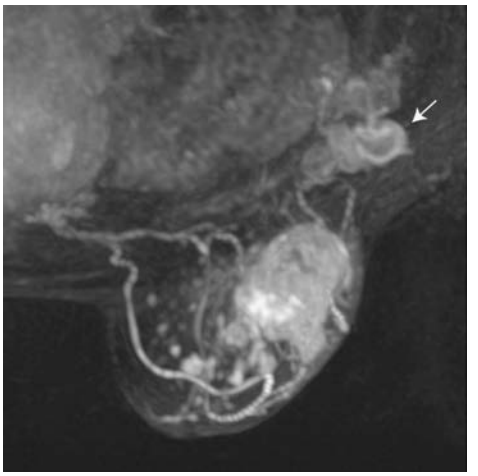


**FIGURE 8-6** Maximum intensity projection. Locally advanced breast cancer. Mass in the right breast with multiple associated satellite masses and enlarged ipsilateral lymph nodes (*arrow*) consistent with metastatic disease.

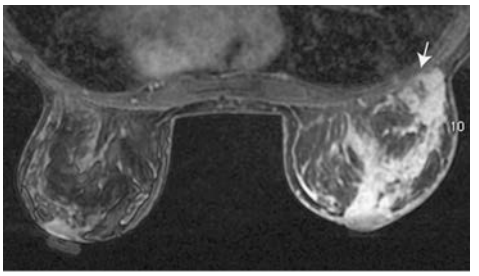
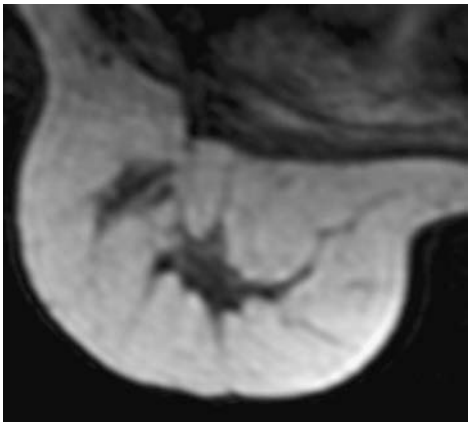


**FIGURE 8-7** Axial T1-weighted image, fat suppression, post-contrast. Locally advanced right breast cancer with associated skin thickening and chest wall invasion (*arrow*).



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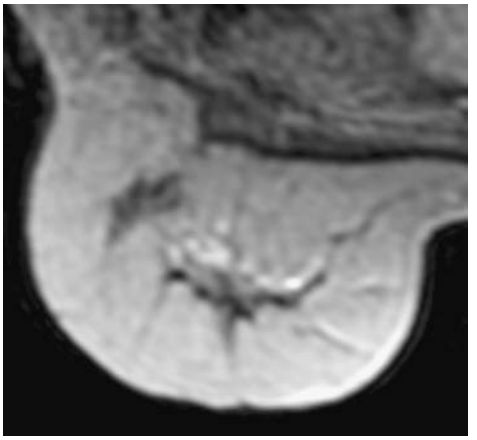

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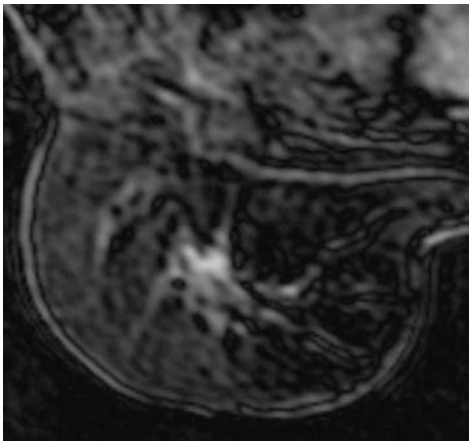


**C**

**FIGURE 8-8** Recurrent invasive lobular carcinoma several years following initial diagnosis. **(A)** Axial T1-weighted image pre-contrast. Low signal intensity mass with spiculated margins at lumpectomy site. **(B)** Axial T1-weighted image immediately following bolus of contrast demonstrates rapid enhancement along posterior edge of lumpectomy site with washout (subsequent images not shown). **(C)** Subtraction image.

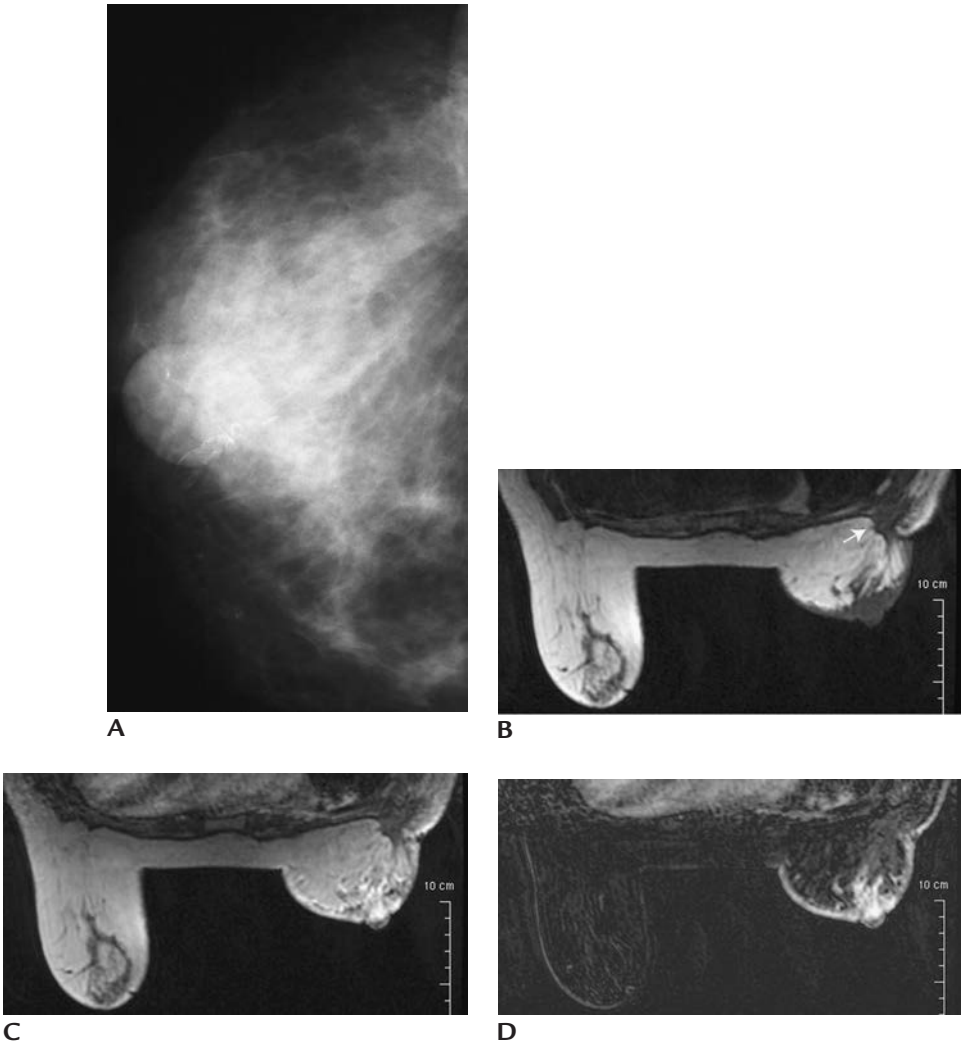



**FIGURE 8-9** Recurrent invasive ductal carcinoma following right lumpectomy. **(A)** Mammogram demonstrates dense tissue. Lumpectomy site posterolaterally is not adequately imaged mammographically (tissue cannot be pulled into image). **(B)** Axial T1-weighted image precontrast demonstrates lumpectomy site (*arrow*) posterolaterally in the right breast. Also apparent is marked skin thickening anteriorly. **(C)** Axial T1-weighted image following bolus of contrast demonstrates rapid initial enhancement of tissue anteriorly in the subareolar area and skin with washout (subsequent images not shown). No enhancement is apparent at the lumpectomy site. **(D)** Subtraction image.

## Technical Considerations

### Key Facts

- Field strength.

  Most advocate the use of at least a 1.5T magnet, although 0.5T to 1.5T is acceptable.

  High field strength.

  High signal to noise ratio with high spatial resolution.

  Magnetic field homogeneity to include both breasts.
- Two-dimensional (2D) versus three-dimensional (3D) techniques.

  2D: excitation of single axial slices.

  3D: excitation of entire breast; breast volume then divided into slices in whichever plane is desired.

  High signal to noise.

  Gapless.

  High-resolution images.
- Fat saturation.

  Intense signal from fatty tissue can reduce ability to detect contrast enhancement on T1-weighted sequences. Need to eliminate fat signal by either subtracting images before and after contrast or generating primary sequences with fat suppression.
- Bilateral imaging, prone positioning with dedicated breast coil.

  Enables comparison of enhancement pattern.

  In patients with known breast cancer, enables detection of unsuspected cancer (3% to 6%) in the contralateral breast.

  Eliminates wrap around artifact from contralateral breast that can be seen with unilateral axial or coronal imaging.

  Compression.
- Scanning protocols vary significantly between practices relative to scan plane (e.g., axial, sagittal and coronal), fat suppression and specific sequences used:

  T2-weighted images.

  T1-weighted images before contrast.

  T1-weighted images immediately following contrast and sequentially after contrast so that subtraction can be done and kinetic curves generated; some do these images with fat suppression.
- Contrast administration.

  Gadolinium-DPTA used most commonly.

  Renal excretion (no tubular reabsorption) dependent on glomerular filtration rate.

  Well tolerated; $<2\%$ adverse reaction rate.

  Nephrogenic systemic fibrosis reported in patients with severe chronic kidney disease and end stage renal disease (and possibly associated tissue injury with ongoing inflammatory reaction); reportedly more common with gadodiamide.

  Contrast uptake varies depending on menstrual cycle phase; to minimize hormonal effects scanning during the second week of menstrual cycle is optimal.

Some investigators advocate suspending hormone replacement therapy 4 to 8 weeks prior to scanning.

Arm positioning: straight down by patient side (as opposed to above head) and do not allow patient to bend arm at elbow).

Dose: 0.1 to 0.2 mMol/kg of gadolinium-DTPA administered intravenously followed by a 20 mL flush of saline; best to use power injection with rate of 2 mL/second.

Assess success of contrast injection by making sure there is vessel, cardiac, and liver enhancement.

A small amount of contrast (0.01%) is eliminated in the breast milk of lactating women and only a small portion of this (2%) is absorbed by GI tract of infant; consider suspending breast feeding for 24-hour period.

Safety of Gd-DTPA during pregnancy is not established; studies not undertaken in pregnant patients.

- Temporal resolution.

  Dynamic measurements with temporal resolution of 1 to 2 minutes per sequence.

  Important for characterization of enhancement patterns in lesions compared with breast parenchyma.
- Spatial resolution.

  Optimizing spatial resolution leads to reduction in temporal resolution.

  Slice thickness: 2 to 4 mm.
- Postprocessing of image.

  Subtraction.

  Kinetic curve analysis.

  Maximum intensity projection (MIP).

  Reconstruction.
- Computed aided detection. Several software packages are available to facilitate detection and characterization of potential lesions.
- Contraindications.

  Cardiac pacemakers.

  Artificial heart valves.

  Surgical clips in heart or brain made of MR incompatible materials.

  Recent heart or brain surgery.

  Cochlear implants.

  Insulin pump.

  Some tissue expanders used for breast reconstruction.

  History of adverse reaction to gadolinium and potentially patients with end stage renal disease (estimated glomerular filtration rates [eGFR] of less than 30 mL/min/1.73 $m^2$; relative contraindication in those with eGFR less than 60 mL/min/1.73 m2).

  Weight greater than 300 lb.

  Claustrophobia not controllable with medication.

# Artifacts and Pitfalls

## Key Facts

- Positioning.

  Breast needs to be well positioned in coil. Although there is significant variability in breast sizes, currently available coils come in one size only, so positioning can be a challenge.
- Motion.

  Ribbon-like areas of signal loss and summation.

  Heart pulsation: left breast more commonly affected.

  Patient movement: breast compression can minimize.

  Subtraction of pre- and post-contrast images is limited if there is motion artifact.
- Adequate fat suppression.
- Out-of-phase imaging.

  Differences in signal of water and fat protons.

  Signal loss at margins between fat and water containing tissues.

  Based on field strength of magnet in use, TE adjusted to avoid this artifact (for 1.5T magnets, TE=4.8 ms).
- Susceptibility artifacts.

  Ferromagnetic materials (e.g., metallic clips in lumpectomy bed, sternal cerclage wires) in breast or chest wall close to breast result in significant signal loss.
- Cardiac flow artifacts.

  Overlapping band of artifacts in the plane of the phase encoding gradient.

  For axial imaging, the phase encoding gradient should be selected in the medio-lateral direction from left to right.

  For coronal imaging, the phase encoding gradient should be positioned superior to inferior (head to foot).

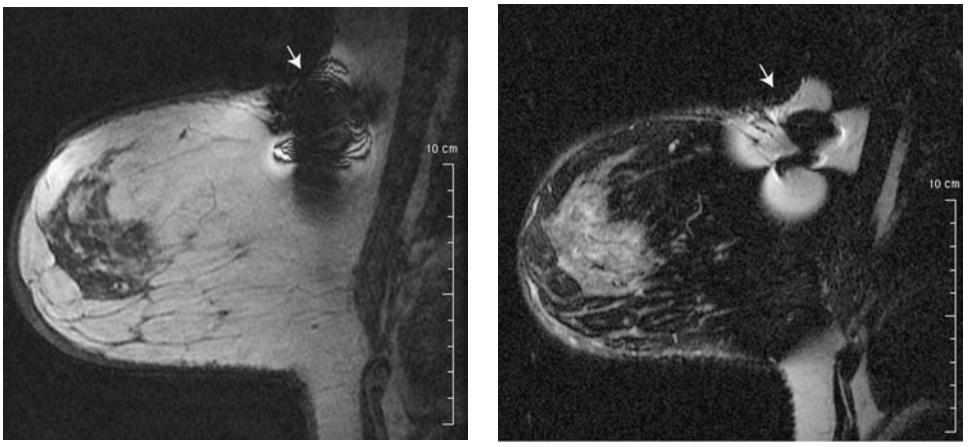
  For sagittal imaging, the phase encoding gradient should be from superior to inferior (head to foot).
- Coil.

  Increased signal seen in the tissue adjacent to the coil windings.
- Timing of imaging relative to contrast administration. Need to image at least once within the first two minutes following contrast administration and at least once 5 minutes after the contrast injection.
- Region of interest (ROI).

  Place region of interest at site of maximal enhancement, particularly applicable to lesions with rim enhancement.

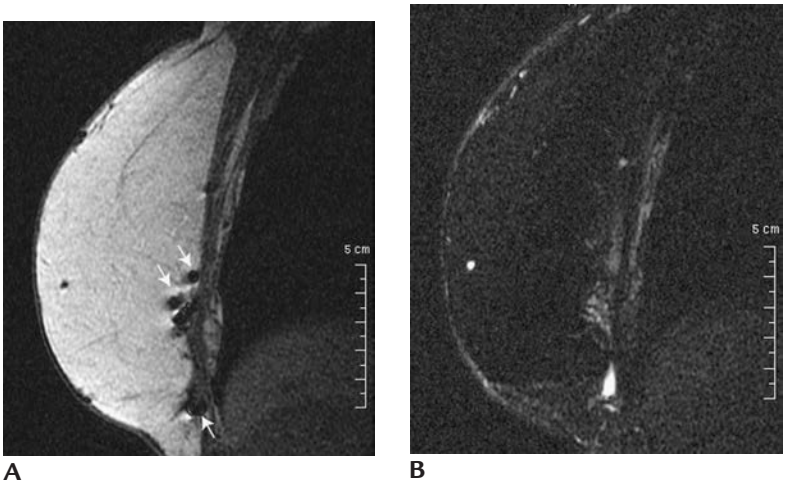
  Avoid using ROI size of less than 3 pixels.
- Postbiopsy changes.

  Increased signal on T1-weighted images secondary to localized or more diffuse hematomas or contrast enhancement related to hyperemia.

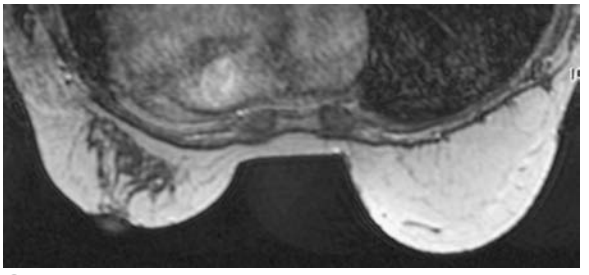



**A** **B**

**FIGURE 8-10** Artifact from portable catheter. **(A)** Sagittal T1-weighted image and **(B)** Sagittal, fat suppressed T2-weighted image. Significant "bloom" artifact with loss of signal noted at the site of a portable catheter used for chemotherapy administration.




**A** **B**



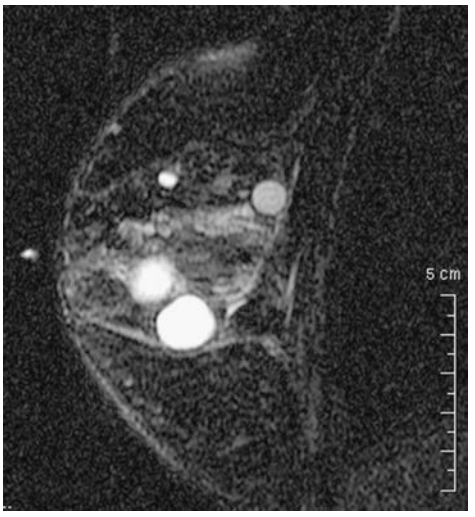
**C**

**FIGURE 8-11** Right TRAM flap reconstruction with artifact from clips along chest wall. **(A)** Sagittal T1 weighted and **(B)** T2-weighted image (with fat suppression) of reconstruction site. "Bloom" artifact can be seen on the T1-weighted image along chest wall (*arrow*). **(C)** T1-weighted axial image demonstrating fatty tissue on the right.

# Lesion Evaluation

## Key Facts

- T2-weighted images.
  Bright signal: cysts and other fluid filled structures (e.g., seromas, ectatic ducts), some cellular/myxoid fibroadenomas, cortical portions of some lymph nodes, subacute hematomas, some mucinous carcinomas, cystic components of papillary lesions, necrotic portions of tumors.
  Low signal: calcifications, acute hematoma, hyalinized fibroadenomas.
- T1-weighted images, pre-contrast.
  Bright signal: fat, subacute hematomas, fatty hilum of lymph nodes.
  Low signal: calcifications, many cancers.
- T1-weighted images, post-contrast; kinetic curve appearance.
  Size and positioning of region of interest important.
  Type I, continuous enhancement, persistent: 6% malignancy.
  Type II, plateau: 65% malignancy.
  Type III, washout: 87% malignancy.
  Tumor neovascularity (and shunting) account for rapid contrast wash out in malignant lesions.
  False negatives reported with ductal carcinoma in situ, well-differentiated invasive ductal and invasive lobular carcinomas.
  False positives include lymph nodes, papillomas, fibroadenomas, LCIS, fibrocystic changes (hyperplasia, atypical hyperplasia), proliferative changes, sclerosing adenosis.

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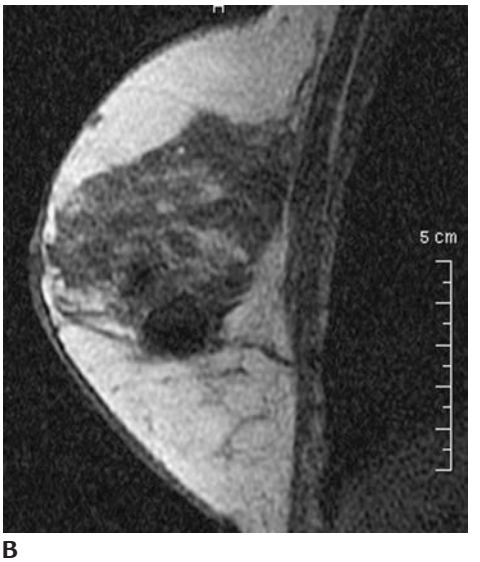
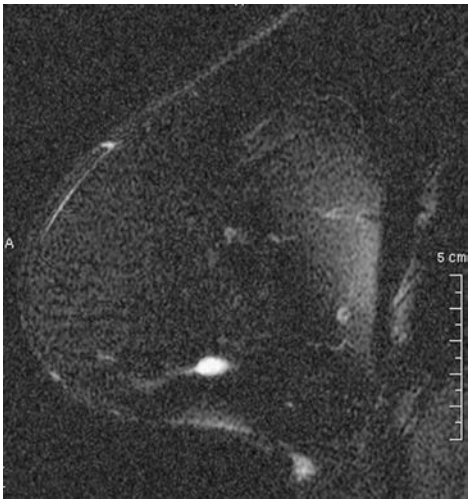



B

**FIGURE 8-12** Cysts. **(A)** Sagittal T2-weighted fat suppressed image. Multiple masses of varying sizes characterized by bright signal. **(B)** Sagittal T1-weighted image, same table top position as in **(A)**. Low signal intensity for the same masses seen on T2-weighted image. When associated with inflammatory changes, these may demonstrate rim enhancement.

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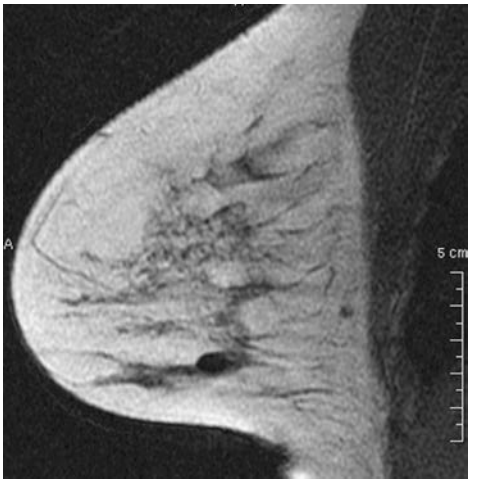
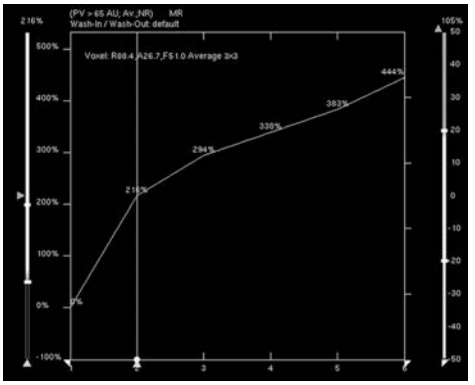



B




C

**FIGURE 8-13** Fibroadenoma (myxoid/cellular). **(A)** Sagittal T2-weighted fat suppressed image. Oval mass characterized by bright signal inferiorly. **(B)** Sagittal T1-weighted image, same table top position as in **(A)**. Low signal intensity for the mass seen on the T2-weighted image. **(C)** Slow initial phase and persistent type delayed curve characterizes lesion. This curve type is commonly seen with benign lesions.

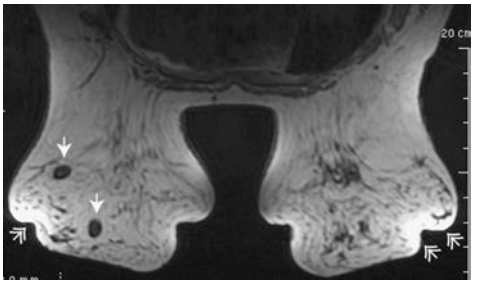
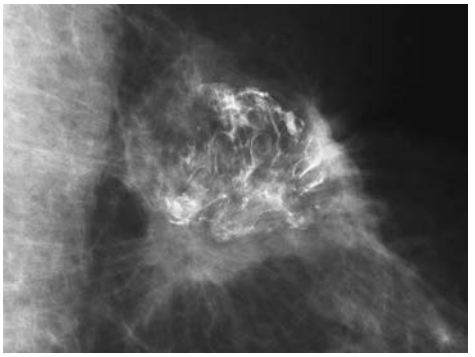



**FIGURE 8-14** Fibroadenoma, hyalinized. **(A)** T1-weighted image, pre-contrast. Oval well-circumscribed masses (*arrows*), low signal intensity. No enhancement following contrast administration. Low signal intensity on T2-weighted images (not shown). Notice poor breast positioning and effect (*double headed arrows*) of close proximity to coil (coil artifact); currently only one size coil is available, which limits the evaluation in some of the patients with larger breasts.



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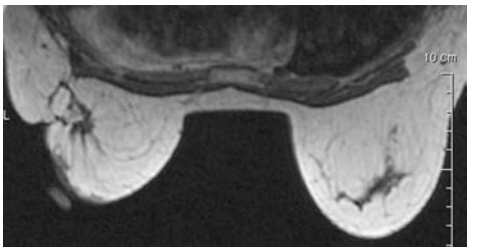


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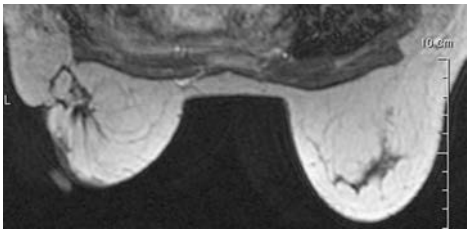
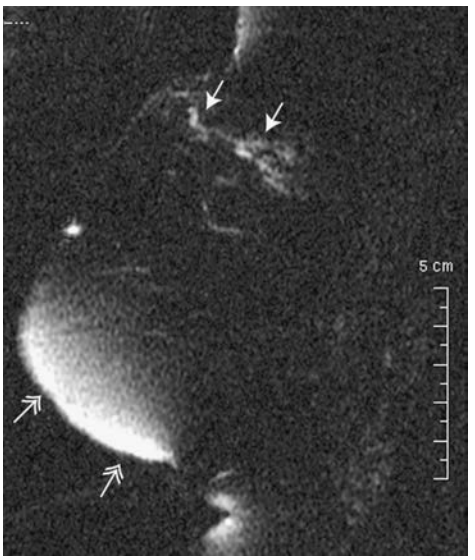
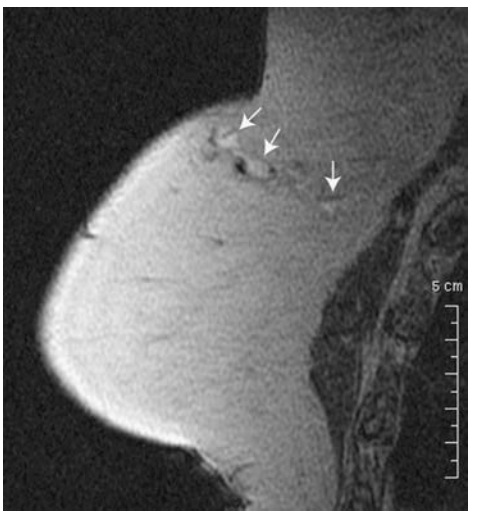



C

**FIGURE 8-15** Fat necrosis, left lumpectomy site. **(A)** Fat containing mass with coarse dystrophic calcifications and spiculated margins at lumpectomy site, left breast. **(B)** Axial T1-weighted pre-contrast image. Mass with spiculated margins and central high-density signal comparable to that of fat. **(C)** Axial T1-weighted imaged immediately following contrast bolus. No enhancement.




A




B

**FIGURE 8-16** Subacute hematomas in patient following seat beat injury. **(A)** T2-weighted image with fat suppression demonstrating linear area of high signal intensity. Notice effect of suboptimal fat suppression inferiorly (*double headed arrows*). **(B)** T1-weighted image demonstrating linear areas of high signal intensity correlating with that seen on T2-weighted image. Patient with history of car accident and seat beat injury to right breast.

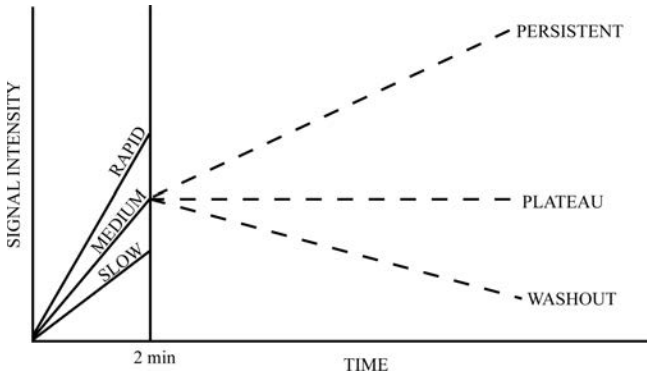
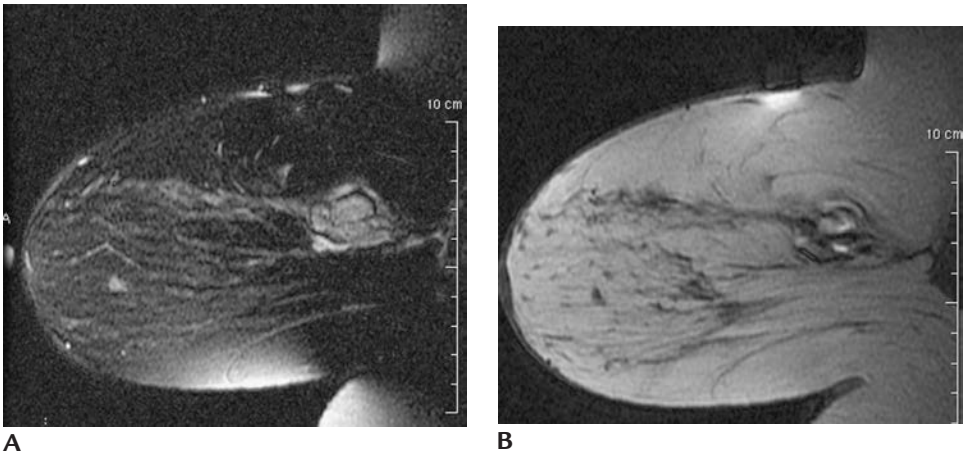
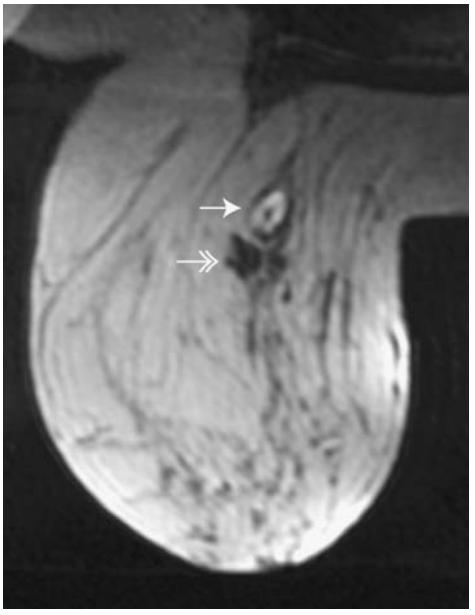



**FIGURE 8-17** Kinetic curves. Initial phase of curve (within first 2 minutes following contrast bolus) described as rapid, medium or slow. Delayed phase of curve described as persistent, plateau or washout.




**A** **B**

**FIGURE 8-18** Invasive ductal carcinoma and adjacent postbiopsy hematoma. **(A)** Sagittal T2-weighted image. Irregular mass with bright (heterogeneous) signal. **(B)** Sagittal T1-weighted image. Mass demonstrates bright signal.



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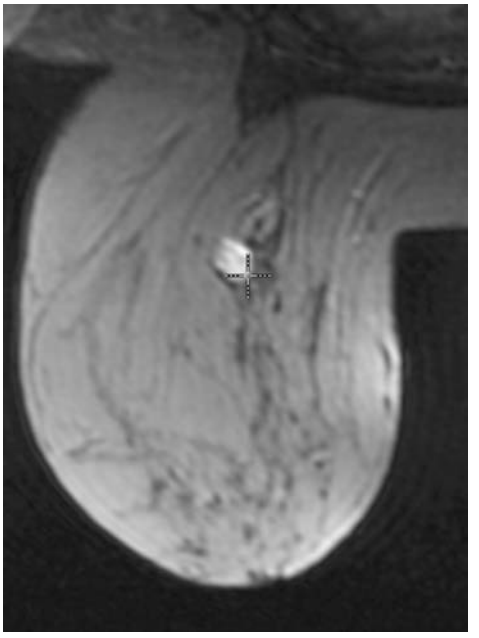

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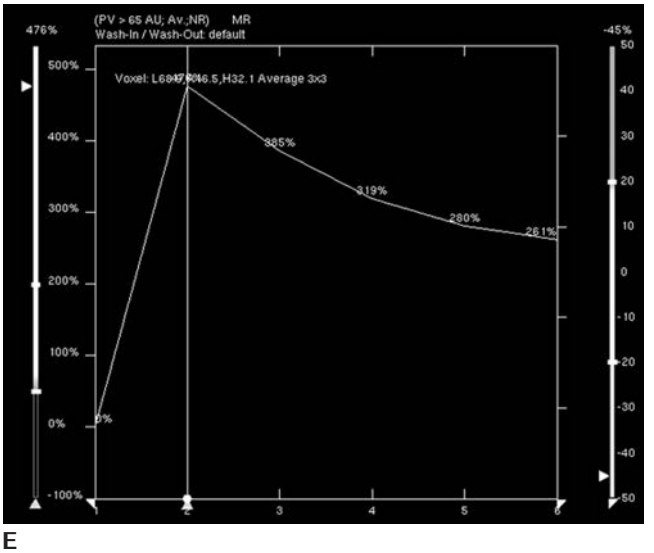



E

**FIGURE 8-18** (*Continued*) **(C)** Axial T1-weighted image pre-contrast. Low signal intensity of breast cancer (*double headed arrow*). Bright signal of hematoma (*arrow*). **(D)** Axial T1-weighted image immediately following contrast bolus. Cancer enhances (cursor placed for kinetic curve evaluation), hematoma demonstrates a small amount of delayed enhancement. **(E)** Mass (see cursor position in **D**) characterized by rapid initial enhancement and wash out of contrast consistent with malignancy.

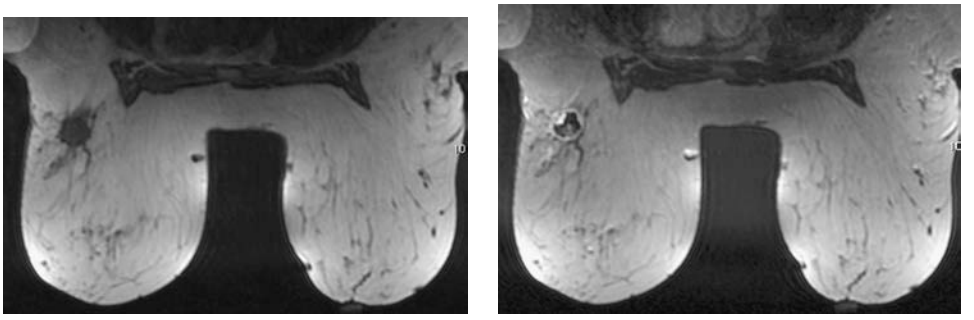
## American College of Radiology MR Lexicon

### Key Facts

- Focus/foci: area of enhancement measuring less than 5 mm in size (have been called "unidentified bright objects," "bright unidentified breast objects," and "incidental enhancing lesions").
- Mass: 3D space occupying lesion.
  Shape:
    Round.
    Oval.
    Lobular.
    Irregular.
  Margin:
    Smooth.
    Irregular.
    Spiculated.
  Mass enhancement:
    Homogeneous.
    Heterogeneous.
    Rim enhancement.
    Dark internal septation.
    Enhancing internal septation.
    Central enhancement.
- Non-mass-like enhancement.
  Distribution modifiers:
    Focal area.
    Linear.
    Ductal.
    Segmental.
    Regional.
    Multiple regions.
    Diffuse.
  Internal enhancement:
    Homogeneous.
    Heterogeneous.
    Stippled, punctuate.
    Clumped.
    Reticular, dendritic.
- Symmetric or asymmetric enhancement on bilateral scans.
- Other findings.
  Nipple retraction.
  Nipple invasion.

Pre-contrast high ductal signal.
Skin thickening (focal).
Skin thickening (diffuse).
Skin invasion.
Edema.
Lymphadenopathy.
Pectoralis muscle invasion.
Chest wall invasion.
Hematoma/blood.
Abnormal signal void.
Cysts.

- Kinetic curve assessment.
  Initial rise: slow, medium, rapid.
  Delayed phase: persistent, plateau, washout.



A B

**FIGURE 8-19** Invasive ductal carcinoma. **(A)** T1-weighted axial image pre-contrast. **(B)** T1-weighted axial immediately post-contrast bolus. Round mass with well-circumscribed margins. Low signal intensity pre-contrast. Rim enhancement post-contrast; rapid initial enhancement and wash out.

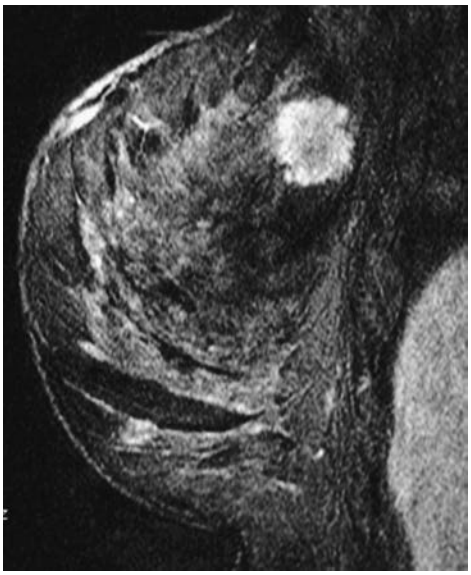
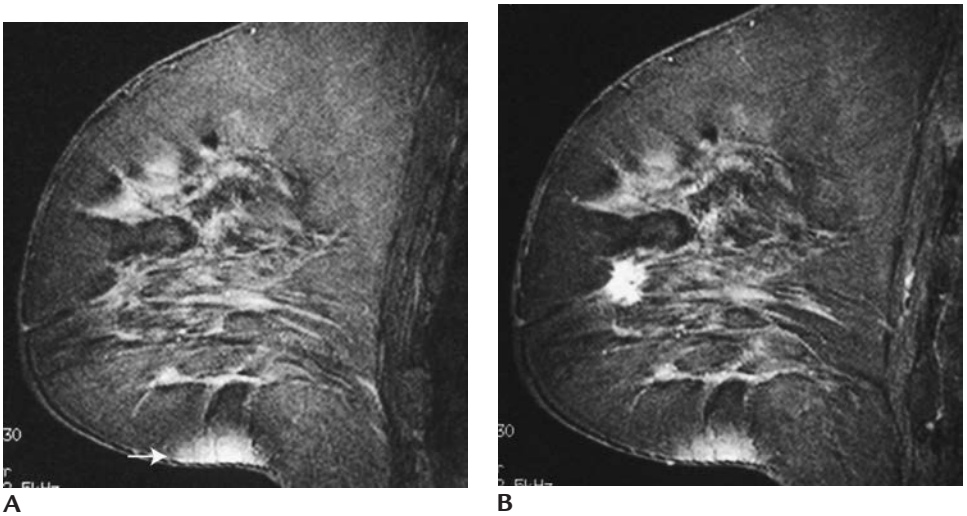
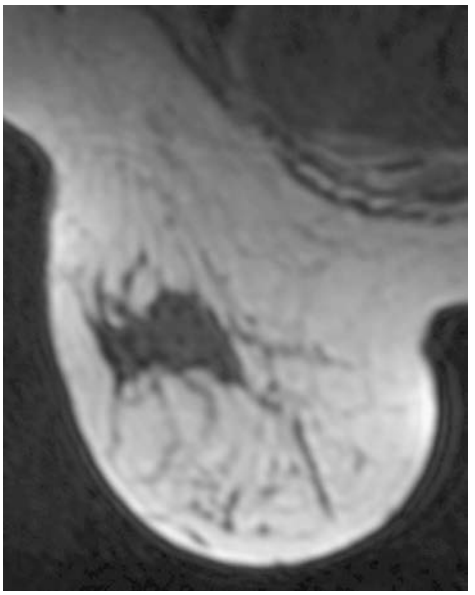


**FIGURE 8-20** Invasive ductal carcinoma. T1-weighted, sagittal fat suppressed image immediately post-contrast bolus. Mass with lobular margins and heterogeneous rapid initial enhancement and wash out.



**A** **B**

**FIGURE 8-21** Invasive ductal carcinoma. **(A)** Sagittal, T1-weighted image pre-contrast. Bright coil artifact (*arrow*). **(B)** Sagittal, T1-weighted image immediately following contrast bolus. Rapidly enhancing irregular mass with spiculated margins.



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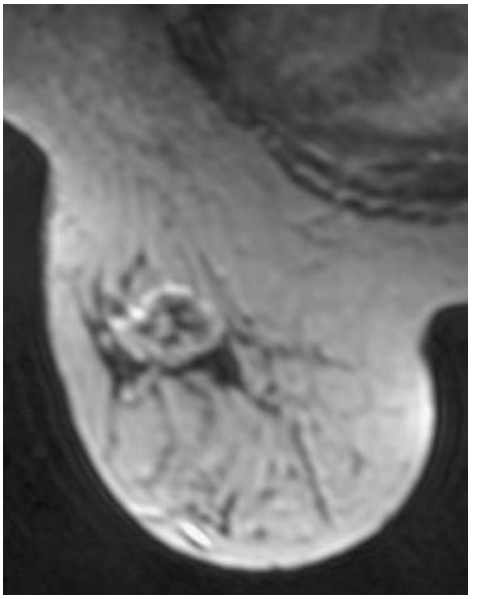
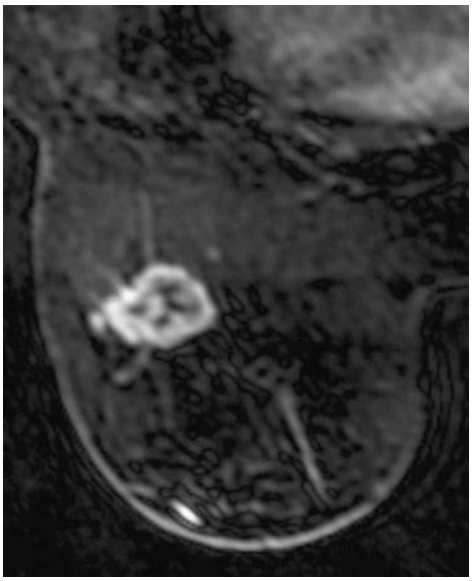
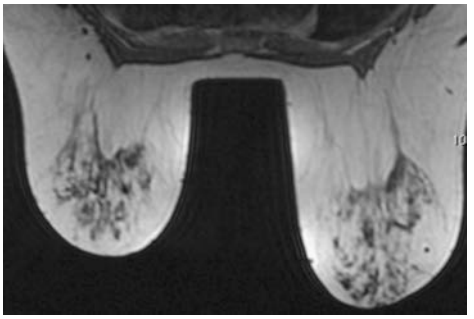


B



C

**FIGURE 8-22** Invasive ductal carcinoma. **(A)** T1-weighted axial, pre-contrast image. **(B)** T1-weighted image immediately post-contrast bolus. **(C)** Subtraction image. Oval, smooth mass with rapidly enhancing rim and internal septations in the left breast.



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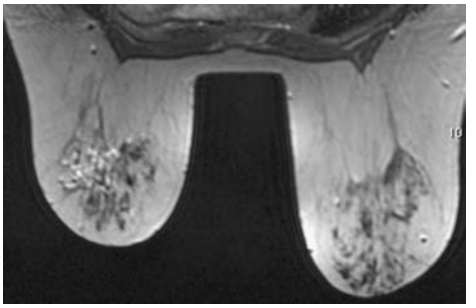
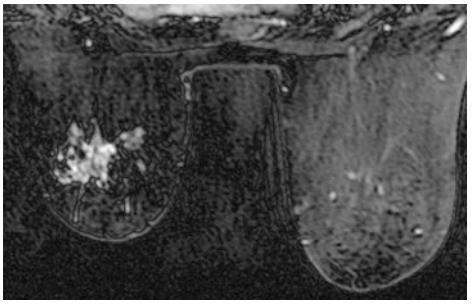


**B**



**C**

**FIGURE 8-23** Ductal carcinoma in situ. **(A)** T1-weighted axial, pre-contrast image. **(B)** T1-weighted image immediately post-contrast bolus and **(C)** Subtraction image. Segmental clumped enhancement in the left breast.

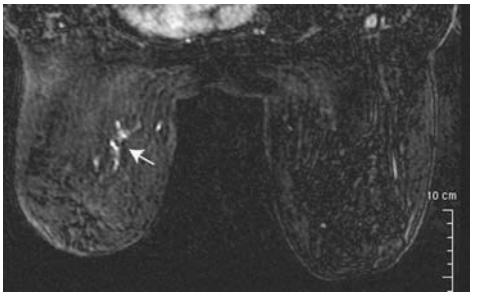



**FIGURE 8-24** Ductal carcinoma in situ. Subtraction image. Linear heterogeneous enhancement (*arrow*) in the left breast.

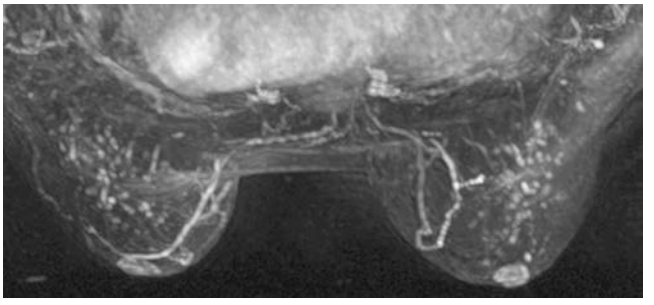


**FIGURE 8-25** Fibrocystic changes. Maximum intensity projection. Diffuse stippled enhancement bilaterally.

## SUGGESTED READINGS

American College of Radiology (ACR). ACR BI-RADS – Magnetic Resonance Imaging. In: *ACR Breast Imaging Reporting and Data System, Breast Imaging Atlas*. Reston: American College of Radiology; 2003.

Fischer U. *Practical MR Mammography*. Stuttgard: Thieme Verlag; 2004.

Lehman CD, Gatsonis C, Kuhl CK, et al. MRI evaluation of the contralateral breast in women with recently diagnosed breast cancer. *N Engl J Med*. 2007;356:1295–1303.

Liberman L, Morris EA, Kim CM, et al. MR imaging findings in the contralateral breast of women with recently diagnosed breast cancer. *AJR Am J Roentgenol*. 2003;180: 333–341.

Liberman L, Morris EA, Dershaw DD, et al. MR imaging of the ipsilateral breast in women with percutaneously proven breast cancer. *AJR Am J Roentgenol*. 2003;180:901–910.

Liberman L, Morris EA, Dershaw DD, et al. Ductal enhancement on MR imaging of the breast. *AJR Am J Roentgenol*. 2003;181:519–525.

Kuhl CK. Concepts for differential diagnosis in breast MR imaging. *Magn Reson Imaging Clin N Am*. 2006;14:305–328.

Kuo PH, Kanal E, Abu-Alfa AK, et al. Gadolinium-based MR contrast agents and nephrogenic systemic fibrosis. *Radiology*. 2007;242:647–649.

Morris EA, Liberman L, Ballon DJ, et al. MRI of occult breast carcinoma in a high risk population. *AJR Am J Roentgenol*. 2003;181:619–626.

Morris EA, Liberman L, eds. *Breast MRI. Diagnosis and Intervention*. New York: Springer; 2005.

Orel SG, Weinstein SP, Schnall MD, et al. Breast MR imaging in patients with axillary node metastasis and unknown primary malignancy. *Radiology*. 1999;212:543–549.

Partridge SC, Gibbs JE, Lu Y, et al. Accuracy of MR imaging for revealing residual breast cancer in patients who have undergone neoadjuvant chemotherapy. *AJR Am J Roentgenol*. 2002;179:1193–1199.

Sadowski EA, Bennett LK, Chan MR, et al. Nephrogenic systemic fibrosis: risk factors and incidence estimation. *Radiology*. 2007;243:148–157.

CHAPTER 9

# SKIN

## General Comments

### Key Facts

- On any mammographic view of the breast, most of the skin is superimposed on the breast parenchyma. In other words, only a small amount of skin is in tangent to the x-ray beam.

  As such, skin lesions often project on the breast parenchyma and can simulate an abnormal parenchymal finding.

  Most of the energy (kV) needed to obtain an optimally exposed mammogram is expended penetrating the two layers of skin superimposed (enveloping) on the breast parenchyma.
- It is helpful if the technologist marks the larger raised skin lesions with a small metallic BB and indicates these findings on the patient's history form.
- If a possible skin lesion is seen on the screening views or, if one is potentially dealing with dermal calcifications, a metallic BB can be placed over the presumed lesion and a tangential view of the BB is obtained. If the lesion is on the skin, it is seen directly underneath the BB (may need to use a hot light) associated with the skin.
- Raised skin masses may appear partially well circumscribed because the raised portion of the lesion is surrounded by air. The marginal definition of the lesion is lost at the site where the lesion attaches to the skin.
- Skin calcifications.

  Isolated cluster, multiple clusters or individually scattered, uni- or bilaterally.

  May have central lucency.

  May have lacelike pattern, particularly if associated with a mole.

  Slightly more common posteromedially (cleavage).
- Seborrheic keratosis.

  Familial predilection, autosomal dominant pattern.

  Epidermal tumors distributed on skin bearing hair.

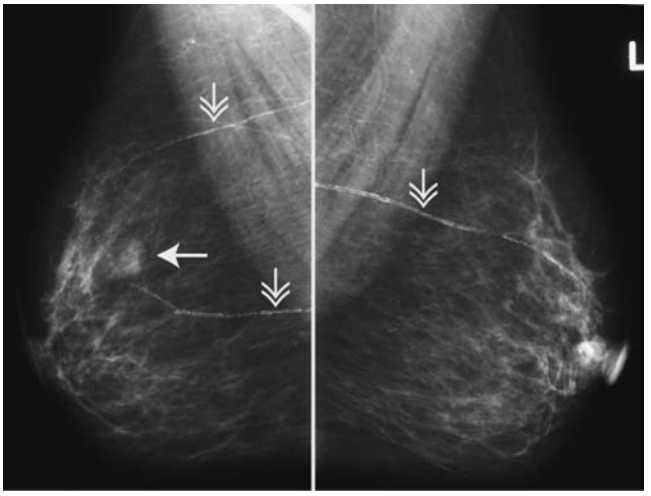
Common, multiple, and continue to develop with age.

Start out as flat lesions, but over time become more verrucous, polypoid, and pedunculated.

Because air outlines the polypoid and pedunculated portions of these lesions, some of the margins are well circumscribed (outlined by air); the marginal definition is lost for the portion of the lesion that is attached to the skin. For the verrucous lesions air outlines the crevices resulting in a characteristic appearance; if desitin or talc is applied to the skin, high density, linear, and curvilinear material can outline the crevices.

May develop calcifications.

- Montgomery's glands: apocrine glands on areola; secrete thick, proteinaceous material during lactation for lubrication and protection of the nipple.
- If medication patches applied to the skin are not removed, they can be seen on the mammogram superimposed on the breast parenchyma.

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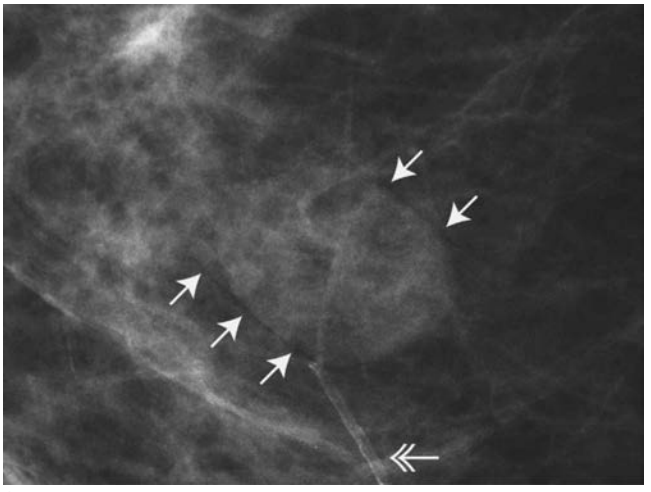
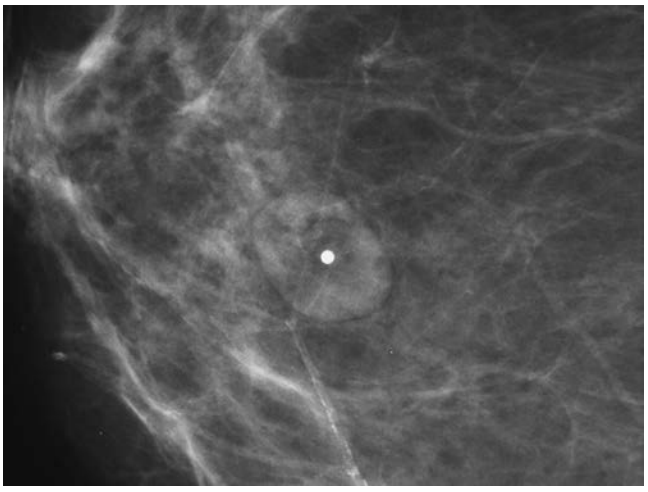


B

**FIGURE 9-1** Skin lesion, seborrheic keratosis. **(A)** Oval mass (*arrow*) projecting on the breast parenchyma on the routine views of the right breast, (only mediolateral oblique views shown). Calcified branches (*double headed arrows*) of the internal mammary arteries are present perforating through the pectoral muscles. **(B)** Photographically coned down view of the mass to demonstrate sharp radiolucency (*arrows*) partially outlining the mass suggesting a dermal location. Vascular calcification (*double headed arrow)* is also seen.



C

**FIGURE 9-1** (*Continued*) **(C)** Although it is not usually necessary, if there is any question about the correlation between a mass seen mammographically and a skin lesion, a metallic BB can be used by the technologist to mark the dermal lesion. A sharp radiolucency (air) outlines the margins of this skin mass. A tangential view can also be done to localize the lesion to the skin. A partially calcified artery is present projecting inferior to the skin lesion.

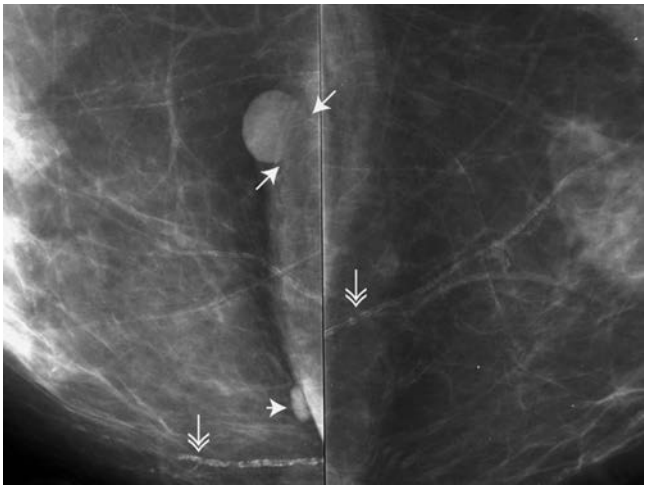
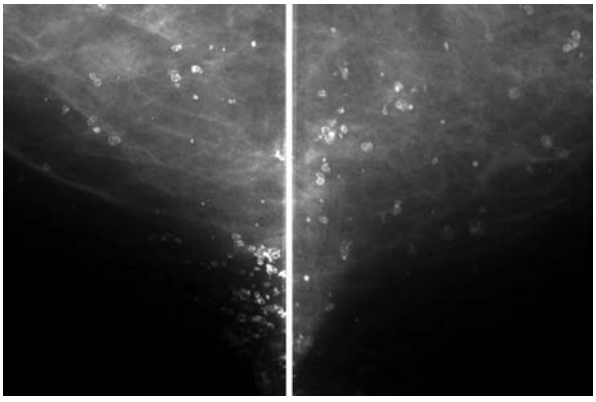


**FIGURE 9-2** Skin lesion. Pedunculated skin mass. Well-circumscribed margins are lost where the lesion attaches to the skin (*arrows*). A second well-circumscribed skin lesion is present (*short arrow*) more medially on the right breast. Vascular calcifications (*double headed arrows* marking some of the arterial calcifications) are also noted bilaterally.



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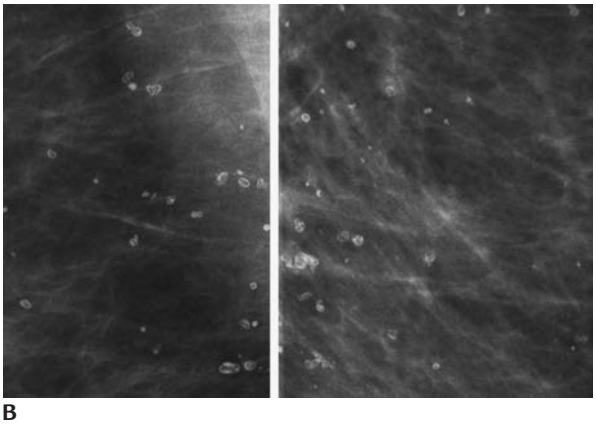

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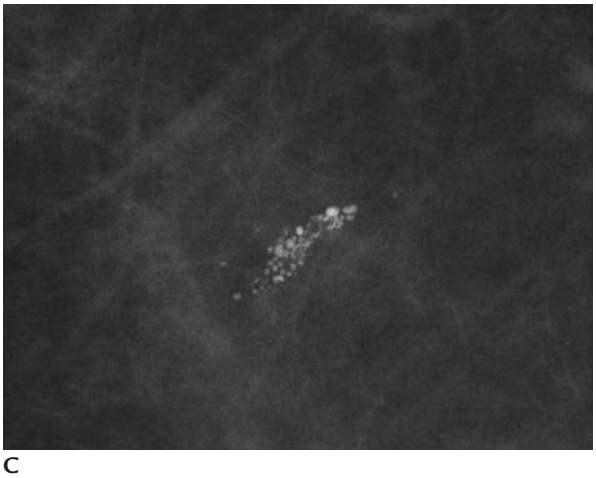


C

**FIGURE 9-3** Skin calcifications. **(A)** Lucent centered calcifications, some in clusters, consistent with skin calcifications. Commonly seen involving the cleavage (as in this patient, particularly on the right). **(B)** Scattered lucent centered calcifications projecting on breast parenchyma posteriorly on the mediolateral oblique views. **(C)** Cluster of well-defined round and oval calcifications some with lucent centers. Tangential views are sometimes needed to confirm the skin location of calcifications or masses.

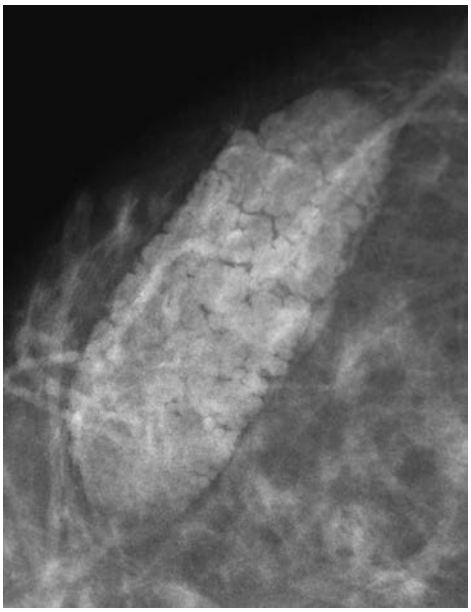
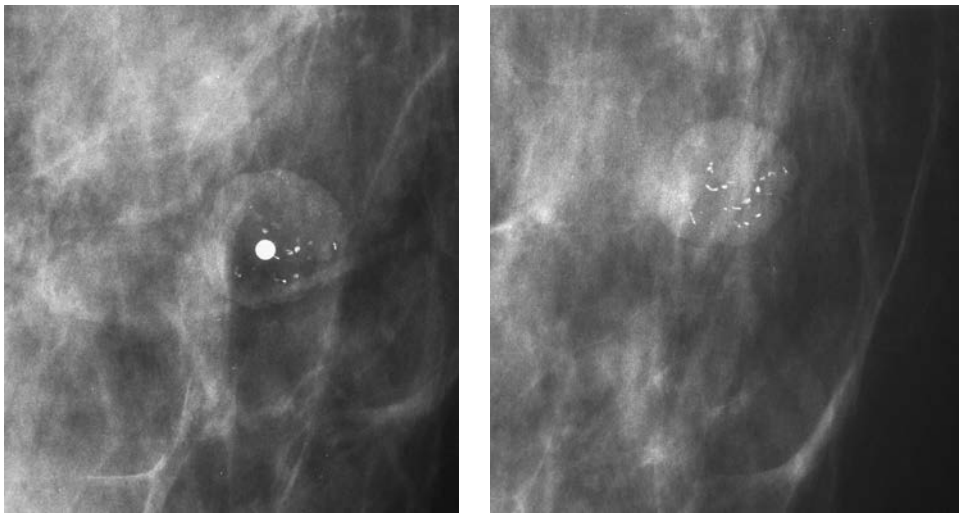
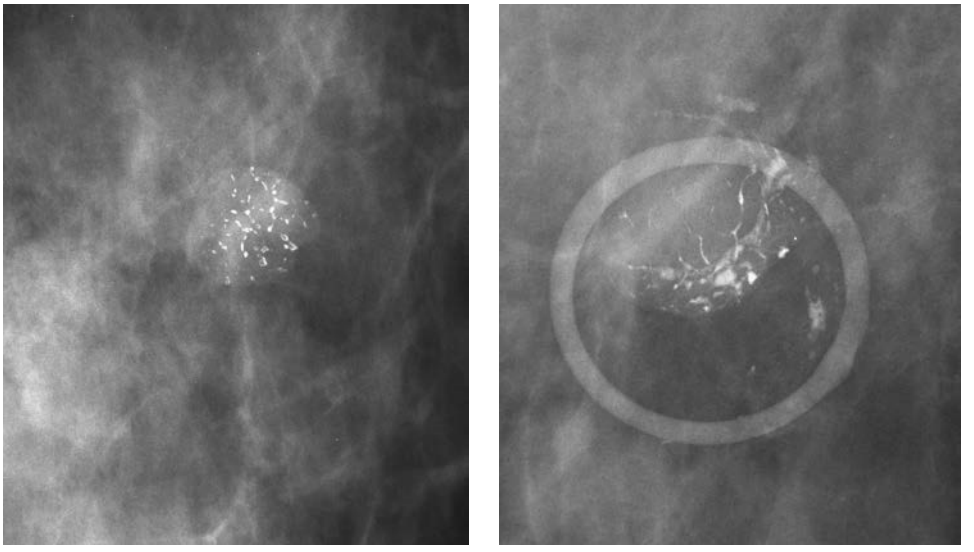


**FIGURE 9-4** Seborrheic keratosis. Verrucous lesion. Air (sharp radiolucency) outlines the interstices and margins of the lesion.



**A** **B**

**FIGURE 9-5** Skin lesion. **(A)** High density artifact outlining crevices of skin lesion. Metallic BB used by technologist to denote skin location of mass. **(B)** One year later, increasing amounts of high density artifact outlining crevices of skin lesion.



C D

**FIGURE 9-5** (*Continued*) **(C)** Two years later, high density artifact continues to increase. **(D)** Three years later, linear and curvilinear high density artifact outlining crevices of dermal lesion. Round radio-opaque marker used by the technologist to denote skin lesion.

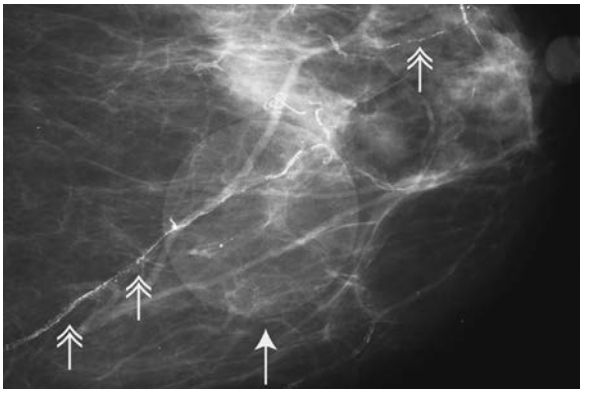


**FIGURE 9-6** Medication patch. Round medication patch (*arrow*) is imaged projecting on the skin parenchyma. Arterial calcifications are present (*double headed arrows* marking some of the arterial calcifications).

# Skin Manifestations of Breast or Systemic Diseases

## Key Facts

- Skin thickening.

  A hot light may be required to see skin thickening because, in order to get adequate exposure of glandular tissue, skin is "burned out" on most high-quality film screen images; on digital images, skin is seen easily.

  May be focal, associated with underlying inflammatory or neoplastic lesions.

  May be diffuse, uni- or bilateral.

  Differential considerations for diffuse skin changes with edema that are usually unilateral, although rarely can be bilateral, include radiation therapy effect, inflammatory changes (e.g., mastitis), trauma, ipsilateral axillary adenopathy with lymphatic obstruction, dialysis shunt in the ipsilateral arm with fluid overload, invasive ductal carcinoma not otherwise specified, inflammatory carcinoma, invasive lobular carcinoma, or lymphoma.

  Differential considerations for diffuse skin changes with edema that are usually bilateral, although they can be unilateral, include congestive heart failure, renal failure with fluid overload, or superior vena cava syndrome. Additional rare benign causes include granulomatous mastitis, Coumadin necrosis, arteritis, autoimmune disorders (e.g., scleroderma), and chronic graft versus-host disease (hormone replacement therapy and weight loss may result in diffuse changes resulting from increases in the density of the parenchyma, but do not usually involve the skin).
- Skin retraction.

  Inflammatory or neoplastic lesions may cause skin retraction.

  Prior breast biopsy.
- Skin ulceration.

  Advanced inflammatory lesion.

  Neoplastic lesions may fungate out onto the skin.

  Primary skin lesions may result in ulceration, with no underlying breast lesion.

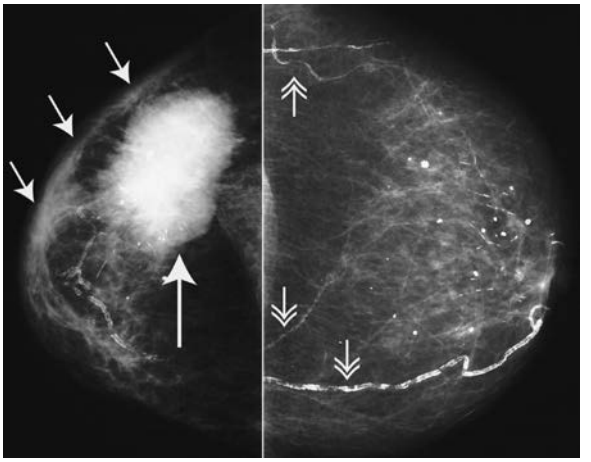
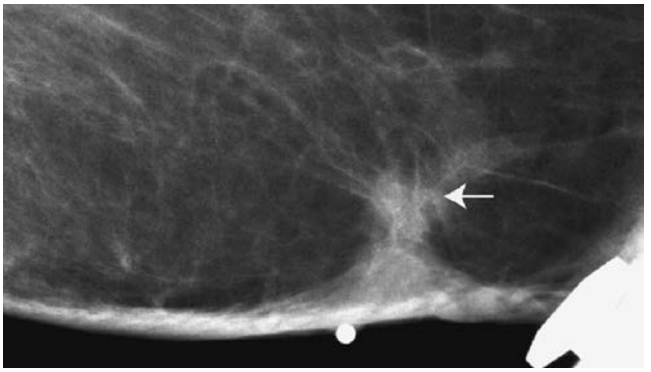


**FIGURE 9-7** Invasive ductal carcinoma not otherwise specified, locally advanced. Craniocaudal views demonstrate asymmetric breast size (e.g., right breast is smaller than left) and an oval mass with indistinct and spiculated margins and associated linear calcifications in the right breast (*large arrow*). Associated skin thickening is present (*small arrows*) on the right. Vascular calcifications are present bilaterally (*double headed arrows* indicating some of these on the left). Large rodlike calcifications and coarse dystrophic calcifications are noted scattered in the left breast anteriorly.



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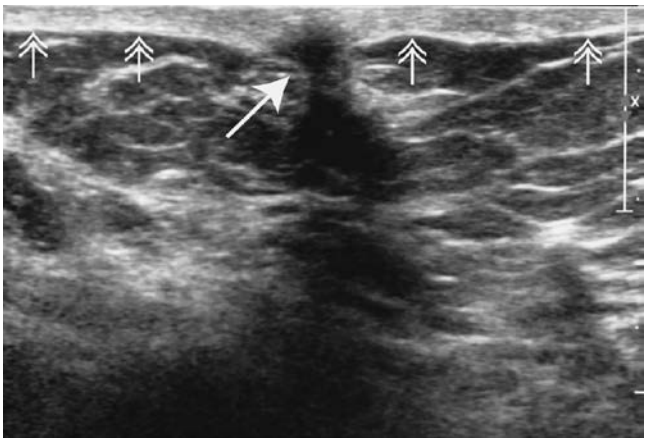
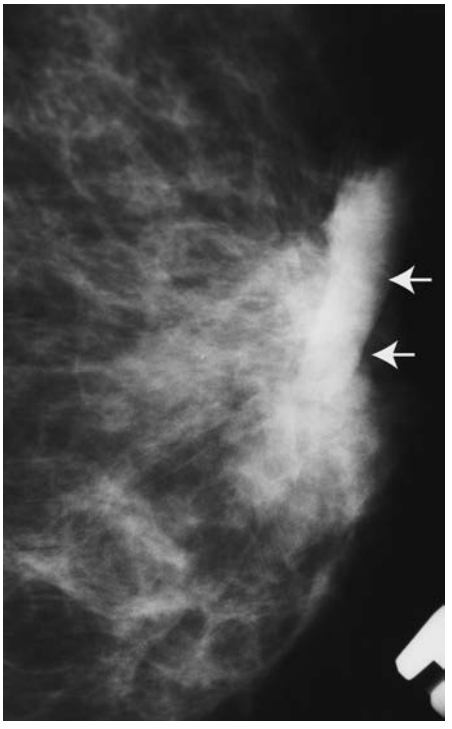


B

**FIGURE 9-8** Invasive ductal carcinoma, not otherwise specified with associated ductal carcinoma in situ, low nuclear grade solid type. **(A)** Spot tangential view of a palpable finding (metallic BB) in the left breast demonstrates a round mass with spiculated margins, associated punctate calcifications (*arrow*) and skin thickening with minimal retraction**. (B)** Hypoechoic mass with posterior acoustic shadowing (*arrow*) corresponding to the palpable finding. The mass secondarily involves the skin as evidenced by disruption of the linear echogenicity of the deep dermal layer (*double headed arrows*).



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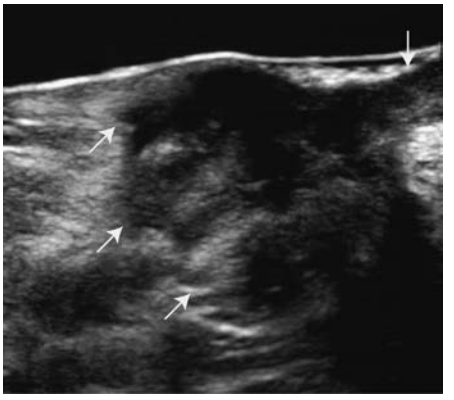

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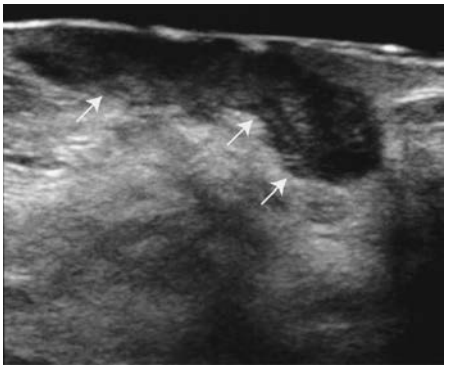
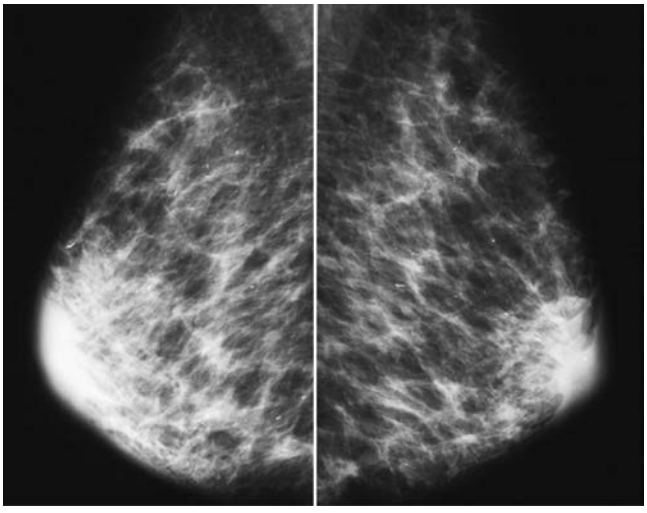


**C**

**FIGURE 9-9** Invasive lobular carcinoma. **(A)** Irregular mass with ill-defined margins and associated skin thickening and retraction (*arrows*). **(B)** Hypoechoic mass (*arrows*) secondarily involving the skin. **(C)** Tubular like area of hypoechogenicity (*arrows*) extending from the dominant tumor mass (seen in B) to secondarily involve the skin.



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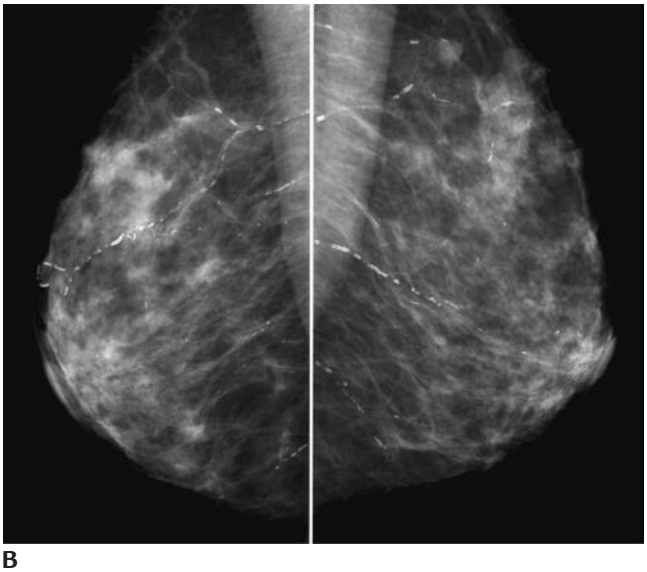
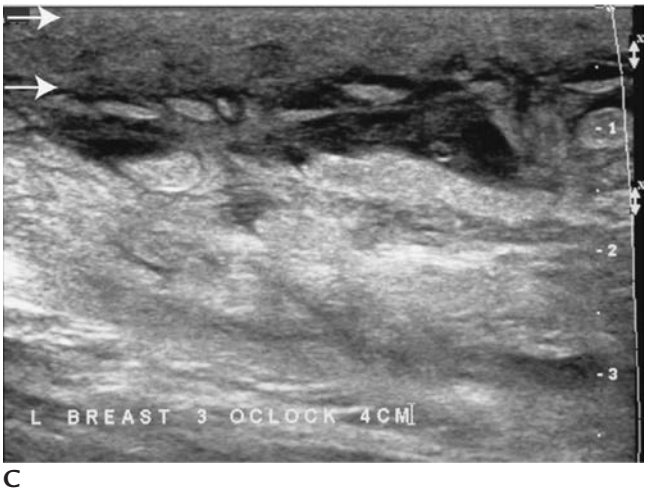


B

**FIGURE 9-10** Congestive heart failure (CHF). **(A)** Increased parenchymal density and trabecular thickening in patient with edema secondary to CHF. Diffuse skin thickening requires use of a hot light for visualization (also, check technical factors needed for exposure and compare with prior studies; in order to adequately penetrate through the two layers of thickened skin enveloping the breast, kV usually needs to be increased and the resulting mAs output is also increased). Increased density of the periareolar region, particularly prominent in this patient on the right, is common in women with edema related to CHF. **(B)** With the patient on appropriate medical therapy, skin and trabecular thickening and the density associated with the periareolar areas resolve on a subsequent mammogram. Arterial calcifications are present bilaterally.

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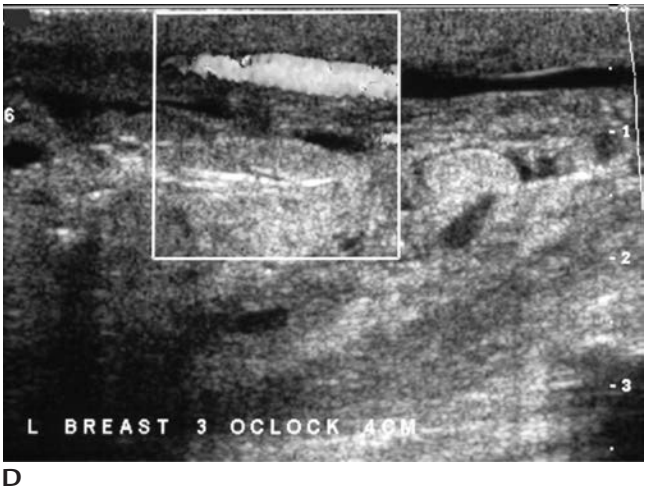



D

**FIGURE 9-10** (*Continued*) **(C)** In another patient with CHF, disruption of the normal tissue architecture (e.g., loss of normal soft tissue planes) and increased echogenicity of the parenchyma as well as associated skin thickening (*arrows* marking thickened skin layer) and interconnected hypoechoic linear channels of dilated lymphatics or interstitial fluid can be seen on ultrasound. These findings are nonspecific and can also be seen in patients with edema from whatever cause, including an inflammatory process, trauma, or inflammatory carcinoma. **(D)** In some patients, prominent vascularity can be see in the subcutaneous tissue (as in this patient) or in the edematous breast parenchyma. Note disruption of normal tissue architecture and planes. The echogenicity of the tissue is increased and there is associated skin thickening.

# Keloids and Hypertrophic Scars

## Key Facts

- Clinical.

  Often familial.

  Higher incidence of occurrence in black and Hispanic patients.

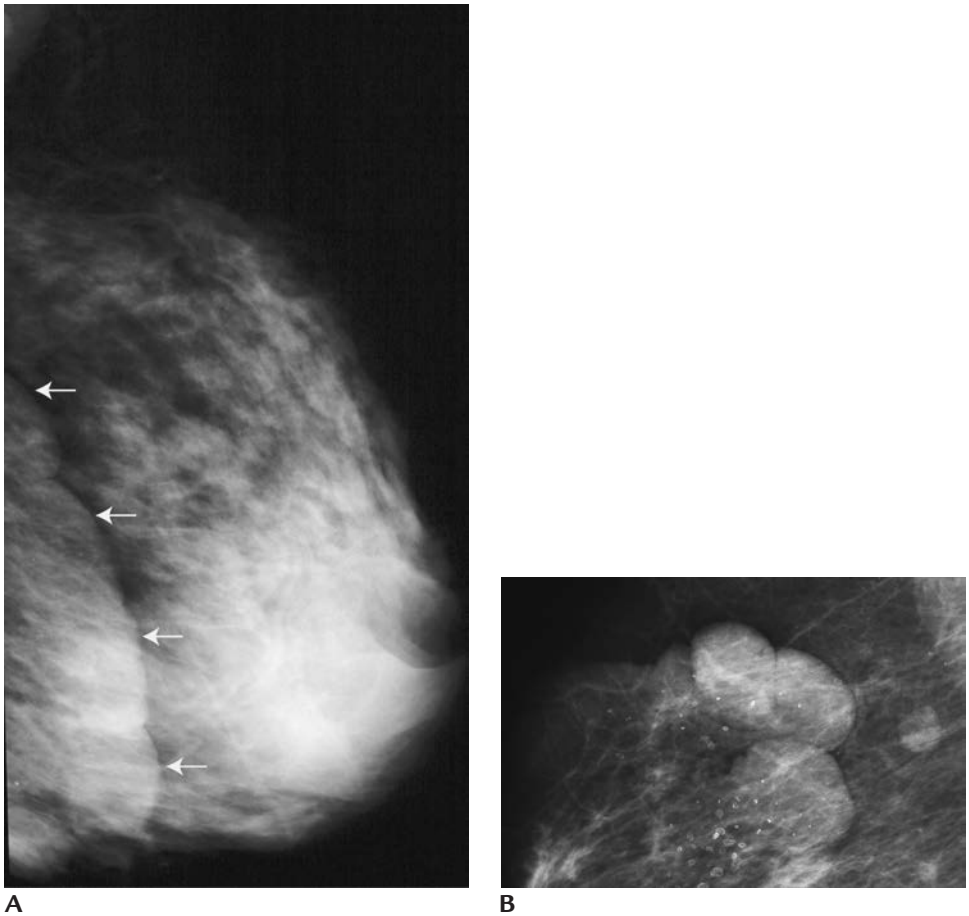
  Reflect abnormal wound repair.

  Disruption of fine equilibrium between deposition and removal of structural proteins and glycoproteins involved in normal wound repair.
- Hypertrophic scars arise in the first 4 weeks following injury and are characterized by rapid growth and regression. They are raised, but typically confined to the borders of the original wound, and increase in size by expanding the margins of the scar not by invading surrounding tissue.
- Keloids appear later than hypertrophic scars, gradually progress, and can proliferate indefinitely; they do not regress. They extend beyond the borders of the original wound and involve the adjacent normal dermis.
- Proposed treatments for keloids include steroid (triamcinolone) injections, surgery, radiation therapy, topical application of silicone gel, pressure therapy, laser treatments, cryosurgery, antihistamines, and intralesional injections of 5 fluorouracil, interferon, retinoids, or calcium channel blockers.
- Mixed results for proposed treatments; treatment and management of patients with keloids remains controversial.
- Mammography.

  Irregular, serpiginous, tubelike or masslike structures; portions of the lesion that protrude from the skin surface are outlined by air consequently these portions of the lesions are sharply marginated by a thin radiolucency.
- Histology.

  The collagen fibers in hypertrophic scars are oriented parallel to the skin surface.

  The collagen fibers in keloids are larger, thicker, wavier, and randomly distributed as compared to those found in hypertrophic scars.



A B

**FIGURE 9-11** Keloid. **(A)** Tubular density with well-defined, macrolobulated contours correlating with a prior biopsy site. Sharp radiolucency at anterior edge of keloid is air outlining the portion of the keloid projecting beyond the skin (*arrows*). **(B)** Irregular, lobulated tubular density and mass corresponding to prior biopsy sites. Radiolucency (air) along the portion of keloids projecting beyond the skin, in conjunction with appearance and correlation with prior biopsy site, are used to characterize the dermal location of these lesions. Skin calcifications are also present.

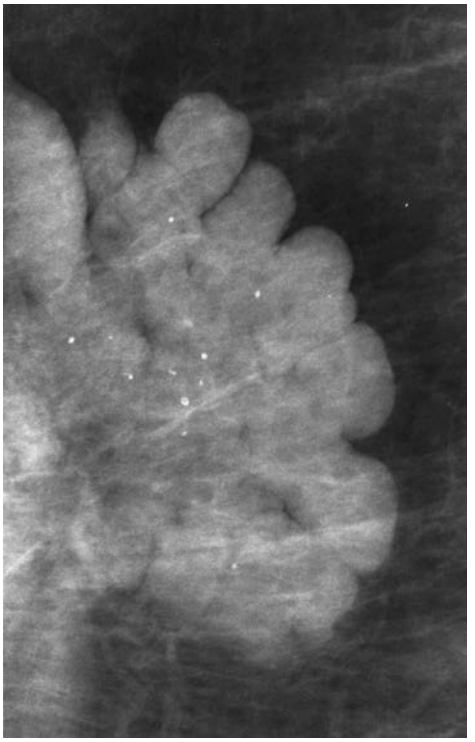


**FIGURE 9-12** Keloid. This keloid demonstrates a more irregular, pedunculated, and verrucous appearance. A few associated skin calcifications are present. Keloids usually extend beyond the confines of the original scar site and can continue to increase in size on subsequent mammograms. They are variable in size and shape and can be multiple if the patient has a history of more than one breast biopsy. The portion of the keloid that extends beyond the skin is sharply marginated by a radiolucency (air) enabling localization of the lesion to the skin. The technologist should indicate presence of keloid on the patient's history form.

## Epidermal and Sebaceous Cysts

### Key Facts

- Clinical.

  Epidermal and sebaceous cysts are clinically indistinguishable. Epidermal inclusion cysts arise in hair follicles; sebaceous cysts arise in sebaceous glands.

  Retention cysts: plugging of gland orifice with resultant keratin accumulation.

  Readily palpable, well-defined subcutaneous mass; often enlarge. On palpation, the lesion moves with the skin (e.g., cannot slide skin over the lesion as can be done with a mass in the breast).

  May be visible, causing smooth skin bulge: orifice of the gland may be seen as a dark point ("black head," punctum).

  If squeezed, white, thick, cheesy material exuding from gland orifice may be seen.

  May become inflamed, particularly if ruptured; may have associated erythema.

  May need to be incised and drained. However, for epidermal cysts, adherence of the cyst wall to surrounding tissue leads to recurrences (unless there is complete removal of the cyst wall).

  Can occur anywhere, however, common in axilla and medial most extent of the inframammary fold (e.g., cleavage). Epidermal inclusion cysts have been reported in breast parenchyma in patients who have undergone reduction mammoplasty.

- Mammography.

  Round or oval isodense to high density masses with well-circumscribed margins; subcutaneous in location. Because, to get adequate exposure of glandular tissue, skin and subcutaneous tissues are often "burned out," a hot light may be required to see lesion.

  Readily apparent on digital images.

  When lesion is inflamed, margins may be indistinct and rarely spiculated.

  Tangential view is helpful in demonstrating lesion and localizing it to the skin.

  May have associated calcifications.

- Ultrasound.

  Superficial location (depending on transducer used, may need offset pad).

  Associated with dermis.

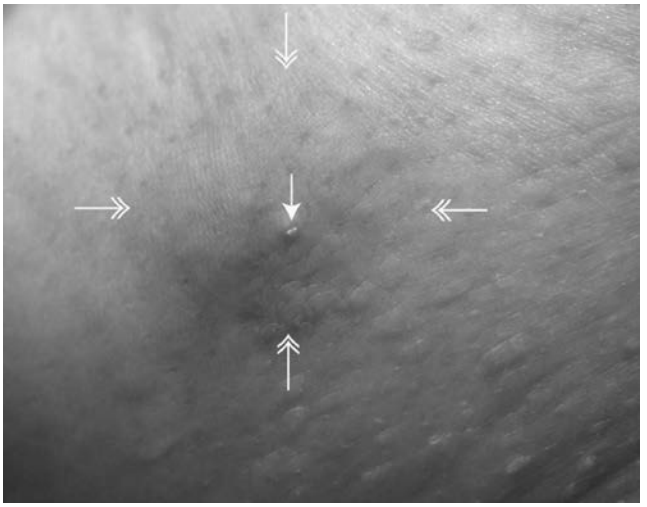
  May be completely anechoic, hypoechoic or echogenic with posterior acoustic enhancement or a complex cystic mass.

  May see thin hypoechoic tract to skin surface.

- Histology.

  Epidermal cysts: true epidermal cell lining (stratified squamous epithelium) with granular cell layer filled with keratin.

  Sebaceous cysts: epithelial cell lining, eosinophilic contents; may contain calcification.



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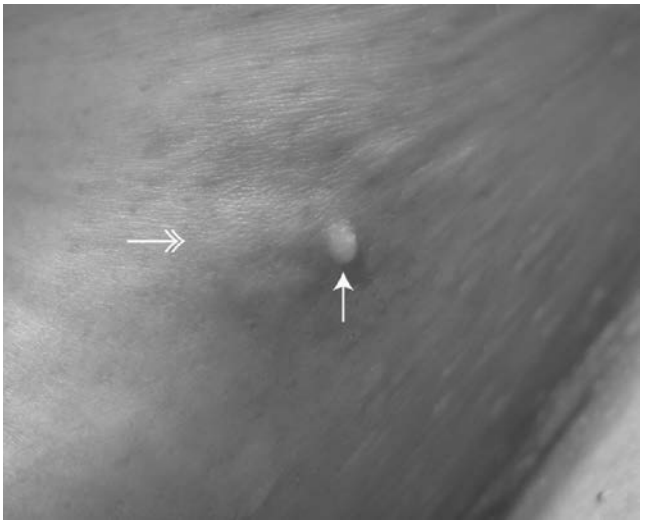
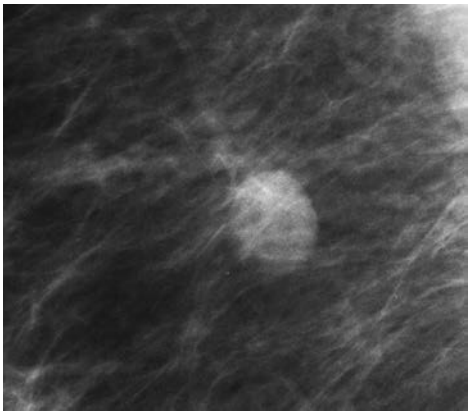
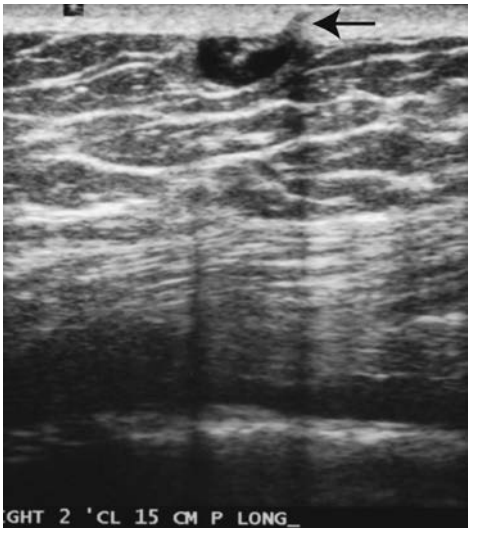


B

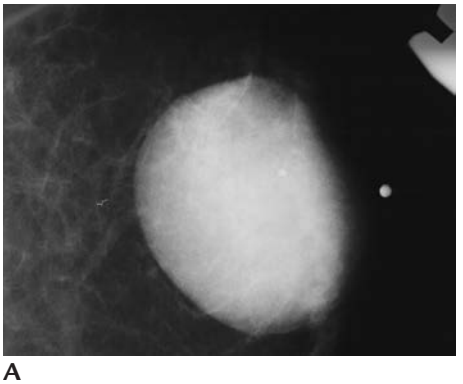
**FIGURE 9-13** Sebaceous cyst. **(A)** On physical examination a smooth, subtle contour deformity (*double headed arrows*) is present associated with a punctum (*arrow*). **(B)** With gentle compression a white, thick sebaceous material (*arrow*) can be expressed from the punctum. Gentle bulging contour (*double headed arrow*).

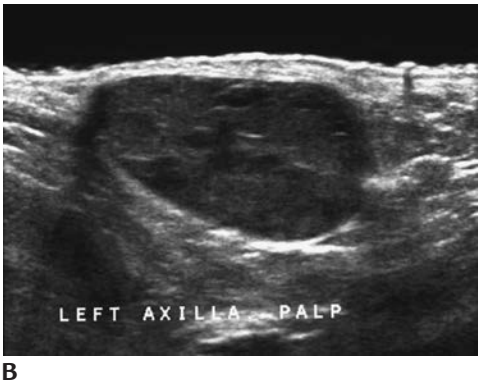





A B

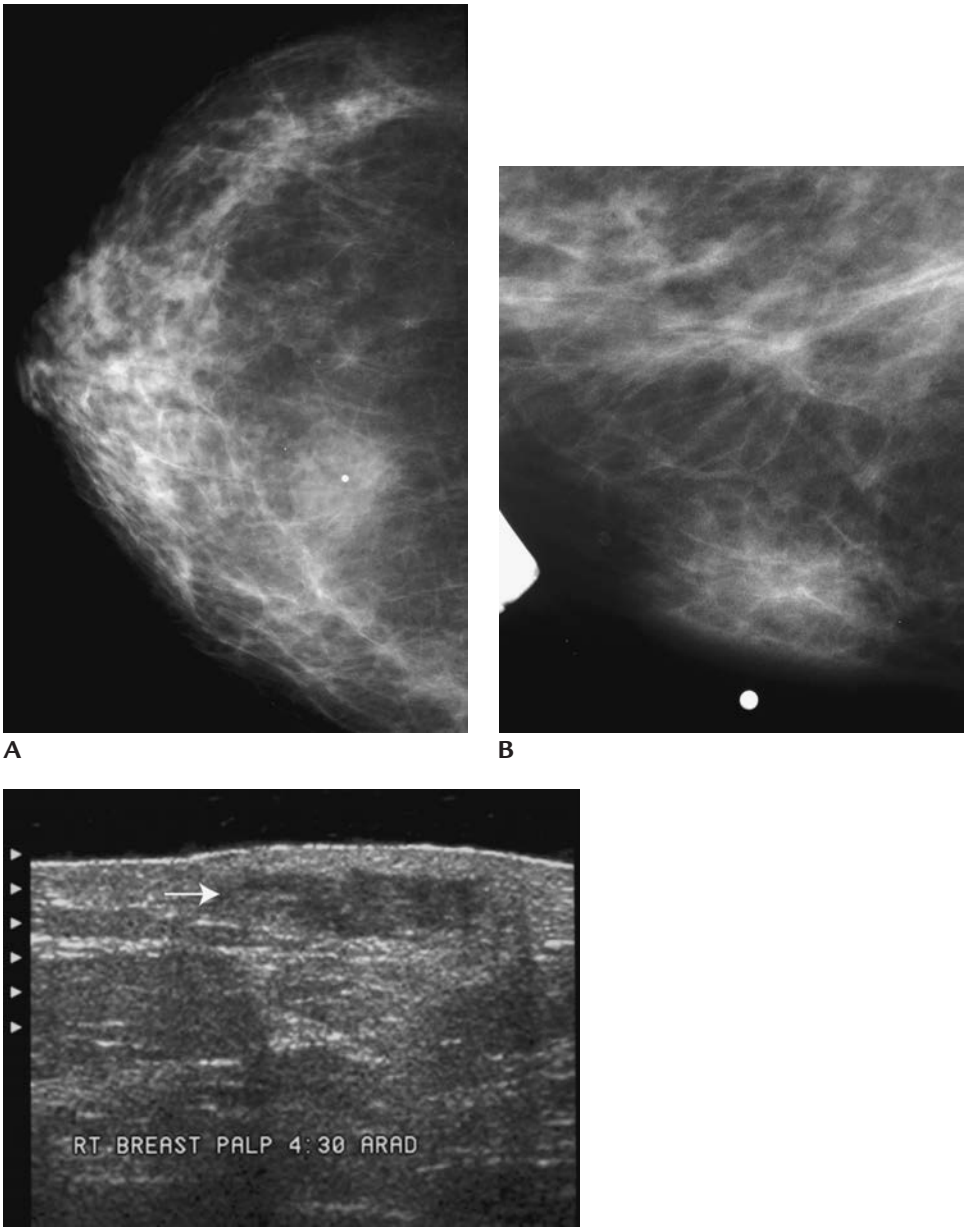
**FIGURE 9-14** Sebaceous cyst. **(A)** Spot compression view in the mediolateral oblique projection demonstrating an oval iso-dense mass with partially indistinct margins in the upper inner quadrant of the right breast (craniocaudal view not shown). **(B)** On physical examination, a mass is palpated in the upper inner quadrant of the right breast posteriorly. On palpation, the lesion moves with the skin (e.g., cannot slide skin over the lesion as can be done when a mass is in the breast). An oval hypoechoic mass with well-circumscribed margins is imaged on ultrasound corresponding to the palpable finding. Although not always apparent, a tract to the skin (*arrow*) is seen in this patient as a hypoechoic tubular structure extending from the mass through a portion of the dermis. Thin edge shadows are present.






A B

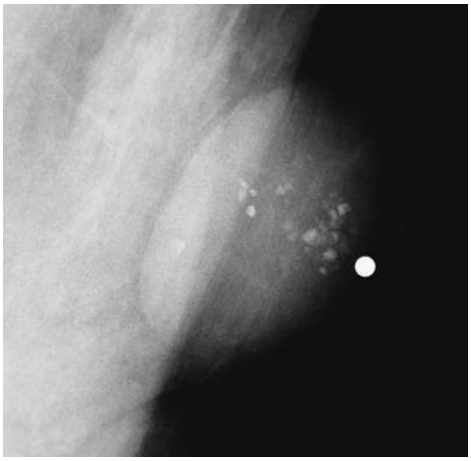
**FIGURE 9-15** Sebaceous cyst. **(A)** Spot tangential compression view of a palpable mass in the left axilla demonstrates an oval high density mass with circumscribed margins and a solitary round calcification. Metallic BB used by technologist to mark palpable finding. These lesions can occur anywhere; however, they are more common in the inner quadrants and axillary regions. **(B)** On ultrasound an oval, complex cystic mass is imaged corresponding to the superficial readily palpable mass associated with the skin.

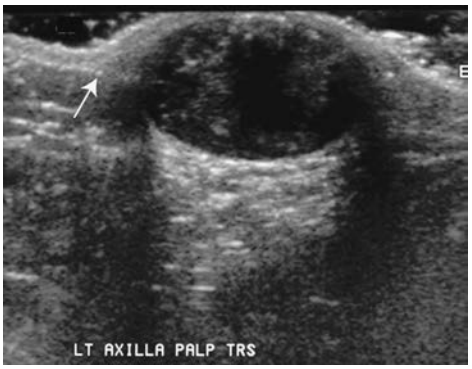



**A** **B**

**C**

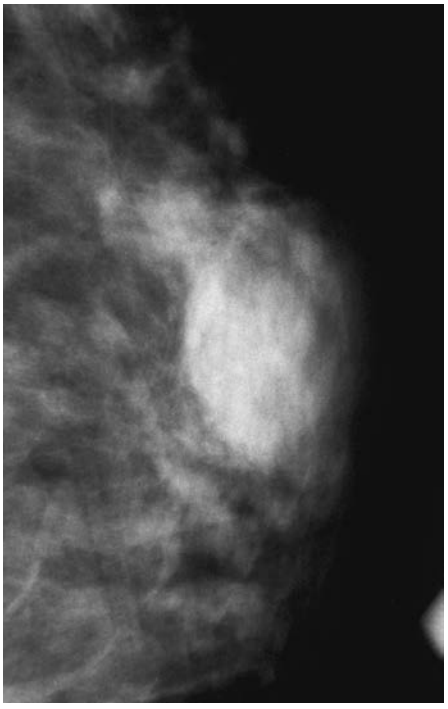
**FIGURE 9-16** Sebaceous cyst. **(A)** Round, isodense palpable (metallic BB) mass with indistinct margins in the medial aspect of the right breast. **(B)** Spot tangential view demonstrating palpable mass (metallic BB) with ill defined margins associated with the skin. **(C)** On ultrasound, an irregular, hypoechoic mass (*arrow*) with indistinct margins is imaged, arising in the dermal layer and causing focal thickening of the skin.

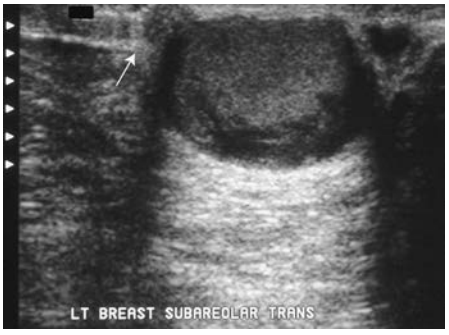





A B

**FIGURE 9-17** Sebaceous cyst. **(A)** Spot tangential view demonstrating an oval, circumscribed, isodense mass with associated calcifications corresponding to a palpable finding (metallic BB) in the left axilla. Sebaceous cysts can arise anywhere; however, they are more common in the inner quadrants and axillary regions. **(B)** On ultrasound, an oval, circumscribed mass with posterior acoustic enhancement and a heterogeneous echotexture related to the presence of calcifications associated with the dermis is imaged corresponding to the palpable finding. Note interruption of the deep dermal layer (*arrow*) commonly seen with lesions arising and expanding the skin.






A B

**FIGURE 9-18** Epidermoid cyst. **(A)** Spot tangential view demonstrating an oval mass with partially obscured margins corresponding to a palpable finding in the left subareolar area. **(B)** A complex cystic mass with posterior acoustic enhancement is imaged sonographically correlating with the clinically and mammographically apparent mass. Note interruption of the deep dermal layer (*arrow*) commonly seen with lesions arising and expanding the skin.

# NEUROFIBROMATOSIS

## KEY FACTS

- Clinical.

  Autosomal dominant disease with high penetrance and variable expressivity; single gene (long arm of chromosome 17) congenital syndrome affecting one in 2,000 to 3,000 individuals.

  Heterogeneous disease with two distinct variants.

  Type I, von Recklinghausen's: most common phakomatosis; accounts for more than 90% of neurofibromatosis patients; cutaneous lesions more common in this type (but can also be seen in type II).

  Café-au-lait, neurofibromas, and neurilemomas.

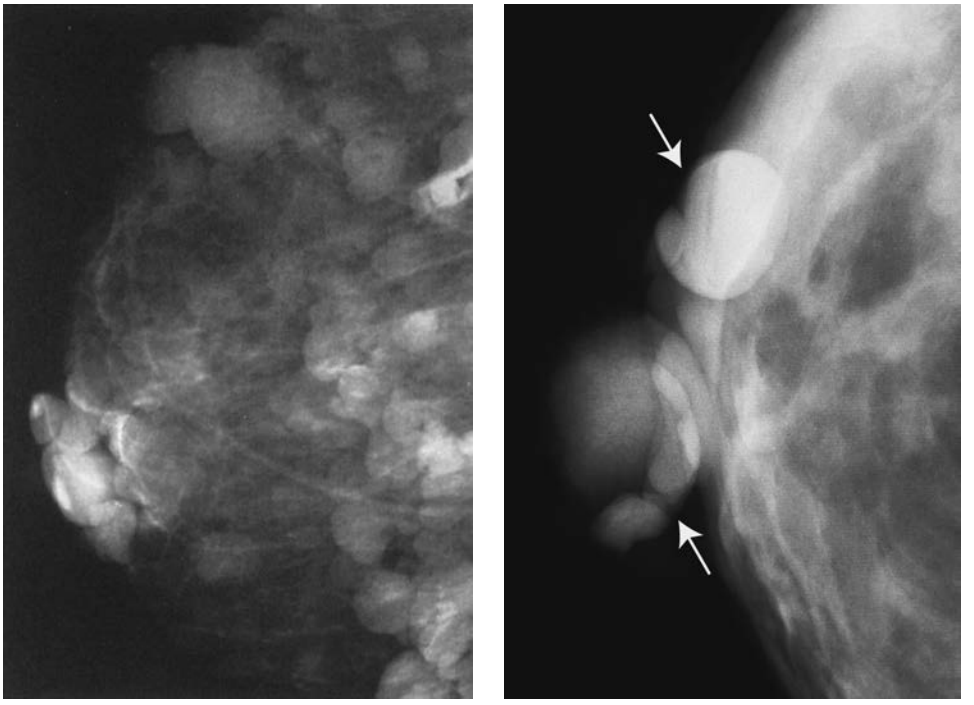
  Neurofibromas involve neural plexus or peripheral nerve sheath.

  Cutaneous lesions increase in size and number with advancing age.

  Other possible diagnoses in patients with multiple skin lesions: Gardner syndrome, cutaneous metastases, lipomatosis, steatocystoma multiplex, multiple leiomyomas, glomangiomas, xanthomatosis, and cysticercosis.
- Mammography.

  Multiple skin lesions: portion outlined by air is well defined.

  Evaluation of the breast may be difficult and limited because of skin lesions projecting on the breast parenchyma.



A B

**FIGURE 9-19** Neurofibromatosis. **(A)** Numerous neurofibromas project on the breast parenchyma. The margins of the lesions outlined by air are well circumscribed; for some of the lesions, a portion of the margin is lost at the site of attachment to the skin. **(B)** Neurofibromas surrounding the nipple, a common location for these to develop. Oval masses (*arrows*) with well-circumscribed margins surrounding the nipple.

## Mondor's Disease

### Key Facts

- Clinical.

  Thrombophlebitis of a superficial vein. In the breast, the thoracoepigastric vein is most commonly affected (traverses obliquely from epigastrium to anterior axillary line over lateral aspect of breast). The lateral thoracic vein, along the lateral margin of the pectoralis major, is involved less frequently.

  Tender, cordlike structure associated with erythema and linear skin dimpling (particularly with arm elevation).

  Limited benign condition; resolves spontaneously (2 to 24 weeks); no treatment is necessary.

  Unknown cause; history of previous trauma, prior breast surgery (reduction mammoplasty, augmentation, lumpectomy), breast cancer (12%), inflammation, extensive physical activity, and/or dehydration have been reported in some patients. Rarely, Mondor's disease can occur following imaging guided core biopsy.

  Can involve other body sites including arms, abdomen, groin, and penis (dorsal penile vein).

- Mammography.

  Dilated vein: ropelike density, may have beaded appearance.

  Subcutaneous thickening parallel to palpable cord.

  Tubular, coarse calcification outlining thrombosed vein.

  Phleboliths (calcifications) may be seen associated with tubular serpiginous density (e.g., if thrombosed vein does not recannulate).

- Ultrasound.

  Superficial, dilated vessel that is hypoechoic to anechoic with focal areas of narrowing creating a beaded appearance.

  No flow seen if Doppler used.

- Histology.

  Inflammation surrounding involved vessel.

  Involved veins usually recannulate.

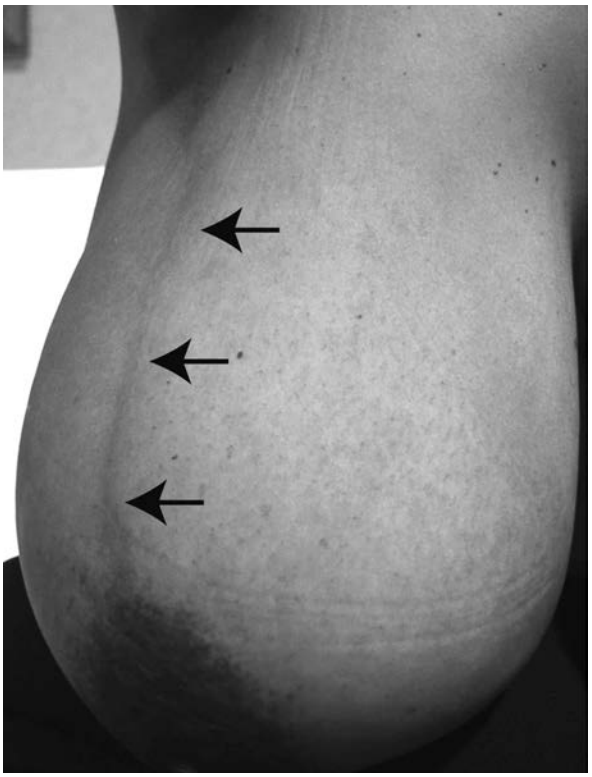
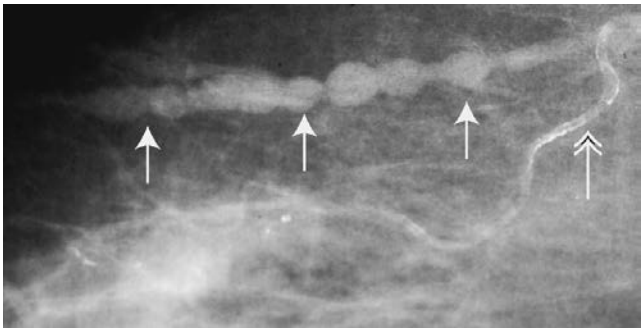


**FIGURE 9-20** Mondor's disease. Acutely, linear dimpling (*arrows*) particularly prominent when the patient raises the ipsilateral arm correlates to a tender, hard cord on physical examination.



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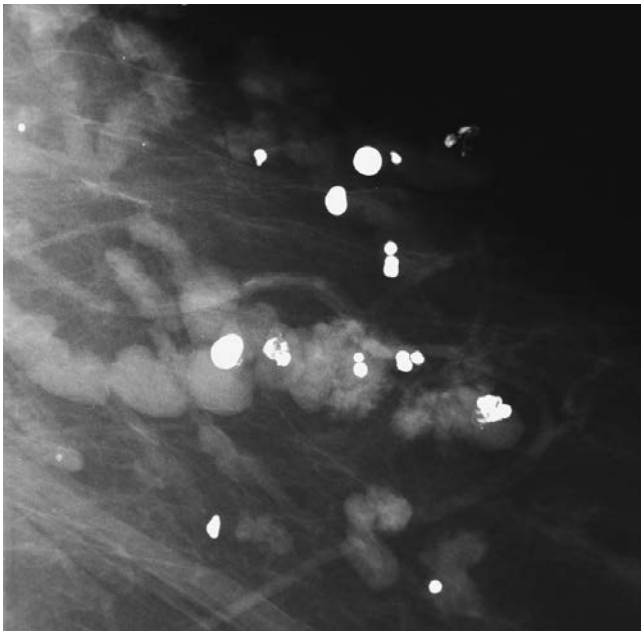


B

**FIGURE 9-21** Mondor's disease. **(A)** Acutely, the affected vein is imaged as a tubular structure (*arrows*) with a beaded appearance. Arterial calcification is present (*double headed arrow*). **(B)** Serpiginous, tubular structure associated with dystrophic calcifications. Although the involved vein reacannulates in most patients, the thrombosed vein may persist and can calcify as seen in this patient.

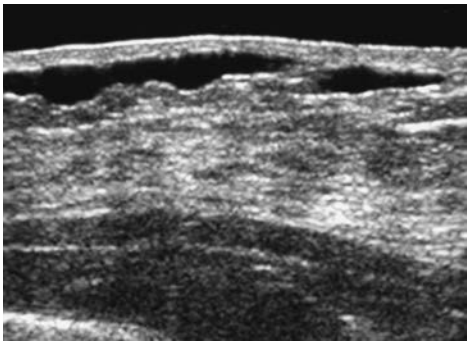


**FIGURE 9-22** Mondor's disease. Acutely, an anechoic tubular structure with a beaded appearance is often imaged sonographically in the subcutaneous tissue corresponding to area of linear dimpling on physical exam. With Doppler, no flow is seen acutely.

## Steatocystoma Multiplex

### Key Facts

- Clinical.

  Autosomal dominant, yet more common in males.
  Multiple cutaneous cysts appearing during adolescence and increasing progressively on trunk, proximal extremities and external genitalia.
  Lesions are soft to firm and smooth, not usually larger than 2 cm in diameter; when incised, oily liquid is released.
  Asymptomatic; may develop secondary inflammatory changes.
  Other possible diagnoses in patients with multiple skin lesions: Gardner syndrome, cutaneous metastases, lipomatosis, neurofibromatosis, multiple leiomyomas, glomangiomas, xanthomatosis, and cysticercosis.
- Mammography.

  Multiple, radiolucent (fatty), well-circumscribed masses (e.g., oil cysts): reportedly larger number of cysts in axillary tail.
- Ultrasound.

  Diagnosis is established based on clinical and mammographic findings; ultrasound is usually not indicated.
  Round or oval well-circumscribed mass with variable echo pattern ranging from anechoic to hypoechoic to isoechoic to hyperechoic.
  Complex cystic mass.
  May see posterior acoustic enhancement, shadowing or some have no posterior acoustic features.
  Unlike post-traumatic oil cysts occurring in the breast parenchyma, these lesions are confined to the dermis (e.g., intradermal) and may expand into the subcutaneous tissue.
- Histology.

  Thin squamous epithelial covering, epithelium may fold into cyst.
  Cyst may incorporate elements such as sebaceous glands.

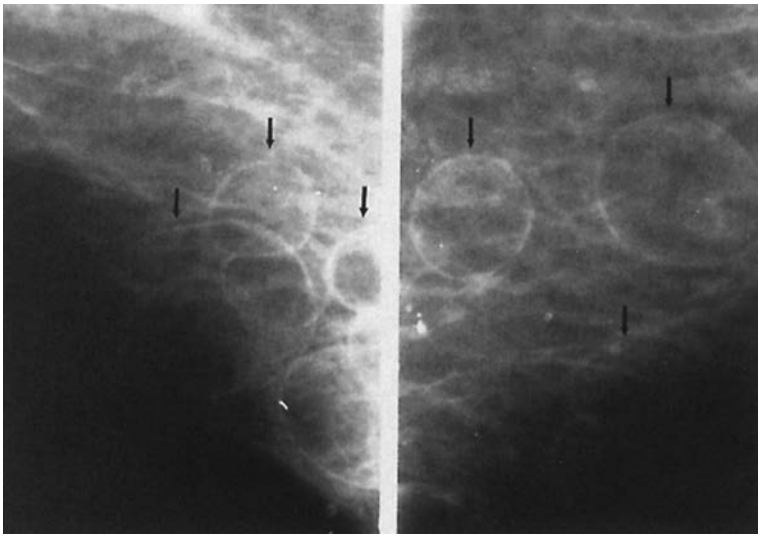


**FIGURE 9-23** Steatocystoma multiplex. Multiple oil cysts bilaterally *(arrows)*.

## Cutaneous Angiosarcoma (Postradiation)

### Key Facts

- Clinical.
  Estimates of incidence range from 0.09% to 0.16% may be as high as 0.3%.
  Skin of breast in prior radiation field.
  Median interval from therapy to development is 5 to 6 years; can range from 1 year postradiation to decades.
  Violaceous or erythematous nodules or larger sized plaques.
  Ecchymotic areas.
  May involve confluent area or present with multiple synchronous lesions.
  Need to be distinguished from atypical vascular lesions that usually develop sooner and are smaller (<5 mm red to brown papules) than angiosarcomas.
- Mammography.
  Round to oval mass with well-circumscribed to indistinct margins.
  Skin thickening.
- Ultrasound.
  Round, oval or irregular hypoechoic mass associated with the dermis.
  Skin thickening.
- Histology.
  Complex anastomosing and focally dilated vascular spaces.
  Ill-defined, infiltrative tumor that is dermal based and commonly invades the subcutaneous tissue.
  Range from well to poorly differentiated.

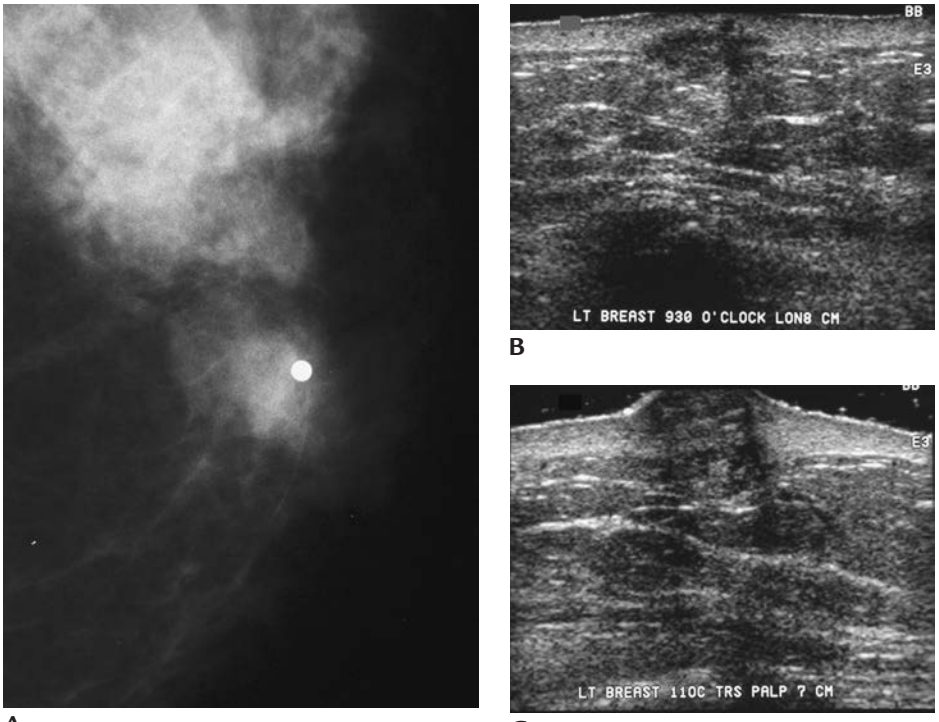



**FIGURE 9-24** Cutaneous angiosarcoma. **(A)** Spot tangential view of one of three superficial palpable masses in the left breast demonstrating a round mass with indistinct margins (metallic BB used to denote clinical finding). **(B)** Oval, hypoechoic mass arising in the dermis and extending into the subcutaneous tissue is imaged sonographically corresponding to one of three palpable, violaceous masses involving the skin in a patient with a history of prior radiation therapy for breast cancer. The margins are not circumscribed and demonstrate some lobulation. **(C)** Oval hypoechoic mass arising in dermis corresponding to second of three palpable, violaceous masses involving the skin in a patient with a history of prior radiation therapy for breast cancer. There is associated expansion of the skin with a resultant, clinically apparent bulging contour. The margins of the mass are not circumscribed and there is associated shadowing.

## Inflammatory Carcinoma

### Key Facts

- Approximately 1% of all breast cancers; definition of inflammatory carcinoma is debated: is the diagnosis dependent on the clinical findings of erythema, edema, and breast warmth or is the diagnosis made on histological sections demonstrating metastatic breast cancer in dermal lymphatics? Not all women with clinical findings suggestive of inflammatory carcinoma have involved dermal lymphatics and not all patients with tumor emboli in dermal lymphatics present with classic clinical signs.
- Clinical.

  Patients present with rapid breast enlargement and firmness (induration); some may have associated tenderness.

Erythema involving more than one third of the breast, edema (peau d'orange) and thickening of the skin, often more prominently involving the dependent portion of the breast, and breast warmth are the clinical findings required to make the diagnosis.

Approximately 80% of patients presenting with these findings have dermal lymphatic involvement on skin biopsy.

Approximately 4% of women with dermal lymphatic involvement do not demonstrate clinical signs associated with inflammatory carcinoma.

A discrete palpable mass is usually not present.

Aggressive lesions having a poor prognosis: most patients die of disease within 2 years of diagnosis.

At presentation differentiation from an acute inflammatory process (mastitis) may be difficult.

T4d tumor, at least Stage IIIB breast cancer.

Important to distinguish inflammatory carcinoma (a distinct entity based on epidemiologic and molecular evidence) from a locally advanced breast cancer with secondary skin involvement and associated inflammatory changes.

Combined modality treatment (neoadjuvant chemotherapy, surgery, radiation therapy, and consolidation chemotherapy) has resulted in improved survival in approximately 50% of patients.

- Mammography.

  Affected breast is usually larger, less compressible and denser than the contralateral normal breast requiring a higher kVp for exposure and higher resulting mAs.

  Diffusely increased density with skin and trabecular thickening are present, often without an identifiable dominant mass.

  On occasion, malignant calcifications can be seen scattered throughout the breast.

  Enlarged, dense axillary lymph nodes with loss of the fatty hilar region.

- Ultrasound.

  Skin thickening, dilated subdermal lymphatic channels and interstitial fluid.

  Prominent vascular structures in the subcutaneous tissue (can be identified with the use of Doppler).

  Diffuse changes: tissue is hyperechoic (use contralateral side for comparison) and there is disruption of normal tissue planes.

  Irregular, ill-defined, hypoechoic mass or masses with or without posterior acoustic shadowing. If a mass is identified core biopsy can be undertaken.

  Microcalcifications (specular echoes with shadowing).

  Enlarged and abnormal appearing axillary lymph nodes: thickened and bulging cortical region with attenuation (mass effect) or obliteration of hyperechogenic hilar region.

- Magnetic resonance imaging.

  Limited number of studies in the literature.

  Skin thickening, skin enhancement, axillary adenopathy, breast enlargement and edema (T2 images).

Mass in up to 38% of patients; either plateau or rapid wash in and out patterns of enhancement.

MR is also being used to monitor response to chemotherapy.

- Gross.

  Distinct tumor may not be identifiable, disease involves breast diffusely.

- Histology.

  Dilated dermal lymphatics with tumor emboli.

  Associated inflammatory response in dermis surrounding vascular channels.

  Poorly differentiated invasive ductal carcinoma.

  Tumor emboli in vessels common.

  High grade tumors, estrogen and progesterone receptor negative (56% to 83%) with overexpression of p53 (30% to 69%).

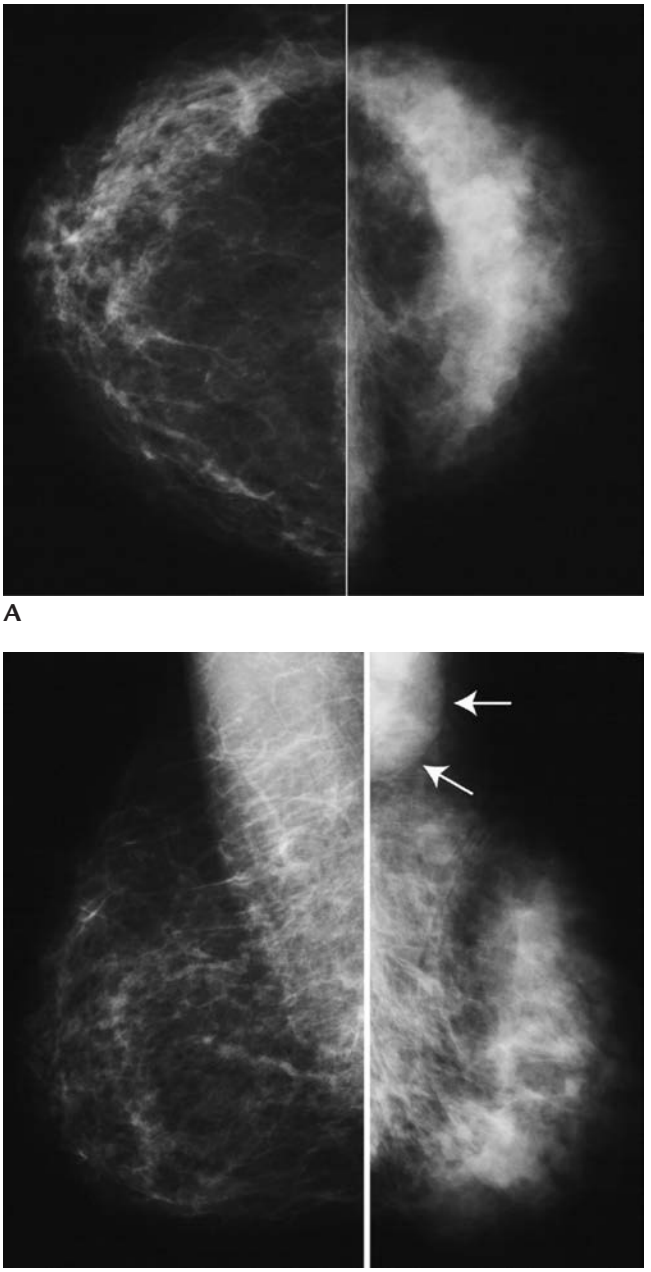
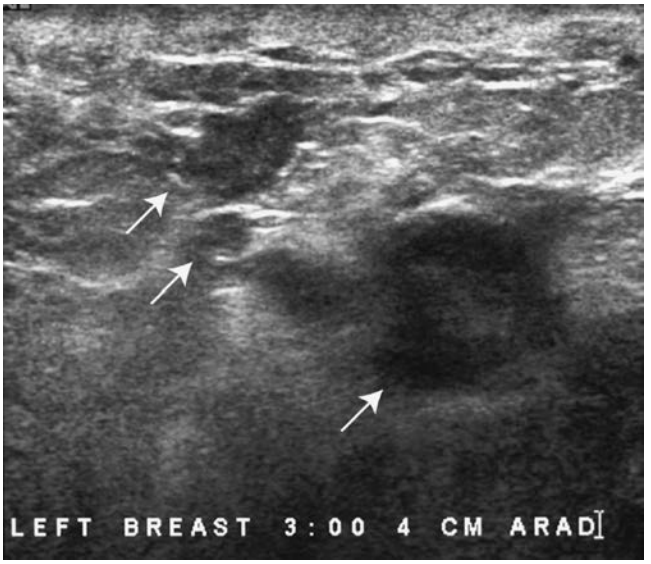


**FIGURE 9-25** Inflammatory breast carcinoma. **(A)** Craniocaudal views demonstrate asymmetric breast size (left breast smaller than right) associated with increased density diffusely involving the left breast. **(B)** Mediolateral oblique views demonstrate asymmetric breast size (left breast smaller than right), associated with increased density, skin thickening (best seen with a bright light) and trabecular thickening. Enlarged and dense axillary lymph nodes (*arrows*) are also present consistent with metastatic disease common in patients presenting with inflammatory carcinoma.

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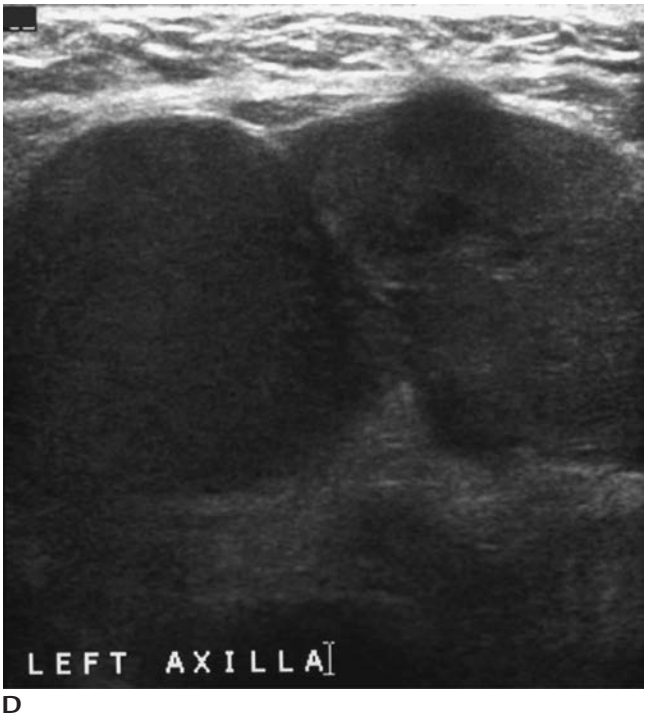



D

**FIGURE 9-25** (*Continued*) **(C)** Although not all patients presenting with inflammatory carcinoma will have a demonstrable focal abnormality on ultrasound that can be biopsied, in this patient, multiple masses (*arrows*) are identified laterally in the left breast. Skin thickening is also present. **(D)** As suspected mammographically, multiple hypoechoic masses are confirmed sonographically in the left axilla. An ultrasound guided core biopsy is done to establish the presence of metastatic disease to left axillary lymph nodes.

## MISCELLANEOUS

### KEY FACTS

- Candidal intertrigo.
  Inframammary area most commonly involved.
  Eroded, weepy lesion with scalloped borders and an erythematous surrounding skin margin.
  When positioning these patients particularly for the craniocaudal view, document extent of lesion prior to starting and exercise care, because the skin is easily torn resulting in bleeding.
- Herpes zoster.
  Virus lies dormant in dorsal root ganglia; cutaneous lesions follow the distribution of the sensory nerves.
  More common in winter.
  10 to 20 day incubation period.
  24-hour prodrome: fever, exanthem.
  2- to 4-mm pink to red papules erupt, coalesce to form central 3- to 4-mm vesicle surrounded by red halo.
  With leukocyte infiltration, the vesicles become turbid.
  The lesion umbilicates, dies, and crusts over.
- Skin necrosis.
  Reported secondary to anticoagulant therapy occurring in 0.1% of patients on Coumadin (to be distinguished from cutaneous hemorrhage).
  Presentation: obese woman with pain in an area of abundant subcutaneous fat 3 to 6 days after the onset of treatment.
  Maplike ecchymosis of skin with halo of erythema progresses to bullous formation and skin necrosis.
  Etiology: thought to be direct toxicity of Coumadin on endothelial cells.
- Syphilis.
  Rare in developed countries.
  Primary and secondary cutaneous involvement of the breast.
  Primary chancre will heal in 2 to 6 weeks without treatment.
  Secondary stage, on average 3 weeks after primary chancre: influenzalike presentation; diffuse lymphadenopathy; generalized rash (discrete lesions, sharply demarcated, coppery hue).
  Early cutaneous manifestation of secondary syphilis includes macular or erythematous eruption on the breast skin.
- Melanoma.
  Primary breast skin melanomas account for approximately 2% to 5% of all melanomas.
  Irregular borders, variation in color (tan, brown, black, pink, blue and gray), depigmentation in surrounding areas.
  Nodularity, induration and ulceration.
  Four histopathological variants (lentigo maligna: sun exposed skin; superficial spreading; acral lentiginous: palm, soles, and periungual areas; nodular melanoma). Superficial spreading and nodular melanoma are the two most common types involving the breast.

**FIGURE 9-26** Candidal intertrigo. Involvement of the inframammary fold area as in this patient is common. The margin is scalloped and the lesion is eroded, weepy, and erythematous. In patients presenting with active lesions, the technologist should document the extent of the lesion in the patient's history form prior to beginning the exam and she should exercise care in positioning the patient particularly for the craniocaudal views. If care is not taken during positioning, the skin is easily torn resulting in bleeding.

## SUGGESTED READINGS


Anderson WF, Schairer C, Chen BE, et al. Epidemiology of inflammatory breast cancer. *Breast Diseases*. 2005,2006;22:9–23.

Apesteguia L, Mellado MT, Inchusta MI, et al. Mammographic demonstration of steatocystoma multiplex. *Eur Radiol*. 1998;8:647–648.

Brenn T, Fletcher CDM. Postradiation vascular proliferations: an increasing problem. *Histopathology*. 2006;48:106–114.

Britstol IJ, Buchholz TA. Inflammatory breast cancer: current concepts in local management. *Breast Diseases*. 2005,2006; 22:75–83.

Chow CK. Imaging in inflammatory breast carcinoma. *Breast Diseases*. 2005,2006;22: 45–54.

Conant EF, Wilkes AN, Mendelson EB, et al. Superficial thrombophlebitis of the breast (Mondor's disease): mammographic findings. *AJR Am J Roentgenol*. 1993;160: 1201–1203.

Fajardo LL, Bessen SC. Epidermal inclusion cyst after reduction mammoplasty. *Radiology*. 1993;186:103–106.

Günhan-Bilgen I, Ünstün EE, Memis A. Inflammatory breast carcinoma: mammographic, ultrasonographic, clinical and pathological findings in 142 cases. *Radiology*. 2002;223:829–838.

Harris AT. Mondor's disease of the breast can also occur after a sonography-guided core biopsy. *AJR Am J Roentgenol*. 2003;180:284–285.

Jaberi M, Willey SC, Brem RF. Stereotactic vacuum-assisted breast biopsy: an unusual cause of Mondor's disease. *AJR Am J Roentgenol*. 2002;179:185–186.

Kell MR, Morrow M. Surgical aspects of inflammatory breast cancer. *Breast Diseases*. 2005,2006; 22:67–73.

Kim HS, Cha ES, Kim HH, et al. Spectrum of sonographic findings in superficial breast masses. *J Ultrasound Med*. 2005;24:663–680.

Kushwaha AC, Whitman GJ, Stelling CB, et al Primary inflammatory carcinoma of the breast: retrospective review of the mammographic findings. *AJR Am J Roentgenol*. 2000;174:535–538.

Lee KW, Chung SY, Yang I, et al. Inflammatory breast cancer: imaging findings. *Clin Imaging*. 2005;29:22–25.

Mester J, Darwish M, Deshmukh SM. Steatocystoma multiplex of the breast. Mammographic and sonographic findings. *AJR Am J Roentgenol*. 1998;170:115–116.

Park KY, Oh KK, Noh TW. Steatocystoma multiplex: mammographic and sonographic manifestations. *AJR Am J Roentgenol*. 2003;180:271–274.

Pollack AH, Kuerer HM. Steatocystoma multiplex: appearance at mammography. *Radiology*. 1991;180:836–838.

Scanlan KA, Propeck PA. Chronic graft-versus-host disease causing skin thickening on mammograms. Case Report. *AJR Am J Roentgenol*. 1995;165:555–556.

Shebi LJ, Pierson KK. Benign and malignant epithelial neoplasms and dermatological disorders. In: Bland KI, Copeland EM, eds. *The Breast*. Philadelphia; WB Saunders; 1991:222–233.

Shetty MK, Watson AB. Mondor's disease of the breast: sonographic and mammographic findings. *AJR Am J Roentgenol*. 2001;177:893–896.

Yang CH, Cristofanilli M. Systemic treatments for inflammatory breast cancer. *Breast Diseases*. 2005,2006;22:55–65.

Walshe JM, Swain SM. Clinical aspects of inflammatory breast cancer. *Breast Diseases*. 2005,2006;22:35–44.

Wu M, Merajver SD. Molecular biology of inflammatory breast cancer: applications to diagnosis, prognosis and therapy. *Breast Diseases*. 2005,2006;22:25–34.

CHAPTER 10

# NIPPLE-AREOLAR COMPLEX

## NORMAL ANATOMY

### KEY FACTS

- Nipple.
  15 to 20 duct openings; some end blindly.
  In the nonlactating state, duct openings may be plugged with keratin.
  Stratified squamous epithelium.
  Connective tissue, bundles of smooth muscle and elastic tissue deep to epidermis.
  Sebaceous and apocrine glands.
  Rich in sensory fibers.
  Lobular elements may be found in the nipple in as many as 17% of women.
  We do not mark the nipple for the routine views, nor do we take special measures to image the nipple in profile. This approach has not created significant problems. If there is a question of an underlying subareolar mass, anterior compression or subareolar spot compression views (that may be taken with the nipple in profile) are obtained.
- Nipple absence.
  May occur in women with Poland's syndrome.
- Supernumerary nipples (polythelia).
  Can affect both sexes.
  Accessory nipples more common just below the normal breast, but can be found anywhere along the milk line (axilla to groin).
  May have associated breast tissue (supernumerary breasts): physiological fluctuations and pathological conditions observed in normal breasts can affect accessory breast tissue.
  Associated with other congenital disorders: urinary tract (renal agenesis, renal cell carcinoma, obstructive disease, supernumerary kidneys); cardiac

(conduction disturbances, hypertension, congenital heart abnormalities); miscellaneous (pyloric stenosis, epilepsy, ear abnormalities).

- Areola.

  Modified sebaceous, apocrine sweat, and rudimentary mammary glands.

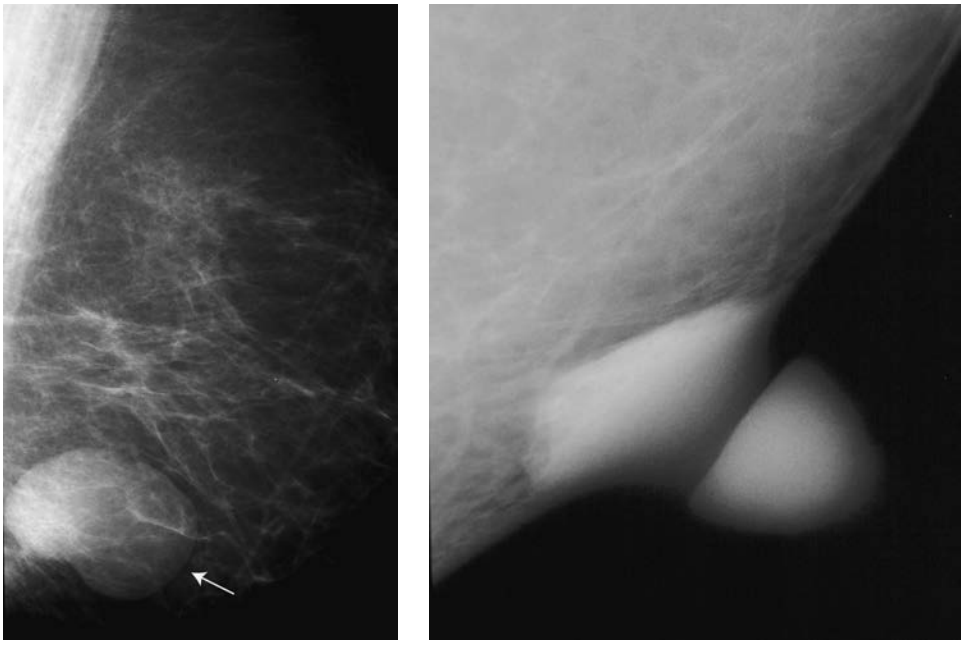
  Hair follicles at periphery of areola only.

  Rounded elevations on the surface of the areola (Morgagni's tubercles) are the openings for Montgomery's glands (sebaceous and rudimentary mammary glands).

  Montgomery's glands secrete thick, proteinaceous material during lactation for lubrication and protection of the nipple. Rarely, women describe milky fluid arising from the Montgomery's glands.

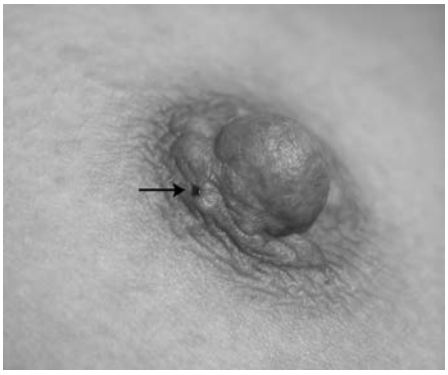
  Stratified squamous epithelium.

  Rarely, patients present with discharge arising from a Montgomery's gland; in most, self-limited and no underlying pathology is identified.
- Nipple-areolar complex enlarges and becomes more pigmented during pregnancy; these changes may be permanent.



**A** **B**

**FIGURE 10-1** Accessory nipple. **(A)** Circumscribed mass superimposed on the left breast inferiorly in the mediolateral oblique view. Air (sharp radiolucency) partially outlines border (*arrow*) of the accessory nipple. **(B)** Spot tangential view demonstrating accessory nipple extending beyond skin just above the inframammary fold centrally. Although in some women accessory breast tissue may be associated with accessory nipples, no associated breast tissue is evident in this patient. Accessory breast tissue can be found extending along the milk line bilaterally from the axilla to the groin.



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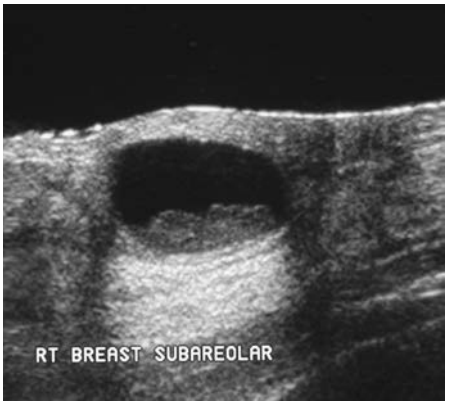


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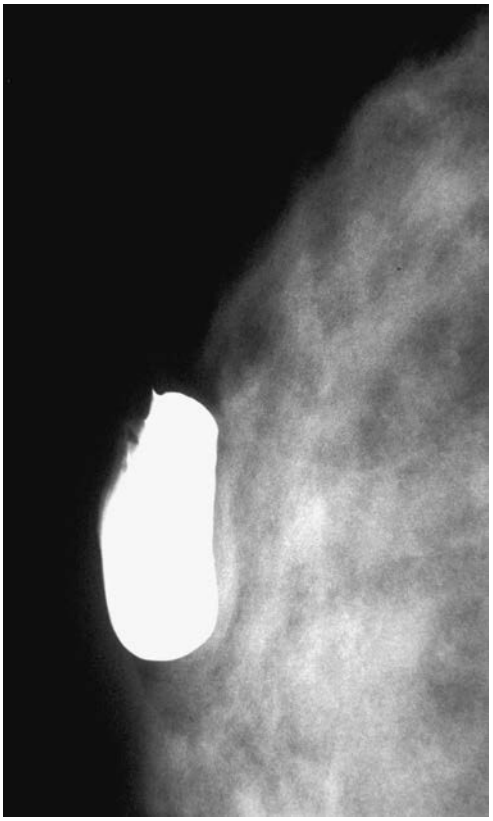


C

**FIGURE 10-2** Montgomery's gland. **(A)** Discharge arising from a Montgomery's gland (*arrow*). **(B)** Ultrasound at the site of the discharge demonstrates a complex cystic mass associated with the dermal layer and causing a smooth contour deformity of the skin at this site. **(C)** Blind ending structure is opacified following cannulation of secreting gland orifice and injection of contrast. No filling defects are identified.

## Nipple Changes Associated with Breast Cancer

### Key Facts

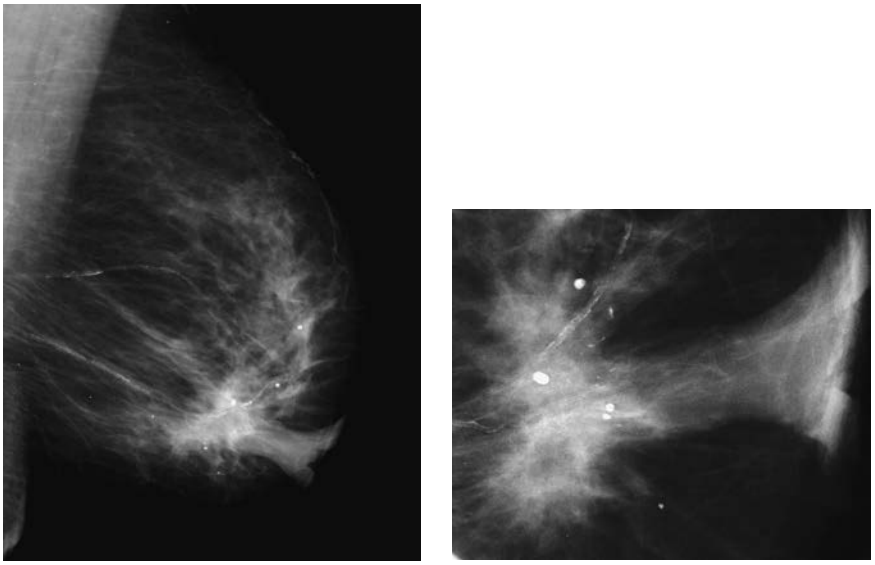
- Nipple retraction.

  Underlying cancers can cause nipple skin thickening and retraction (nipple inversion).

  Demonstration of lesion causing nipple retraction may require spot compression views of the subareolar area. As the thickest part of the breast, the base may limit compression anteriorly. Also, given the convergence of ducts and possible nipple superimposition the subareolar area may be "busy."
- Nipple ulceration.

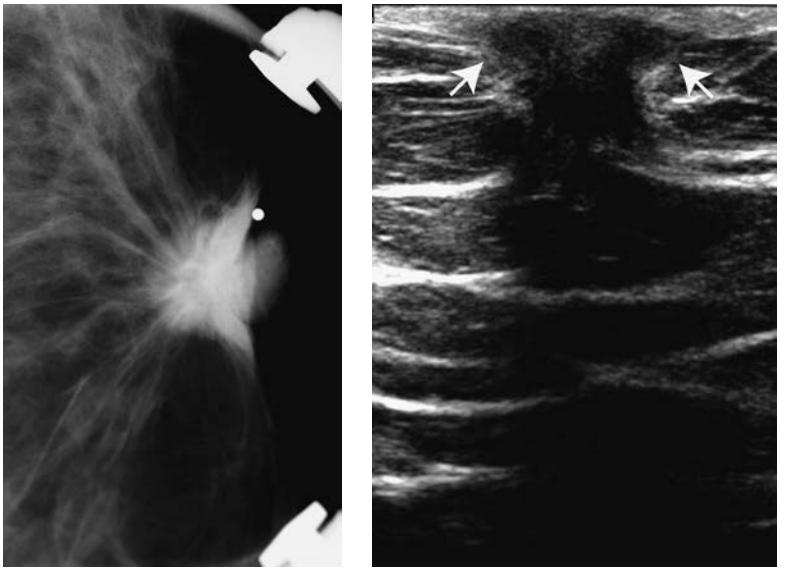
  Related to Paget's disease.

  Rarely, advanced breast cancer extending out to involve the surface of the nipple.



A B

**FIGURE 10-3** Invasive ductal carcinoma. **(A)** Left mediolateral oblique views demonstrating an irregular mass in the subareolar area associated with nipple and skin thickening, retraction, and inversion. Vascular and coarse dystrophic calcifications are present. **(B)** Subareolar microfocus (0.1 mm) spot compression magnification view (1.8×) confirming irregular mass with spiculated margins and associated nipple thickening, inversion, and retraction. In addition to vascular and coarse dystrophic type calcifications, smaller oval and linear microcalcifications are present in the mass reflecting associated ductal carcinoma in situ.



A B

**FIGURE 10-4** Invasive ductal carcinoma. **(A)** Spot compression view, left subareolar area demonstrates a round, high density mass with spiculated margins and associated nipple retraction. Metallic BB used to mark clinical findings (e.g., palpable mass and nipple retraction). **(B)** Hypoechoic mass in the subareolar area with angular and spiculated margins and associated shadowing, difficult to separate from nipple (*arrows*).

## DERMATITIS

### KEY FACTS

- Clinical.

  Contact dermatitis: bacterial infection, irritation from clothes, soap, cosmetics or unknown etiology.

  Differentiation from Paget's disease can be difficult.

  Rapid time course, in contrast to slower development of Paget's disease.

  The nipple is not destroyed with dermatitis.

  If the lesion involves the nipple only, it is more likely to be Paget's disease. If it involves both the nipple and areola, it is Paget's disease or (less likely) dermatitis. If it involves the areola and surrounding skin with no nipple involvement, it is not Paget's disease.

## Paget's Disease

### Key Facts

- Clinical.

  1% to 3% of all breast carcinomas.

  Distinct clinical features involving the nipple.

  Appearance of nipple varies depending on extent and stage of disease.

  Initial: reddening of nipple and areola associated with pruritus.

  Progression: moist, scaling, and eczematoid changes leading to ulceration and erosion of nipple.

  If lesion involves nipple only, it is more likely to be Paget's disease. If it involves both the nipple and areola, it is Paget's disease or (less likely) dermatitis. If it involves the areola and surrounding skin with no nipple involvement, it is not Paget's disease.

  Approximately 50% of patients have a palpable mass.

  Usually unilateral.

  Often associated with underlying malignancy that may be extensive and difficult to assess clinically and mammographically; invasive disease, usually poorly differentiated, in approximately 60% of patients.

  Associated ductal carcinoma in situ is usually high nuclear grade with over expression of the c-erb-B2 oncogene.

  Occasionally intraductal papillomas protrude onto the nipple surface, producing a weeping, red lesion so that Paget's disease comes into differential. A palpable mass, however, is usually identified with papillomas (unlike Paget's disease).

  Mastectomy is often the treatment of choice; breast conservative therapy with complete resection of the nipple areolar complex and radiation therapy may be used in patients with less extensive underlying disease.

  Prognosis determined by extent of associated underlying malignancy.

- Mammography.

  Normal in some patients; underlying malignancy identified in 50% to 75% of patients.

  Nipple retraction.

  Nipple and areolar thickening.

  Nipple calcifications.

  Mass may be subareolar but can occur anywhere in the breast.

  Pleomorphic, linear, and linearly oriented calcifications, anywhere in the breast reflecting ductal carcinoma in situ.

- Magnetic resonance imaging.

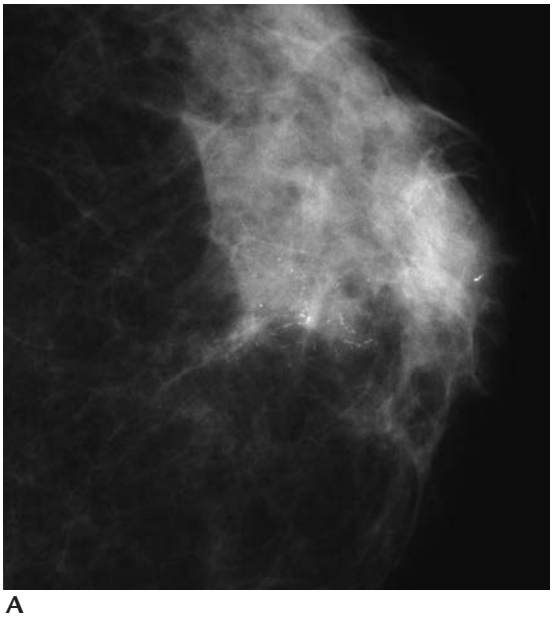
  May be helpful in identifying underlying malignancy, particularly when mammogram is normal.

  For characterizing extent of disease preoperatively and evaluating contralateral breast.

- Histology.

Large cells (Paget's disease cells) with abundant pale cytoplasm and large nuclei with prominent nucleoli (adenocarcinoma cells) infiltrate epidermis of nipple.

Cells may have melanin pigment (phagocytosis).



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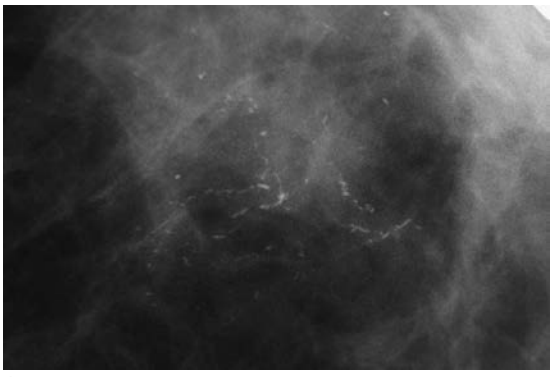


B

**FIGURE 10-5** Paget's disease of the nipple with underlying ductal carcinoma in situ, high nuclear grade with associated central necrosis. **(A)** Pleomorphic calcifications with fine linear forms demonstrating linear orientation consistent with ductal carcinoma in situ and associated central necrosis. **(B)** Double spot compression magnification (1.8×) view demonstrating pleomorphic calcifications including linear calcifications with clefts, irregular margins, and linear orientation in a patient presenting with nipple erosion. Although the underlying malignancy in patients with Paget's disease of the nipple is not always apparent, a mass or calcifications is demonstrated in 50% to 75% of patients.

## Nipple Adenoma

### Key Facts

- Clinical.

  Rare, usually unilateral.

  Nipple discharge is a common presentation (65% to 70%).

  Enlargement and induration of nipple with associated redness and crusting (findings may be mistaken for Paget's disease).

  Adenoma may protrude through duct orifice (friable, granulating mass).

  Pain, itching, or burning.

  Has been described in male patients.

  To be distinguished from syringomatous adenoma that can be locally recurrent if not widely excised.
- Mammography.

  Normal.

  Well circumscribed mass, subareolar in location; may have associated round and punctate calcifications.

  Cluster of round and punctate calcifications in subareolar area.
- Ultrasound.

  Intraductal lesion extending to nipple.

  Circumscribed, hypoechoic mass; may have associated calcifications.
- Ductography.

  Filling defect extending to nipple (on cannulation of duct may see lesion protruding through duct orifice).
- Magnetic resonance imaging.

  Limited experience; single case reports describe early strong enhancement with rim enhancement on dynamic contrast enhanced T1 weighted images with gradual washout of contrast in the periphery and more rapid washout from internal portions of the mass.

  High signal intensity on T2-weighted images.
- Histology.

  Adenomatous proliferation of small tubules.

  Has also been termed florid papillomatosis because of associated intraductal epithelial proliferation.

  Myoepithelial cells are present.

  To be distinguished from syringomatous adenomas that are characterized by proliferation of angulated, round tubules that infiltrate the fibrous stroma of the nipple without associated intraductal epithelial hyperplasia; the presence of a two-cell layer (epithelial and myoepithelial cells) distinguishes these lesions from tubular carcinomas; unlike nipple adenomas, syringomatous adenomas can be locally recurrent when not widely excised.

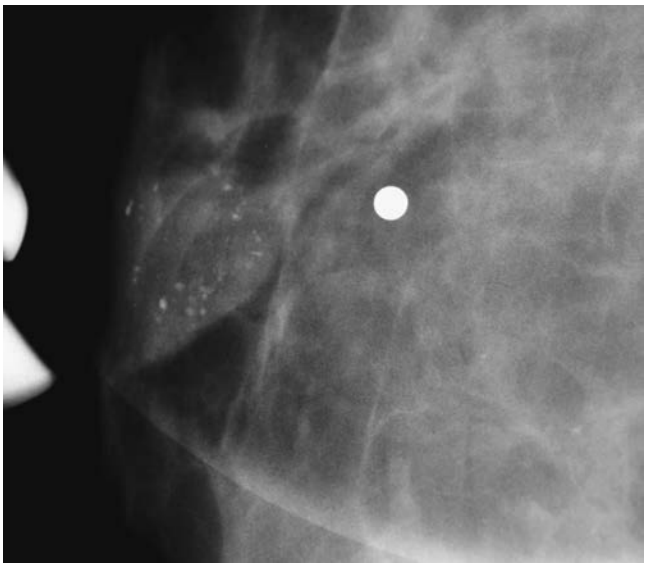
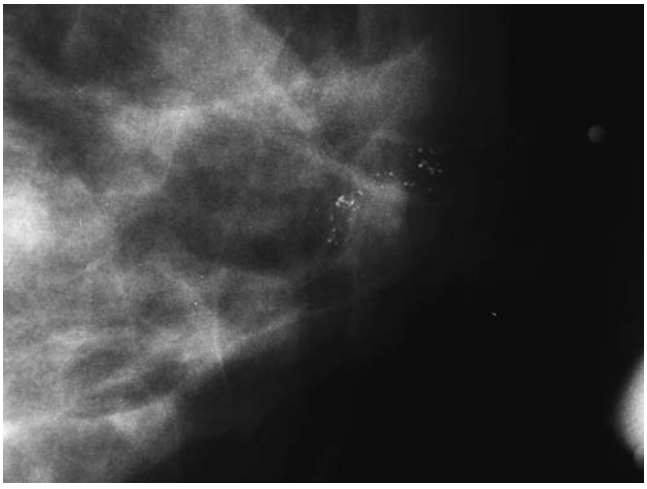


**FIGURE 10-6** Nipple adenoma. Spot compression magnification (1.8×) view, right subareolar area. Round, isodense, circumscribed mass with associated pleomorphic calcifications in the right subareolar area correlates to palpable finding. Metallic BB used to mark palpable finding.



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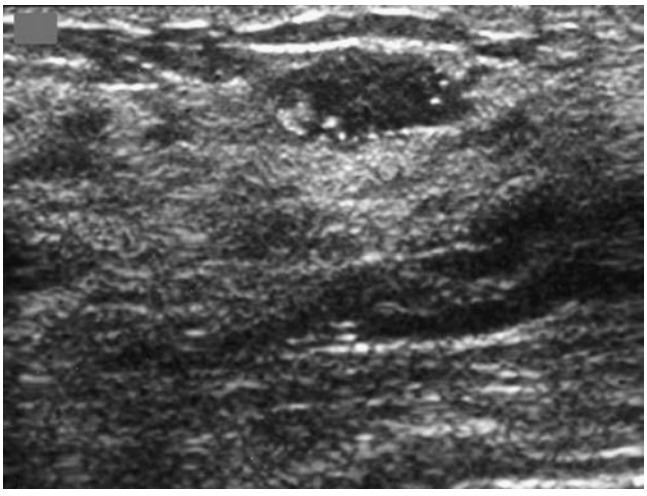


**B**

**FIGURE 10-7** Nipple adenoma. **(A)** Double spot compression microfocus (0.1 mm), magnification (1.8×) view of the left subareolar area. Cluster of predominantly round and punctate calcifications corresponding to palpable finding, left subareolar area. No mass is readily apparent on the mammogram. **(B)** Oval, hypoechoic mass with multiple high specular echoes consistent with associated calcifications (seen mammographically) corresponding to the palpable finding, left subareolar area.

## SUGGESTED READINGS

Burke ET, Braeuning MP, McLelland R, et al. Paget disease of the breast: a pictorial essay. *RadioGraphics*. 1998;18:1459–1464.

Fornage BD, Faroux MJ, Pluot M, et al. Nipple adenoma simulating carcinoma: misleading clinical, mammographic, sonographic and cytologic findings. *J Ultrasound Med*. 1991;10:55–57.

Frei KA, Bonel HM, Pelte MF, et al. Paget disease of the breast: findings at magnetic resonance imaging and histopathologic correlation. *Invest Radiol*. 2005;40: 363–367.

Gilula LA, Destouet JM, Monsees B. Nipple simulating a breast mass on a mammogram. *Radiology*. 1989;170:272.

Haagensen CD. Paget's carcinoma of the breast (758–781). *Diseases of the Breast*. 3rd ed. Philadelphia: WB Saunders; 1986:758–781.

Ikeda DM, Helvie MA, Frank TS, et al. Paget disease of the nipple: radiologic-pathologic correlation. *Radiology*. 1993; 189:89–94.

Kothari AS, Beechey-Newman N, Hamed H, et al. Paget disease of the nipple. *Cancer*. 2002;95:1–7.

Ku J, Bennett RD, Chong KD, et al. Syringomatous adenoma of the nipple. *The Breast*. 2004;13:412–415.

Matsubayashi RN, Adachi A, Yasumori K, et al. Adenoma of the nipple: correlation of magnetic resonance imaging findings with histologic features. *J Comput Assist Tomogr*. 2006;30:148–150.

Page DL, Anderson TJ. *Diagnostic Histopathology of the Breast*. Edinburgh: Churchill Livingstone; 1987.

Tabár L, Dean PB. *Teaching Atlas of Mammography*. New York: Thieme Verlag; 1985.

Tavassoli FA. *Pathology of the Breast*. New York: Elsevier; 1992.

Yosepovich A, Perelman M, Ayalon S, et al. Syringomatous adenoma of the nipple: a case report. *Pathology—Research and Practice*. 2005;201:405–407.

CHAPTER 11

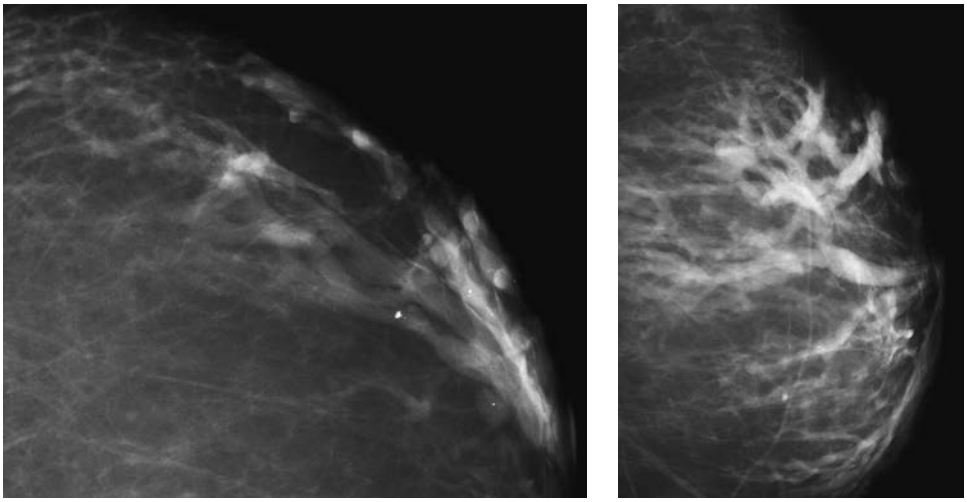
# MAJOR SUBAREOLAR DUCTS

## General Comments

### Key Facts

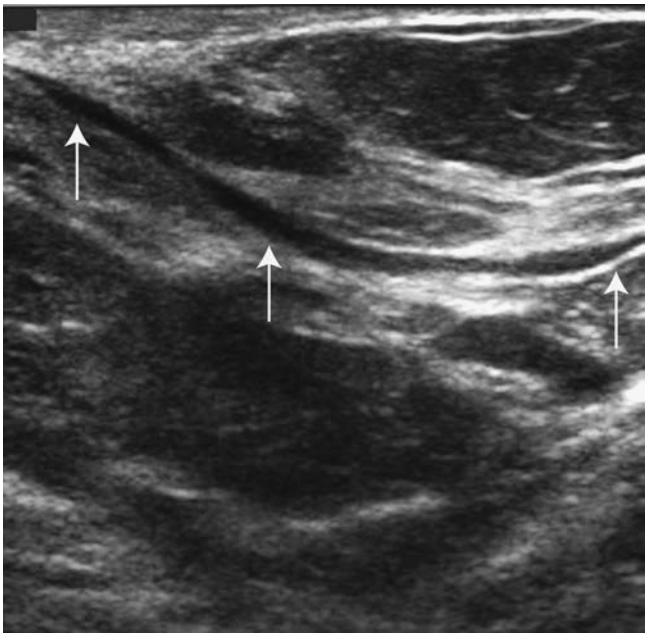
- There are only a few studies available that describe breast ducts and duct anatomy and how these may vary with hormonal changes during pregnancy or in disease states.
- The number of major ducts varies; estimated range from 8 to 20.
- The branching pattern and distribution of ducts in the breast vary among women and in the individual woman during the course of her lifetime.
- The concepts of "lobes," "segments," and "quadrants" in the breast, as though these can be defined anatomically, must be reevaluated. It is probably impossible to isolate a single duct as defining a lobe, segment, or quadrant. Ducts do not delineate specific anatomic areas in the breast; they overlap and can have widely divergent courses.
- In some women, ducts connect because injection of methylene blue in one duct opening can result in methylene blue arising from one or more adjacent duct openings.
- The collecting duct is the portion of the duct connecting the ductal orifice on the nipple to the lactiferous sinus.
- Lactiferous sinuses, in turn, connect to major subareolar ducts.
- The major subareolar ducts divide into a variable number of subsegmental ducts.
- Subsegmental ducts, in turn, divide into a variable number of terminal duct lobular units.
- Unless dilated or calcified, ducts are usually not seen mammographically. They may be seen for variable lengths on ultrasound as tubular structures converging on the subareolar area.
- On ductograms, normal ducts are variable in branching and distribution (caliber 1 to 2 mm).

- Two cell layers line normal ducts: a contiguous layer of epithelial cells on the luminal side and a discontinuous layer of myoepithelial cells at the base of the epithelial cells; these are contained by the basement membrane.
- Elastic tissue surrounds major and subsegmental ducts in the breast.



A B

**FIGURE 11-1** Dilated ducts. **(A)** Single dilated duct. If the patient has no prior films for comparison, single dilated ducts can be characterized as a probably benign finding and a follow up in six months can be done. In the absence of any clinical or other mammographic findings, the likelihood that this finding is related to an underlying breast cancer is exceedingly low. Normal caliber ducts are not usually apparent mammographically. **(B)** Multiple dilated ducts. In the absence of any clinical or other mammographic findings, the likelihood that this finding is related to an underlying breast cancer is exceedingly low. Normal caliber ducts are not usually apparent mammographically.



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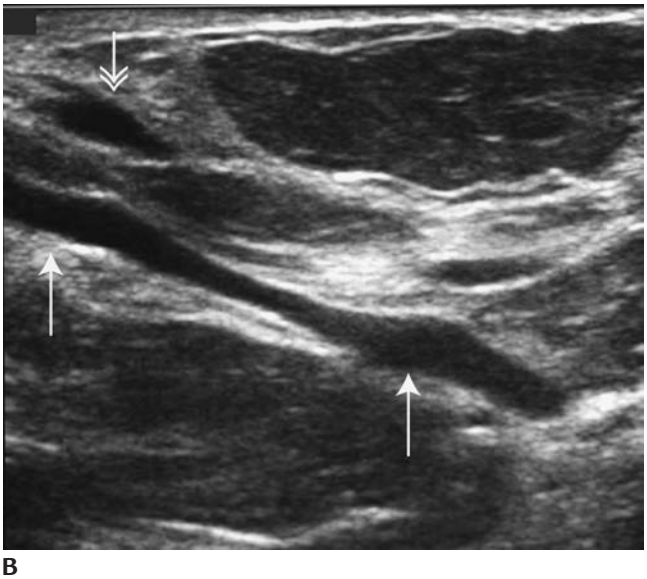


**B**

**FIGURE 11-2** Ducts on ultrasound. **(A)** When scanning the subareolar area one (*arrows*) or multiple ducts can sometimes be imaged for variable distances proximally from the nipple. Normal ducts are not always apparent sonographically, however, in some patients, particularly if there is some degree of dilatation, they may be imaged. When imaging patients, keep in mind that ducts come into and out of the plane being scanned. Therefore, it can be difficult to image them as continuous structures. Small movements including angulation and rotation of the transducer are often needed to demonstrate ducts longitudinally thereby distinguishing them from cysts. **(B)** Slightly more dilated duct (*arrows*) is imaged in this patient. The caliber of the duct can be changed as pressure is applied over it during scanning. A portion of a second duct (*double headed arrow*) is imaged in this patient. Methodical transducer manipulation (and patience) is usually needed in documenting the course of ducts and particularly when trying to establish the presence of intraductal lesions.

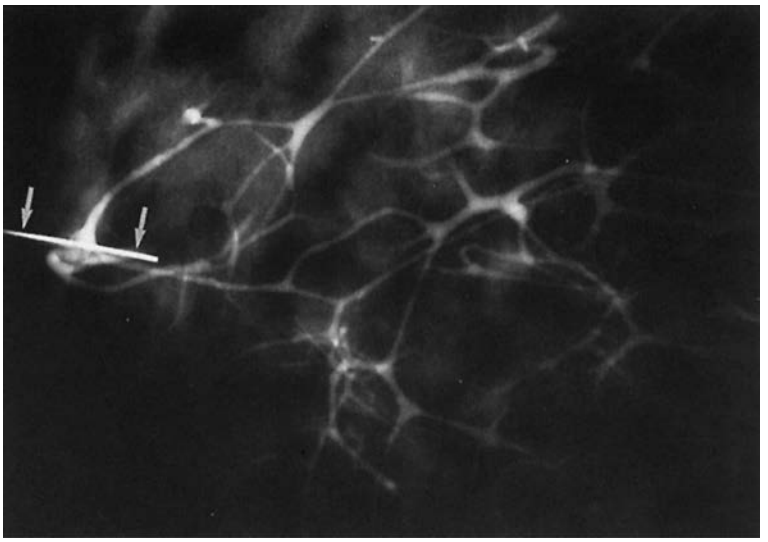


**FIGURE 11-3** Normal duct (1.6×) on ductography. Duct branching and tissue distribution are variable. Normal caliber: 1 to 2 mm. A 30 G sialography cannula (*arrows*) in the duct can serve as reference point for normal ductal caliber.

## Duct Ectasia

### Key Facts

- Clinical.

  Different terms have been used to describe this condition including periductal mastitis, plasma cell mastitis, comedomastitis, and mastitis obliterans.

  Usually an older patient population compared to those presenting with subareolar abscesses and there is no significant association with smoking.

  Nipple discharge (thick, milky), retraction and inversion: in many patients the inversion affects the central portion of the nipple horizontally.

  Pain and tenderness, often localized to subareolar area.

  Mass in subareolar area.

  Although not common, in some patients the inflammatory changes may lead to abscess formation.

- Mammography.

  Many women have subareolar ductal prominence or dilatation mammographically; however, few are symptomatic.

  Spot compression views of the subareolar area may be needed to distinguish dilated ducts from an underlying mass.

  Findings are not always limited to the subareolar area; a tubelike density or focal parenchymal asymmetry may be seen more peripherally.

Coarse, smooth-bordered, rodlike, cigar-shaped calcifications (secretory) point toward the nipple and involve both breasts diffusely. If the calcifications form periductally (as opposed to intraductally), a central lucency is seen in the coarse, linear calcifications.

In the end stage, fibrosis may be seen in the subareolar area, in some patients, with coarse calcifications; rarely, distortion and spiculation may be apparent.

- Ultrasound.

  Anechoic tubular structures in the subareolar area.

  Hypo- to hyperechoic tubular structures, "gurgling" of internal echoes may be apparent during real time.

  Periductal fibrosis may be seen as hyperechoic bands periductally.

  An anechoic mass simulating a septated cyst.

  Tubular (tortuous) area of hypoechogenicity.

- Magnetic resonance imaging.

  Intraductal bright signal may be seen on T2 weighted images.

  With proteinaceous or bloody fluid, bright signal may be seen on T1 weighted images.

- Ductography.

  Opacified duct is dilated typically close to the subareolar area; duct assumes a more normal caliber peripherally. No intraductal abnormality is identified.

- Histology.

  Subareolar duct dilatation, periductal inflammation (periductal mastitis), and fibrosis.

  Epithelial lining of ducts attenuated or denuded; myoepithelial cells are present.

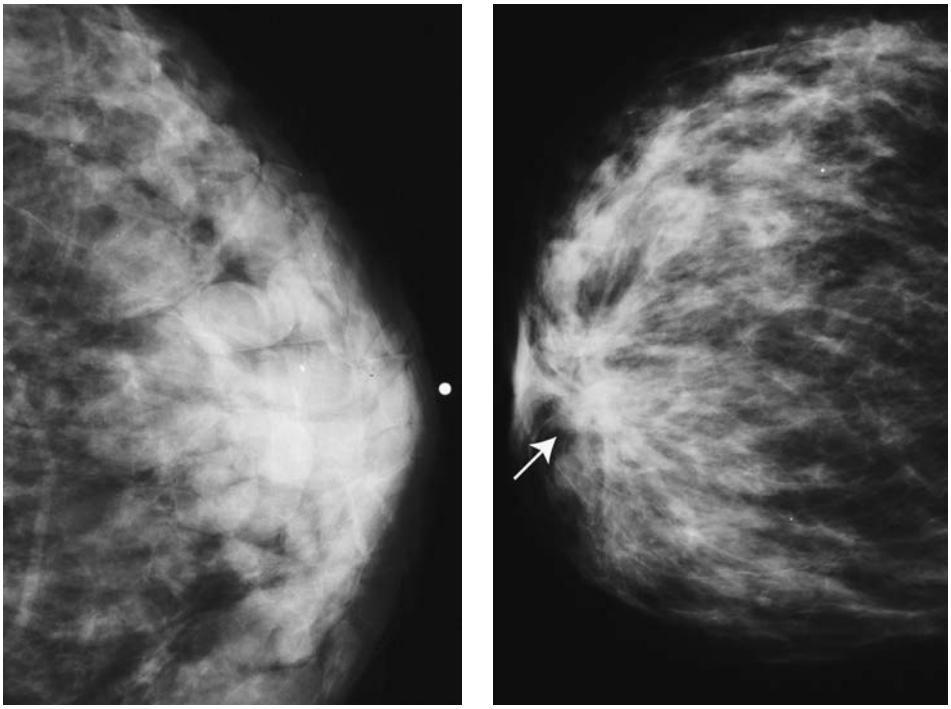
  Progressive fibrosis and thickening of the duct walls leads to foreshortening and obliteration (mastitis obliterans) of the ducts.

  Squamous metaplasia is not usually seen.

  Etiology and pathogenesis are unknown.

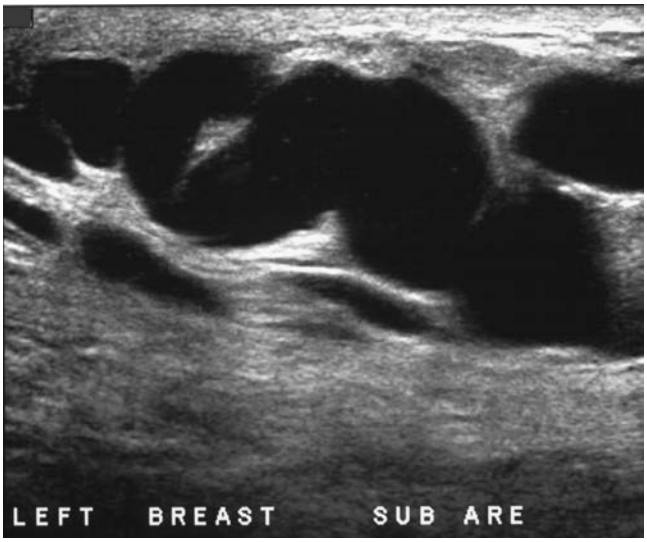
  Suggested etiologic factors: dilatation of ducts with stasis of contents leading to an inflammatory response, or periductal inflammation leading to ductal disruption and dilatation.

  Pregnancy and lactation have been implicated; however, duct ectasia has been reported in nulliparous women and in men.



A B

**FIGURE 11-4** Duct ectasia. **(A)** Multiple dilated and ectatic ducts are present in the left subareolar area. **(B)** Same patient with dilated ducts (although less than on the left) and an associated area of distortion and spiculation (*arrow*) in the right subareolar area.

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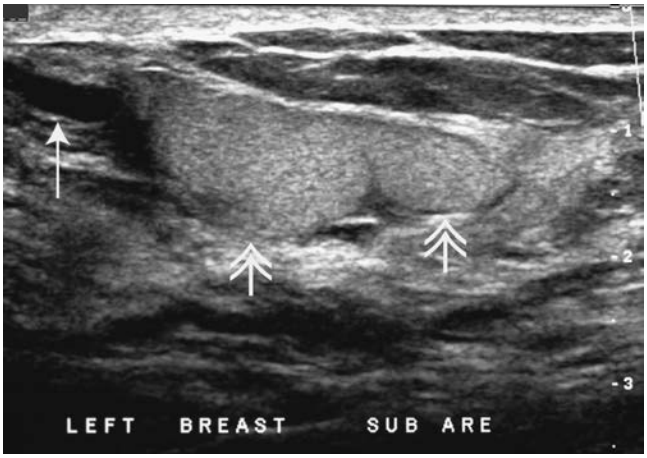
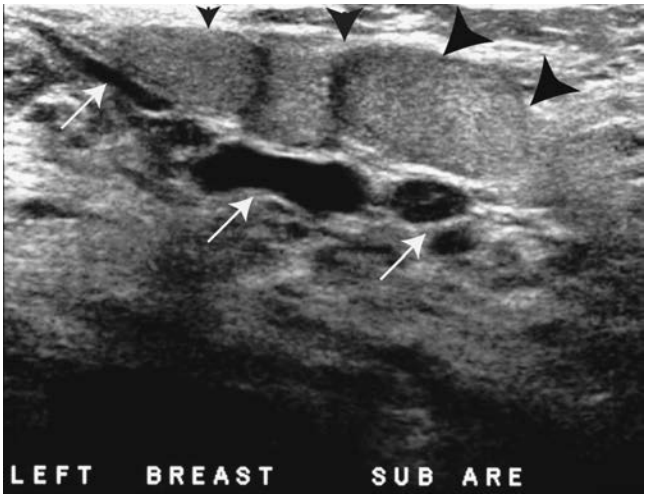



**D**

**FIGURE 11-4** (*Continued*) **(C)** On ultrasound, tortuous, ecstatic, and variably dilated anechoic ducts are readily apparent in the left subareolar area. **(D)** However, variable echo patterns are noted in the ducts raging from anechoic (*arrow*) to iso- or slightly hyperechoic (*double headed arrows*). With the transducer held steady over one of these ducts, the contents (echogenic material) are seen swirling in the duct. **(E)** Dilated ducts in the left subareolar area. One of the ducts is anechoic (*arrows*) and appears discontinuous as it comes into and out of the imaging plane. A second more dilated duct (*arrowheads*) is characterized by hyperechoic contents that during real time are noted swirling in the lumen of the duct. **(F)** Magnetic resonance imaging. Delayed postcontrast T1 weighted fast spin gradient image demonstrating dilated and tortuous ducts bilaterally with high signal intensity reflecting the presence of proteinaceous fluid. **(G)** Magnetic resonance imaging, sagittal T1 weighted image, precontrast of the right breast. Convergence of the dilated, fluid filled ducts on an area of distortion and spiculation (*arrow*). No enhancement was identified in this area on the post contrast T1 weighted images. Although fibrosis from the inflammatory process that can accompany duct ectasia is suspected, a biopsy of this mass is indicated. Fibrosis and chronic inflammatory changes are diagnosed histologically.

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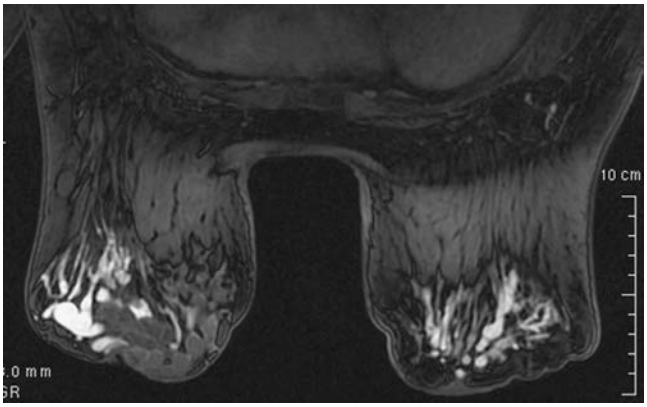


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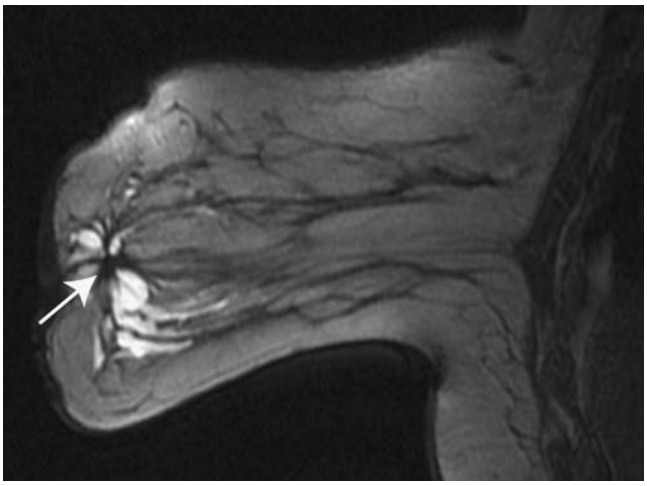


G

**FIGURE 11-4** (*Continued*)

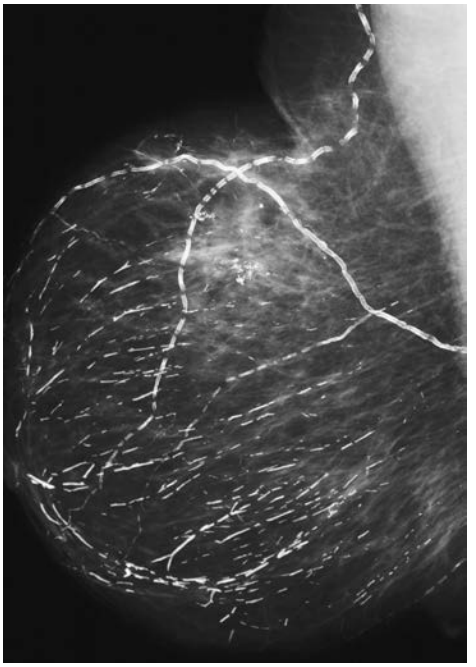


**FIGURE 11-5** Large rodlike calcifications. Dense coarse calcifications having a smooth border, commonly diffuse and bilateral, pointing toward the nipple. Sometimes, when the calcifications develop periductally, they can have a lucent center. In the past, these have been referred to as secretory calcifications. Dense arterial calcifications are also present.

## Subareolar Abscess

### Key Facts

- Clinical.

  Nonlactating, commonly premenopausal women, but can be seen in women of all ages.

  Not usually related to nipple piercing or rings.

  Reportedly more common in heavy smokers.

  Can affect both breasts.

  Difficult to manage since persistence and recurrence are common even following surgical drainage.

  Rapid onset breast pain (80% to 100% of patients) with swelling of central subareolar tissue, erythema (70% to 75%), and systemic symptoms (e.g., febrile, 10% of patients).

  Periareolar fistula formation (sometimes called Zuska's disease) occurs spontaneously in many patients.

  Ipsilateral lymphadenopathy (reactive) in some patients.

  Surgical drainage and excision is often required; recent reports describe effective management following imaging guided aspirations, irrigation, and antibiotic instillation in conjunction with oral antibiotic coverage.

  Several courses of antibiotics may be required to minimize likelihood of recurrence.

With recurrent episodes, horizontal inversion of the central aspect of the nipple may develop.

- Mammography.

  Acutely, compression may be limited by tenderness. Technical factors may need to be adjusted for adequate exposure.

  Mass with obscured, indistinct, ill-defined or spiculated margins in the subareolar area.

  Increased density in the subareolar area.

  Enlarged and dense reactive lymph nodes may be apparent in the ipsilateral axilla.

- Ultrasound.

  Complex mass with irregular margins, heterogeneous echotexture and mixed solid and cystic components.

  Tubular or lenticular shaped areas of hypoechogenicity associated with the skin and subcutaneous tissue.

  Skin thickening and dilated subdermal lymphatics may be seen.

  Aspiration requires adequate anesthesia (sometimes difficult to obtain in the acute setting) and preferably an 18 G needle: thick fluid often makes complete aspiration with 20 G needle difficult.

- Magnetic resonance imaging.

  Diagnosis is established based on clinical, mammographic and sonographic findings. MRI is usually not indicated.

  Rim enhancement of abscess cavity may be intense on post contrast T1 weighted images.

  High signal intensity on T2 weighted images may be seen in the abscess as well as in the skin and surrounding tissues (reflecting edema).

  Axillary adenopathy may be present.

- Histology.

  Squamous metaplasia resulting in duct obstruction, distention and, eventually, periductal inflammation proposed as the primary etiologic process.

  Often mixed aerobic and anaerobic organisms; associated organisms commonly include Staphylococcus, Streptococcus, Proteus, and Bacteroides. Methicillin resistant S. aureus grown in some patients.

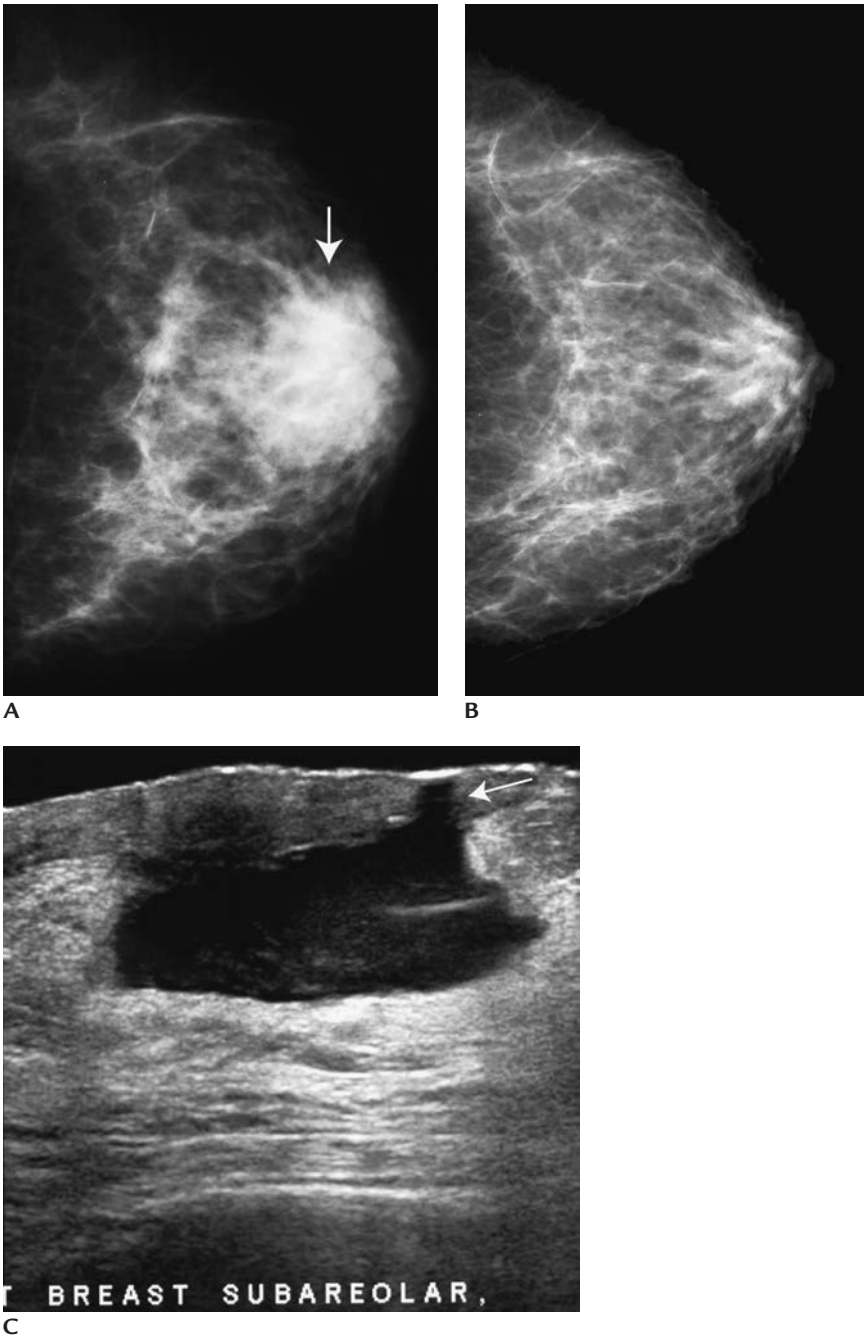
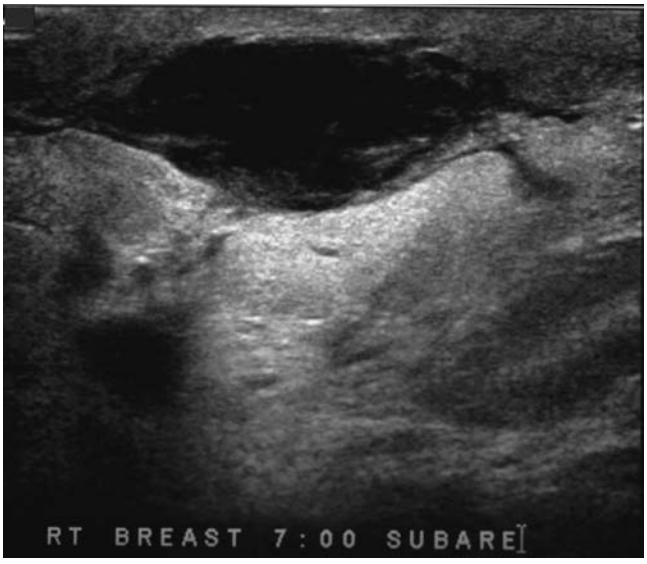



**FIGURE 11-6** Subareolar abscess. **(A)** Oval mass (*arrow*) with indistinct and obscured margins in the left subareolar area corresponding to a tender "lump" with associated erythematous skin changes. **(B)** Prior left craniocaudal view for comparison demonstrating normal subareolar area. **(C)** Sonographically, a nearly anechoic, oval mass with associated posterior acoustic enhancement is present in the left subareolar area corresponding to the clinical and mammographic finding. Secondary involvement of the skin and skin thickening are present and a common finding in patients with subareolar abscesses. Spontaneous fistula formation (Zuska's disease) in the periareolar region is common in these patients. A fistula is close to forming in this patient as evidenced by the close proximity to the superficial dermal layer of a portion of the abscess (*arrow*).

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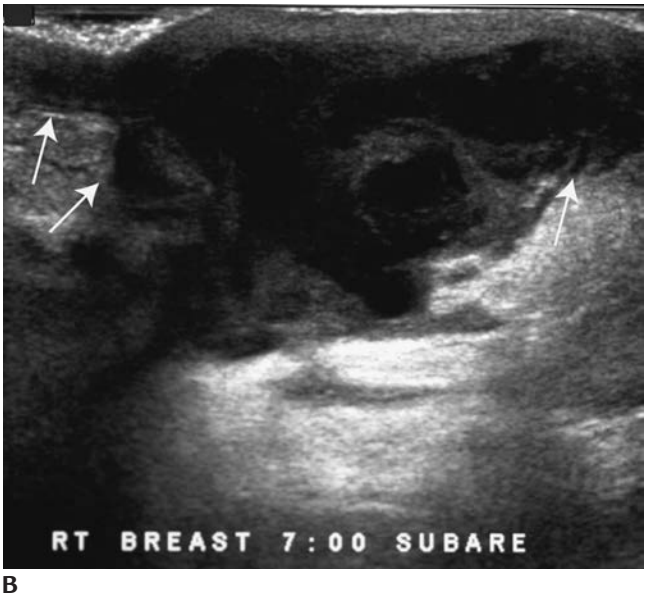
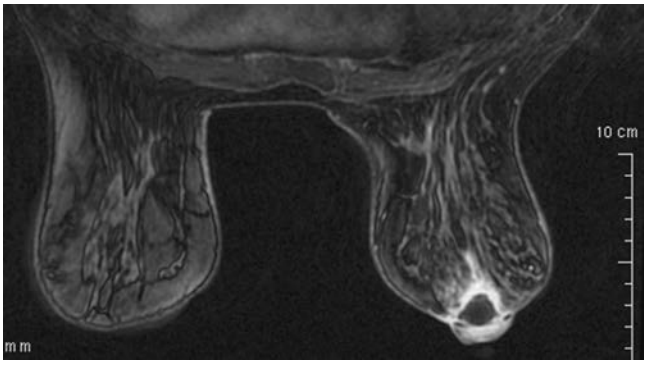



B

**FIGURE 11-7** Subareolar abscess. **(A)** Complex cystic mass with posterior acoustic enhancement and typical lenticular shape seen in the early stages of subareolar abscess formation. Close proximity and secondary involvement of the skin with thickening is also noted. As in this patient, the margins are usually not well circumscribed and there are small tubular extensions (or areas of sacculation) into the surrounding tissue. **(B)** With progression, an irregular complex cystic mass with associated posterior acoustic enhancement is now apparent. Secondary involvement of the skin and skin thickening are present. Tubularlike extensions or sacculations (*arrows* marking some of these) of the abscess into the subcutaneous and glandular tissues are also noted.

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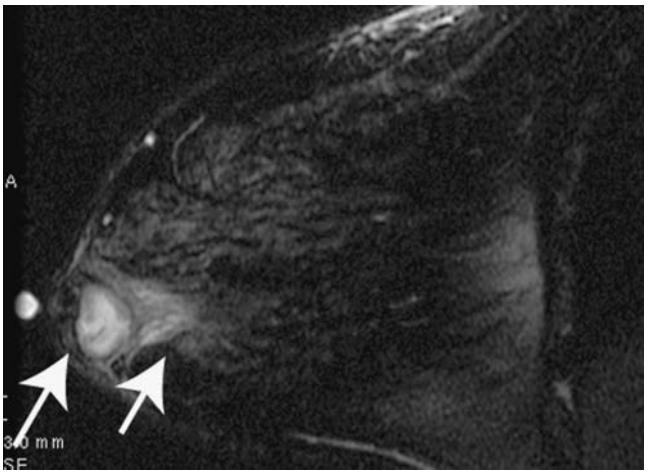


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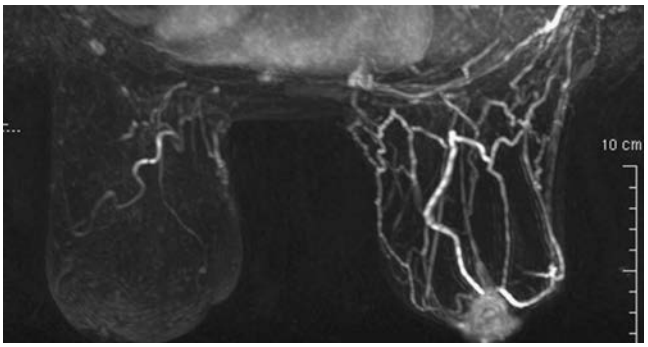



**C**

**FIGURE 11-8** Subareolar abscess. **(A)** Magnetic resonance imaging. Delayed post contrast T1 weighted fast spin gradient image demonstrating right subareolar mass with rim enhancement and irregular/spiculated margins in patient with known subareolar abscess. **(B)** Sagittal T2 weighted image with fat suppression of the right breast demonstrating high signal intensity of abscess contents (*arrow*) as well as in surrounding tissue (*shorter arrow*) reflecting edematous change. **(C)** Maximum intensity projection demonstrating right subareolar mass with associated increased vascularity in the breast reflecting inflammatory change.

## Solitary Papillomas

### Key Facts

- Clinical.

  Patients with central, subareolar papillomas commonly present with spontaneous nipple discharge (clear, serous, bloody); in contrast, patients with multiple peripheral papillomas are asymptomatic with masses or clusters of calcifications detected on screening mammography.

  In patients with discharge, a trigger point (Haagensen) may be identified: pressure applied over area of papilloma reliably elicits discharge.

  Palpable mass.

  Associated with slight increase in relative risk of breast cancer (1.5 to 2×).
- Mammography.

  Normal in most patients.

  Single dilated duct.

  Calcifications ranging from coarse and curvilinear to more pleomorphic clusters with round, punctate and amorphous forms; these can occur in isolation or associated with a mass, commonly in subareolar location.

  Round or oval mass; well-circumscribed to ill-defined and sometimes spiculated margins commonly in subareolar location.
- Ultrasound.

  Normal.

  Dilated duct with intraductal lesion.

  Complex cystic mass.

  Solid, homogeneously hypoechoic mass.

  Management of these lesions following imaging guided biopsy remains controversial. Following core biopsy, many recommend excision for all papillary lesions. Certainly, papillary lesions with associated or adjacent cytologic atypia or atypical ductal hyperplasia require excision.
- Magnetic resonance imaging.

  High signal intensity from fluid in dilated duct on T2 weighted images with low signal intensity from papilloma.

  Enhancement on T1-weighted images is variable; some papillomas are characterized by rapid wash in and wash out of contrast simulating malignant lesions.
- Ductography.

  Complete obstruction of duct by lesion (meniscus seen at point of obstruction).

  Intraluminal filling defect.

  Duct wall irregularity (sessilelike papilloma).

  Expansion and apparent distortion of duct.

  Segment of duct between lesion and nipple is usually dilated.
- Gross.

  Commonly, papillomas are soft and friable. If a papilloma is suspected, the pathologist should be advised and extra care taken otherwise these friable lesions can be lost during specimen processing.

- Histology.

  Epithelial and myoepithelial cells (as arranged in normal ducts) cap the fibrovascular core.

  Hyperplasia, atypical ductal hyperplasia and ductal carcinoma in situ (usually low or intermediate grade) may involve the epithelial elements of the papilloma.

  May undergo infarction and fibrosis.

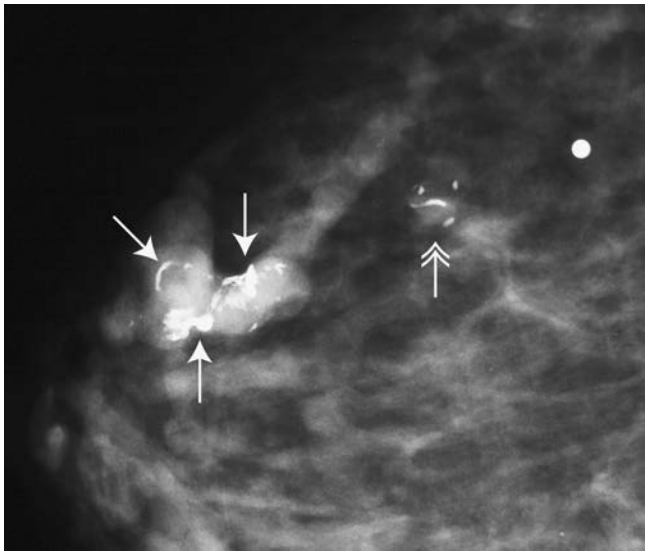
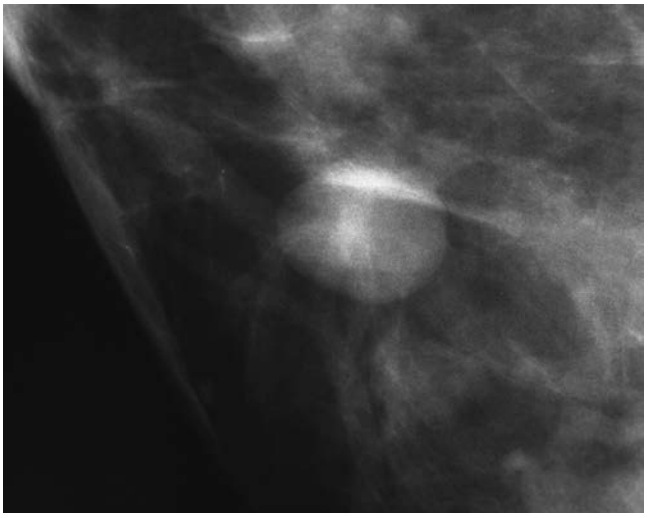


**FIGURE 11-9** Papillomas. Dilated duct with associated coarse and curvilinear calcifications (*arrows*) occurring in a papilloma. Unlike the dense popcorn type calcifications associated with fibroadenomas, these coarse curvilinear calcifications are more commonly seen with papillomas. Additionally, a mass (*double headed arrow*) with associated curvilinear calcifications is present consistent with the presence of a second papilloma.



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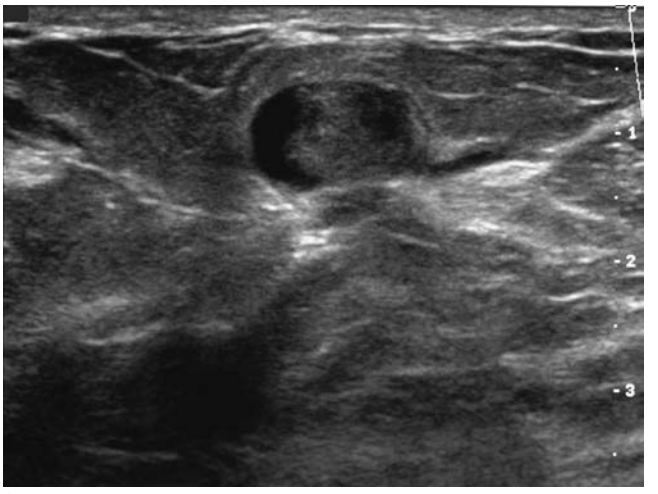



B

**FIGURE 11-10** Papilloma. **(A)** Round mass with circumscribed margins. **(B)** Complex cystic mass corresponding to the mass seen mammographically. This is a common appearance for single or multiple peripheral papillomas and papillary carcinomas. Less commonly these are solid and indistinguishable from any other solid mass occurring in the breast.

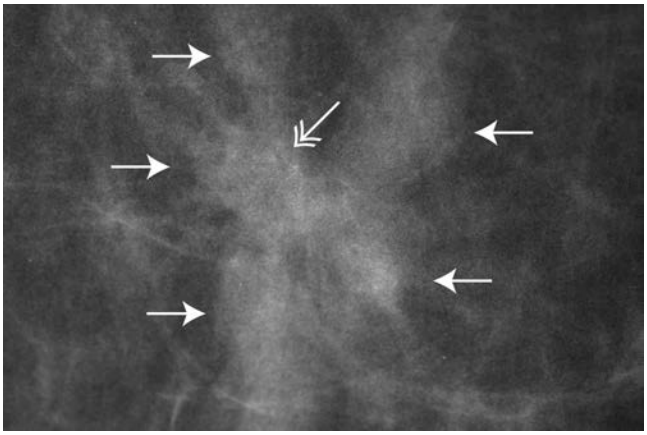
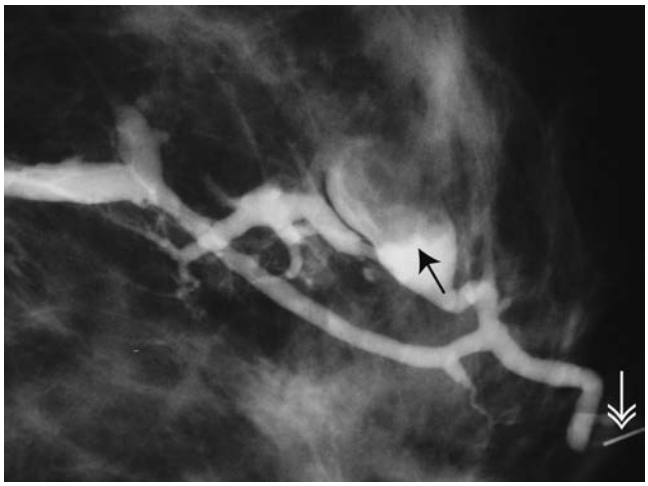
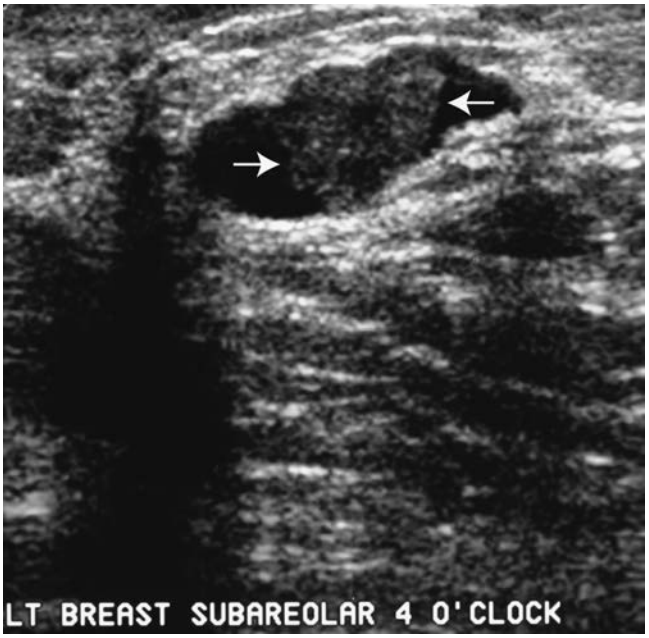


**FIGURE 11-11** Papilloma. Irregular mass with indistinct, spiculated margins (*arrows*), distortion and associated amorphous calcifications (*double headed arrow*).



**A**

**FIGURE 11-12** Papilloma. **(A)** Ductogram in patient presenting with spontaneous nipple discharge demonstrates dilated duct with intraductal filling defect (*arrow*). Contrast is seen outlining the interstices of the lesion. A 30G blunt tipped sialography needle (*double headed arrow*) is used to cannulate the discharging duct and can serve as an internal reference point for normal duct caliber.




**B**

**FIGURE 11-12** (*Continued*) **(B)** Intraductal lesion (*arrows*) confirmed on ultrasound. The intraductal (as opposed to intracystic) location of the lesion is determined during the real time portion of the study as the transducer is manipulated over this area. When the lesion is within a duct, the duct elongates and can be seen coming into and out of the scanning plan. With an intracystic lesion, the round or oval shape of the complex cystic mass is maintained as the transducer is rotated and manipulated over the lesion.

## Papillary Carcinoma

### Key Facts

- Clinical.
  Approximately 1% to 2% of all breast cancers.
  Older patients affected (mean age 63 to 67 years) more commonly.
  Higher incidence reported among black women.
  As with papillomas, central papillary carcinomas are usually solitary while peripheral lesions are commonly multiple.
  Nipple discharge (22% to 34%), often bloody.
  Nipple retraction and deviation.
  Palpable, often large, lobulated, circumscribed mass commonly in the subareolar area (90%).
  Lesions may protrude, stretching overlying skin and causing erythema and sometimes ulceration.
  Estrogen-receptor positive.
  Slow growth rate.
- Mammography.
  Well-circumscribed mass (may be macrolobulated) in subareolar area (central lesions).
  Multiple, round or oval, well-circumscribed masses (peripheral papillary carcinomas).
  Benign-appearing calcifications may be associated with the mass.
  Less commonly, multiple clusters of pleomorphic calcifications that may include coarse, round, punctuate, and amorphous forms; rarely linear, branching type calcifications.
- Ultrasound.
  Complex cystic mass (although seemingly developing in a cyst, these are thought to develop in ducts) with a variable solid component.
  Solid components may predominate with no associated fluid collection.
  Solid, hypoechoic mass (common for the peripheral lesions).
- Magnetic resonance imaging.
  Variable patterns on T2 weighted images: cystic portions are characterized by high signal intensity; solid portions more likely to be characterized by low signal intensity.
  Solid components demonstrate variable enhancement pattern on post contrast T1 weighted images.
- Gross.
  Soft, friable tumors.
  Hemorrhagic fluid may be found in dilated duct or cyst.
- Histology.
  Noninvasive and invasive variants.
  Intraductal carcinoma variants (noninvasive papillary carcinomas) in the absence of stromal or vascular invasion.

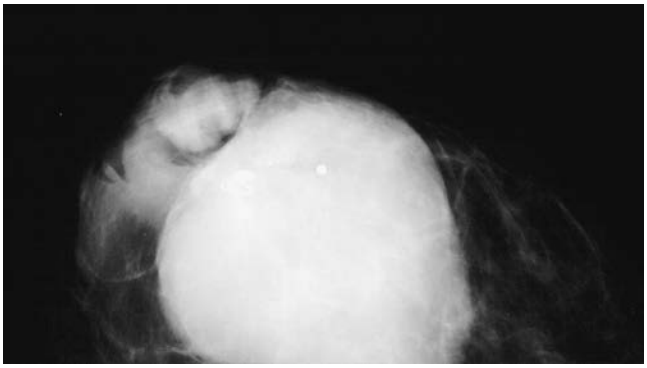
Most papillary carcinomas are found in dilated ducts (less commonly as intracystic lesion).

Absence of myoepithelial cells noted in at least some of the papillary processes distinguishing these from benign papillary lesions.

Epithelial cells in papillary carcinomas demonstrate carcinoembryonic antigen reactivity (85%) and may contain neurosecretory-type cytoplasmic granules, features not found in benign papillomas.

Stromal invasion in a small proportion of women.

Well-differentiated, cribriform, and micropapillary-type ductal carcinoma in situ can be found in adjacent tissue.



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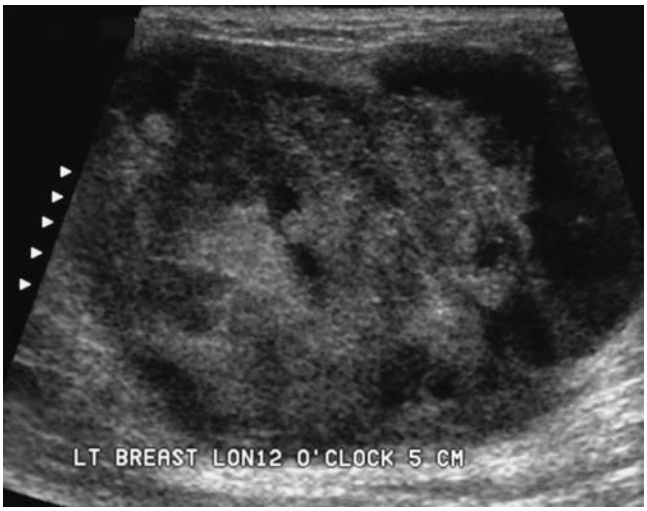
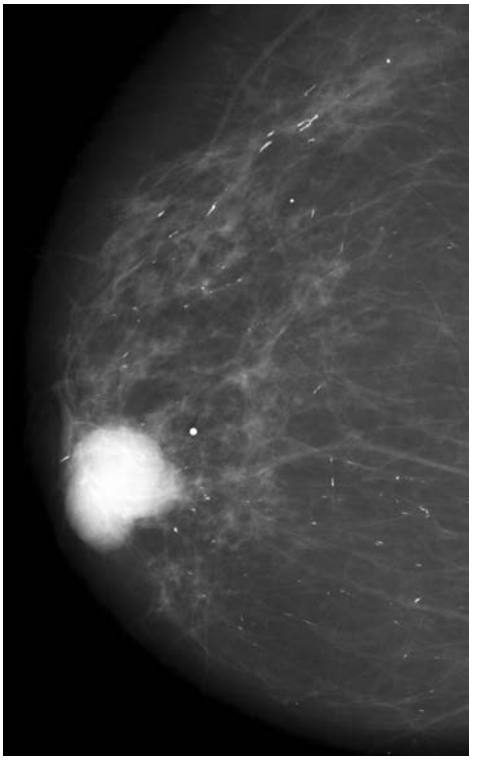



B

**FIGURE 11-13** Papillary carcinoma. **(A)** Round mass with circumscribed margins and associated coarse calcifications in the left subareolar area. Metallic BB used by technologist to mark clinical finding (e.g., "lump" described by the patient). As they enlarge, subareolar papillary lesions can cause nipple deviation and skin stretching. Some patients may also have associated spontaneous nipple discharge. **(B)** Complex cystic mass corresponding to the clinically and mammographically apparent mass. This is a common appearance for the larger, solitary central papillary lesions.



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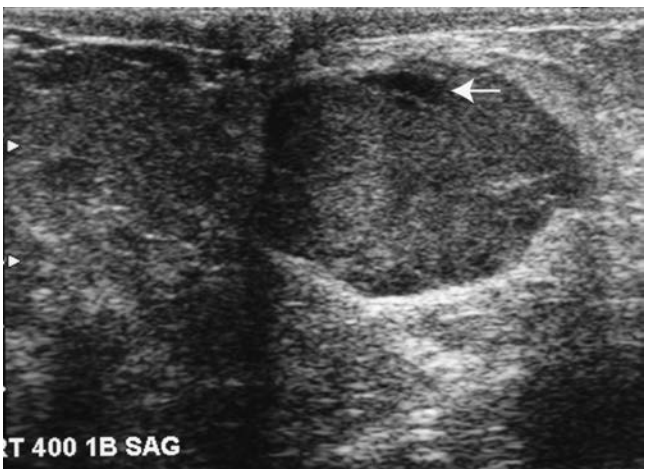
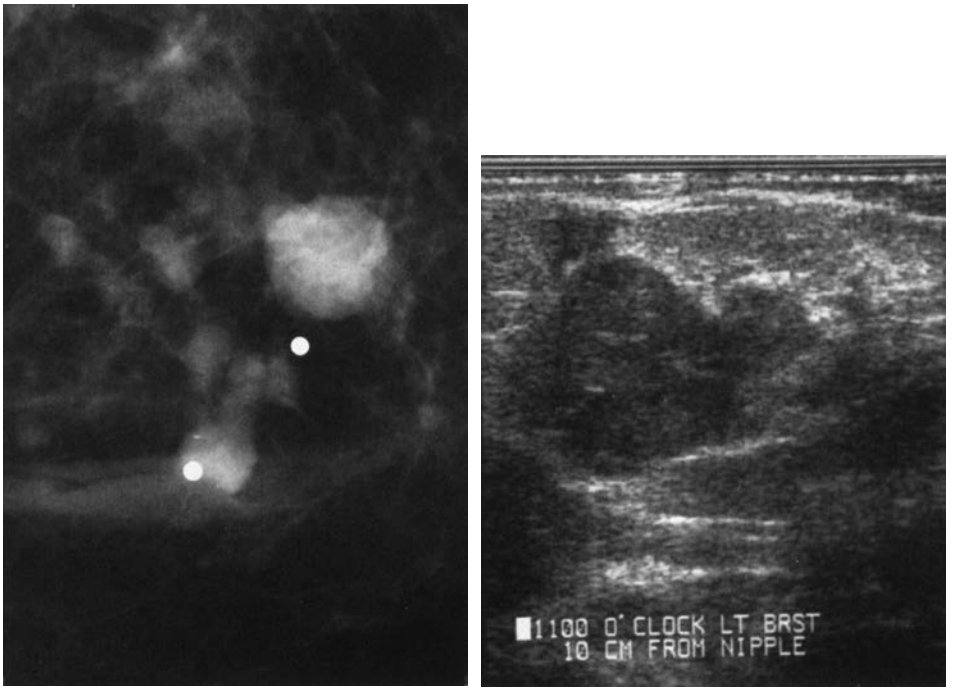



**B**

**FIGURE 11-14** Papillary carcinoma. **(A)** Round mass with well circumscribed, macrolobulated margins in the right subareolar area. Large rodlike calcifications pointing toward the nipple are present scattered in the parenchyma. **(B)** Solid mass with a small associated cystic space (*arrow*) and posterior acoustic enhancement corresponding to mammographic finding.




A B

**FIGURE 11-15** Multiple papillary carcinomas. **(A)** Multiple well-circumscribed masses. Some of the smaller masses are lobulated and have ill-defined margins. The metallic BBs mark two palpable masses corresponding to the two largest lesions. **(B)** Hypoechoic lobulated mass corresponding to the largest of the masses imaged mammographically. Peripheral papillary carcinomas are commonly multiple and solid on ultrasound. In contrast, papillary carcinomas occurring in the subareolar area are commonly solitary and imaged as a complex cystic mass on ultrasound.

## SUGGESTED READINGS

Cardeñosa G, Eklund GW. Benign papillary neoplasm of the breast: mammographic findings. *Radiology*. 1991;181:751–755.

Hook GW, Ikeda DM. Treatment of breast abscesses with US-guided percutaneous needle drainage without indwelling catheter placement. *Radiology*. 1999;213:579–582.

Kalisher L, Rickert RR, Sharo RJ. Solitary peripheral papilloma of the breast: radiologic-pathologic correlation of a benign lesion that may mimic breast cancer on mammography. *AJR Am J Roentgenol.* 1998;171:695–609.

Leborgne F, Leborge J. Treatment of breast abscesses with sonographically guided aspiration, irrigation and instillation of antibiotics. *AJR Am J Roentgenol.* 2003;181:1089–1091.

Liberman L, Feng TL, Susnik B. Case 35: intracystic papillary carcinoma with invasion. *Radiology*. 2001;219:781–784.

Schneider JA. Invasive papillary carcinoma: mammographic and sonographic appearance. *Radiology*. 1989;171:377–379.

Soo MS, Williford ME, Walsh R, et al. Papillary carcinoma of the breast: imaging findings. *AJR Am J Roentgenol.* 1995;164:321–326.

Tavassoli FA. Benign lesions. *Pathology of the Breast*. New York: Elsevier; 1992:114–116.

Woods ER, Helvie MA, Ikeda DM, et al. Solitary breast papilloma: comparison of mammographic, galactographic and pathologic findings. *AJR Am J Roentgenol.* 1992;159:487–491.

CHAPTER 12

# TERMINAL DUCTS

## Normal Anatomy

### Key Facts

- The terminal duct lobular unit (TDLU) is divided arbitrarily into terminal duct and lobular segments.
- The terminal duct is divided into extralobular and intralobular segments.
- The two cell layers described for major subareolar and subsegmental ducts are also found in the terminal duct: a contiguous epithelial cell layer lining the lumen of the ducts and a discontinuous myoepithelial cell layer on the basement membrane at the base of the epithelial cells.
- Unlike the major subareolar and subsegmental ducts, terminal ducts are not surrounded by elastic tissue.
- The stroma surrounding TDLUs is distinct: loose, rich in capillaries, and cellular.
- Most ductal breast cancers are thought to arise in the extralobular segment of the terminal duct.

## Multiple (Peripheral) Papillomas

### Key Facts

- Clinical.

  Usually asymptomatic; diagnosed on biopsies done for mammographic findings.

  Spontaneous nipple discharge in approximately 20% of patients.

  Possible marker lesion for increased breast cancer risk, but no long-term epidemiological studies have been done to confirm this.

  Develop in terminal duct (hence the "peripheral papilloma" designation): may explain why some of these lesions appear as "intracystic" (in contrast

to solitary papillomas which, although occurring within dilated ducts, are not commonly intracystic). We postulate that as papillomas develop, they obstruct the TDLU with resultant accumulation of fluid, effacement of acini, and cyst formation.

- Mammography.

  Multiple, small, circumscribed, or partially circumscribed masses.

  Cluster or multiple clusters of punctate, pleomorphic calcifications; no linear or casting-type calcifications are usually seen nor is there significant ductal orientation of the calcifications in a cluster.

  Some of the calcifications have a curvilinear, coarse appearance.

  Findings (masses or microcalcifications) may be bilateral and multiple.
- Ultrasound.

  Solid, homogeneously, hypoechoic mass or masses.

  Complex cystic mass.
- Magnetic resonance imaging (MRI).

  Enhancing mass or masses may demonstrate rapid initial enhancement and wash out of contrast.
- Histology.

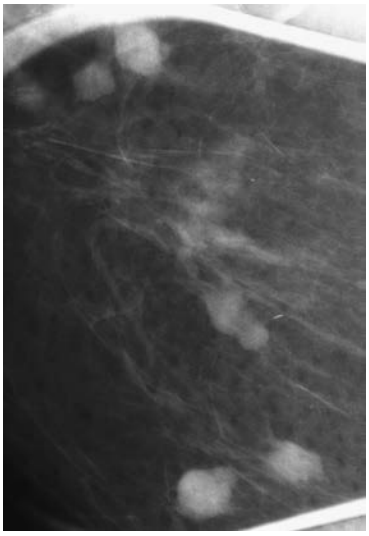
  Indistinguishable from solitary papillomas.

  Two cell layer: contiguous epithelial cell layer (contiguous with ductal epithelium) and discontinuous myoepithelial, basilar layer on basement membrane.

  Fibrovascular core.

  In up to 43% of our patients, atypical ductal hyperplasia (ADH), ductal carcinoma in situ (DCIS) (low to intermediate nuclear grade), lobular neoplasia (lobular carcinoma in situ [LCIS], ALH), or low-grade invasive ductal carcinoma is seen in the parenchyma adjacent to multiple peripheral papillomas. The presence of these proliferative changes may justify the consideration of these lesions as risk marker lesions for breast cancer.

  If the term *papillomatosis* is used, clarify how it is defined: some pathologists use this term to denote hyperplasia, whereas others use it when describing peripheral papillomas.



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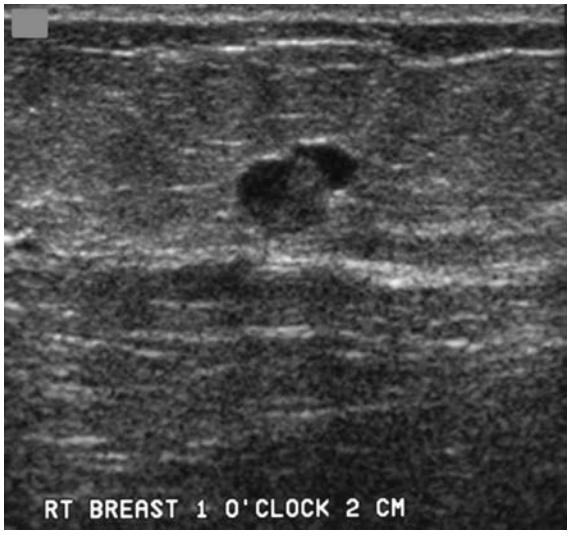


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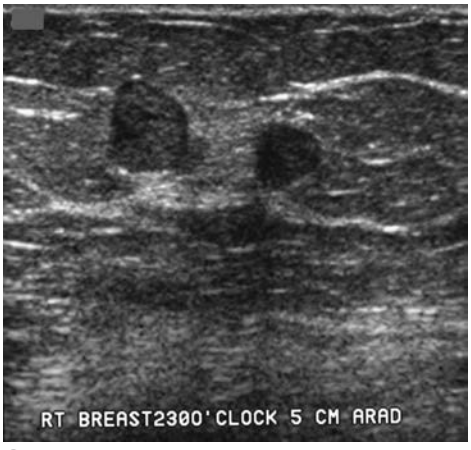


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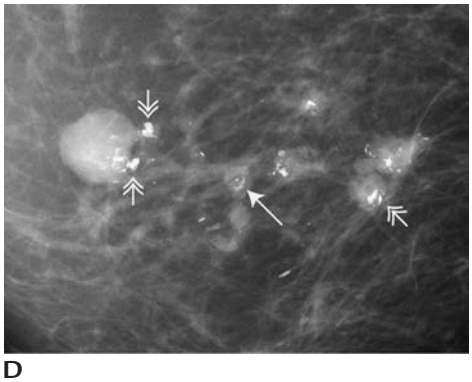
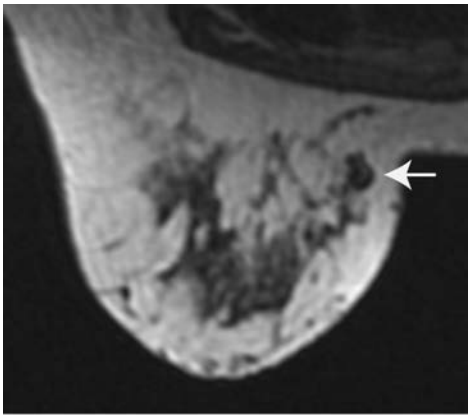


D

**FIGURE 12-1** Multiple peripheral papillomas. **(A)** Spot compression view. Multiple masses of varying but similar sizes, densities, and shapes. Margins are variable (circumscribed, indistinct). Diagnostic considerations include multiple cysts, fibroadenomas, papillomas, pseudoangiomatous stromal hyperplesia, invasive ductal carcinoma, and metastatic disease. **(B)** Complex cystic mass imaged sonographically at the 1 o'clock position, 2 cm from the right nipple corresponding to one of the masses seen mammographically. **(C)** Two additional complex cystic masses are imaged at the 2 to 3 o'clock position, 5 cm from the right nipple. The size of the cystic component in these lesions is variable; in some papillomas, the cystic component is not apparent such that they are indistinguishable from other solid masses in the breast (or they can be isoechoic). Exercise care if the pathologist uses the term *papillomatosis* when you suspect multiple peripheral papillomas. Some pathologist use this term when referring to multiple peripheral papillomas (with an associated fibrovascular core) and others use the term *papillomatosis* to refer to hyperplasia. This distinction is important since multiple peripheral papillomas are probably marker lesions for an increased risk for breast cancer. **(D)** Different patient. Multiple masses of varying sizes, densities, and shapes. Margins are also variable (circumscribed, indistinct). Coarse (*double headed arrows* used to mark some) and curvilinear (*arrow*) calcifications are associated with most of the masses. Dystrophic calcifications developing in papillomas often have this curvilinear appearance (distinctive from that of the "popcorn" type calcifications characteristic of fibroadenomas). In approximately 43% of patients with multiple peripheral papillomas, ADH, low nuclear grade DCIS, lobular neoplasia, and low-grade invasive ductal carcinoma are seen in close proximity to the papillomas. It is for this reason that some suggest that patients with these lesions be considered at increased risk for developing breast cancer.



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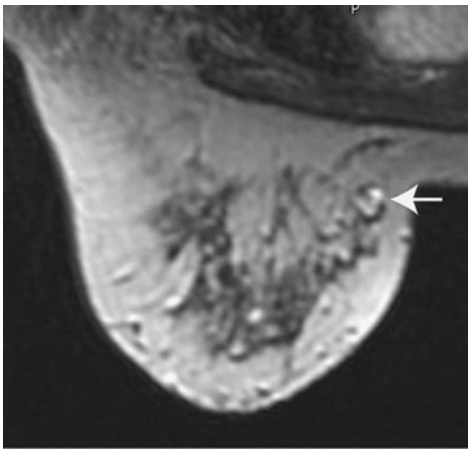

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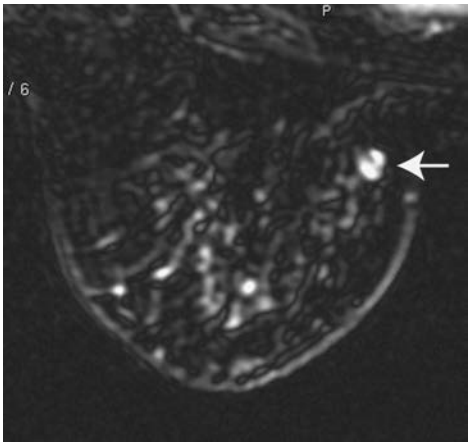
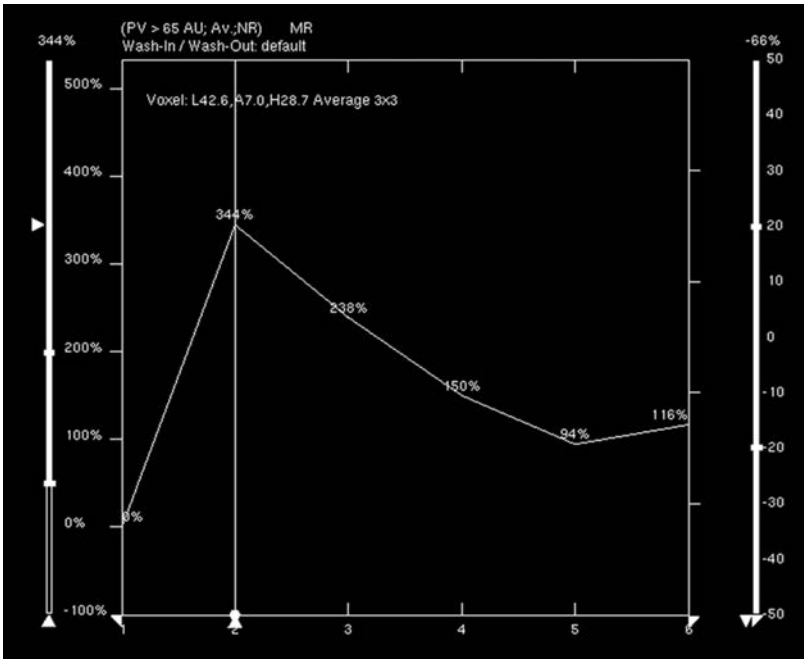



C

**FIGURE 12-2** MRI, peripheral papilloma. **(A)** Axial pre-contrast T1-weighted image, right breast. Round mass (*arrow*) in the medial aspect of the right breast posteriorly, low signal intensity. **(B)** Axial, post-contrast T1-weighted image. Mass, with heterogeneous enhancement (*arrow*); rim does not enhance. **(C)** Subtraction image, enhancing mass (*arrow*).

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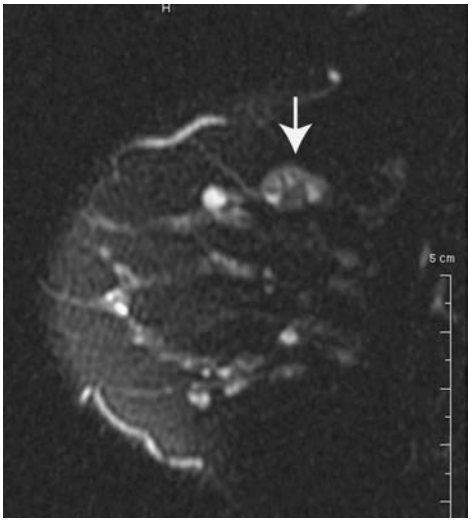



**E**

**FIGURE 12-2** (*Continued*) **(D)** Kinetic curve demonstrating rapid initial enhancement with washout. As in this patient, the kinetic curve for papillomas and intramammary lymph nodes can simulate that seen with malignant lesions. **(E)** Sagittal, T2-weighted fat suppressed image demonstrating papilloma (*arrow*). Several circumscribed masses with bright signal are seen in the surrounding tissue consistent with cysts.

# Radial Scars/Complex Sclerosing Lesions (CSL)

## Key Facts

- Clinical.

  Not related to previous trauma or surgery (don't let the word "scar" mislead you); etiology is unknown; some have suggested that these reflect an infarct occurring in preexisting areas of proliferative change.

  Controversial significance: benign, risk marker or premalignant lesions? In up to 30% to 40% of patients reported to contain or be associated with areas of ADH, low nuclear grade DCIS, lobular neoplasia, and tubular carcinoma.

  Radial scars measure 1 to 9 mm; common histologically but not readily apparent mammographically.

  CSLs are larger than 10 mm; may be incidental finding in biopsies done for unrelated clinical or mammographic findings but can be suspected in some women following appropriate mammographic workup.

  Unclear if the only difference between radial scars and CSLs is size.

  Although the lesion may be large (>2 cm), there is usually no correlative palpable abnormality (opposite to what characterizes many invasive ductal carcinomas: on palpation most ductal carcinomas palpate larger than what is imaged).

  Relative risk (RR) of 1.8× in women with radial scars compared to those without radial scars.

  RR of 3.0× in women with proliferative disease (no atypia) and radial scars compared to 1.5× in women with proliferative disease and no radial scar.

  RR of 5.8× in women with ADH and radial scars compared to 3.8× for those with ADH and no radial scar.

- Mammography.

  Distortion characterized by central fatty locules and long, thin radiating spicules sometimes curvilinear; punctate and round calcifications may be seen in as many as 30% of CSLs.

  Differential appearance between views: well seen in one projection, harder to identify in orthogonal view (planar lesions).

  Round or lobular mass uncommon presentation.

  Although controversial, when we suspect a complex sclerosing lesion we recommend excisional biopsy (as opposed to core biopsy) with deferment of frozen section for two reasons. First, the pathologist may have a difficult time making a precise diagnosis (on histology differential diagnosis includes tubular carcinoma and sclerosing adenosis). Second, even if the pathologist can make a diagnosis on core biopsies, the high incidence of associated proliferative changes with and without atypia, lobular neoplasia, and tubular carcinoma is such that we feel these lesions are best excised.

  If we do a core biopsy on a woman with a spiculated mass or distortion and the histological diagnosis is that of radial scar or complex sclerosing lesion (or if the pathologist says these lesions cannot be excluded), we recommend excisional biopsy following preoperative wire localization.

- Ultrasound.

Patients do not usually have an ultrasound (spiculated mass mammographically, no clinical symptoms); however, for subtle mammographic lesions, ultrasound can be helpful in localizing and confirming the presence of a lesion.

Normal.

In a few patients evaluated with ultrasound, we have seen an irregular mass with shadowing or an area of shadowing without a definable mass.

- MRI.

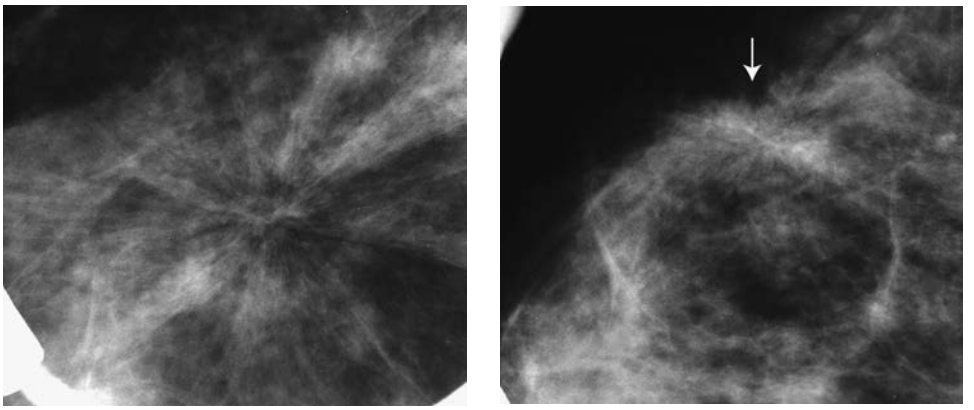
  Preliminary reports suggest these lesions do not demonstrate significant contrast enhancement.

  Spiculated mass, low signal intensity on T1-weighted images.

- Histology.

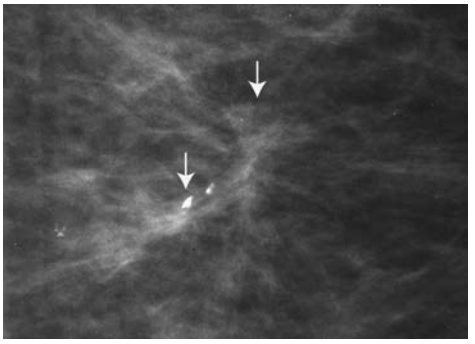
  Central fibroelastotic core from which spicules of proliferating epithelial elements arise; epithelial proliferation without atypia (epithelial hyperplasia, sclerosing adenosis), with atypia (ADH, lobular neoplasia), and low- to intermediate-grade DCIS.

  Tubular carcinomas have been reported in association with, or arising in, CSLs.



A B

**FIGURE 12-3** Complex sclerosing lesion. **(A)** Double spot compression magnification view (1.8×) in the craniocaudal projection demonstrates an area of distortion characterized by central lucency and long radiating spicules. **(B)** Double spot compression magnification view (1.8×) in the mediolateral oblique projection demonstrates an area of distortion and spiculation. As is common for these lesions, the appearance of the lesion between craniocaudal and oblique views varies (more apparent in one projection compared with the orthogonal projection). Although these lesions can measure 2 cm or more, there is usually no correlative palpable abnormality. In contrast, an invasive ductal carcinoma of this size is typically palpable and seems larger on physical examination than what is measured on imaging studies.



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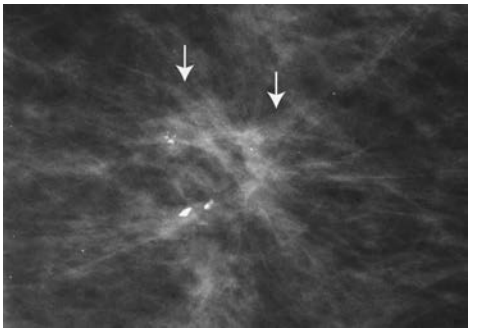
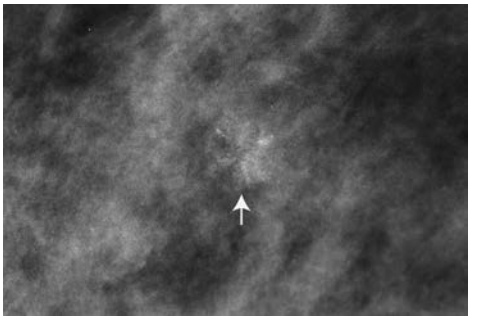


B

**FIGURE 12-4** Complex sclerosing lesion (CSL). **(A)** Spot compression magnification view (1.8×) in the mediolateral (ML) projection demonstrates architectural distortion (*arrows*) with associated coarse calcifications. **(B)** Spot compression magnification view (1.8×) in the craniocaudal projection demonstrates architectural distortion (*arrows*) that is more conspicuous than that on the ML view. Also noted are associated coarse calcifications. We recommend excisional biopsy when, based on clinical and imaging features, we suspect a CSL. Alternatively, if a CSL is diagnosed on a core biopsy, we recommend an excisional biopsy because of the association of these lesions with ADH, lobular neoplasia, and tubular carcinomas in close to 33% of patients.

**FIGURE 12-5** CSL. **(A)** Double spot compression magnification view (1.8×) demonstrates an area of distortion associated with amorphous calcifications. Approximately 30% of these lesions will have associated calcifications. Histologically, these calcifications are found in areas of fibrocystic change (including sclerosing adenosis, columnar alteration with prominent apical snouts and secretions, hyperplasia, and ADH) or DCIS (usually low nuclear grade).



## DUCTAL HYPERPLASIA

### KEY FACTS

- Hyperplasia refers to cellular proliferation only.
- Hyperplasia is present when more than the two normal cell layers lining a duct overlie the basement membrane. In more severe cases, the proliferating cells usually distend the ducts.
- *Mild*, *moderate*, *severe*, and *atypical* are terms used by pathologists to qualify ductal hyperplasia.
- Some ADH and borderline lesions (i.e., ADH vs. low nuclear grade DCIS) may present a challenge to pathologists. Variation has been described among pathologists in their classification of these lesions (e.g., subjective diagnosis). Following imaging guided biopsies yielding a diagnosis of ADH, it is often helpful to discuss this diagnosis directly with the pathologist to ascertain their confidence level and degree of concern.
- Histologically, ADH is considered as having some but not all of the features of DCIS or in a lesion having all of the features of DCIS but involving only one duct or measuring less than 2 mm.
- A slightly higher relative risk (1.5× to 2×) for the development of breast cancer has been described in women with mild to moderate ductal hyperplasia.
- A moderate relative risk (5×) for breast cancer development has been described in women with ADH; this risk increases (10× to 11×) if ADH is diagnosed in women with a positive family history (first-degree relative) of breast cancer.
- Ductal hyperplasia is a common component of fibrocystic change. It may be in a constant state of flux. In some women, ADH and low nuclear grade DCIS are probably also reversible.
- It has been proposed that in some women there is progression (evolution) from ductal hyperplasia to ADH to low nuclear grade DCIS and eventually, in some patients, well- or intermediately differentiated invasive ductal carcinoma. This theory, however, remains unproven and controversial. Some suggest that this evolution is applicable to some types of breast cancers only (e.g., low nuclear grade DCIS, but not high nuclear grade DCIS).
- Ductal hyperplasia can be an incidental finding in biopsies done for clinical or mammographic findings. In 40% to 50% of patients, the mammographic findings (most commonly microcalcifications) are correlated directly with the area of hyperplasia.
- Rarely, ADH can present as an area of architectural distortion or a mass with spiculated, lobulated, indistinct, or macrolobulated margins with no associated microcalcifications.
- Ductal distention and cellular proliferation characterize the ductal hyperplasias and DCIS. Microscopic evaluation of the cells, their nuclei, and proliferative patterns is needed to distinguish between these processes.
- Morphologically, the calcifications that develop in secretions associated with ductal hyperplasia, ADH and low nuclear grade DCIS are similar

mammographically. These calcifications tend to be round, punctate, or amorphous. Some may demonstrate linear orientation.

- In contrast, the calcifications that develop in necrotic debris are linear, casting-type calcifications. They are characteristic of DCIS (commonly, high nuclear grade DCIS) and usually distinctive enough so as not to be confused with the calcifications associated with ductal hyperplasia, ADH or low nuclear grade DCIS-type calcifications.
- Linear (casting-type) calcifications, reflecting the presence of central necrosis may be seen in as many as 22% of patients with low or intermediate nuclear grade DCIS.
- Excisional biopsy is recommended for patients diagnosed with ADH following imaging biopsy. Regardless of biopsy methodology (e.g., 11G vacuum assisted biopsy vs. 14G core biopsies) ADH is upgraded to DCIS or invasive ductal carcinoma on excisional biopsy in 10% to 45% of patients.
- Treatment with tamoxifen or raloxifene may be considered for chemoprevention in women diagnosed with ADH.

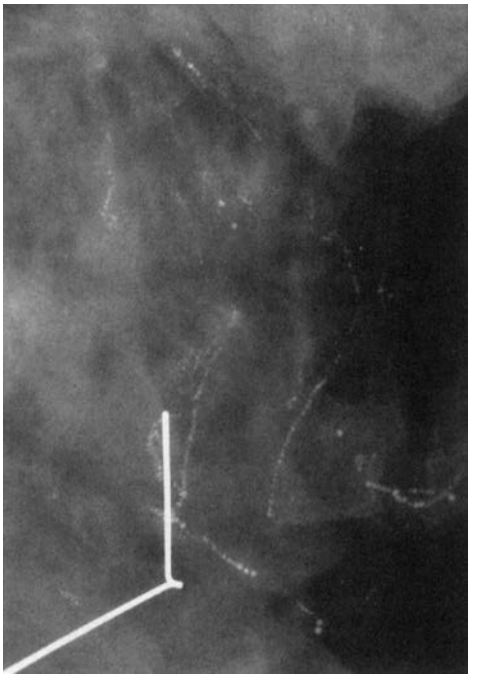


**FIGURE 12-6** Ductal hyperplasia. Round and punctate calcifications in a linear or ductal distribution. These calcifications are thought to develop in secretions within the duct and can also be seen associated with ADH and DCIS lacking central necrosis. These contrast with the linear (casting) calcifications that characterize DCIS lesions with central necrosis (commonly high nuclear grade DCIS).

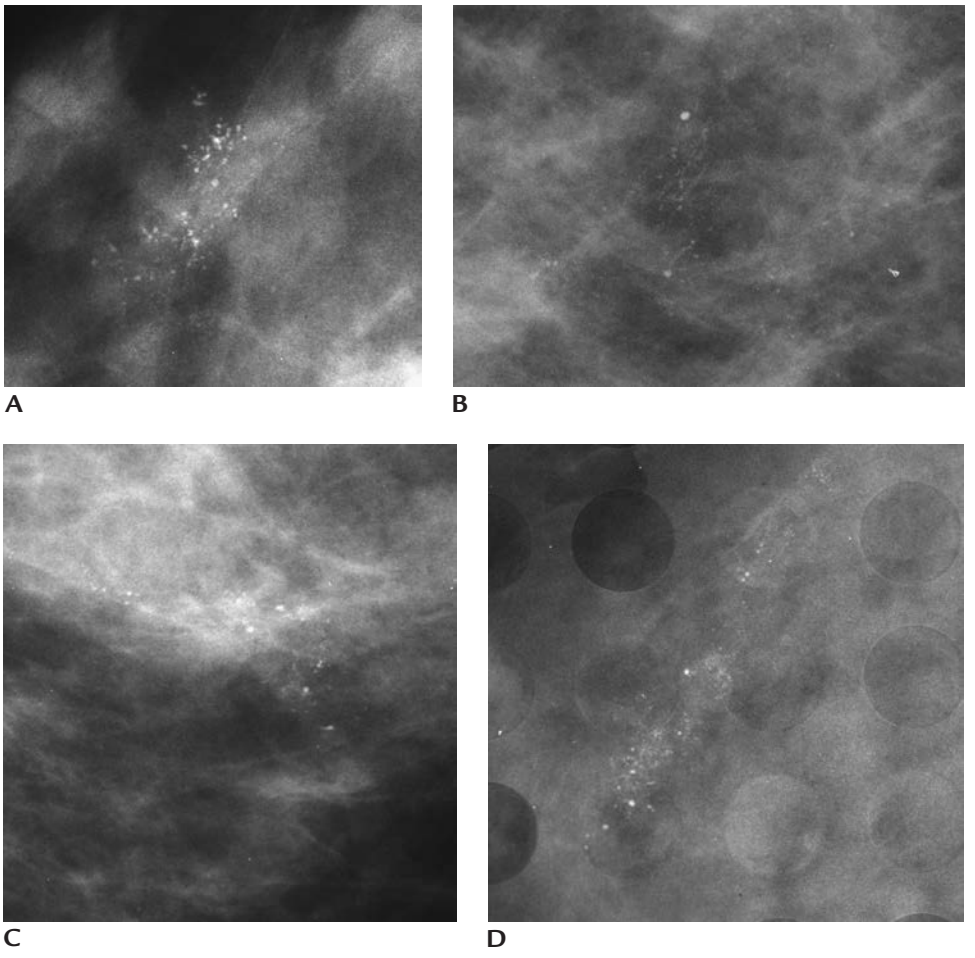



**FIGURE 12-7** ADH. Double spot compression magnification (1.8×) views **(A-C)**. **(A)** Cluster of round, punctate, irregular calcifications. Variable in density. No linear (casting) calcifications or linear orientation. DCIS (low to intermediate nuclear grade), hyperplasia, sclerosing adenosis, columnar alteration with prominent apical snouts and secretions (CAPSS), fibroadenoma, and papilloma(s) are in the differential. ADH is diagnosed on a core biopsy. Because of the association (and upstaging) with DCIS, patients diagnosed with ADH on a core biopsy should go on to excisional biopsy. DCIS (low nuclear grade solid and cribriform types) is diagnosed on the excisional biopsy. **(B)** Different patient. Loose cluster of punctate and amorphous calcifications, some demonstrating linear orientation. Low density predominates. Contrast the density of these calcifications with those seen in **(A)**. ADH confirmed on excisional biopsy. **(C)** Different patient. Loose cluster of round, punctate, and amorphous calcifications some demonstrating linear orientation. Low, but variable density among the calcifications. **(D)** Specimen radiograph from the patient shown on **(C)**. As is sometimes noted, many more calcifications are apparent on the specimen radiograph. Overall morphology, density and suggested linear/ductal orientation are better characterized on the specimen radiograph. Multifocal ADH involving areas of sclerosing adenosis (both processes with associated calcifications) is reported on the excisional biopsy. There is some subjectivity involved in the histological evaluation of these lesions such that what one pathologist calls hyperplasia another may call ADH and yet another may call DCIS. This is troubling given the implications of an ADH or DCIS diagnosis for the patient.

# Ductal Carcinoma in Situ (DCIS)

## Key Facts

- Prior to the advent of high-quality mammographic studies and the ability to detect microcalcifications, DCIS was considered a rare type of breast cancer; DCIS now constitutes 22% to 45% of all breast cancers diagnosed mammographically.
- Based on biological markers, 3D studies, and histology as well as mammographic and clinical presentation, DCIS is a heterogeneous disease.
- In general, intraductal (noninvasive) carcinomas are clinically occult lesions detected with microcalcifications mammographically or linear clumped or stippled enhancement on MRI; invasive ductal carcinomas present with a mass that is detected clinically, mammographically, sonographically, or on MRI. If a mass and malignant-type calcifications are identified mammographically, both invasive and intraductal components are usually present. When reporting these lesions, it is important to describe the presence and extent of both components.
- It is thought that DCIS with central necrosis is an obligate invader compared with DCIS lacking central necrosis (usually low or intermediate nuclear grade) only some of which progress to invasion. Currently, we are unable to determine the biological behavior of low grade DCIS.
- Although a rare occurrence, the disappearance of pleomorphic calcifications demonstrating either linear forms or ductal orientation may be seen as intraductal lesions progress to invasion.
- Sentinel lymph nodes biopsy is controversial in patients with DCIS. Sampling of the lymph nodes is probably not indicated in patients with small lesions. Sentinel lymph node biopsy is probably indicated in patients with more extensive, high nuclear grade lesions because the incidence of microinvasion is probably higher and histological evaluation is limited by virtue of the size of the lesion (e.g., the pathologist sample the larger lesions, they do not look at continuous serial sections).
- Clinical.

  Most patients are asymptomatic.

  Palpable mass (3% to 5%).

  Spontaneous nipple discharge (3% to 10%) that is not necessarily bloody; specifically, clear, hem negative discharge may be seen in women with an underlying malignancy.

  Paget's disease of the nipple (1% to 3%).
- Mammography.

  Normal.

  Calcifications developing in secretions are punctate, round or oval; variable in density in one or multiple clusters; some may have a linear/ductal orientation (i.e., punctate or round calcifications lined up in a ductal distribution); some may also be amorphous (likely tight cluster of punctate calcifications, which cannot be resolved into the individual calcifications with the degree of magnification obtainable in a patient).

Calcifications developing in necrotic (cellular) debris are linear, branching, casting type calcifications that often demonstrate linear orientation and a segmental distribution; variable in density within a cluster and among patients.

Less commonly, DCIS (without associated invasive disease) can produce a mass with ill-defined, lobulated, or spiculated margins, architectural distortion, or parenchymal asymmetry.

- Ultrasound.

  Normal.

  High specular echoes (calcifications) that may have associated shadowing.

  Associated mass or dilated ductal structures.

- MRI.

  Sensitivity of MRI for DCIS detection may be higher compared to that of mammography.

  Normal.

  Clumped enhancement in a linear/ductal or segmental distribution.

  Irregular, spiculated masses with heterogeneous or rim enhancement.

- Gross.

  Cut surface through an area of DCIS (usually high nuclear grade DCIS) may be associated with the presence of comedos, the necrotic contents of the abnormal ducts.

  No gross abnormality is usually evident with low or intermediate nuclear grade DCIS (unless, these are associated with central necrosis).

- Histology.

  Based on nuclear and architectural features sub classified into low, intermediate (cribriform, micropapillary, solid, small cell), or high nuclear grade (comedo, large cell).

## DCIS with no Central Necrosis, Often Low, Intermediate Nuclear Grade DCIS (Well-Differentiated, Cribriform, Micropapillary, Solid)

- Mammography.

  Normal.

  One or more clusters of punctate, round, or oval microcalcifications of varying sizes and density.

  Amorphous calcifications.

  Calcifications develop in luminal secretions; when you target this type of calcifications they may or may not be associated with the malignant cells, wider sampling of the calcifications (11G needles and increased number of cores or excisional biopsy) may be appropriate to minimize false negatives.

  Histology.

  Ductal distention with monomorphic cellular proliferation creating cribriform spaces (punched out) or micropapillary processes; solid growth present in some.

  Necrosis is uncommon.

If there is central necrosis (approximately 20%) calcifications may be linear.

Monomorphic nuclei, small or absent nucleoli.

Mitotic figures, rare.

No individual cell necrosis, no autophagocytosis.

Cellular polarization.

Multifocal origin and growth (in almost 50% of patients) in the duct; adjacent areas of hyperplasia and ADH (which may or may not be calcified) may be present.

Microcalcifications seen mammographically may not be intimately associated with malignant disease histologically; the calcifications may be associated with areas of hyperplasia or ADH that are adjacent to DCIS that has no associated calcifications (this is why excision is recommended when ADH is diagnosed on core biopsy; a significant number of patients with ADH or core biopsy are found to have DCIS when more tissue is excised). Mammographically we underestimate the extent of disease found histologically.

Approximately 47% of lesions calcify.

## DCIS with Central Necrosis: Often High Nuclear Grade DCIS (Poorly Differentiated, Comedo, Large Cell)

- Mammography.

  Normal.

  Pleomorphic, linear, branching, casting-type microcalcifications that may be linearly oriented and may extend to subareolar area.

  The border of the linear calcifications is often irregular (not smooth as seen with benign secretory-type calcifications) and there are clefts in the calcifications.

  Variable density within a cluster and among clusters.

  May have segmental distribution.

  Calcifications develop in necrotic debris in the duct lumen in close proximity to the malignant cells; if you target the calcifications, you are targeting the malignant cells.

  Close association between microcalcifications seen mammographically and extent of disease found histologically.

  Distortion (rare).

  Rarely, DCIS presents as a round or oval mass with indistinct to spiculated margins, architectural distortion, or focal parenchymal asymmetry that may be palpable.

- Histology.

  Ductal distention with pleomorphic cellular proliferation circumferentially encroaching the duct lumen.

  Central necrosis generally present.

  Distended ducts with periductal fibrosis and lymphocytes.

  Pleomorphic nuclei with multiple nucleoli.

  Mitotic figures.

Individual cell necrosis and autophagocytosis.
No true cellular polarization.
Thought to be contiguous in the duct with no skip areas.
Approximately 90% of lesions calcify.

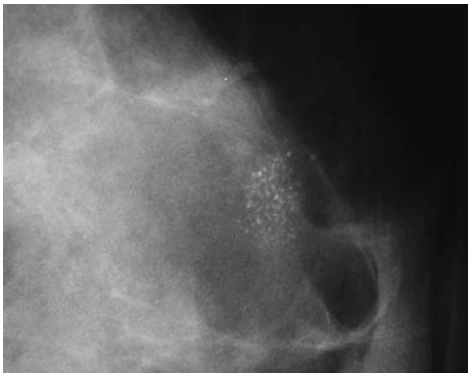


**FIGURE 12-8** DCIS, low nuclear grade, cribriform type with associated calcifications. Spot compression magnification view (1.8×) demonstrates a cluster of punctate, round and amorphous calcifications of varying density. No associated linear (casting) forms or linear orientation. In addition to DCIS (usually low or intermediate nuclear grade), fibrocystic changes (e.g., hyperplasia, ADH, sclerosing adenosis, columnar alteration with prominent apical snouts and secretions), papilloma, and fibroadenoma are in the differential for these calcifications.

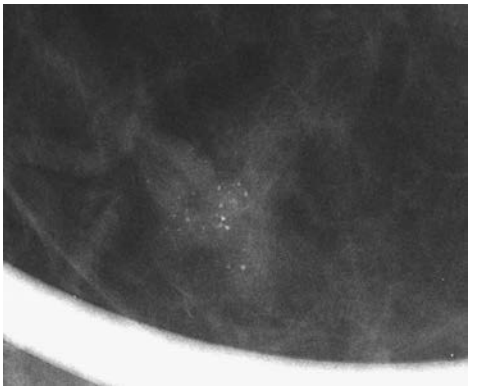


**FIGURE 12-9** DCIS, low to intermediate nuclear grade. Spot compression magnification view (1.8×) demonstrates a loose cluster of irregular, round and punctate microcalcifications of varying density. No associated linear (casting) forms or linear orientation. In addition to DCIS, fibrocystic changes (e.g., hyperplasia, ADH, sclerosing adenosis, columnar alteration with prominent apical snouts and secretions), papilloma, and fibroadenoma are additional considerations in the differential.

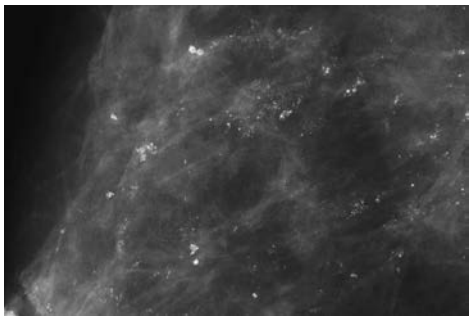


**FIGURE 12-10** DCIS, low nuclear grade, micropapillary, and cribriform types. Multiple clusters of round and punctate calcifications demonstrating variable density and a regional distribution. Some of the calcifications demonstrate linear orientation but no linear forms are apparent. This patient's mammogram had been stable for 10 years. ADH and fibrocystic changes including columnar alteration with prominent apical snouts and secretions and sclerosing adenosis with associated calcifications are also seen histologically. As in this patient, this type of DCIS is not an obligate invader persisting as DCIS for years. Biologically, these lesions may be indolent and progression to invasive disease does not occur in all patients. However, the biological behavior of these lesions is not currently predictable.

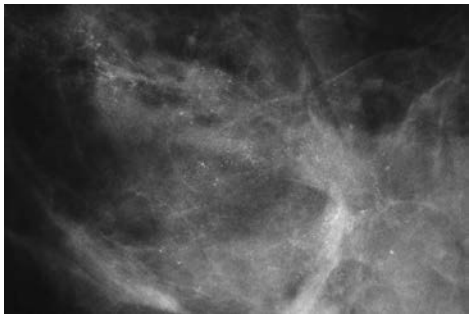


**FIGURE 12-11** DCIS low nuclear grade, solid, and cribriform types with associated calcifications. Double spot compression magnification (1.8×) view. Amorphous and punctate calcifications characterized by low but variable density are present demonstrating regional distribution. Sclerosing adenosis is the primary differential consideration in this patient. When related to DCIS, these calcifications are not always intimately associated with the malignant cells. Some of these may be found in areas of hyperplasia, ADH, or sclerosing adenosis and the adjacent DCIS has no associated calcifications. To minimize the likelihood of a false negative core biopsy, larger amounts of tissue (11G cores with vacuum assistance), increasing the number of cores (14G) taken, or excisional biopsy may be appropriate.

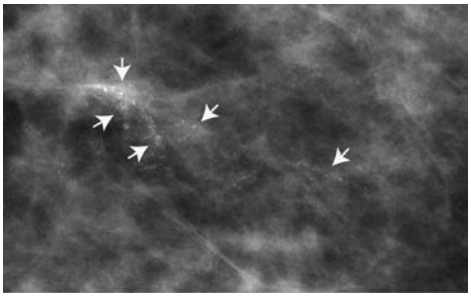
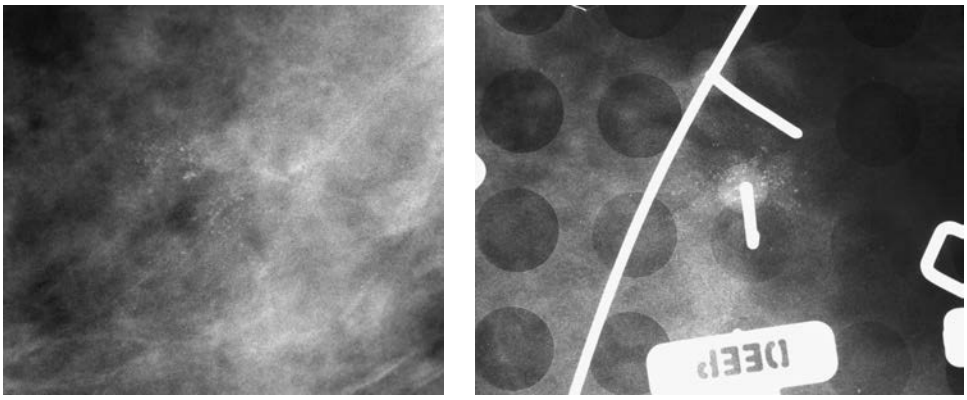


**FIGURE 12-12** DCIS intermediate grade, apocrine type. Double spot compression magnification (1.8×) view. Punctate, round, and amorphous calcifications (*arrows*) of variable density demonstrate a linear orientation (segmental distribution). A few linear (casting) forms are present.



**A** **B**

**FIGURE 12-13** DCIS, intermediate to high nuclear grade. **(A)** Spot compression magnification (1.8×) view demonstrating a cluster of amorphous calcifications with low but variable density. Fibrocystic changes (e.g., hyperplasia, ADH, sclerosing adenosis, columnar alteration with prominent apical snouts and secretions), papilloma, and fibroadenoma are in the differential. **(B)** Specimen radiography with magnification (3.5×) highlights the punctate nature of amorphous calcifications seen mammographically. On a specimen, magnification can be increased so that amorphous calcifications are better "resolved" into tight clusters of punctate calcifications. On a patient, the amount of magnification that can be obtained is limited, and as such, tight clusters of punctate calcifications are not well defined and may appear "amorphous."

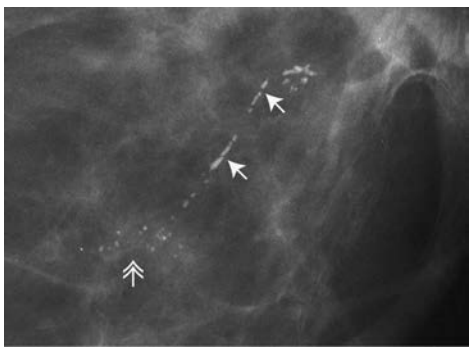


**FIGURE 12-14** DCIS, high nuclear grade with central necrosis. Double spot compression magnification (1.8×) view. Linear, casting-type calcifications demonstrating linear or ductal orientation; round and punctate calcifications are also present (*double headed arrow*). Irregular border and "clefts" (*arrows*) within linear calcifications are common. Density of calcifications is variable within and among lesions. These calcifications develop in necrotic debris commonly seen in high nuclear grade DCIS are less commonly seen in patients with intermediate or low nuclear grade DCIS. This is an active biological process such that the calcifications can disappear as invasive disease develops. Morphology is better characterized on high-contrast well-exposed (double) spot magnification views (1.8×) with no blur. Calcifications like these are highly suspicious for malignancy (>95% likelihood) and biopsy is indicated. Because these calcifications are intimately associated with the malignant cells, targeting the calcifications is accurate in establishing the diagnosis.

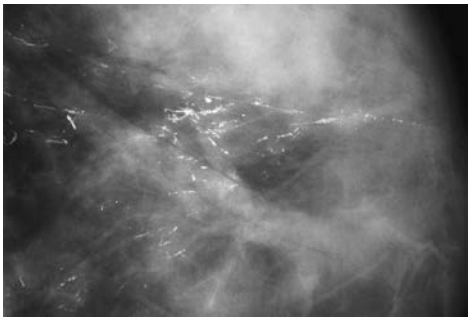


**FIGURE 12-15** DCIS, high nuclear grade with necrosis. Casting type calcifications demonstrating linear orientation and a segmental distribution with extension to the subareolar area. Calcifications like these are highly suspicious for malignancy. Given the extent of the disease seen mammographically, and the difficulty pathologists may have adequately evaluating all of the tissue for invasion, sentinel lymph node is often done in patients with an extensive area of calcifications.

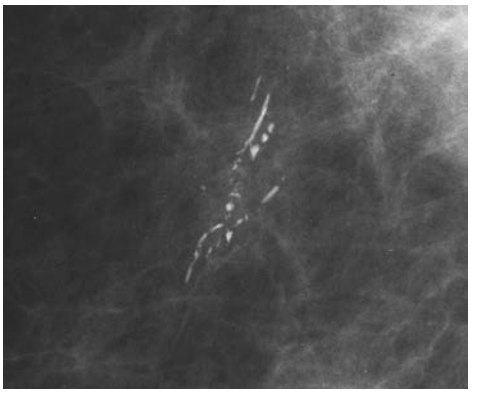


**FIGURE 12-16** DCIS, high nuclear grade with central necrosis. Double spot compression magnification (1.8×) view. Casting type calcifications demonstrating linear orientation. These are highly suggestive of DCIS (>95% likelihood) with central necrosis (usually high nuclear grade) and as such, biopsy is indicated.

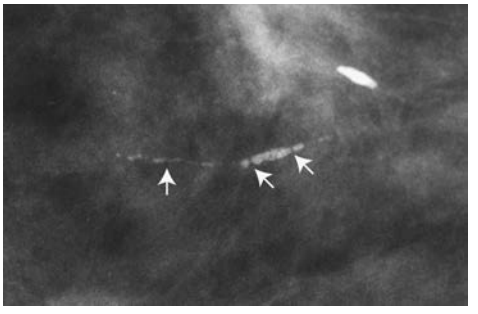


**FIGURE 12-17** DCIS, high nuclear grade with central necrosis. Double spot compression magnification (1.8×) view. Linear, casting type calcifications demonstrating linear orientation. These calcifications develop in necrotic cellular debris in the lumen of the duct and are actively molded by the proliferating cancer cells. Biologically this is an active ongoing process. Calcifications can disappear (particularly when invasion occurs) or progress. The margins of the calcifications are often irregular and they have associated clefts (*arrows*).

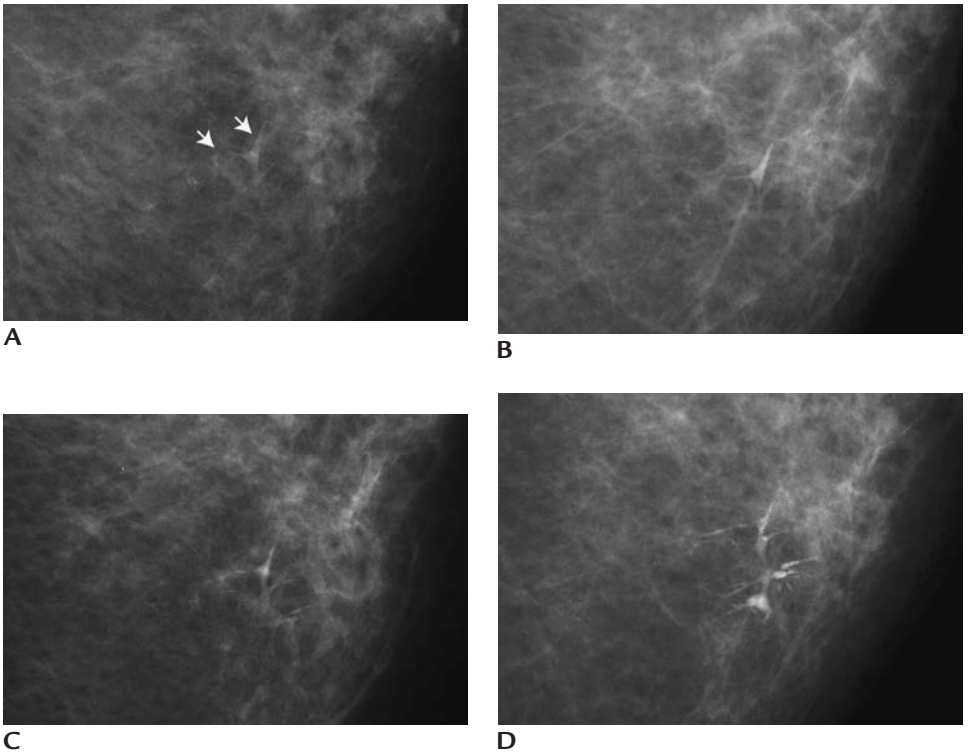



**FIGURE 12-18** DCIS, intermediate nuclear grade with central necrosis. **(A)** Low density calcifications (*arrows*) demonstrating linear orientation. **(B)** A year later some of the smaller calcifications have resolved and the density of some of the remaining calcifications is increased. **(C)** Three years following **(A)**, linear calcifications are increasing in number and density. **(D)** Seven years following **(A)**, linear calcifications continue to develop and the overall density of the calcifications is increased.

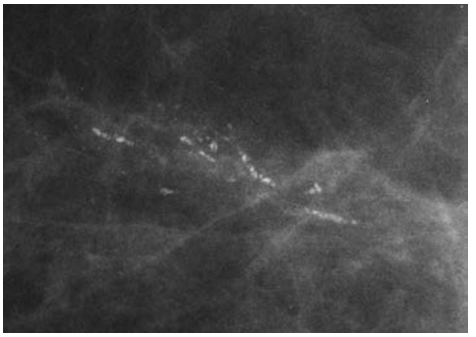


**FIGURE 12-19** DCIS, high nuclear grade with central necrosis. Double spot compression magnification (1.8×) view. Linear, casting type calcifications demonstrating linear orientation. Variable in density. These calcifications are characterized by irregular margins and clefts reflecting the active cellular proliferation ongoing in the duct. The proliferating cancer cells mold these calcifications. They can increase in size, density and number or disappear as the disease progresses and evolves. Calcifications like these are highly suspicious for malignancy (>95% likelihood) and biopsy is indicated.

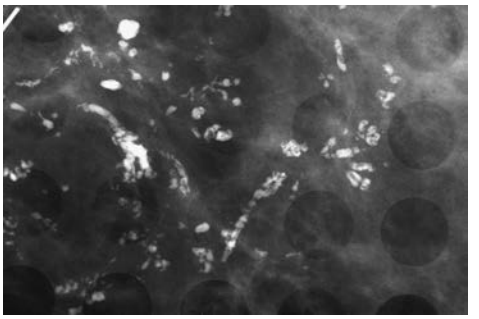
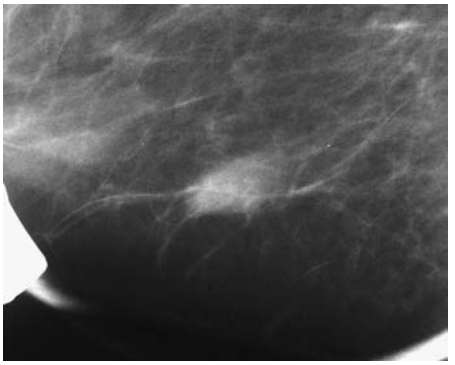
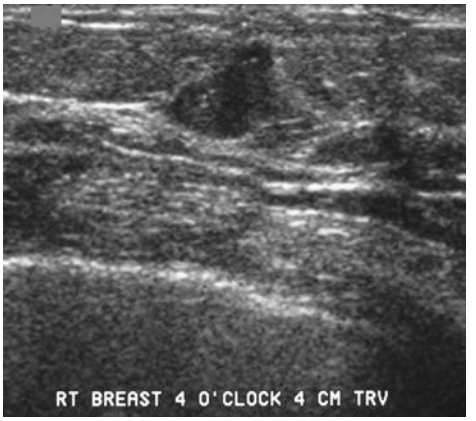


**FIGURE 12-20.** DCIS, high nuclear grade with central necrosis. Specimen radiograph. Linear casting type calcifications. In this patient the calcifications are high, though variable, in density. Some are coarse.



A

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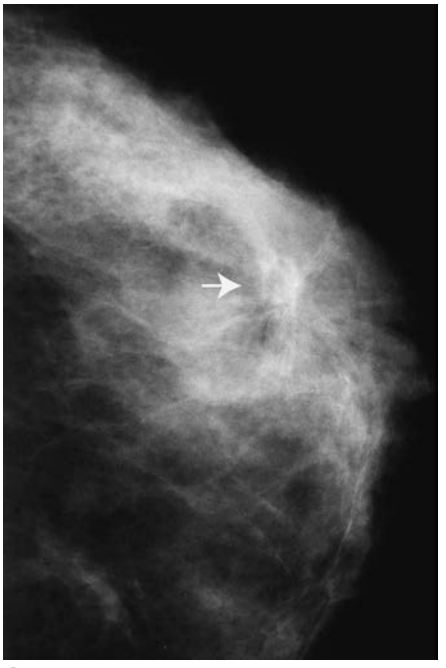

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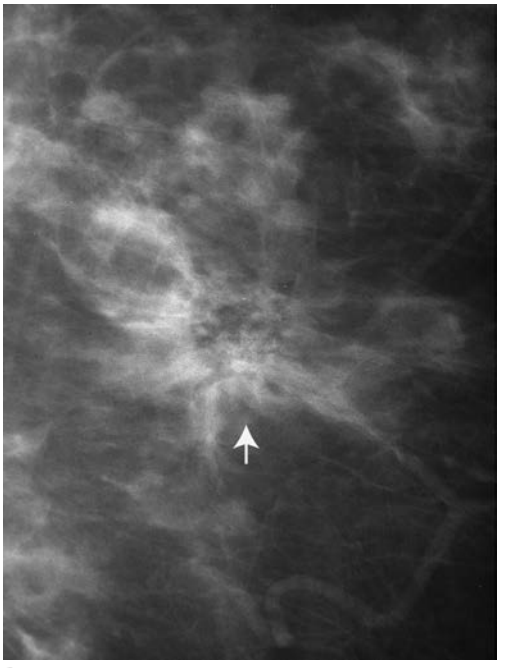
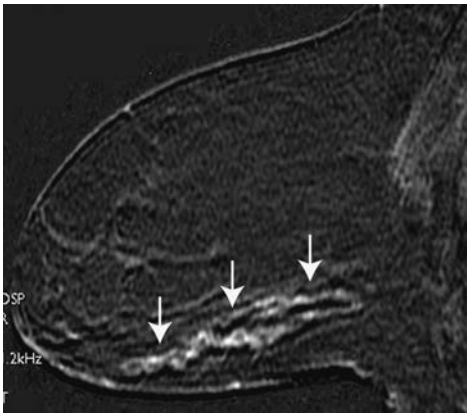
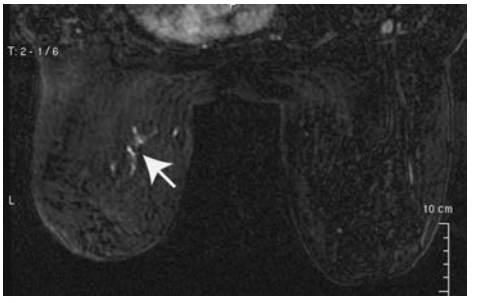


D

**FIGURE 12-21** DCIS can rarely present as a mass with circumscribed, indistinct or spiculated margins, distortion or parenchymal asymmetry in the absence of any associated calcifications. **(A)** Spot compression view. Oval mass with indistinct margins. **(B)** Irregular, vertically oriented hypoechoic mass corresponding to the mammographically detected mass. **(C)** Different patient. Mass (*arrow*) with spiculated margins. **(D)** Different patient. Distortion (*arrow*).




A

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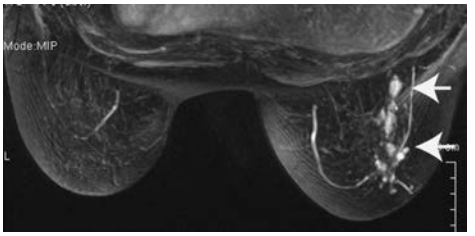



C

**FIGURE 12-22** DCIS. **(A)** MRI, sagittal subtraction image demonstrating linear, clumped enhancement (*arrows*) characteristic of DCIS. **(B)** Different patient. Axial subtraction image demonstrating linear clumped enhancement (*arrow*) centrally in the left breast corresponding to a site of DCIS. **(C)** Different patient. Maximum intensity projection (MIP). Demonstrating a 7-cm area of linear clumped and stippled enhancement (*arrows*) laterally in the right breast. In this patient, a 1-cm cluster of calcifications was identified posteriorly on the mammogram (not shown). The true extent (7 cm) of the disease (confirmed pathologically) was shown on the MRI.

# Invasive Ductal Carcinoma, Not Otherwise Specified (NOS)

## Key Facts

- Clinical.

  Most common type of breast cancer (constitutes approximately 65% to 75% of all breast cancers): no specific histologic findings or patterns present to sub classify as a "special" breast cancer type.

  Palpable mass, often seems larger on physical examination than what is seen on imaging studies.

  Focal breast tenderness.

  Nipple discharge, nipple inversion.

  Skin dimpling with larger masses or if lesion is close to the skin.

  Skin retraction or ulceration in women with advanced disease.

- Mammography.

  Mass with spiculated (infiltrative) margins: often reflect low- to intermediate-grade lesions.

  Round mass with well to partially circumscribed or indistinct margins (expansile): often reflect poorly differentiating, lesions; also associated with some of the "special" breast cancer subtypes (e.g., medullary, mucinous, papillary), but because NOS is so common, the most common histological finding in women with well- or partially circumscribed masses is invasive ductal carcinoma NOS.

  Architectural distortion (isolated or associated with a mass).

  Focal or global parenchymal asymmetry.

  Diffuse changes including either an enlarging or shrinking breast, increased density, and prominence of the trabecular markings.

  Malignant-type calcifications can be seen with any of the previously mentioned findings. When malignant-type calcifications are associated with a soft tissue component, the patient usually has a combination of invasive ductal carcinoma (mass) and DCIS (calcifications).

  The presence of an extensive intraductal component (EIC) may be of prognostic significance. The rate of local recurrence after conservative treatment is reportedly higher in women with EIC, particularly younger women ages 40 to 49. This may be related to the presence of residual disease in the breast. It is important to alert the surgeon and pathologist when EIC is suspected mammographically (i.e., extensive area of microcalcifications associated with a mass or microcalcifications extending away from the mass).

- Ultrasound.

  Round, oval, lobular, or irregular hypoechoic mass with variable posterior acoustic characteristics: commonly associated with shadowing when the mass is spiculated; commonly associated with enhancement when it is a round, expansile mass mammographically (particularly with poorly differentiated lesions and those with necrosis).

  Marked hypoechogenicity.

  Vertical orientation ("lesion is tall").

  Spiculation.

Microlobulation.

Angular margins.

Extension of the tumor into distended ducts (toward nipple).

Branching of tumor away from nipple.

Echogenic rim of tissue surrounding hypoechoic mass.

In women with a high likelihood of malignancy, the ipsilateral axilla and parasternal region (looking for internal mammary adenopathy) are scanned to determine if there are potentially abnormal axillary or internal mammary lymph nodes; if any are identified, either a core biopsy or fine needle aspiration is undertaken.

- MRI.

  Mass: round, oval, or irregular with margins ranging from circumscribed to spiculated.

  Rim enhancement.

  Diffuse enhancement.

  Low signal intensity on T2-weighted images.

  Low signal intensity on T1-weighted pre-contrast images.

  Many demonstrate rapid and intense enhancement with rapid wash out or plateau type kinetic curves.

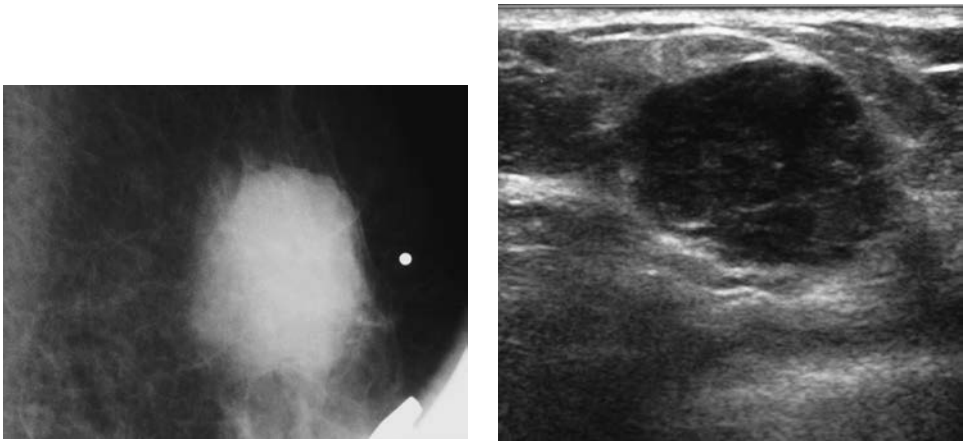
  Assessment of axillary, internal mammary, and supraclavicular lymph nodes.

- Histology.

  Variable architectural growth patterns (i.e., tubule formation and appearance) and cellular morphology.

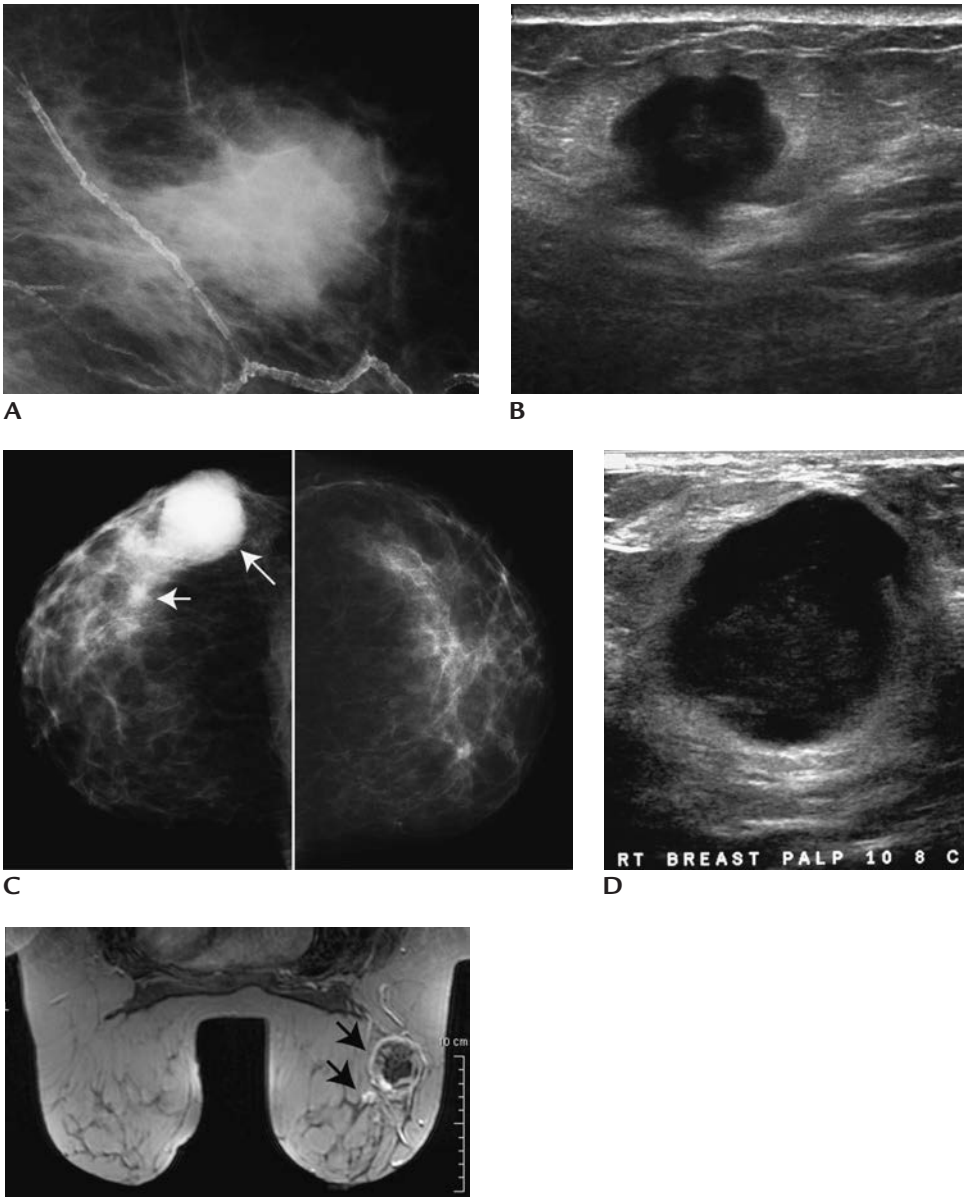
  Several grading systems are available. Most are modifications of the Bloom and Richardson grading system based on architectural growth patterns, nuclear morphology, and proliferation activity (mitotic count). All in-situ lesions and invasive breast cancers measuring 1 cm or less in greatest diameter are considered minimal breast cancer.

  Invasive ductal carcinomas in which DCIS constitutes 25% or more of the tumor or in which the DCIS extends well beyond the invasive component are classified as invasive ductal carcinomas with EIC.



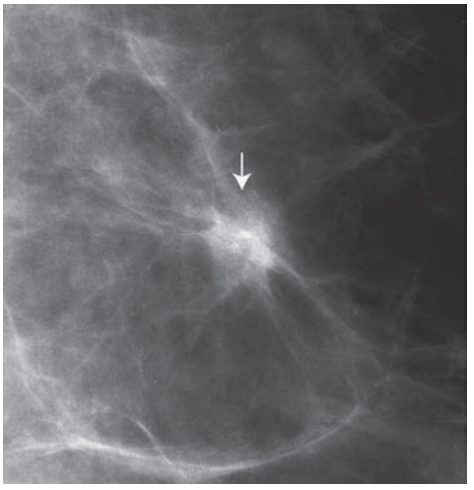
A B

**FIGURE 12-23** Invasive ductal carcinoma, not otherwise specified NOS, poorly differentiated (grade III). **(A)** Spot compression view. Metallic BB used to denote palpable finding. Oval, dense mass with indistinct and partially obscured margins is imaged corresponding to the palpable finding. Although these types of masses are most commonly associated with the subtypes (e.g., "special forms") of invasive ductal breast cancer, the most common histological diagnosis in women with well- or partially circumscribed round or oval masses is invasive ductal carcinoma NOS just because invasive ductal carcinomas NOS are so common (65% to 75% of all breast cancers). **(B)** Hypoechoic mass with posterior acoustic enhancement. A poorly differentiated histology is common in patients who are diagnosed with invasive ductal NOS presenting as a round or oval mass (expansile), particularly when associated with posterior acoustic enhancement.

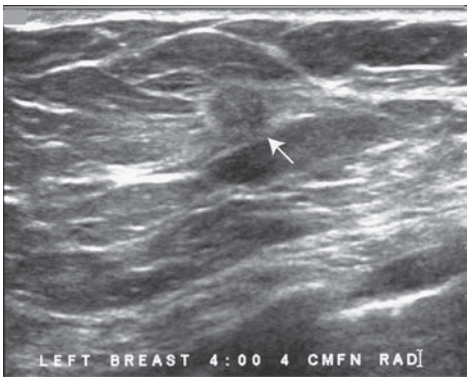



**A** **B** **C** **D** **E**

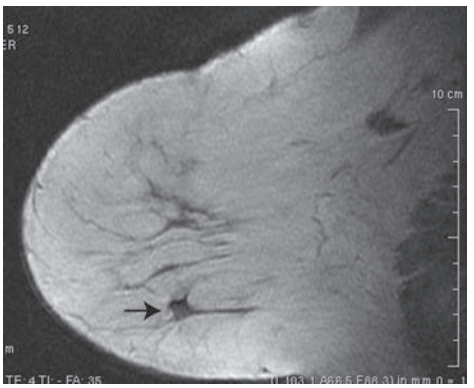
**FIGURE 12-24** Invasive ductal carcinoma NOS, poorly differentiated (grade III). **(A)** Spot compression view. Round, mass with indistinct and partially obscured margins. Dense vascular calcification is present. **(B)** Hypoechoic mass with lobulated and angular margins and posterior acoustic enhancement. **(C)** Different patient **(C-E)**. Round (expansile) high density mass (*long arrow*) with adjacent satellite mass (*short arrow*) laterally in the right breast. **(D)** Vertically oriented mass with posterior acoustic enhancement corresponding to the dominant mass seen mammographically. Portions of the mass are markedly hypoechoic **(E)** Axial T1-weighted image 1 minute post contrast demonstrates dominant mass with rim enhancement and adjacent enhancing mass (*arrows*). Both masses demonstrate rapid initial enhancement and wash out of contrast following intravenous bolus of gadolinium. A poorly differentiated histology is common in patients such as these who are diagnosed with invasive ductal NOS presenting as a round or oval mass (expansile), particularly when associated with posterior acoustic enhancement sonographically.



A

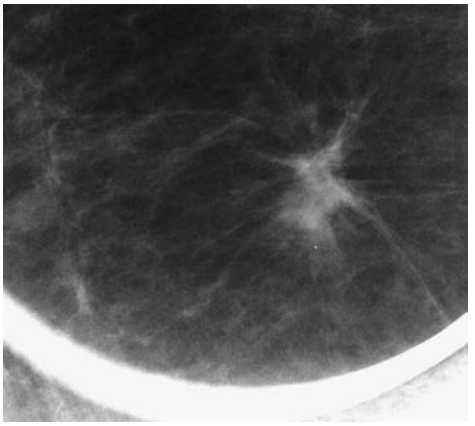



B




C

**FIGURE 12-25** Invasive ductal carcinoma NOS, well differentiated (grade I). **(A)** Spot compression view demonstrating a mass with indistinct and spiculated margins (*arrow*). When spiculated, these tumors are commonly well or intermediately differentiated. **(B)** A nearly isoechoic mass (*arrow*) with an echogenic rim is imaged at the 4 o'clock position, 4 cm from the left nipple corresponding to the mass seen mammographically. **(C)** Sagittal T1 weighted MRI demonstrating a mass with spiculated margins (*arrow*) and low signal intensity corresponding to the mass seen mammographically. Rapid initial enhancement with wash out of contrast (not shown) is noted following contrast administration.



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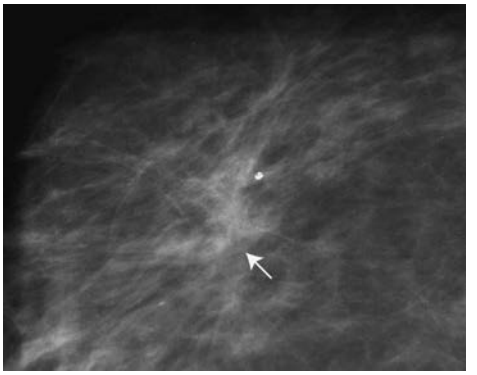
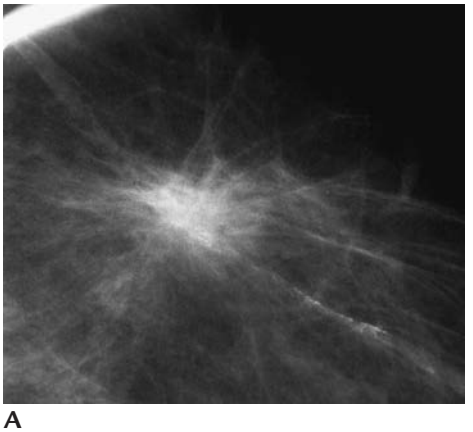


B

**FIGURE 12-26** Invasive ductal carcinoma, not otherwise specified, well differentiated (grade I). **(A)** Spot compression view. Mass with spiculated margins. **(B)** Different patient. Low density mass with spiculated margins and associated distortion. Histologically, grade I or II lesions are commonly diagnosed when these lesions present as a spiculated mass.



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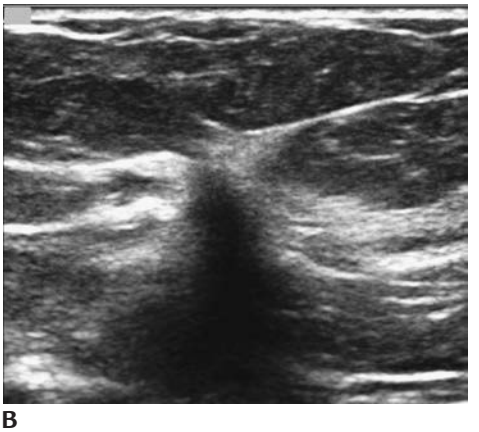
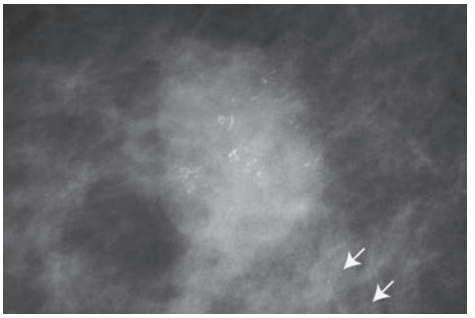


B

**FIGURE 12-27** Invasive ductal carcinoma, not otherwise specified, (grade II). **(A)** Spot compression view. Round mass with spiculated margins. Vascular calcifications are present. **(B)** Hypoechoic mass with associated posterior acoustic shadowing corresponding to the mass seen mammographically.



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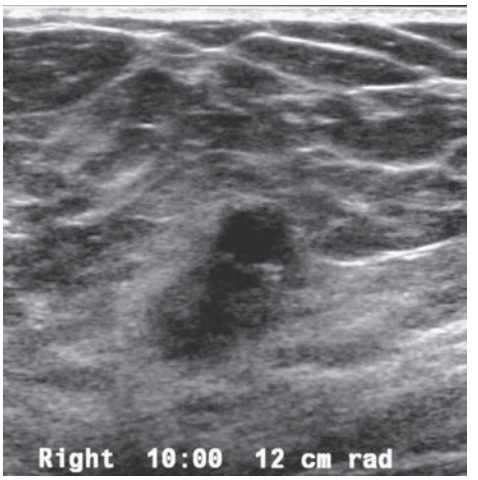


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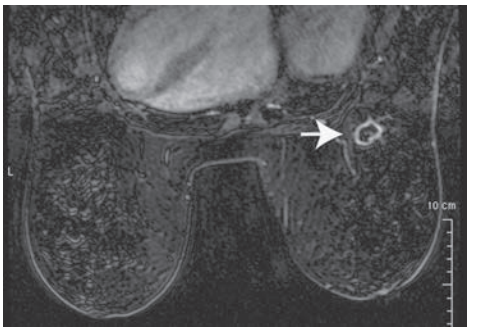



C

**FIGURE 12-28** Invasive ductal carcinoma, not otherwise specified, poorly differentiated with associated DCIS, high nuclear grade with central necrosis. **(A)** Double spot compression magnification view (1.8×). Oval mass with indistinct and lobulated margins associated with linear, casting type calcifications. Mass reflects invasive component; calcifications reflect intraductal component. On the magnification views, additional unsuspected calcifications are detected extending inferiorly from the mass (*arrows*). Even when there is an obvious finding, additional views are helpful in characterizing the extent of the disease. **(B)** Ultrasound demonstrates irregular, vertically oriented mass with high specular echoes characteristic of calcifications. Partial echogenic rim. **(C)** Magnetic resonance, subtraction image. Mass (*arrow*) with rim enhancement corresponding to the mammographic finding.

## Tubular Carcinoma

### Key Facts

- Clinical.

  In pure form, less than 2% of all breast cancers; median age 44 to 49.

  Palpable mass, but most tubular carcinomas are diagnosed mammographically.

  Multicentric in up to 28% of patients, bilaterality in 12% to 38%; family history of breast cancer in up to 40% of women diagnosed with tubular carcinoma.

  Pure lesions associated with excellent prognosis; axillary nodal metastases for pure tubular carcinoma approximately 10%.

  Some reported arising in association with radial scars or CSLs.

- Mammography.

  Small (less than 1 cm) spiculated mass; ill-defined mass less common.

  Indeterminate or malignant-type calcifications (may be apparent on magnification views only) within and beyond the spiculated mass; usually round, punctate, or amorphous in appearance.

  Look for satellite lesions, possibly bridging with the dominant spiculated mass; multifocality is common.

- Ultrasound.

  Irregular, vertically oriented mass with spiculated and angular margins often with associated shadowing and disruption of ligaments.

- MRI.

  Normal (e.g., false negative).

  Low signal intensity on T2-weighted images and pre-contrast T1-weighted images.

  Mass with spiculated margins and rapid initial enhancement and wash out of contrast or a plateau type kinetic curve.

- Gross.

  Tan, poorly circumscribed scirrhous mass; infiltrative margin.

- Histology.

  Proliferation of angulated, oval and elongated tubules lined by a single epithelial cell layer (no myoepithelial cells); cells may display apical snouts; basement membrane absent or poorly formed.

  Mitotic figures rare; nucleoli not apparent.

  Fibroblastic stroma may be dense and elastotic.

  Calcification in up to 50% of lesions.

  Low nuclear grade, cribriform type DCIS in as many as 65% of patients.

  Lobular neoplasia (LCIS) in close proximity in approximately 15%; some of these patients have tubulobular carcinoma.

Differentiating tubular carcinomas from sclerosing adenosis and complex sclerosing lesions (radial scars) can be difficult (particularly on frozen sections); immunohistochemical stains for actin useful in separating benign lesions from tubular carcinomas.

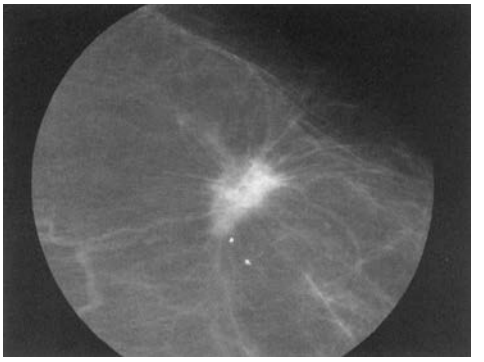


**FIGURE 12-29** Tubular carcinoma. Spot compression magnification (1.8×) view. Irregular mass with spiculated margins. Of the special forms of invasive ductal carcinoma (e.g., tubular, mucinous, medullary, papillary etc), tubular is the only one that typically presents with a spiculated mass.

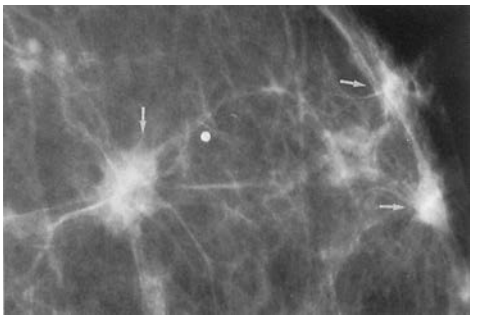


**FIGURE 12-30** Tubular carcinoma. Spot compression magnification (1.8×) view. Dominant mass (*arrow*) with spiculated margins and two additional masses (*arrows*) with spiculated margins not appreciated on screening views. Multifocality (or multicentricity) and bridging between small spiculated masses is common with tubular carcinomas.

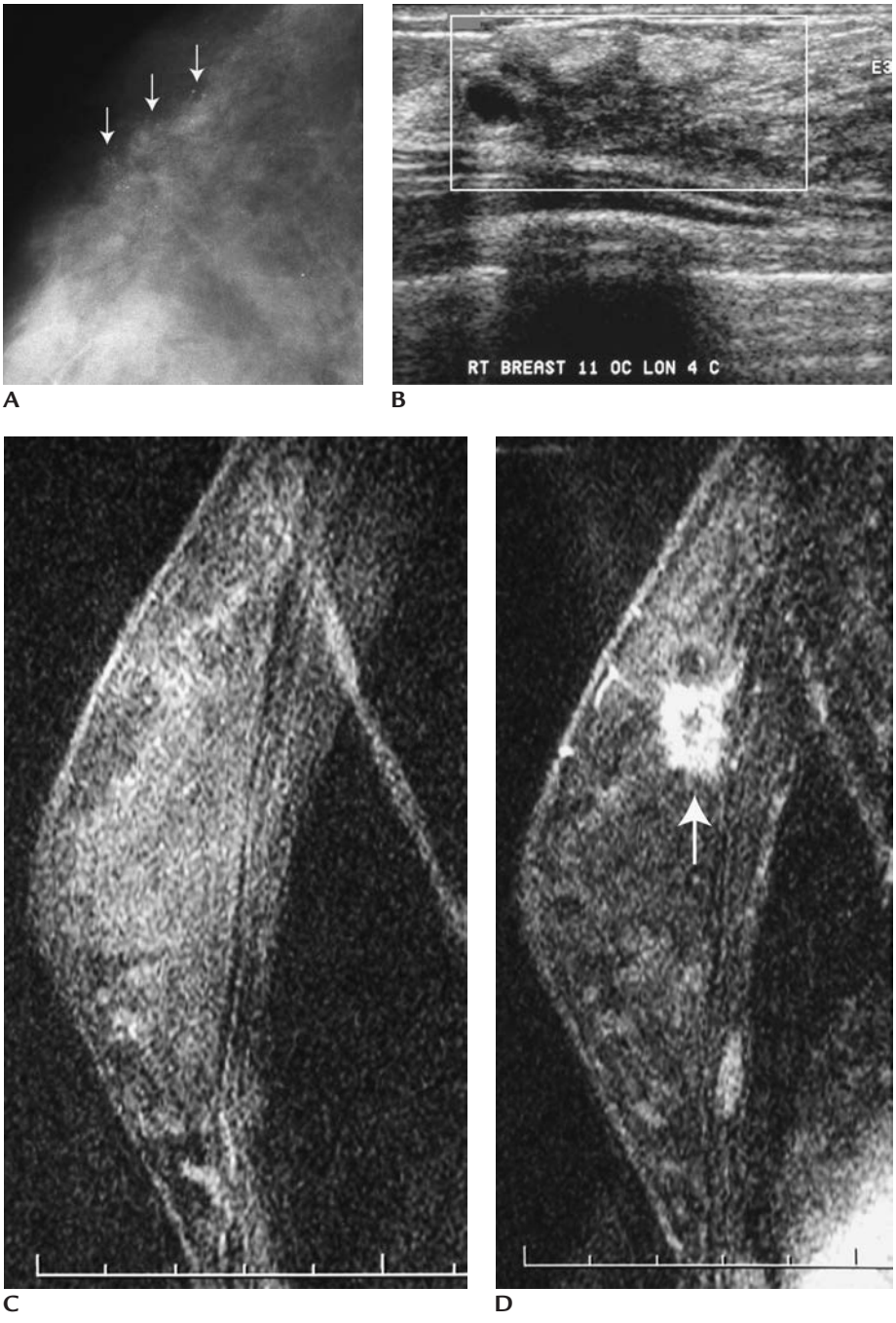



**FIGURE 12-31** Tubular carcinoma. **(A)** Distortion with associated punctate and amorphous calcifications (*arrows*). Because DCIS, low nuclear grade cribriform type is found in as many as 65% of patients with tubular carcinomas, many of these lesions have associated punctate and amorphous, low density calcifications. **(B)** Irregular hypoechoic mass with spiculated, not well circumscribed (*box*) margins and associated high specular echoes consistent with the calcifications seen mammographically. **(C)** MRI. Pre-contrast sagittal T1-weighted image of the right breast. **(D)** Post-contrast image at the same table top as that in **(C)**. Mass (*arrow*) with spiculated margins and rim enhancement. Portions of the mass demonstrate rapid initial enhancement with wash out of contrast.

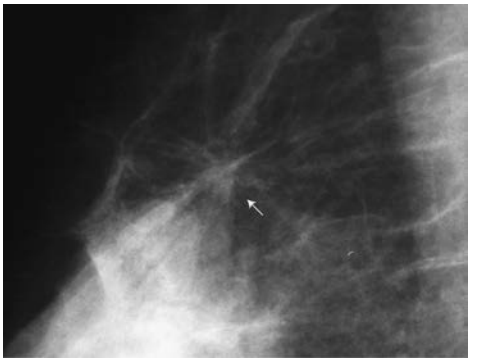


**FIGURE 12-32** Tubular carcinoma arising in complex sclerosing lesion (CSL). Spot compression magnification (1.8×) view demonstrates a mass (*arrow*) with spiculated margins. A tubular carcinoma arising in a CSL is reported histologically. The association between tubular carcinoma, DCIS low nuclear grade, ADH and CSL's is the reason why many recommend excisional biopsy when a CSL is suspected based on mammographic findings or diagnosed on core biopsy.

## MUCINOUS CARCINOMA

### KEY FACTS

- Clinical.

  Also known as colloid, mucoid or gelatinous carcinoma.

  In pure form, 2% of all breast cancers; can occur at all ages, but more common in older women (1% in women less than 35 years of age and 7% in women older than 75).

  Mass lesion; palpatory "swish" sign described by Halstead rare.

  Slow growth rate.

  Good prognosis for pure lesions; systemic recurrences more than 10 years after initial treatment have been reported.

  Prognosis of mixed lesions (mucinous and invasive ductal NOS components) determined by the characteristics of the invasive ductal component.

  Commonly diploid, estrogen receptor positive.

  Mucin embolization is a rare complication.

  Axillary node positive in approximately 25% of patients.
- Mammography.

  Round, oval, or lobular mass with circumscribed, indistinct or obscured margins.
- Ultrasound.

  Round or oval, hypo- to nearly isoechoic mass, rarely slightly hyperechoic mass with circumscribed margins.

  Posterior acoustic enhancement is a prominent feature in some patients.
- MRI.

  Limited data at this time, no large series available.

  High signal intensity reflecting mucinous content on T2-weighted images.

  Variable signal intensity on pre-constrast T1-weighted images.

  T1-weighted dynamic: gradual or plateau type enhancement pattern; irregular thickened rim enhancement.

- Gross.

  Cores are distinctive, gelatinous, clear, fragment easily, and develop tiny air droplets along the edges when placed in 10% formalin.

  Glistening cut surface, soft consistency, well-defined, round, expansile lesions.
- Histology.

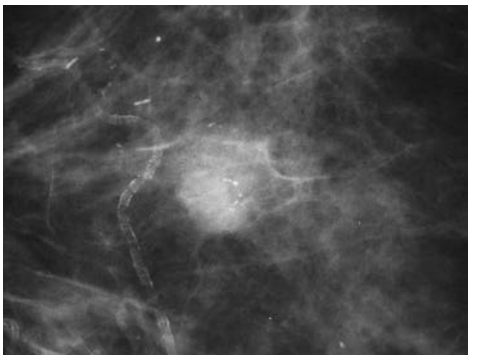
  Aggregates of tumor cells surrounded completely by mucin and compartmentalized by fibrovascular bands.

  Cellularity of aggregates varies from a few to large clumps of malignant cells floating in mucin.

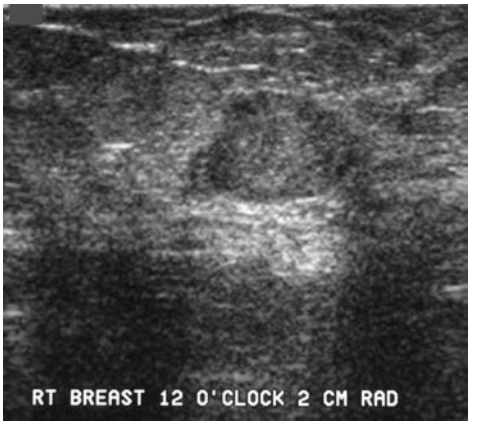
  Cells contain little intracellular mucin.

  Necrosis uncommon.

  Low nuclear grade DCIS (cribriform) may be found in adjacent breast tissue, but DCIS is not a prominent component of these lesions.



A




B

**FIGURE 12-33** Mucinous carcinoma. **(A)** Round mass with indistinct margins and calcifications reflecting the presence of co-existing DCIS. Vascular and benign type calcifications are present in the surrounding tissue. **(B)** Iso- to slightly hyperechoic mass with posterior acoustic enhancement corresponding to the mass seen mammographically. Mucinous carcinomas are commonly isoechoic or slightly hypo- or hyperechoic with posterior acoustic enhancement possibly related to the mucinous content of the lesions.

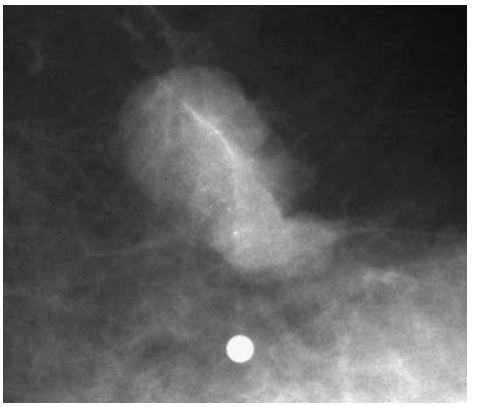
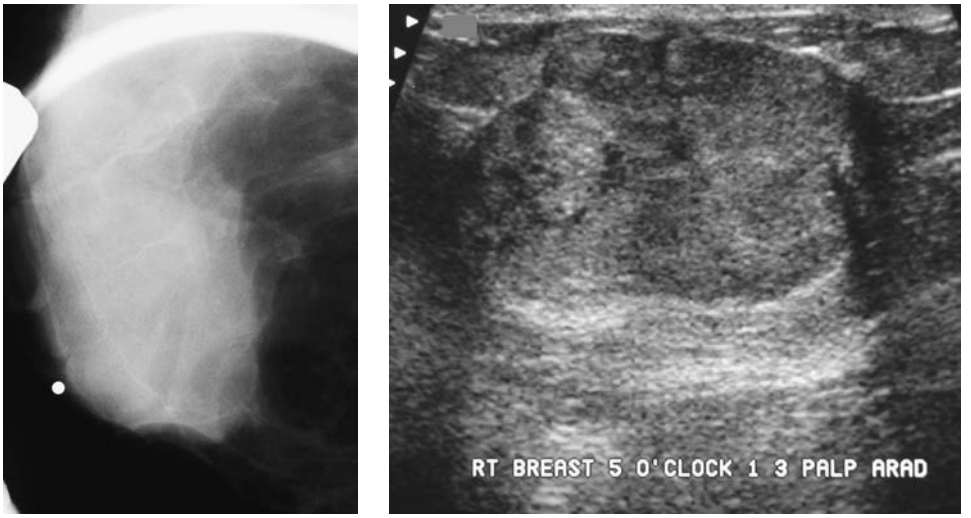
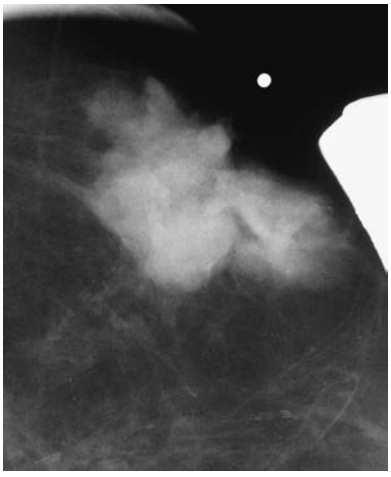


**FIGURE 12-34** Mucinous carcinoma. **(A)** Irregular mass with circumscribed and lobulated margins. Associated punctate and round calcifications reflect the presence of co-existing DCIS. Metallic BB used to denote palpable finding.

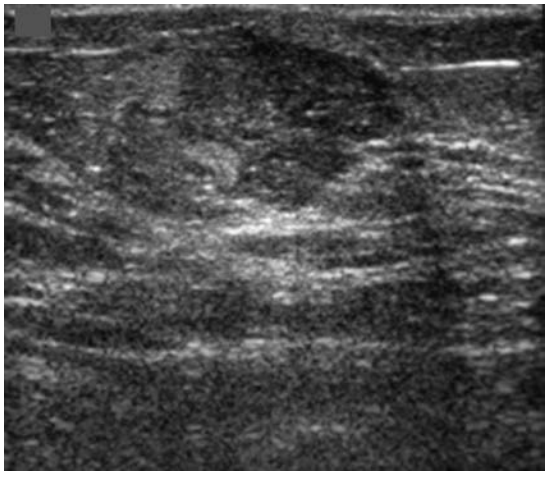



**A** **B**

**FIGURE 12-35** Mucinous carcinoma. **(A)** Spot tangential view. Metallic BB used to mark palpable finding. Oval mass with partially obscured and indistinct margins corresponding to the area of concern to the patient. **(B)** Iso- to hyperechoic mass with posterior acoustic enhancement. Mucinous carcinomas are commonly isoechoic or slightly hypo- or hyperechoic with posterior acoustic enhancement possibly related to the mucinous content of the lesions.



**A**



**B**

**C**

**FIGURE 12-36** Mucinous carcinoma. **(A)** Irregular, high density mass with indistinct margins. Metallic BB used to denote palpable finding. **(B)** Iso- to slightly hypoechoic mass with posterior acoustic enhancement corresponding to the palpable finding and the mass seen mammographically. Margins are not well circumscribed. **(C)** Different patient. The cores obtained from mucinous carcinomas have a distinctive gelatinous ("glassy") appearance, fragment easily and develop small round air bubbles at the edge when placed in 10% formalin.

# Medullary Carcinoma

## Key Facts

- Clinical.

  In pure form, less than 2% of all breast cancers. The reported variation in frequency may be due to differences in definition criteria used by pathologists.

  More common in younger women (11% of all breast cancers in women younger than age 35), rare in elderly patients.

  Circumscribed, mobile mass (given young age of many patients, may be mistaken for a fibroadenoma).

  Fast growth rate, high thymidine labeling.

  Usually aneuploid, estrogen receptor negative; expression of nuclear p53, and lack of HER2/neu reactivity.

  Locally aggressive. Despite aggressive histologic features, the prognosis of pure medullary carcinomas is better than that seen with invasive ductal carcinomas NOS.

  When fatal, death usually occurs within 5 years of diagnosis.
- Mammography.

  Round or oval mass, circumscribed to ill-defined margins.
- Ultrasound.

  Solid, homogeneously hypoechoic (may be markedly hypoechoic) round mass.

  Posterior acoustic enhancement.
- MRI.

  No significant data is available.

  When tumor is necrotic, a high signal intensity may be seen centrally on T2-weighted images.

  Enhancing mass on T1-weighted images.
- Gross.

  Well-defined, round, expansile lesion; soft in consistency.

  May have associated areas of hemorrhage or necrosis.
- Histology.

  Strict adherence to histological criteria is critical for diagnostic accuracy.

  Intense lymphoplasmacytic reaction around and within tumor.

  Expansile, well-circumscribed margins histologically.

  Syncytial, solid, sheet-like growth pattern of medium to large anaplastic cells.

  High mitotic rate; poorly differentiated nuclear grade.

  Gross and microscopic necrosis, but calcification uncommon.

  Plasma cells associated with these tumors produce IgA in contrast to IgG-producing plasma cells seen in invasive ductal carcinomas NOS.

  In-situ component rare.

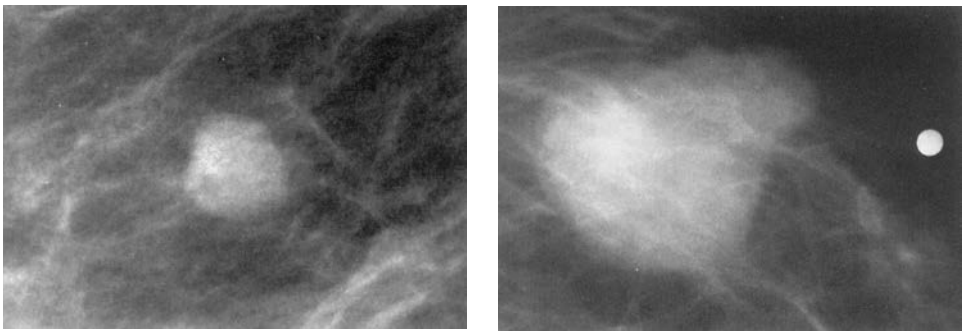
Epidermoid differentiation in as many as 15%.

Diagnosis may not be made conclusively on core biopsy.

Need to distinguish from lymphoepithelioma-like carcinoma a rare tumor simulating lymphoepithelioma of the nasopharynx.

## Atypical Medullary Carcinomas

- Lesions with a syncytial growth pattern of anaplastic cells having foci of invasive ductal carcinoma NOS, dense fibrosis or fibrous bands, and lacking a significant lymphoplasmacytic reaction.
- Atypical medullary carcinomas do not have the good prognosis of pure medullary carcinomas; prognosis similar to that of invasive ductal carcinomas NOS, strict adherence to diagnostic criteria is critical.



A B

**FIGURE 12-37** Medullary carcinoma. **(A)** Round, well-circumscribed mass. **(B)** One year later, the mass is larger and now lobulated and palpable. This tumor is locally aggressive.

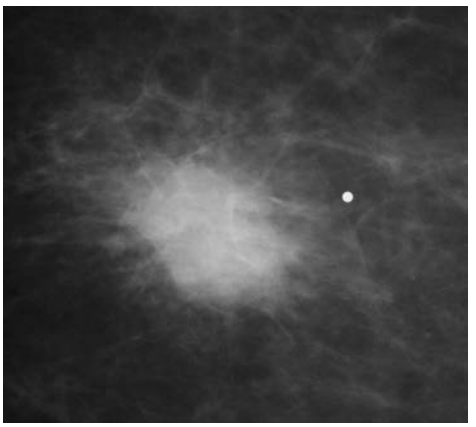
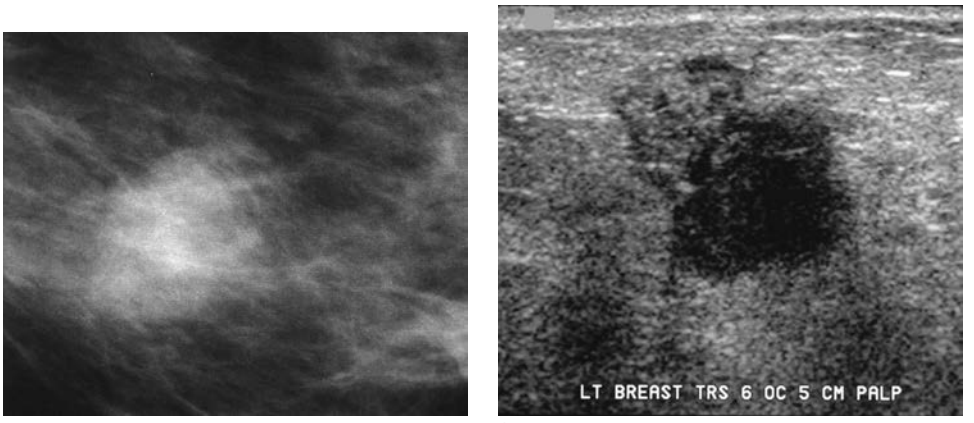
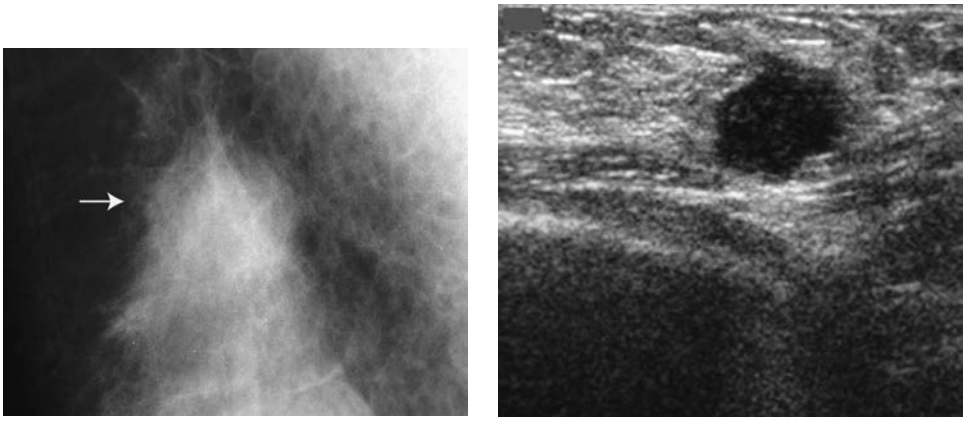


**FIGURE 12-38** Medullary carcinoma. Oval high density mass with indistinct margins. Metallic BB used to mark palpable finding.




A B

**FIGURE 12-39** Medullary carcinoma. **(A)** Oval mass with indistinct margins. **(B)** Hypoechoic mass corresponding to the area of mammographic concern. Margins are not well circumscribed.



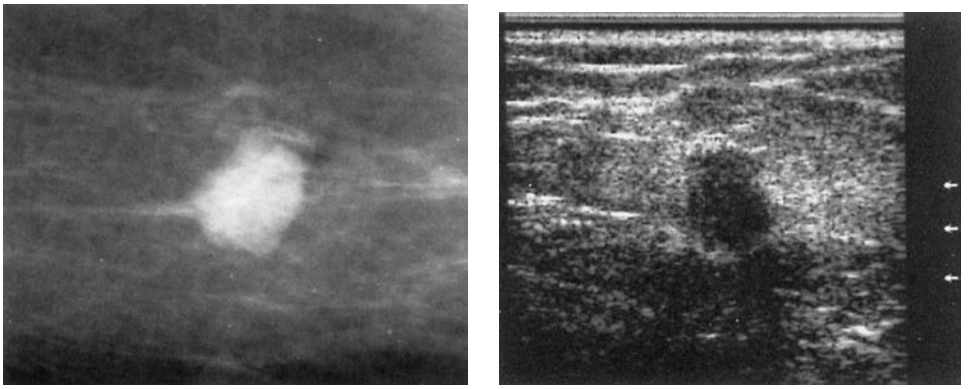
A B

**FIGURE 12-40** Atypical medullary carcinoma. **(A)** Spot compression view. Mass (*arrow*) with ill-defined and obscured margins rounding out the upper cone of glandular tissue on the mediolateral oblique view. **(B)** Round, hypoechoic mass with lobulated margins. Medullary carcinomas are often markedly hypoechoic (e.g., they can be nearly anechoic such that they can be mistaken for a cyst).

## Invasive Cribriform Carcinoma

### Key Facts

- Clinical.
  Approximately 1.7% to 3.5 % of all breast cancers.
  Excellent prognosis.
- Mammography.
  Mass with circumscribed to ill-defined margins.
  Microcalcifications may be present.
- Histology.
  Stromal invasion.
  Same cribriform arrangement seen in low nuclear grade, cribriform-type DCIS.
  Approximately 25% of tumors have associated features of tubular carcinoma.
  Well-differentiated, cribriform DCIS present in adjacent tissue (75%).
  Differential includes tubular carcinoma, cribriform-type DCIS, and adenoid cystic carcinoma.



A B

**FIGURE 12-41** Invasive cribriform carcinoma. **(A)** Round mass with circumscribed lobulated margins. **(B)** Hypoechoic, vertically oriented ('taller than wide') mass with angular margins and minimal posterior acoustic shadowing.

## Adenoid Cystic Carcinoma

### Key Facts

- Clinical.

  Less than 0.5% of all breast cancers.

  Palpable mass with slight predilection for the subareolar area.

  Morphologically indistinguishable from adenocystic carcinomas/cylindromas of the salivary glands and tracheobronchial tree; unlike lesions at other sites, however, breast lesions are characterized by excellent prognosis.

  Estrogen and progesterone receptor negative.

  Axillary nodal involvement and distant metastases are uncommon.
- Mammography.

  Mass may be calcified, with partially circumscribed to ill-defined or obscured margins.

  Lobulation may be present.
- Gross.

  Firm mass, no necrosis.

  Larger lesions may have areas of cystic degeneration.
- Histology.

  Mixture of glandular and stromal material; epithelial and myoepithelial components.

  Glandular (cribriform), tubular and solid (basaloid) types frequently occur in combination.

  Glandular component of lesion may be difficult to distinguish from cribriform carcinomas and collagenous spherulosis.

  Mixture of basophilic cells with hyperchromatic, monomorphic nuclei and scant cytoplasm (possibly myoepithelial origin) and smaller eosinophilic cells is needed to make diagnosis.

  In some lesions, sebaceous cells may be seen in addition to the two primary cell types.

  Intercellular spaces lined with basement membrane material and filled with eosinophilic basement membrane-like material.

  Perineural space involvement may be present.

  Lymphatic involvement rare.

  Although associated with good prognosis, recurrences can occur many years after initial treatment. Pulmonary involvement common in patients with metastatic lesions.

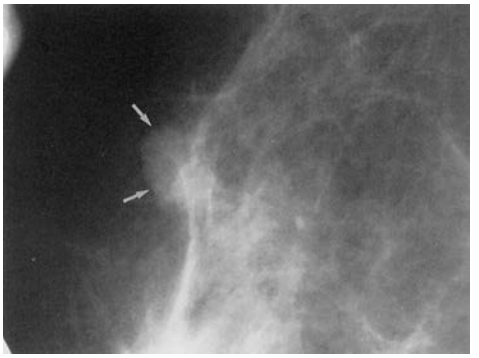


**FIGURE 12–42** Adenoid cystic carcinoma of the breast. Spot compression view. Mass (*arrows*) with partially circumscribed and obscured margins.

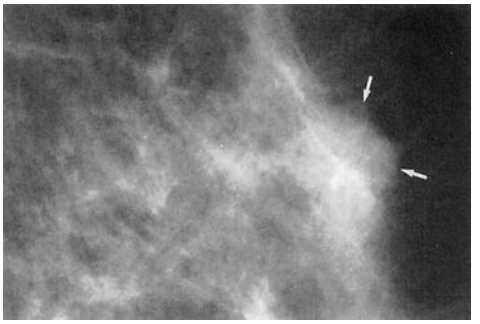
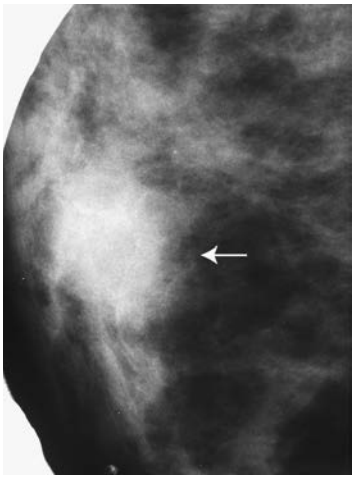


**FIGURE 12-43** Adenoid cystic carcinoma of the breast. Spot compression view. Mass (*arrows*) at subcutaneous-glandular tissue interface. Partially obscured margins.



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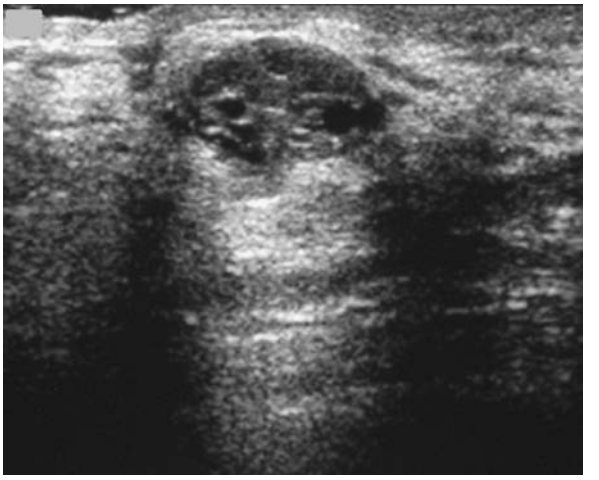


B

**FIGURE 12-44** Adenoid cystic carcinoma of the breast. **(A)** Spot compression view. Round mass (*arrow*) with partially indistinct and obscured margins. As in this patient, these lesions occur close to the nipple in close to 50% of patients. **(B)** Oval complex cystic mass with circumscribed margins and posterior acoustic enhancement corresponding to the mass seen mammographically.

# MISCELLANEOUS

## KEY FACTS

### Squamous Cell Carcinoma

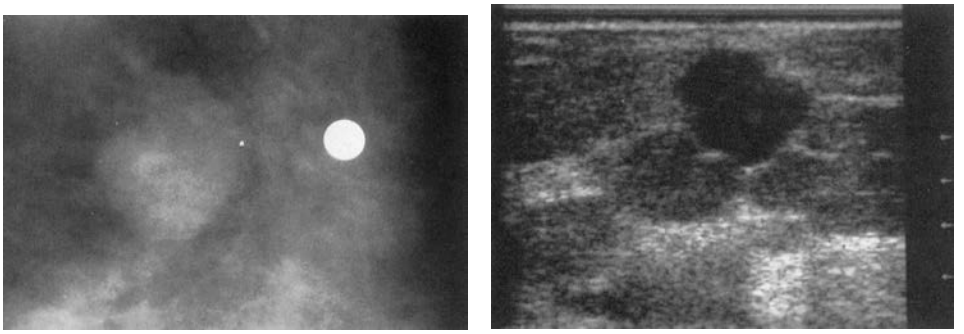
- Pure lesions in the breast are exceedingly rare.
- Lesions must have no connection to skin and patient has no other breast cancer; possibility of metastatic from primary elsewhere must also be excluded.
- Central necrosis and cyst formation.
- Stratification, intercellular bridges, keratin production, and acantholysis.

### Metaplastic Carcinoma

- Heterogeneous group of tumors: epithelial or mesenchymal (osseous or chondroid) cell populations with varying degrees of differentiation.

### Secretory Carcinoma (Juvenile Carcinoma)

- Median age 25 (approximately 33% in women 30 or older).
- Presents as breast mass.
- Well-circumscribed margins common, but may have infiltrative pattern.
- Prognosis may be related to age of diagnosis. Younger patients have good prognosis; in older patients, the prognosis is similar to that of invasive ductal carcinoma NOS.
- Abundant extra- and intracellular secretory material.



A B

**FIGURE 12–45** Metaplastic carcinoma. **(A)** Mass with circumscribed lobulated margins corresponding to palpable finding (metallic BB). **(B)** Markedly hypoechoic, vertically oriented mass with circumscribed and angular margins.

## SUGGESTED READINGS

Adler DD, Helvie MA, Oberman HA, et al. Radial sclerosing lesion of the breast: mammographic features. *Radiology*. 1990;176:737–740.

Cardenosa G, Eklund GW. Benign papillary neoplasms of the breast: mammographic findings. *Radiology*. 1991;751–755.

Cardenosa G, Doudna C, Eklund GW. Mucinous (colloid) breast cancer: clinical and mammographic findings in 10 patients. *AJR Am J Roentgenol*. 1994;162: 1077–1079.

Ciatto S, Morrone D, Catarzi S, et al. Radial scars of the breast review of 38 consecutive mammographic diagnoses. *Radiology*. 1993;187:757–760.

Cohen MA, Sferlazza SJ. Role of sonography in evaluation of radial scars of the breast. *AJR Am J Roentgenol*. 2000;174:1075–1078.

Elson BC, Helvie MA, Frank TS, et al. Tubular carcinoma of the breast: mode of presentation, mammographic appearance and frequency of nodal metastases. *AJR Am J Roentgenol*. 1993;161:1173–1176.

Fechner RD, Mills SE. *Breast Pathology: Benign Proliferations, Atypias and In-situ Carcinomas*. Chicago: American Society of Clinical Pathologists; 1990.

Frouge C, Tristant H, Guinebretiere JM, et al. Mammographic lesions suggestive of radial scars: microscopic findings in 40 cases. *Radiology*. 1995;195:623.

Helvie MA, Hessler C, Frank TS, et al. Atypical hyperplasia of the breast: mammographic appearance and histologic correlation. *Radiology*. 1991;179:759–764.

Helvie MA, Paramagul C, Oberman HA, et al. Invasive tubular carcinoma: imaging features and clinical detection. *Invest Radiol*. 1993;28:202–207.

Holland R, Hendriks JHCL, Verbeek ALM, et al. Extent, distribution and mammographic/histological correlations of breast ductal carcinoma-in-situ. *Lancet*. 1990;335:519–522.

Holland R, Connolly JL, Gelman R, et al. The presence of an extensive intraductal component following a limited excision correlates with prominent residual disease in the remainder of the breast. *J Clin Onc*. 1990; 8:113–118.

Ikeda DM. Andersson I. Ductal carcinoma-in-situ: atypical mammographic appearances. *Radiology*. 1989;172:661–666.

Kawashima M, Tamaki Y, Nonka T, et al. MR imaging of mucinous carcinoma of the breast. *AJR Am J Roentgenol*. 2002;179:179–183.

Kurose A, Ichinohasama R, Kanno H, et al. Lymphoepithelioma-like carcinoma of the breast. Report of a case with the first electron microscopic study and review of the literature. *Virchows Arch*. 2005;447:653–659.

Leibman AJ, Lewis M, Kruse B. Tubular carcinoma of the breast: mammographic appearance. *AJR Am J Roentgenol*. 1993;160:263–265.

Meyer JE, Amin E, Lindfors KK, et al. Medullary carcinoma of the breast: mammographic and US appearance. *Radiology*. 1989;170:79–82.

Millis RA, Eusebi V., eds. Ductal carcinoma in situ. *Seminars in Diag Pathol*. 1994;11: 167–235.

Mitnick JS, Gianutsos R, Pollack AH, et al. Tubular carcinoma of the breast: sensitivity of diagnostic techniques and correlation with histopathology. *AJR Am J Roentgenol*. 1999;172: 319–323.

Mitnick JS, Vasquez MF, Harris MN, et al. Differentiation of radial scar from scirrhous carcinoma of the breast: mammographic-pathologic correlation. *Radiology*. 1989;173:697–700.

Orel SG, Evers K, Yeh I-T, et al. Radial scar with microcalcifications: radiographic-pathologic correlation. *Radiology*. 1992;183:479–482.

Page DL, Anderson TJ. *Diagnostic Histopathology of the Breast*. Edinburgh: Churchill Livingstone; 1987.

Pediconi F, Occhiato R, Venditti F, et al. Radial scars of the breast: contrast-enhanced magnetic resonance mammography appearance. *Breast J*. 2005;11:23–28.

Poplack SP, Wells WA. Ductal carcinoma in situ of the breast: mammographic-pathologic correlation. *AJR Am J Roentgenol*. 1998;170:1543–1549.

Rosai J. Borderline epithelial lesions of the breast. *Am J Surg Pathol*. 1991;15:209–221.

Santamaria G, Velasco M, Zanón G, et al. Adenoid cystic carcinoma of the breast: mammographic appearance and pathologic correlation. *AJR Am J Roentgenol*. 1998;171:1679–1683.

Sheppard DG, Whitman GJ, Huynh PT, et al. Tubular carcinoma of the breast: mammographic and sonographic findings. *AJR Am J Roentgenol*. 2000;174:253–257.

Sickles EA. Breast masses: mammographic evaluation. *Radiology*. 1989;173:297–303.

Stomper PC, Connolly JL. Ductal carcinoma in situ of the breast: correlation between mammographic calcification and tumor subtype. *AJR Am J Roentgenol*. 1992;159:483–485.

Stomper PC, Cholewinski SP, Penetrante RB, et al. Atypical ductal hyperplasia: frequency and mammographic and pathologic relationships in excisional biopsies guided with mammography and clinical examination. *Radiology*. 1993;189: 667–671.

Tabár L, Dean PB. Teaching Atlas of Mammography. New York: Thieme Verlag; 1985.

Tavassoli FA. *Pathology of the Breast*. New York: Elsevier; 1992.

Wilson TE, Helvie MA, Oberman HA, et al. Pure and mixed mucinous carcinoma of the breast: pathologic basis for differences in mammographic appearance. *AJR Am J Roentgenol*. 1995; 165:285.

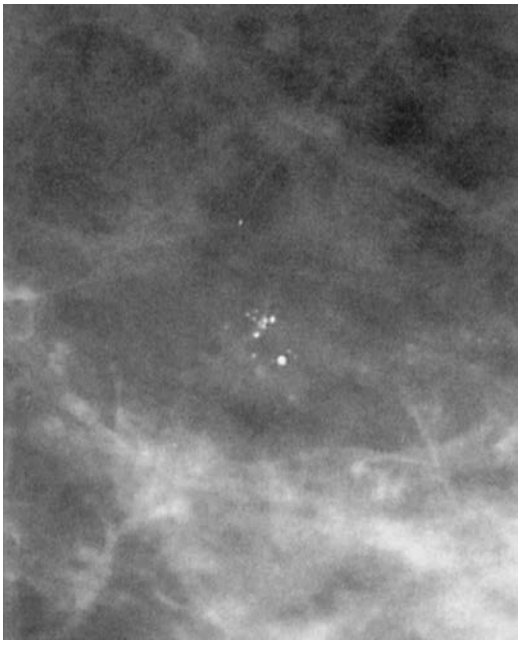
CHAPTER 13

# LOBULES

## NORMAL ANATOMY

### KEY FACTS

- Ducts terminate in blind-ending sacs called acini.
- Acini are grouped into lobules (like leaves on a branch).
- The acini produce milk during pregnancy and lactation.
- Epithelial and myoepithelial cells in ducts continue into lobules to line the acini.
- Unlike ducts, lobules have no associated elastic tissue.
- Lobules are usually not seen on mammography. On ultrasound, if a duct is followed proximally from the nipple, small hypoechoic mass-like areas can occasionally be seen arranged around the duct; presumably these are acini.
- Round, sharply defined (pearl-like), high-density calcifications, either in tight clusters or scattered diffusely in both breasts, form in acini.
- On ductography, a contrast blush is seen in a small number of women, presumably representing filling of the acini with contrast. Why this contrast blush is not seen more often is unknown.



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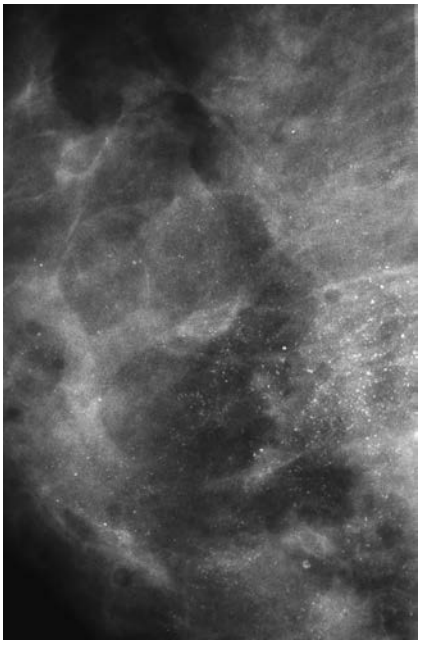

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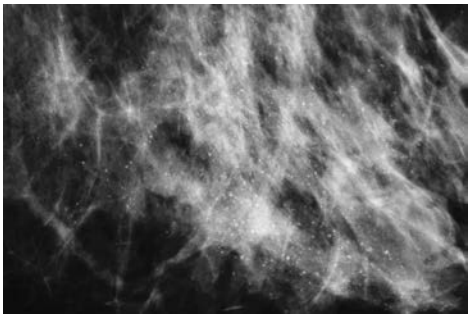


C

**FIGURE 13-1** Lobular calcifications. **(A)** Tight cluster of round calcifications. **(B)** Different patient. High-density round and punctate calcifications scattered diffusely in the breast parenchyma. **(C)** Different patient, round calcifications scattered diffusely in the breast parenchyma.

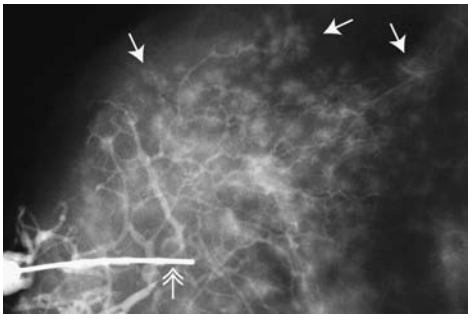


**FIGURE 13-2** Lobular blush. Ductogram (1.8×). When compared to the size of the cannula (*double headed arrow*), the caliber of the duct is normal. Contained contrast blush in a lobular distribution is associated with the terminal portion of the ducts (some areas of lobular blush marked with *arrows*).

## CYSTS

### KEY FACTS

- Clinical.

  Variable presentation.

  Develop perimenopausally in many women, but can be found in women of all ages.

  Stimulated by estrogen (can develop or grow when women are started on estrogen replacement therapy).

  Palpable mass or masses may develop rapidly and be associated with tenderness.

  Cyclic tenderness in the absence of a palpable abnormality.

  Nipple discharge with or without an associated mass.

  Usually asymptomatic, detected on screening mammography.

- Mammography.

  Mass or masses: variable size, marginal characteristics and density.

  Halo (1-mm sharp lucency) may be seen partially surrounding mass, particularly if cyst is growing rapidly.

  Milk of calcium: calcium usually in suspension within microcysts, rarely macrocysts. On mammography, milk of calcium is characterized by a differential appearance between craniocaudal and oblique/90-degree lateral views. Most commonly, a bilateral, diffuse process; however, may be unilateral, focal, or segmental. In some patients may be see precipitated calcium in the form of individual "pellets" (as a tight cluster of calcifications in a cyst) that shift in position when the position of the patient changes.

  Rim, eggshell (mural) calcifications; may be coarse.

- Ultrasound.

  Well-circumscribed, anechoic mass with posterior acoustic enhancement.

  In some, high specular echoes shift in position as gain is increased ("gurgling cyst").

  May have echoes in near field ("acorn" cysts).

  Rarely, hypoechoic with posterior acoustic enhancement—fluid obtained on aspiration.

  Early in cyst development may see clustered small hypo- to anechoic masses separated by echogenic septations; core biopsy of these areas commonly yields apocrine metaplasia in combination with epithelial cell lined cysts. Also, these lesions commonly decrease significantly in size or disappear after the first core sample is obtained.

  Posterior acoustic enhancement is not always demonstrable, particularly if the cyst is small or close to the chest wall. If there is any question as to the cystic nature of a lesion consider aspiration.

  Rarely, aspiration is unsuccessful; fluid is gelatinous and thick (possibly related to high protein content or cyst age, or it may represent a mucocele-like lesion).

Following aspiration the fluid is discarded unless it is grossly bloody, the patient requests cytology or the patient has a history of breast cancer or atypia.

If a mural or intracystic abnormality is suspected, pneumocystography is done for diagnostic purposes (see Chapter 17).

- Magnetic resonance imaging.

  Long T1 and T2 values.

  Slightly lower signal intensity than breast tissue on T1-weighted images.

  Bright compared to breast tissue on T2-weighted images.

  Do not usually enhance, however, if there are associated inflammatory changes, rim enhancement may be seen (need to look at in conjunction with T2-weighted images).

- Histology.

  Type I: epithelial cell lining; fluid is a transudate (high $Na^+$, low $K^+$ content).

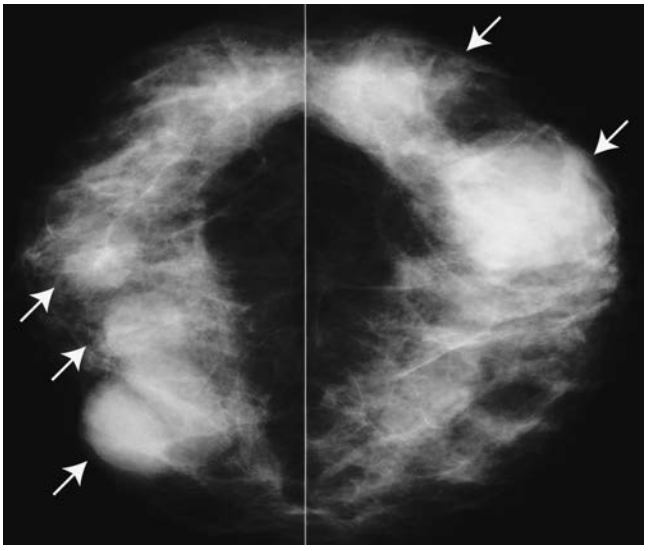
  Type II: lined by cells demonstrating apocrine metaplasia (apical snouts); fluid is secreted actively (low $Na^+$, high $K^+$ content).

  Type II (apocrine) cysts have a higher incidence of recurrence following aspiration.

  Gross cystic fluid proteins (GCDFP): molecular size in Daltons is used to designate protein (GCDFP: 10, −44, −24, and –15). GCDFP-70, albumin; GCDFP-44, zinc2 glycoprotein (found in sweat); GCDFP-24, apolipoprotein D (involved in cholesterol transport, constitutes approximately half of the total protein in cyst fluid); GCDFP-15, unknown biologic function.

  Several different hormones (ß-human chorionic gonadotropin) have been isolated in cyst fluid.

  Calcium oxalate (as opposed to calcium phosphate, associated with ductal carcinoma in situ) is found associated with cysts and fibrocystic changes; may require polarizing light microscopy for visualization.



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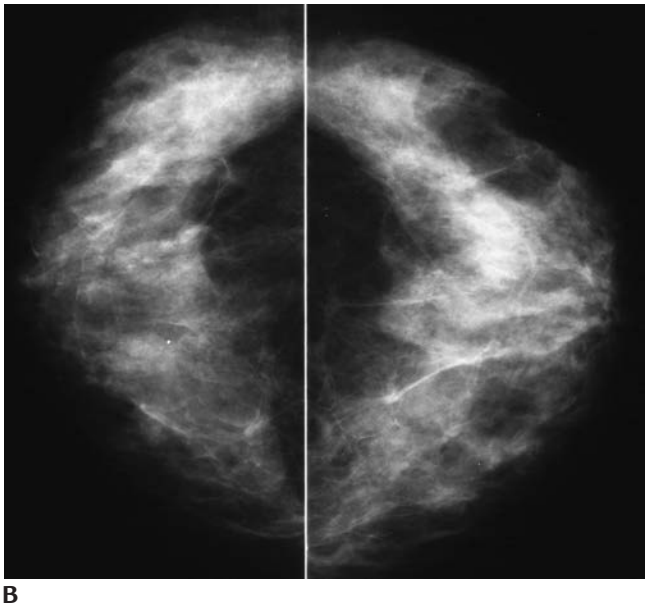
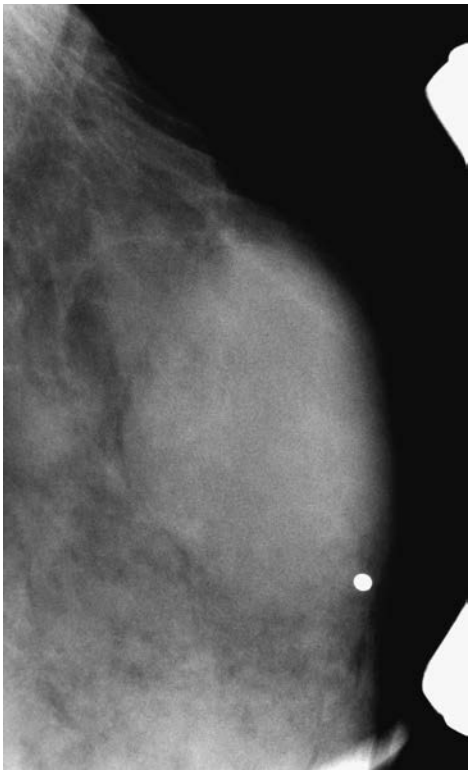
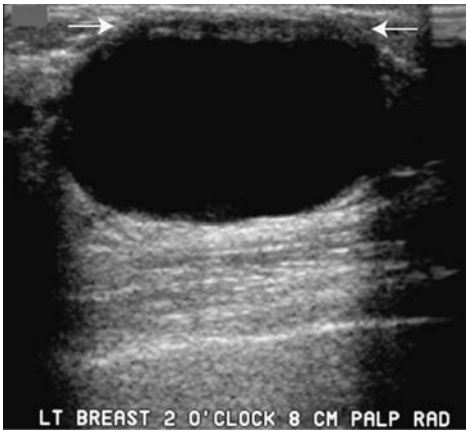


B

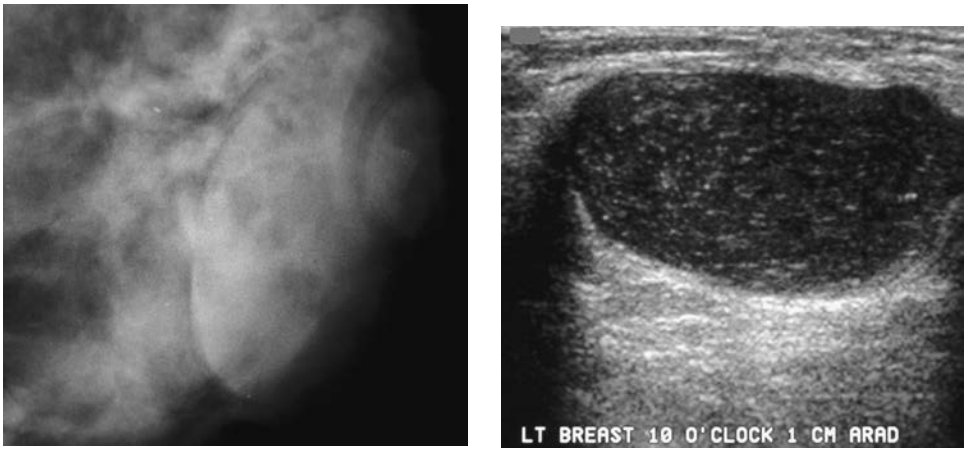
**FIGURE 13-3** Cysts. **(A)** Craniocaudal views demonstrating multiple masses of varying sizes and densities bilaterally. Multiple cysts are imaged on ultrasound (not shown). **(B)** Subsequent mammogram demonstrates decrease in size or resolution of the cysts. Cysts often develop as a preamble to menopause and usually resolve after menopause unless the patient is placed on hormone replacement therapy. They are hormonally responsive such that they are characterized by fluctuations in size and associated tenderness.






A B

**FIGURE 13-4** Cyst. **(A)** Spot compression tangential view of palpable finding (metallic BB) confirms the presence of an oval mass with partially circumscribed margins. **(B)** Anechoic oval mass with circumscribed margins and posterior acoustic enhancement is imaged corresponding to the palpable finding. Near field reverberation artifact (arrows) is noted. Aspiration is not undertaken unless the patient is symptomatic (tender), specifically requests it or atypical features are imaged sonographically.




A B

**FIGURE 13-5** "Gurgling" cyst. **(A)** Spot compression view. Oval isodense mass with circumscribed margins in the left subareolar area. **(B)** Oval mass with well-circumscribed margins, thin edge shadows and posterior acoustic enhancement. As the study is being done, the internal high specular echoes in this static image demonstrate movement (e.g., swirl) confirming a fluid internal matrix. Aspiration is not undertaken with this type of cyst unless the patient requests it or she is symptomatic (tender).

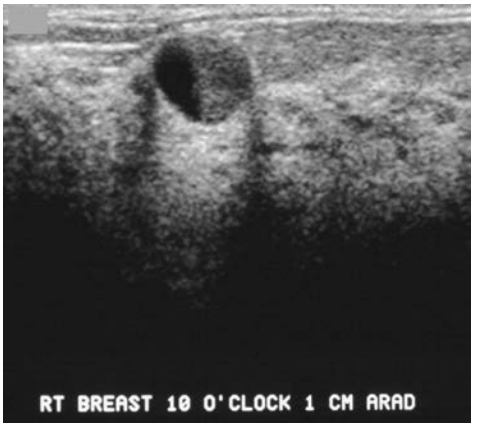
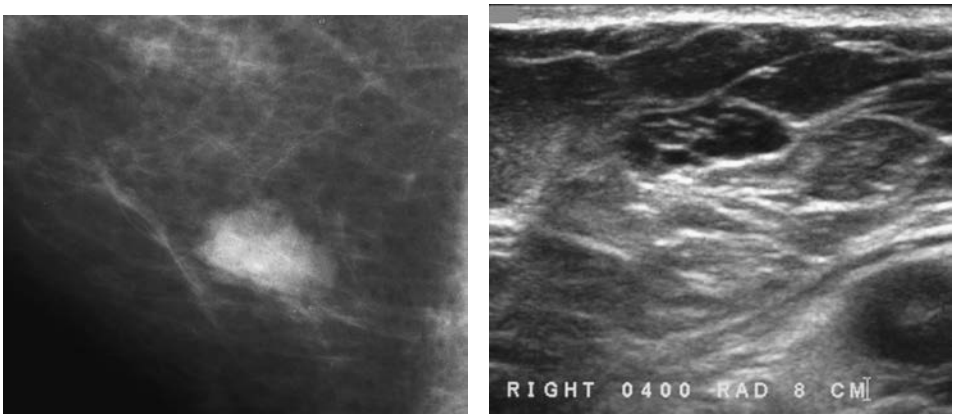
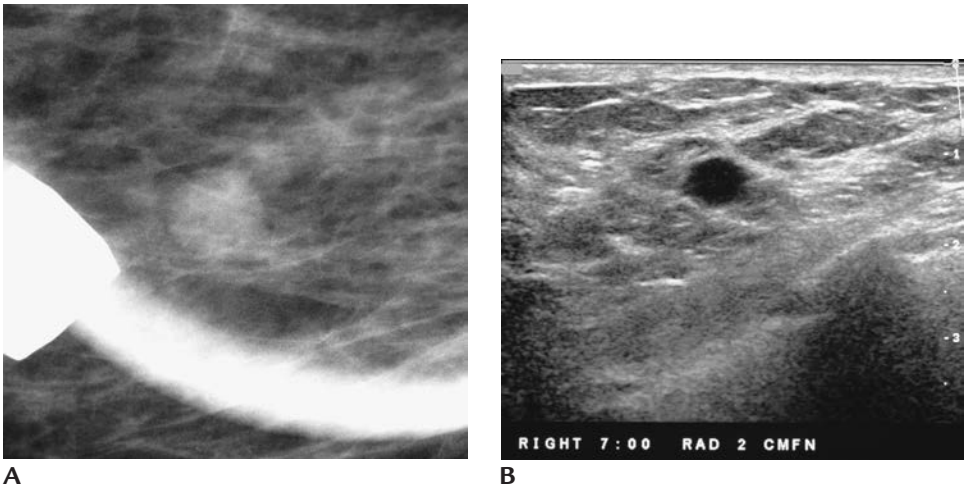



**FIGURE 13-6** Cyst. Ultrasound demonstrating a complex cystic mass with well circumscribed margins and posterior acoustic enhancement. There is almost a linear demarcation between the cystic and "solid" appearing component. In some patients, the demarcation is more "S" shaped ("ying/yang" sign). Aspiration commonly yields serous fluid and no residual solid component is present. The internal echoes can sometimes be seen being aspirated into the needle. What creates this appearance is unknown.



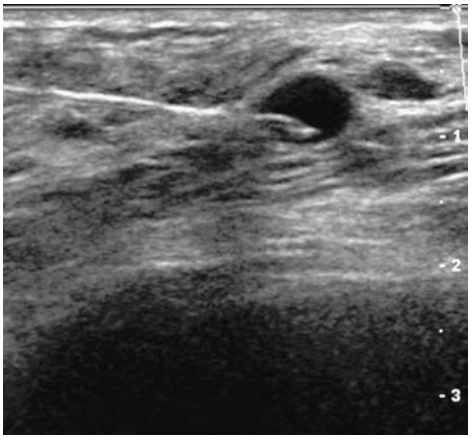

A B

**FIGURE 13-7** Developing cysts, apocrine metaplasia. **(A)** Lobular dense mass. **(B)** Complex cystic mass characterized by clustered round and oval anechoic areas separated by hyperechoic bands. This is the appearance of cysts early in development as acini begin to distend with fluid. Although core biopsy is not absolutely indicated for these lesions, if undertaken, the mass decreases significantly in size or disappears after the first pass and apocrine metaplasia is often the histological diagnosis. Apocrine metaplasia is a histologic diagnosis that can characterize areas of cystic change in the breast.




A B

**FIGURE 13-8** Cyst. **(A)** Spot compression view. **(B)** Round mass with obscured margins. **(B)** Anechoic round mass. Margins are not well circumscribed and there is no posterior acoustic enhancement. Small cysts or those close to the chest wall may have internal echoes and lack posterior acoustic enhancement. If there is any question about the diagnosis an aspiration is undertaken.

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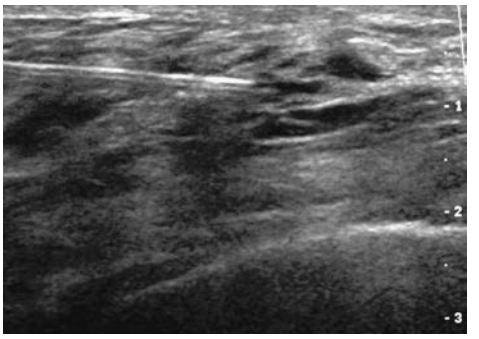
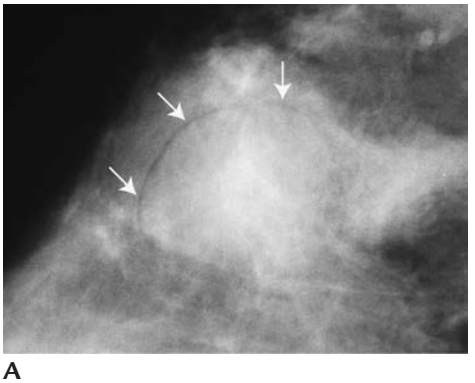



D

**FIGURE 13-8** (*Continued*) **(C)** Needle in cyst pre aspiration. **(D)** Post aspiration. No residual abnormality is seen.



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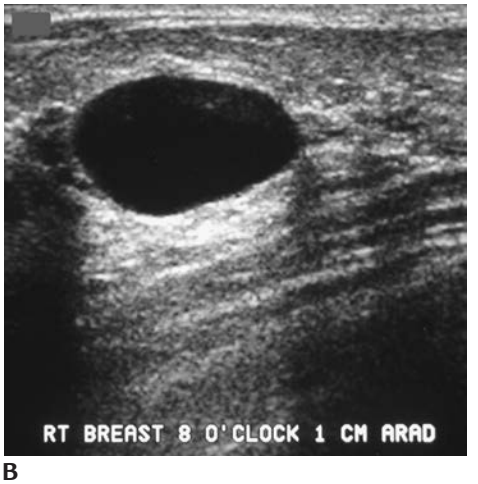



B

**FIGURE 13-9** Cyst. **(A)** Round mass with partially obscured margins. A "halo" (sharp radiolucency) partially outlines (*arrows*) the margin of the cyst. The halo sign is a good indication that a mass is benign, usually one that is enlarging. **(B)** Anechoic mass with well-circumscribed margins, posterior acoustic enhancement and thin edge shadows.

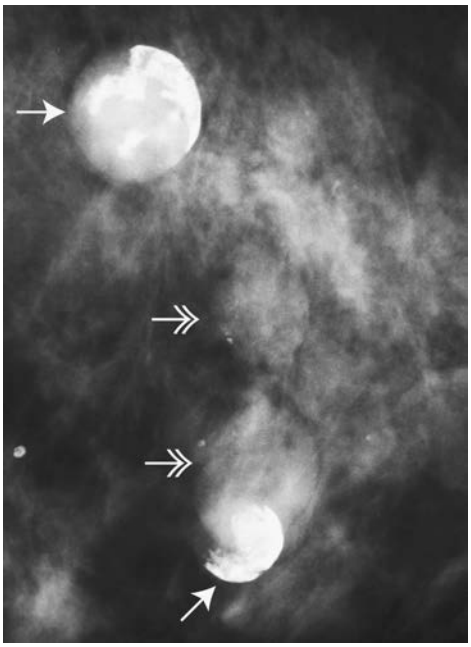
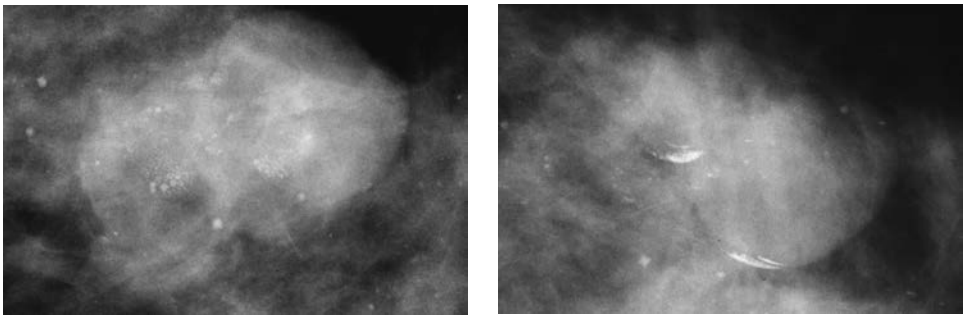


**FIGURE 13-10** Cysts. Coarse calcifications developing on cyst walls (*arrows*). Additional cysts (*double headed arrows*) with no associated calcifications are present (diagnostic ultrasound not shown).



**A** **B**

**FIGURE 13-11** Cysts with milk of calcium. **(A)** Craniocaudal view. Multiple clusters of round, punctate and amorphous calcifications associated with two masses. Additional calcifications are present in the adjacent parenchyma. **(B)** Lateral view. Calcifications are layering in the dependent portions of the macro- and microcysts consistent with milk of calcium. This type of calcification is benign and requires no further intervention or short interval follow up. These are usually calcium oxalate type calcifications that may require polarizing light microscopy for identification on hematoxylin-eosin stained histological sections.

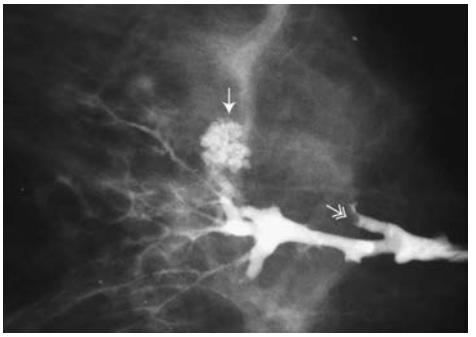
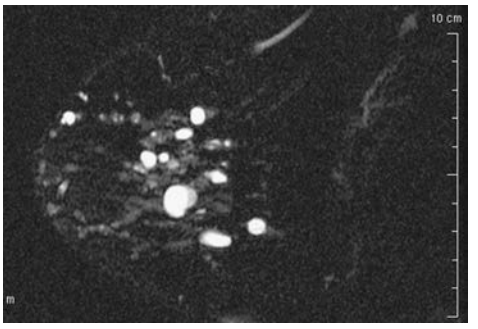


**FIGURE 13-12** Small developing cyst filling (*arrow*) with contrast on ductogram. Magnification view (1.8×). Papilloma obstructing side branch (*double headed arrow*) of opacified duct is also present. Duct is dilated a common finding in ducts containing papillomas.

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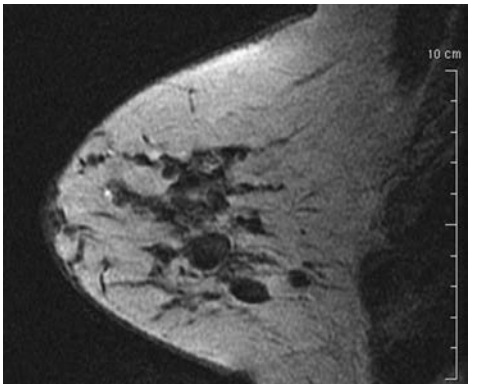


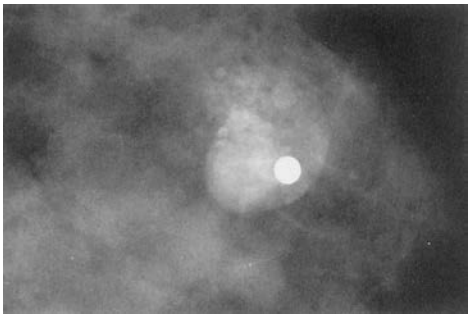

B

**FIGURE 13-13** Cysts, magnetic resonance imaging. **(A)** Sagittal T2-weighted fat suppressed image. Multiple masses of varying sizes characterized by bright signal. **(B)** Sagittal T1-weighted image, same table top position as in **(A)**. Low signal intensity for the same masses seen on T2-weighted images. When associated with inflammatory changes, these may demonstrate rim enhancement.

# GALACTOCELE

## KEY FACTS

- Clinical.
  Cyst with milky fluid that may be inspissated.
  Palpable mass in pregnant or lactating patient; may be seen up to several years post-lactation.
  May be multiple, unilateral, or bilateral.
  Diagnosed after aspiration.
- Mammography.
  Well-circumscribed mass; density may be variable.
  Some may have mixed density with fat/fluid level on 90-degree lateral views.
- Ultrasound.
  Variable appearance.
  Features of cyst: well-circumscribed, anechoic mass.
  Complex cystic mass.
  Solid mass with posterior acoustic enhancement.
  Fluid-fluid level.
  Shadowing.



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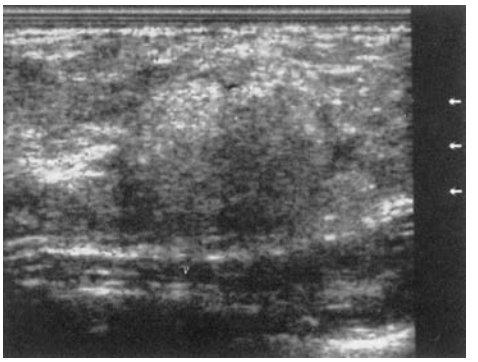


B

**FIGURE 13-14** Galactocele. **(A)** Palpable mass (metallic BB). Mixed density mass with fluid-fat level. **(B)** Lower portion of mass is hypoechoic relative to upper portion (probable fluid-fluid level). Some shadowing is seen.

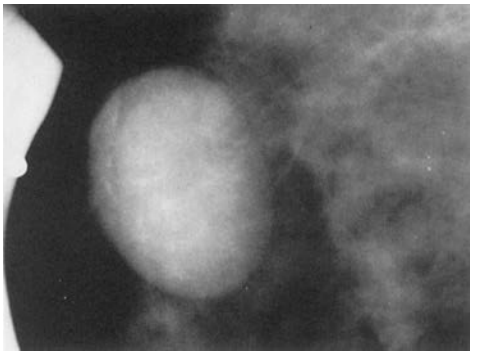
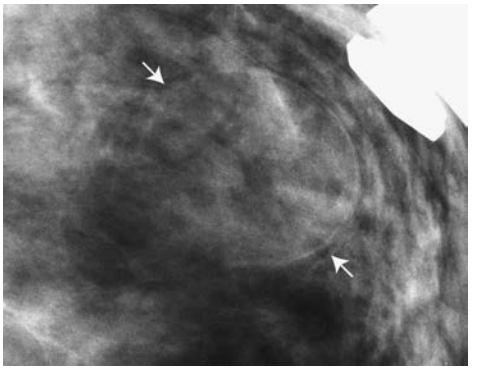


**FIGURE 13-15** Galactocele. Spot compression view. Well-circumscribed mass in a woman with a palpable mass during lactation. Thick, milky fluid is aspirated.



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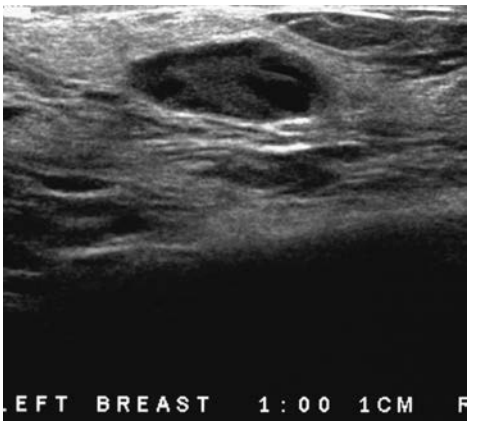
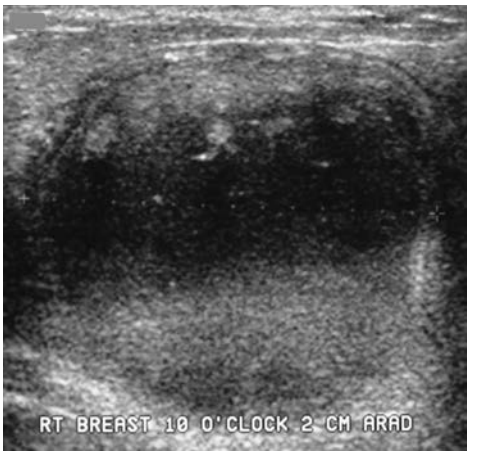



**B**




**C**

**FIGURE 13-16** Galactocele. **(A)** Spot compression view demonstrating a round mass (*arrows*) with fat (e.g. mixed density mass). **(B)** Oval complex cystic mass with minimal posterior acoustic enhancement. **(C)** Different patient, presenting with a palpable mass during lactation. Complex cystic mass with posterior acoustic enhancement and fluid-fluid levels corresponding to palpable finding. Thick, milky fluid is aspirated.

## Juvenile Papillomatosis

### Key Facts

- Clinical.

  Adolescent and young women (mean age 23 years); a few patient reports describe entity in males.

  Some reports suggest an increased incidence of breast cancer in women with juvenile papillomatosis and within the female members in the family.

  No relation to parity, age at menarche, or use of oral contraceptives.

  Painless, circumscribed, mobile mass.
- Imaging.

  Not usually done because of patient's young age at time of presentation.

  Hypoechoic mass with associated cystic spaces.

  One patient report describes multiple small cysts on T2-weighted images, a hypointense lobulated mass on pre-contrast T1-images with marked enhancement in the post-contrast images; benign enhancement curve.
- Gross.

  Well circumscribed.

  Multiple cysts (like Swiss cheese), some with papillary excrescences and dense stroma between cysts.
- Histology.

  Multiple cysts.

  Well circumscribed, but not encapsulated.

  Marked ductal hyperplasia (papillomatosis: bordering intraductal carcinoma), apocrine and nonapocrine cysts, papillary apocrine metaplasia, sclerosing adenosis, and duct stasis.

## Fibroadenomas

### Key Facts

- Clinical.

  Hard, movable mass in younger patient.

  Hormonally mediated (cyclic) changes in size and associated tenderness.

  Multiplicity (7% to 16%).

  "Complex" fibroadenomas may have an associated increased breast cancer risk.

  Giant fibroadenomas: 8 to 10 cm in size more commonly seen in adolescent patients (e.g., juvenile).

  Do not usually develop in postmenopausal patients unless receiving hormone replacement therapy.

  Have been reported to develop in patients of all ages (including post menopausal women) following 16 to 130 months of treatment with cyclosporine A; these patients commonly develop multiple lesions bilaterally.

- Mammography.

  Variable in appearance.

  As patients age, and estrogen stimulation decreases, fibroadenomas may decrease in size, increase in density (becoming more apparent in some patients), and develop coarse dense calcifications.

  Mass or masses: variable size, marginal characteristics, and density.

  Mass or masses with punctate, (pleomorphic) calcifications.

  Mass or masses with coarse, "popcorn" calcification: more common in older women (with hyalinization of fibroadenoma).

  Cluster(s) of coarse, dense calcifications some with associated lucency ("bubbly").

  Cluster(s) of coarse, dense calcifications some with jagged sharp edges ("coral" like).

  Cluster of punctate (pleomorphic) or amorphous calcifications without a perceptible mass.

  Coarse "popcorn" type calcification in isolation of a mass.
- Ultrasound.

  Variable appearance.

  Homogeneously hypoechoic, oval mass with no posterior acoustic enhancement or shadowing. Undulations (macrolobulation) of contours may be present.

  May have heterogeneous echotexture, some with small cystic components.

  May see associated posterior acoustic enhancement particularly in the younger patients.

  Shadowing may be prominent feature particularly with hyalinization (aging) or if there are associated calcifications.
- Magnetic resonance imaging.

  Round, oval, or lobular mass with circumscribed margins.

  Imaging features depend on extent of hyalinization.

  T2-weighted images: high signal intensity in fibroadenomas with epithelial elements; low signal intensity in hyalinized, fibrotic fibroadenomas.

  T1-weighted images: marked enhancement in lesions with epithelial elements; little or no contrast enhancement when hyalinized.

  Internal, non-enhancing, septations in 40% to 65% of lesions.
- Gross.

  Bulging, white, firm tumor.
- Histology.

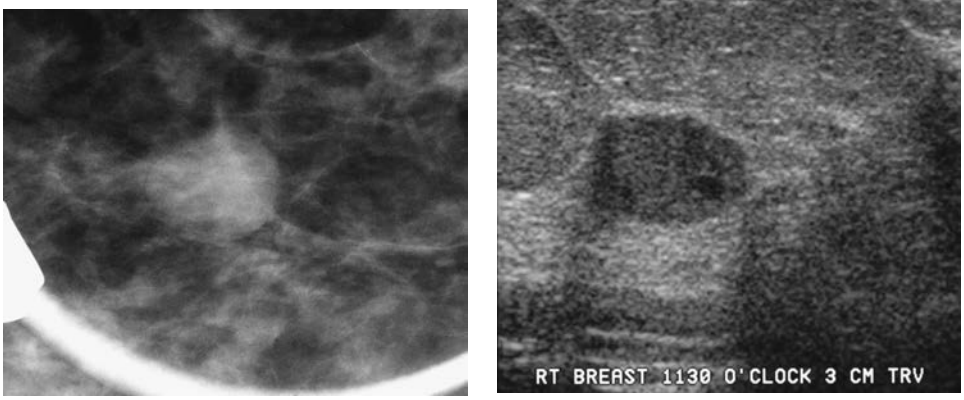
  Lobular derivatives under estrogenic stimulation; hyalinization of fibrous stroma and regression of epithelial elements following menopause (particularly in women not on estrogen replacement) or in patient following bilateral oopherectomy.

  Proliferation of lobular elements (epithelial and mesenchymal—intralobular stroma) in an expansile fashion.

  Normal two cell layer arrangement of epithelial elements (epithelial and myoepithelial cells).

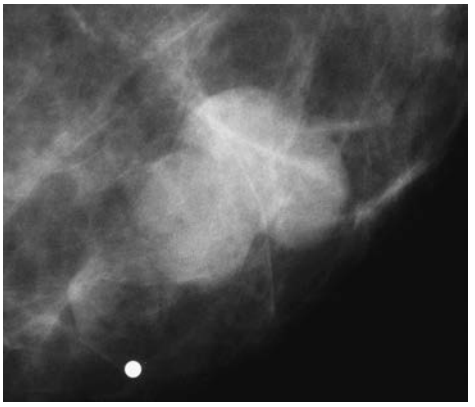
Stromal proliferation around tubular (pericanalicular) or compressed (intracanalicular) ducts.

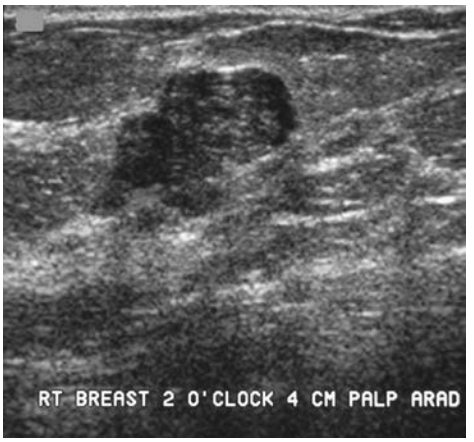
Calcification may develop in the stroma (coarse) and within the epithelial elements (punctate, pleomorphic, coral-like).




A B

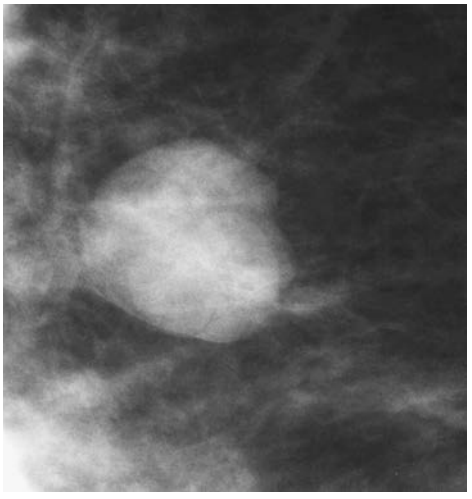
**FIGURE 13-17** Fibroadenoma. **(A)** Spot compression view. Round mass with partially circumscribed and obscured margins. **(B)** Slightly hypoechoic mass with circumscribed margins and posterior acoustic enhancement corresponding to mammographic finding. A small cyst is present in the mass. In younger patients, fibroadenomas may demonstrate posterior acoustic enhancement. As patients age, and estrogen levels decrease, fibroadenomas undergo hyalinization such that some develop posterior acoustic shadowing.

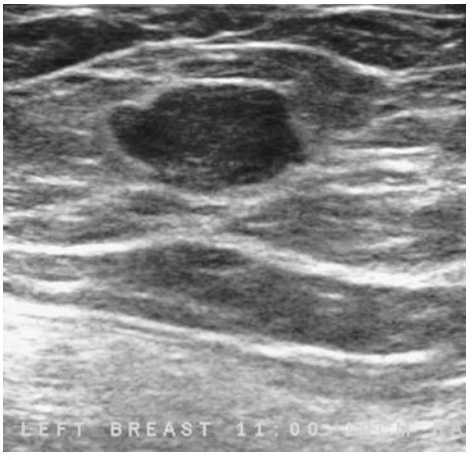





A B

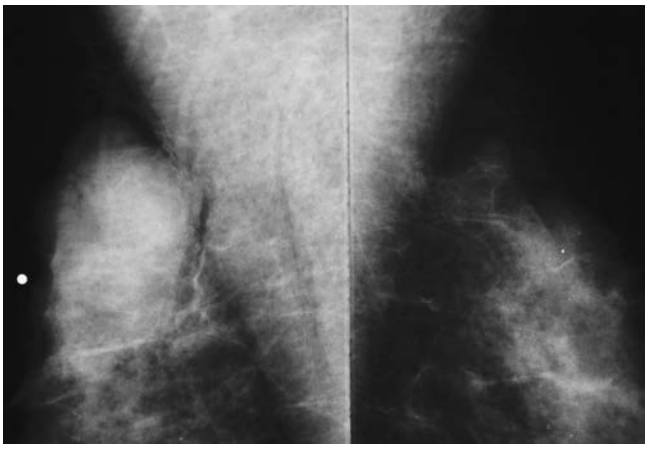
**FIGRUE 13-18** Fibroadenoma. **(A)** Lobular mass with circumscribed margins. Metallic BB indicates finding is palpable. **(B)** Irregular hypoechoic mass with well-circumscribed, lobulated margins corresponding to the palpable finding.



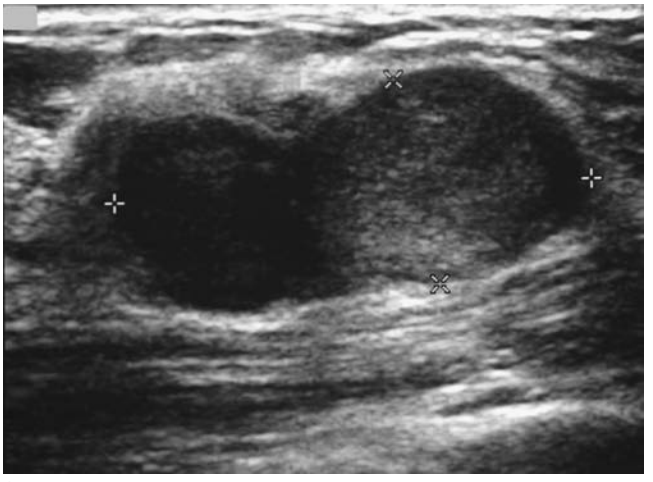



A B

**FIGURE 13-19** Fibroadenoma. **(A)** Lobular mass with circumscribed margins. **(B)** Hypoechoic oval mass with circumscribed, macrolobulated margins.

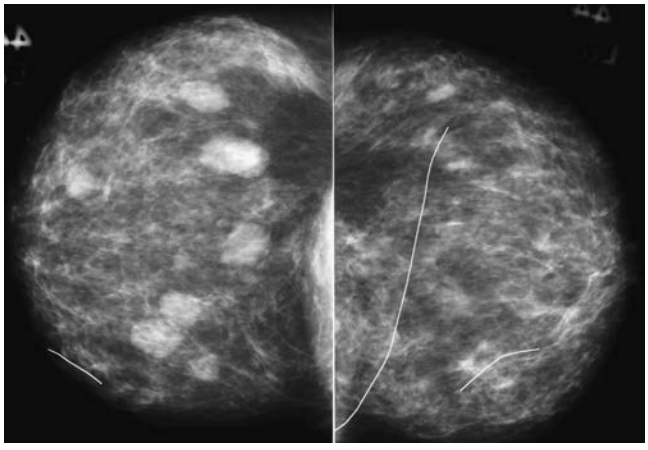


A

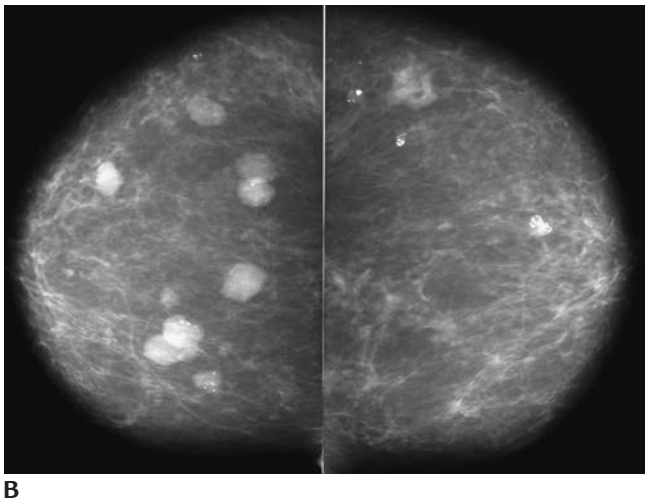


B

**FIGURE 13-20** Fibroadenoma. **(A)** Palpable (metallic BB), oval mass with indistinct and obscured margins in the upper outer quadrant of the right breast. **(B)** Hypoechoic, horizontally oriented mass with circumscribed, macrolobulated margins, and posterior acoustic enhancement.



A



B

**FIGURE 13-21** Fibroadenomas. **(A)** Craniocaudal views demonstrating multiple masses predominantly in the right breast. Metallic wires mark prior biopsy sites. Approximately 20% of patients have multiple fibroadenomas. **(B)** Craniocaudal views done 10 years following **(A)**. The masses have decreased in size, increased in density, and some have developed coarse, dystrophic type calcifications. As estrogen levels decrease, the epithelial elements in fibroadenomas atrophy, fibrous tissue in the stroma increases and undergoes hyalinization such that the size of the mass may decrease, density may increase and dystrophic ("popcorn" type) calcifications develop in the hyalinized stroma. Calcifications may be seen in the absence of an associated mass.

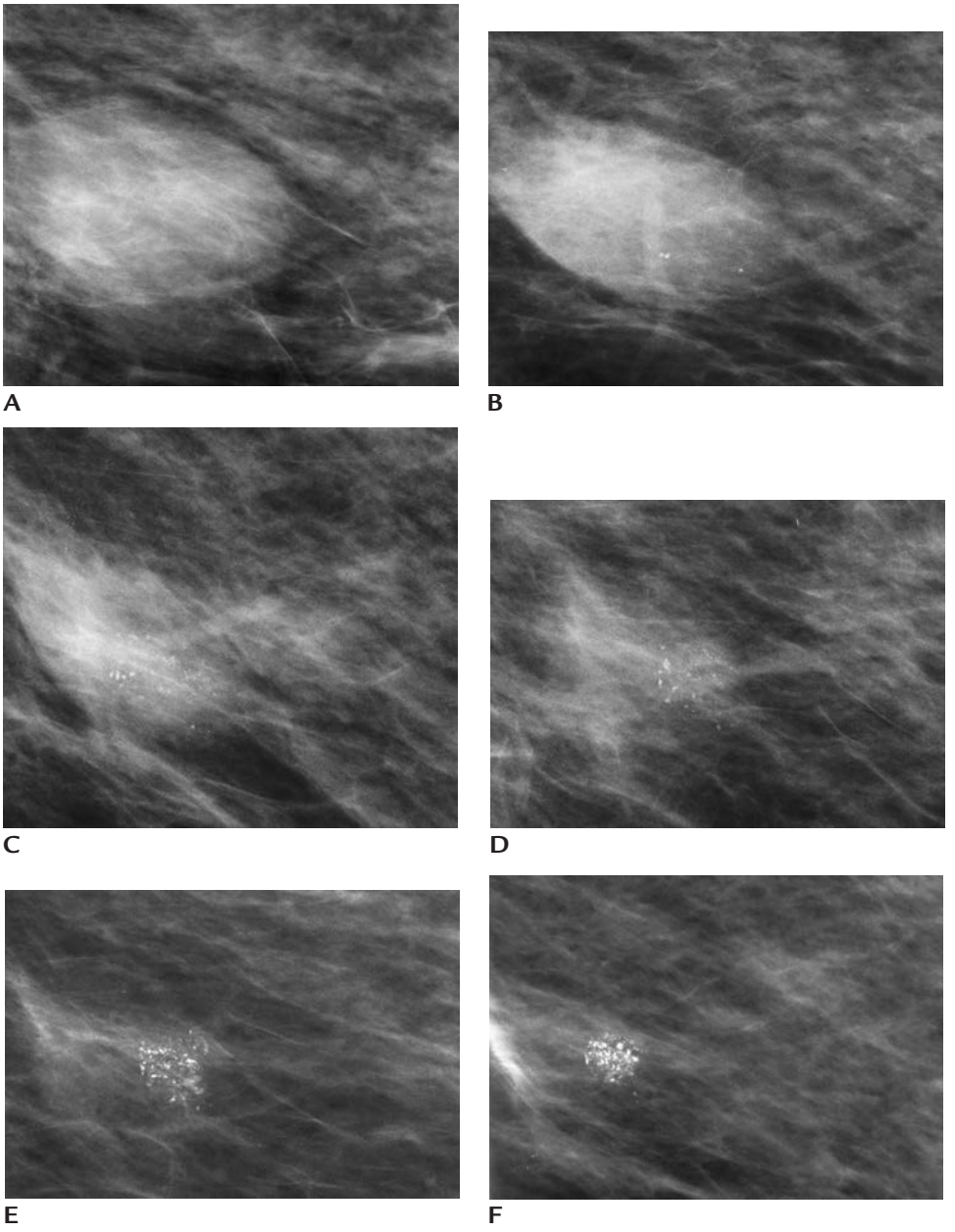
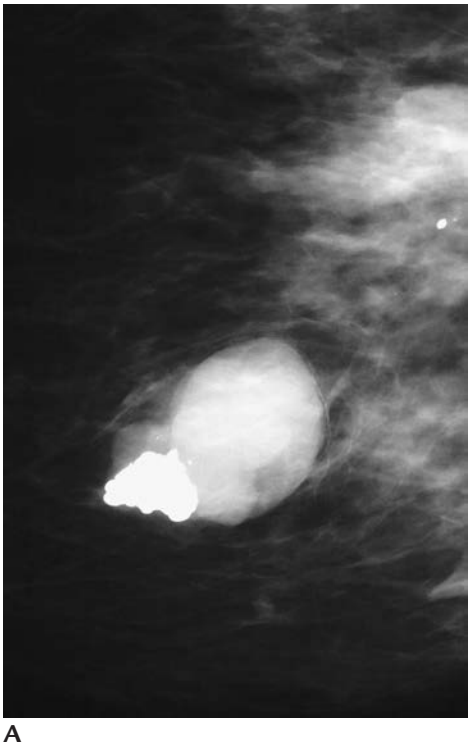
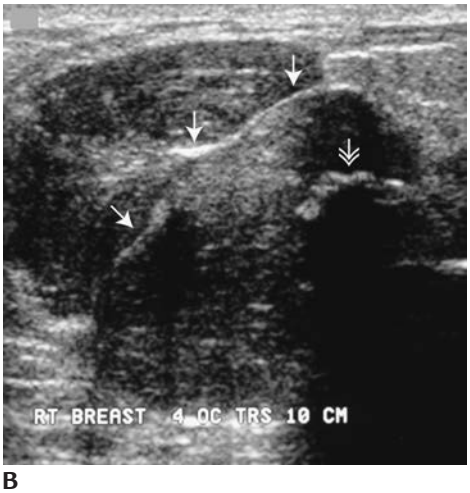



**FIGURE 13-22** Fibroadenoma. **(A)** Oval mass with obscured margins. **(B)** Two years following **(A)**. Oval mass with obscured margins slightly smaller than previously developing a few scattered round calcifications. **(C)** Three years after **(A)**. Oval mass with obscured and indistinct margins. Decreasing in size and increasing in density compared with prior studies. Increasing number of round and punctate calcifications. **(D)** Four years after **(A)**. Mass is no longer readily apparent, although some remaining density is seen associated with a cluster of round and punctate calcifications. **(E)** Five years after **(A)**. Increasing number of now dense round and punctate calcifications; associated density is now almost completely resolved. **(F)** Six years after **(A)**. Increasing number of what is now a tight cluster of dense round and punctate calcifications. No associated mass or density is apparent at this time. These changes reflect decreasing levels of estrogen with resultant atrophy of the epithelial elements, hyalinization of the fibrous stroma, and development of dystrophic calcifications.

**FIGURE 13-23** Fibroadenoma. Cluster of low density amorphous calcifications. No associated mass. Fibrocystic changes (includes hyperplasia, atypical ductal hyperplasia, sclerosing adenosis, columnar alteration with prominent apical snouts and secretions), papilloma and ductal carcinoma in situ low to intermediate nuclear grade are also in the differential.






**A** **B**

**FIGURE 13-24** Fibroadenoma. **(A)** Dense, lobular mass with circumscribed margins and a dense, coarse ("popcorn" type) calcification. **(B)** Irregular hypoechoic mass with circumscribed, macrolobulated margins is imaged corresponding to the mammographic finding. Hyperechoic (fibrous) bands (*arrows*) are present in the mass. The coarse calcification (*double headed arrow*) is imaged as a thick irregular hyperechoic band with associated dense shadowing. The benign diagnosis of this finding is established mammographically such that an ultrasound, although included out of interest, is not indicated in these patients.

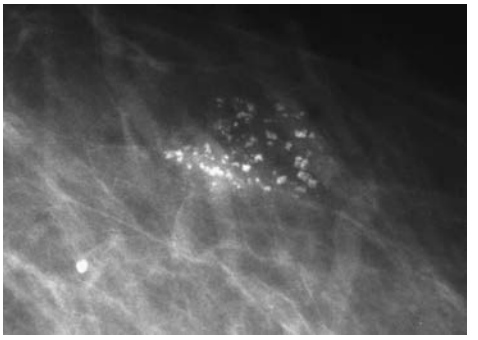


**FIGURE 13-25** Fibroadenoma. Coarse, dense calcifications some with associated lucency ("bubbly"). There is no associated mass. These calcifications often progress and consolidate becoming more of the classic "popcorn type" calcification.

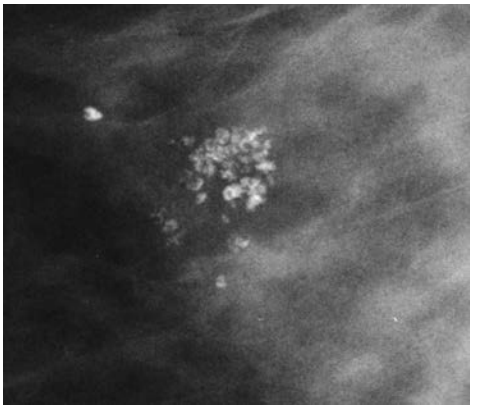


**FIGURE 13-26** Fibroadenoma. Cluster of coarse dense calcifications most with an associated lucency ("bubbly"). No associated mass is present.

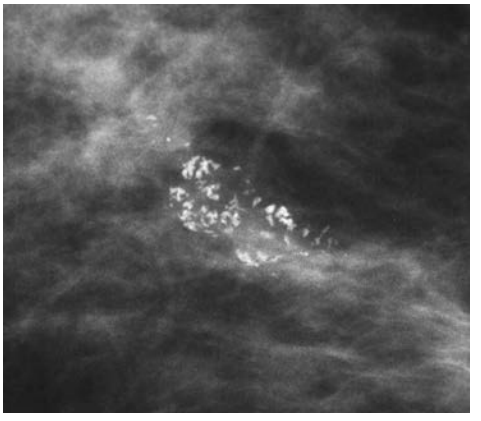


**FIGURE 13-27** Fibroadenoma. Cluster of coarse, dense calcifications. No associated mass is present.

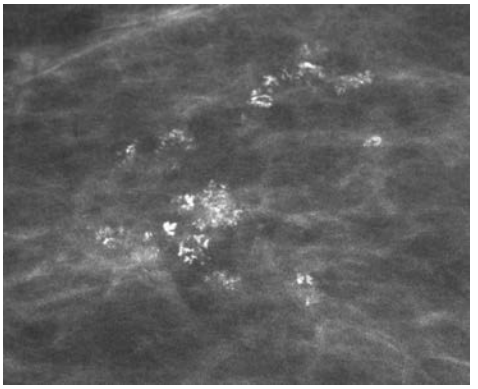


**FIGURE 13-28** Fibroadenoma. Cluster of coarse, dense dystrophic calcifications ("coral" type) calcifications. No associated mass is present.

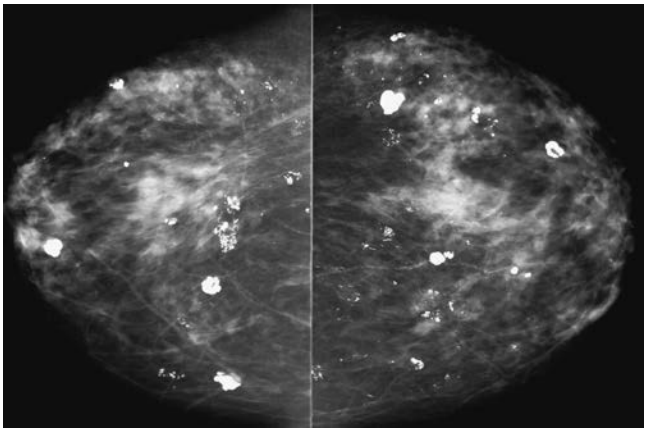
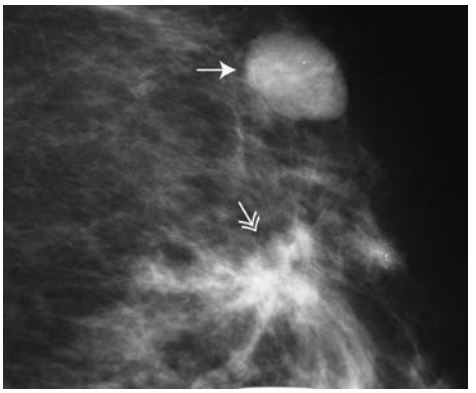
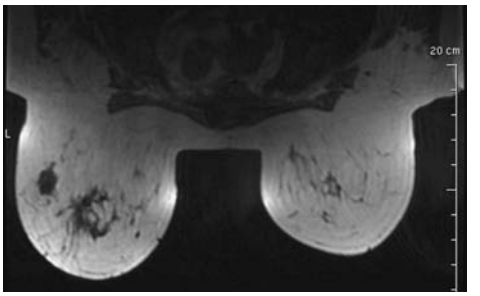


**FIGURE 13-29** Fibroadenomas bilaterally in varying stages of calcification. Also present are vascular calcifications. Scattered popcorn type and clusters of coarse ("bubbly") calcifications with and without associated masses.

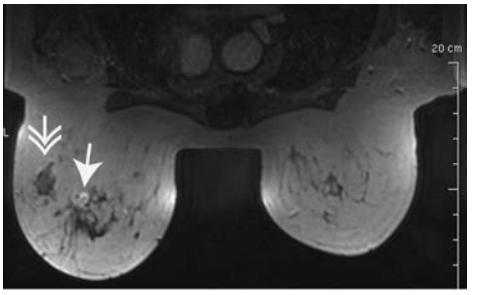


A



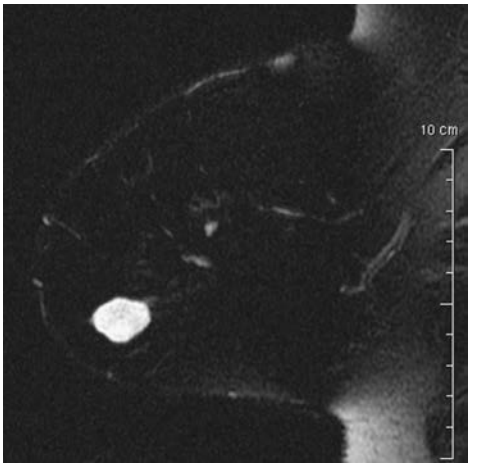

B

**FIGURE 13-30** **(A)** Cyclosporine induced fibroadenoma. Oval mass with circumscribed margins developing in a patient on cyclosporine following cardiac transplantation. Prior mammogram (not shown) is normal. Fibroadenomas do not typically develop in postmenopausal women. Also noted is a mass with spiculated margins (*double headed arrow*) consistent with invasive ductal carcinoma not otherwise specified. **(B)** Magnetic resonance imaging. Pre-contrast T1-weighted axial image.

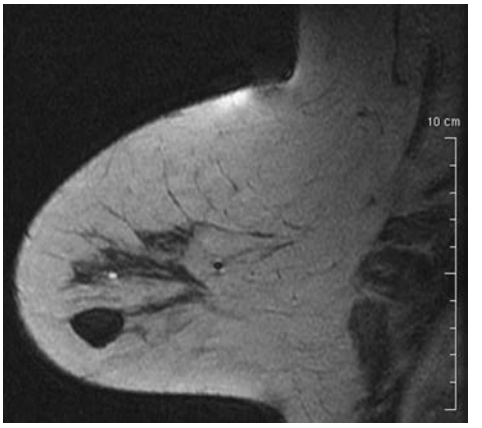



C

**FIGURE 13-30** (*Continued*) **(C)** One minute post-contrast T1-weighted image. Rapid initial enhancement of the spiculated mass seen mammographically (*arrow*). Fibroadenoma (*double headed arrow*) demonstrates slow initial uptake of contrast and a persistent type kinetic curve (not shown).




A

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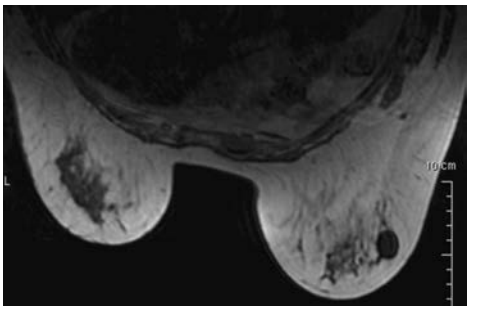
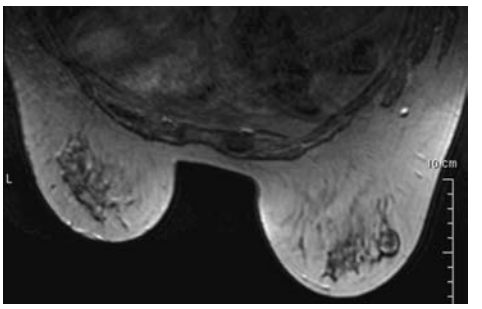



C



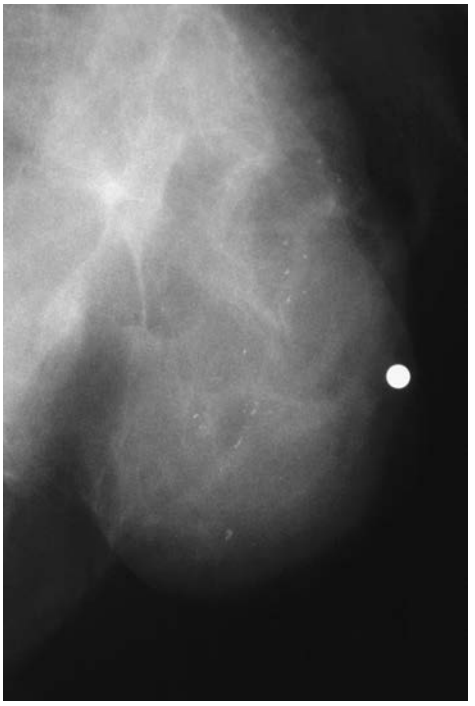

D

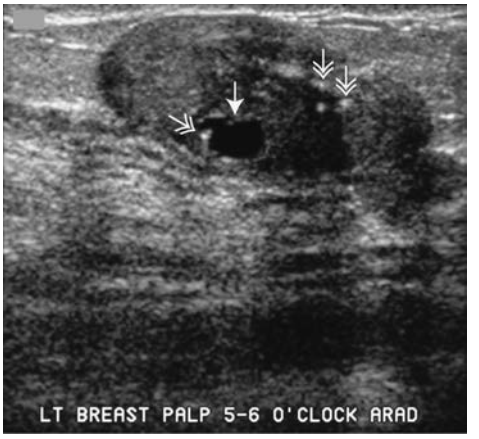
**FIGURE 13-31** Fibroadenoma. Magnetic resonance imaging. **(A)** Sagittal T2-weighted, fat suppressed image. Oval mass with bright signal intensity. As estrogenic stimulation decreases and epithelial elements atrophy, the signal intensity on T2-weighted images usually decreases. **(B)** Sagittal T1-weighted image. Mass, low signal intensity. **(C)** Axial pre-contrast T1-weighted image. Oval mass in the right breast, low signal intensity. **(D)** Axial T1-weighted image one minute post contrast. Heterogeneous enhancement with internal non-enhancing septations. Low signal intensity from rim of lesion. Did you notice the regional stippled enhancement laterally in the left breast? Patient with invasive ductal carcinoma, left breast.

## Complex Fibroadenomas

### Key Facts

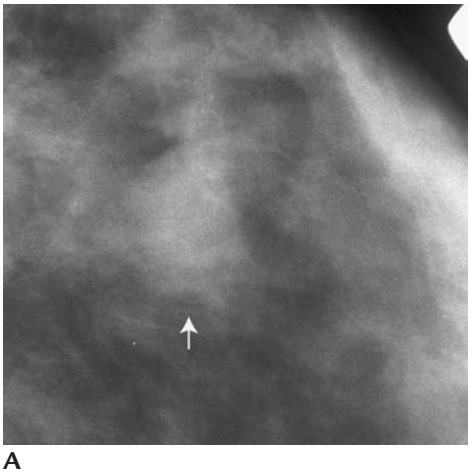
- Described and defined by Dupont and colleagues.
  Fibroadenomas containing:
    Cysts greater than 3 mm.
    Sclerosing adenosis.
    Epithelial calcifications.
    Papillary aprocrine changes.
  Parenchyma adjacent to fibroadenomas should be evaluated and characterized as:
    Free of proliferative changes.
    Proliferative changes with no atypia.
    Proliferative changes with atypia.
  Approximately 33% of all fibroadenomas are complex.
  Relative risk of breast cancer.
    In women with noncomplex fibroadenomas: 2.17×.
    In women with complex fibroadenomas: 3.10×.
    In women with complex fibroadenomas and a positive family istory: 3.72×.
    In women with complex fibroadenomas and benign proliferative changes in surrounding stroma: 3.88×.
- Mammography.
  Mass (may be lobulated) with circumscribed, obscured, or ill-defined margins.
  Mass with associated pleomorphic calcifications.
  Mass with punctate or amorphous calcifications (calcifications associated with sclerosing adenosis).
- Ultrasound.
  Oval well circumscribed hypoechoic mass indistinguishable from noncomplex fibroadenoma.
  Hypoechoic mass with heterogeneous echotexture and associated cystic spaces.
  High specular echoes reflecting the presence of epithelial calcifications.
  Posterior acoustic enhancement or shadowing may be seen.

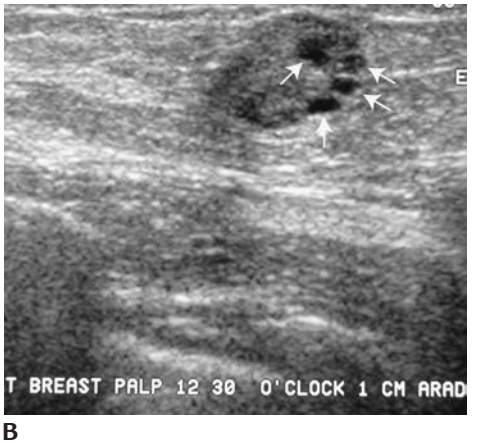





A B

**FIGURE 13-32** Complex fibroadenoma. **(A)** Spot tangential view of palpable finding (metallic BB). Oval mass with obscured margins and associated punctate calcifications. **(B)** Oval, hypoechoic mass with circumscribed margins, associated cystic area (*arrow*) and calcifications (*double headed arrows*). Portions demonstrate posterior acoustic enhancement and others shadowing. Complex fibroadenomas are fibroadenomas with superimposed fibrocystic changes including cysts larger than 3 mm, sclerosing adenosis, epithelial calcifications, and papillary apocrine change.






A B

**FIGURE 13-33** Complex fibroadenoma. **(A)** Spot compression view. Oval mass (*arrow*) with indistinct margins. **(B)** Hypoechoic mass with circumscribed margins, cystic areas (*arrows*) and posterior acoustic enhancement.

## JUVENILE FIBROADENOMA

### KEY FACTS

- Clinical.
  Approximately 5% to 10% of fibroadenomas in adolescence fall into this category.
  Usually unilateral, but can be multiple and bilateral.
  Rapid growth, attaining a massive size with stretching of the overlying skin, dilatation of the superficial veins, and nipple displacement.
  To be distinguished from adolescent breast hypertrophy (bilateral diffuse breast enlargement with no discrete mass, skin stretching, venous distention, or nipple displacement) and phyllodes tumors (rare in this age group).
  Excision is treatment of choice.
  Many qualify as giant fibroadenomas (8 to 10 cm).
- Ultrasound.
  Well-circumscribed, hypoechoic mass; echotexture may be heterogeneous.
  May have associated posterior acoustic enhancement.
- Histology.
  Not a specific histological entity (diagnosis based on clinical presentation).
  More commonly pericanalicular type.
  Dense cellular stroma.

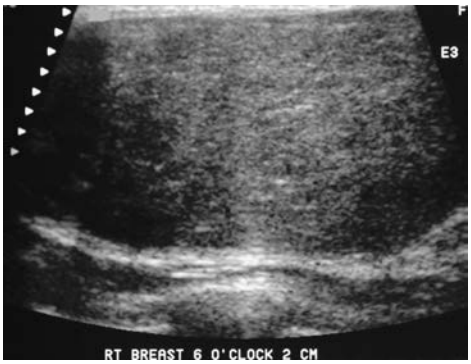
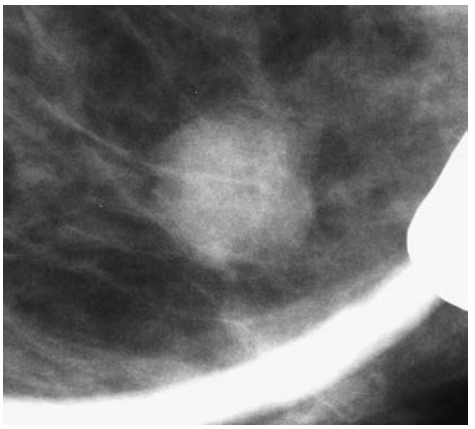



**FIGURE 13-34** Fibroadenoma. Adolescent patient presenting with palpable mass. Oval circumscribed mass with posterior acoustic enhancement. Given the size of the lesion, it cannot be imaged completely with a single view. Fibroadenomas presenting in young women may have a more cellular stroma (phyllodes may be considered). Other than the age of the patient, the usually larger size of these lesions, and a more cellular stroma on histology, these lesions cannot be distinguished from fibroadenomas occurring in older women.

# Tubular Adenoma

## Key Facts

- Clinical.
  Freely mobile, nontender mass.
- Mammography.
  Mass with well-circumscribed to indistinct margins, may be lobulated.
  Mass with tightly packed punctate and irregular calcifications.
- Ultrasound.
  Oval hypoechoic mass with homogeneous echo texture and variable marginal characteristics. May have associated posterior acoustic enhancement or shadowing.
  Excision is not required following imaging guided biopsy.
- Histology.
  Well-circumscribed (no true capsule).
  Densely packed, uniformly small, round, proliferating tubules.
  Two cell lining, myoepithelial cells may be inconspicuous; no vacuole formation.
  Sparse intervening stroma.



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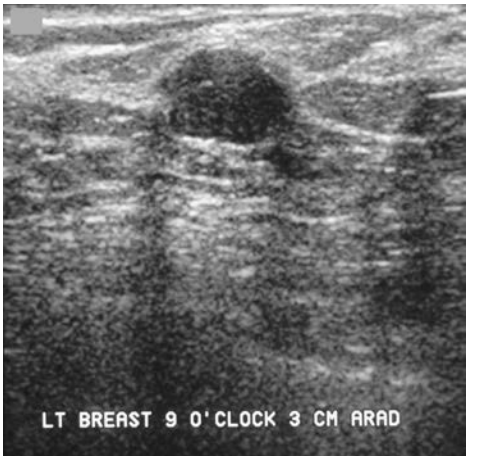
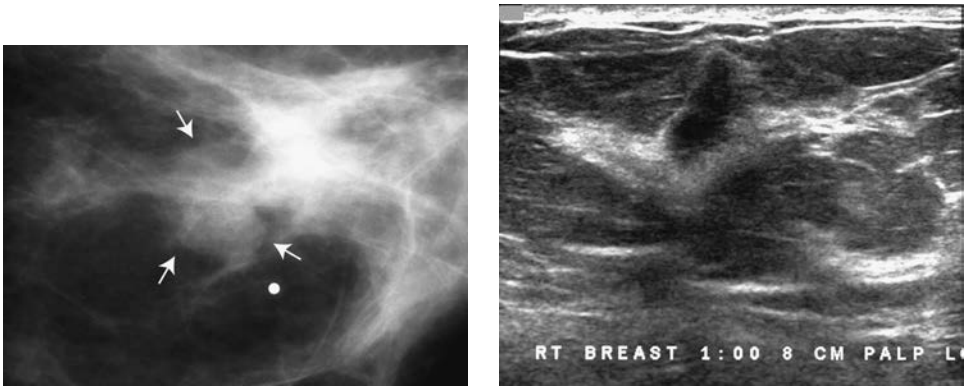



B

**FIGURE 13-35** Tubular adenoma. **(A)** Spot compression view. Round mass with indistinct margins. **(B)** Hypoechoic mass with posterior acoustic enhancement.




A B

**FIGURE 13-36** Tubular adenoma. **(A)** Spot compression view. Palpable mass (metallic BB). Mass (*arrows*) with obscured margins. **(B)** Hypoechoic, vertically oriented mass with a partial thick echogenic rim and spiculated margins corresponding to the palpable and mammographic finding.

## Lactational Adenoma

### Key Facts

- Clinical.
  Most patients present during pregnancy or postpartum.
  Well-circumscribed, freely mobile mass.
  May enlarge rapidly during pregnancy.
  Can undergo infarction (patients present with associated tenderness).
  May be multiple.
  Typically regress after cessation of lactation.
  Bromocriptine has been used to decrease their size.
- Ultrasound.
  Because presentation occurs during pregnancy or immediately postpartum mammography is usually not done.
  Macrolobulated, oval hypoechoic mass with well-circumscribed margins.
  Posterior acoustic enhancement.
  Hyperechoic (fibrous) bands coursing through mass or small curvilinear bands of hyperechogenicity.
  Irregular margins, heterogeneous echo texture, and posterior acoustic shadowing less common.
  Excision is not required following imaging guided biopsy.
- Histology.
  Well circumscribed (but no true capsule).
  Lobulated margin.
  Tubules distended with variable secretory activity (depending on stage of pregnancy or lactation when biopsy is done).
  Epithelial lining cells show vacuolization and mitotic activity.

May be associated with fibrotic bands (explain hyperechoic bands seen on ultrasound).

Approximately 5% show areas of infarction.

Unclear whether these arise de novo during pregnancy and lactation or whether they reflect morphologic changes in pre-existing fibroadenomas or tubular adenomas when stimulated by hormonal changes associated with pregnancy.

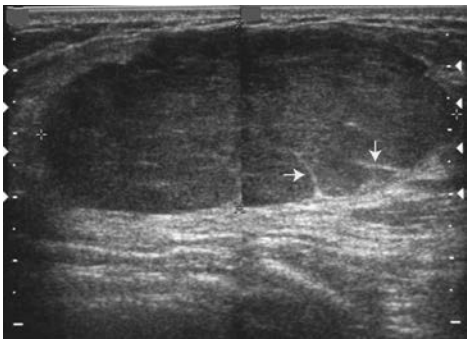


**FIGURE 13-37** Lactational adenoma. Oval mass with circumscribed margins and posterior acoustic enhancement. Echogenic (fibrous) bands (*arrows*) can be seen in some of these lesions.

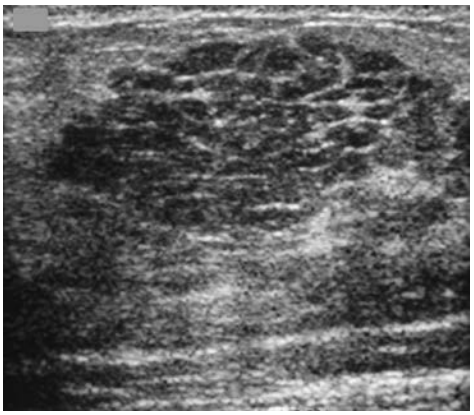


**FIGURE 13-38** Lactational adenoma. Oval, hypoechoic mass with lobulated margins and posterior acoustic enhancement. Multiple internal linear and curvilinear echogenic septations are present, a common feature in these lesions.

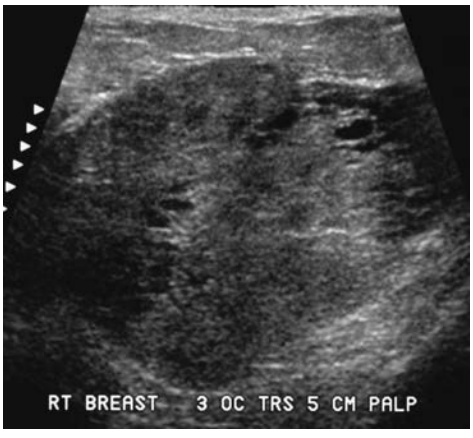



**FIGURE 13-39** Lactational adenoma. Round, hypoechoic mass with small cystic spaces and posterior acoustic enhancement. Patients present during the trimester of pregnancy and when lactating such that a mammogram is not usually done.

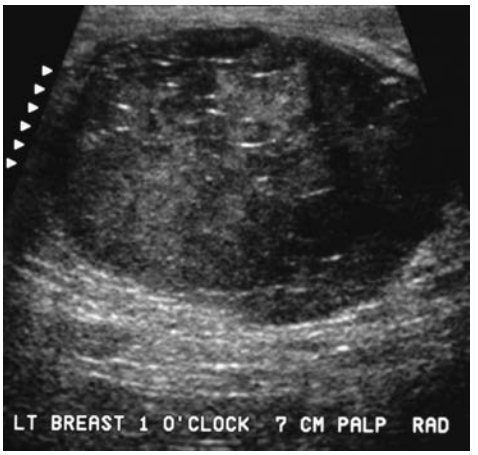



**FIGURE 13-40** Lactational adenoma. Round hypoechoic mass with small cystic spaces, curvilinear echogenic septations and posterior acoustic enhancement. Patients usually present during the third trimester of pregnancy with a palpable mass. It is unclear if these arise de-novo during pregnancy or if they represent pre existing fibroadenomas that undergo hormonal stimulation during pregnancy. Many of these resolve spontaneous following delivery and cessation of breast feeding.

## Phyllodes Tumor

### Key Facts

- Clinical.

  Solitary, unilateral tumors, rarely multifocal or bilateral; less than 1% of all breast tumors.

  Palpable mass; may enlarge rapidly.

  Patients are typically 15 to 20 years older (mean age, mid 40's) than women with fibroadenomas; malignant variants in slightly older patients.

  Resemble fibroadenomas; distinction made primarily on cellularity of stroma (not the epithelial elements).

  Co-existing fibroadenomas reported in 20% to 40% of patients.

  Wide local excision is critical to minimize likelihood of local recurrence; in some patients this may require a mastectomy.

  Higher recurrence rates seen following incomplete excision and in tumors with invasive borders and secondary nodules at the periphery of main lesion.

  Reportedly up to 25% of lesions are malignant.

  Approximately 3% to 12% of patients have metastasis (hematogenous to lungs, bones, heart, and liver). Axillary dissection is rarely indicated unless axillary lymph nodes are enlarged and even in these patients reactive changes are more common than metastatic disease.

  Response to chemotherapy, radiotherapy, and hormonal manipulation is reportedly poor.

- Mammography.

  Mass with variable marginal characteristics; some may be macrolobulated.

  Rarely, entrap fat.

  Rarely in lesions with osseous metaplasia may see dense calcifications.

  Lesions greater than 3 cm in size more likely to be malignant.

- Ultrasound.

  Hypoechoic well-circumscribed mass.

  Lesions with cystic spaces more likely to be malignant.

  Require wide surgical excision if diagnosis is established following imaging guided biopsy.
- Magnetic resonance imaging.

  Mass with circumscribed margins; cystic changes may be present.

  Continuous uptake or plateau type kinetic curves; some may be characterized by rapid initial enhancement and washout of contrast.

  Rim enhancement may be seen.
- Histology.

  Benign epithelial elements and cellular stroma. Differentiation from fibroadenoma is subjective, based on estimates of stromal cellularity and presence of leaf-like processes protruding into cystic spaces.

  Contiguous epithelial cell layer and discontinuous myoepithelial cells line ducts and cover leaf-like processes.

  Spindle cells in stroma, atypia, and multinucleated cells can be seen.

  Osseous and lipomatous metaplasia and pseudoangiomatous stromal hyperplasia can be seen in stroma.

  Lesions assessed for stromal cellularity, cellular atypia, mitotic rate, and border features (expansile, infiltrative); size alone is not a criterion for diagnosis. Heterogeneity of histological features within lesions is common.

  Biologic behavior is difficult to establish. Classification schemes vary. Benign, low-grade (borderline), and high-grade malignant are commonly used descriptors.

  Benign lesions have modest stromal cellularity, slight to moderate atypia, few (one to two) if any mitotic figures per ten high-power fields, and well-defined margins.

  Low-grade lesions are characterized by expansile growth or microscopically invasive borders, mild atypia, and less than three mitotic figures per ten high-power fields.

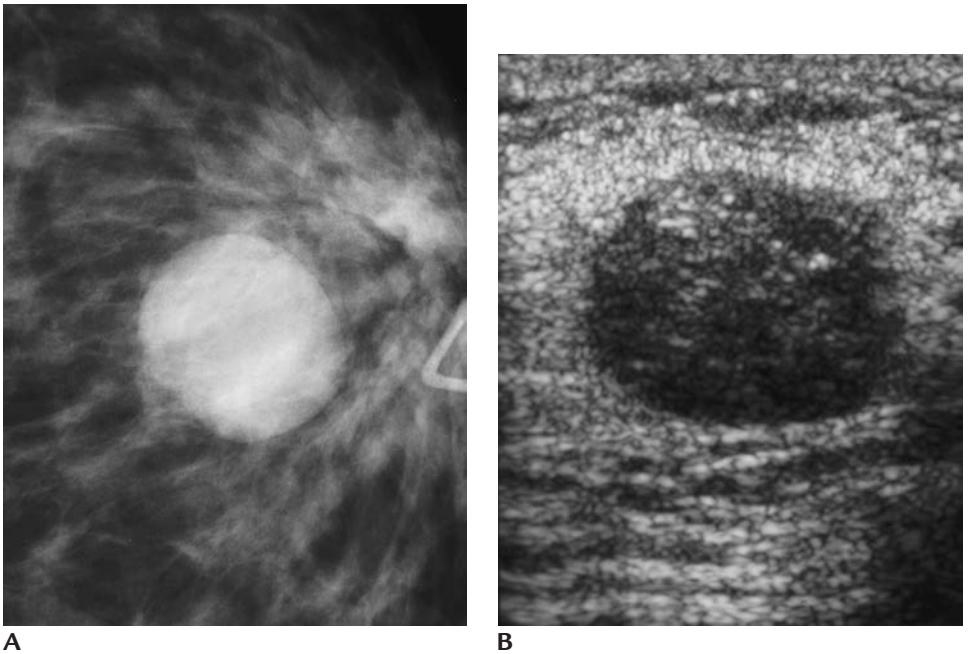
  Marked stromal cellular overgrowth and atypia, five or more mitotic figures per ten high-power fields, and an infiltrative growth pattern characterize high-grade lesions.

  Recurrence following excision reported in 25%, 46%, and 65% of benign, low- and high-grade malignant lesions, respectively. With "wide surgical excision" (1 to 2 cm of normal tissue surrounding the tumor) reported recurrence rates are 8%, 29%, and 36% for benign, low- and high-grade malignant lesions, respectively.

  Recurrences usually occur within the first 2 years following excision.

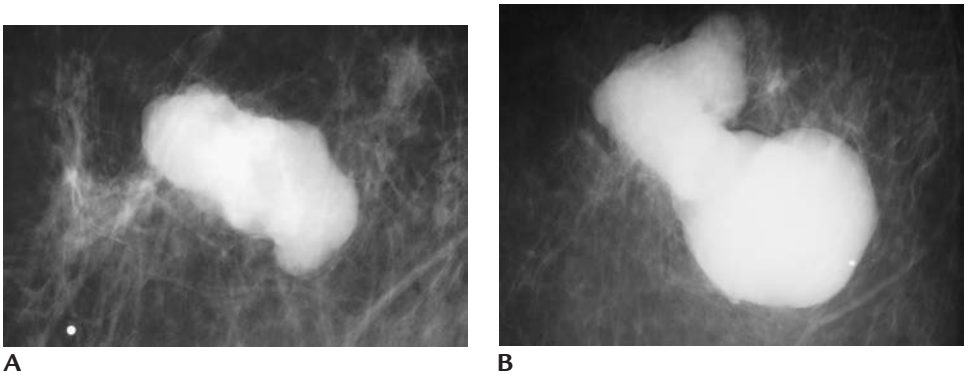
  A higher histological grade may be seen with the recurrence.

  Death from phyllodes tumors reported in 0.3%, 6.6%, and 20% of patients with benign, low- and high-grade malignant lesions, respectively.



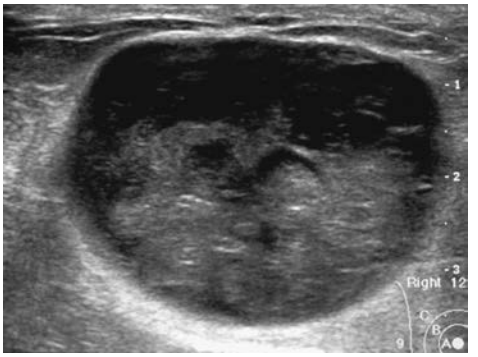
A B

**FIGURE 13-41** Phyllodes tumor. **(A)** Palpable mass. Dense mass with well circumscribed margins. **(B)** Hypoechoic mass with minimal posterior acoustic enhancement corresponding to palpable and mammographic finding.



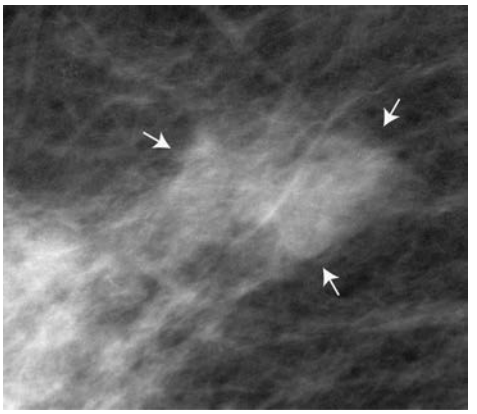
A B

**FIGURE 13-42** Phyllodes tumor initially diagnosed as fibroadenoma. **(A)** Palpable mass (metallic BB). Dense, irregular mass with circumscribed, macrolobulated margins. Fibroadenoma described on core biopsy. **(B)** Subsequent mammogram demonstrates enlargement of the mass. Although fibroadenomas can undergo some increase in size, the change in size in this patient is significant. A repeat biopsy is done and a phyllodes tumor is diagnosed and confirmed on wide surgical excision.




C

**FIGURE 13-42** (*Continued*) **(C)** Complex cystic mass with well circumscribed margins and posterior acoustic enhancement. Distinguishing a cellular fibroadenoma (usually in younger patients) from phyllodes tumor can be difficult and is subjective. When a cellular fibroadenoma is described histologically in a peri-menopausal patient (or a fibroadenoma develops in a post menopausal patient not on hormone replacement therapy), specifically ask the pathologist how concerned they are about a phyllodes tumor and should an excisional biopsy be done.



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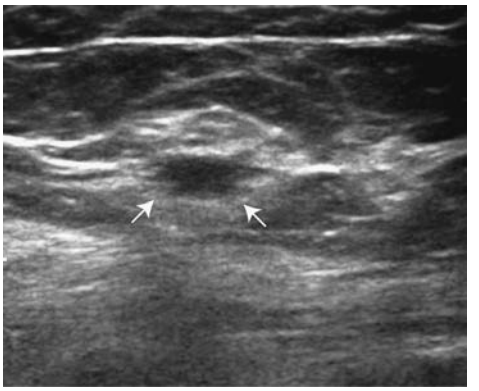
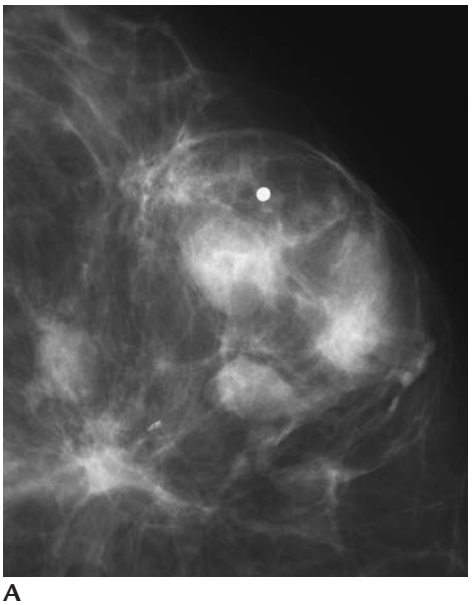
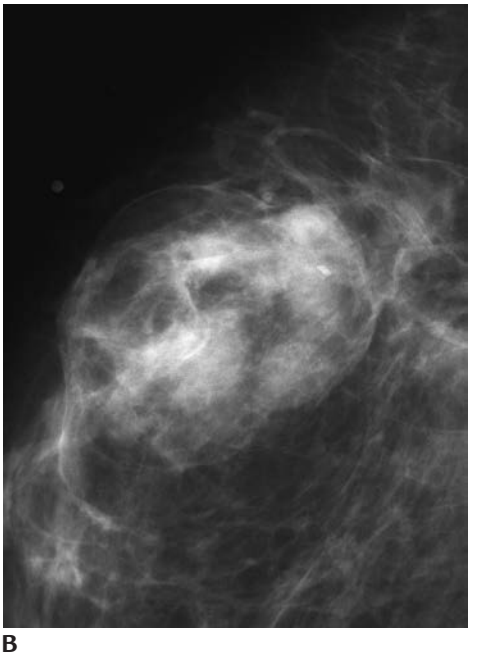


B

**FIGURE 13-43** Phyllodes tumor. **(A)** Irregular mass (*arrows*) with indistinct margins new compared with previous study (not shown). **(B)** Irregular hypoechoic mass (*arrows*) with spiculated margins.



A



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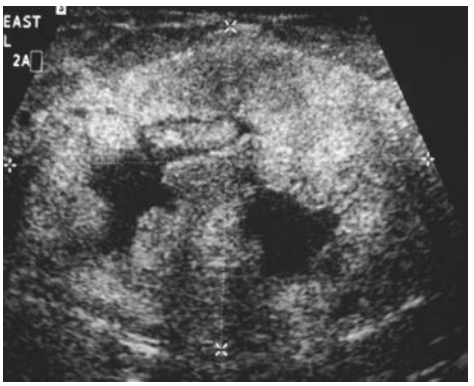
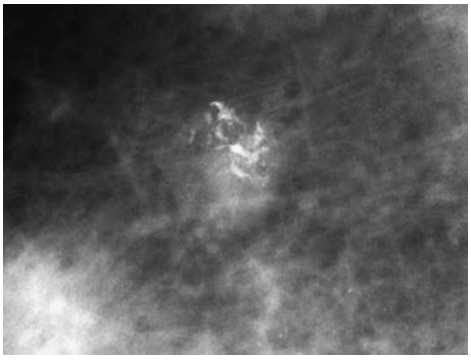
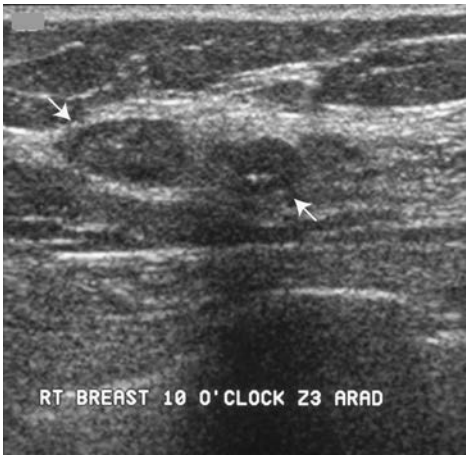



C

**FIGURE 13-44** Phyllodes tumor, malignant. **(A)** Craniocaudal (CC) and **(B)** mediolateral oblique views. Palpable mass (metallic BB on CC view). Mixed density mass (simulating a fibroadenolipoma) with fatty component and several round water density masses seemingly encapsulated. **(C)** Hyperechoic mass with irregular areas of hypoechogenicity corresponding to palpable and mammographic findings.



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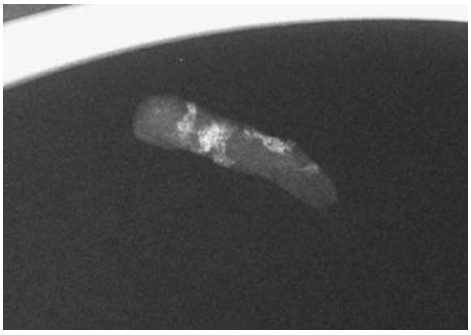
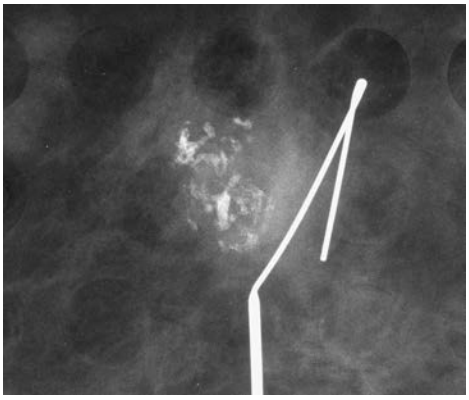




C D

**FIGURE 13-45** Phyllodes tumor with osseous metaplasia. **(A)** Mediolateral oblique view. Mass with indistinct margins and associated osseous changes. **(B)** Hypoechoic mass (*arrows*) with high specular echoes related to calcification corresponding to mammographic finding. **(C)** Core radiograph and **(D)** specimen radiograph. Mass with indistinct margins and osseous metaplasia (can see bony trabecula). Hookwire portion of localization wire is present in the specimen.

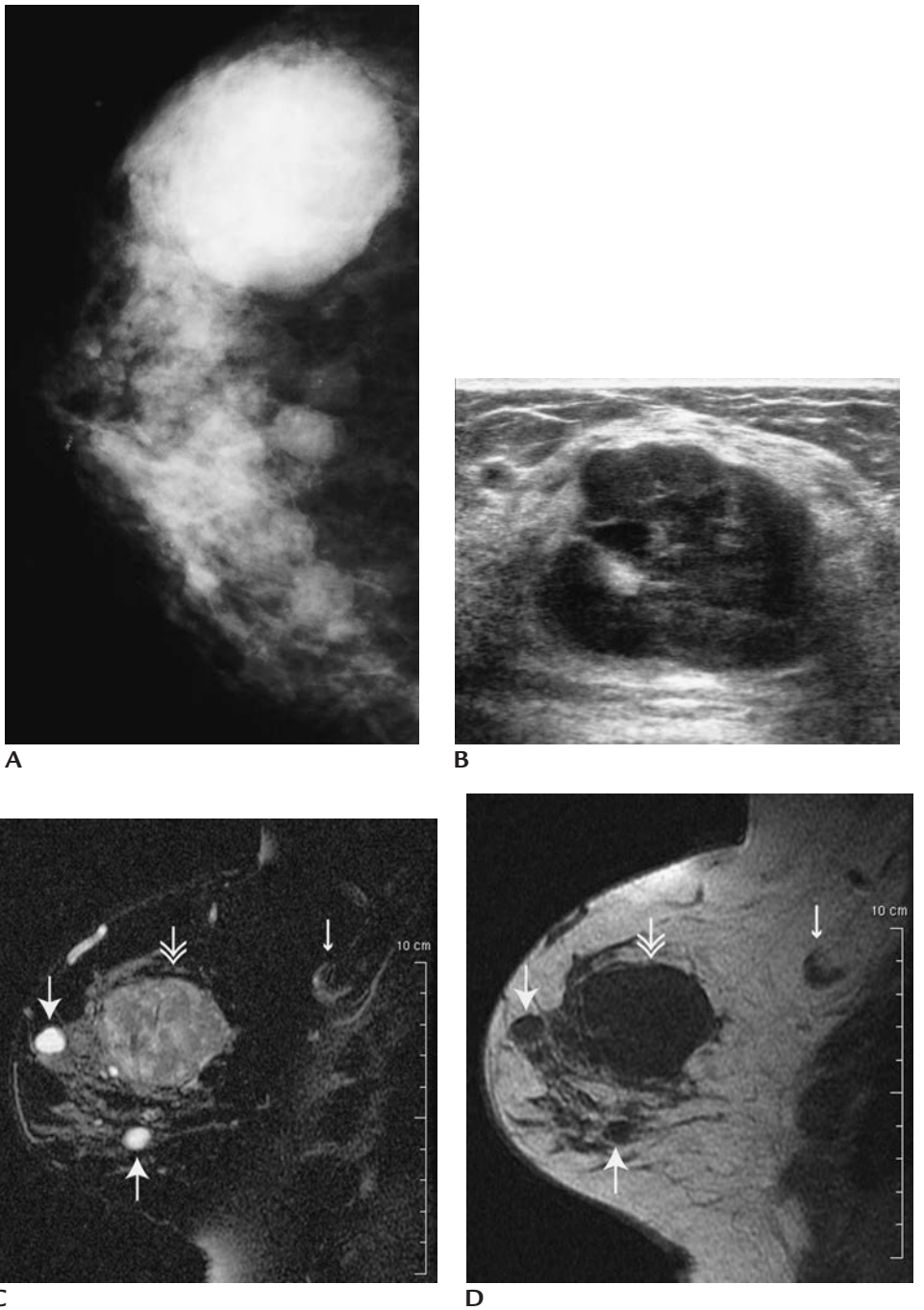
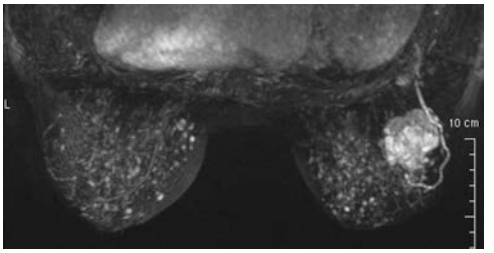



**FIGURE 13-46** Phyllodes tumor, malignant with liposarcomatous changes. **(A)** Round dense mass laterally in the right breast new compared with prior mammogram 8 months previously. Additional smaller masses are present consistent with multiple cysts (ultrasound of cysts not shown). **(B)** Round mass with heterogeneous echotexture, circumscribed, lobulated margins and posterior acoustic enhancement corresponding to palpable and mammographic finding. **(C)** Magnetic resonance imaging. Sagittal T2-weighted image with fat suppression. Round mass (*double headed arrow*) with mixed signal intensity corresponding to dominant mass. Two masses (*arrows*) with bright signal consistent with cysts. Low axillary lymph node (*thin arrow*) with central fatty hilar region. **(D)** Sagittal T1-weighted image. Round mass with low signal intensity (*double headed arrow*). Cysts (*arrows*) demonstrate low signal intensity. Lymph node (*thin arrow*) characterized by high signal intensity from central fatty hilar region.




E

**FIGURE 13-46** (*Continued*) **(E)** Maximum intensity projection demonstrating mass with heterogeneous enhancement in the right breast corresponding to phyllodes tumor. Rapid initial enhancement and wash out of contrast characterizes most of the lesion (kinetic curve not shown). Multiple non-specific foci of enhancement are present bilaterally.

## ADENOSIS

### KEY FACTS

- "Adenosis" refers to proliferation of glandular elements involving the terminal duct lobular unit.
- Clinical.

  Asymptomatic, abnormal screening mammogram.

  Palpable mass uncommon ("adenosis tumor" described by Haagensen).

  Controversy as to whether this is an involutional or proliferative process.

  Considered a marker of slightly (1.5× to 2× ) increased relative risk for subsequent breast cancer.

  Component of fibrocystic change.
- Mammography.

  Most common pattern: cluster of discrete, punctate, pleomorphic calcifications.

  Smudgy, ill-defined, amorphous calcifications: wide area of dense breast tissue. Resembles milk of calcium, but unlike milk of calcium, which has a differential appearance between craniocaudal (CC) and 90-degree lateral views, when related to sclerosing adenosis, the calcifications are amorphous (smudgy) on CC, mediolateral oblique, and 90-degree lateral views.

  Well-circumscribed to spiculated (uncommon presentation) mass.

  Architectural distortion.
- Ultrasound.

  Hypoechoic mass.

  Distortion and shadowing.
- Histology.

  Various terms used to qualify adenosis including sclerosing adenosis, blunt duct adenosis and microglandular adenosis.

  Proliferation of closely packed lobular units elongated and distorted as a result of compression by surrounding stroma.

Two cell layers in epithelial elements; hyperplasia of the myoepithelial cells may be present.

May be focal or diffuse and florid.

May extent into perineural spaces (2% of women).

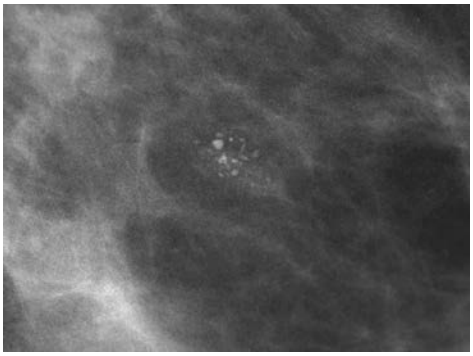


**FIGURE 13-47** Sclerosing adenosis. Double spot compression magnification (1.8×) view. Cluster of pleomorphic calcifications. Variable density.

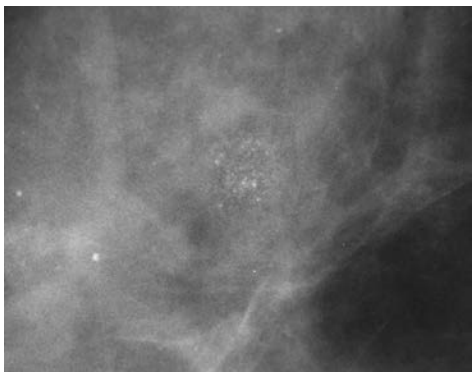


**FIGURE 13-48** Sclerosing adenosis. Double spot compression magnification (1.8×) view. Tight cluster of punctate and amorphous calcifications. Predominantly low density however there is some variation in the density of the calcifications.

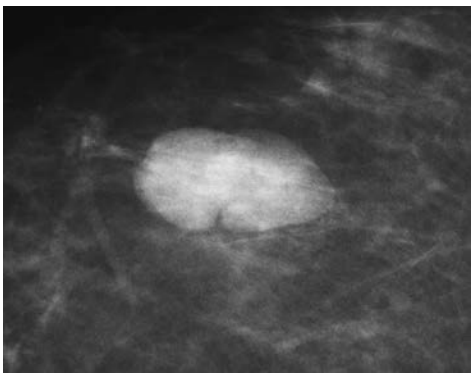
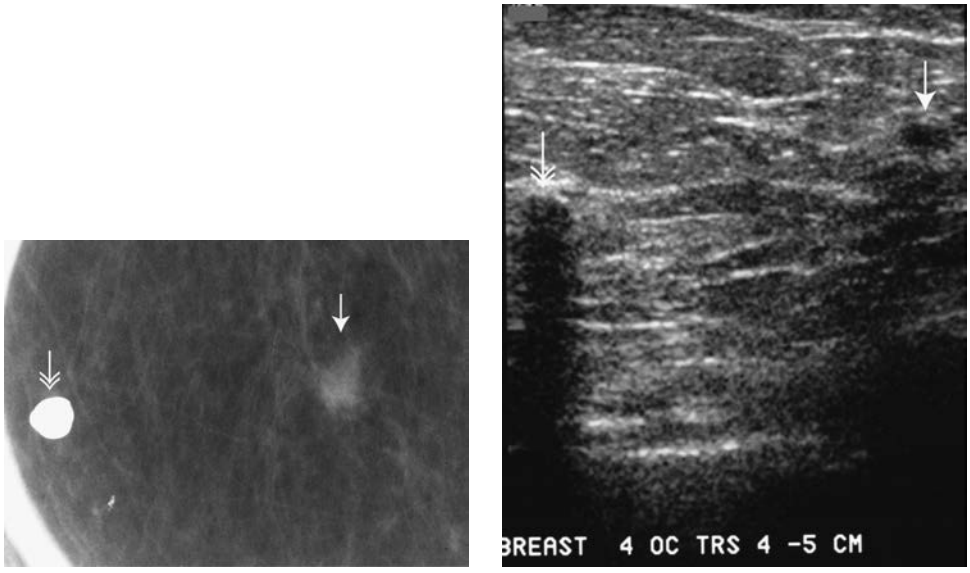
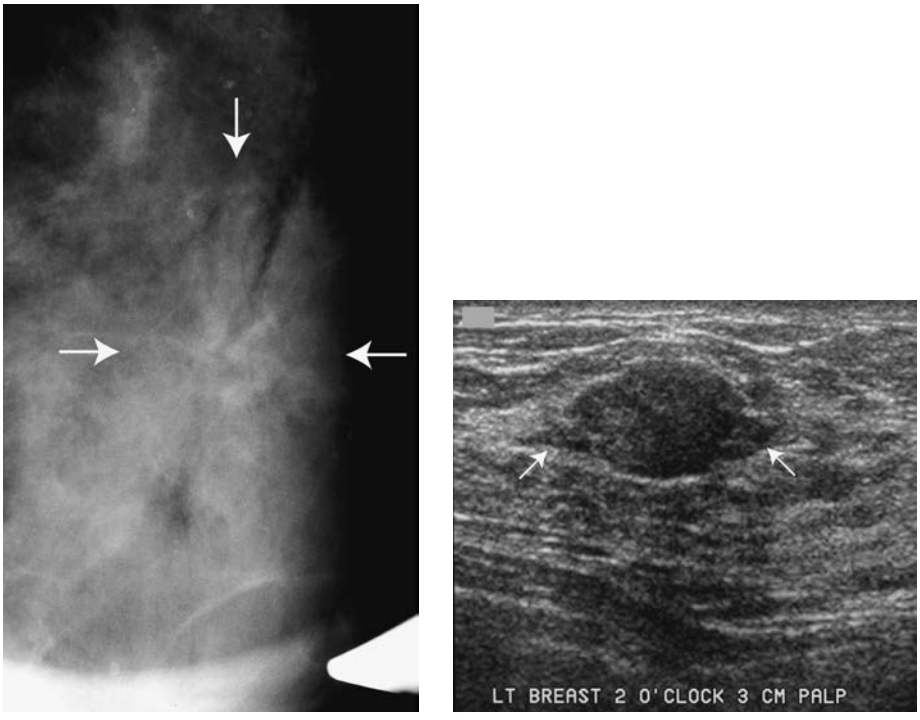


**FIGURE 13-49** Adenosis tumor. Oval, lobular dense, mass with circumscribed margins.




A B

**FIGURE 13-50** Adenosis tumor. **(A)** Spot compression view. Irregular mass (*arrow*) with indistinct margins. Dense coarse dystrophic calcification (*double headed arrow*) likely related to a hyalinized fibroadenoma. **(B)** Oval hypoechoic mass (*arrow*) corresponding to mammographic finding. Margins are not well circumscribed. Calcification (*double headed arrow*) with associated posterior acoustic shadowing.




A B

**FIGURE 13-51** Sclerosing adenosis. **(A)** Spot compression tangential view of palpable finding. Mass (*arrows*) with spiculated margins and associated distortion corresponding to clinical finding. **(B)** Hypoechoic mass with angular margins and tubular like extensions (*arrows*, ductal extension and branch patterns).

## Columnar Alteration with Prominent Apical Snouts and Secretions (CAPSS)

### Key Facts

- Clinical.

  Usually asymptomatic; diagnosed on biopsies done for round, punctate or amorphous calcifications detected mammographically.

  Affects premenopausal women 35 to 50 years of age.

  Component of fibrocystic changes.
- Mammography.

  Cluster of round and punctate, pleomorphic calcifications; no linear or casting-type calcifications are usually seen.

  Linear (ductal) orientation of round and punctate calcifications may be seen.

  Amorphous calcifications.
- Ultrasound.

  Normal.
- Magnetic resonance imaging.

  Enhancing mass or masses, may demonstrate rapid wash in and wash out of contrast.
- Histology.

  Variable terminology used includes: columnar cell change, blunt duct adenosis, columnar alteration of lobules, columnar metaplasia, and flat epithelial atypia (FEA).

  Metaplastic change of cuboidal epithelial cells to columnar epithelial cells with associated vacuoles on the luminal side (e.g., snouts) of the cells involving the terminal duct lobular units.

  When CAPSS without associated atypia is diagnosed on core biopsy done for calcifications, excisional biopsy is not indicated; excisional biopsy is indicated when associated atypical changes or FEA are described.

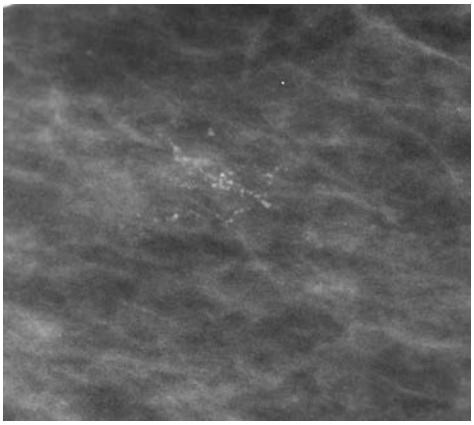


**FIGURE 13-52** Columnar alteration with prominent apical snouts and secretions (CAPSS). Cluster of round and punctate calcifications demonstrating linear (ductal) orientation. Diagnostic considerations include other fibrocystic changes (e.g., hyperplasia, atypical ductal hyperplasia, and sclerosing adenosis), fibroadenoma, papilloma, and ductal carcinoma in situ (usually low to intermediate grade). When CAPSS is associated with atypia, excisional biopsy is indicated following core biopsy.

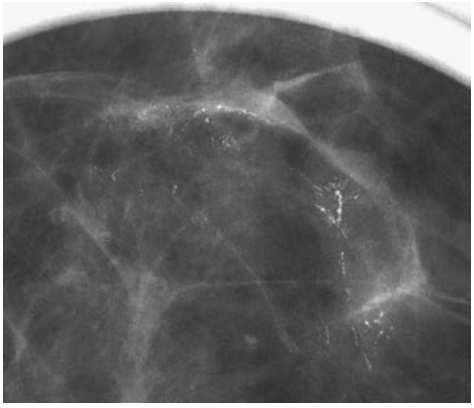


**FIGURE 13-53** Columnar alteration with prominent apical snouts and secretions (CAPSS). Clusters of round and punctate calcifications demonstrating linear (ductal) orientation.

## Mucocele-Like Lesions

### Key Facts

- Clinical.
  Usually asymptomatic; diagnosed on biopsies done for mammographic findings.
- Mammography.
  Multiple, small, well-circumscribed or partially circumscribed masses.
  Cluster or multiple clusters of punctate, pleomorphic calcifications; no linear or casting-type calcifications are usually seen nor is there significant ductal orientation of the calcifications in a cluster.
  Some of the calcifications have a curvilinear, coarse appearance.
  Findings (masses or microcalcifications) may be bilateral and multiple.
- Ultrasound.
  Solid, homogeneously, hypoechoic mass or masses.
  Intracystic mass.
- Magnetic resonance imaging.
  Variable enhancement of one or more masses, may demonstrate rapid wash in and wash out of contrast.
  May demonstrate high signal on pre-contrast T1-weighted images.
- Histology.
  Indistinguishable from solitary papillomas.
  Two cell layer: contiguous epithelial cell layer (contiguous with ductal epithelium) and discontinuous myoepithelial, basilar layer on basement membrane.
  Some these lesions may be associated with atypical ductal hyperplasia.
  Some recommend excisional biopsy when these lesions are diagnosed following imaging guided biopsy.

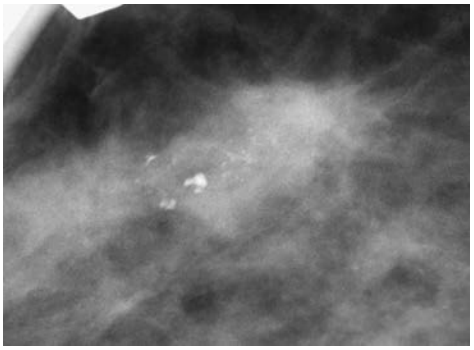


**FIGURE 13-54** Mucocele-like lesion. Spot compression view. Irregular dense mass with indistinct margins and associated pleomorphic calcifications including coarse forms as well as round and punctate calcifications.

# Lobular Neoplasia

## Key Facts

- Synonymous with lobular carcinoma in situ (LCIS).
- Because this is not a true cancer, "carcinoma" should not be used in describing this entity. As proposed by Haagensen, *lobular neoplasia* (although not an ideal term either) may be a more appropriate term.
- Incidental finding that is often bilateral, multifocal.
- More common in premenopausal women; many of these lesions are thought to regress after menopause (unless there is estrogen replacement therapy).
- Biologic behavior different from that of most ductal carcinoma in situ (ductal carcinoma in situ considered a true breast cancer).
- Significant risk marker lesion for the subsequent development of breast cancer and increased risk applies to both breasts (not limited to breast with diagnosis of lobular neoplasia).
- Cancers that develop may be either ductal or lobular.
- If this is the only diagnosis given in a biopsy done for clinical or mammographic findings, there is no explanation for what prompted the biopsy in the first place. Lobular neoplasia is an incidental histologic diagnosis with no clinical or mammographic findings.
- Lobular neoplasia should not be counted as a positive biopsy in clinical or mammographic series. It is not a cancer and the abnormality that prompted the biopsy is usually something other than the lobular neoplasia.
- Mammography.

  Usually normal.

  Rarely calcifications may be identified in direct associated with the lobular neoplasia.

  Although controversial, some advocate the need for excisional biopsy when the diagnosis of lobular neoplasia (LCIS or atypical lobular hyperplasia) is incidentally diagnosed on core biopsies.
- Gross.

  No visible lesion.
- Histology.

  Uniform cell population distending and distorting at least one half the acini in the lobular unit.
- Management.

  Controversial.

  Periodic follow-up (clinical, mammography).

  Bilateral mastectomy (unilateral mastectomy is not appropriate because the increased breast cancer risk applies to both breasts).

## Invasive Lobular Carcinoma

### Key Facts

- Clinical.

  Approximately 10% to 15% of all breast cancers; 2% of all breast cancers in women less than age 35; 11% of all breast cancers in women over the age of 75; may be increasing in frequency.

  Bilaterality is high (6% to 28%); advanced disease at the time of presentation is common.

  Given histological features, clinical and mammographic diagnosis often difficult.

  Findings can be overlooked because a discrete mass may not be palpated.

  Areas of thickening or induration are described.

  Some women present with an area of focal tenderness.

  Metastatic lobular carcinoma may simulate ovarian cancer: pleural and peritoneal studding with pleural effusions and ascites; involvement of leptomeninges, uterus and ovaries. In contrast, metastatic disease from invasive ductal carcinoma usually involves solid organs (e.g., liver, bone, brain).
- Mammography.

  Spiculated mass (Susan G. Komen Breast Center [SKBC] 40%).

  Parenchymal asymmetry (SKBC = 16%).

  Architectural distortion (SKBC = 15%).

  Diffuse breast changes either decreased breast size (shrinking breast) or enlarging breast with diffuse density increases (SKBC = 11%).

  Relatively well circumscribed mass (SKBC = 11%).

  Although microcalcifications have been described as a finding for invasive lobular carcinoma, in our experience, invasive lobular carcinomas do not develop or present with calcifications. Given the histological behavior of classic infiltrating lobular carcinoma the lack of calcification is not surprising.

  Normal (SKBC = 3%).

  Extent of disease is often underestimated based on imaging studies.

  In as many as 65% of patients, metastatic disease is identified in one or more axillary lymph nodes at the time of diagnosis.
- Ultrasound.

  Hypoechoic mass with angular, ill-defined, or spiculated margins; may have associated posterior acoustic shadowing. In some patients, the shadowing can be striking.

  Shadowing without a discreet mass.

  Hypoechoic, lobulated, well-circumscribed mass.

  Normal.
- Magnetic resonance imaging.

  Malignant type enhancement pattern seen in most lesions.

  Solitary mass with irregular margins.

  Multiple masses with intervening strands of enhancing tissue.

Multiple masses with non-enhancing intervening tissue.

Enhancing septa with no associated mass.

Diffuse enhancement pattern may be seen simulating breast parenchyma.

Helpful to establish the extent of the disease; however, in some patients the extent of the disease is overestimated.

Compared with mammography and ultrasound may have a lower false negative rate of detection.

- Gross.

  Poorly defined area of induration may be apparent; relatively well-circumscribed mass sometimes present.

- Histology.

  Small, monomorphic cells infiltrating the stroma in single file.

  Targetoid appearance produced by circumferential infiltration around ducts and lobules by abnormal cells.

  Given small, round monomorphic appearance of the malignant cells, lymphoma is in the differential.

  Associated lobular neoplasia and atypical lobular hyperplasia is present in more than 50% of patients (in some it is extensive), suggesting that lobular neoplasia may be more than just a marker lesion of increased risk. For example, lobular neoplasia is considered to be more common in premenopausal women. However, if this is so, why are many of the elderly women with invasive lobular carcinoma found to have extensive associated lobular neoplasia?

  Variants include alveolar, solid, pleomorphic, and mixed/atypical.

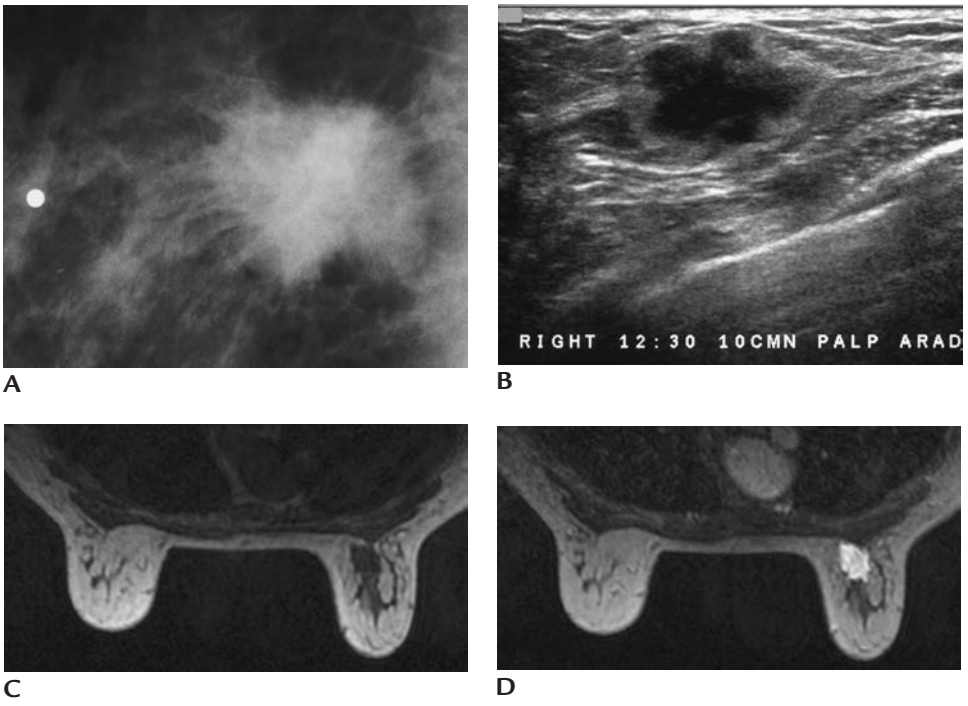
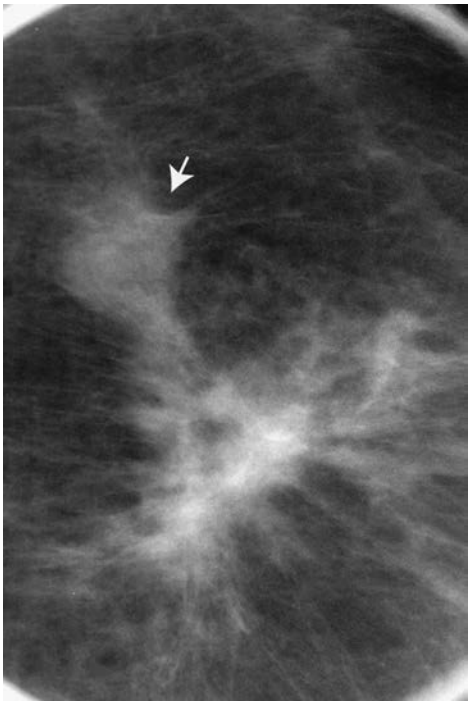
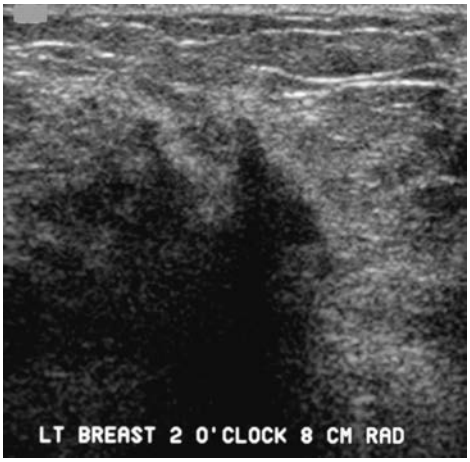


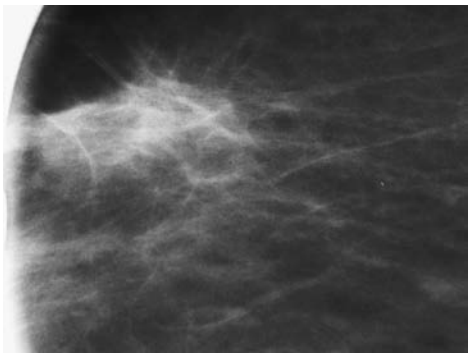

**FIGURE 13-55** Invasive lobular carcinoma. **(A)** Dense mass with spiculated margins corresponding to palpable finding (metallic BB). **(B)** Irregular, hypoechoic mass with lobulated margins and a thick echogenic rim. Approximately 90% of spiculated masses are malignant and of these approximately 20% are invasive lobular carcinomas. **(C)** Magnetic resonance imaging. Pre-contrast T1-weighted image. **(D)** Post-contrast T1-weighted image at same table top position as **(C)**. Mass with low signal intensity on pre-contrast images and rapid initial enhancement and wash out on the contrast images.






**A** **B**

**FIGURE 13-56** Invasive lobular carcinoma. **(A)** Spot compression view. Irregular mass with spiculated margins and distortion. Associated satellite mass (*arrow*) with spiculated margins is present. **(B)** Irregular, hypoechoic mass with spiculated margins and significant posterior acoustic shadowing. Although ultrasound may be normal in some patients with invasive lobular carcinoma, many of these lesions are characterized by striking posterior acoustic enhancement.



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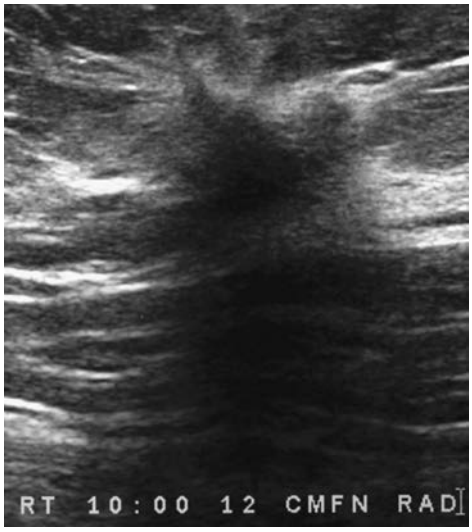


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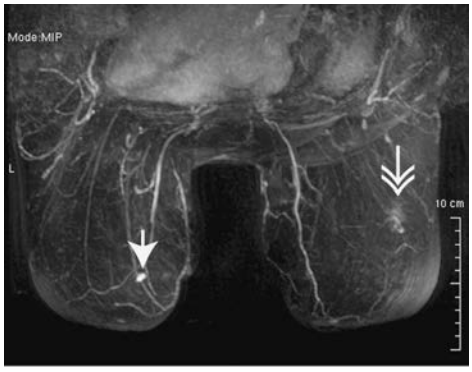
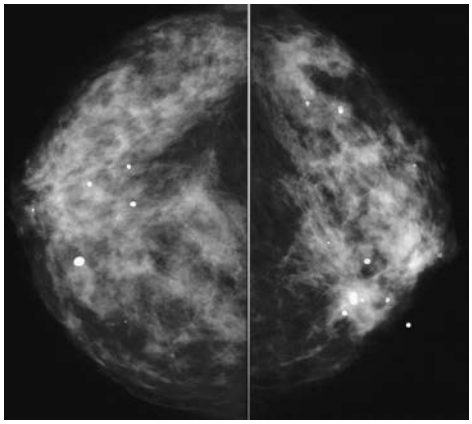



C

**FIGURE 13-57** Invasive lobular carcinoma. **(A)** Spot compression view. Focal parenchymal asymmetry corresponding to an area of thickening described by the patient as a change in her breast exam. Areas of focal parenchymal asymmetry are usually normal variants, however, if the asymmetry is palpable, and represents a change clinically, or from prior mammograms, further evaluation with ultrasound is indicated. **(B)** Irregular, hypoechoic mass with spiculated margins, a thick echogenic rim and significant posterior acoustic shadowing. **(C)** Magnetic resonance imaging. Maximum intensity projection demonstrating irregular area of rapid initial enhancement and wash out of contrast in the upper outer quadrant of the right breast; invasive lobular carcinoma. This corresponds to the area of palpable parenchymal asymmetry (*double headed arrow*). Additionally, an unsuspected mass (*arrow*) is detected medially in the left breast characterized by rapid initial enhancement and wash out of contrast. Biopsy proven invasive ductal carcinoma. As in this patient, MRI is proving helpful in establishing the presence of synchronous, unsuspected bilateral breast cancers.



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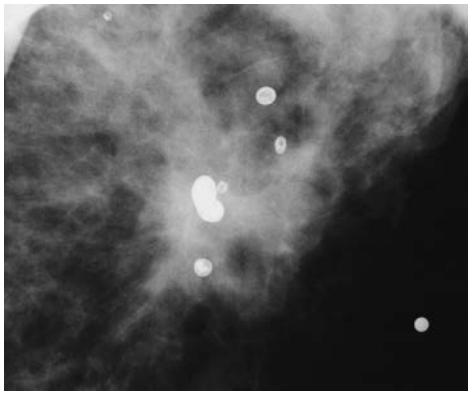

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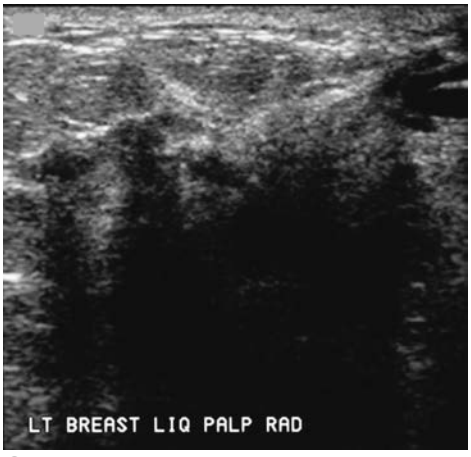



C

**FIGURE 13-58** Invasive lobular carcinoma. **(A)** Craniocaudal views. A mass is present medially corresponding to a palpable finding (*metallic BB*) described by the patient. The asymmetric breast size (left smaller than right) and increased density on the left should also be noted. These lesions are often more extensive than anticipated even in those patients in whom diffuse changes are not present. Coarse, dystrophic type calcifications are scattered bilaterally. **(B)** Spot compression view. Irregular mass with spiculated margins and distortion is imaged corresponding to the palpable finding. **(C)** Dense shadowing in the lower inner quadrant (LIQ) of the left breast corresponding to the clinical and mammographic findings. Intense shadowing is seen associated with many invasive lobular carcinomas.

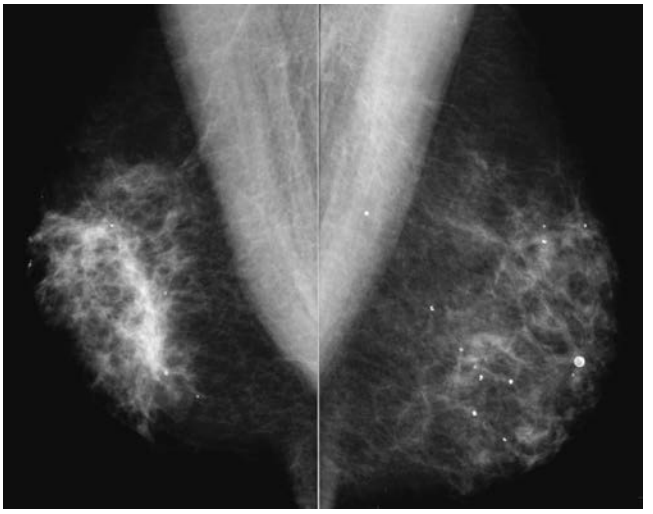
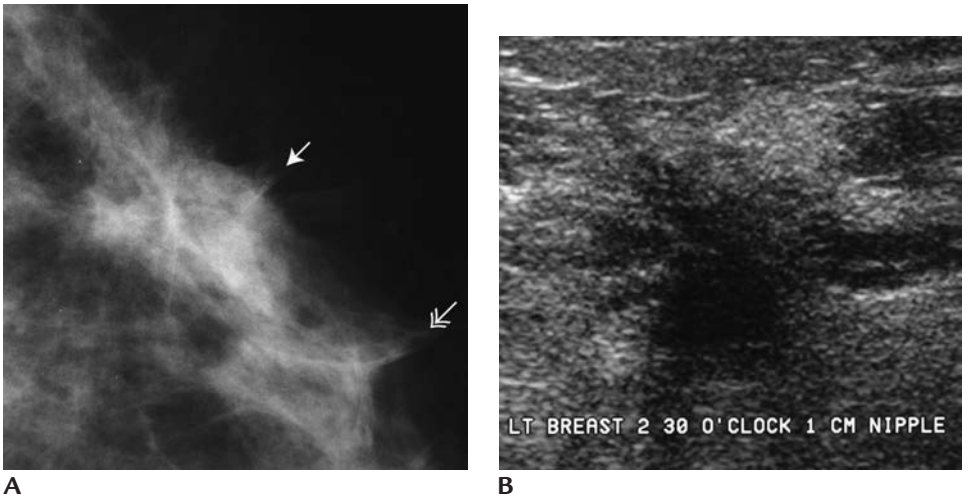
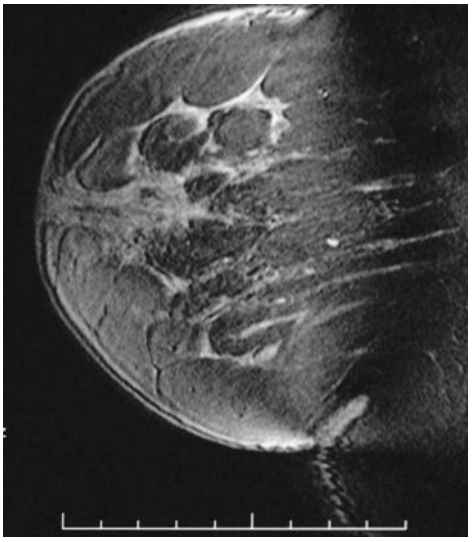


**FIGURE 13-59** Invasive lobular carcinoma. Mediolateral oblique views. Diffuse changes involving the right breast characterized by asymmetric breast size and increased density (and trabecular prominence–reticular pattern). Described as the "shrinking" breast, the progressive changes are gradual and often not appreciated by the patient. Although this pattern can also be seen with invasive ductal carcinoma, it is more commonly associated with invasive lobular carcinoma.




**A** **B**

**FIGURE 13-60** Invasive lobular carcinoma. **(A)** Spot compression view. A mass (*arrow*) with obscured margins, associated distortion and thickening of a Cooper's ligament (*double headed arrow*) is present corresponding to an area of palpable concern to the patient. **(B)** Irregular, hypoechoic mass with spiculation and associated posterior acoustic shadowing corresponding to the palpable finding. The margins are not circumscribed.



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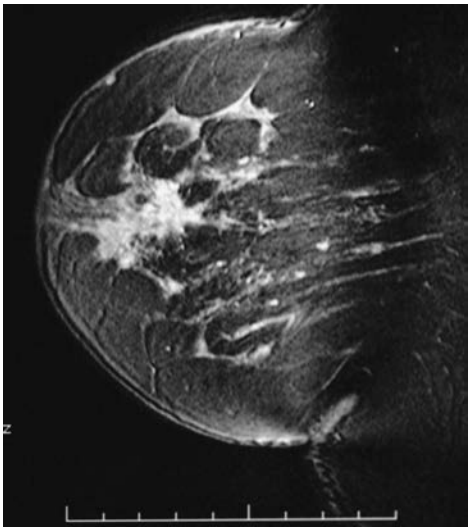

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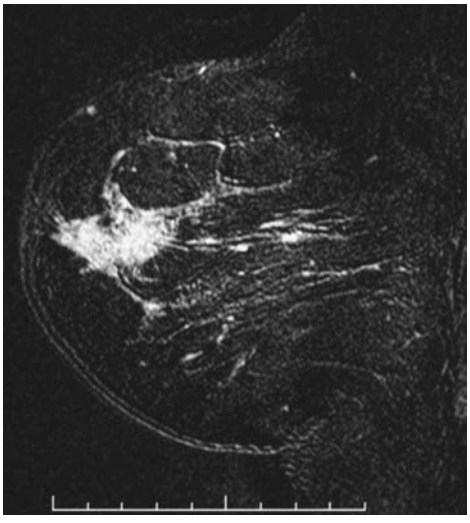


E

**FIGURE 13-60** (*Continued*) **(C)** Sagittal, T1-weighted image of the left breast, precontrast. **(D)** Sagittal, T1-weighted imaging 1 minute following bolus administration of gadolinium, same table top position as that of **(C)**. **(E)** Subtraction image, same table top position as (**C** and **D**). An irregular mass with rapid initial enhancement and wash out of contrast is imaged anteriorly in the left breast. Enhancing strands of intervening tissue are present consistent with more extensive disease than suspected based on mammographic and sonographic findings.

## SUGGESTED READINGS

Adler DD. Mammographic evaluation of masses. *RSNA Categorical Course in Breast Imaging Syllabus*. 1995;107–116.

Azzopardi JG, Salm R. Ductal adenomas of the breast: a lesion which can mimic carcinoma. *J Pathol*. 1984;144:15–23.

Boetes C, Veltman J, van Die J, et al. The role of MRI in invasive lobular carcinoma. *Breast Cancer Res Treat*. 2004; 86:31–37.

Buchberger W, Strasser K, Heim K, et al. Phyllodes tumor: findings on mammography, sonography and aspiration cytology in 10 cases. *AJR Am J Roentgenol*. 1991;157: 715–719.

Butler RS, Venta LA, Wiley EL, et al. Sonographic evaluation of infiltrating lobular carcinoma. *AJR*. 1999;172:325–330.

Cardenosa G, Doudna CD, Eklund GW. Infiltrating lobular carcinoma: mammographic and ultrasonographic findings [abstract]. *AJR Am J Roetgenol*. 1994: 162:217(abst).

Donegan WL. Evaluation of a palpable mass. *N Engl J Med*. 1992;327:937–942.

Dupont WD, Page DL, Parl FF, et al. Long-term risk of breast cancer in women with fibroadenoma. *N Engl J Med*. 1994;331:10–15.

Feig SA. Breast masses: mammographic and sonographic evaluation. *Radiol Clin North Am*. 1992;30:67–92.

Fornage BD, Lorigan JG, Andrey E. Fibroadenomas of the breast: sonographic appearance. *Radiology*. 1989;172:671–675.

Gomez A, Mata JM, Donoso L, et al. Galactocele: three distinctive radiographic appearances. *Radiology*. 1986;158:43–44.

Harvey JA, Fechner RE, Moore MM. Apparent ipsilateral decrease in breast size at mammography: a sign of infiltrating lobular carcinoma. *Radiology*. 2000;214: 883–889.

Hertel BF, Zaloudek C, Kempson RL. Breast adenomas. *Cancer*. 1976;37:2891–2905.

Hilleren DJ, Andersson IT, Lindholm K, et al. Invasive lobular carcinoma: mammographic findings in a 10 year experience. *Radiology*. 1991;178:149–154.

Ikeda DM, Helvie MA, Adler DD, et al. The role of fine needle aspiration and pneumocystography in the treatment of impalpable breast cysts. *AJR Am J Roentgenol*. 1992;158:1239.

Krecke KN, Gisvold JJ. Invasive lobular carcinoma of the breast: mammographic findings and extent of disease at diagnosis in 184 patients. *AJR Am J Roentgenol*. 1993;161:957–960.

Le Gal M, Ollivier L, Asselain B, et al. Mammographic features of 455 invasive lobular carcinomas. *Radiology*. 1992;185:705–708.

Liberman L. Breast MR imaging in assessing extent of disease. *Magn Reson Imaging Clin N Am*. 2006;14:339–349.

Liberman LL, Bonaccio E, Hamele–Bean D, et al. Benign and malignant phyllodes tumors: mammographic and sonographic findings. *Radiology*. 1996;198:121–124.

Mendelson EB, Harris KM, Doshi N, et al. Infiltrating lobular carcinoma: mammographic patterns with pathologic correlation. *AJR Am J Roentgenol*. 1989;153: 265–271.

Newstead GM, Baute PB, Toth HK. Invasive lobular and ductal carcinoma: mammographic findings and stage at diagnosis. *Radiology*. 1992;184:623–627.

Page DL, Anderson TJ. Diagnostic Histopathology of the Breast. Edinburgh: Churchill Livingstone; 1987:108–112.

Pope TL, Fechner RE, Wilhelm MC, et al. Lobular carcinoma-in-situ of the breast: mammographic features. *Radiology*. 1988;168:63–66.

Qayyum A, Birdwell RL, Daniel BL, et al. MR imaging features of infiltrating lobular carcinoma of the breast: histopathologic correlation. *AJR Am J Roentgenol*. 2002;178:1227–1232.

Rosen PP, Holmes G, Lesser ML, et al. Juvenile papillomatosis and breast carcinoma. *Cancer*. 1985;55:1345–1352.

Rosen PP. Papillary duct hyperplasia of the breast in children and young adults. *Cancer*. 1985;56:1611–1617.

Salvador R, Salvador M, Jimenez JA, et al. Galactocele of the breast: radiologic and ultrasonographic findings. *Br J Radiol*. 1990;63:140–142.

Sickles EA. Breast masses: mammographic evaluation. *Radiology*. 1989;173:297–303.

Schelfout K, Van Goethem M, Kersschot E, et al. Preoperative breast MRI in patients with invasive lobular breast cancer. *Eur Radiol*. 2004;14:1209–1216.

Scott Soo M, Dash N, Bentley R, et al. Tubular adenomas of the breast: imaging findings with histologic correlation. *AJR Am J Roentgenol*. 2000;174:757–761.

Sumkin JH, Perrone AM, Harris KM, et al. Lactating adenoma: US features and literature review. *Radiology*. 1998;206:271–274.

Tabàr L, Pentek Z. The diagnostic and therapeutic value of breast cyst puncture and pneumocystography. *Radiology*. 1981;141:659–663.

Venta LA, Kim JP, Pelloski CE, et al. Management of complex breast cysts. *AJR Am J Roentgenol*. 1999;173:1331–1336.

Warner JK, Kumar D, Berg WA. Apocrine metaplasia: mammographic and sonographic appearances. *AJR Am J Roentgenol*. 1998;170:1375–1379.

Weinstein SP, Orel SG, Heller R, et al. MR imaging of the breast in patients with invasive lobular carcinoma. *AJR Am J Roentgenol*. 2001;176:399–406.

Yeh ED, Slanetz PJ, Edmister WB, et al. Invasive lobular carcinoma: spectrum of enhancement and morphology on magnetic resonance imaging. *Breast J*. 2003; 9:13–18.

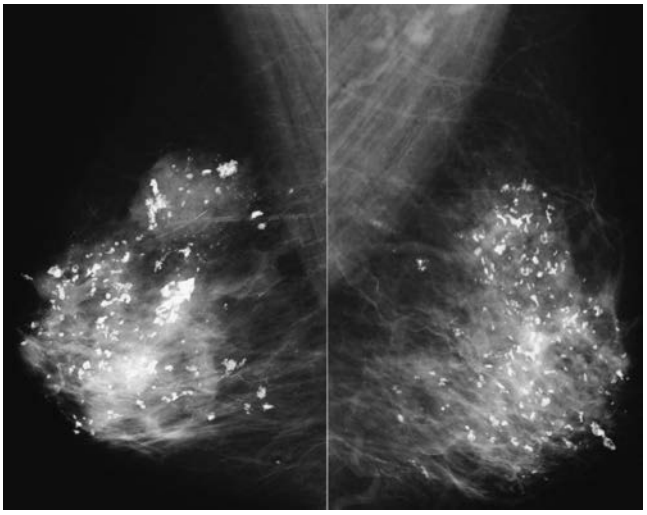
CHAPTER 14

# STROMA

## General Comments

### Key Facts

- Periductal stroma.
  Connective tissue surrounding ducts.
  Different from interlobular stroma: slightly more cellular and vascular.
  Contains periductal lymphatics.
- Interlobular stroma.
  Connective tissue found between lobules.
- Intralobular stroma.
  Connective tissue surrounding acinar structures within a lobule.
  Fine collage fibrils, looser than periductal.
  Reticulin.
  Highly vascular.
  More cellular than interlobular stroma.
  Mucoid character (may be hydrophilic).
- Stromal calcifications: dystrophic.
  Because calcifications do not develop in a predefined space (e.g., they are not molded by a space) shapes, density and sizes vary significantly.
  Dense.
  May develop following trauma or surgery.
  May develop in women with underlying metabolic disorders (e.g., renal failure).
  May be focal, segmental, or diffuse; uni- or bilateral.
- Anterior and lateral cutaneous branches of third to sixth intercostal nerves innervate breast; the nipple-areolar complex rich in sensory fibers.



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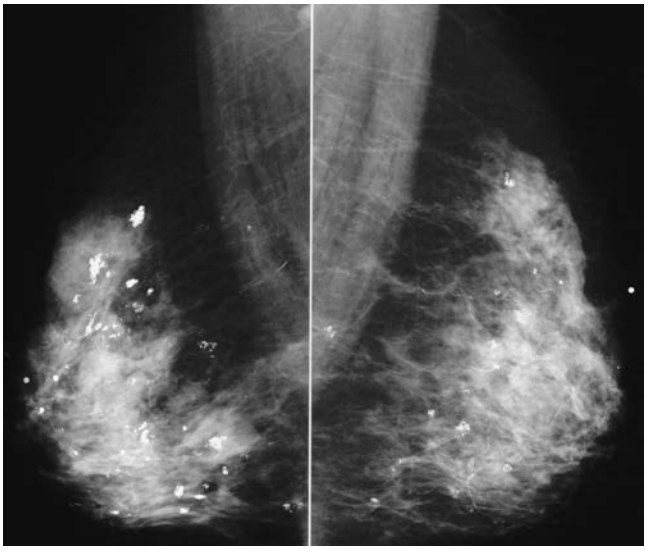


B

**FIGURE 14-1** Dystrophic calcifications developing in fibrous stroma. **(A)** Coarse, dense calcifications with irregular shapes. Diffusely scattered bilaterally. Because these do not develop in preformed spaces (e.g., they are not molded), they are variable in size, shape, and density. Many vascular type calcifications are also noted. **(B)** Prior mammogram. Although some dystrophic and arterial calcifications are present previously, these have increased significantly. When extensive dystrophic type calcifications develop bilaterally metabolic disorders (e.g., renal disease, autoimmune disorders, severe chest wall trauma, or burns) should be considered. Progressive renal failure was suspected and confirmed by the patient's referring physician. When dystrophic calcifications are focal consider post-traumatic or surgical changes, fibroadenoma or papilloma.

# ANATOMY

## KEY FACTS

### Vasculature

- Breast blood supply.

  Perforating branches from second, third, and fourth intercostal arteries supply deep portions of breasts.

  Branches of the internal thoracic supply the medial portion of breasts.

  Superior thoracic artery arising from the first part of axillary artery supplies the pectoralis major muscle; terminal branches may supply deep portions of breasts.

  Acromioclavicular artery arises from second portion of the axillary; the pectoral branch courses between the pectoralis major and minor, supplying these muscles; terminal branches supply breasts.

  Lateral thoracic, coursing lateral to the pectoralis major muscle, also arises from the second portion of the axillary artery and supplies lateral breast tissue.

  Branches of the subscapular artery, arising from the third portion of the axillary artery, also supply lateral breast tissue.

- Blood vessels: imaging.

  Variable in size.

  In some women veins are prominent (normal variant or, rarely, related to breast, axillary, mediastinal, or cardiac process and development of collaterals). Unilateral venous dilatation and fluid overload may be seen in patients with a shunt for dialysis in the ipsilateral arm.

  Arteries can calcify producing dense, linear calcifications ("tram-like"). When arteries start to calcify, linear calcifications involving one portion of vessel wall may be confused with malignant-type (linear) calcifications. Magnification views may be needed to establish the vascular nature of the calcifications (the vessel can be seen coming into and going out of calcifications, or the noncalcified portion of vessel wall can be seen).

  Smaller vessels (arterioles or capillaries) also calcify, producing "quirky" calcifications. Subtle central lucency is usually seen on magnification views.

  Arterial calcifications usually develop in older women (postmenopausal). When they occur in younger patients, consider an underlying metabolic disorder (e.g., diabetes) or significant arteriosclerotic vascular disease and describe in mammography report.

  Rarely, if underlying etiology is addressed, arterial calcifications can disappear.

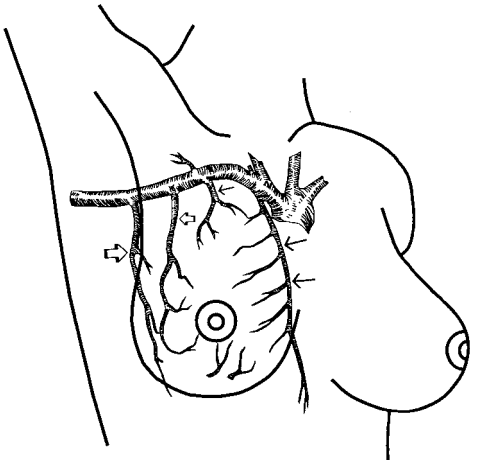


**FIGURE 14-2** Vascular supply. Internal mammary artery (*large arrows*); thoracoacromial (*small arrow*); lateral thoracic artery (*small open arrow*) and thoracodorsal artery (*large open arrow*). (Modified from: Cardenosa G, Eklund GW. Imaging the altered breast. In: Taveras JM, Ferucci JT, eds. *Radiology: Diagnosis, Imaging Intervention*. Philadelphia: JB Lippincott; 1994).

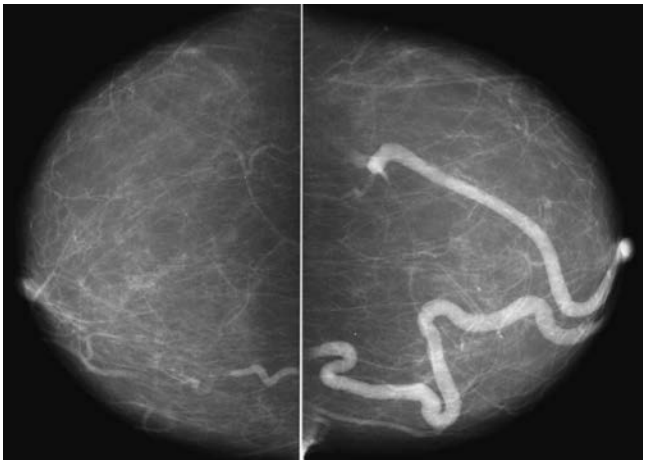
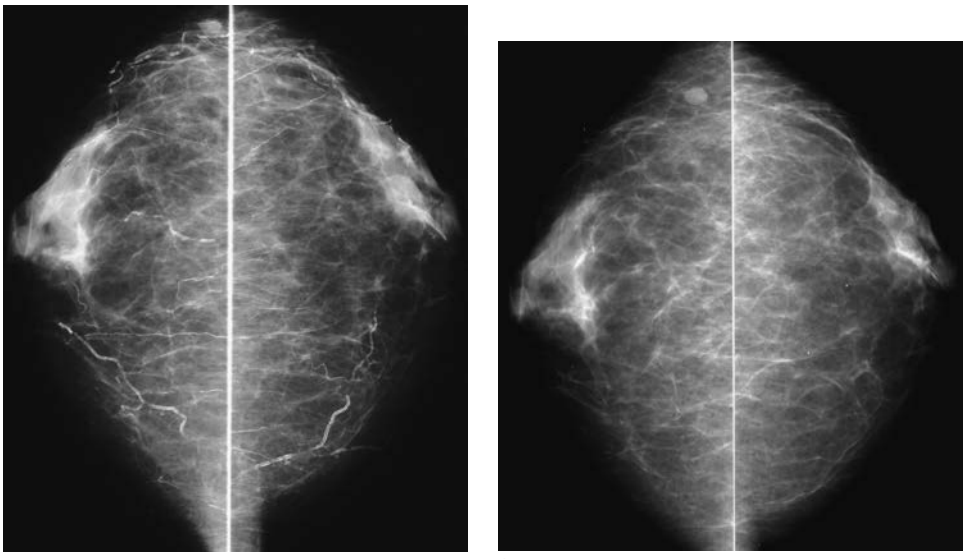


**FIGURE 14-3** Prominent veins, left breast. Although dilated veins have been described with underlying breast cancer, they are usually a normal variant. Axillary, mediastinal, or cardiac processes with associated development of collateral flow may also lead to dilated veins. In these patients, other changes in the breast (e.g., increased density, prominence of the trabecular markings) are usually present in addition to the venous dilatation.



A B

**FIGURE 14-4** Arterial calcifications developing in a patient on dialysis. **(A)** Arterial calcifications. Variable vessel size. Generally seen in older postmenopausal women. In younger women, arterial calcifications may reflect the presence of an underlying metabolic disorder (e.g., diabetes). **(B)** Craniocaudal views from 2 years previously illustrate how rapidly arterial calcifications can develop. In some patients, as the underlying metabolic disorder is treated, vascular calcifications can resolve. An intramammary lymph node is present laterally in the right breast.

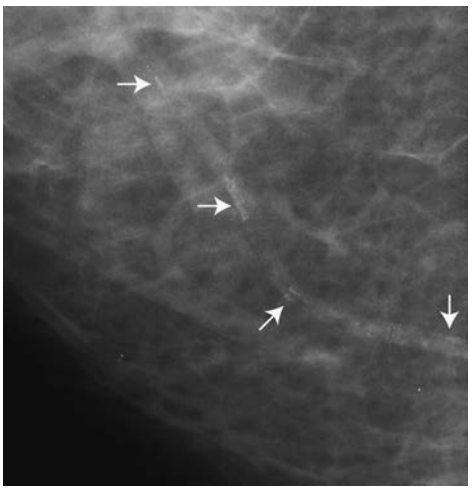


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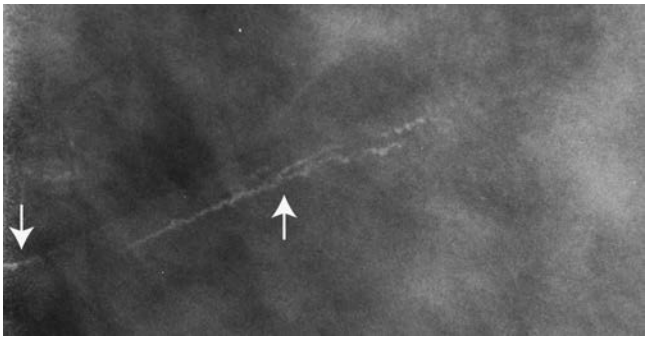
**FIGURE 14-5** Arterial calcifications, early stage. **(A)** Linear calcifications (*arrows*) developing on arterial wall. Contralateral arterial wall is seen with no calcification.



**B**

**FIGURE 14-5** (*Continued*) **(B)** Irregular linear calcifications (*arrows*) developing in arterial wall. Contralateral arterial wall is seen with no calcification. Noncalcified vessel is seen coming into and going out of the area of calcifications.

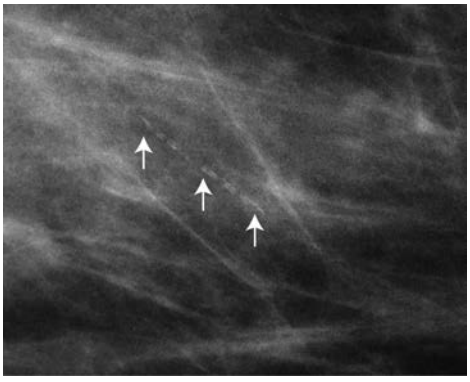


**FIGURE 14-6** Arterial calcifications. Arterial calcifications (*arrows*) involving smaller vessel. Lucent center.

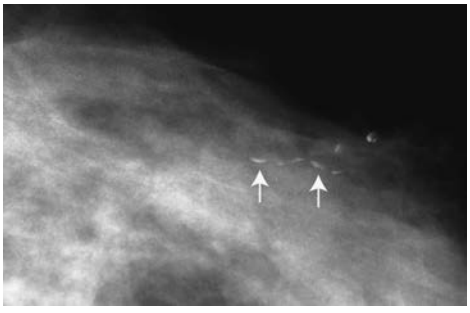


**FIGURE 14-7** Small vessel (*arrows*) calcification (quirky). More common in younger, otherwise healthy patients with dense breast tissue. On follow-up studies, calcifications can resolve completely. Magnification views may be needed to establish vascular etiology.

## Lymph Nodes

- Lymphatic drainage.

  From superficial to deep toward regional lymph nodes via a plexus of thin walled, valveless vessels; in the absence of obstruction, flow is unidirectional.

  All quadrants of the breast drain to both axillary and internal mammary lymph nodes.

  Of the lymphatic drainage, 75% goes to axillary lymph nodes.

  The remaining 25% goes to the internal thoracic lymph node chain.

  Isolated drainage to the internal mammary nodes is uncommon; 5% incidence of metastases isolated to this group of nodes alone.

  Supraclavicular nodes are contiguous with level III axillary lymph nodes; direct lymphatic drainage occurs, however, metastatic involvement is uncommon without extensive involvement of the axillary lymph nodes.

  Rotter's nodes: interpectoral nodes between the pectoralis major and minor muscles; rarely (0.5%) involved without extensive involvement of axillary lymph nodes.

- Mammography.

  Lymph nodes usually occur in the upper outer quadrant of the breast, but they can be seen anywhere in the breast, including medially and inferiorly.

  A fatty hilum should be demonstrated in a mass before assuming it is a lymph node.

  Demonstrating a fatty hilum may require spot compression views.

  Can fluctuate in size. If a benign appearance is maintained, lymph nodes that demonstrate small increases in size in patients with no history of an underlying malignancy can be followed mammographically.

  Loss of the fatty hilum, increase in density, rounding out, loss of marginal definition, or spiculation should suggest an ongoing pathologic process in the lymph node, such as metastatic disease, lymphoma, inflammatory process or connective tissue disorders (e.g., rheumatoid arthritis, systemic lupus, sarcoid, tuberculosis or psoriasis).

  High association with malignancy reported in dense lymph nodes with ill-defined or spiculated margins measuring more than 33 mm.

  Coarse calcifications in lymph nodes are associated with a history of granulomatous disease and although there are sporadic case reports of metastatic breast cancer producing microcalcifications in lymph nodes, this is rare. Ovarian and thyroid carcinomas metastatic to the axillary lymph nodes may have associated punctate calcifications (psammoma bodies).

  In women with rheumatoid arthritis treated with gold, small, high density particles (gold) may precipitate in the axillary lymph nodes, bilaterally.

- Ultrasound.

  Well-circumscribed, round, or oval hypoechoic mass with a central echogenic area (fatty hilum).

In patients with known malignancy, we routinely ultrasound the ipsilateral axilla, parasternal area, and supraclavicular region. Lymph nodes with increased cortical width and bulging, mass effect on, or loss off, the echogenic hilar region and increased blood flow warrant either fine needle aspiration or core biopsy. If metastatic disease is identified percutaneously, a full axillary dissection is done at the time of surgery bypassing the need for a sentinel lymph node biopsy.

Intramammary lymph nodes found to have metastatic disease should be localized at the time of definitive surgery because intramammary lymph nodes are not usually removed during sentinel lymph node biopsy.

- Magnetic resonance imaging.

  Well circumscribed, round, or oval.

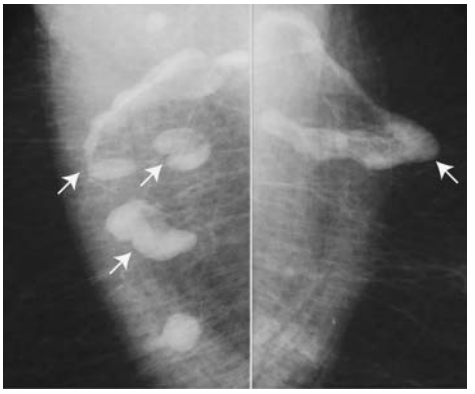
  Vessels commonly seen in hilar region.

  Bright on T2-weighted images (low signal from hilar region on fat suppressed images).

  T1-weighted: low signal intensity; bright signal of fatty hilar region on non-fat suppressed images.

  Rapid initial enhancement and washout.

  Can be used to assess axillary, supraclavicular, and internal mammary lymph nodes.



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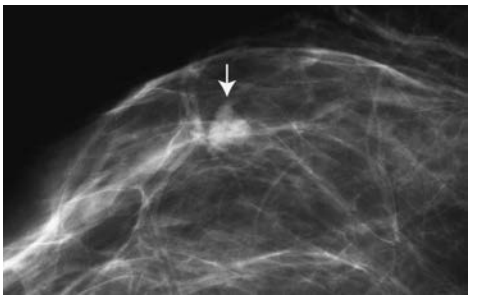

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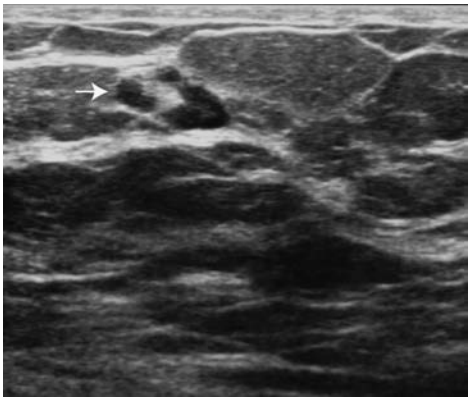

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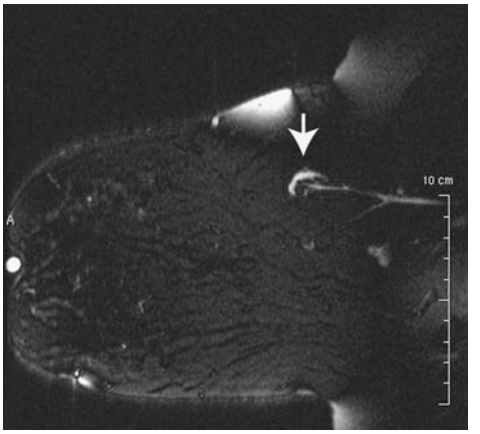


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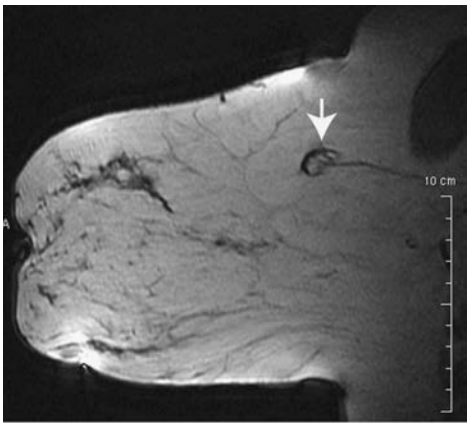


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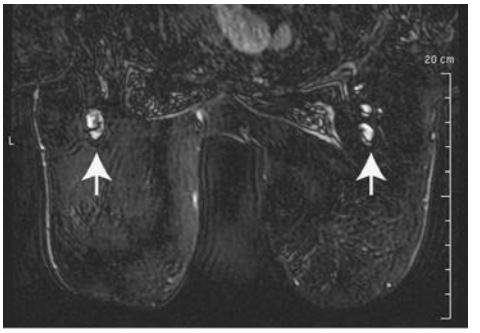



F

**FIGURE 14-8** Lymph nodes. **(A)** Multiple masses (*arrows*) of mixed density right axilla, one in left axilla. No fatty hilum is apparent in two of the masses in the right axilla; however, these are unchanged compared with prior studies (not shown). Size and proportion of soft tissue to fatty hilum are variable. **(B)** Different patient. Lobular mass (*arrow*) with circumscribed margins. Lymph nodes can vary in size between examinations, sometimes going away completely only to reappear on subsequent studies. **(C)** Hypoechoic lobular mass (*arrow*) with central area of echogenicity (fatty hilum). **(D)** Different patient. Sagittal T2-weighted image, fat suppression. Lymph node (*arrow*) demonstrating bright signal intensity. Low signal intensity associated with fatty hilar region. Vessel (bright signal, linear) entering at hilar region. **(E)** Corresponding sagittal T1-weighted image. Lymph node (*arrow*). Low signal intensity. Bright signal from fatty hilar region; vessel entering hilar region. **(F)** Subtraction axial image. Several lymph nodes (*arrows*) demonstrating rapid initial enhancement and wash out of contrast bilaterally.

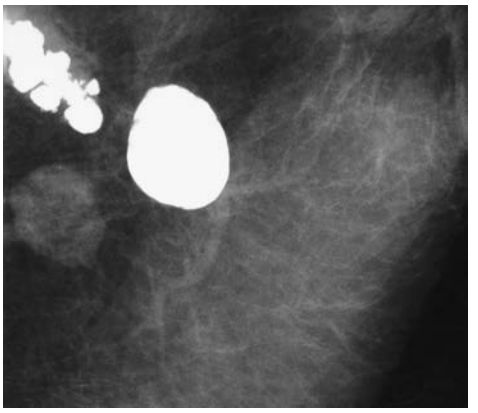


**FIGURE 14-9** Calcified lymph nodes. Coarse calcifications involving axillary lymph nodes in a woman with a history of granulomatous disease. Another, noncalcified lymph node (mixed density mass) is seen inferiorly.

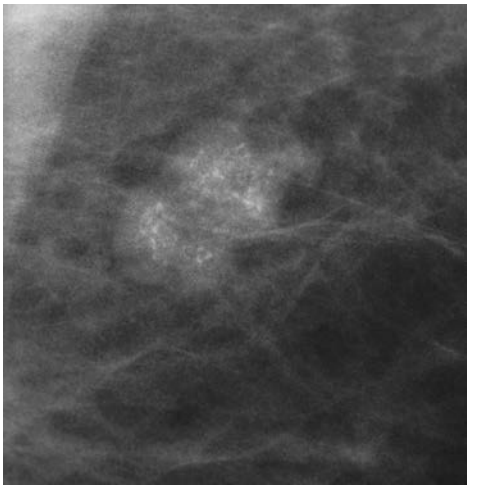
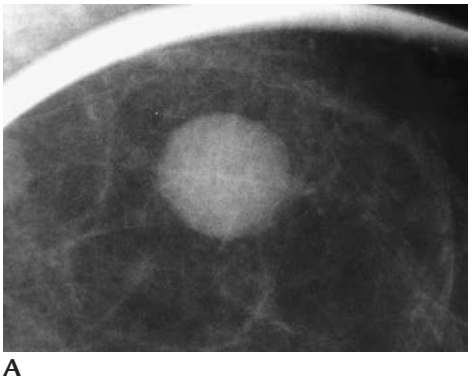


**FIGURE 14-10** Gold. Intramammary lymph node with particles of gold. This patient with rheumatoid arthritis was treated with gold. Particles are dense, even the small ones. Usually affects lymph nodes bilaterally.



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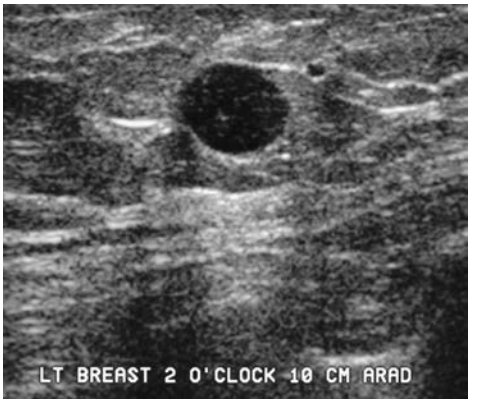
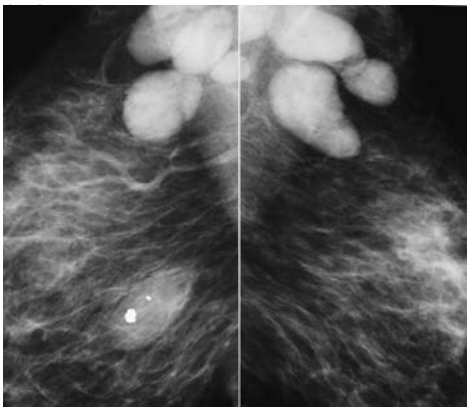



B

**FIGURE 14-11** Reactive lymph node. **(A)** Spot compression view. Round mass with circumscribed margins. **(B)** Round markedly hypoechoic mass with circumscribed margins and posterior acoustic enhancement. Lymphoid tissue with no malignancy reported histologically.



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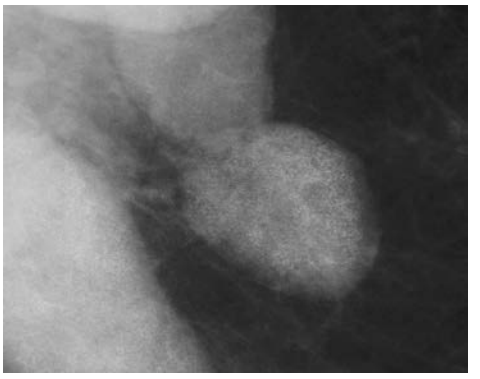
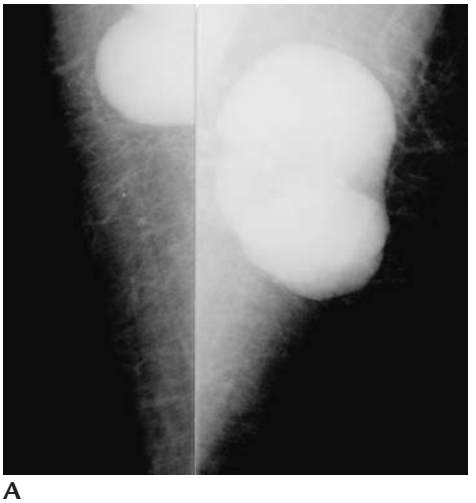


B

**FIGURE 14-12** Sarcoidosis. **(A)** Enlarged, dense axillary lymph nodes bilaterally in a patient with sarcoidosis. Also noted in the right breast is an oval mass with coarse calcifications consistent with a hyalinizing fibroadenoma. **(B)** Photographic coned down view of some of the left axillary lymph nodes demonstrating the presence of amorphous, low density calcifications in two of the enlarged lymph nodes.



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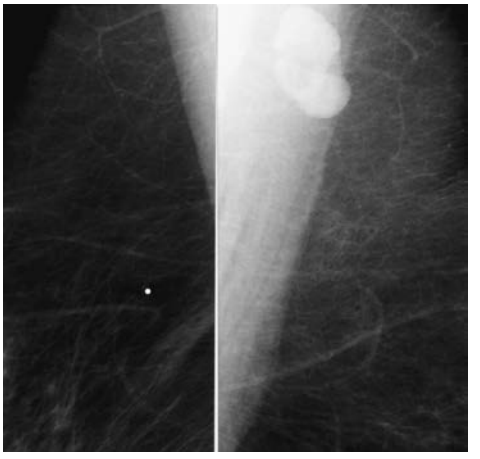

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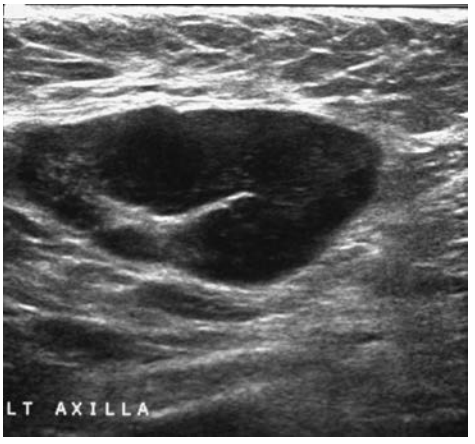



C

**FIGURE 14-13** Lymphoma. **(A)** Dense nodes in the axilla bilaterally. **(B)** Prior mammogram for comparison. Changes in pre-existing lymph node on the left include increase in size and density. **(C)** Ultrasound, left axilla demonstrates a markedly hypoechoic mass with thickening of the hypoechoic cortex, a bulging contour and attenuation of the central fatty hilum.

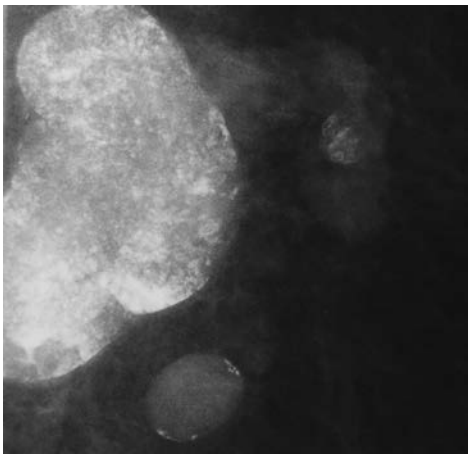
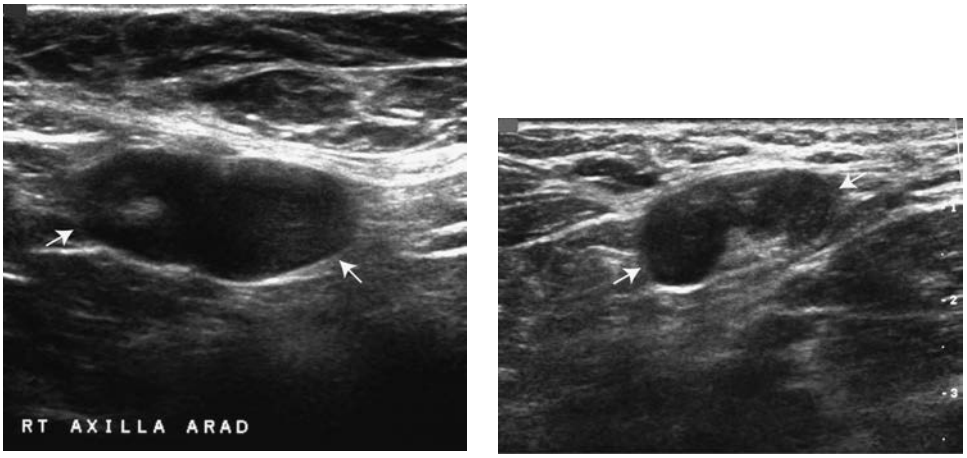
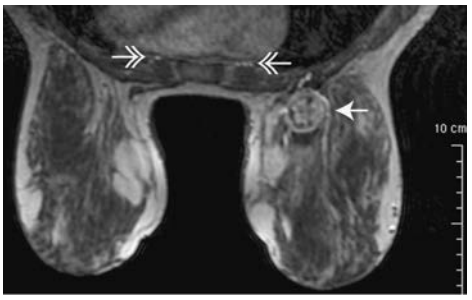


**FIGURE 14-14** Metastatic ovarian cancer. Amorphous calcifications involving an enlarged axillary lymph node. Histologically the calcifications in these patients are usually psammoma bodies. Calcifications are present in two smaller adjacent lymph nodes.




**A** **B**

**FIGURE 14-15** Metastatic breast cancer. **(A)** Axillary lymph node (*arrows*) demonstrating thickening of hypoechoic cortex with bulging contour and attenuation of fatty hilar region. **(B)** Different patient. Axillary lymph node (*arrows*) with thickened cortex and attenuation of fatty hilum. Although these changes can be seen in reactive lymph nodes, we do either core biopsy or fine needle aspiration through axillary lymph nodes with these changes in patients with an underlying breast cancer.

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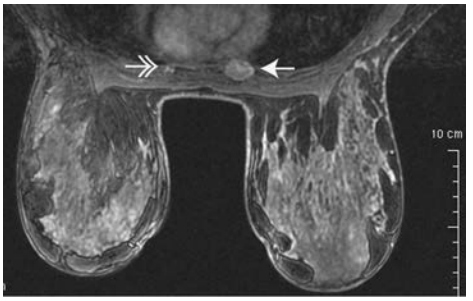


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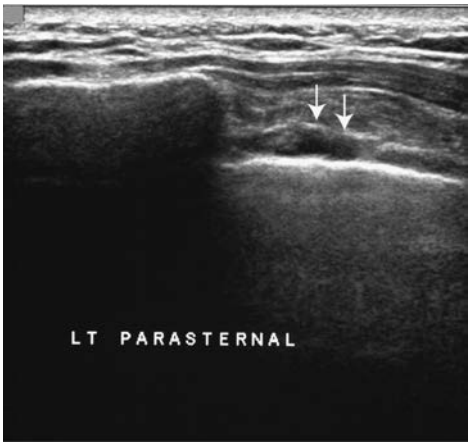


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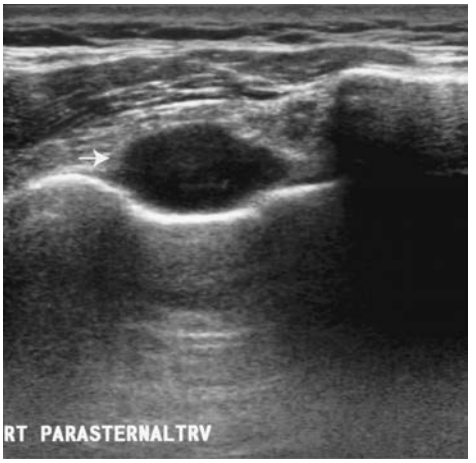


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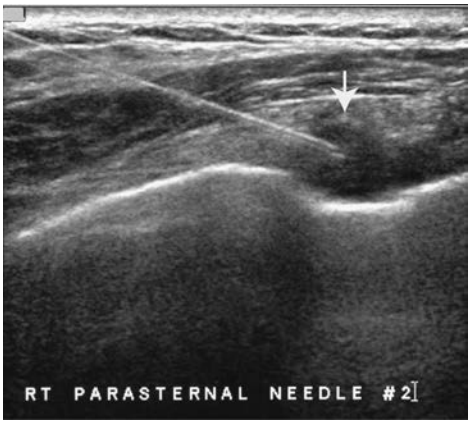


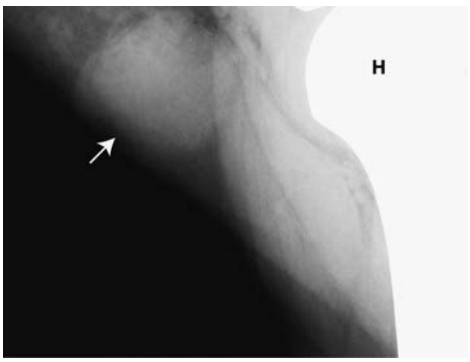

E

**FIGURE 14-16** Internal mammary lymph node metastasis, invasive ductal carcinoma, poorly differentiated. **(A)** Magnetic resonance imaging (MRI). Delayed T1-weighted axial image. Round mass (*arrow*) with rim enhancement corresponding to invasive ductal carcinoma. Normal internal mammary vessels (*double headed arrows*) at this level. **(B)** Delayed T1-weighted image. Lower down an enhancing mass (*arrow*) is identified associated with the right internal mammary vessels. Normal internal mammary vessels on left side (double headed arrow). **(C)** Ultrasound through left parasternal region demonstrates normal internal mammary vein and artery (*arrow*). **(D)** Ultrasound through right parasternal area demonstrates oval hypoechoic mass (*arrow*) correlating to the MRI finding. **(E)** Fine needle aspiration right internal mammary lymph node (*arrow*) confirming the presence of metastatic disease. Tip of needle is in the lymph node.

# Cat Scratch Disease

## Key Facts

- Clinical.
  Benign, self limited infection.
  Regional, usually unilateral, lymphadenopathy.
  Enlarged, tender lymph nodes.
  Cat (or kitten) scratches may be apparent on ipsilateral arm.
  Causative agent: Bartonella henselae.
  Seasonal variation: September to January.
- Mammography.
  Enlarged axillary lymph nodes, usually unilateral.
  Increased size and density with loss of fatty hilum.
- Ultrasound.
  Increased cortical width, bulging contour and attenuation of echogenic hilar region.
  Increased vasculature.

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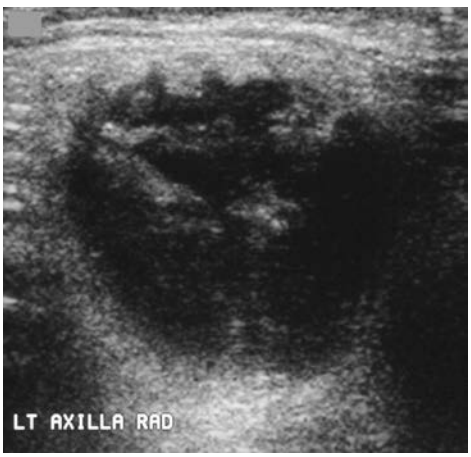


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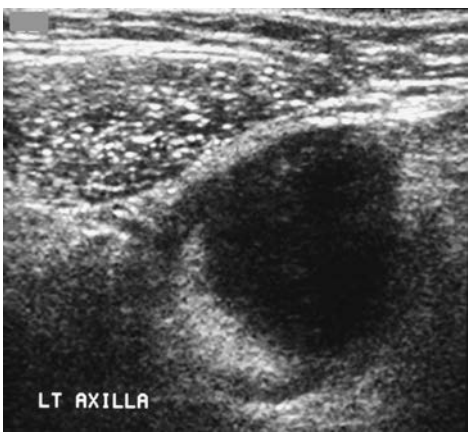


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**FIGURE 14-17** Cat scratch disease. **(A)** Spot tangential view of palpable mass in right axilla. Round mass (*arrow*) with circumscribed margins. Humeral *(H)* head is seen on image. **(B)** Axillary lymph node demonstrating microlobulated margins, heterogeneous echotexture and posterior acoustic enhancement. Normal lymphoid architecture is lost. **(C)** Different patient. Axillary lymph node demonstrating a thickened cortex with bulging contours. Attenuated crescent shaped fatty hilar region is seen inferolaterally.

## Fat Necrosis

### Key Facts

- Clinical.

  Nonsuppurative inflammatory process related to trauma or surgery.

  Asymptomatic in most women.

  Palpable mass rarely causes skin retraction when symptomatic.

  Less commonly associated with ecchymosis, erythema, induration, skin thickening, and adenopathy.
- Mammography.

  Mass (dense center) with spiculated or indistinct margins.

  Mass with variable amounts of central lucency (mixed density) and spiculated or indistinct margins.

  Irregular mass with or without associated calcifications.

  Typically, areas of fat necrosis stabilize or progressively decrease in size; rarely fat necrosis may increase in size on subsequent mammograms.

  Oil cysts: round or oval, smooth-bordered (thin "capsule") lucent mass; some may have an irregular soft tissue margin; calcification of fibrous rim (eggshell or rim calcifications) or thin, wavy, linear calcifications. They may progressively decrease in size.

  Cluster of microcalcifications: pleomorphic (indeterminate).

  Coarse microcalcifications (in some women may develop in oil cysts or masses).

  After seat belt injury, a band-like area of increased density occurs. If the patient was the driver, findings are localized to the upper inner or central part of left breast or the lower inner part of the right breast. If the patient was a front-seat passenger, findings are localized to the upper inner part of right breast or the lower inner part of left breast.
- Ultrasound.

  When the mammographic finding is a spiculated mass, an irregular, hypoechoic mass with a variable amount of shadowing is found on ultrasound.

  When the mammographic finding is an oil cyst, an anechoic, round, well-circumscribed mass is found on ultrasound with or without posterior acoustic enhancement or shadowing.

  Complex mass with internal echoes, septations, or an intracystic soft-tissue component.

  Solid mass.
- Magnetic resonance imaging.

  Mass, low signal intensity on T1-weighted pre-contrast images.

  Variable appearance on T1-weighted post-contrast images; acutely findings may be indistinguishable from those of malignancy.

  Nonfat suppressed T1-weighted images demonstrate central bright signal intensity in rim enhancing lesion.
- Histology.

  Fat cell death with vacuole formation.

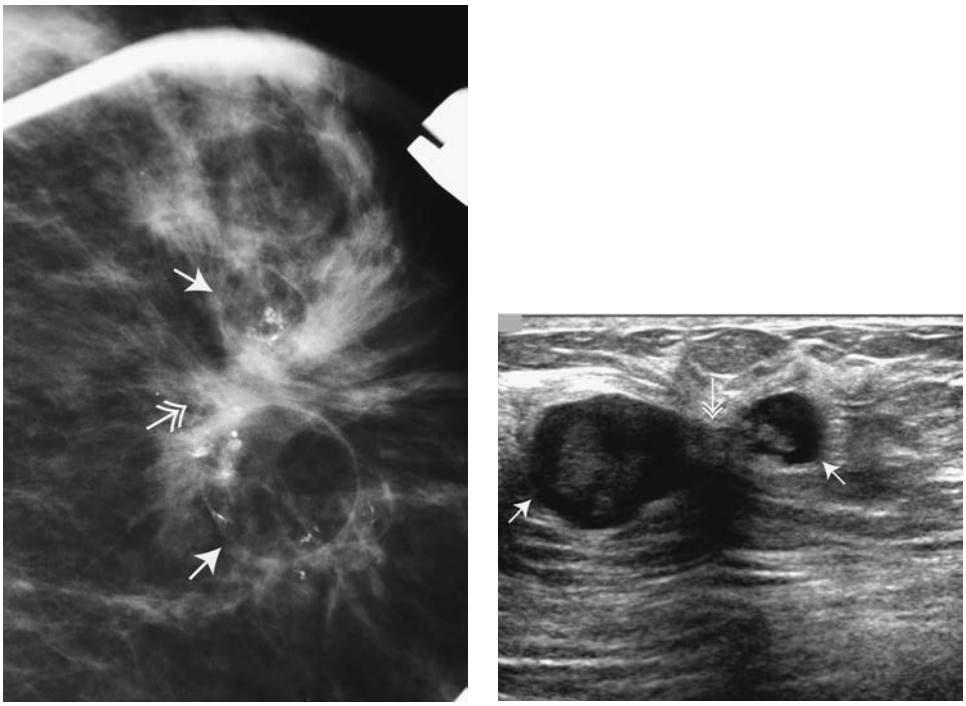
Fibroblasts, lipid laden macrophages, and multinucleated giant cells surround dying fat cells.

Fibrosis.

Calcifications may develop, initially pleomorphic; with regression they may solidify, the end point being coarse dystrophic calcifications.

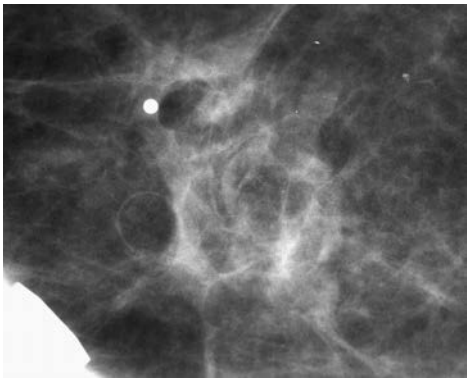
## Oil Cysts

- Liquefaction of fatty tissue (contents: triglycerides).
- It is unclear if these all arise from fat necrosis. Given their presence in patients with steatocystoma multiplex, some may arise independent of trauma or surgery.
- May be palpable (hard mass).
- Mass containing fat (lucent) with circumscribed margins.
- Mass containing fat (lucent) and soft tissue component or fat-fluid level.
- Some develop thin mural calcifications (eggshell) others, coarser curvilinear (wavy) calcifications.
- Nearly anechoic mass on ultrasound; some are anechoic with hyperechoic intracystic soft tissue component (complex cystic mass).
- Thick oily material obtained on aspiration.



A B

**FIGURE 14-18** Fat necrosis. **(A)** Spot compression view. Mass (*double headed arrow*) with spiculated margins flanked by oil cysts (*arrows*) developing at a prior biopsy site. Coarse calcifications are present in the oil cysts. **(B)** Mass with associated shadowing (*double headed arrow*) corresponding to spiculated mass seen mammographically. Fat necrosis diagnosed on biopsy. Complex cystic masses (*arrows*), a common ultrasound appearance for oil cysts, flanking spiculated mass (*double headed arrow*).



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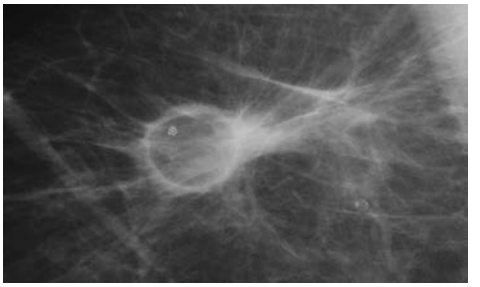
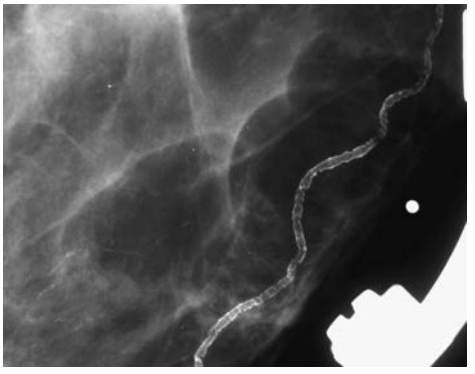


B

**FIGURE 14-19** Fat necrosis. **(A)** Cluster of masses containing fat (lucent) with irregular margins corresponding to palpable finding (metallic BB) at prior site of trauma. **(B)** Different patient. Mass with spiculated margins and fatty (lucent) center. Although the margins are spiculated, given the fat content no further intervention or follow-up is indicated.



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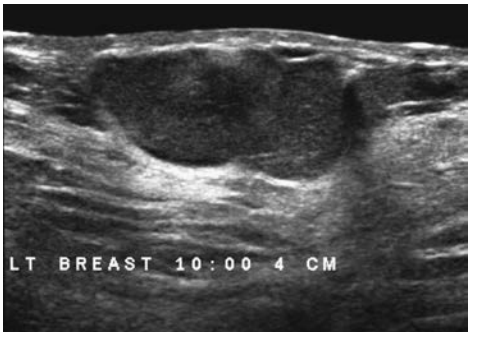
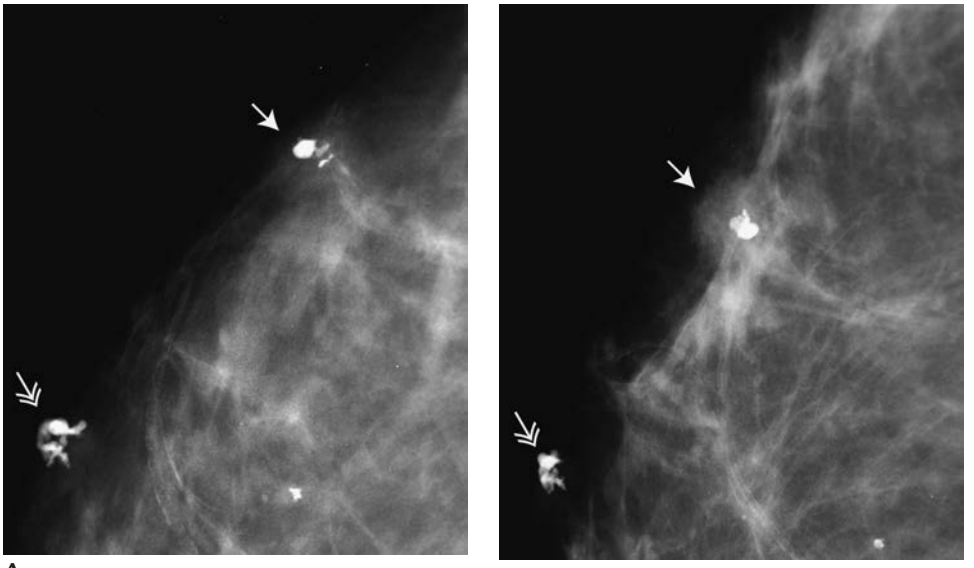


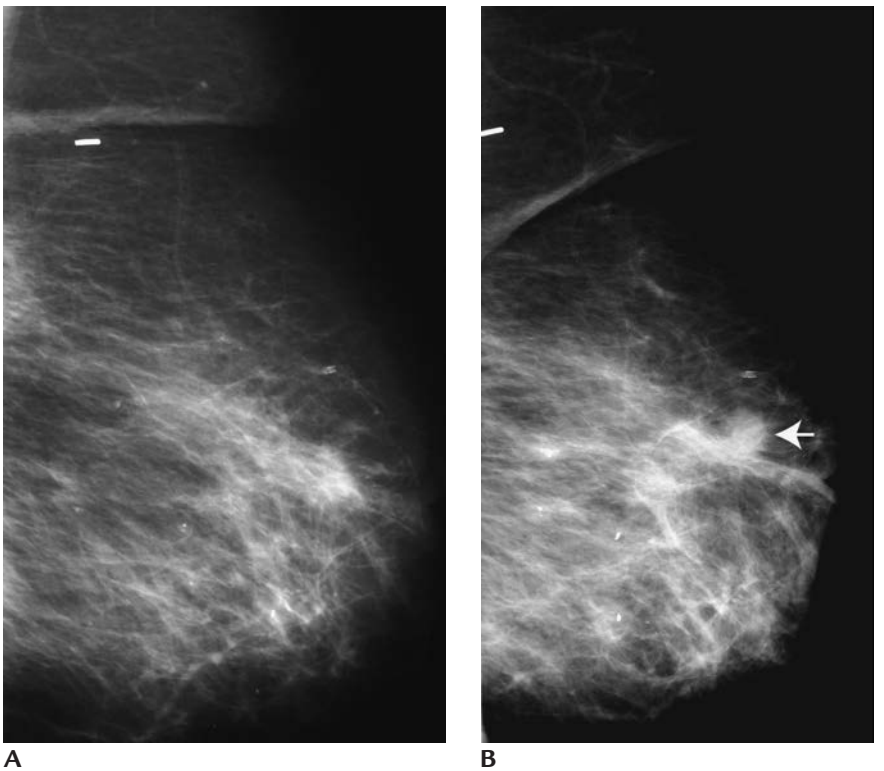

B

**FIGURE 14-20** Fat necrosis. **(A)** Cluster of masses containing fat (lucent) corresponding to palpable finding (metallic BB). Arterial calcification is present. **(B)** Lobular mass with circumscribed margins and posterior acoustic enhancement.



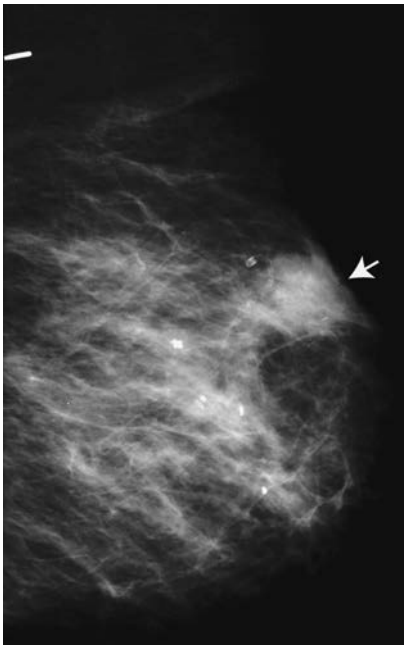
A B

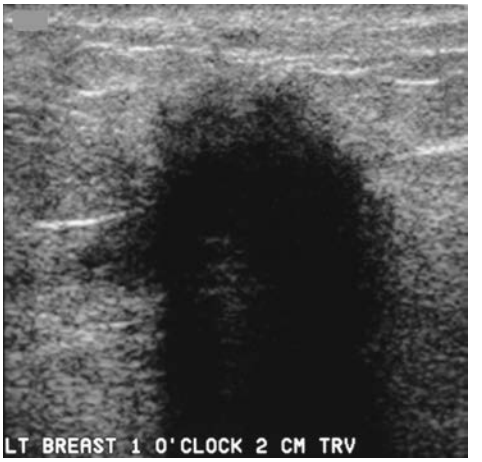
**FIGURE 14-21** Fat necrosis. **(A)** Two areas of dystrophic calcifications (*arrow*, *double headed arrow*) at lumpectomy site. **(B)** Subsequent mammogram demonstrates mass developing in association with one of the calcifications (*arrow*). Fat necrosis diagnosed on core biopsy. Although fat necrosis typically stabilizes or resolves on sequential mammograms, rarely it can increase in size on follow up mammograms.



A B

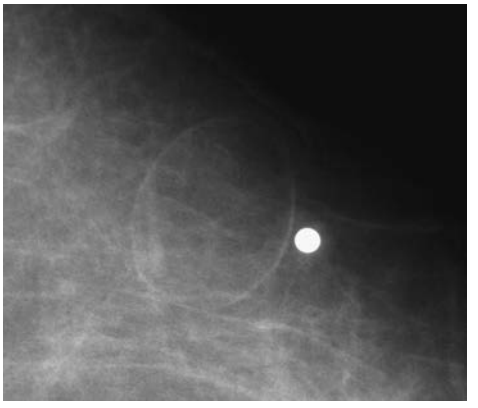
**FIGURE 14-22** Fat necrosis. **(A)** Mediolateral oblique view, following lumpectomy. **(B)** Follow up mammogram a year later demonstrates a new mass (*arrow*). Fat necrosis diagnosed on biopsy.

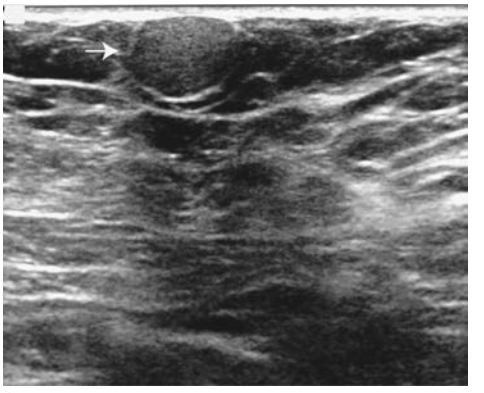





**C** **D**

**FIGURE 14-22** (*Continued*) **(C)** Mammogram a year after **(B)**. Mass has increased in size. **(D)** Hypoechoic mass with posterior acoustic shadowing. Excisional biopsy confirms diagnosis of fat necrosis. Although fat necrosis typically stabilizes or resolves on sequential mammograms, rarely it can increase in size on follow up mammograms.





**A** **B**

**FIGURE 14-23** Oil cyst. **(A)** Oval mass, fat (lucent) containing with circumscribed margins corresponding to hard, palpable "lump" described by the patient (*metallic BB*). Fatty masses are benign lesions. **(B)** Oval iso- to slightly hyperechoic mass (*arrow*) corresponding to palpable finding. The benign diagnosis is established mammographically and, although the ultrasound is included out of interest, it is not indicated.

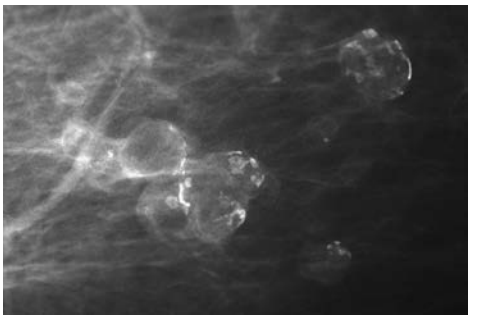
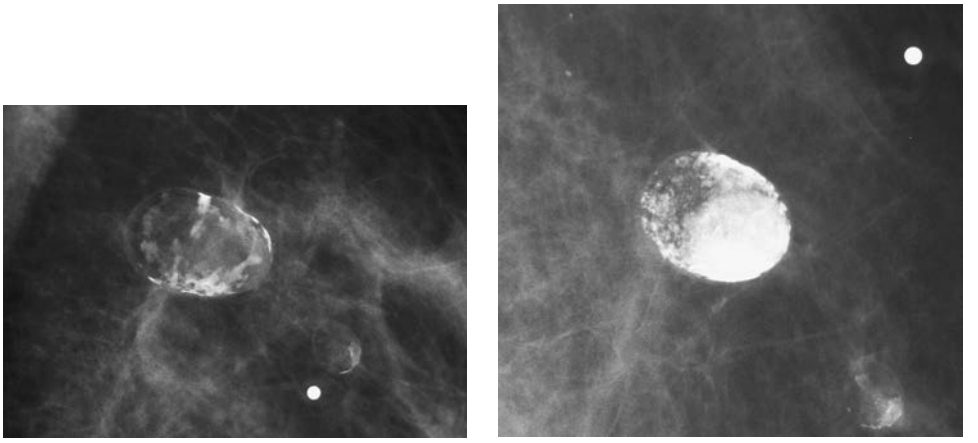
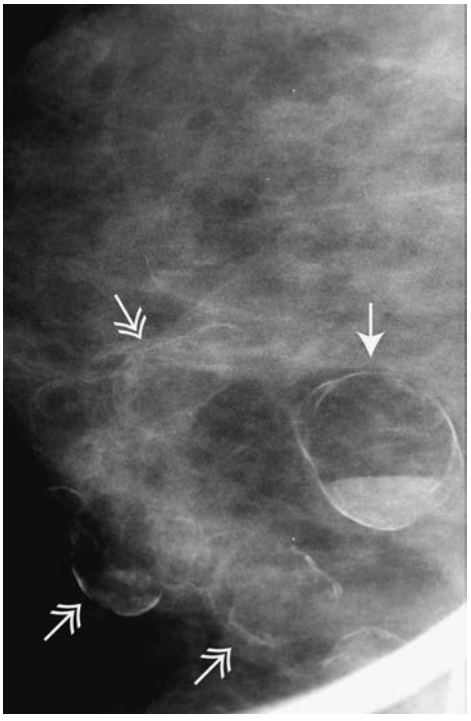


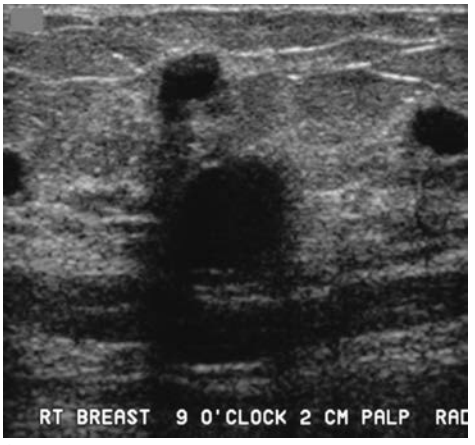
**FIGURE 14-24** Oil cysts. Cluster of fat containing masses with circumscribed margins and coarse calcifications.



**A** **B**

**FIGURE 14-25** Oil cysts. **(A)** Two adjacent masses with mural, dense calcifications. Metallic BB used to indicate palpable finding. The benign diagnosis is established mammographically and ultrasound is not indicated. **(B)** A year later, the larger of the two masses has decreased in size and calcification has progressed. Metallic BB used to indicate palpable finding.





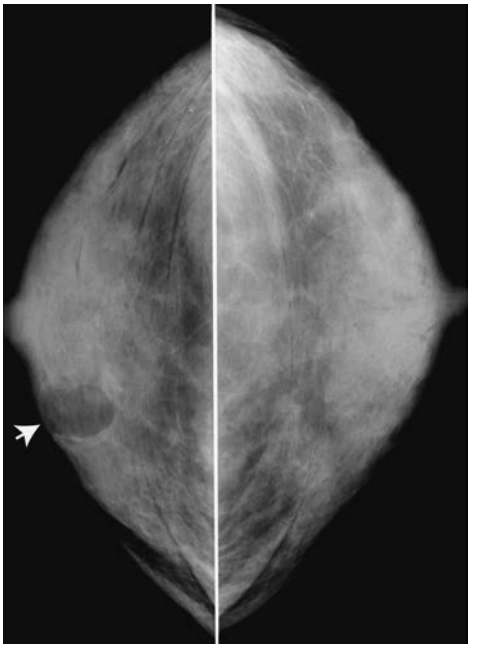

A B

**FIGURE 14-26** Oil cysts. **(A)** Cluster of fat containing masses (*double headed arrows*) with rim-like calcifications. One of these (*arrow*) has a fat-fluid level. **(B)** Anechoic masses some with posterior acoustic shadowing are imaged on ultrasound. Given the presence of fat containing masses mammographically, ultrasound is not indicated (included here out of interest).

# Lipoma

## Key Facts

- Clinical.
  Common.
  Asymptomatic.
  Usually unilateral; bilateral in 3%.
  Palpable, soft mass.
- Mammography.
  May occur in the breast or in the pectoral muscle.
  Fatty tissue (lucent) with apparent thin fibrous capsule.
  May demonstrate mass effect on surrounding tissue.
- Ultrasound.
  Homogenous hypo- to slightly hyperechoic mass (compared with oil cysts which are nearly anechoic).
  Usually oval and well circumscribed.
- Magnetic resonance imaging.
  Mass with circumscribed margins and high signal intensity on T1-weighted images (no fat suppression); no contrast enhancement.
  Signal on T2-weighted images similar to that of subcutaneous fat.
- Histology.
  Well circumscribed, yellow mass.
  Mature lipocytes.
  Must see at least a delicate thin capsule.



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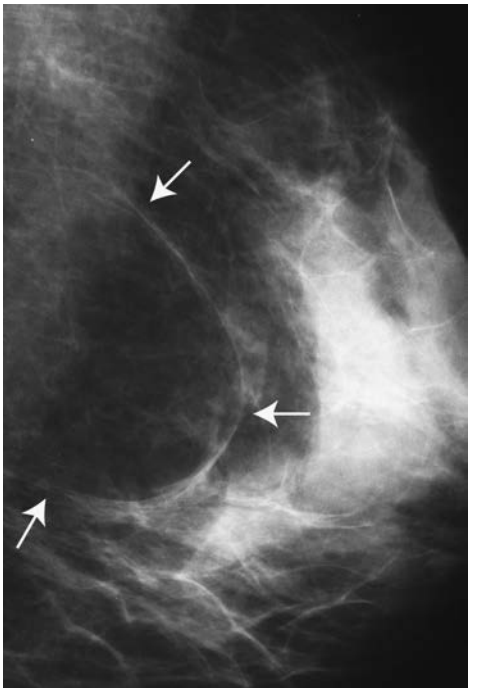

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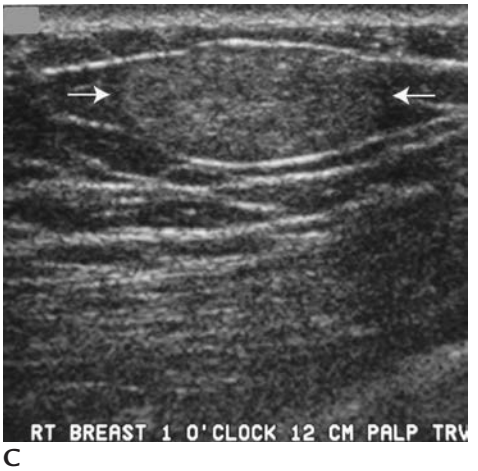
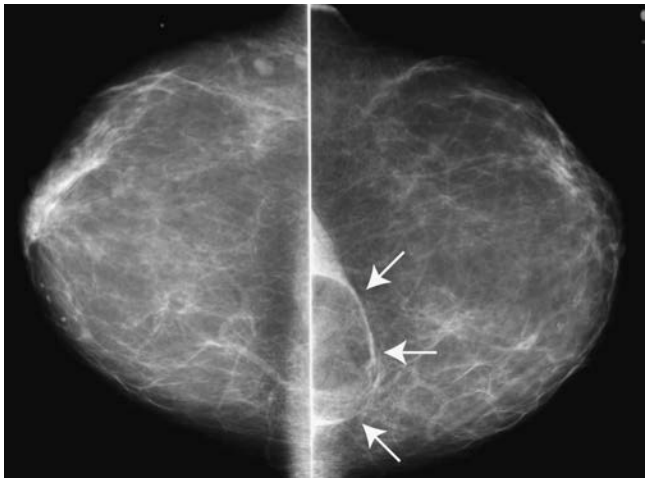



C

**FIGURE 14-27** Lipomas. **(A)** Oval mass (*arrow*), fat containing, with circumscribed margins. **(B)** Different patient. Oval mass, fat containing, delineated by thin pseudocapsule (*arrows*). Lucent masses in the breast are benign. **(C)** Different patient. Homogeneously hyperechoic oval mass (*arrows*) with circumscribed margins. Unlike oil cysts that are often anechoic or complex cystic in appearance, lipomas are solid on ultrasound.



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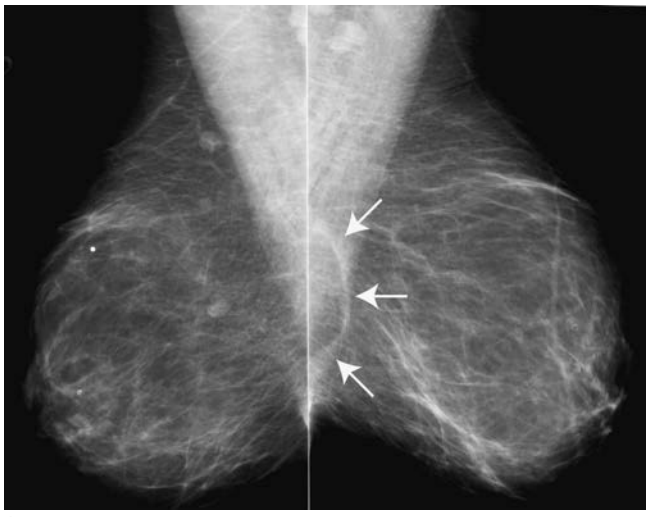


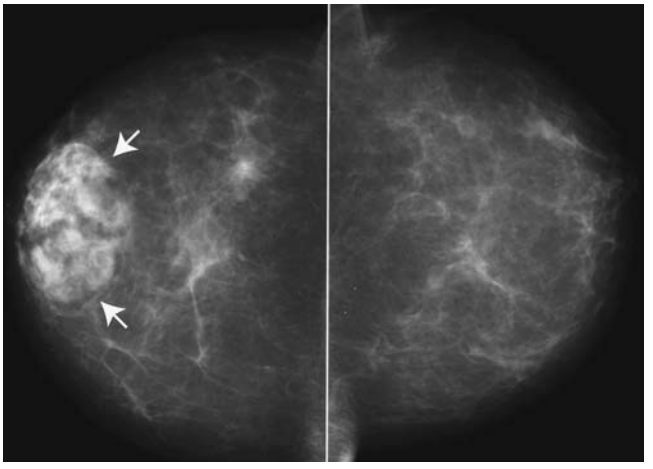
B

**FIGURE 14-28** Lipoma. **(A)** Craniocaudal views. Fat containing mass involving the medial aspect of the pectoral muscle (*arrows*). The mass is altering the contour of the muscle. **(B)** Mediolateral oblique views. Fat containing mass (*arrows*), intrapectoral. Intramammary and axillary lymph nodes bilaterally.

## HAMARTOMA (FIBROADENOLIPOMA)

### KEY FACTS

- Clinical.
  "Breast within a breast."
  Palpable mass.
- Mammography.
  Seemingly encapsulated glandular and fatty tissue.
  Breast cancer can arise in the glandular elements of a hamartoma.
- Ultrasound.
  Heterogeneous echotexture: round and oval hypoechoic areas surround by hyperechoic tissue.
  Normal breast tissue with no distinctive features.
- Histology.
  Variable, partial, or complete encapsulation of normal breast tissue. Fibrocystic changes, including cyst formation and sclerosing adenosis, may be seen within nodule.
  Overgrowth of mature breast cells and tissue; one element may predominate.



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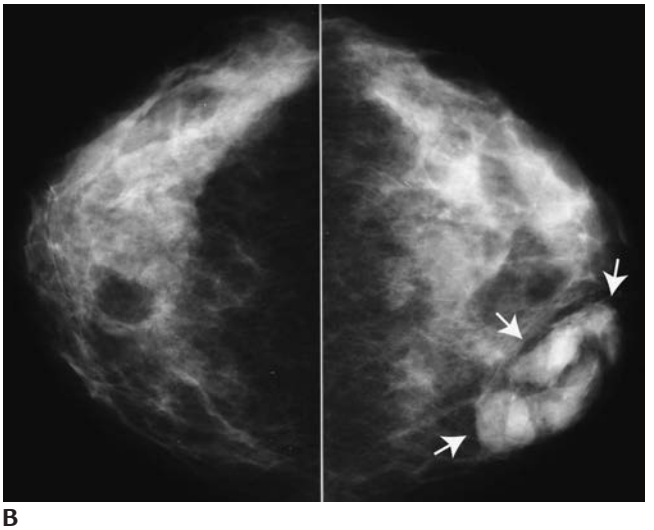
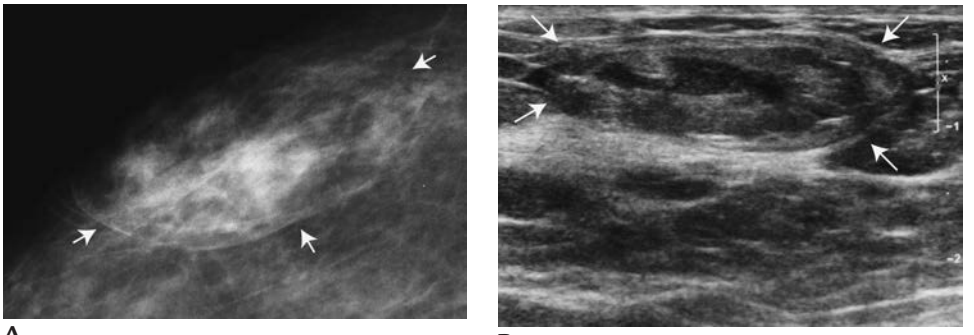


B

**FIGURE 14-29** Hamartoma (fibroadenolipoma). **(A)** Craniocaudal views. Oval mass (*arrows*) containing fat (mixed density) in the right subareolar area. Seemingly encapsulated glandular and fatty tissues. **(B)** Different patient. Craniocaudal views. Oval mass (*arrows*), containing fat (mixed density) in the left subareolar area. Glandular and fatty tissues delineated by pseudocapsule. The proportion of fatty to glandular elements varies among lesions. Mixed density (fat containing) masses are usually benign.



A B

**FIGURE 14-30** Hamartoma (fibroadenolipoma). **(A)** Oval mass (*arrows*) with glandular and fatty elements (*arrows*) laterally in the right breast ("breast within a breast"). These are sometimes palpable. **(B)** Oval mass with heterogeneous echotexture (*arrows*) and associated posterior acoustic enhancement corresponding to mammographic finding. Oval areas of hypoechogenicity surrounded by more echogenic tissue.

## FIBROSIS

### KEY FACTS

- Clinical.
  Palpable, hard mass.
  May be bilateral (15% to 20%).
  More common in premenopausal women.
  In some women, associated with diabetes, thyroiditis, arthropathy, renal disease; in others, idiopathic.
- Mammography.
  Mass with circumscribed to ill-defined to spiculated margins in more than 50% of patients.
  Architectural distortion or parenchymal asymmetry less likely.
  May be lobulated.
  Coarse calcifications.
  Reported in 4% to 15% of women undergoing imaging guided needle biopsies.
- Ultrasound.
  Hypo- or isoechoic mass with circumscribed margins; in some, margins may be angular or spiculated and not circumscribed.
  Hypoechoic mass with central hyperechogenicity (may simulate lymph node).
  Intense shadowing that may not be associated with a mass.
  Complex cystic mass.
- Histology.
  Localized, poorly defined areas of stromal fibrosis involving intra- or interlobular stroma.

Obliteration of ducts and lobules.

Variable, lymphocytic infiltrate.

Possible autoimmune etiology in some patients.

Depending on sampling, hyalinizing fibroadenomas may be inappropriately diagnosed as fibrosis.

Nonspecific histologic features may be incidental finding (i.e., not forming a mass).

Terms used interchangeably by pathologists for this entity include *focal fibrosis*, *fibrous disease*, *fibrous mastopathy*, *breast sclerosis*, *fibrous mastopathy*.

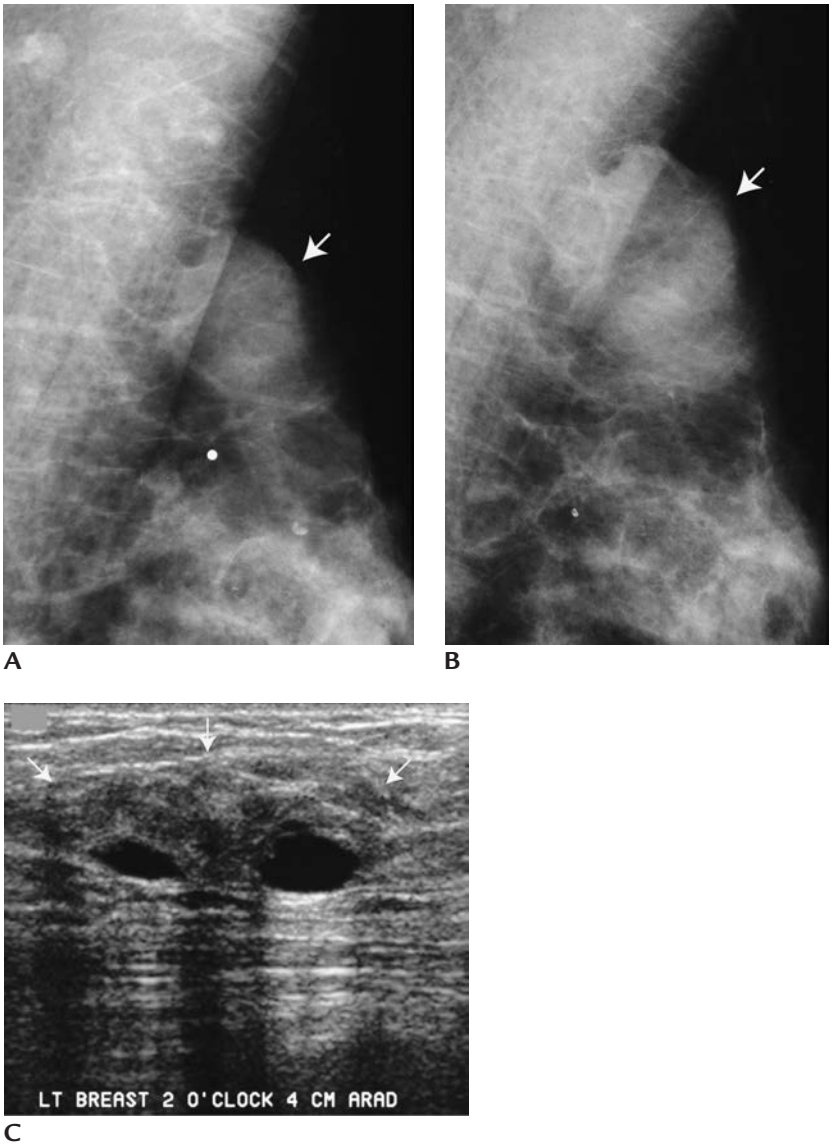
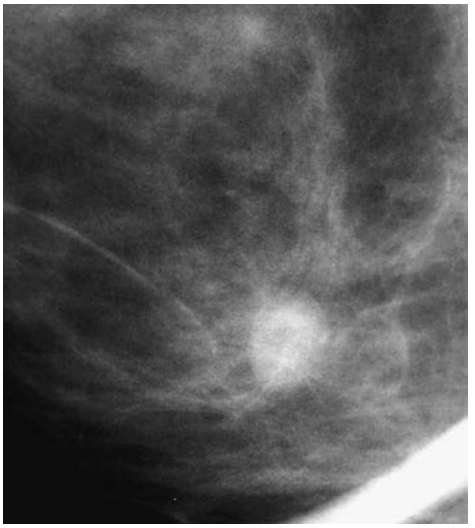
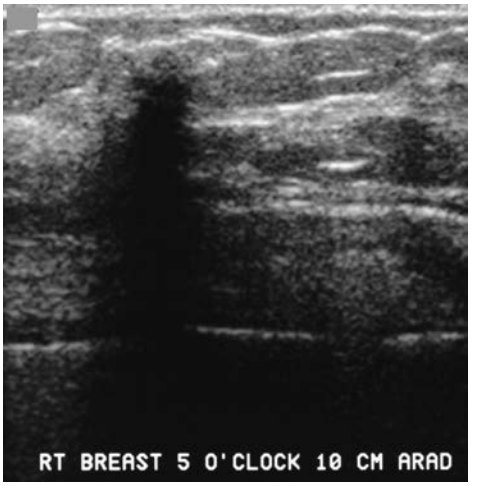



**FIGURE 14-31** Fibrosis. **(A)** Round mass (*arrow*), with partially obscured margins. **(B)** Two years following **(A)**. Mass (*arrow*) has increased in size. **(C)** Hypoechoic mass with associated cystic spaces. Margins are not well circumscribed. Posterior acoustic enhancement and shadowing are seen.






A B

**FIGURE 14-32** Fibrosis. **(A)** Spot compression view. Oval mass with partially indistinct margins. **(B)** Mass with shadowing corresponding to mammographic finding.

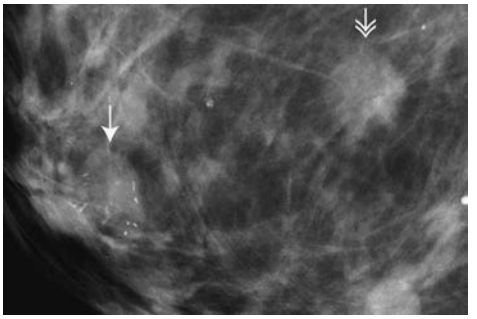
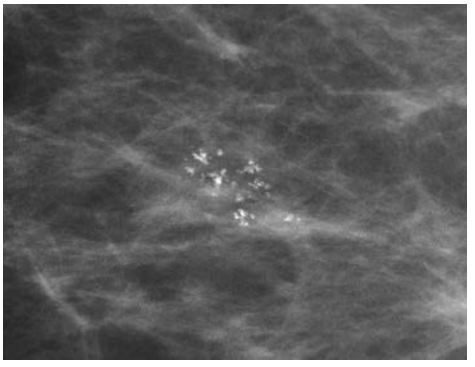
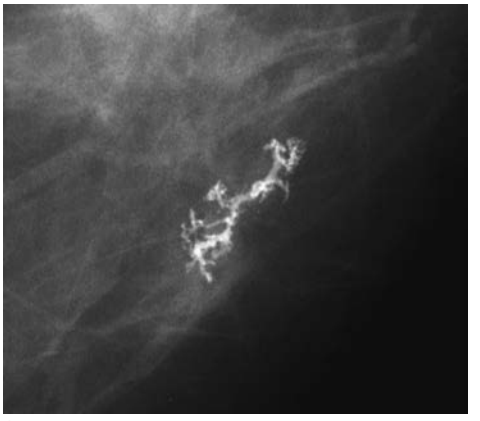


**FIGURE 14-33** Fibrosis. **(A)** Spot compression view. Oval mass (*arrow*) with partially obscured margins and associated calcifications. Although some of the calcifications are linear on close inspection a central lucency is seen. A second round mass (*doubled headed arrow*) with spiculated margins is present; this is an invasive ductal carcinoma histologically.





A B

**FIGURE 14-34** Fibrosis. **(A)** Cluster of coarse, dystrophic calcifications. **(B)** Coarse, dystrophic calcifications.

## MASTITIS

### KEY FACTS

- Clinical.

  Acute mastitis is commonly associated with lactation; chronic disease.

  A localized area of inflammation is common in lactating women. Acute mastitis begins with a crack on the nipple (pH change of the nipple toward the alkaline side) that may progress to the formation of an abscess.

  Some have also suggested that plucking of periareolar hairs may lead to breast abscesses.

  May develop in some patients following nipple piercing.

  Overlying skin may be thinned, edematous, and erythematous.

- Mammography.

  Patient discomfort may limit compression; increased kV (and mAs) may be needed for adequate tissue penetration; acutely patients may not tolerate a mammogram.

  Normal.

  Diffuse changes: increased tissue density, thickening of trabecula and skin.

  Spiculation and distortion.

- Ultrasound.

  Normal.

  Diffuse alteration in echotexture: diffusely increased tissue echogenicity; may see associated irregular areas of hypoechogenicity.

  Obliteration of normal tissue planes.

  Increased vasculature: small serpiginous tubular structures coursing through edematous tissue.

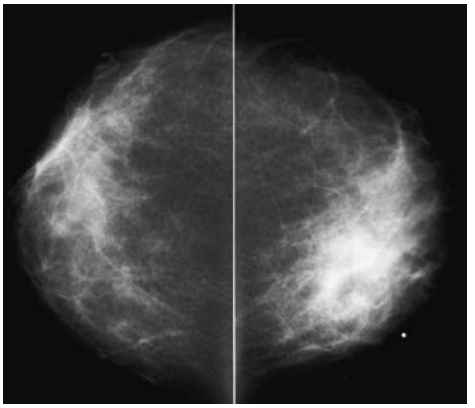
  Skin thickening, dilated subdermal lymphatics.

  Associated tenderness in area of mastitis (may be entire breast).

- Histology.

  Inflammatory cell infiltrate.

  Skin thickening.



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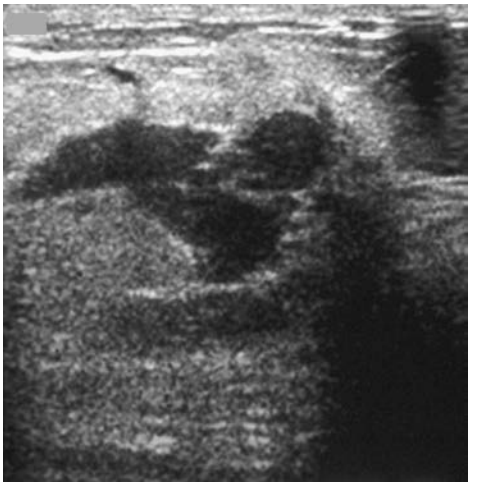
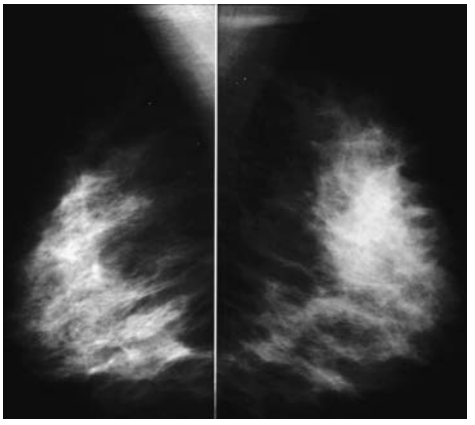


B

**FIGURE 14-35** Mastitis. **(A)** Craniocaudal views. Diffuse changes involving the medial aspect of the left breast. Increased density and prominence of the trabecular markings. Metallic BB used to denote clinical findings. **(B)** Disruption of normal tissue planes with increased echogenicity of tissue and associated irregular areas of hypoechogenicity as medial quadrants of the left breast are scanned.



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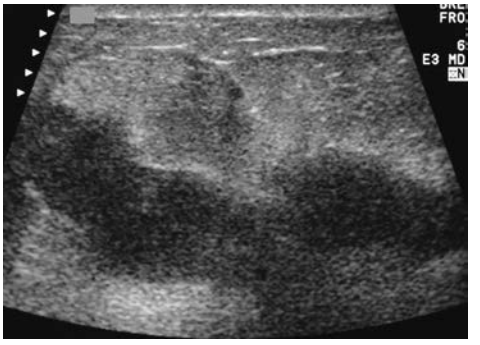


B

**FIGURE 14-36** Mastitis. **(A)** Mediolateral oblique views. Diffuse changes involving the left breast. Increased density and prominence of the trabecular markings. **(B)** Tissue planes are disrupted and the overall echogenicity of the parenchyma is increased. Irregular tubular areas of hypoechogenicity are present.

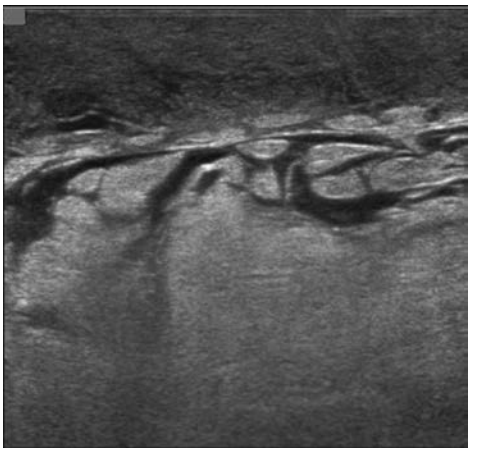


**FIGURE 14-37** Mastitis. Marked skin thickening, dilated subdermal lymphatic channels and interstitial fluid. Tissue planes are disrupted and the overall echogenicity of the parenchyma is increased.

## ABSCESS (PERIPHERAL)

### KEY FACTS

- Clinical.

  May develop de novo in patients of all ages or in patients with pre-existing mastitis during pregnancy or lactation, in women with underlying diabetes or idiopathic.

  Tender mass.

  Usually respond well to percutaneous drainage and antibiotic therapy.

  Not associated with high recurrence rate or bilaterality.

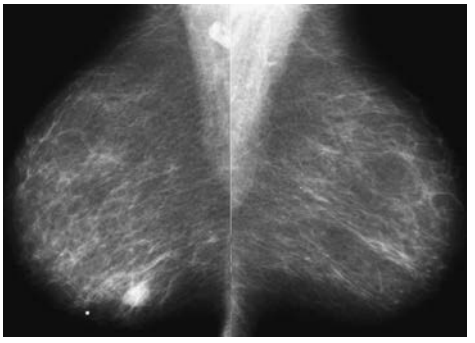
  To be contrasted with subareolar abscesses typically seen in young pre menopausal women; associated with high recurrence rates (even after surgery) and bilaterality.
- Mammography.

  Mass with ill-defined, indistinct, or spiculated margins.
- Ultrasound.

  Complex, irregular mass with solid/cystic components.

  Irregular margins with microlobulations and small tubular extensions into the surrounding tissue.

  Skin thickening, dilated dermal lymphatics.



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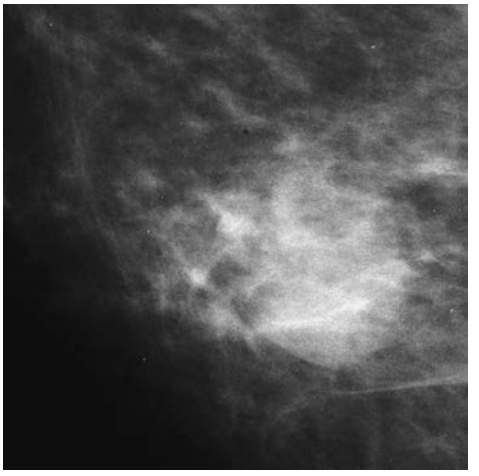

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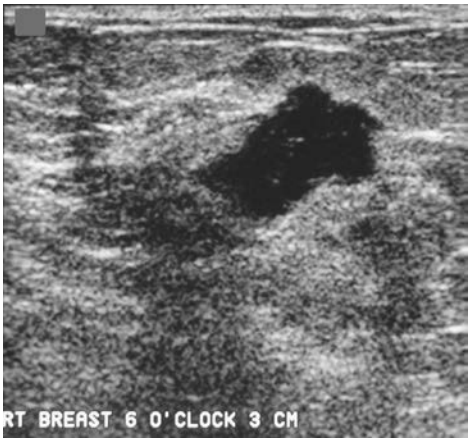
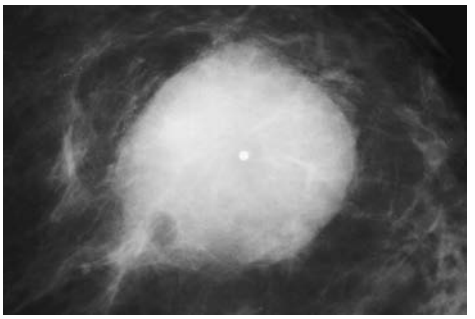



C

**FIGURE 14-38** Peripheral abscess. **(A)** Mediolateral oblique views. Mass inferiorly in the right breast corresponding to tender "lump" with associated erythema. **(B)** Spot compression view. Mass with indistinct margins. **(C)** Irregular anechoic mass with minimal posterior acoustic enhancement. Surrounding tissue planes are disrupted and the echogenicity of the tissue is increased.



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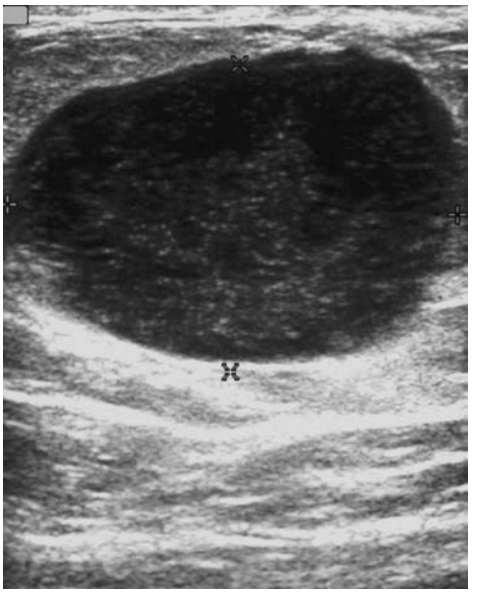


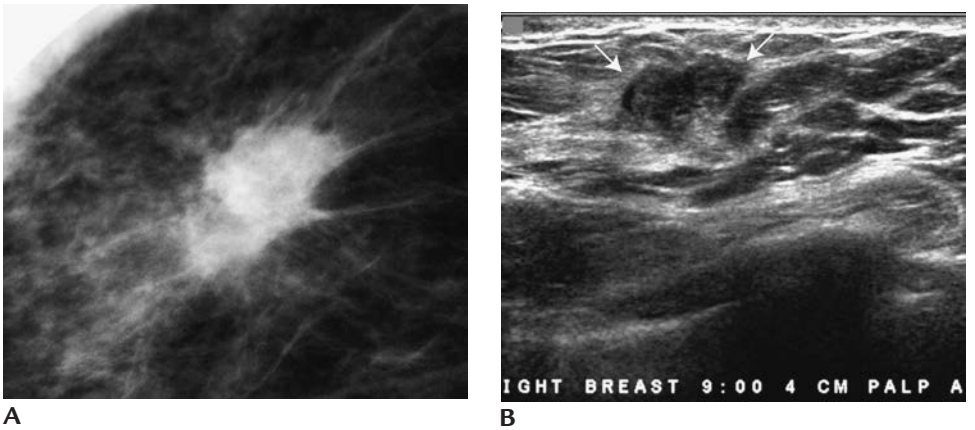
B

**FIGURE 14-39** Peripheral abscess. **(A)** Spot compression view. Round dense mass with indistinct margins corresponding to palpable (metallic BB), tender "lump." **(B)** Mass with internal echoes and posterior acoustic enhancement. Purulent fluid aspirated percutaneously. Unlike subareolar abscesses, peripheral abscess respond well to aspiration and antibiotic therapy. Recurrences and bilaterality are uncommon following treatment.

# Granulomatous Mastitis

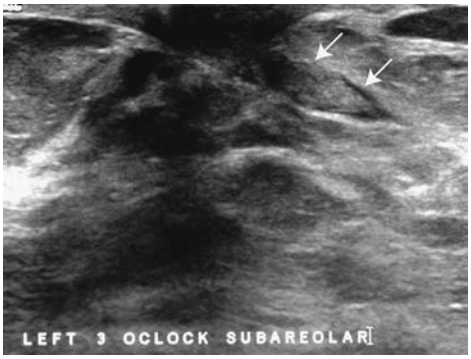
## Key Facts

- Clinical.
  Firm, hard mass.
  Recent pregnancy in most patients.
  Etiology unknown, no organisms cultured.
  Unlikely autoimmune (no vasculitis; no significant plasma cell component to infiltrate).
  Treatment with corticosteroids (need to rule out possible infectious etiologies) or wide local excision.
  Need to exclude other disorders such as Wegner's granulomatosis, sarcoidosis, cat scratch, or tuberculosis.
- Imaging.
  Mass with indistinct to spiculated margins.
  Diffuse change including skin thickening, increased density and trabecular prominence.
- Ultrasound.
  Mass, margins may not be circumscribed.
  Diffuse changes with disruption of normal tissue planes and increased echogenicity of tissue.
  Irregular tubular areas of hypoechogenicity.
- Histology.
  Granulomatous inflammatory reaction centered on lobules.
  Can extend to surrounding tissue with formation of microabscess.
  No necrosis or caseation.
  Critical to distinguish this benign entity from a granulomatous reaction occurring in association with cancer.




A B

**FIGURE 14-40** Granulomatous mastitis. **(A)** Spot compression view. Irregular mass with indistinct and spiculated margins. **(B)** Hypoechoic mass (*arrows*) with echogenic rim. Margins are not well circumscribed.




C

**FIGURE 14-40** (*Continued*) **(C)** Different patient. Irregular tube-like mass (*arrows*) with heterogeneous echotexture in the left subareolar area.

## Pseudoangiomatous Stromal Hyperplasia

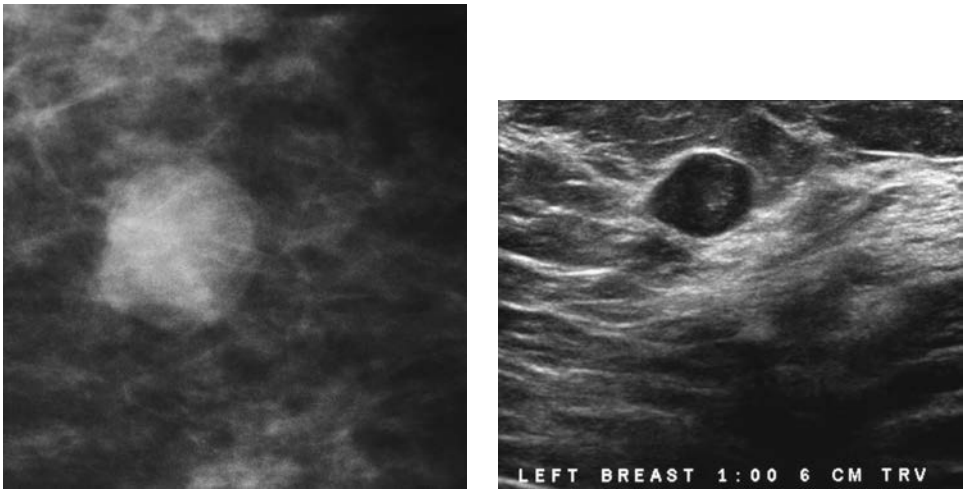
### Key Facts

- Clinical.
  More common in premenopausal women.
  Palpable mass.
  May recur locally (15% to 22%) after excision.
  Hormonal etiology; possibly a response to progesterone in estrogen stimulated tissue.
  Multifocal in up to 60% of women.
  Not considered premalignant or associated with malignancy.
- Mammography.
  Mass with well- or partially circumscribed margins.
  Progressively developing asymmetric tissue.
  May have associated coarse, round punctate, or amorphous calcifications.
- Ultrasound.
  Solid, well-circumscribed, hypoechoic mass (may have heterogeneous echo pattern).
  Complex cystic mass.
- Histology.
  Variable size, from microscopic to several centimeters; microscopic lesions common.
  Must be distinguished from low-grade angiosarcoma.
  A complex pattern of anastomosing channels is formed by the disruption and separation of collagen fibers in the interlobular and intralobular stroma.
  Spaces are lined incompletely by spindled myofibroblasts simulating endothelial cells (pseudovascular) and contain mucopolysaccharides. Similar pattern is seen during the luteal phase of the menstrual cycle.

Immunohistological staining for endothelial markers (e.g., factor VIII) is negative in these lesions.

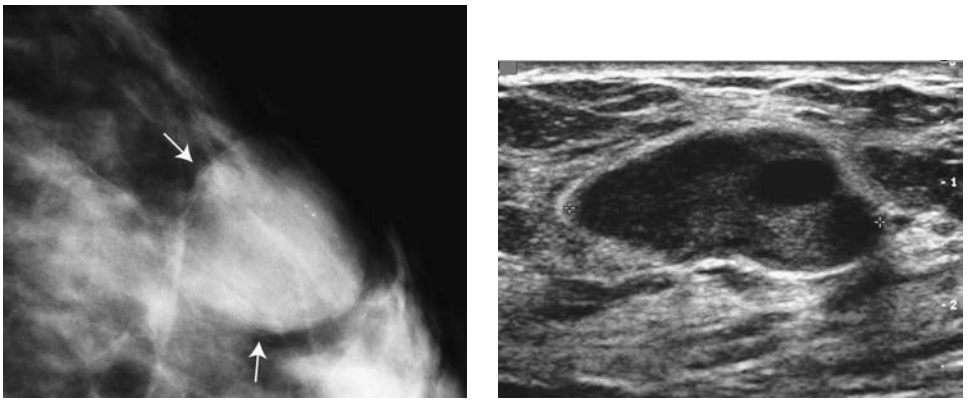
Positive staining for CD34 and muscle actin.

Progesterone receptor positive, estrogen receptor negative.




A B

**FIGURE 14-41** Pseudoangiomatous stromal hyperplasia (PASH). **(A)** Round mass with indistinct margins. **(B)** Round hypoechoic mass with circumscribed margins.



A B

**FIGURE 14-42** Pseudoangiomatous stromal hyperplasia (PASH). **(A)** Spot compression view. Round mass with partially circumscribed and obscured margins. Two round calcifications are present in the mass. **(B)** Complex cystic mass with echogenic rim and posterior acoustic enhancement.

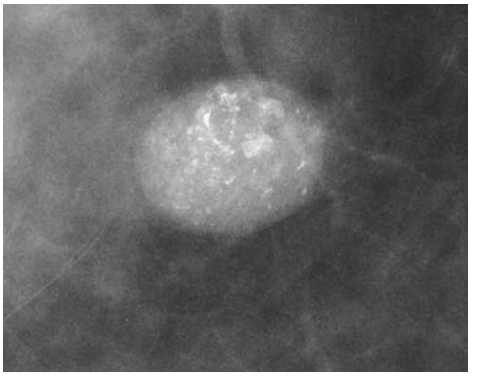
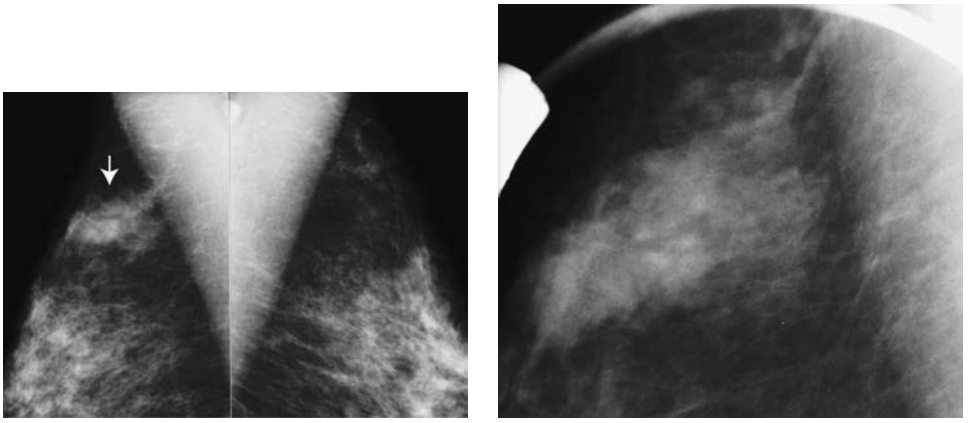
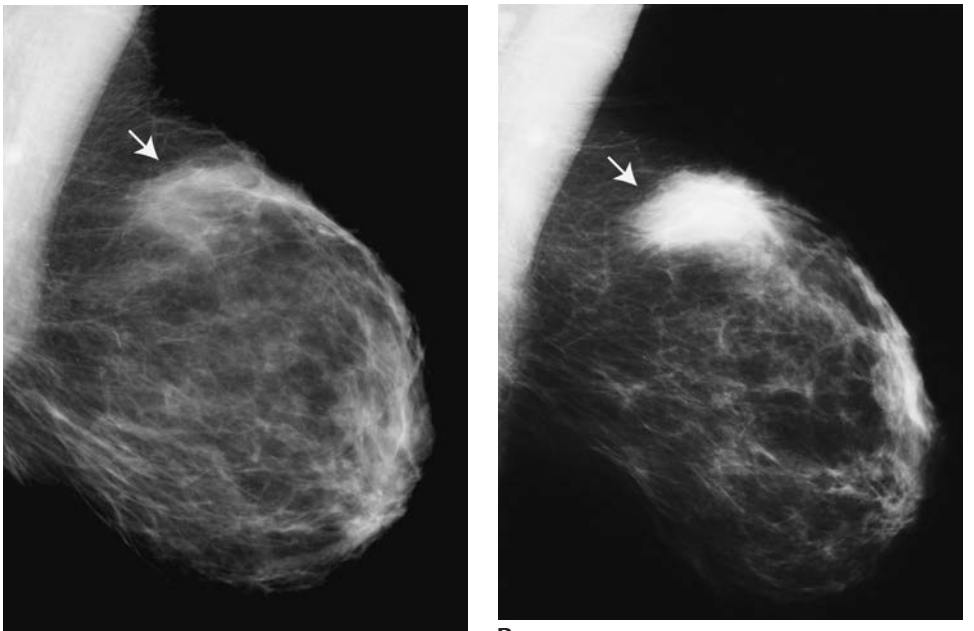


**FIGURE 14-43** Pseudoangiomatous stromal hyperplasia (PASH). Oval mass with irregular coarse calcifications.



**A** **B**

**FIGURE 14-44** Pseudoangiomatous stromal hyperplasia (PASH). **(A)** Focal parenchymal asymmetry (*arrow*) developing compared with prior studies (not shown). Patient presents with focal tenderness at this site. **(B)** Spot compression view. Focal parenchymal asymmetry corresponding to site of focal tenderness.



A B

**FIGURE 14-45** Pseudoangiomatous stromal hyperplasia (PASH). **(A)** Focal parenchymal asymmetry (*arrow*). **(B)** One year following **(A)**. The area of parenchymal asymmetry (*arrow*) is increased in size and density and the margins are indistinct.

## HEMANGIOMA

### KEY FACTS

- Clinical.

  Variable incidence reported (1.2% to 11%).

  Some are incidental histologic findings; others present with a palpable mass.
- Mammography.

  Normal.

  Well-circumscribed, macrolobulated mass; may have associated punctate calcifications.

  Punctate microcalcifications in isolation of a mass.
- Histology.

  Perilobular: small (0.5 to 4.0 mm), easily overlooked; ill-defined margins; endothelial cells, no atypia.

  Cavernous, capillary, juvenile, and venous: greater than 5 mm in size; well-defined margins; cavernous have dilated vessels, normal endothelial cells; capillary have capillary-sized vessels, normal endothelial cells; juvenile are immature capillary hemangiomas; venous have thick walled vessels (elastic vessel wall).

  Less than a low-power microscopic field in diameter.

  Well circumscribed, perilobular.

  Uniform vascular spaces.

  No atypical endothelial cells.

  Scant connective tissue stroma.

  Multiple lesions.

  Bilateral in some women.

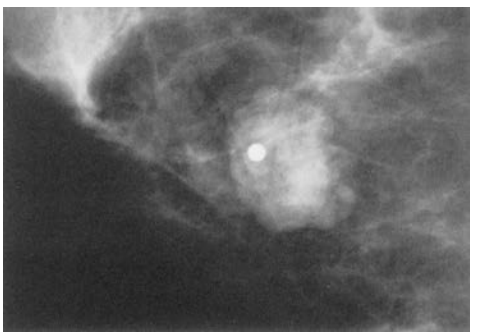
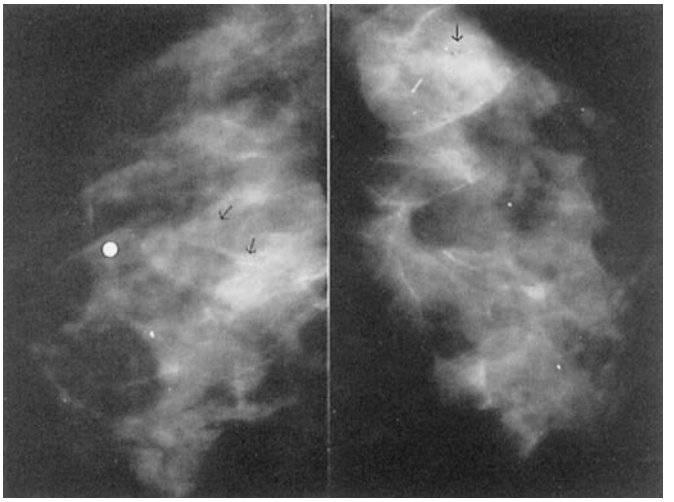


**FIGURE 14-46** Cavernous hemangioma. Metallic BB marks palpable mass. Lobular mass with circumscribed margins mammographically. These lesions are not typically palpable. Histologically, small (mammographically occult) lesions are common.

## Diabetic Fibrous Breast Disease

### Key Facts

- Clinical.
  Early onset, longstanding insulin-dependent diabetes mellitus.
  Hard, ill-defined, nontender mass, uni-, or bilateral.
- Mammography.
  Dense breast tissue.
  Vascular calcifications (diabetic patient).
- Ultrasound.
  Significant shadowing in area of clinical concern.
- Histology.
  Dense stromal fibrosis.
  Ductal and lobular obliteration.
  Perivascular and periductal lymphocytic infiltration.
  Possible autoimmune disorder.



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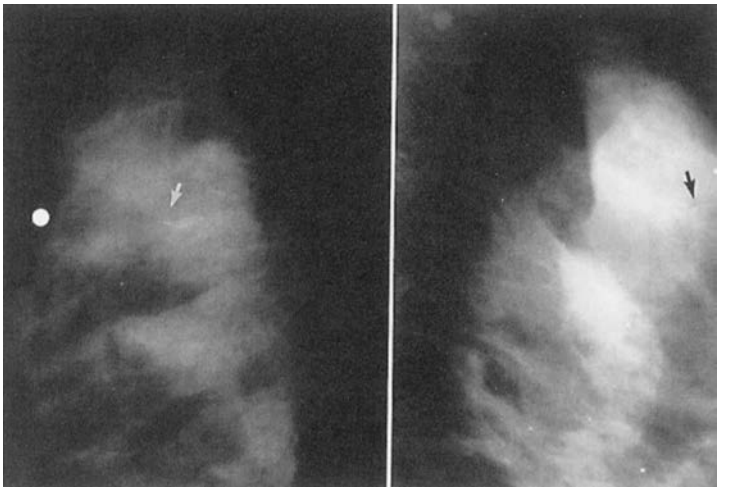
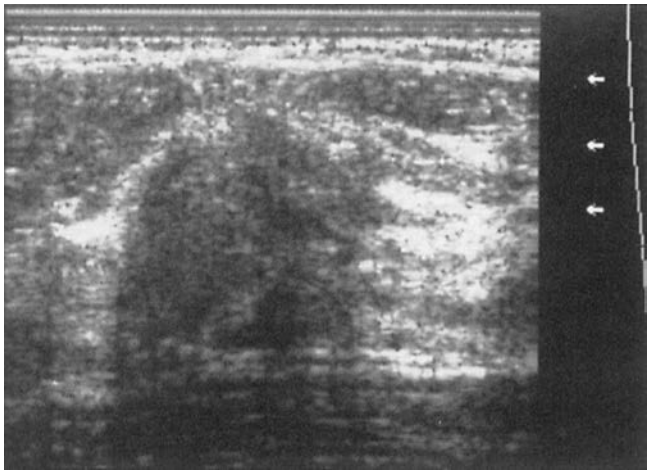


B

**FIGURE 14-47** Diabetic fibrous mastopathy. **(A)** Right and left craniocaudal views back to back. Metallic BB marks palpable mass. Dense tissue with no discrete abnormality mammographically. Vascular (quirky) calcifications in a 40-year-old woman (*arrows*). The tip off is the patient's young age. In a young patient, vascular calcifications may be related to an underlying metabolic disorder (in this patient, insulin-dependent diabetes). **(B)** Right and left mediolateral oblique views back to back. Metallic BB marks palpable mass. Dense tissue with no discrete abnormality mammographically. Vascular (quirky) calcifications (*arrows*).



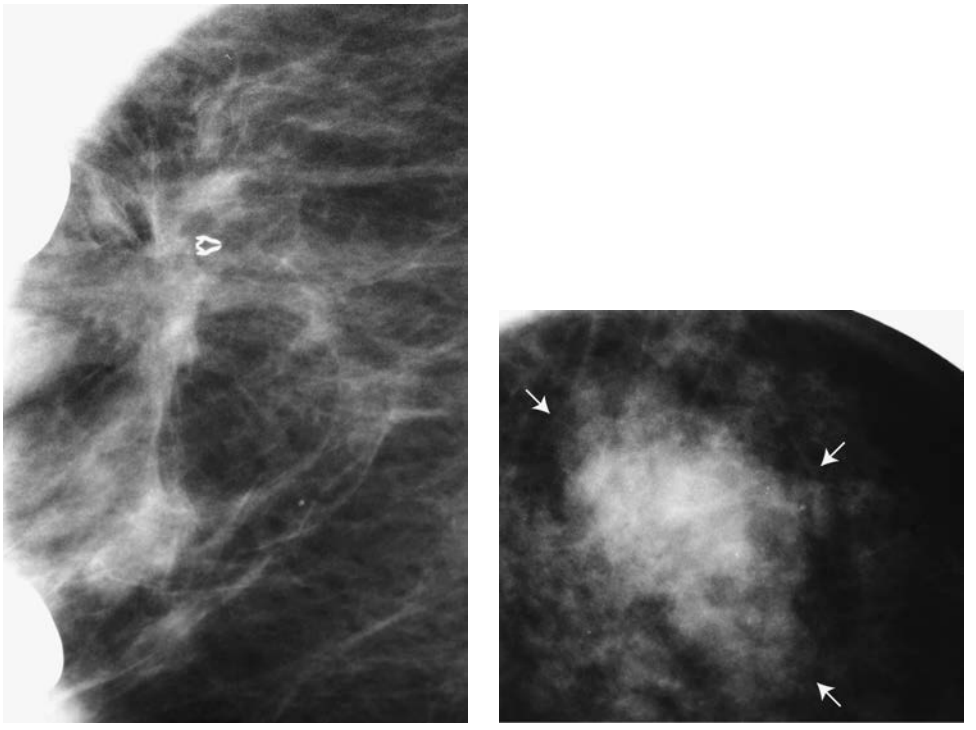
C

**FIGURE 14-47** (*Continued*) **(C)** Posterior acoustic shadowing when palpable mass is scanned.

## Extraabdominal Desmoid

### Key Facts

- Clinical.
  Fibromatosis.
  Association with Gardner's syndrome.
  Locally aggressive; requires wide excision.
  May recur (20%), usually within first 5 years.
  May be related to previous trauma or surgery; has been reported in women with saline implants.
  Some reports suggest alterations of the APC/beta-catenin pathway similar to that reported for desmoid tumors of the abdomen, paraspinal region, and extremities.
- Mammography.
  Mass with indistinct to spiculated margins.
  Distortion.
  Close proximity to pectoral muscle.
- Ultrasound.
  Hypoechoic mass with variable acoustic shadowing.
  Indistinct, angular or spiculated margins.
- Histology.
  Ill defined; variable cellularity.
  Proliferation of fibroblasts (admixture of fibroblasts and myofibroblasts).



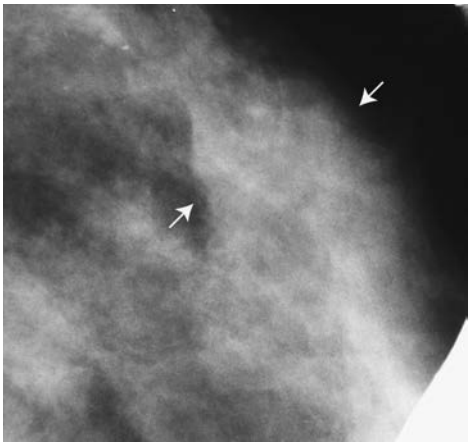
A B

**FIGURE 14-48** Extra abdominal desmoid. **(A)** Spot compression view. Mass with spiculated margins and distortion. Micromark clip post stereotactic biopsy. **(B)** Different patient. Spot compression view. Lobular mass with indistinct margins. Scattered round and punctate calcifications are present.

# Granular Cell Tumor

## Key Facts

- Clinical.
  Reported in a wide variety of visceral and cutaneous sites.
  Positive staining for S-100 protein consistent with neural origin.
  Most in women, however, it has been reported in male patients.
  Can be infiltrative, may recur when incompletely excised and rarely metastasize.
  Predilection for the upper inner quadrants.
- Mammography.
  Mass with variable margins ranging from circumscribed to spiculated.
- Ultrasound.
  Hypoechoic mass.
- Histology.
  Well-circumscribed to infiltrative margins.
  Solid nests of cells coarsely granular cytoplasm.
  Estrogen and progesterone receptor negative.



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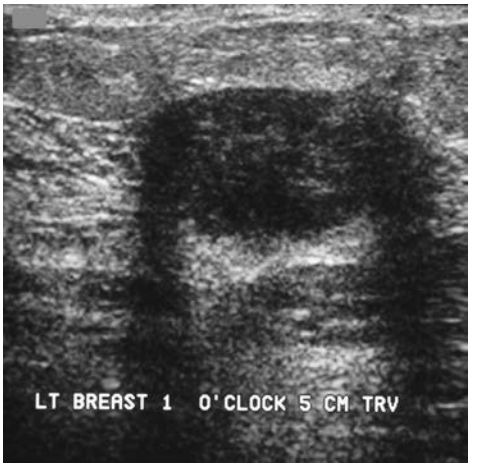


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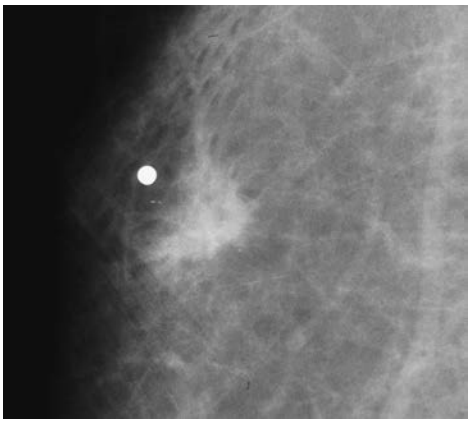


C

**FIGURE 14-49** Granular cell tumor. **(A)** Spot compression view. Mass with obscured margins. **(B)** Oval hypoechoic mass with combined posterior acoustic enhancement and shadowing. A portion of the margins is not well circumscribed. **(C)** Different patient. Irregular mass with spiculated margins corresponding to palpable finding (metallic BB).

## LYMPHOMA

### KEY FACTS

- Clinical.

  Primary in breast, if widespread or prior extra-mammary lymphoma is excluded.

  Primary breast lymphoma rare (0.1 to 0.5%); secondary involvement more common.

  Primary breast lymphoma accounts for 2.5% of all extranodal forms of lymphoma.

  Axillary involvement: 30% to 40%.

  Bilaterality: 13%.

  Approximately 10% present with night sweats, fever, and weight loss.

  Although experience is limited, estrogen- and progesterone-receptor positivity has been reported.

  Two divergent clinical patterns: diffuse large cell of B-cell origin, commonly unilateral, broad age spectrum, variable course); Burkett's type (rapidly fatal course, develops bilaterally in pregnant or lactating women, ovarian and CNS involvement).

- Mammography.

  Mass or multiple masses, well circumscribed to ill-defined, rarely spiculated; variable size.

  Diffuse increase in parenchymal density; trabecular thickening.

  Skin thickening.

- Ultrasound.

  Well-defined to irregular hypoechoic mass or masses.

  Skin thickening, dilated subdermal lymphatics.

- Histology.

  May be difficult to differentiate from medullary carcinomas, but epithelial markers are absent in lymphomas.

- Pseudolymphoma (lymphoid pseudotumor).

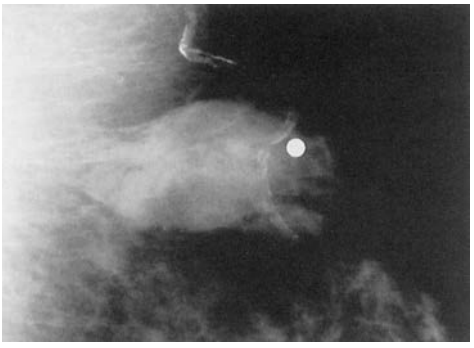
  Large mass (2.5 to 5 cm), rapid development.

  May represent an overwhelming response to trauma; also associated with anticonvulsive therapy.

  Irregular mass mammographically (nonspecific).

  Ultrasonographically, echogenic (isoechoic with glandular tissue, hyperechoic. relative to subcutaneous fat) tissue with hypoechoic, "reticular" bands representing lymphocytic infiltrate.

  Aggregation of nonneoplastic lymphocytes (more commonly involving GI tract [stomach] and lung).



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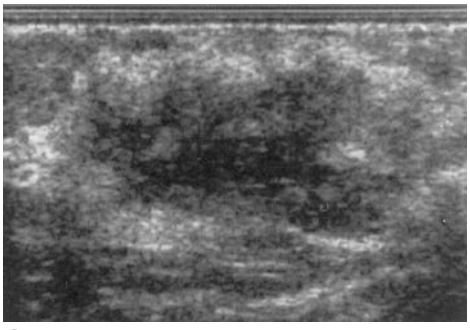

C

**FIGURE 14-50** Lymphoma. **(A)** Oval mass. Metallic BB marking palpable finding. **(B)** Spot compression magnification view. Oval mass with indistinct margins. Arterial calcification. **(C)** Irregular, horizontally oriented hypoechoic mass. Margins are not well circumscribed.

## ANGIOSARCOMA

### KEY FACTS

- Clinical.
  Less than 0.05% of all primary breast cancers.
  Younger women (average age 35).
  Painless, discrete mass; in superficial lesions, bluish-red discoloration of overlying skin may be present.
  Diffuse breast enlargement (approximately 12%).
  Vascular metastasis, bypass axillary lymph nodes (axillary dissection is not done).
  Contralateral breast involvement is reportedly common.
  Tumor size may be of prognostic significance.
  Increasingly being reported in women following breast irradiation after breast conserving therapy (commonly older patients).
- Angiosarcoma associated with lymphedema (Stewart-Treves).
  Develops in women with chronic lymphedema most commonly (90%) after radical mastectomy and axillary nodal dissection with or without radiation therapy for breast cancer.
  Also reported in patients with lymphedema from other causes (e.g., after treatment for melanoma, congenital lymphedema or filariasis).
  Develops 10 to 20 years or more after treatment.
  Initial focal purple discoloration progresses into plaques and nodules with ulceration and bleeding.
- Mammography.
  Microlobulated, irregular mass ("cloud-like") may have associated coarse calcifications.
  Round or oval mass with indistinct margins.
- Ultrasound.
  Irregular, hypoechoic mass with indistinct, angular, or spiculated margins.
  Homogeneous to heterogeneous echotexture.
- Gross.
  Poorly defined mass.
  Soft, spongy consistency with hemorrhagic areas.
- Histology.
  Irregular, anastomosing vascular channels lined by hyperchromatic, atypical endothelial cells permeating breast parenchyma.
  Solid nests of spindle cells.
  Based on amount of solid, spindle cell component and tufting of atypical endothelial cells, angiosarcomas can be divided in type I, II or III (well-, moderately, or poorly differentiated).

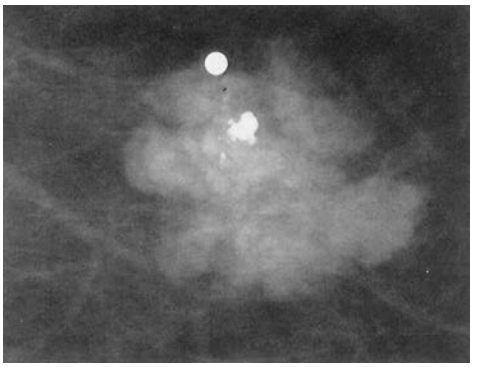

**FIGURE 14-51** Angiosarcoma. Lobular mass with circumscribed margins ("cloud-like"), which is common appearance for vascular lesions, with coarse calcifications. Skin coloration (bluish) may be clinically apparent in area of palpable mass.

## METASTATIC DISEASE

### KEY FACTS

- Clinical.
  Palpable mass.
  The most common metastatic lesion to the breast is from the contralateral breast through lymphatic channels of the anterior chest.
  Extramammary metastasis are uncommon (1.2% to 2.7% of cancers in the breast); hematogenous.
  Hematopoietic and lymphoreticular (leukemia, lymphoma).
  Melanoma.
  Lung.
  Ovarian, stomach, and cervical.
- Mammography.
  Round, well- to ill-defined mass: commonly, multiple bilateral masses.
  When multiple, similarly sized.
- Ultrasound.
  Solid, hypoechoic mass.
  Indistinct margins, heterogeneous echotexture.
- Histology.
  Well demarcated lacking an intraductal or lobular component.

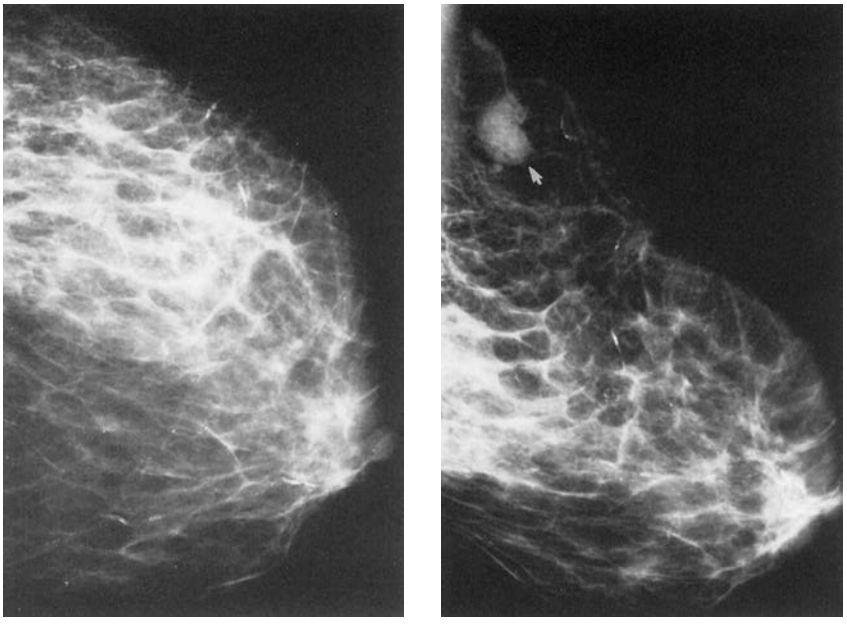

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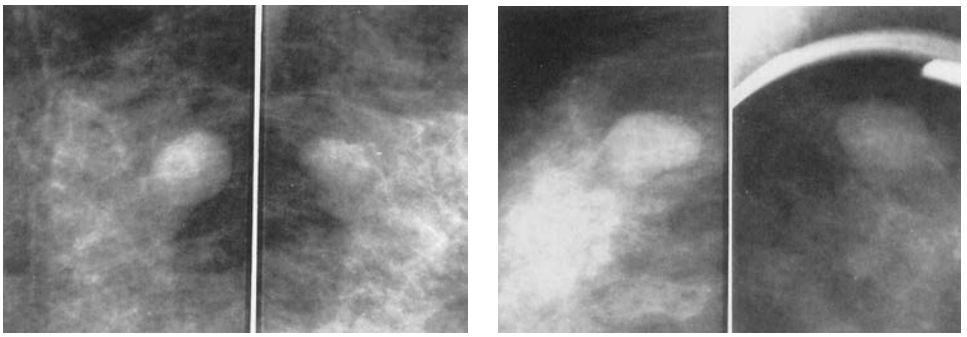
**FIGURE 14-52** Metastatic follicular lymphoma. **(A)** Left craniocaudal and **(B)** left mediolateral oblique views. Trabecular thickening and increased density. Enlarged intramammary lymph node (*arrow*).



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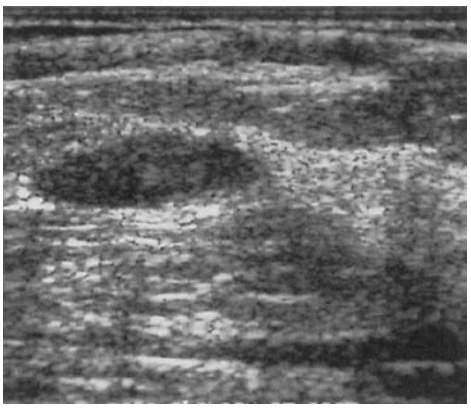
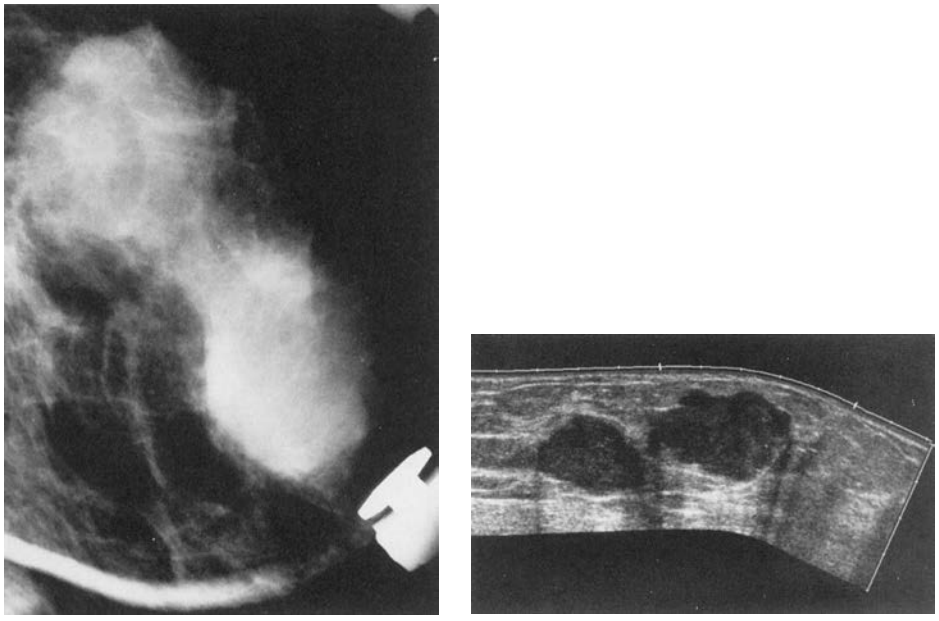


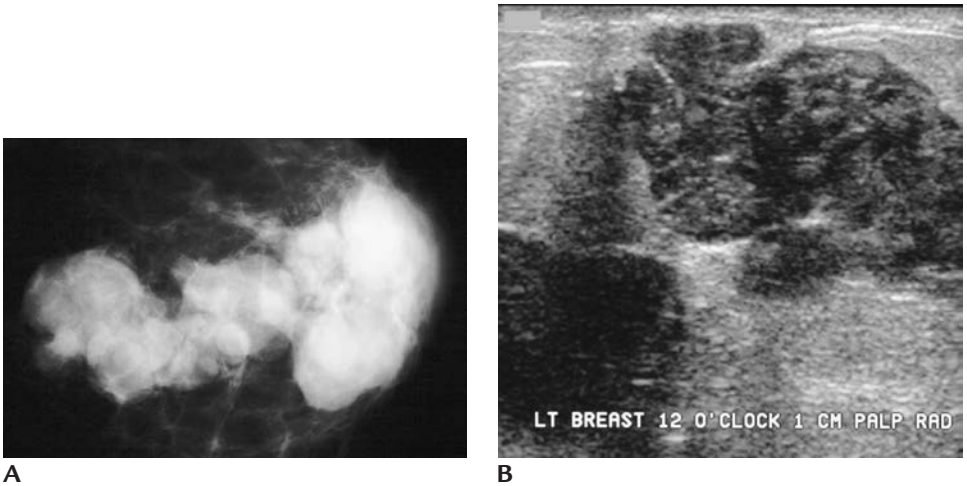
C

**FIGURE 14-53** Metastatic melanoma. **(A)** Right craniocaudal (CC) views 1 year apart back–to-back. Oval mass increasing in size. **(B)** Routine right CC and spot compression view back–to-back. Margins of mass are partially obscured. **(C)** Oval, hypoechoic mass.



A B

**FIGURE 14-54** Metastatic small cell lung carcinoma. **(A)** Spot compression view. Two, round, masses with indistinct margins. **(B)** Round masses with lobulated margins and slight posterior acoustic enhancement. Margins better defined on ultrasound.




A B

**FIGURE 14-55** Metastatic disease, likely lung primary. **(A)** Multiple masses with indistinct margins; similar size. **(B)** Irregular mass with heterogeneous echotexture, macrolobulated margins, and posterior acoustic enhancement. Second mass partially visualized in this image.

## MISCELLANEOUS

### KEY FACTS

### Suture Calcifications

- Clinical.

  More common following lumpectomy and radiation therapy; radiation damage to tissue delays the resorption of suture material, permitting calcium deposition. They can, however, be seen following biopsy with benign histology.

  Catgut sutures have been proposed as nidus for calcium precipitation.
- Mammography.

  Curvilinear calcifications forming loops.

  Coarse linear calcifications (nonanatomic distribution), smooth border limited to area of surgery.

  Calcified knots; may be evenly spaced.

### Parasites

- Filarial infections (lymphatic filariasis, onchocerciasis, loiasis) cysticerosis, dracunculosis, schistosomiasis.
- Multiple clusters of linear, curvilinear, coiled, serpiginous calcifications.
- May have an associated soft tissue component (may be palpable).
- Trichinosis.

  Punctate, round well-defined "pearl-like" calcifications limited to the pectoral muscles.

### Dermatomyositis

- Subcutaneous calcifications.

  Coarse, dense, may be pleomorphic simulating microcalcifications associated with ductal carcinoma in situ.

  May regress completely following treatment.
- Vascular calcifications.
- Association with malignancies including breast cancer.

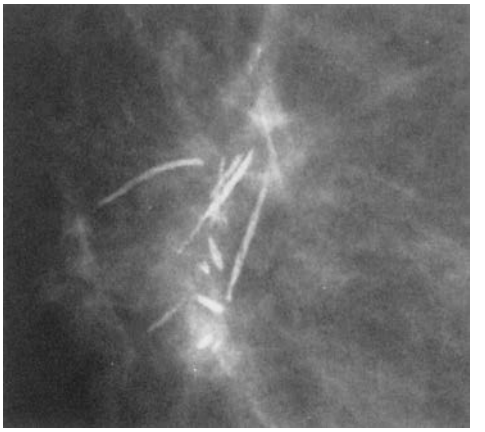


**FIGURE 14-56** Suture calcifications. Coarse, linear calcifications, smooth border. Nonanatomic distribution in area of previous surgery. In some women, knots in suture can be seen.

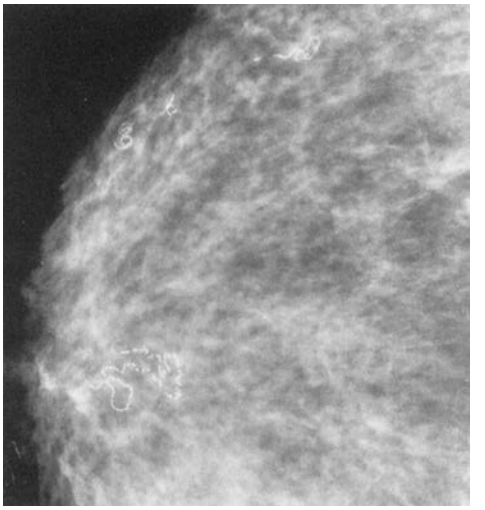


**FIGURE 14-57** Parasites. Linear, coiled, serpiginous calcifications.

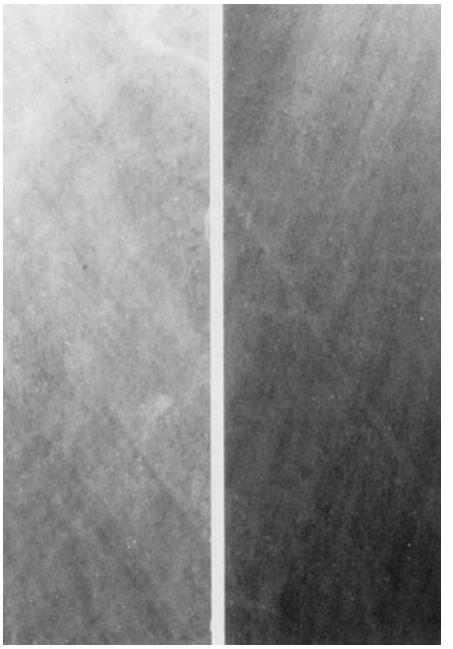
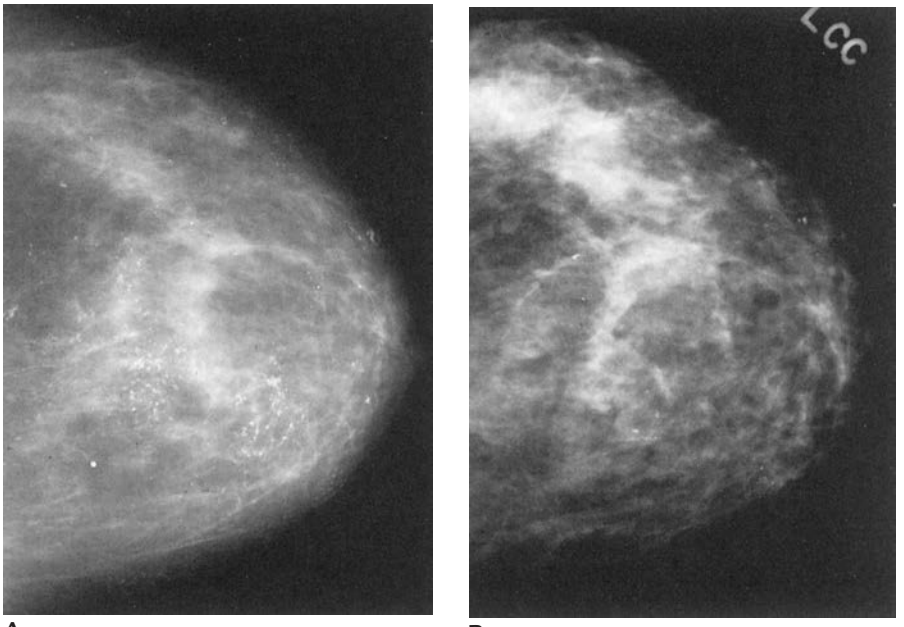


**FIGURE 14-58** Trichinosis. Round, well-defined calcifications scattered in, but limited to, the pectoralis major muscles.




A B

**FIGURE 14-59** Dermatomyositis. **(A)** Calcifications diffusely involving the breast. Some of the calcifications are pleomorphic with linear forms and linear orientation. **(B)** Follow-up mammogram several years after treatment of dermatomyositis demonstrates almost complete resolution of calcifications.

## SUGGESTED READINGS

Adler DD. Mammographic evaluation of masses. *RSNA Categorical Course in Breast Imaging Syllabus*. 1995:107–116.

Apesteguía L, Murillo A, Biurrun J, et al. Calcified trichinosis of pectoral muscle: mammographic appearance. *Eur Radiol*. 1995;5:414–416.

Bohman LG, Bassett LW, Gold RH, et al. Breast metastases from extramammary malignancies. *Radiology*. 1982;144:109–312.

Cardenosa G, Eklund GW. Breast anatomy, histology and cancer. *RSNA Categorical Course in Breast Imaging Syllabus*. 1995:21–28.

Cardenosa G, Eklund GW. Imaging the altered breast. In: Taveras JM, Ferrucci JT, eds. *Radiology, Diagnosis Imaging Intervention*. Philadelphia: JB Lippincott Co.; 1994.

Chow CK, McCarthy JS, Neafie R, et al. Mammography of lymphatic filariasis [case report]. *AJR Am J Roentgenol*. 1996;167:1425–1426.

Cohen MA, Morris EA, Rosen PP, et al. Pseudoangiomatous stromal hyperplasia: mammographic, sonographic and clinical patterns. *Radiology*. 1996;198:117–120.

Dershaw DD, Selland DLG, Tan LK, et al. Spiculated axillary adenopathy. *Radiology*. 1996;201:439–442.

DiPiro PJ, Meyer JE, Frenna TH, et al. Seat belt injuries of the breast: findings on mammography and sonography. *AJR Am J Roentgenol*. 1995;164:317–320.

Donegan WL. Evaluation of a palpable mass. *N Engl J Med*. 1992;327:937–942.

Feig SA. Breast masses: mammographic and sonographic evaluation. *Radiol Clin North Am*. 1992;30:67–92.

Harvey SC, Denison CM, Lester SC, et al. Fibrous nodules found at large-core needle biopsy of the breast: imaging features. *Radiology*. 1999;211:535–540.

Helvie MA, Adler DD, Rebner M, et al. Breast hamartomas: variable mammographic appearance. *Radiology*. 1989;170:417–421.

Hogge JP, Robinson RE, Magnant CM, et al. The mammographic spectrum of fat necrosis of the breast. *RadioGraphics*. 1995;15:1347–1356.

Lee CH, Giursen ME, Philpotts LE, et al. Clinical importance of unilaterally enlarging lymph nodes on otherwise normal mammograms. *Radiology*. 1997;203:329–334.

Leibman AJ, Wong R. Findings on mammography in the axilla. *AJR Am J Roentgenol*. 1997;169:1390–1385.

Liberman LL, Dershaw DD, Kaufman RJ, et al. Angiosarcoma of the breast. *Radiology*. 1992;183:649–654.

Mendelson EB, Doshi N, Grabb BC, et al. Pseudolymphoma of the breast: imaging findings. *AJR Am J Roentgenol*. 1994;162:617–619.

Meyer JE, Ferraro FA, Frenna TH, et al. Mammographic appearance of normal intramammary lymph nodes in an atypical location. *AJR Am J Roentgenol*. 1993;161: 779–780.

Piccoli CW, Feig SA, Palazzo JP. Developing asymmetric breast tissue. *Radiology*. 1999;211:111–117.

Polger MR, Denison CM, Lester S, et al. Pseudoangiomatous stromal hyperplasia: mammographic and sonographic appearances. *AJR Am J Roentgenol*. 1996;166: 349–352.

Rosen EL, Scott Soo M, Bentley RC. Focal fibrosis: a common breast lesion diagnosed at imaging-guided core biopsy. *AJR Am J Roentgenol*. 1999;173:1657–1662.

Sickles EA. Breast masses: mammographic evaluation. *Radiology*. 1989;173:297–303.

Soo MS, Kornguth PJ, Hertzberg BS. Fat necrosis in the breast: sonographic features. *Radiology*. 1998;206:261–269.

Stacey-Clear A, McCarthy KA, Hall DA, et al. Calcified suture material in the breast after radiation therapy. *Radiology*. 1992;183:207–208.

Venta LA, Wiley EL, Gabriel H, et al. Imaging features of focal breast fibrosis: mammographic-pathologic correlation of noncalcified breast lesions. *AJR Am J Roentgenol*. 1999;173: 309–316.

Walsh R, Kornguth PJ, Scott SM, et al. Axillary lymph nodes: mammographic, pathologic and clinical correlation. *AJR Am J Roentgenol*. 1997;168:33–38.

Westinghouse LW, Yanes HN. Diabetic fibrous breast disease. *Radiology*. 1989;172: 667–670.

CHAPTER 15

# THE ALTERED BREAST

## EXCISIONAL BREAST BIOPSIES

### KEY FACTS

- The number of open surgical biopsies to excise mammographically detected lesions is decreasing as more of these lesions are evaluated using imaging guided needle biopsies.

  Extent to which this is happening varies throughout the country.

  Given the safety, accuracy, and cost effectiveness of imaging guided breast biopsies, should the number of open surgical breast biopsies become a QA issue?
- The level of suspicion that a lesion is cancer and surgical techniques largely determine the amount of tissue removed for clinically occult lesions.

  Likely benign lesions should be removed with minimal surrounding tissue.

  Lesions with a high likelihood of malignancy should be removed with wide margins.
- Mammography.

  No discernable change in more than 50% of women, particularly after accurate localization and minimal volume breast biopsies.

  Skin changes: thickening and deformity.

  Parenchymal asymmetry: removal of breast tissue may lead to asymmetries compared with the contralateral breast.

  Parenchymal distortion may be associated with skin thickening and dimpling; usually resolves completely within the first year after the biopsy.

  A spiculated mass (fat necrosis) may be seen in the first year after biopsy. Possible outcomes include complete resolution, decrease in the size and density of the mass, gradual development of an oil cyst or dystrophic calcifications (see Chapter 14).

  Dystrophic calcifications may be pleomorphic and linear initially, but with time they coarsen.

- We do not routinely mark biopsy scars. Markers are distracting and the time taken to place them decreases the efficiency of the technologist.

  More than 50% of women have no mammographic change at a prior biopsy site.

  Costly. Why incur the cost if it is not needed in most patients?
- If biopsy changes are present, correlation is established from the patient's history.

  Images with a marker at the biopsy site can always be obtained if it is unclear that a change on a mammogram represents a postoperative finding.
- If the biopsy results include nonproliferative benign changes (e.g., apocrine metaplasia, sclerosing adenosis, epithelial hyperplasia with no atypia, cysts, fibrosis), the woman is returned to annual screening.
- If a marker lesion (e.g., atypical ductal hyperplasia, lobular neoplasia [lobular carcinoma in situ] radial scar, complex sclerosing lesion or multiple papillomas) is diagnosed on histology, or if the woman has a significant family history of breast cancer:

  Follow-up 6 months after biopsy is recommended to establish a new baseline for the patient.

  If there is an area of fat necrosis, its appearance is documented early at its more prominent stage and at which time it is also unlikely to represent the development of cancer.

  Confusion in the future (18 to 24 months after biopsy) relative to a spiculated mass at the surgical site can be avoided if 6-month post-biopsy images are available for comparison.

  Fat necrosis should remain stable or decrease in size and density with time.

  Although fat necrosis can rarely increase in size, biopsy should be considered if there is increasing distortion or density or a new mass at the biopsy site.
- When evaluating postoperative changes on a mammogram, review all prior mammograms, including the first mammogram obtained after the biopsy. Subtle, progressive changes at a biopsy site may not be apparent if comparison is limited to the exam from 1 year ago.

  If there are equivocal changes at a previous biopsy site, knowing the histology of the prior biopsy can be useful in determining the need for repeat biopsy.

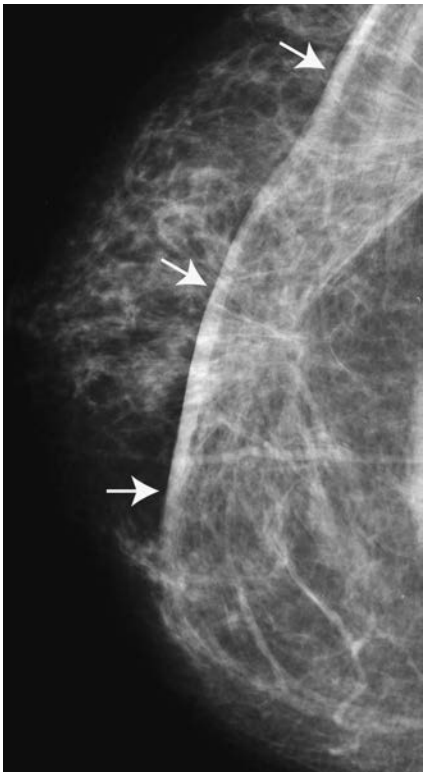


**FIGURE 15-1** Post-biopsy changes. Right craniocaudal view. Skin thickening and deformity (*arrows*) at prior biopsy site. The skin changes generate a skin fold such that a "shelf" is created when positioning the breast (the anterior most aspect of the breast is well exposed, however, the base (because of increased thickness) is underexposed and there is less contrast.

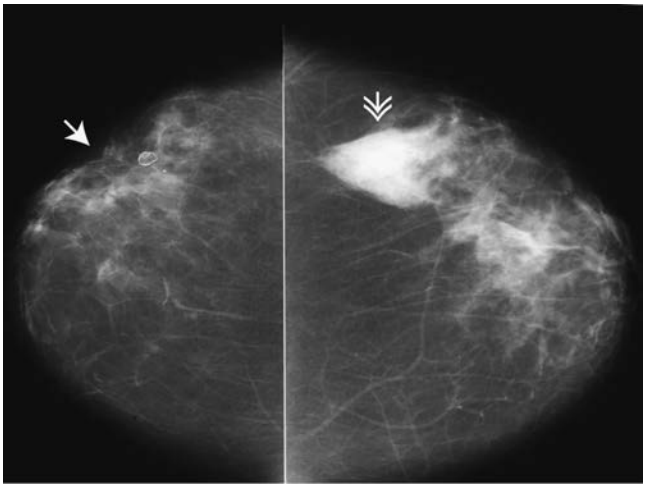


**FIGURE 15-2** Post-biopsy changes. Parenchymal asymmetry (*double headed arrow*) laterally in the left breast is the result of a prior excisional biopsy on the right. The corresponding tissue on the right has been excised. The right breast is now smaller than the left and there is minor distortion (*arrow*) and a calcifying oil cyst at the biopsy site.

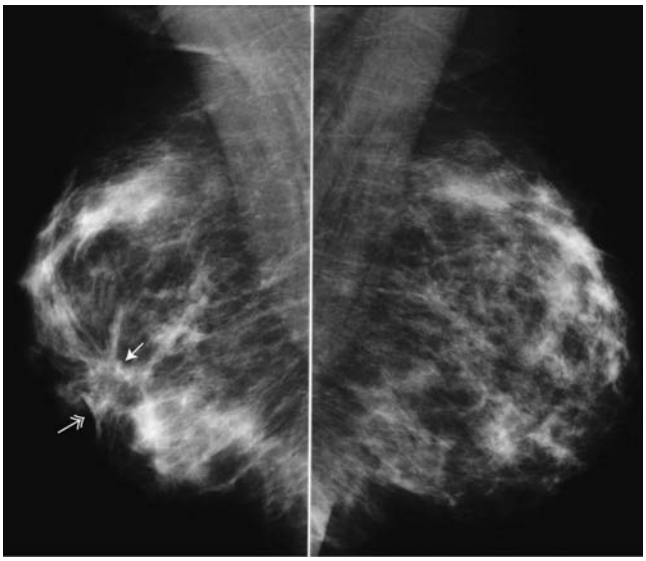
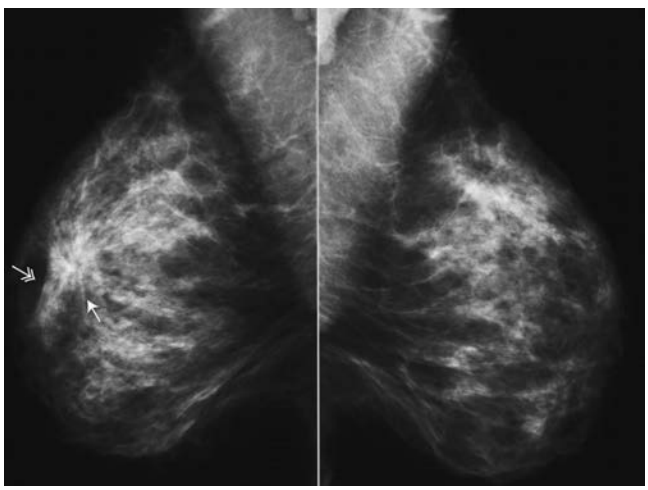
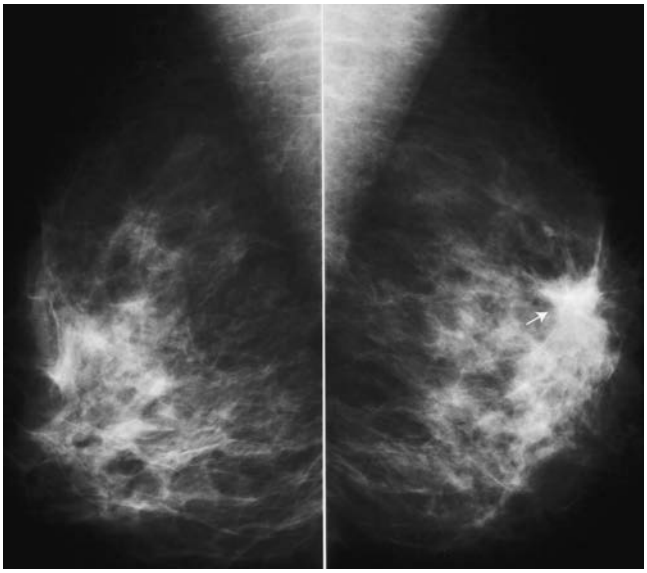


**FIGURE 15-3** Post-biopsy changes. Distortion (*arrow*) with associated skin thickening and deformity (*double headed arrow*) at prior biopsy site. Right breast is now smaller than the left.



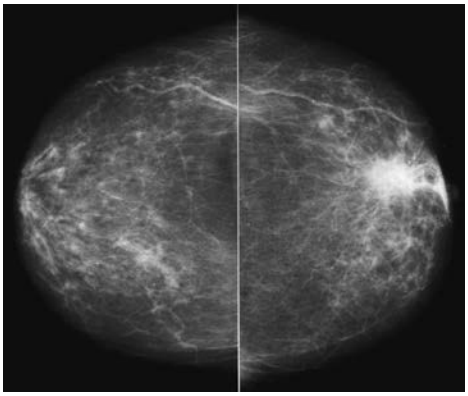
**A**

**FIGURE 15-4** Post-biopsy changes. **(A)** A spiculated mass (*arrow*) with associated distortion is seen in this patient following an excisional biopsy. Skin deformity (*double headed arrow*) is also apparent. More than 50% of patients who undergo excisional biopsy, however, have no identifiable changes mammographically.



**B**

**FIGURE 15-4** (*Continued*) **(B)** Different patient. Dense irregular mass (*arrow*) with spiculated margins and associated distortion at prior excisional biopsy site. Post-biopsy changes should remain stable or decrease in size and density with time.



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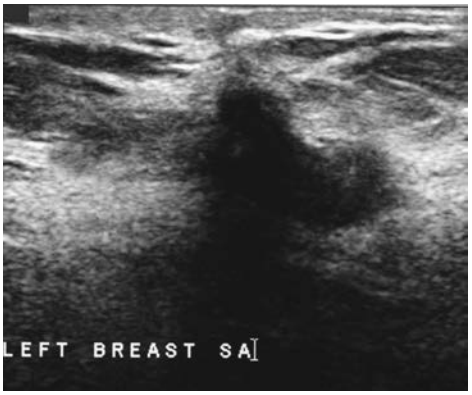



**B**

**FIGURE 15-5** Post-biopsy change, fat necrosis. **(A)** Mass with indistinct margins and associated skin thickening at prior excisional biopsy site, left subareolar area. **(B)** Irregular mass with associated shadowing is imaged directly under biopsy scar, left subareolar area.

# Lumpectomy and Radiation Therapy

## Key Facts

### General Comments

- Clinical.

  Conservative breast cancer therapy: excision of the breast cancer with a wide, tumor free margin, followed, in most women, by radiation therapy.

  Tumor and breast size are considered so that complete excision is accomplished with good cosmetic results.

  Subareolar lesions may require removal of the nipple areolar complex. Obtaining acceptable cosmetic results may be difficult; nipple reconstruction may be undertaken.

  Positive axillary lymph nodes are not a contraindication.

  Whole breast irradiation (XRT) is started 2 to 5 weeks following lumpectomy; 40 to 50 Gy; electron beam boost may bring total to 60 to 66 Gy; axilla is not usually radiated.

  Results from seven randomized controlled trials throughout the world have shown no survival difference between mastectomy and conservative treatment (with XRT) in women with tumors less than 5 cm in diameter and no distant disease.

  Mastectomy is usually recommended if a local recurrence develops in a woman following lumpectomy and XRT. The overall survival, even in women with local recurrences, is not significantly different from that of women who have a mastectomy after the initial diagnosis.

  Accelerated partial-breast irradiation (APBI) is now under investigation.

  Because most recurrences occur close to the lumpectomy site, APBI is designed to deliver a higher irradiation dose to a limited volume of tissue in a shorter period of time (days) as compared to conventional whole breast irradiation (weeks).

  Selection of patients for APBI is critical (considerations include tumor size, node-negative disease, patient age, and tumor-free surgical margins).

  Current APBI methods under investigation:

  Interstitial brachytherapy: uses multiple afterloading catheters placed around lumpectomy cavity.

  Intracavitary brachytherapy (MammoSite): uses an inflatable balloon catheter placed in the lumpectomy cavity at the time of surgery or percutaneously following the lumpectomy.

  Intraoperative radiotherapy.

  Three-dimensional conformal external beam radiotherapy.

- Contraindications (relative).

  Multicentric or diffuse breast cancer.

  Diagnosis during first or second trimester of pregnancy; if diagnosed during third trimester, radiation can be done after delivery.

  Prior XRT to chest wall (e.g., Hodgkin's lymphoma): adding radiation for breast cancer treatment may result in an unacceptable cumulative dose.

Collagen vascular disorders.

Presence of a pacemaker.

- Local recurrences.

  Recurrence rates are 5% to 10% within 5 years and 10% to 15% at 10 years.

  The tumor recurs at, or close to lumpectomy site, during first 7 years of follow-up (mean time to recurrence is 3 years); after 7 years, recurrences (or secondary primaries) occur in any quadrant.

  Increased likelihood of recurrence in women with an invasive cancer having an extensive intraductal component (particularly in young women), large ductal carcinomas in situ (DCIS), women less than 30 years of age, vascular invasion and inadequate treatment of the original tumor (residual disease in the breast).

  Recurrences are usually mammographically similar to the primary tumor.

  After breast conserving therapy for DCIS, local recurrences usually contain DCIS and present with microcalcifications. Associated invasive disease may be present in approximately 50% of patients initially diagnosed with DCIS.

- Mammography.

  Assess extent of tumor (possibility of an extensive intraductal component, extending away from the invasive lesion), possibility of multicentricity, and contralateral breast preoperatively.

  Magnetic resonance imaging (MRI) is helpful in assessing extent of disease (multifocality, multicentricity), contralateral synchronous lesions and axillary, internal mammary, infraclavicular, and supraclavicular lymph nodes.

  Accurate preoperative wire localization to ensure complete removal of lesion; with extensive areas of microcalcifications bracketing with two or more wires is appropriate.

  Specimen radiography. Although this is a 2D depiction of a 3D structure, evaluate proximity of lesion to margins. Multiple projections of specimen can be done.

  Consider obtaining a mammogram if residual disease is thought to be present in the breast.

  In patients with positive margins at the time of the lumpectomy, MRI is helpful in assessing extent of residual disease.

  In women with DCIS, consider a mammogram before starting XRT to document the presence of residual calcifications. This can be done within 6 weeks of surgery.

  If residual calcifications (DCIS) are present, reexcision may be undertaken.

  There is no consensus (or data) on appropriate imaging protocols for patient follow-up after breast conserving therapy:

  Some image affected side at 6 month intervals for 3, 5, or 7 years and unaffected side annually.

  Some image affected and unaffected side at annual intervals using standard views.

  We schedule these patients for annual bilateral diagnostic studies to include a spot compression magnification view of the lumpectomy site for the first 7 years following surgery and then return the patients back to screening.

## Mammographic Findings After Lumpectomy and XRT

- Fluid collections.

  Identified in as many as 50% of patients 4 weeks after lumpectomy and in 25% at 6 months.

  Mass with circumscribed or indistinct margins, variable in size (surgical bed is allowed to fill in gradually; drains are not routinely left in place).

  Variable density within an individual seroma or hematoma and between different fluid collections.

  Some have lucent (fat) locules in them. Some have an internal halo partially outlining their inner margin.

  Ultrasound: complex cystic mass at lumpectomy site; septations that may be seen "waving" on real time, thickened wall and mural nodules; others may appear more solid with cystic spaces.

  Most resolve by 12 months, however, some may persist for years.

  If patient is asymptomatic, aspiration is not indicated.
- Scar.

  Fluid collections replaced by architectural distortion or spiculated mass (6 to 18 months).

  Fat trapped in center of mass.

  Appearance differs between views.

  Contract and shrink over time with increasing amounts of fat accumulating in center of scar.

  Consider recurrence if the size or density of the scar increases after two stable examinations.
- Edema.

  Breast enlarges, compression may be limited thus making adequate exposure difficult to obtain.

  Changes may be more prominent in periareolar and inferior (dependent) portions of breast.

  Density is increased relative to contralateral breast and preoperative mammogram.

  Increased density and thickening of trabecula (Kerley-B lines in the breast).

  Changes usually resolve within 2 years.
- Skin thickening.

  Follows time course of breast edema.

  Approximately 20% of women have residual skin thickening 2 years after XRT.

  Tangential views may be needed if skin changes simulating distortion are superimposed on the lumpectomy site.

  Skin thickening is a factor in the overall increased density of the breast after XRT.
- Calcifications.

  Magnification views should be done after surgery and before XRT to identify residual calcifications in patients with DCIS.

Reexcision may be undertaken if residual calcifications (DCIS) are found before XRT.

Calcifications related to fat necrosis may be punctate and pleomorphic initially.

Dystrophic: round, smooth, some with lucent centers, large, coarse, linear or curvilinear with smooth borders; usually progress on sequential mammograms.

Suture.

Tumor recurrence: spot compression magnification views are needed for full evaluation.

Follow up is appropriate if calcifications develop within 3 years of lumpectomy and have a benign appearance.

- Recurrences.

  Mass with circumscribed, indistinct, or spiculated margins at lumpectomy site.

  Calcifications: linear (casting), round, punctate developing at lumpectomy site.

  Architectural distortion, increases in density and distortion compared with the earliest available comparison study following the lumpectomy.

  Diffuse changes including increases in parenchymal density, developing prominence of the trabecular markings, progressive decrease in breast size and skin thickening.

  Magnetic resonance imaging is helpful in evaluating patients in whom there is a question of postoperative scarring versus recurrence; recurrent tumor enhances, scar tissue does not.

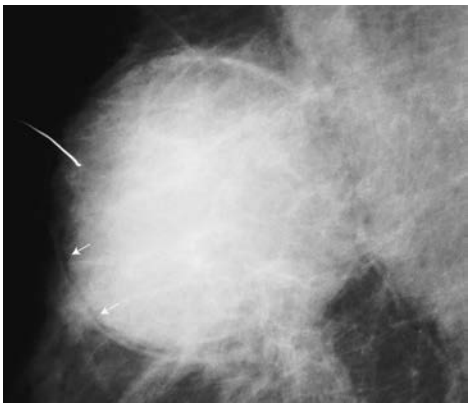
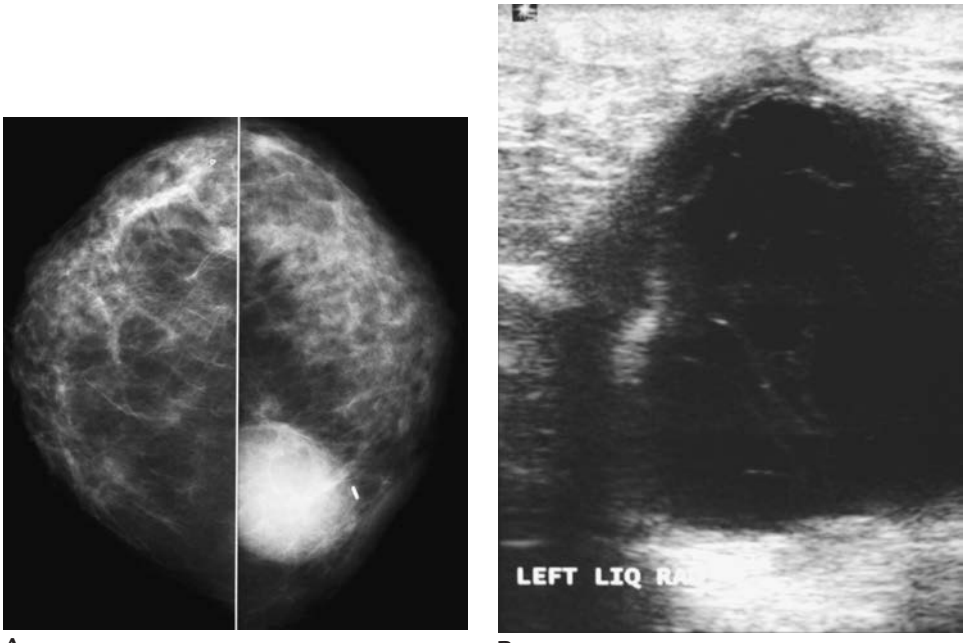
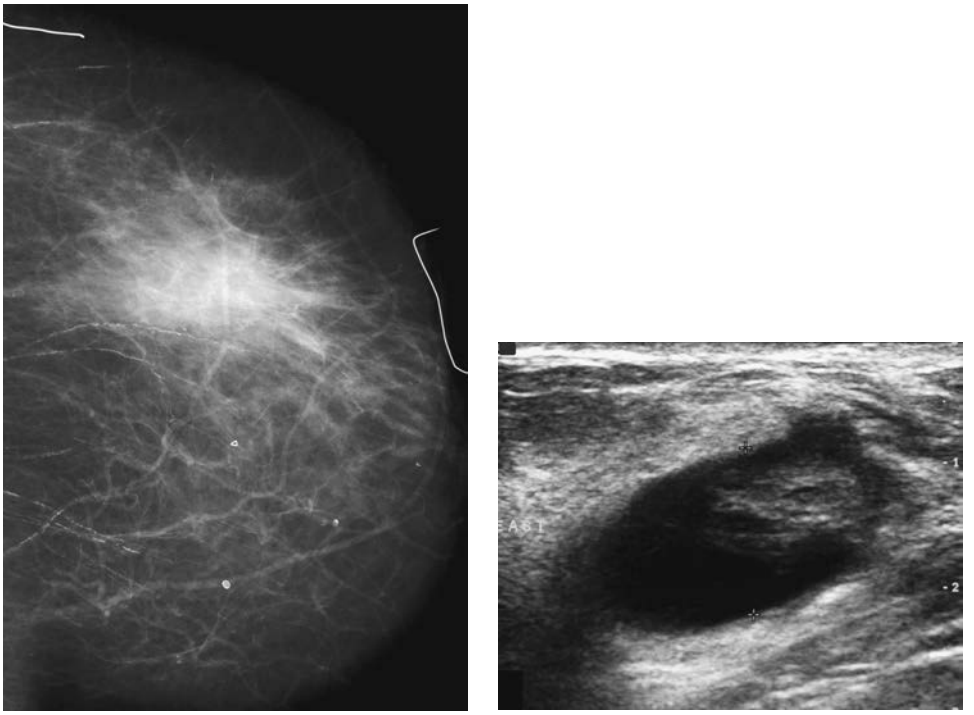


**FIGURE 15-6** Post-lumpectomy fluid collection. Round mass with indistinct and obscured margins at lumpectomy site (metallic wire used to mark lumpectomy site). Thin, 1mm lucency (*arrows*) within mass, partially outlines the inner margin of the mass (e.g., internal halo) is a common finding in postoperative or traumatic fluid collections.



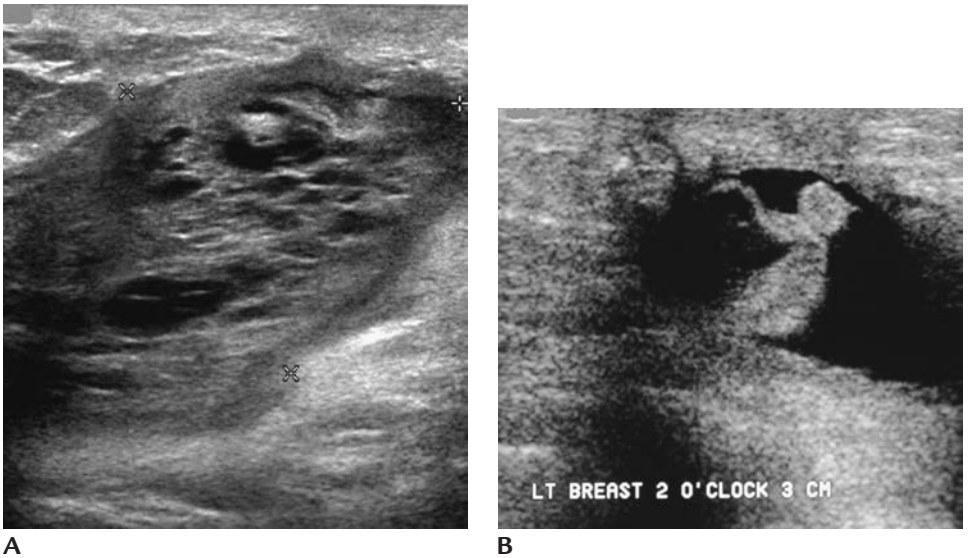

**A** **B**

**FIGURE 15-7** Post-lumpectomy fluid collection. **(A)** Oval fat-containing mass medially in the left breast at a lumpectomy site. **(B)** Complex cystic mass with posterior acoustic enhancement and internal septations that can be seen "waving" in the fluid during the real time evaluation. Postoperative fluid collections are not aspirated unless superimposed infection is a concern. If aspirated, most recur.



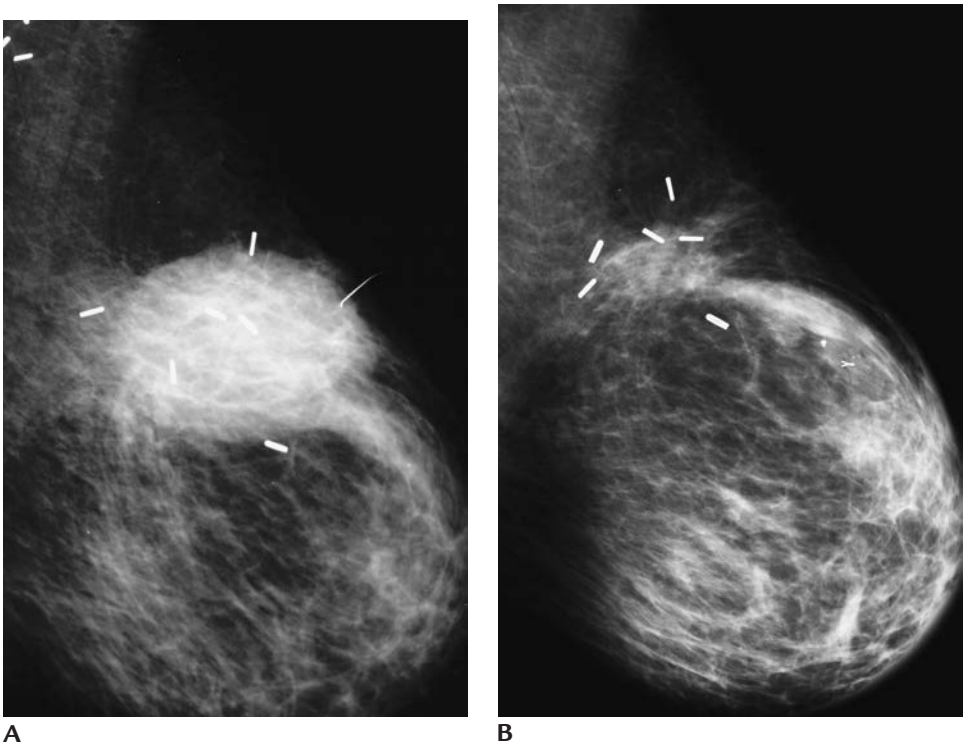
**A** **B**

**FIGURE 15-8** Post-lumpectomy fluid collection. **(A)** Irregular mass with indistinct margins. Metallic wires used to mark lumpectomy and axillary biopsy sites. Arterial calcifications are present. **(B)** Oval complex cystic mass with posterior acoustic enhancement.




**A** **B**

**FIGURE 15-9** Post-lumpectomy fluid collection. **(A)** Complex cystic mass with posterior acoustic enhancement. Predominately solid appearance with associated cystic spaces and some posterior acoustic enhancement. **(B)** Complex cystic mass with posterior acoustic enhancement and some shadowing. Predominantly cystic in appearance with mural nodule and internal echoes. Postoperative fluid collections do not need to be aspirated unless superimposed infection is a concern. If aspirated, most recur.



A B

**FIGURE 15-10** Post-lumpectomy fluid collection. **(A)** Oval mass with obscured, indistinct, and partially circumscribed margins at lumpectomy site. Clips present at lumpectomy site in the breast and in the left axilla. These collections are seen in as many as 50% of patients 4 weeks after the lumpectomy and in 25% at 6 months. **(B)** One year following **(A)**. The fluid collection is resolved. Residual density and distortion is seen at the lumpectomy site. Most postoperative fluid collections resolve by 12 months. Also noted is residual prominence of the trabecular markings reflecting radiation therapy effect.

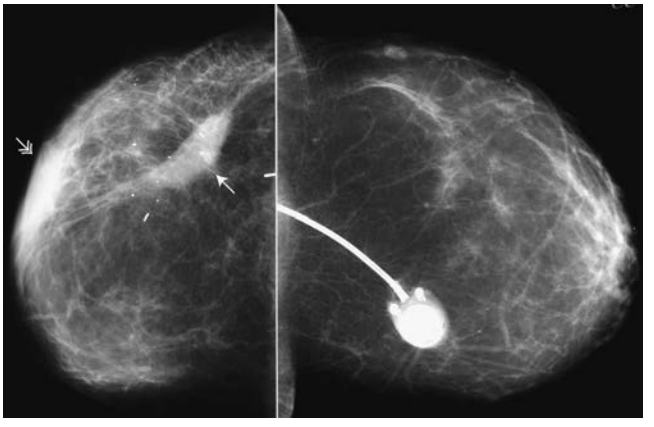
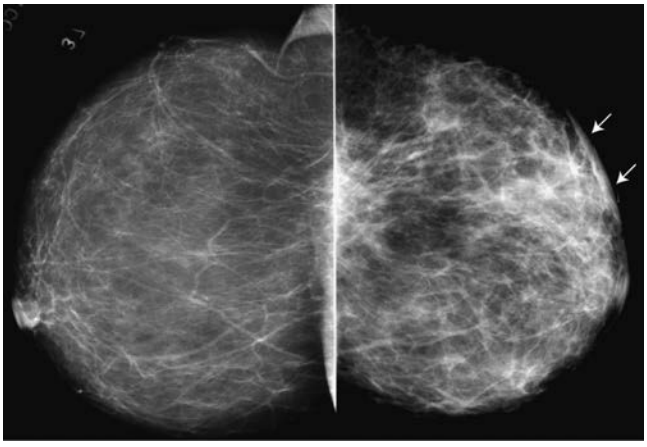


**FIGURE 15-11** Post-lumpectomy and radiation therapy changes. Craniocaudal views. Right breast is smaller than left. An irregular mass with spiculated margins is present at the lumpectomy site (*arrow*), there is associated skin thickening (*double headed arrow*) anteriorly and prominence of the trabecular markings particularly in the lateral aspect of the breast. Portable catheter is present in the left breast medially.



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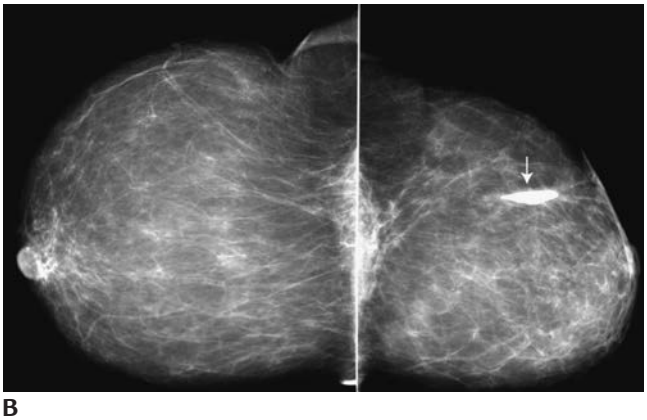
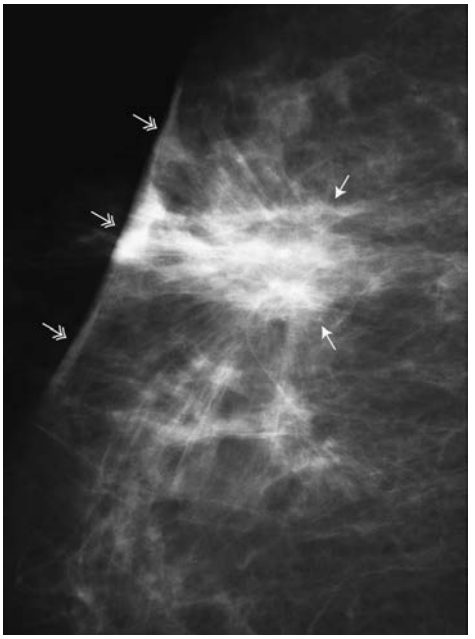


**B**

**FIGURE 15-12** Post lumpectomy and radiation therapy changes. **(A)** Craniocaudal views. Left breast is smaller than right. The overall density of the parenchyma is increased, there is prominence of the trabecular markings and skin thickening (*arrows*). **(B)** Two years following **(A)**. The overall density of the parenchyma is decreased. Trabecular prominence and skin thickening are almost completely resolved. A coarse dystrophic calcification (*arrow*) has developed at the lumpectomy site.



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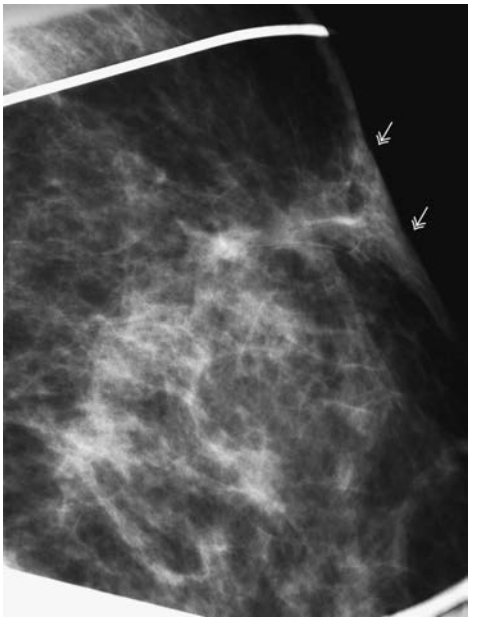

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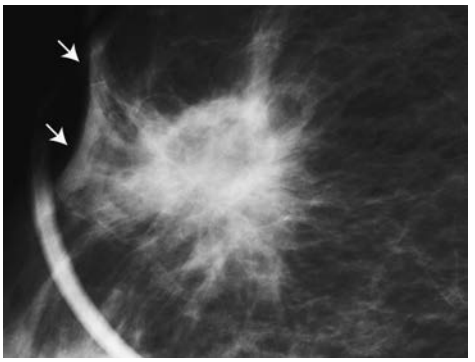
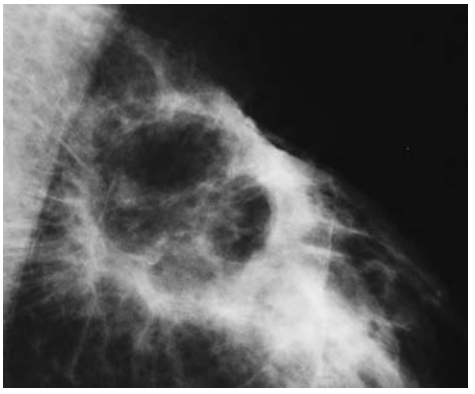


C

**FIGURE 15-13** Post-lumpectomy changes. **(A)** Spot tangential view of lumpectomy site demonstrates an irregular, fat containing mass (*arrows*) with indistinct margins. Associated skin thickening (*double headed arrows*) seen in tangent and not superimposed on the lumpectomy site. **(B)** Different patient. Spot tangential view. Skin thickening (*double headed arrows*) localized to lumpectomy site. The tangential view can effectively eliminate superimposition of skin changes on the lumpectomy site. **(C)** Different patient. Double spot compression magnification tangential view of right lumpectomy site. A fat containing mass with irregular and spiculated margins consistent with fat necrosis is seen at the lumpectomy site. On tangential views of the lumpectomy site, associated skin thickening (*arrows*) and retraction is seen separate (e.g. not superimposed) from the changes at the lumpectomy site.



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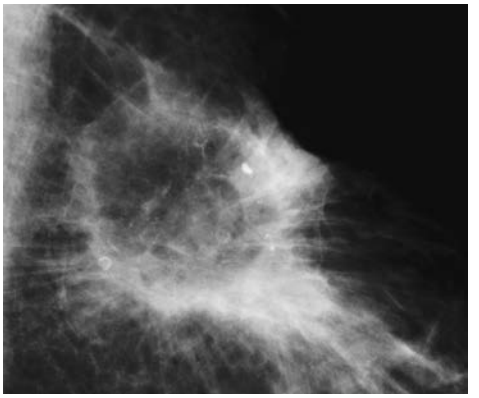

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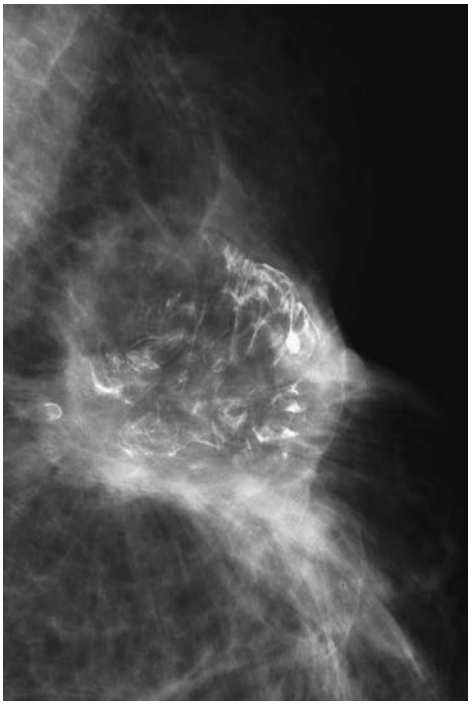

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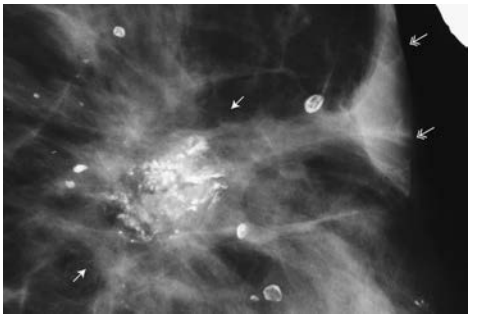
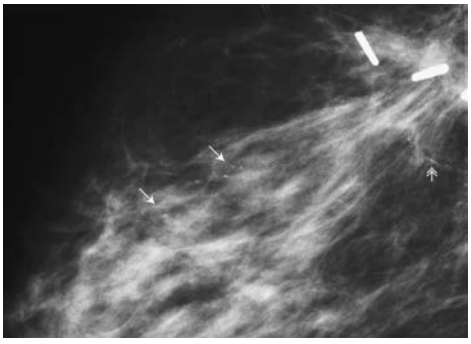


D

**FIGURE 15-14** Post lumpectomy changes. Fat necrosis. **(A)** Irregular, fat containing mass with indistinct and spiculated margins at lumpectomy site. **(B)** One year following **(A)**. Calcifications are developing in the fatty component. Margins remain indistinct and spiculated. **(C)** Two years following **(A)**. Mass is decreasing in size particularly soft tissue component. Dense curvilinear calcifications developing in fatty component of mass. **(D)** Different patient. Mass (*arrows*) with spiculated margins, associated distortion and coarse dystrophic calcifications at prior lumpectomy site. Skin thickening and retraction (*double headed arrows*). Scattered lucent centered calcifications are also present.



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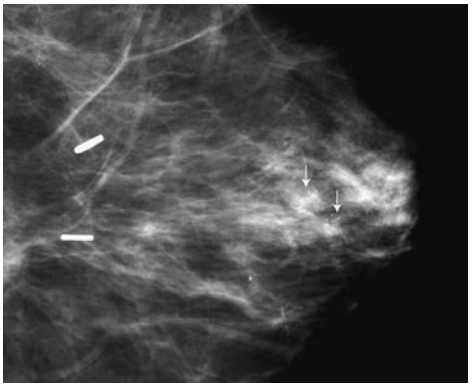

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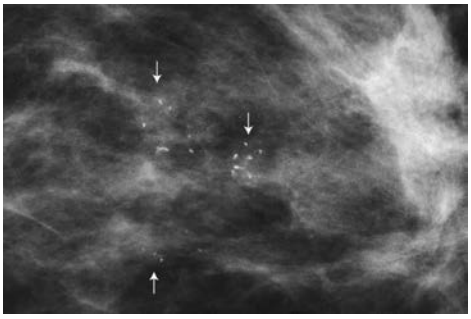
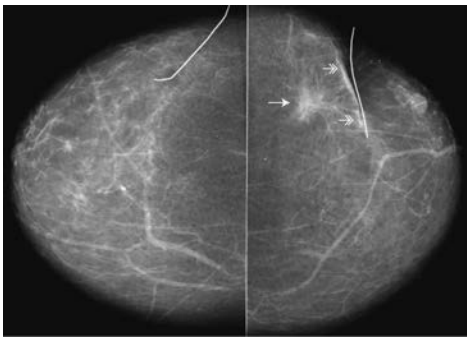


C

**FIGURE 15-15** Recurrence following lumpectomy and radiation therapy. **(A)** New cluster of pleomorphic calcifications in a patient following lumpectomy (surgical clips) and radiation therapy. Recurrent ductal carcinoma in situ (DCIS), high nuclear grade with comedonecrosis, cribriform pattern. Arterial calcification (*double headed arrow*). **(B)** Different patient. Calcifications (*arrows*) developing anterior to prior lumpectomy site (surgical clips). **(C)** Double spot compression magnification view (1.8×). Cluster of pleomorphic calcifications developing compared with prior studies. Recurrent intermediate grade DCIS with comedonecrosis, solid and papillary types.



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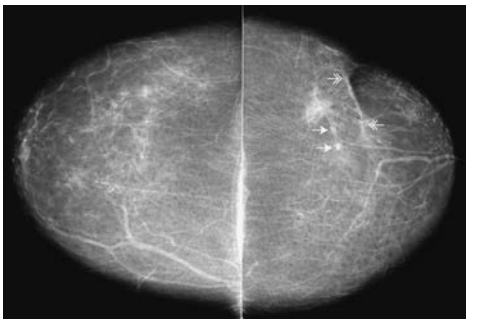

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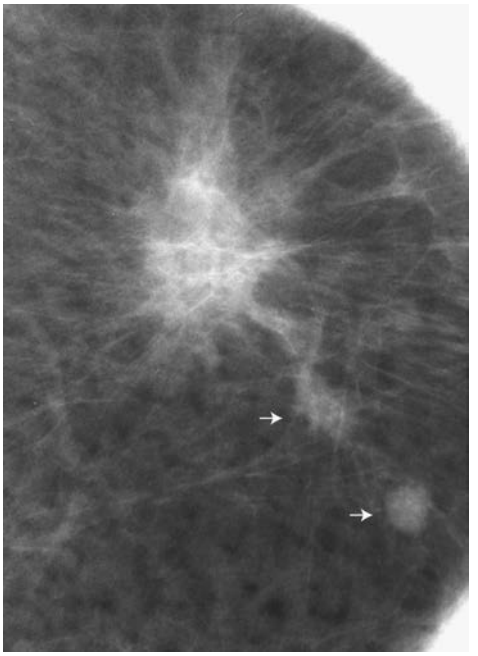

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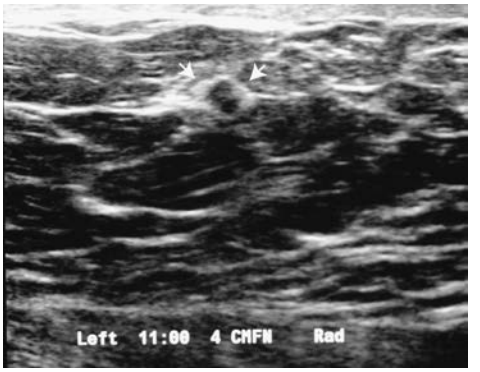



D

**FIGURE 15–16** Recurrence following lumpectomy (with no radiation therapy) for ductal carcinoma in situ (DCIS). **(A)** Craniocaudal views demonstrating spiculation and distortion at prior lumpectomy site (*arrow*). Associated skin thickening is present. Metallic wires used to indicate prior benign biopsy site on the right and lumpectomy site on the left. The skin changes at the lumpectomy site create a "shelf" resulting in uneven compression and the creation of an air pocket (lucency) anterior to area of skin thickening. **(B)** Mammogram several years following **(A)**. The patient has now developed two 4 to 5 mm masses (*arrows*) in close proximity to the prior lumpectomy site. Associated skin thickening (*double headed arrows*). The skin changes create a "shelf" resulting in uneven compression and the creation of an air pocket (lucency) anterior to the area of skin thickening. **(C)** Spot compression view. Two masses (*arrows*) with indistinct margins are confirmed in close proximity to the lumpectomy site. **(D)** Vertically oriented hypoechoic mass (*arrows*) with echogenic margin and disruption of Cooper's ligament corresponding to one of the masses seen mammographically. Invasive ductal carcinoma, intermediate nuclear grade is diagnosed on core biopsy. Invasive disease is diagnosed in 50% of patients who recur following an initial diagnosis of DCIS.

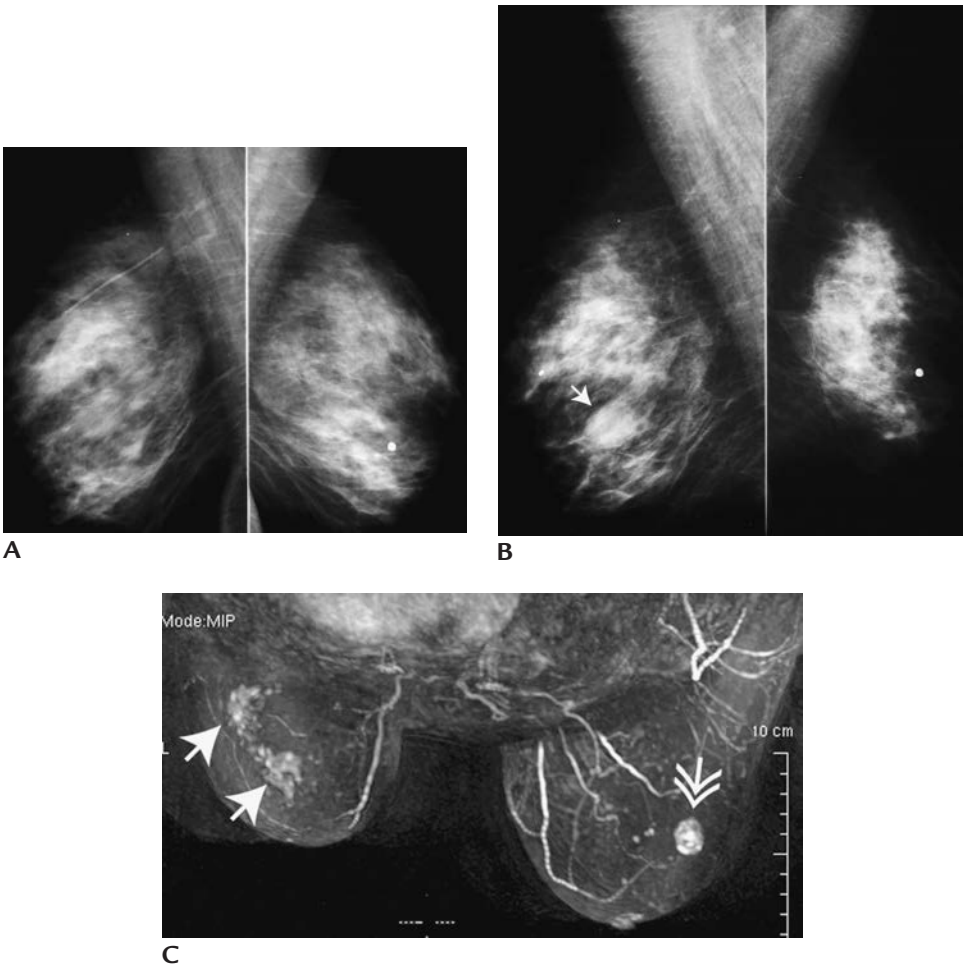



**FIGURE 15-17** Recurrence, diffuse. **(A)** Mediolateral oblique views. Dense glandular tissue. Left breast is slightly smaller than right but there are no significant findings following a left lumpectomy and radiation therapy for invasive ductal carcinoma. Radio-opaque wire used to mark prior biopsy (benign) site on the right. **(B)** Mammogram several years following **(A)**. The left breast has decreased in size and the overall density of the parenchyma is increased. An oval mass (*arrow*) is present in the right breast (fibroadenoma). **(C)** Magnetic resonance imaging, maximum intensity projection (MIP) image. Regional, irregular, stippled enhancement (*arrows*) laterally in the left breast. Diffuse recurrence, intermediate grade invasive ductal carcinoma with lobular features. Mass with heterogeneous enhancement (*double headed arrow*) laterally in the right breast corresponding to fibroadenoma.

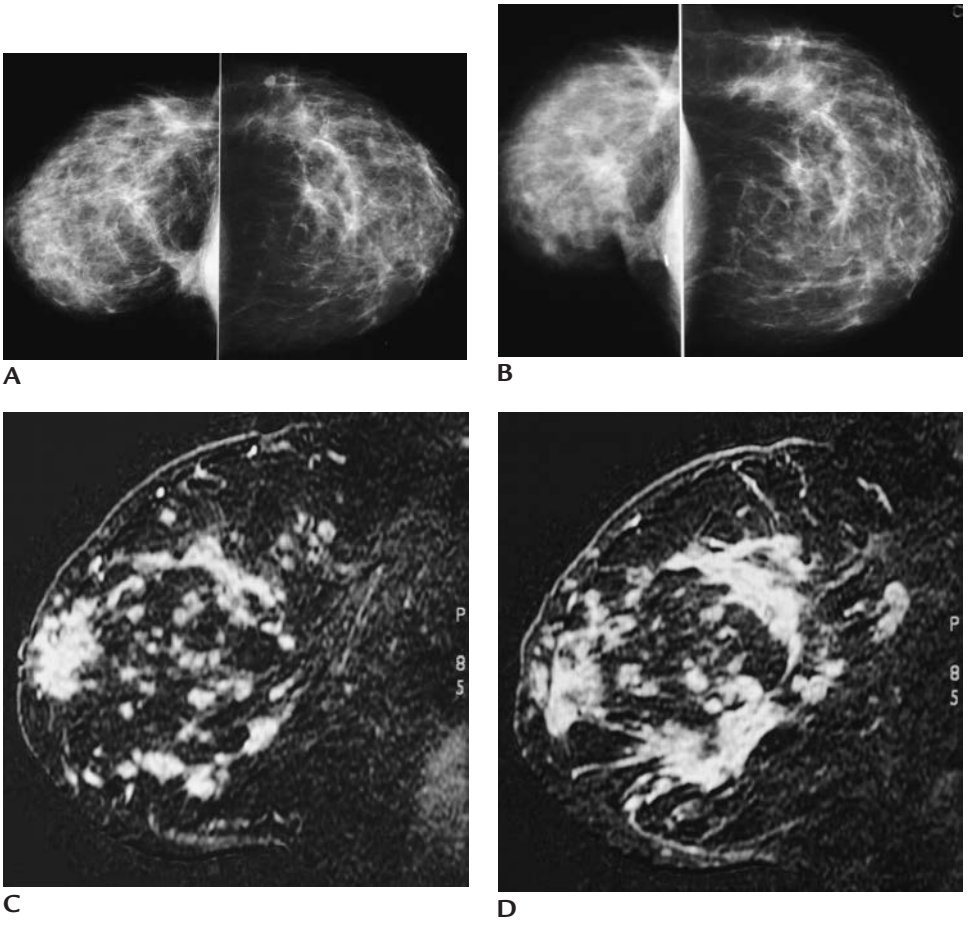



**FIGURE 15-18** Recurrence, diffuse. **(A)** Craniocaudal views. Diffuse changes post lumpectomy and radiation therapy, right breast. A mass with indistinct margins is seen posteromedially abutting the right pectoral muscle corresponding to fat necrosis at the lumpectomy site. Increased density of the parenchyma and marked prominence of the trabecular markings reflect radiation therapy effect. **(B)** Follow up mammogram. The size of the right breast is decreased and the density is increased even more. **(C)** and **(D)** Magnetic resonance imaging, subtraction sagittal images, right breast at different table top positions. Multiple enhancing masses are present diffusely involving the breast.

# Breast Reconstruction

## Key Facts

- After mastectomy some women undergo reconstruction.
  Immediate versus delayed.
  Implant versus autologous tissue transplantation.
- Advantages of immediate breast reconstruction.
  Psychosocial benefits over delayed reconstruction that compare favorably to breast conserving therapy.
  Improved cosmetic results because soft tissue contraction and scar formation are not allowed to develop.
  Reduced morbidity: one episode of anesthesia, one hospitalization an convalescence.
  Reduced cost.
- Implants.
  Saline and silicone implants.
  Expanders are used in most women to expand the skin and chest wall space to accommodate the final implant. Complete expansion takes 6 to 8 weeks. The final implant is put in 4 to 6 months after the initial surgery.
  Implant placed in subpectoral location.
  Technically simplest and safest form of reconstruction. The implant can be removed if the reconstruction is unsuccessful.
  The breast mound is less natural than what is obtained with autologous tissue.
  Complications include leakage of implant material, capsule formation and contracture.
  Complications increase as implant ages.
  Depending on breast size, and for symmetry, the contralateral breast may need to be augmented or reduced.
  Changes in body weight may lead to size asymmetry.
  Imaging following reconstruction with implants is of limited usefulness and not indicated.
- Autologous tissue transplantation.
  Transverse rectus abdominis myocutaneous (TRAM) flap; latissimus dorsi flap; superior or inferior gluteal flap, Rubens flap.
  Skin sparing mastectomy is done.
  Most durable; appear and behave more natural and reflect changes in body weight.
  No capsule formation or contracture.
  Results improve over time.
  Technically more complex and initial surgical procedure is longer.
  Initially, costs are higher compared with reconstructions with implants; however, as implants age, complications develop and costs increase.
- Data support use of imaging to study autologous tissue reconstructions.

Physical examination may be limited because there is now tissue interposed between examining fingers and chest wall, and hardening of the breast mound related to fat necrosis develops.

Chest wall recurrences may be imaged before they are clinically detectable.

- Mammographic findings after TRAM flap reconstruction:

  Variable amounts of fat and surgical clips; soft tissue posteriorly represents rectus muscle pedicle and may appear mass like.

  Soft tissue densities superiorly and inferiorly on the mediolateral oblique view commonly decrease in size and density and may develop calcifications on follow-up studies.

  Soft tissue defect at umbilicus site.

  Calcifications.

    Linear, curvilinear, lucent centered (bubbly), coarse.

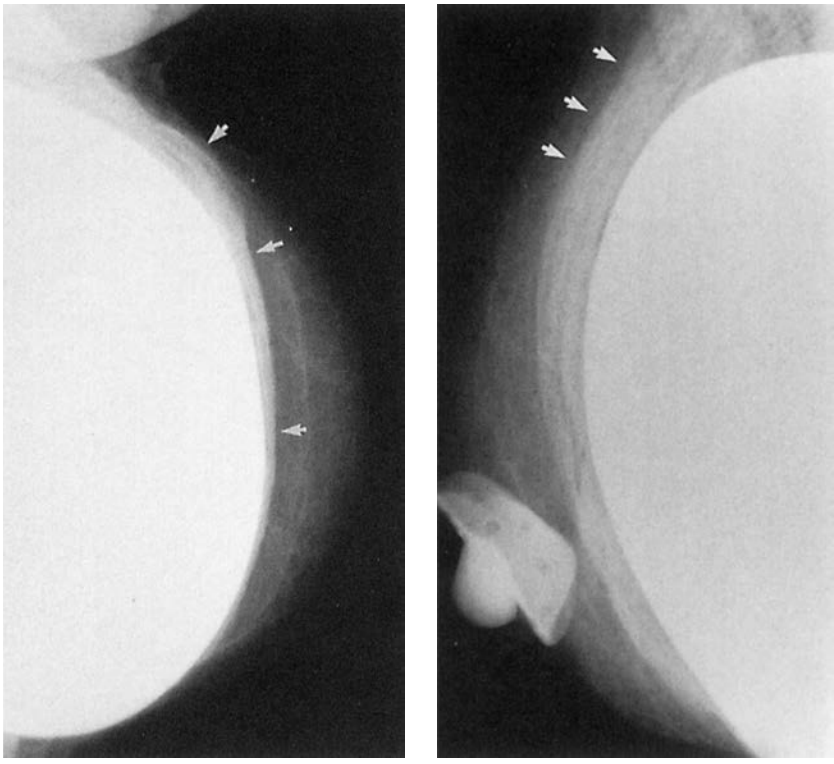
    Linear, pleomorphic simulating microcalcifications associated with DCIS.

  Fluid collections (seromas, hematomas).

- Mammographic findings after latissimus dorsi flap:

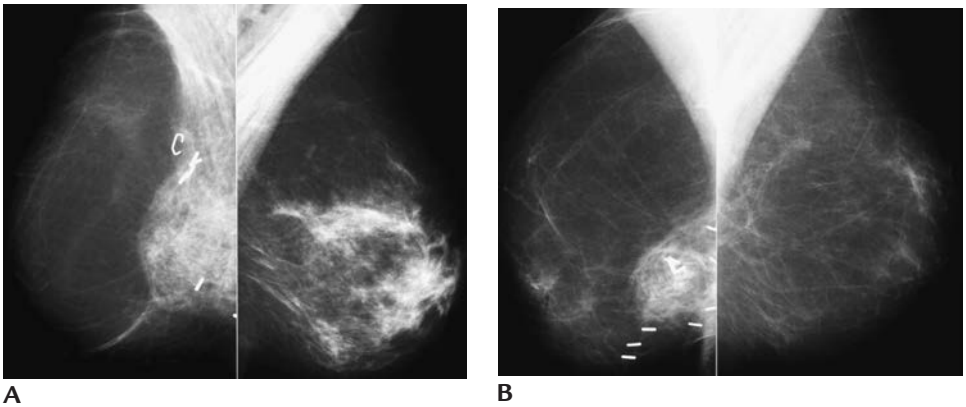
  Muscle can be seen as striated density superiorly in the mediolateral oblique view superimposed on the pectoral muscle.

- Adjuvant therapy is started 14 to 21 days following surgery. Compared to mastectomy alone, adjuvant therapy is not delayed after immediate reconstruction.
- Skin sparing mastectomy is not associated with higher recurrence rates.



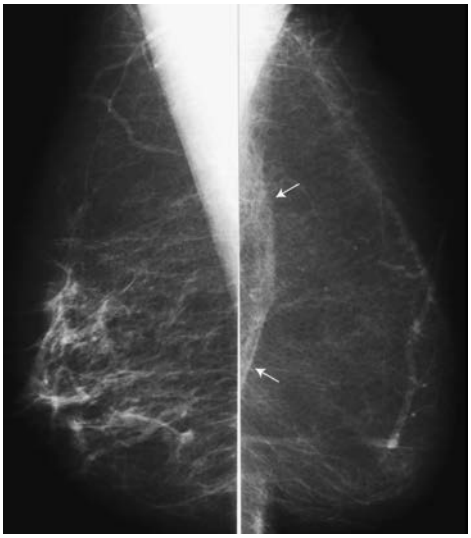
A B

**FIGURE 15-19** Reconstruction. **(A)** Subpectoral silicone implant. Pectoral muscle (*arrows*) coursing anterior to implant (*arrows*). **(B)** Breast and nipple reconstruction after mastectomy. As in most patients with reconstruction, the implant is subpectoral in position. The pectoral muscle can be seen coursing over the implant (*arrow*).



A B

**FIGURE 15-20** Transverse rectus abdominis muscle (TRAM) flap. **(A)** Mediolateral oblique views. Predominantly fatty tissue, right TRAM flap. Rectus muscle seen as soft tissue mass like area close to chest wall at site of surgical clips. **(B)** Different patient. Mediolateral oblique views. Predominantly fatty tissue, right TRAM flap. Rectus muscle seen as soft tissue mass like area close to chest wall at site of surgical clips.



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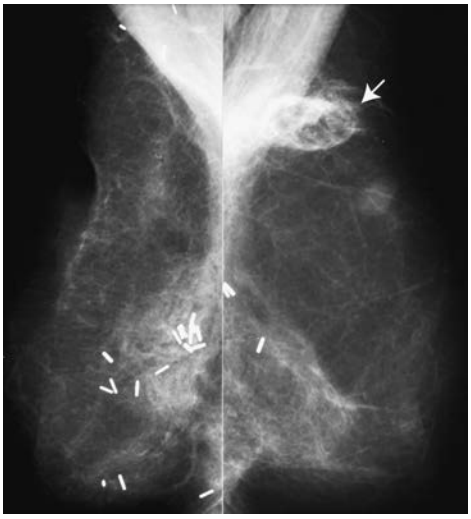

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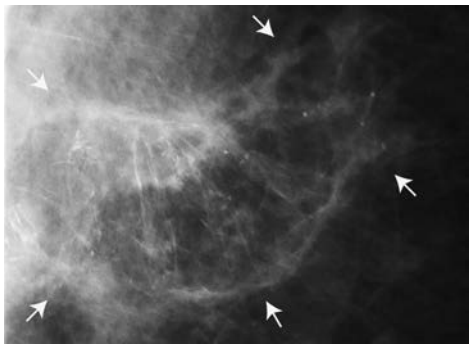
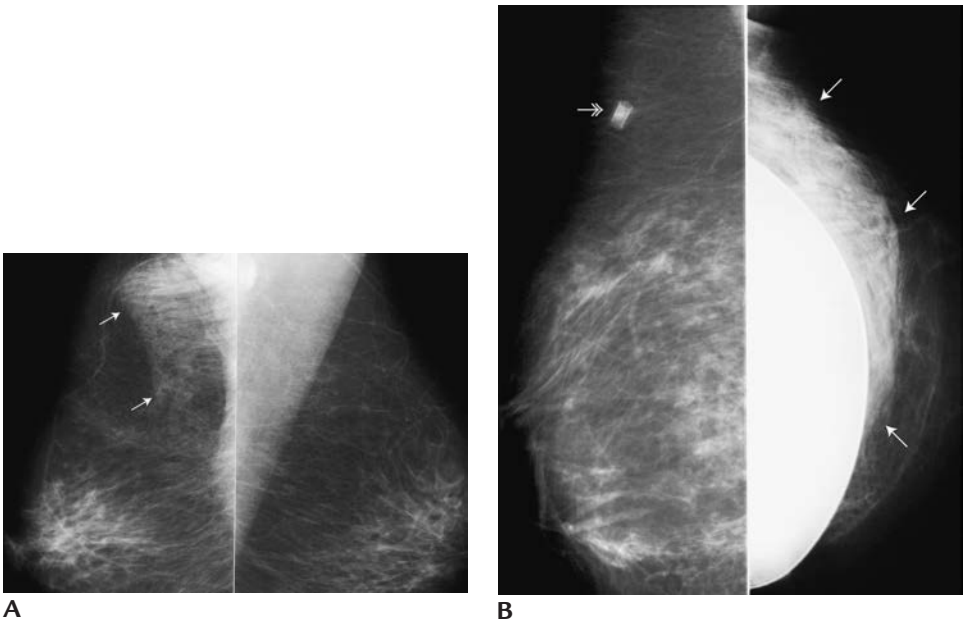


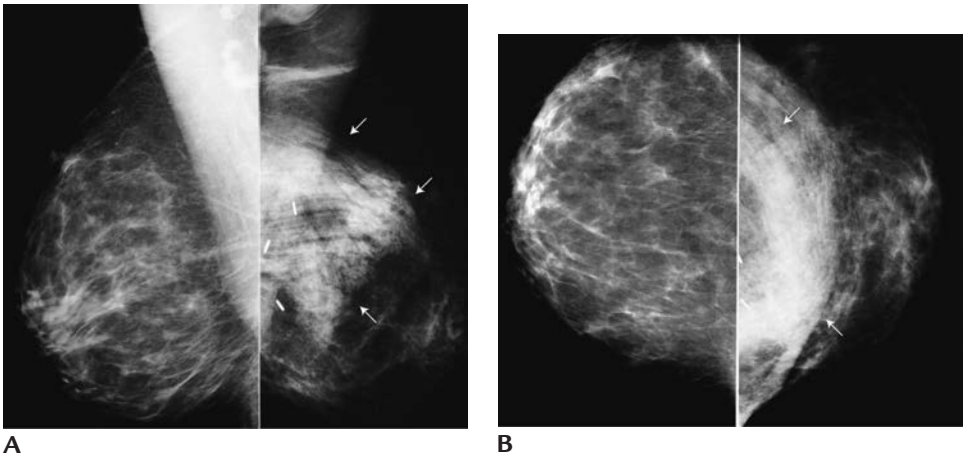
**E**

**FIGURE 15-20** (*Continued*) **(C)** Different patient. Predominantly fatty tissue, left TRAM flap. Rectus muscle (*arrows*) less prominent than that seen in **(A)** and **(B)**. In patients with autologous tissue reconstructions, recurrences occurring along the chest wall may be imaged before they become clinically apparent. Imaging the reconstruction may be more appropriate in women with autologous tissue transplants because the increased tissue overlying the chest wall can limit physical examination for an early recurrence. Also, fat necrosis may harden the tissue further limiting the physical examination. **(D)** Different patient. Bilateral TRAM flap reconstructions. Rectus muscles seen as soft tissue mass like areas inferiorly at site of surgical clips. An oval fat containing mass (*arrow*) is seen superiorly on the left consistent with fat necrosis. This is a common place to see fat necrosis in TRAM flaps. **(E)** Double spot compression magnification view left TRAM flap superiorly. An oval fat containing mass with indistinct margins and associated calcifications (linear, curvilinear, round, punctate) is imaged corresponding to a palpable area of concern to the patient. This is an area of fat necrosis and warrants no further intervention.



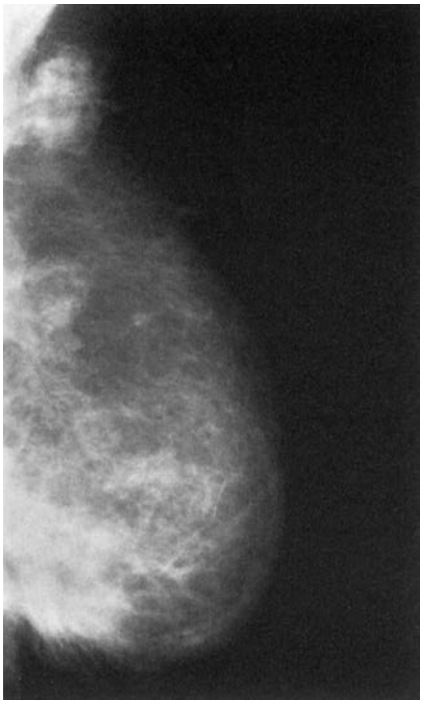
A B

**FIGURE 15-21** Latissimus dorsi flap. **(A)** Mediolateral oblique views. Latissimus dorsi muscle (*arrows*) with fatty striations. **(B)** Different patient. Mediolateral oblique views. Reconstruction with implant and latissimus dorsi muscle (*arrows*). The muscle is characterized by fatty striations and in this patient is positioned anterior to the implant. A hickman catheter Dacron cuff (*double headed arrow*) is present on the right.



A B

**FIGURE 15-22** Latissimus dorsi flap. **(A)** Mediolateral oblique and **(B)** Craniocaudal views. Latissimus dorsi muscle (*arrows*) flap reconstruction on the left. Muscle is characterized by fatty striations. As in this patient, the latissimus dorsi is commonly seen superimposed on the pectoral muscle.



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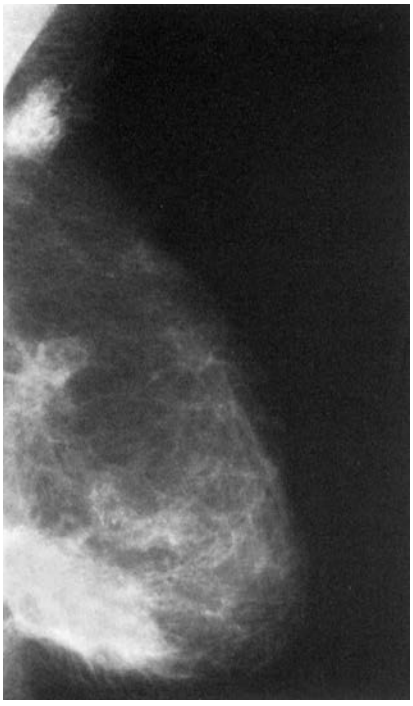

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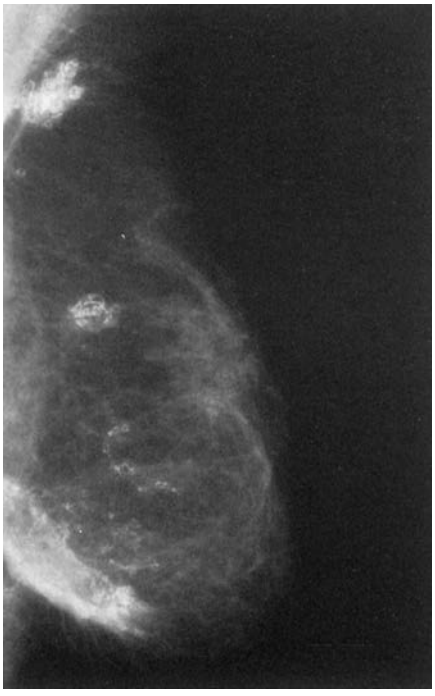
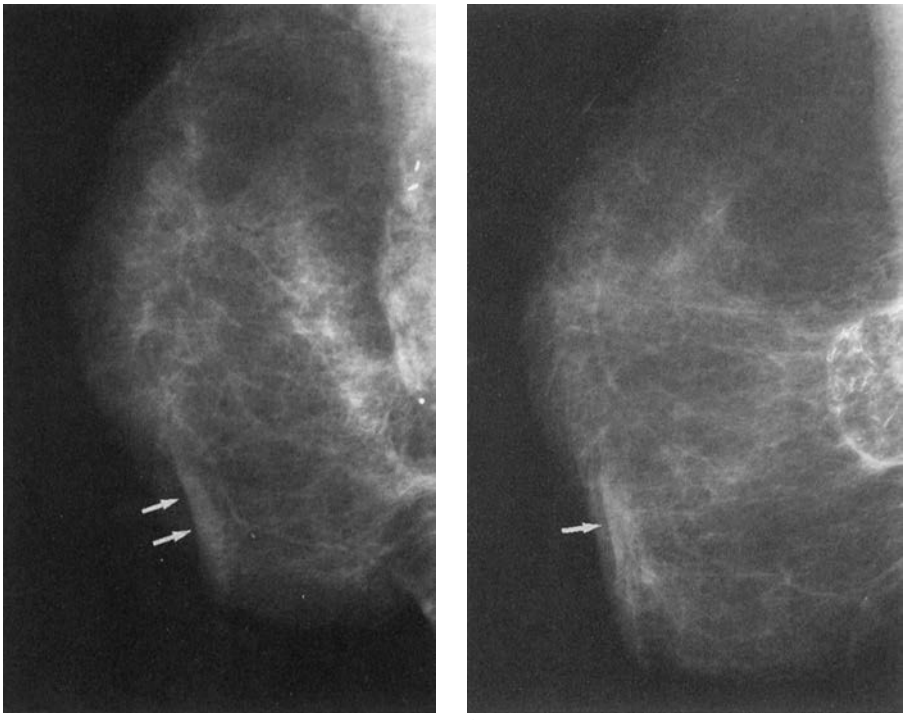


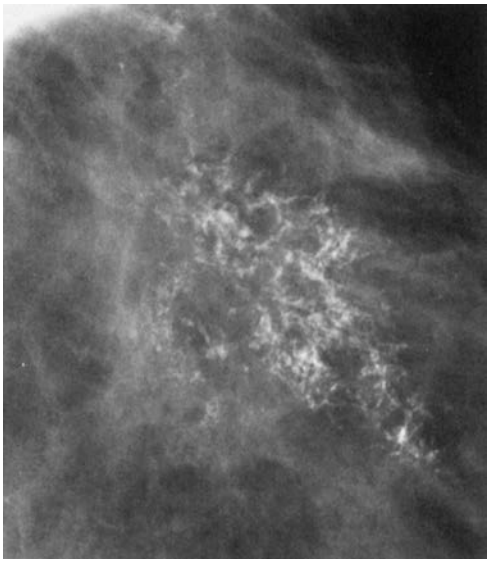
**C**

**FIGURE 15-23** Transverse rectus abdominis muscle (TRAM) flap reconstruction, sequential changes. **(A)** First postoperative mediolateral oblique view of a TRAM flap demonstrating irregular areas of increased soft tissue inferiorly, posteriorly, anterior to the pectoral muscle and in the axillary tail. **(B)** Two years after the TRAM flap, the soft tissue densities have decreased in size and dystrophic calcifications are starting to develop in association with the residual soft tissue. **(C)** Three years after the TRAM flap, further reduction in the size and density of the soft tissue components is noted. Additional dystrophic calcifications have developed. The calcifications, associated with the residual soft tissue components, are coarse and lucent centered (bubbly). The changes illustrated are common in patients following TRAM flap reconstruction.



A B

**FIGURE 15-24** Transverse rectus abdominis muscle (TRAM) flap reconstruction. **(A)** First postoperative mediolateral oblique view of a TRAM flap. Predominantly fatty with a small amount of increased soft tissue anterior to, and superimposed, on the pectoral muscle. The sutured umbilicus defect is apparent in this patient (*arrows*). **(B)** Three years after the TRAM flap, the soft tissue component seen initially has evolved into an oil cyst with coarse, curvilinear calcifications. The sutured umbilicus defect is again noted (*arrow*).



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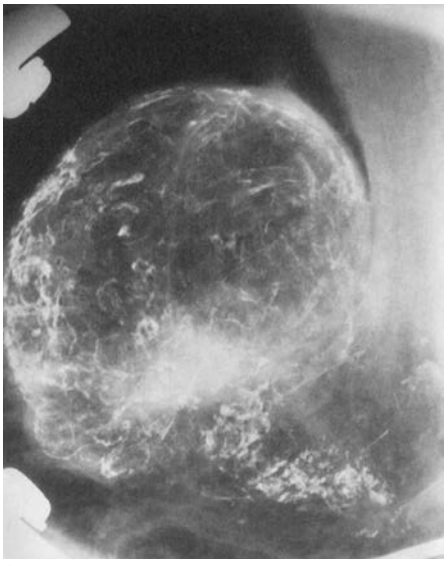

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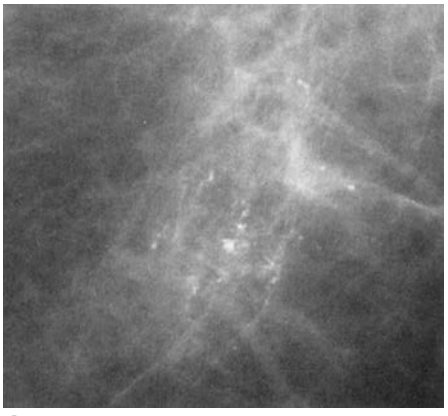


**C**

**FIGURE 15-25** Transverse rectus abdominis muscle flap. Calcifications. **(A)** Pleomorphic. coarse, lacelike dystrophic calcifications developing in areas of fat necrosis. The appearance of the calcifications is variable from patient to patient. In some, the calcifications are lucent centered ("bubbly"; see Fig. 15–23). **(B)** Coarse, curvilinear, dystrophic calcifications may develop in patients in whom oil cysts form. **(C)** In the early stages of development, calcifications in fat necrosis can be pleomorphic, punctate, round and linear. Depending on the time course and location of the developing calcifications and, if the patient's initial presentation was ductal carcinoma in situ, recurrence may need to be considered.

# Mastectomy Side Views

## Key Facts

- Clinical.

  A good clinical examination of the mastectomy site usually detects local recurrences.

  Without the breast, it is easier to interpose residual fatty tissue between the examining fingers and the chest wall and to palpate any developing mass.

  A thorough examination is needed, however; otherwise, even clinically apparent lesions may go undetected.
- Mammography.

  To detect clinically occult local recurrences, some advocate mediolateral oblique view of the mastectomy side.

  However, several investigators have suggested that this is not cost effective, as a thorough physical examination usually identifies local recurrences. Others state that in some women, imaging the mastectomy side detects early local recurrence and therefore should be done.

  Most facilities in the United States do not do images of the mastectomy side.

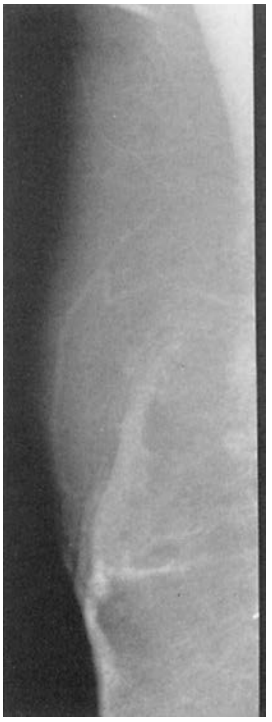
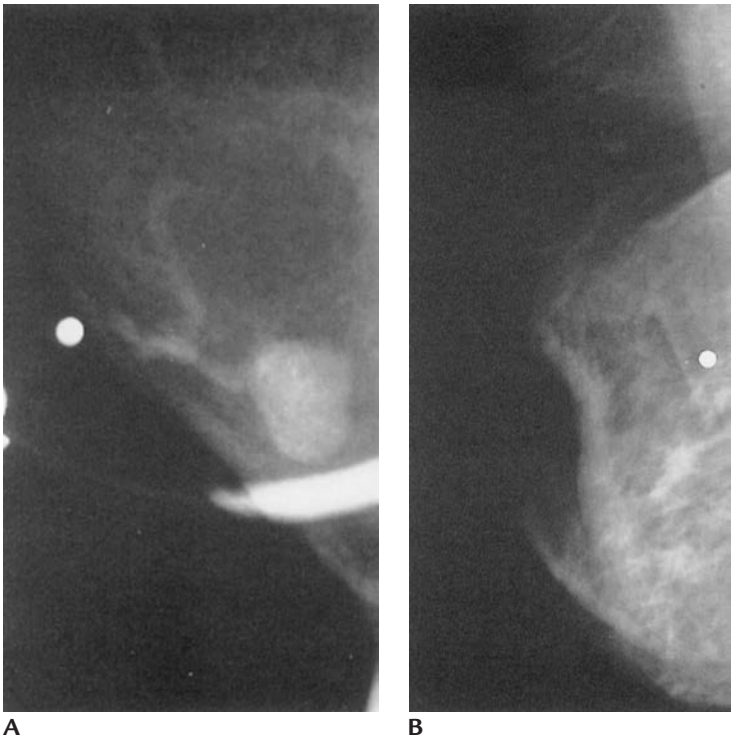


**FIGURE 15-26** Mastectomy side. Single mediolateral view. Because in most patients there is only a small amount of fatty tissue on the mastectomy side, even small masses should be readily apparent during thorough physical examination. Some, however, advocate that these views should be done because early local, clinically occult recurrences may be detected in some patients.



**A** **B**

**FIGURE 15-27** **(A)** Local recurrences (mucinous carcinoma) on mastectomy side. In this patient the local recurrence is palpable. Well-circumscribed mass with punctate calcifications. **(B)** Local recurrence (poorly differentiated infiltrating ductal carcinoma). Diffuse trabecular and skin thickening. Clinically apparent.

# AUGMENTATION

## KEY FACTS

- Clinical.

  Over 2 million women in the United States have augmentation implants (aesthetic).
- Methods.

  Subcutaneous silicone or paraffin injections not approved in the United States, but still done in some countries.

  Autologous tissue transplants not generally used for aesthetic augmentation; done in some women after mastectomy.
- Implant types.

  Silicone.

  Smooth.

  Polyurethane coated.

  Textured.

  Double lumen.

  Saline.
- Implant placement.

  Subglandular (prepectoral), between glandular tissue and pectoralis major muscle.

  Subpectoral, between pectoralis major and minor muscles.
- Implant placement methods.

  Inframammary fold incision.

  Periareolar incision.

  Transaxillary.
- Imaging.

  Four views of each breast: two (craniocaudal [CC] and mediolateral oblique [MLO]) with the implant in the field of view and two (CC and MLO) with the implant displaced (ID views).

  Additional views are done if indicated (e.g., spot compression, magnification, tangential).

  Implant bulging (part of implant protrudes through capsule).

  Implant wrinkles are seen commonly with saline implants; they occur just as commonly with silicone implants but are not apparent on mammograms becomes of the high density of silicone.

  Coarse calcification of capsule.

  Round, punctate, and coarse calcifications can develop associated with saline implant valve. Calcifications limited to the valve.

  With rupture, may see extracapsular silicone surrounding implant and extending to axilla.

  Intact implants are anechoic on ultrasound, but may see reverberation artifact. Membrane may be seen as one or two echogenic lines at the implant margin. Radial folds may be seen as echogenic bands partially extending from implant edge into center of implant.

Sonographically saline implant valve may be imaged as rectangular area with associated shadowing (in some patients, the valve is readily palpable).

Depending on implant type appearance of MRI is variable.

Radial folds commonly seen on MRI extend to the periphery of the implant.

- Findings following implant removal.

  Fluid collections localized to site previously occupied by implants.

  Uni- or bilateral spiculated masses reflecting fat necrosis at prior site occupied by implant.

  Irregular remnants of capsule, variable in thickness that may have associated coarse calcifications posteriorly on mediolateral oblique and craniocaudal views.

  Dystrophic calcifications.

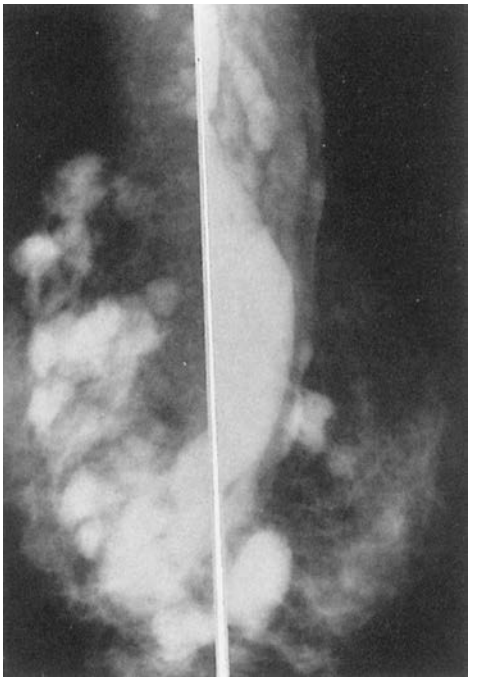
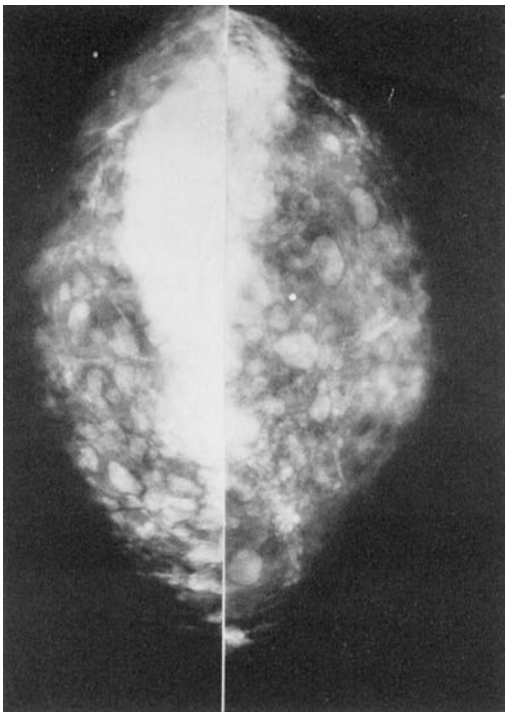


**FIGURE 15-28** Subcutaneous silicone injections. Dense, irregular, variably sized masses scattered bilaterally consistent with previous subcutaneous silicone injections.



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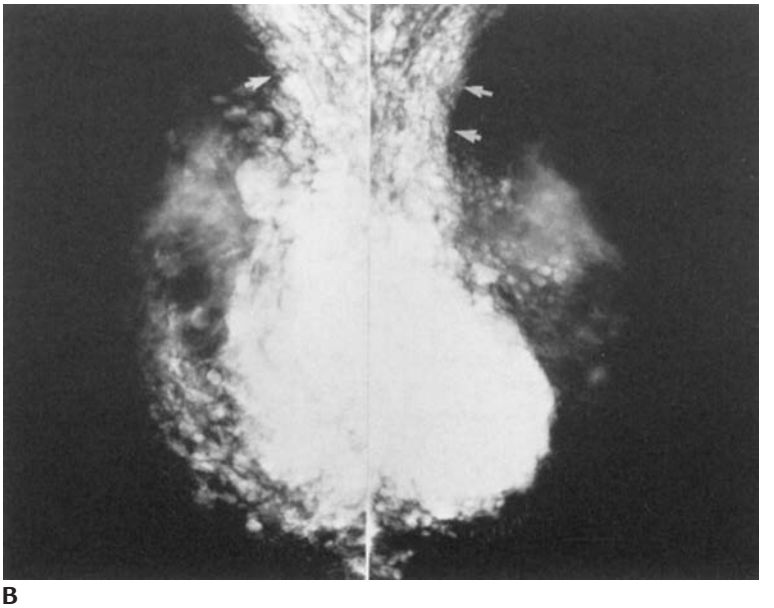


B

**FIGURE 15-29** Silicone implants and subcutaneous silicone injections. **(A)** Craniocaudal views. Silicone granulomas bilaterally secondary to subcutaneous silicone injections. **(B)** Mediolateral oblique views. Subglandular silicone implants and scattered silicone granulomas. Silicone is also present in lymphatic channels extending into axillary lymph nodes (*arrows*).

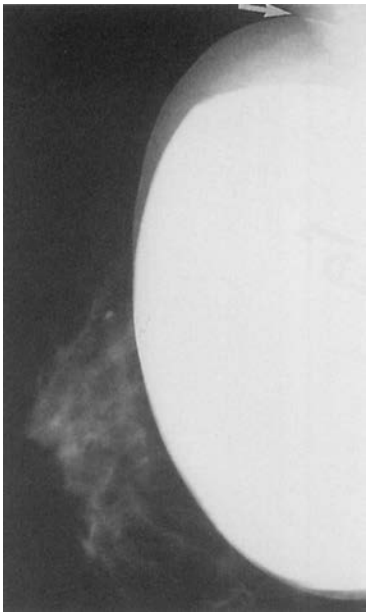


**FIGURE 15-30** Subglandular (prepectoral), double lumen (outer saline, inner silicone) implant, right mediolateral oblique view. Double lumen implants are characterized by density differences seen superiorly in this patient. Pectoral muscle is seen "diving" (*arrow*) behind implant (when implant is prepectoral).

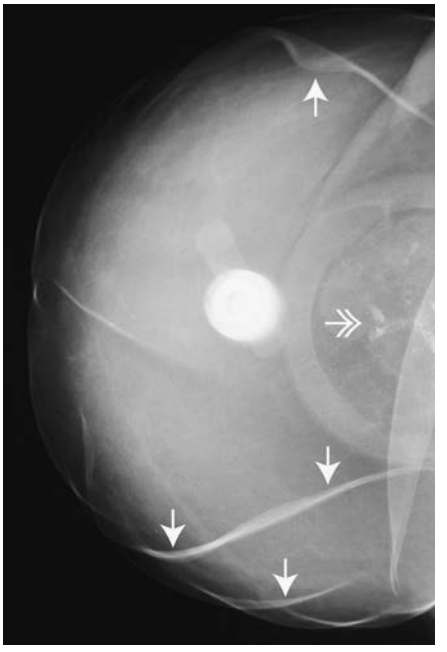
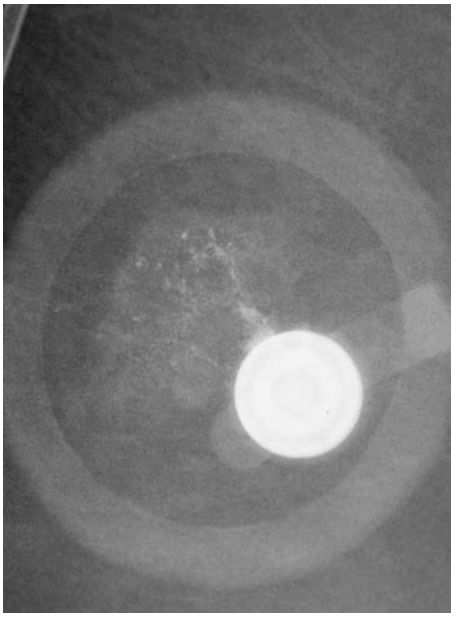


**FIGURE 15-31** Saline implant with wrinkles (*arrows* marking some of the wrinkles) and calcifications associated with implant valve (*double headed arrow*).



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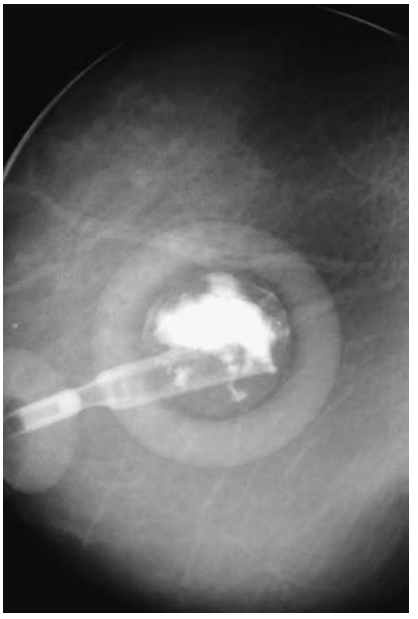

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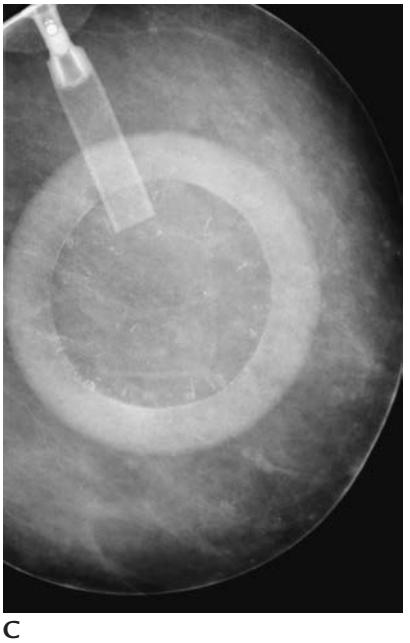

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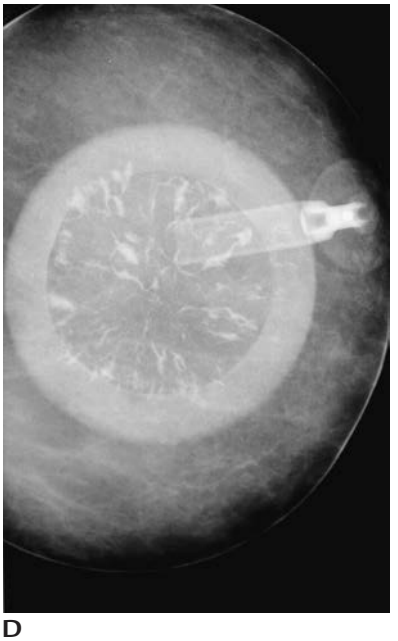


D

**FIGURE 15-32** Saline implants with calcifications developing in association with the valve. **(A)** Implant valve with associated punctate and amorphous calcifications. **(B)** Different patient. Dense coarse calcifications associated with implant valve. **(C)** Different patient. Calcifications, some linear, developing at the periphery of the implant valve. Not to be mistaken for calcifications in breast tissue. **(D)** Two years following **(C)**, the calcifications have progressed increasing in size, number and density.

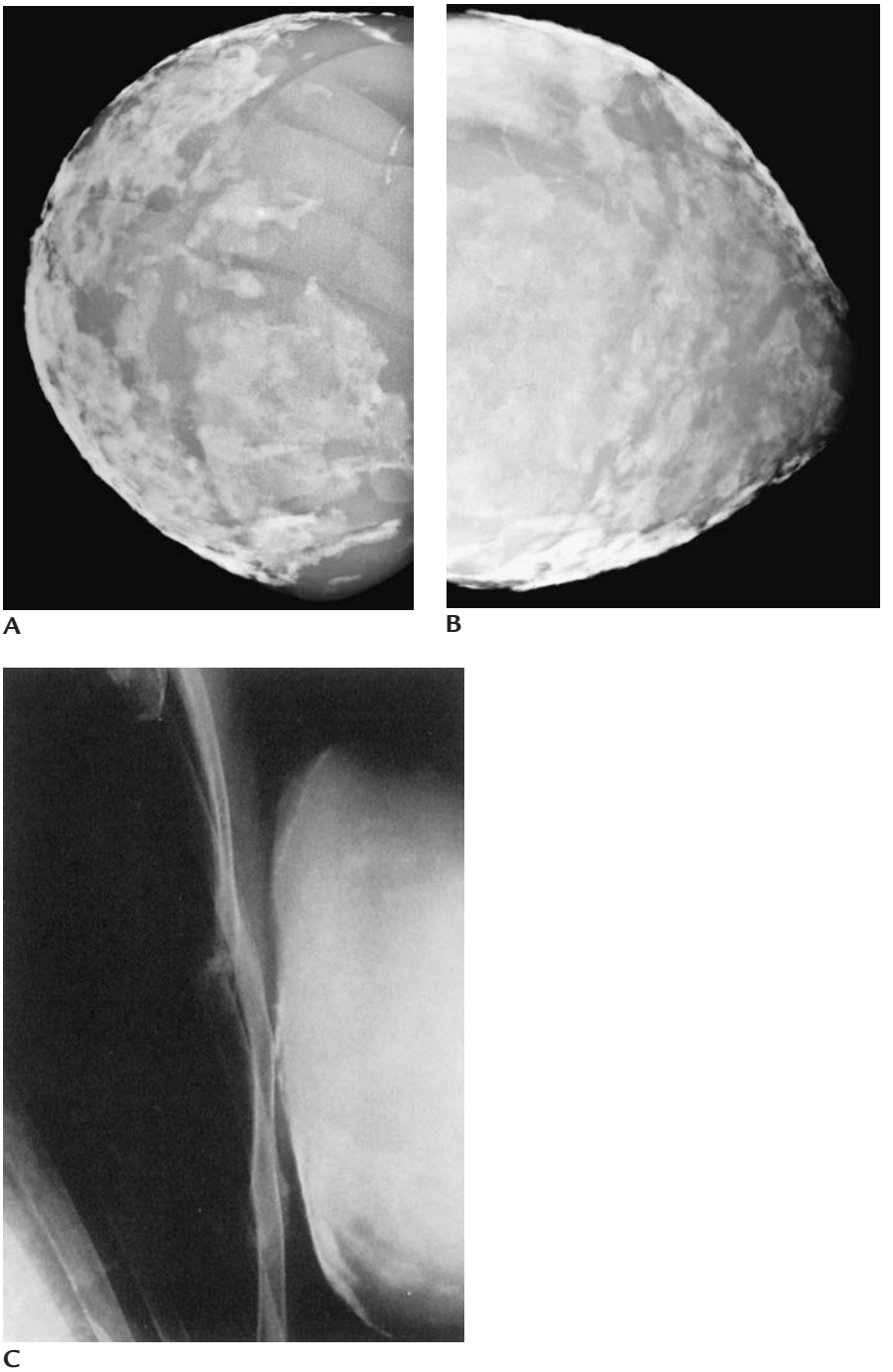
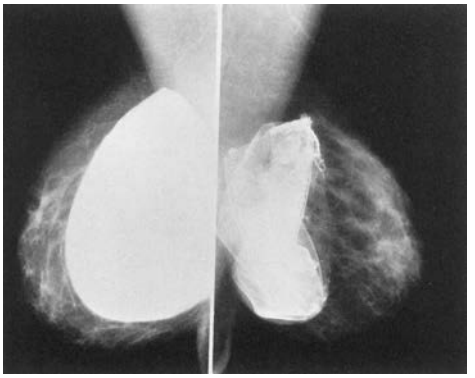


**FIGURE 15-33** Capsular calcifications. **(A)** Coarse capsular calcifications. These calcifications develop in the fibrous capsule that forms around the implant. **(B)** Coarse calcifications that develop are associated with the capsule that forms around implants. **(C)** Chest wall view done to demonstrate the posterior portion of the implant. Chest wall view is done with aluminum filter, no compression, and 38 to 42 kV.



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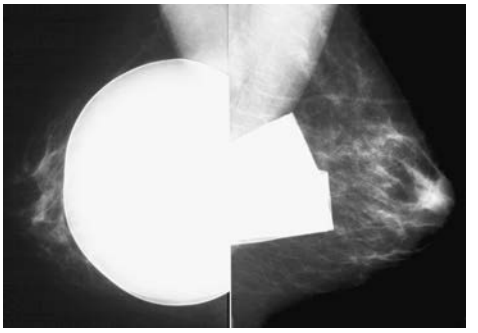

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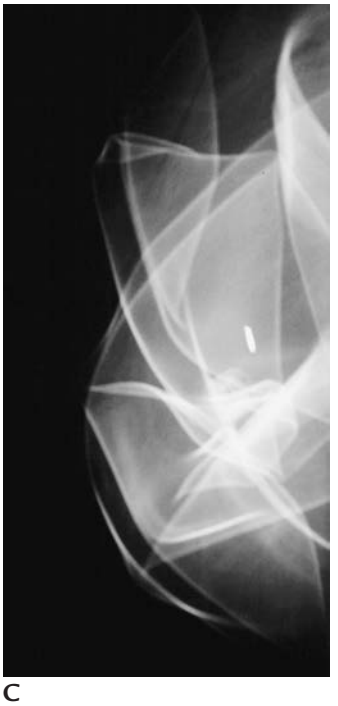

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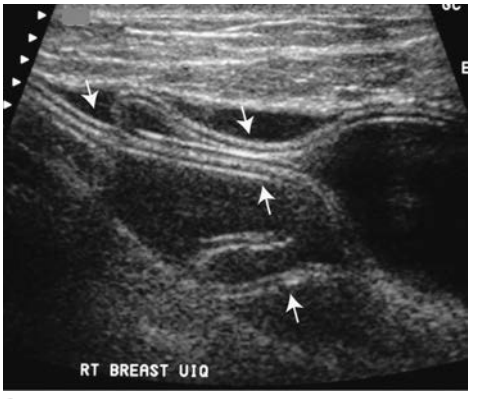



D

**FIGURE 15-34** Saline implants. **(A)** Saline implants in a subglandular location. Left implant is folded on itself, partially collapsed. Capsular calcifications are present. **(B)** Different patient. Saline implants, subglandular in location. Left implant is collapsed. **(C)** Different patient. Partially collapsed right saline implant. **(D)** On ultrasound, implant shell is seen folded/collapsed on itself and there is fluid external to the folds either extravasated or reactive fluid.

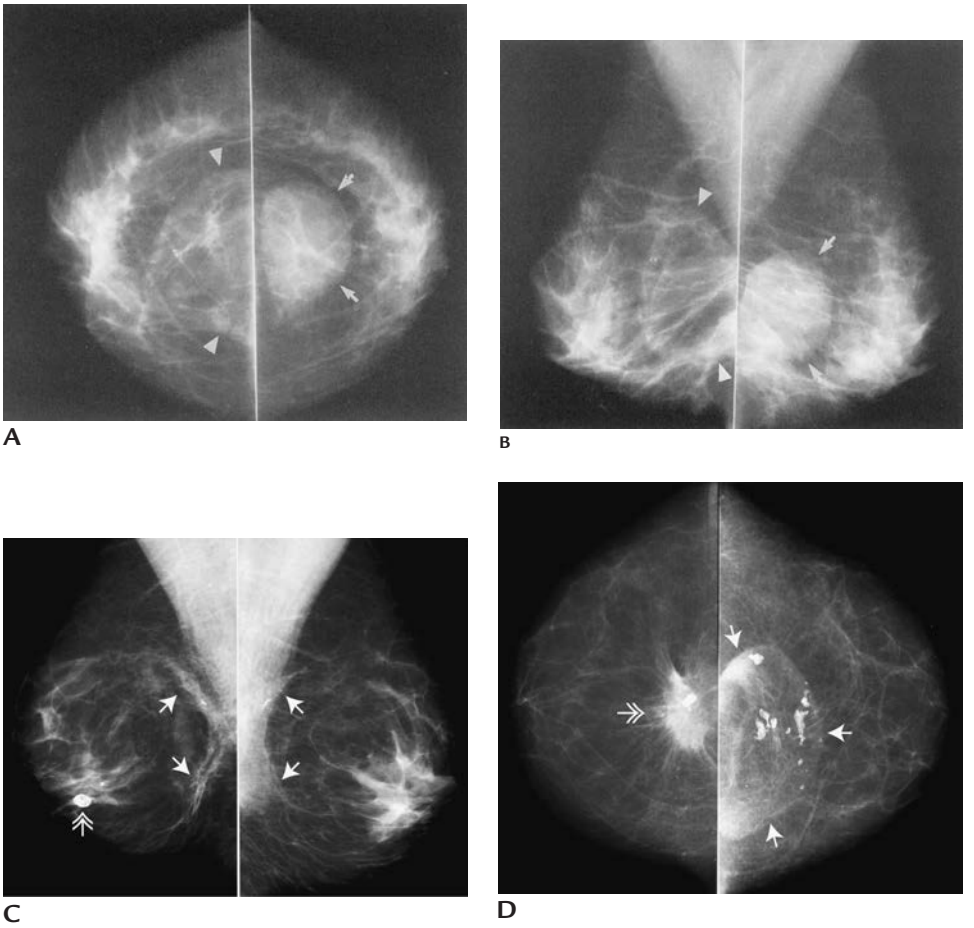



**FIGURE 15-35** Changes following implant removal. **(A)** Craniocaudal and **(B)** Mediolateral oblique views. Round mass (seroma) posteriorly (*arrows*) on the left and residual capsule (*arrowheads*) posteriorly on the right after implant removal. **(C)** Different patient. Mediolateral oblique views. Curvilinear remnants (*arrows*) of capsule on the oblique views posteriorly with some associated coarse dystrophic calcifications. A calcified oil cyst (*double headed arrow*) is present anteriorly on the right. **(D)** Different patient. Craniocaudal views. Mass (*double headed arrow*) with spiculated margins and associated coarse calcifications, right breast posteriorly consistent with fat necrosis following implant removal. Remnants of capsule (*arrows*) with associated coarse calcifications are present on the left posteriorly at prior implant site.

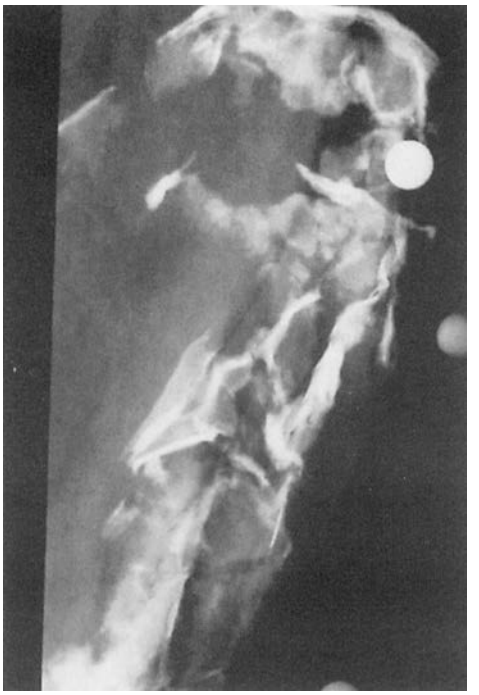
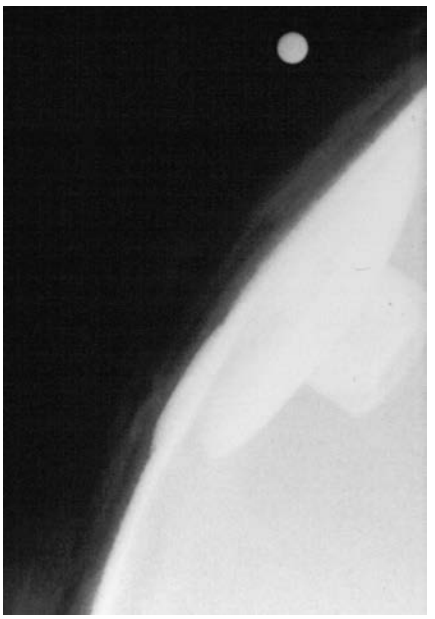


**FIGURE 15-36** Dystrophic, dense calcifications seen on follow-up after implant removal.



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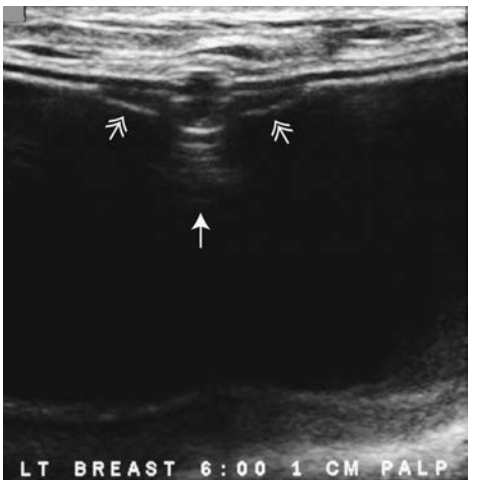



B

**FIGURE 15-37** Valve, saline implant. **(A)** Metallic BB (*arrows*) placed at "lump" described by the patient. The implant valve correlates with the "lump" described by the patient. On physical examination this is hard but can be "reduced" or pushed into the implant ('bloatable'). **(B)** Rectangular hypoechoic area with reverberation artifact (*arrow*) corresponding to central port in valve. Symmetric areas of hypoechogenicity (*double headed arrows*) are seen commonly extending on either side of the central port.

## Implant Complications

### Key Facts

- Gel bleed.

  A semipermeable silicone outer shell surrounds inner silicone or saline.

  Depending on the extent of cross linking of the silicone elastomer shell, implants are characterized by low or high grades of gel bleed. Silicone or saline bleeds out of intact implants because of the semipermeable nature of the shell.

  The immune system of women with intact implants is exposed to variable amounts of silicone soon after augmentation.

  On MRI, gel bleed is reflected by the filling in of wrinkles keyholes.
- Capsule.

  As foreign bodies, implants are walled off by the formation of a fibrous capsule.

  This capsule (bands of fibrous tissue) forms in all women with implants.

  In some women, the capsule remains soft.

  In other women, the capsule starts to strangulate the implant leading to various degrees of encapsulation (e.g., capsular contraction).

  With encapsulation, implants become hard and difficult to move (displaced implant views may be difficult to obtain) and no longer feel or look natural.

  Encapsulation is apparent mammographically: the implants become round on mediolateral oblique.

  Many implant modifications were attempts to deal with capsular contraction. For instance, textured implants were introduced under the theory that the rough surface would create a disturbance of the fibrous tissue in the capsule, preventing contraction.

  Subpectoral placement was introduced in hopes that the muscular movement over the implant would serve to disrupt capsule formation.

  Closed capsulotomy: physical compression of the capsule so as to break capsule, softening the feel of the implant. Complications of closed capsulotomies include bleeding, implant rupture, and, for the plastic surgeon, injury to ulnar collateral ligament ("gamekeepers thumb").

  Open capsulotomy: surgical removal of capsule.
- Intracapsular rupture.

  Silicone is free within the capsule formed by the patient.

  This type of rupture is not identified mammographically.

  Small usually discontinuous horizontal echogenic lines in the interior of the implant on ultrasound (e.g., "stepladder" sign)—analogous to linguini sign described in MRI.

  Linguini sign on MRI—multiple low signal curvilinear thin bands contained in the high silicone signal.

  It has been suggested that with time (more than 10 years), the shell of most implants may be nonexistent and the silicone or saline is contained only by the woman's native capsule.

- Extracapsular rupture.

  Silicone is free and found outside of implant and capsule.

  Silicone can be seen as one, or more commonly, multiple high-density round or oval masses with indistinct margins adjacent to and extending away from the rupture implant.

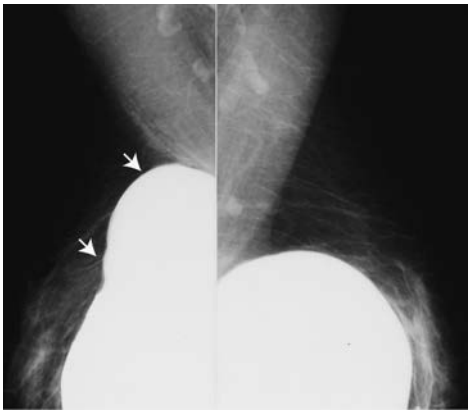
  Extravasated silicone can also be seen as beaded, linear-like tracks of high-density material (e.g., possibly within lymphatic channels) extending toward the axilla.

  Hypo- or hyperechoic masses some with echogenic rims may be seen on ultrasound representing silicone granulomas.

  "Snowstorm" appearance also described for extracapsular silicone reflects dispersion of ultrasound beam.

  On MRI even small amounts of free silicone can be seen as focal areas of high signal intensity.
- Autoimmune disorders.

  No definitive proof of a relation between silicone and autoimmune disorders exists.



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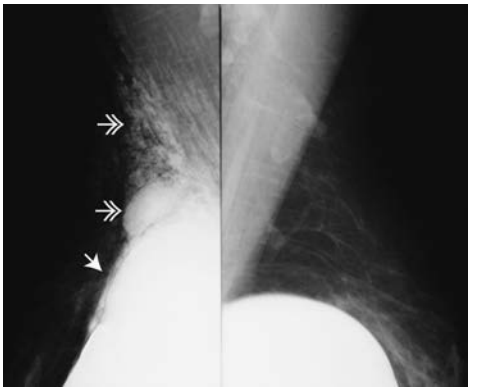

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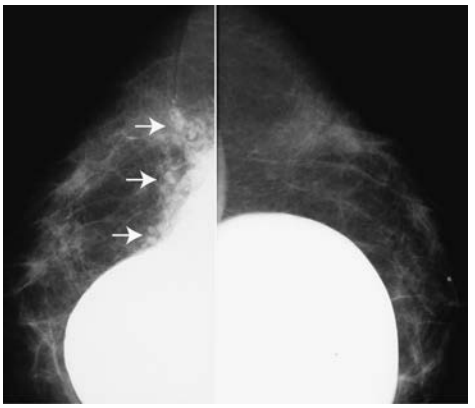
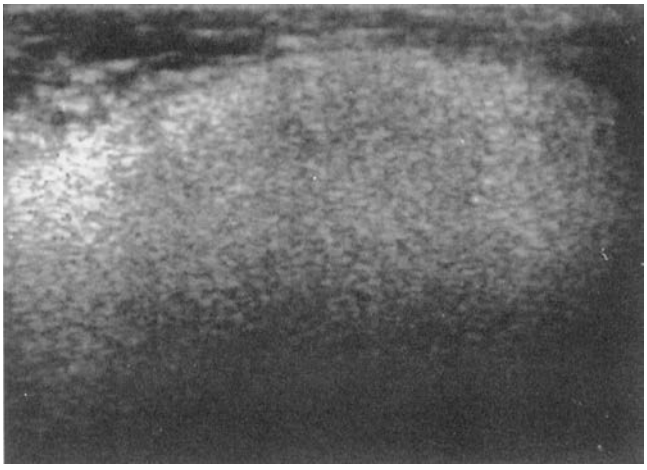


C

**FIGURE 15-38** Extracapsular rupture. **(A)** Mediolateral oblique views. Silicone implants, subglandular in location. Contour and appearance of left implant is normal. High-density material (silicone) is seen altering the contour of the right implant (*arrows*). **(B)** Follow up. Silicone implants, subglandular in location. Contour and appearance of left implant remains normal. High-density material (*arrow*) is seen altering contour of right implant. At this time silicone is also seen as linear-like tracks of high density beads (*double headed arrows*) extending into axilla (presumably represents silicone in lymphatic channels). **(C)** Craniocaudal views demonstrating extracapsular silicone (*arrows*) extending laterally from the implant on the right.



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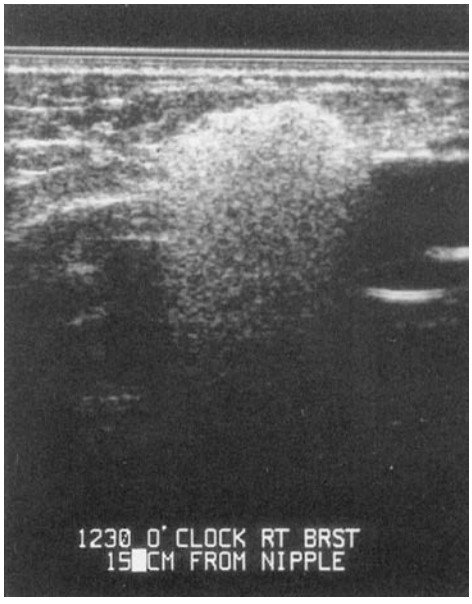


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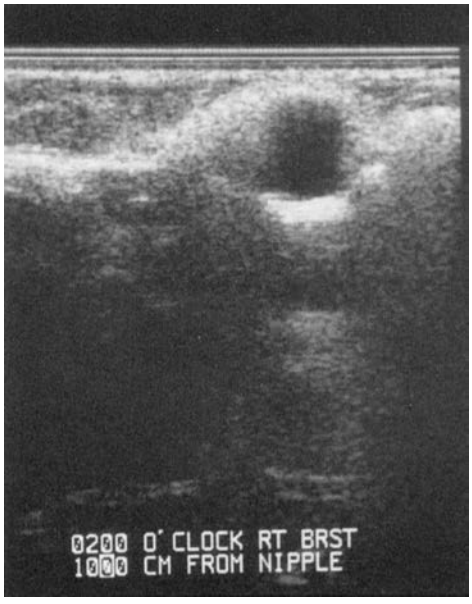



C

**FIGURE 15-39** Implant rupture. **(A)** "Snowstorm" appearance described for extraluminal silicone. **(B)** More focal area of extracapsular silicone with "snowstorm" appearance. **(C)** Irregular nearly anechoic mass secondary to extracapsular silicone. Irregular, hypoechoic masses have also been described after implant rupture.

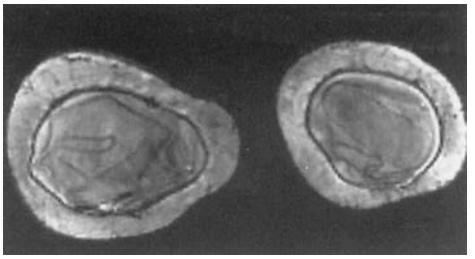


**FIGURE 15-40** Implant rupture, linguini sign on MRI. Presumably implant shell is floating in silicone.

## Reduction Mammoplasty

### Key Facts

- Medical indications for reduction.
  Extra weight may lead to respiratory compromise.
  Alterations in posture may lead to development of kyphosis.
  Back, anterior thoracic or breast pain.
  Shoulder strap marks from bra.
  Intertrigal infections (inframammary fold).
  Psychosocial issues.
- Understanding the surgical approach used facilitates understanding mammographic changes.
  Circumareolar incision (keyhole incision) attention to maintaining vascular supply.
  Sagittal incision from areola to inframammary fold (6 o'clock position).
  At the inframammary fold, horizontal incisions are made to create two flaps (lateral and medial).
  Tissue is scooped out.
  The nipple and areola are repositioned. In older women, the ducts can be transected behind the nipple and the nipple areolar complex is moved in isolation (transplantation).
  In younger women who may want to breast feed in the future, the duct nipple connection is maintained and the nipple areolar complex is moved with the subareolar ducts attached (transposition).
- Complications.
  Avascular necrosis of nipple areolar complex, skin or breast parenchyma.
  Wound infections (unusual).
  Loss of sensation around nipple area.
  Fat necrosis.
  Hypertrophic scarring.
  Inadequate or overreduction.
  Bottoming out.

- Mammographic findings on mediolateral oblique views.
  Redistribution inferiorly and swirling pattern of tissue.
  Tilting or elevation of nipple may become more striking with time ("bottoming out").
  Skin thickening along sagittal scar.
- Mammographic findings on MLO and craniocaudal views.
  Nonanatomically distributed islands of glandular tissue.
  Fibrotic bands in subareolar area (non-anatomic in appearance).
  Fat necrosis, oil cysts (single or multiple), dystrophic calcifications.
  Skin thickening.
  Skin calcifications particularly prominent along scars.
  Disruption of subareolar ducts following nipple transplantation.
  Epidermal inclusion cysts.

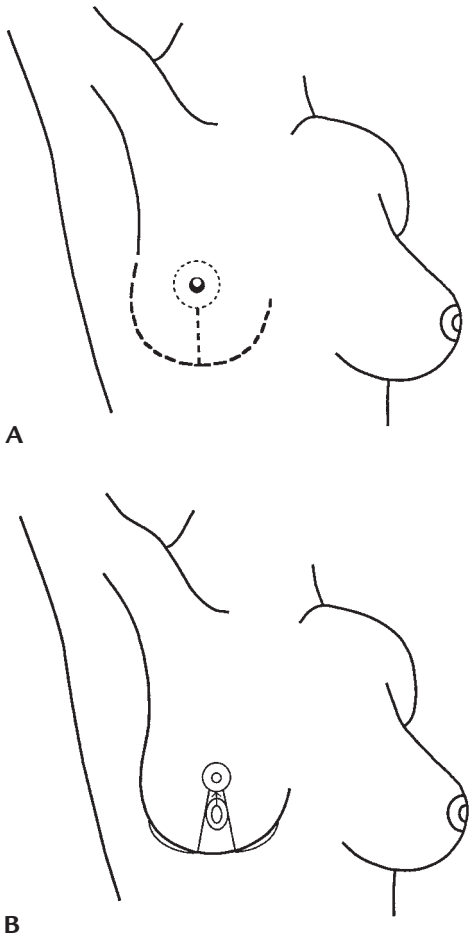
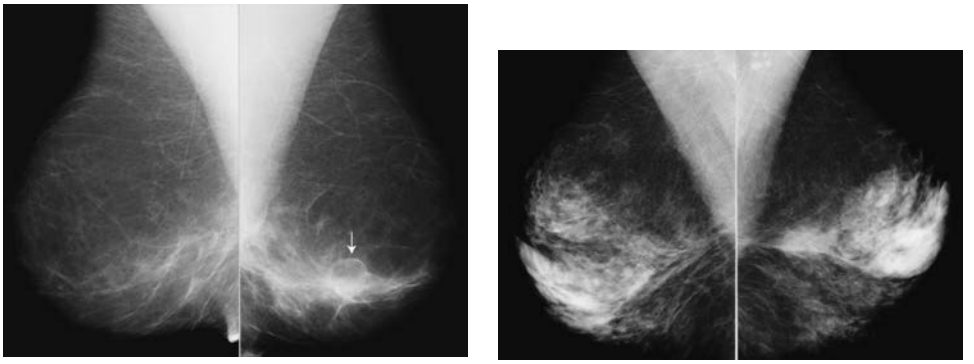
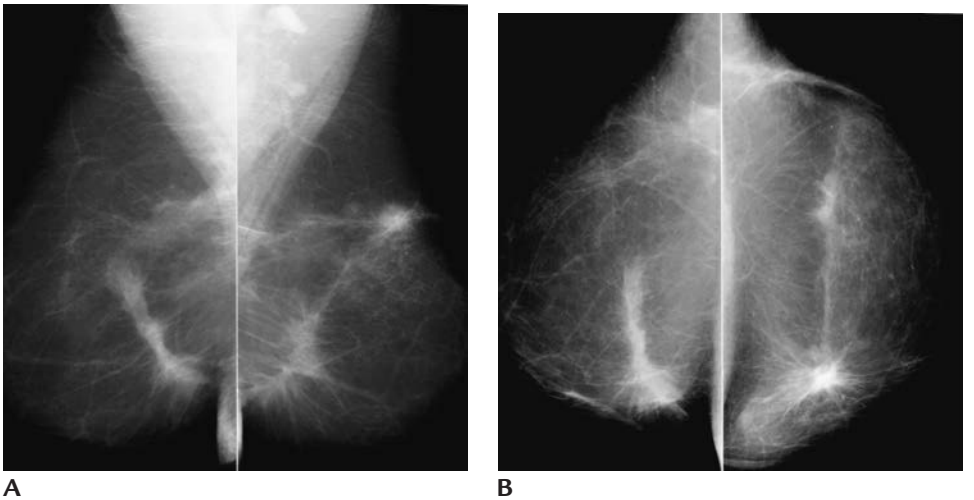



**FIGURE 15-41** **(A)** Circumareolar and sagittal incisions (6 o'clock) to inframammary fold (IMF) then horizontal incisions along IMF creating medial and lateral flaps. Tissue is then scooped out inferiorly. **(B)** Nipple areolar complex must be repositioned superiorly either isolated from subareolar ducts (transplantation) or with subareolar ducts still attached (transposition).



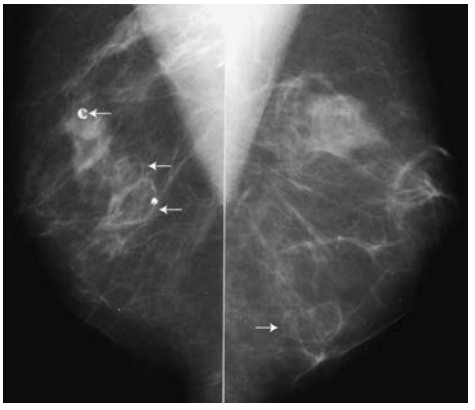
**A** **B**

**FIGURE 15-42** Reduction mammoplasty. **(A)** Mediolateral oblique views. As breast tissue is scooped out through from below, remaining tissue is displaced inferiorly ("swirling"). Oil cyst (*arrow*) is present on the left. **(B)** Different patient. Mediolateral oblique views. Remaining breast tissue is non-anatomically distributed and inferiorly displaced.

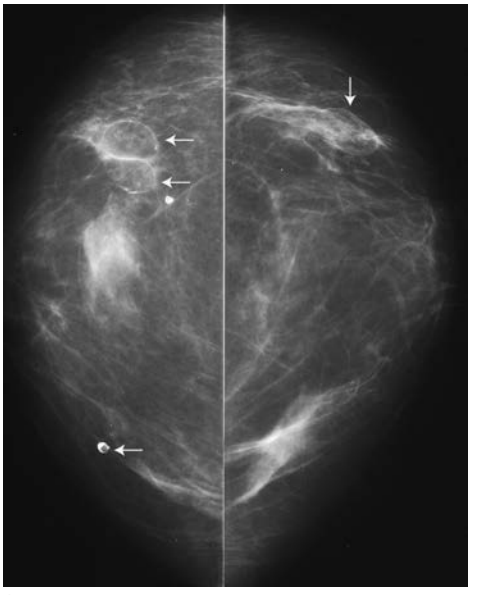


**A** **B**

**FIGURE 15-43** Reduction mammoplasty. **(A)** Mediolateral oblique and **(B)** craniocaudal views. Non-anatomically distributed islands of glandular tissue with associated distortion and spiculation reflecting fat necrosis. Some focal skin thickening is noted medially on the right.



A



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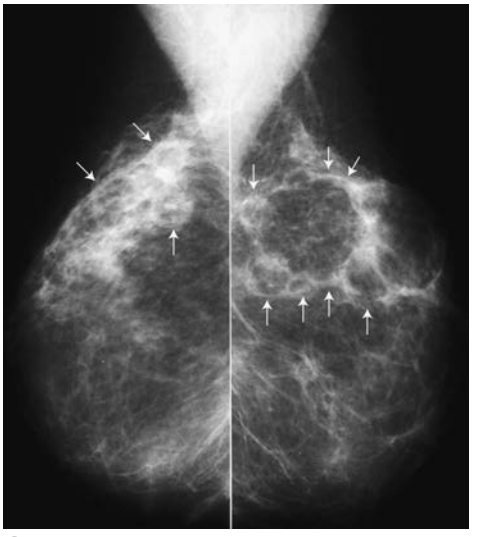
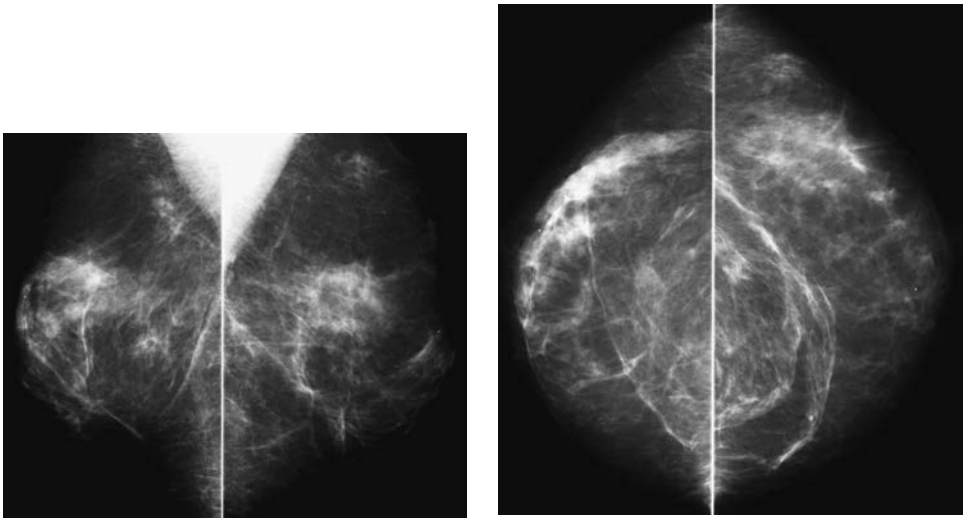


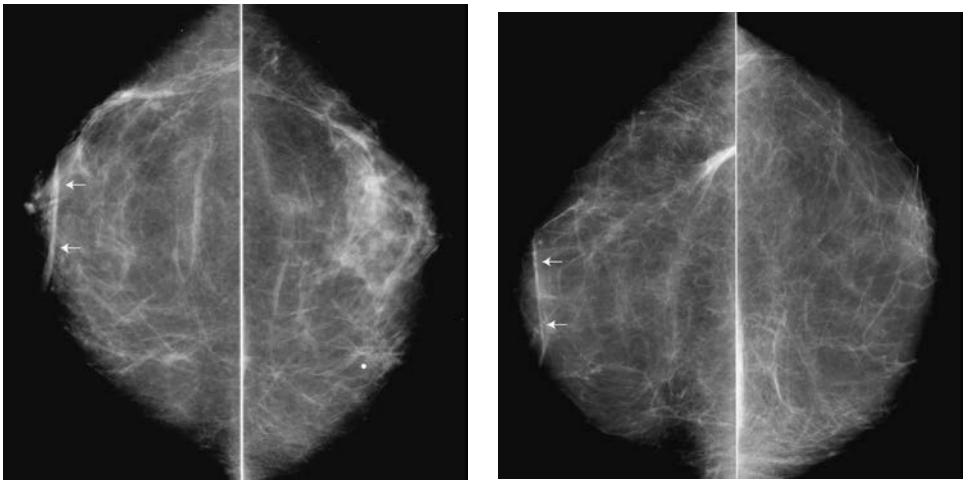
C

**FIGURE 15-44** Reduction mammoplasty. **(A)** Mediolateral oblique and **(B)** craniocaudal views. Non-anatomically distributed islands of glandular tissue. Oil cysts with variable amounts of rim calcifications are present (*arrows*) bilaterally. **(C)** Different patient. Mediolateral oblique views. Fat necrosis and oil cyst formation (*arrows*) bilaterally. As fat necrosis resolves, oil cysts with varying amounts of surrounding ill-defined density can be seen. In this patient, remaining breast tissue is not displaced inferiorly but it is asymmetric.



**A** **B**

**FIGURE 15-45** Reduction mammoplasty. **(A)** Mediolateral oblique views and **(B)** craniocaudal views. Focal islands of parenchymal asymmetry and curvilinear, non-anatomically distributed bands of scar tissue.



**A** **B**

**FIGURE 15-46** Reduction mammoplasty. **(A)** Craniocaudal views. Horizontal band (*arrows*) in the right subareolar area (non-anatomic), parenchymal asymmetry and islands of tissue in a non-anatomic distribution. **(B)** Different patient. Craniocaudal views. Horizontal band (*arrows*) in the right subareolar area.

# Hormone Replacement Therapy

## Key Facts

- Clinical.

  Estrogen stimulates proliferation of ductal system and periductal stroma.

  Progesterone counteracts some of the proliferative effects of estrogen and promotes lobular development.

  Estrogen and progesterone combination recommended in women with an intact uterus.

  Estrogen alone should be used in women who have had a hysterectomy.

  Estrogen replacement therapy is advocated for treating postmenopausal symptoms, preventing osteoporosis and providing potential cardiovascular benefits.

  Breast pain, fullness, masses, and nodularity may develop in women on estrogen.
- Possible role in breast cancer development is controversial consider type of estrogen used duration of estrogen therapy, increased risk after 5 to 10 years of hormone therapy.
- Mammography.

  Diffusely increased density of breast tissue.

  Asymmetric densities.

  Cyst formation.

  Changes in as many as 24% of patients placed on exogenous estrogen.

  May be related to duration of treatment.

  More common in women on estrogen-progesterone (as opposed to estrogen alone).

  If diffuse bilateral mammographic changes are seen after estrogen therapy is started, we do not obtain short-term follow-up nor do we alter (stop) the hormone replacement.

  Women started on estrogen are imaged at annual intervals. Additional imaging (6 month) is not indicated unless there is a focal change.

## Tamoxifen

- Antiestrogenic and estrogenic action.

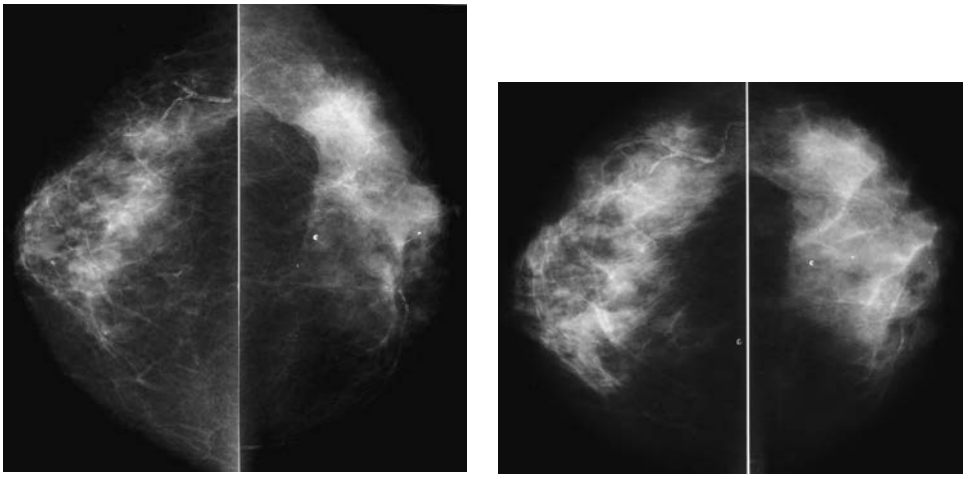
  Treatment in some women after a breast cancer diagnosis.

  Chemoprevention.

  Used in Europe to treat symptoms of severe, symptomatic, fibrocystic change.
- Mammography.

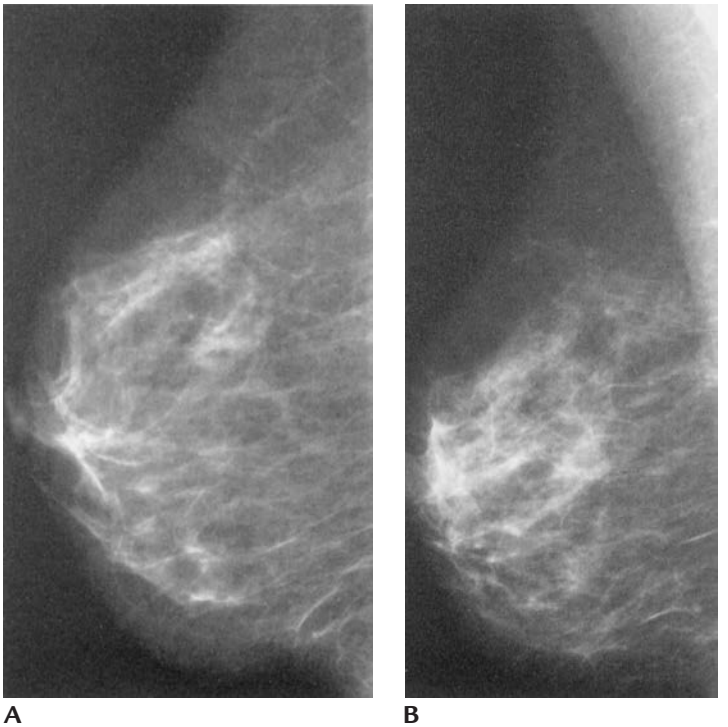
  In a small number of patients breast tissue density decreases.

  After cessation of tamoxifen therapy the amount and density of tissue may increase (tamoxifen rebound).



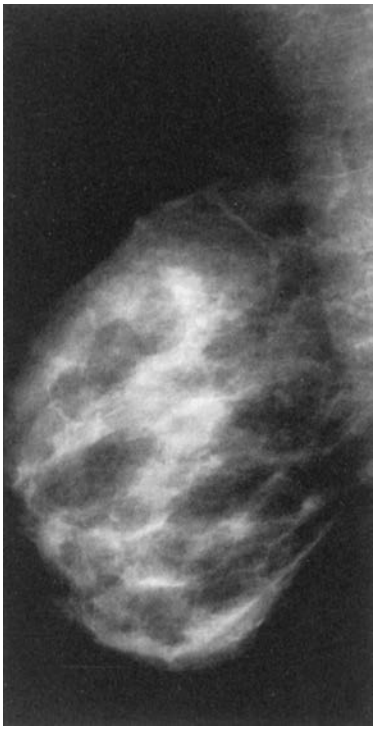
**A** **B**

**FIGURE 15-47** Estrogen effect. **(A)** Right and left craniocaudal (CC) views. Pre-estrogen. **(B)** Right and left CC views. Increased tissue and tissue density developing during the first year of exogenous estrogen use. Effects can be diffuse and symmetric as in this patient or asymmetric and more focal. Some patients develop single or multiple cysts.



**A** **B**

**FIGURE 15-48** Tamoxifen effect. **(A)** Right mediolateral oblique (MLO) view. Predominantly fatty pattern. Patient on tamoxifen for breast cancer (mastectomy on the left). **(B)** Right MLO view. Several months after completion of tamoxifen therapy, more glandular tissue is imaged.



C

**FIGURE 15-48** (*Continued*) **(C)** Right MLO view. Eighteen months after completion of tamoxifen therapy. Progressive increase in the amount and density of glandular tissue (tamoxifen rebound).

## MISCELLANEOUS

### KEY FACTS

- Weight changes.

  Weight increase may result in mammographically perceptible breast size changes, breast tissue dispersal, and increases in the amount of fatty tissue.

  Weight loss may result in a mammographically perceptible decrease in breast size, breast tissue aggregation, and loss of fatty tissue.
- Portable catheter (port-a-cath) site.

  No changes may be apparent following removal of these catheters. In some patients, may see mass with indistinct or spiculated margins at the port-a-cath site following removal of catheter.

  Localized fluid collection.

  Calcifications.

  Catheter tract may calcify.
- Dacron central line cuff.

  For Hickman catheter placement a 4 to 6 subcutaneous tunnel is made and a Dacron cuff is used to anchor the catheter to the subcutaneous tissue.

  When the Hickman catheter is pulled out, the cuff remains in place and may be seen on MLO (more common) and craniocaudal views may be palpable.

  Irregular mass (that may contain air) around cuff may indicate abscess formation.
- Pacemakers.

  May be partially or completely seen on mediolateral oblique views superimposed on pectoral muscle.

  If the pacemaker is removed, coarse calcification of pacemaker cavity may develop.

  If the pacemaker is removed, remaining pacemaker wires may be seen.
- Lactation.

  Increases breast tissue density diffusely.

  Prominent subareolar ducts seen ultrasonographically.

  Increased echogenicity of tissue with loss of normal tissue planes (Cooper's ligaments not seen as readily).
- Premenstrual edema.

  In some women, there can be significant density increases premenstrually, presumably related to fluid accumulation and retention.

  Enlargement of pre-existing cysts.
- Trauma.

  Localized findings (mass, architectural distortion, parenchymal asymmetry) related to hematoma formation and fat necrosis (see Chapter 14).

  Diffuse findings (increased density, decreased compressibility, decreased breast size, trabecular, and skin thickening) if trauma involves entire breast.

  Acutely ultrasound appearance is distinctive: loss of normal tissue planes, increased echogenicity of breast parenchyma (compare with contralateral

breast) with associated round, oval or tubular anechoic or hypoechoic areas.

Complete resolution of mammographic and sonographic findings is common.

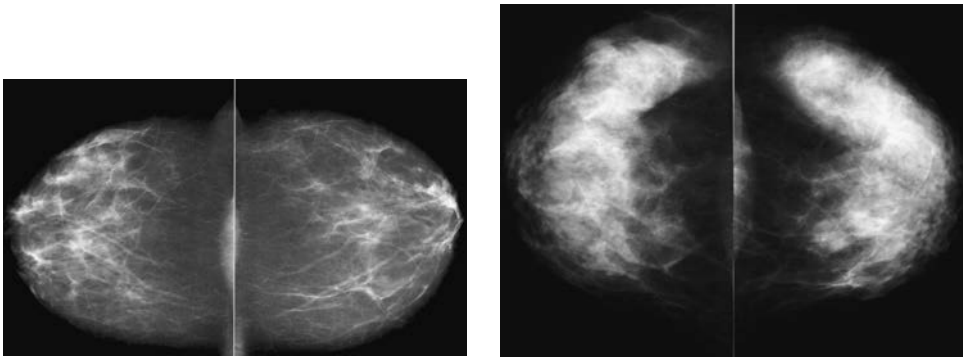
Oil cysts may develop as soft tissue changes resolve.

Oil cysts may develop rim calcifications.

Dystrophic calcifications.

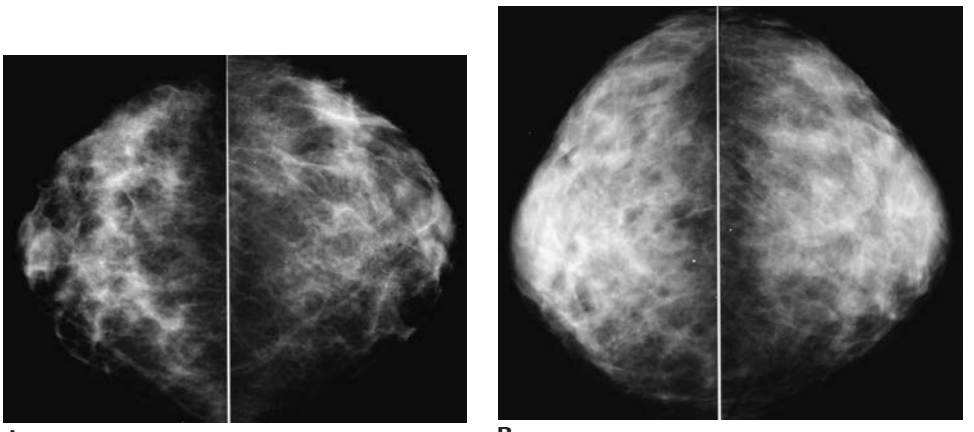
- Chemotherapy.

  May result in decreases in the amount of tissue present.
- Subcutaneous air following pneumothorax/chest tube(s).



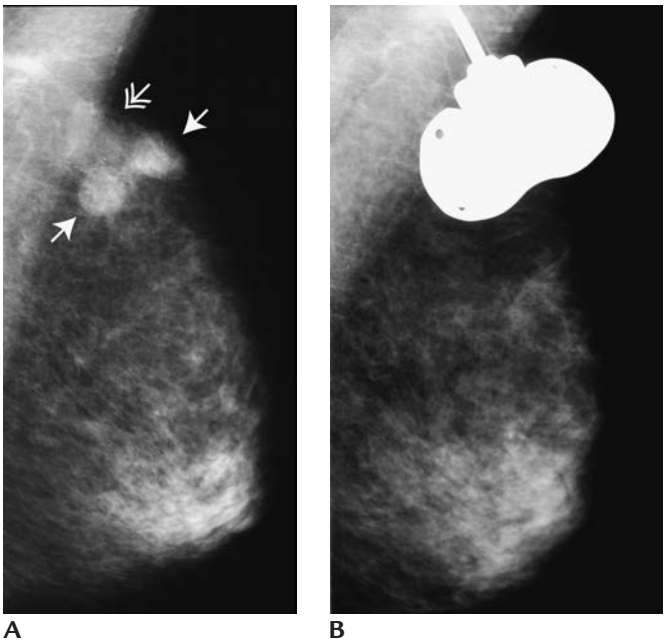
A B

**FIGURE 15-49** Weight loss. **(A)** Right and left craniocaudal (CC) views before weight loss. **(B)** Right and left CC screening views after significant weight loss. Decreased breast size, reduction in fatty tissue, confluence of glandular tissue with increased density of tissue. When a striking change like this is seen, it is important to review the history and verify that the films belong to the same patient.

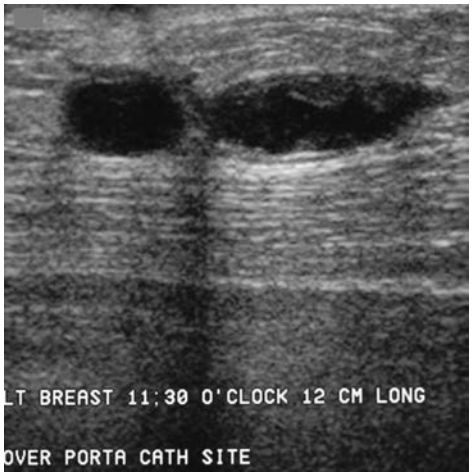


A B

**FIGURE 15-50** Weight loss. **(A)** Right and left craniocaudal (CC) views before weight loss. **(B)** Right and left CC screening views after significant weight loss. Decreased breast size, reduction in fatty tissue, confluence of glandular tissue, and increased tissue density. Review history and technical factors used for exposure (e.g., kVp, mAs and centimeter of compressions used for exposure).



**A** **B**




**C**

**FIGURE 15-51** Portable catheter (port-a-cath) site changes. **(A, B)** Left mediolateral oblique views, 1 year apart. Two adjacent masses (*arrows*) and an irregular area of increased density (*double headed arrow*) are seen at the prior port-a-cath site. **(C)** Two adjacent fluid collections are identified on ultrasound corresponding to the mammographic findings. No further intervention is required. Complete resolution is noted a year following **(A)**.

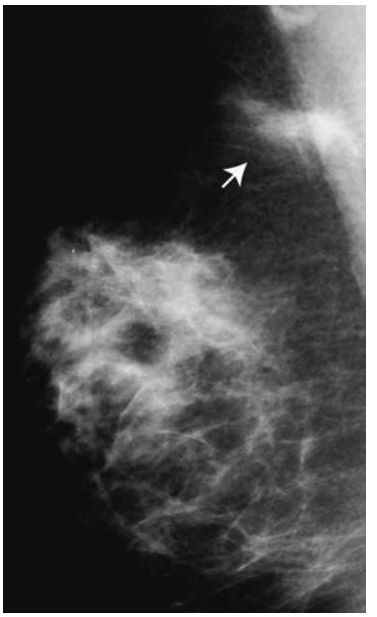
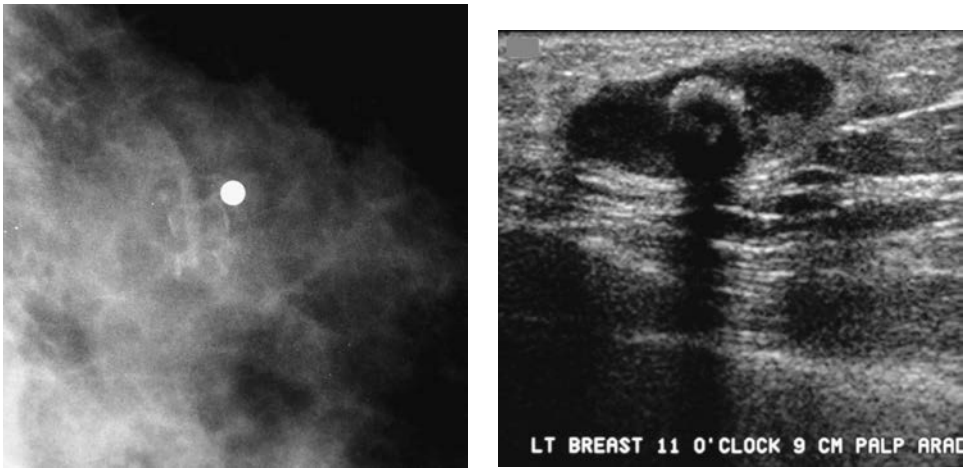


**FIGURE 15-52** Portable catheter (port-a-cath) site changes. **(A)** Right mediolateral oblique view. Irregular area of increased density (*arrow*) with distortion and spiculation corresponding to a port-a-cath site. Decrease in size and complete resolution occurred over the course of 2 years. In some patients, changes at prior port-a-cath sites can simulate a malignant lesion.




**A** **B**

**FIGURE 15-53** Portable catheter (port-a-cath) site changes. **(A)** Spot compression view of "lump" described by the patient. Metallic BB used to mark area of clinical concern. Low density calcifications possibly associated with surrounding radiolucent tissue. **(B)** Oval anechoic mass with well-circumscribed margins and posterior acoustic enhancement is imaged corresponding to palpable finding. Echogenic curvilinear focus internally with associated shadowing corresponding to one of the calcifications seen mammographically. The clinical, mammographic and sonographic findings correlate with the prior port-a-cath site. No further intervention is indicated. In most patients, these changes resolve spontaneously.

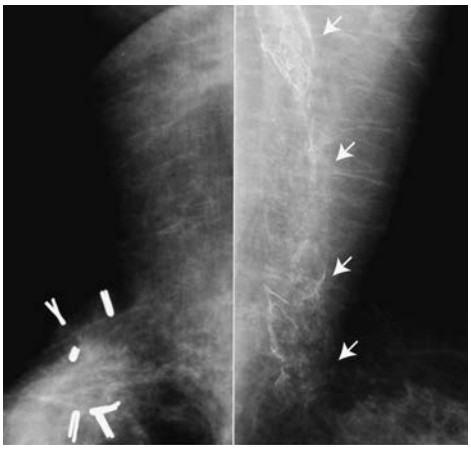
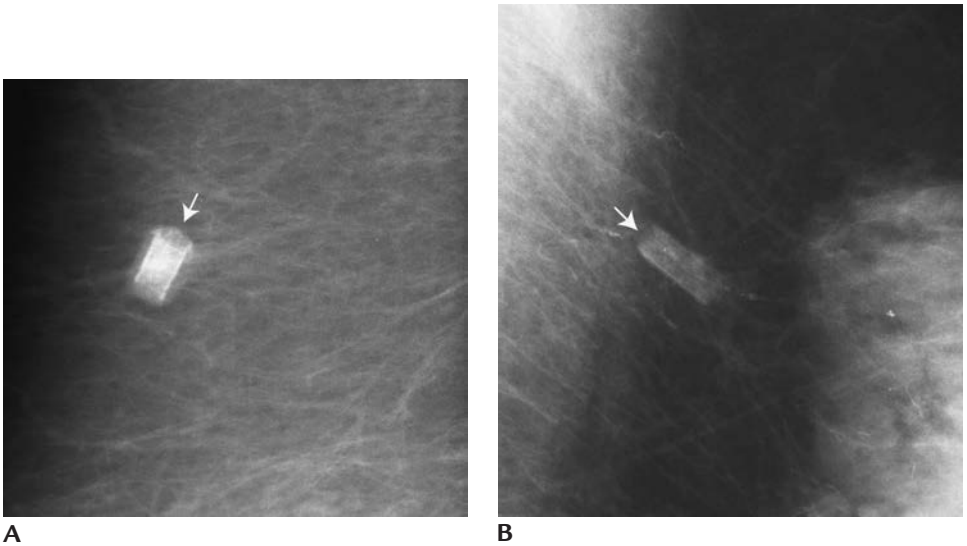
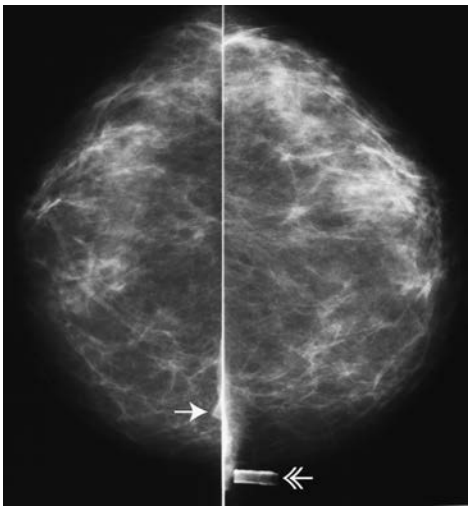


**FIGURE 15-54** Portable catheter (port-a-cath) site change. Dystrophic calcifications (*arrows*) developing at prior port-a-cath tract. Surgical clips are seen on the right at a lumpectomy site.



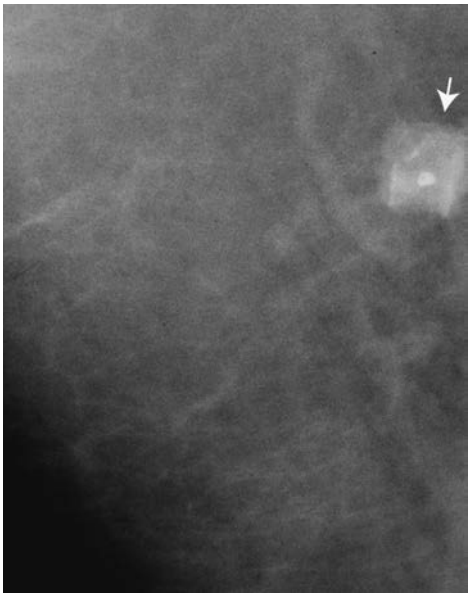
**A** **B**

**FIGURE 15-55** Hickman catheter Dacron cuff. **(A)** Mediolateral oblique view. Cuff used to anchor central line. When line is pulled out cuff remains in place (*arrow*). May be palpable. **(B)** Different patient. Slightly longer cuff (*arrow*) just anterior to pectoral muscle edge on mediolateral oblique view. Arterial calcification is also noted.



C

**FIGURE 15-55** (*Continued*) **(C)** Different patient. Craniocaudal views. Although more commonly seen on MLO views superimposed on the pectoral muscle, the cuff can be seen in some patients, medially on the craniocaudal views. In this patient, a cuff is partially imaged postero-medially on the right (*arrow*) and another cuff is imaged in its entirety postero-medially on the left (*double headed arrow*).



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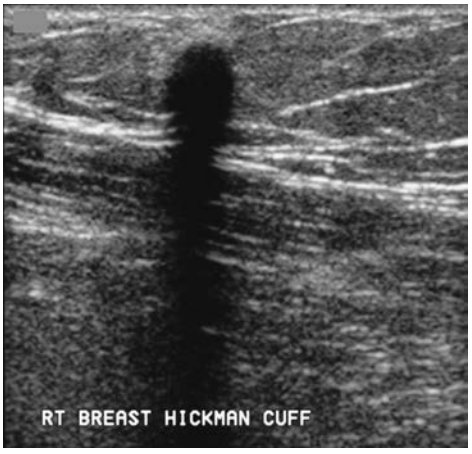
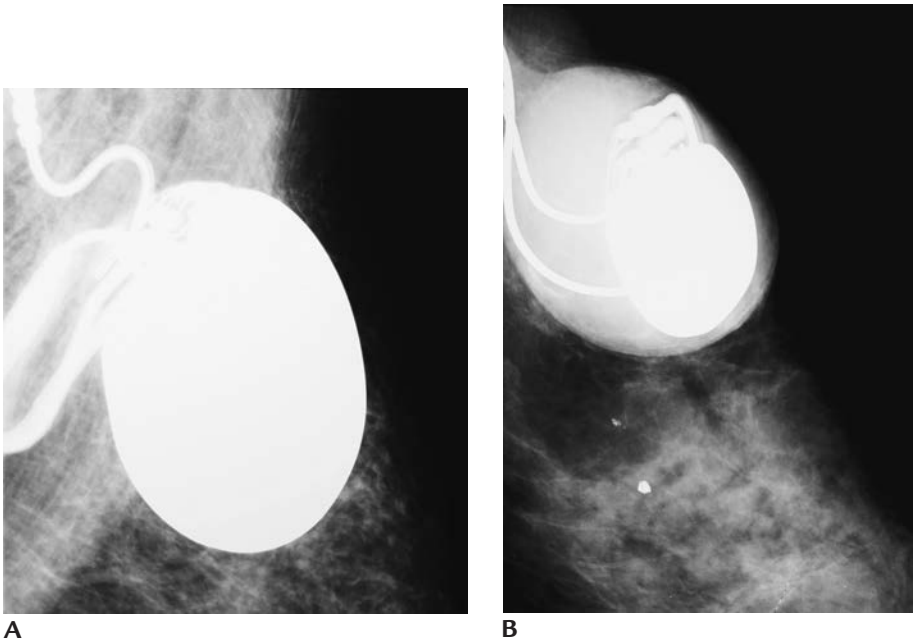



B

**FIGURE 15-56** Hickman catheter Dacron cuff. **(A)** As they age, the cuff (*arrow*) can increase in density and become frayed and some calcify. Typically these are identified in the upper inner quadrants and may be palpable. **(B)** Ultrasound demonstrating intense shadowing at palpable cuff site.



**A** **B**

**FIGURE 15-57** Pacemaker. **(A)** Left mediolateral oblique view. Pacemakers are typically seen on the mediolateral oblique views superimposed on the pectoral muscle. **(B)** Pacemaker with surrounding density reflecting an associated seroma. Fluid collection slowly decreased on follow up mammograms.

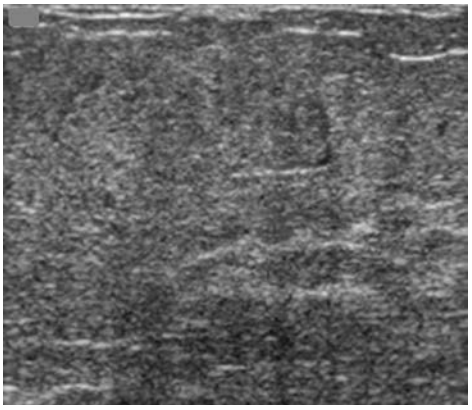
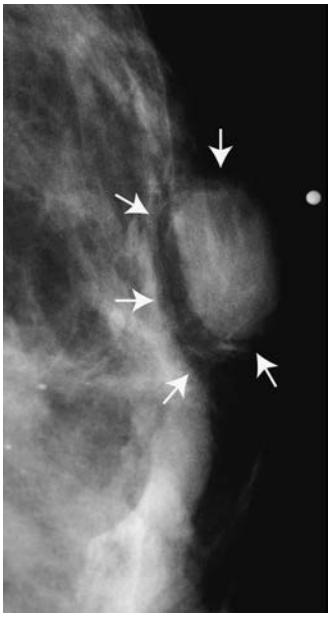


**FIGURE 15-58** Lactational change. Increased echogenicity of breast tissue with loss of "normal" soft tissue (e.g., Cooper's ligaments are not evident) planes. No skin thickening or interstitial fluid collections are present. In some patients, tubular structures (ducts or vessels) may be imaged in the parenchyma.



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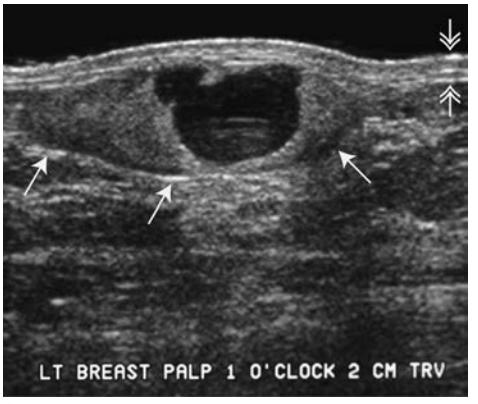


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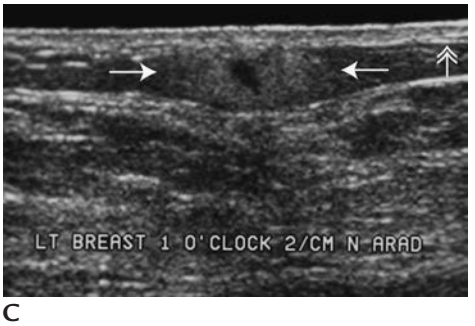
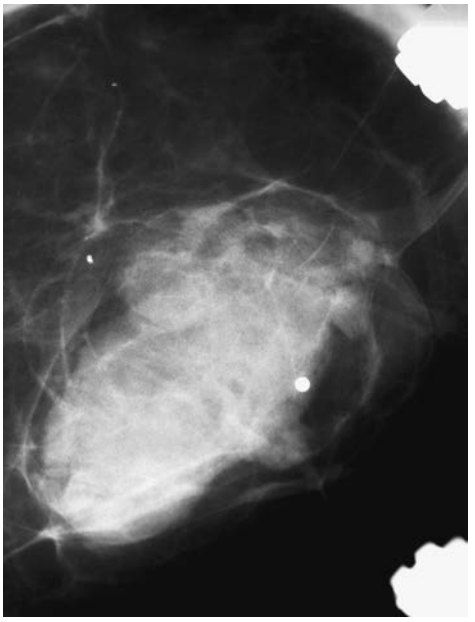



C

**FIGURE 15-59** Hematoma. **(A)** Spot tangential view of a "lump" described by the patient developing following trauma to this site. Metallic BB used to mark clinical finding. Oval mass (*arrows*) with fat (e.g. mixed density mass) corresponding to palpable finding. **(B)** Bulging contour is apparent at the site of the palpable finding. Mass (*arrows*) with heterogeneous echotexture and a cystic component closely apposed to the skin. Posterior acoustic enhancement is present associated with the cystic component of the mass. Skin (*double headed arrows*). **(C)** Follow-up ultrasound 3 months following **(B).** Residual mass (*arrows*) characterized by hyperechogenicity and a small cystic space. Deep dermal layer (*double headed arrow*).



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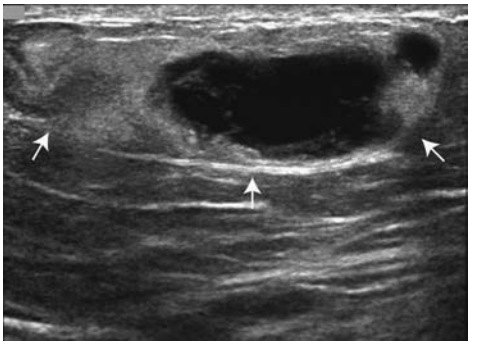

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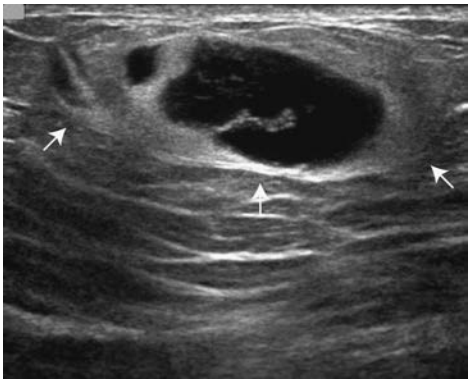
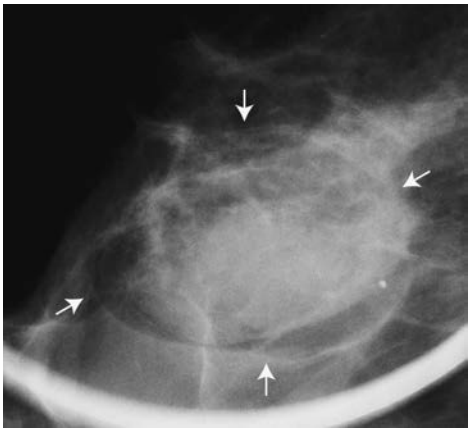


**C**

**FIGURE 15-60** Hematoma. **(A)** Spot tangential view of a "lump" described by the patient developing following trauma to this site. Metallic BB used to mark clinical finding. Fat containing oval mass with indistinct margins. **(B)** and **(C)** Ultrasound images through different portions of palpable mass (*arrows*), left breast. Mass is characterized by hyperechogenicity and irregular cystic areas. Normal tissue planes are disrupted at this site and echogenicity of surround tissue is increased.



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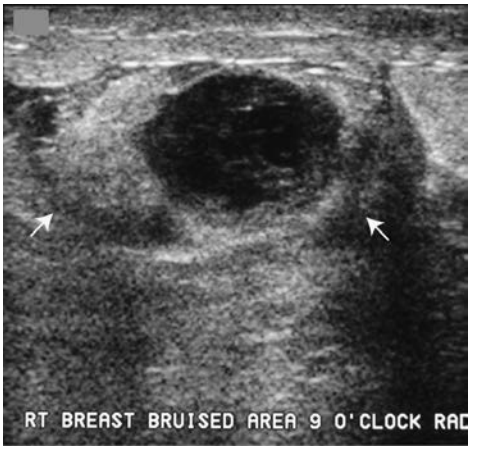


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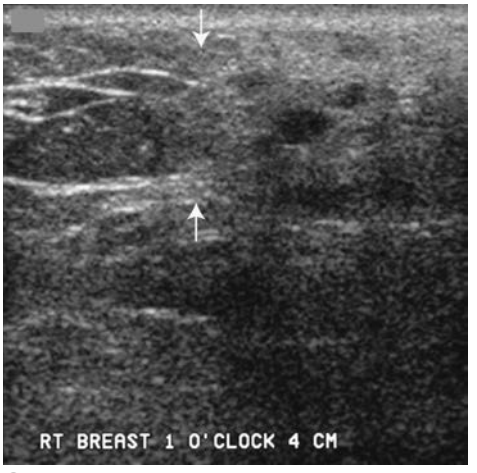
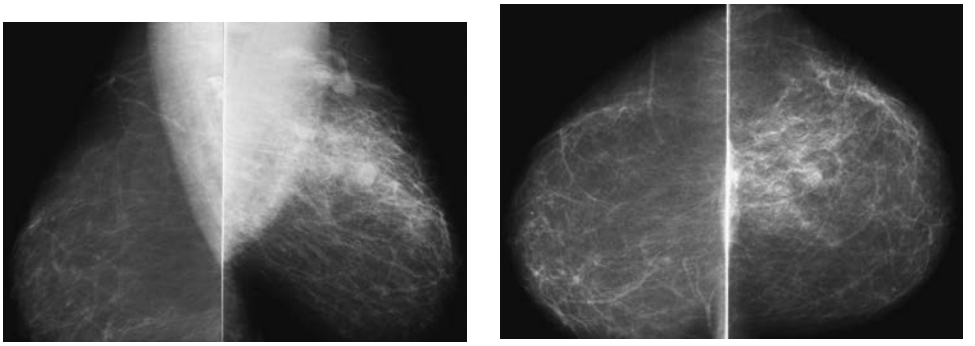


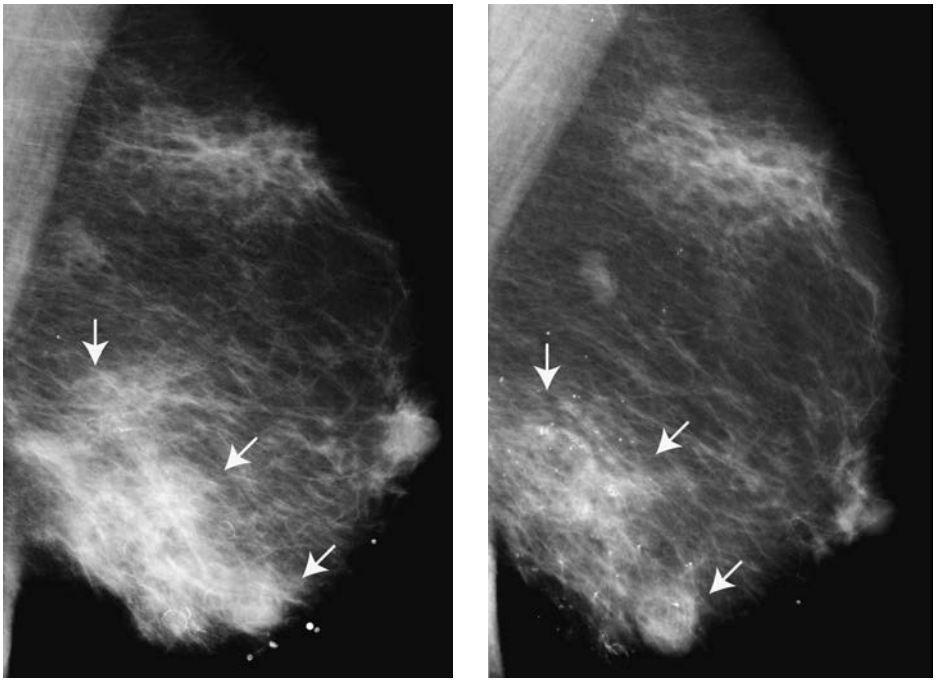

C

**FIGURE 15-61** Hematoma. **(A)** Spot compression view of "bruised" site, right breast. Fat containing mass (*arrows*) with partially indistinct and circumscribed margins. **(B)** Oval mass (*arrows*) with areas of hyperechogenicity and a cystic space. Posterior acoustic enhancement is seen associated with the cystic component. Normal tissue planes are disrupted. **(C)** Different patient. Ultrasound demonstrating transition point (*arrows*) between normal tissue planes and hematoma. Increased echogenicity associated with small anechoic areas is seen corresponding to trauma site. Normal Cooper's ligaments with subcutaneous fat seen to the left of the arrows.



**A** **B**

**FIGURE 15-62** Trauma. **(A)** Mediolateral oblique (MLO) and **(B)** craniocaudal views. Increased density and prominence of the trabecular markings in the upper central aspect of the left breast following trauma. Complete resolution a year later. Did you notice sagging breast and suboptimal compression on the left MLO view? Optimal positioning could not be obtained secondary to discomfort at trauma site.



**A** **B**

**FIGURE 15-63** Trauma. **(A)** Left mediolateral oblique view demonstrates increased density (*arrows*) inferiorly in the breast (prior films not shown). Scattered oil cysts with rim calcification are also noted. **(B)** A year later the density (*arrows*) is decreased. Skin calcifications have developed.

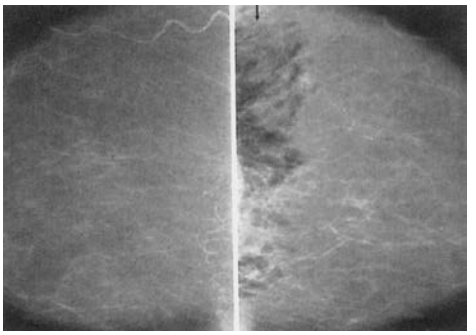


**FIGURE 15–64** Subcutaneous emphysema. Right and left craniocaudal views. Subcutaneous air (*arrow*), left breast posteriorly

## SUGGESTED READINGS


Cardenosa G, Eklund GW. Imaging the altered breast. In: Taveras JM, Ferrucci JT, eds. *Radiology, Diagnosis Imaging Intervention*. Philadelphia: JB Lippincott Co.; 1994.

Cardenosa G, Eklund GW. Breast parenchymal change following treatment with tamoxifen [Letter]. *Breast Dis*. 1992;5:55–58.

Berkowitz JE, Gatewood OMB, Goldblum LE, et al. Hormonal replacement therapy: mammographic manifestations. *Radiology*. 1990;174:199–201.

Beyer GA, Thorsen MK, Shaffer KA, et al. Mammographic appearance of the retained Dacron cuff of a Hickman catheter. *AJR Am J Roentgenol*. 1990;155:1204.

Brenner RJ, Pfaff JM. Mammographic features after conservative therapy for malignant breast disease: serial findings standardized by regression analysis. *AJR Am J Roentgenol*. 1996;171–178.

DeBruhl ND, Gorczyca DP, Ahn CY, et al Silicone breast implants: US evaluation. *Radiology*. 1993;189:95–98.

Dershaw DD. Mammography in patients with breast cancer treated by breast conservation (lumpectomy with or without radiation). *AJR Am J Roentgenol*. 1995;164: 309–316.

Destouet JM, Monsees BS, Oser RF, et al. Screening mammography in 350 women with breast implants: Prevalence and findings of implant complications. *AJR Am J Roentgenol*. 1992;159:973–978.

Everson LI, Parantainen H, Detlie T, et al. Diagnosis of breast implant rupture: imaging findings and relative efficacies of imaging techniques. *AJR Am J Roentgenol*. 1994;163:57–60.

Fajardo LL, Roberts CC, Hunt KR. Mammographic surveillance of breast cancer patients: should the mastectomy site be imaged? *AJR Am J Roentgenol*. 1993;161: 953–955.

Fajardo LL, Bessen SC. Epidermal inclusion cysts after reduction mammoplasty. *Radiology*. 1993;186:103–106.

Ganott MA, Harris KM, Ilkanipour ZS, et al. Augmentation mammoplasty: normal and abnormal findings with mammography and US. *RadioGraphics*. 1992;12:281–295.

Gorczyca DP, DeBruhl ND, Mund DF, et al. Linguini sign at MR imaging: does it represent the collapsed silicone implant shell? *Radiology*. 1994;191:576–577.

Harris KM, Ganott MA, Shestak KC, et al. Silicone implant rupture: detection with US. *Radiology*. 1993;187:761–768.

Helvie MA, Wilson TE, Roubidoux MA, et al. Mammographic appearance of recurrent breast carcinoma in six patients with TRAM flap breast reconstructions. *Radiology*. 1998;209:711–715.

Hogge JP, Zuurbier RA, S de Paredes E. Mammography of autologous myocutaneous flaps. *RadioGraphics*. 1999;19:S63–S72.

Krishnamurthy R, Whitman GJ, Stelling CB, et al. Mammographic findings after breast conservation therapy. *RadioGraphics*. 1999;19:S53–S62.

Liberman L, Van Zee KJ, Dershaw DD, et al. Mammographic features of local recurrence in women who have undergone breast conserving therapy for ductal carcinoma in situ. *AJR Am J Roentgenol*. 1997;489–493.

Mendelson EB, Tobin CE. Imaging the breast after surgery and radiation therapy. *RSNA Categorical Course in Breast Imaging Syllabus*. 1995:175–184.

Mendelson EB. Evaluation of the postoperative breast. *Radiol Clin North Am*. 1992;30:107–138.

Mendelson EB. Imaging the post surgical breast. *Semin Ultrasound CT MR*. 1989;10:154–170.

Miller CL, Feig SA, Fox JW. Mammographic changes after reduction mammoplasty. *AJR Am J Roentgenol*. 1987;49:35–38.

Miller MJ. Immediate breast reconstruction. *Clin Plast Surg*. 1998;25:145–156.

Mund DF, Farria DM, Gorczyca DP, et al. MR imaging of the breast in patients with silicone gel implants: spectrum of findings. *AJR Am J Roentgenol*. 1993;161:773–778.

Philpotts LE, Lee CH, Haffty BG, et al. Mammographic findings of recurrent breast cancer after lumpectomy and radiation therapy: comparison with primary tumor. *Radiology*. 1996;201:767–771.

Ricciardi I, Ianniruberto A. Tamoxifen induced regression of benign breast lesions. *Obstet Gynecol*. 1979;51:80–84.

Rissanen TJ, Makarainen HP, Mattila SI, et al. Breast cancer recurrence after mastectomy: diagnosis with mammography and US. *Radiology*. 1993;188:463–467.

Rosculet KA, Ikeda DM, Forrest ME, et al. Ruptured gel filled silicone breast implants: sonographic findings in 19 cases. *AJR Am J Roentgenol*. 1992;159:711–716.

Sanders ME, Scroggins T, Ampil FL, et al. Accelerated partial breast irradiation in early stage breast cancer. *J Clin Oncol*. 2007;25:996–1002.

Sirpa AS. Delayed breast reconstruction. *Clin Plast Surg*. 1998;25:157–166.

Stomper PC, Van Voorhis BJ, Ravnikar VA, et al. Mammographic changes associated with postmenopausal hormone replacement therapy: a longitudinal study. *Radiology*. 1990;174:487.

Willett CG, Czito BG, Tyler DS. Intraoperative radiation therapy. *J Clin Oncol*. 2007;25:971–977.

CHAPTER 16

# THE MALE BREAST

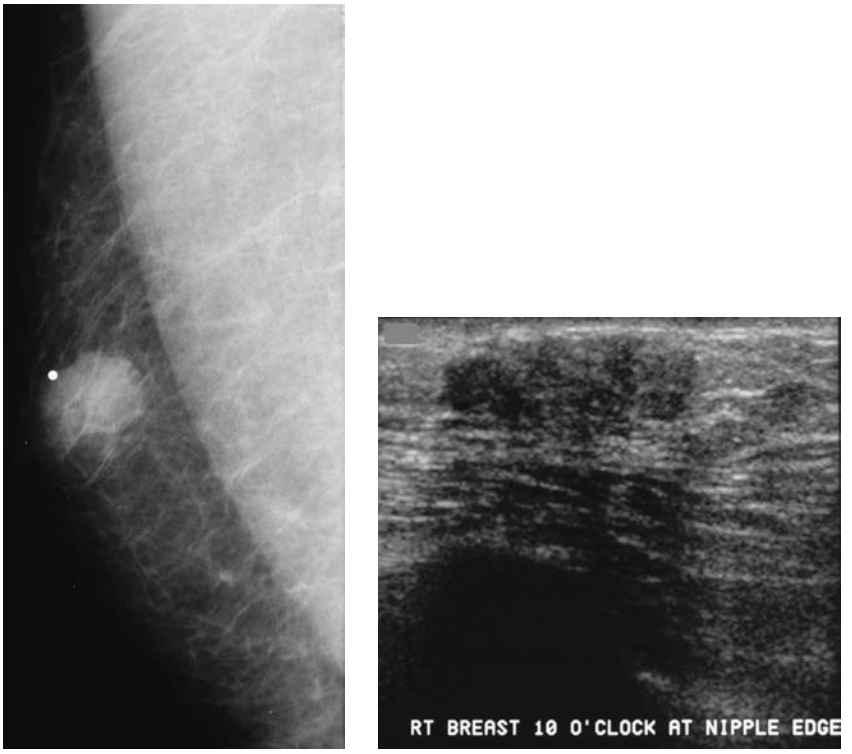
## IMAGING THE MALE BREAST

### KEY FACTS

- The initial evaluation of male patients presenting with breast related symptoms includes craniocaudal and mediolateral oblique views of the symptomatic breast. Images of the contralateral breast may be done for comparison.

  A metallic BB is used to mark the area of clinical concern.

  Spot tangential view is taken at site of any clinical finding.
- The compression paddle used for most female patients makes it difficult for the technologist to hold the male breast in place as compression is applied. Technologists may find it difficult to slide their hand out from under the compression paddle without scrapping their knuckles. For this reason, some equipment manufacturers provide a narrow paddle (approximately half the width of the standard compression paddle, see Fig. 5-5B).
- As in female patients, diagnostic views (e.g., spot compression, spot magnification, tangential, rolled) may be indicated if an abnormality is detected on initial views.
- In male patients, predominantly fatty tissue, prominent pectoral muscles and a small nipple are mammographic characteristics. When evaluating films and discussing cases, look at all of the information provided on the film (e.g., patient name, age, date of study).
- Male breast tissue contains major subareolar ducts with little secondary branching.
- Lobular units are rare (approximately 1 in 1,000 men), lobular lesions are unusual.
- Although only a few entities are presented in this chapter, all lesions described in female patients can occur in males. However, the incidence in men is significantly lower, particularly for the lobular derived lesions (e.g., fibroadenoma, sclerosing adenosis, lobular neoplasia, invasive lobular carcinoma).




A B

**FIGURE 16-1** Diabetic fibrous mastopathy. **(A)** Mediolateral oblique view, right breast in a male patient presenting with a mass. Metallic BB is used to mark clinical finding. Oval mass in the subareolar area corresponding to palpable finding. Prominent pectoral muscle. **(B)** Oval hypoechoic mass with associated shadowing. Margins are not well circumscribed. Patient with history of early onset, longstanding insulin-dependent diabetes. Dense stromal fibrosis with perivascular and periductal lymphocytic infiltration consistent with diabetic fibrous mastopathy is reported histologically.

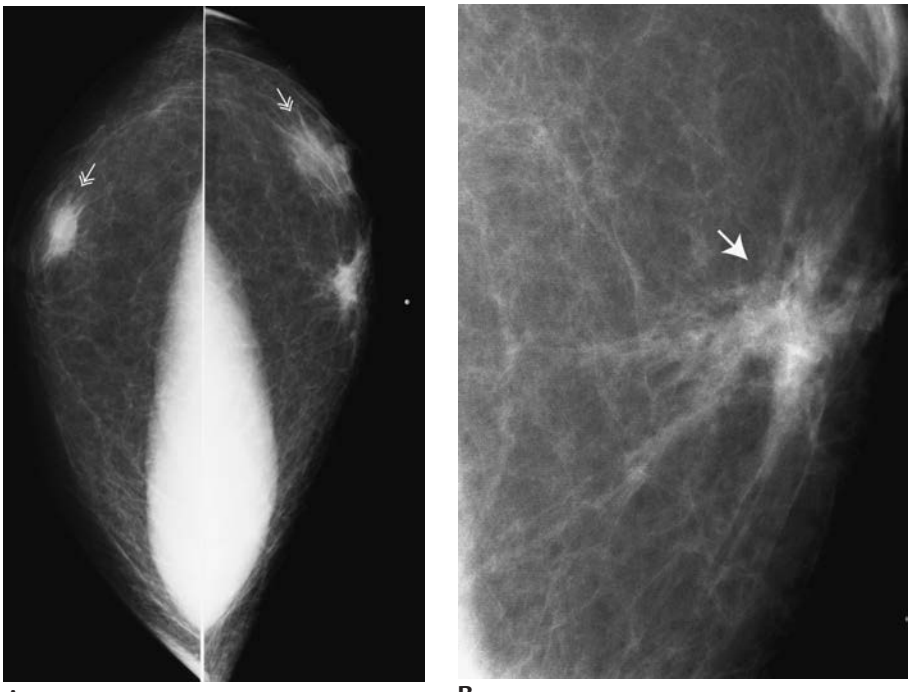



**FIGURE 16-2** Fibromatois (extraabdominal desmoid). **(A)** Craniocaudal views in a male patient presenting with a palpable mass in the left breast (metallic BB used to mark area of clinical concern). Prominent pectoral muscles are noted. Glandular tissue centered on the nipples (*double headed arrows*) is present bilaterally consistent with gynecomastia. In addition, an eccentric mass with distortion is present corresponding to the palpable finding in the left breast. **(B)** Spot compression view of palpable finding, left breast. An irregular mass with spiculation and distortion (*arrow*) is imaged corresponding to the palpable finding. Wide surgical excision is recommended to minimize likelihood of local recurrence. All lesions described in female patients can occur in male patients, but the incidence in men is significantly lower, particularly for the lobular derived lesions (rare in men unless patient is on estrogens).

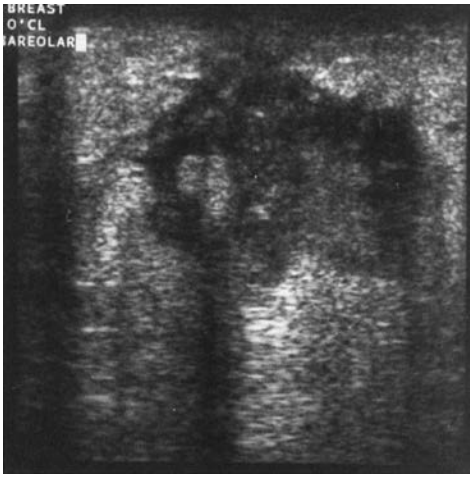



**FIGURE 16-3** Chronic abscess in a male patient. Irregular subareolar mass with heterogeneous echotexture. Focal areas of shadowing and posterior acoustic enhancement.

## GYNECOMASTIA

### KEY FACTS

- Clinical.

  Enlargement of the male breast: subareolar ducts develop secondary branching and there is proliferation of the surrounding stroma.

  Most men present with a subareolar mass or tenderness.

  Unilateral or bilateral, symmetric or asymmetric.

  Not associated with increased breast cancer risk.

  Early: subareolar with concentric distribution; eccentric masses are of concern.

  Idiopathic or related to estrogen excess (hormone imbalance).

  Physiologic: neonate (placental estrogens); pubertal (60% to 70% of adolescent males; breast enlargement and tenderness may be asymmetrical); elderly (related to decreases in plasma testosterone levels).

  Underlying diseases with estrogen excess: testicular tumors; nontesticular tumors (skin, adrenocortical, lung, hepatocellular carcinoma); liver cirrhosis; endocrine (hypo- and hyperthyroidism); nutritional deprivation: in some men gynecomastia develops after a period of nutritional deprivation when normal feeding is resumed (re-feeding gynecomastia).

  Androgen deficiency: aging, primary testicular failure, hypogonadism (Klinefelter's syndrome); secondary testicular failure (trauma, orchitis, cryptorchidism, irradiation, hydrocele); renal failure.

  Drugs: estrogenic activity (anabolic steroids, digitalis, heroin, marijuana); inhibition of testosterone action or synthesis (cimetidine, diazepam, phenytoin, spironolactone, vincristine, methotrexate); idiopathic mechanism (furosemide, isoniazid, methyldopa, nifedipine, reserpine, theophylline, verapamil).

  Systemic disorders associated with gynecomastia, mechanism unknown: non neoplastic diseases of the lung; trauma to chest wall; AIDS.

- Mammography.

  Early: nodular pattern increased tissue focally in the subareolar area.

  Late: fibrous phase tissue radiating out from nipple (triangular).

  Diffuse glandular pattern.

  Unilateral or asymmetric, 72%.

  If classic gynecomastia is seen with no microcalcifications or eccentric mass, biopsy may be averted unless patient is symptomatic.

- Ultrasound.

  Normal appearing tissue corresponding to palpable abnormality.

  Useful in distinguishing gynecomastia from other lesions particularly in patients with nodular appearing gynecomastia.

- Histology.

  Male breast contains major ducts only.

  Early: proliferation of ducts and surrounding connective tissue; reversible if source of estrogens is withdrawn.

Late: fibrosis and hyalinization; ducts become less prominent; once fibrosis occurs, process is irreversible.

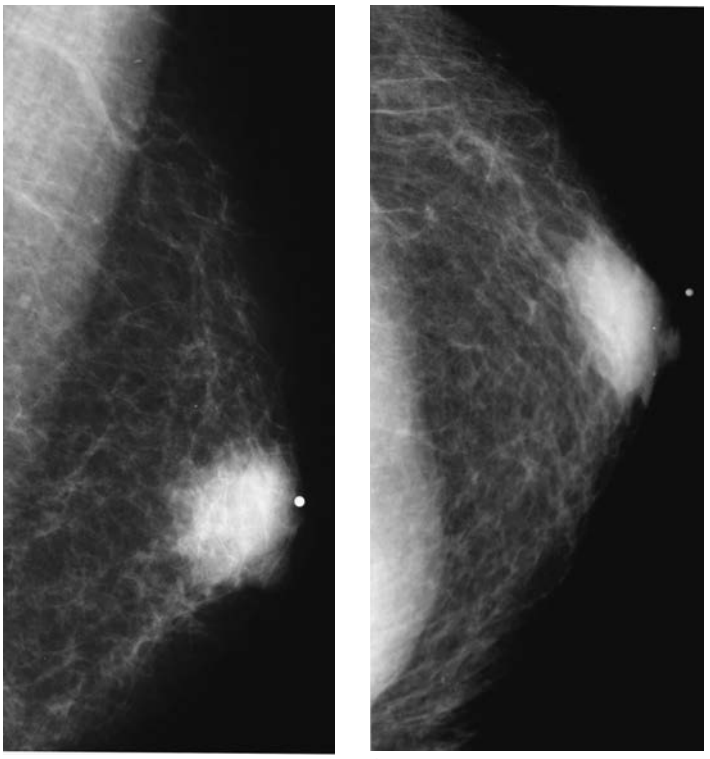
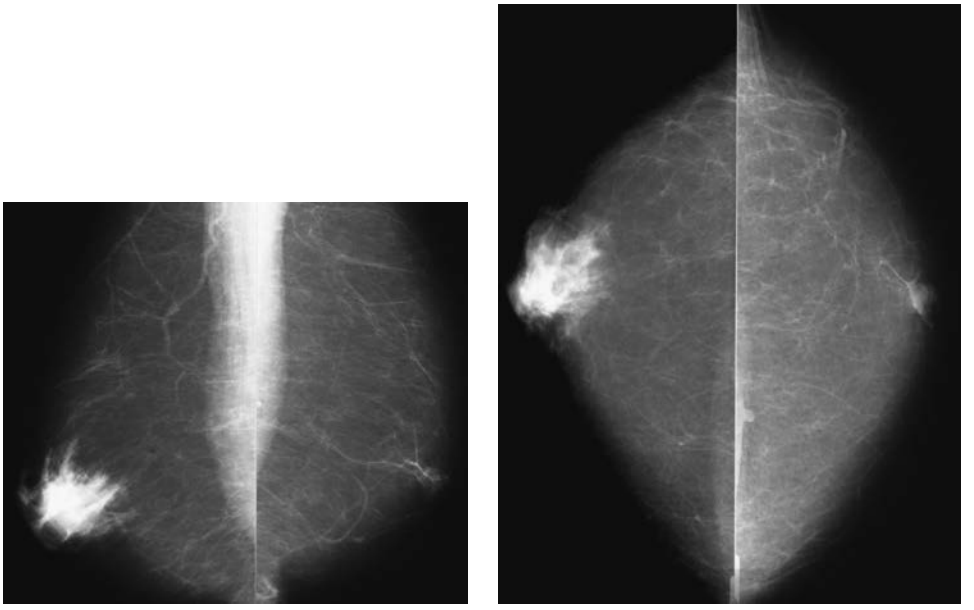
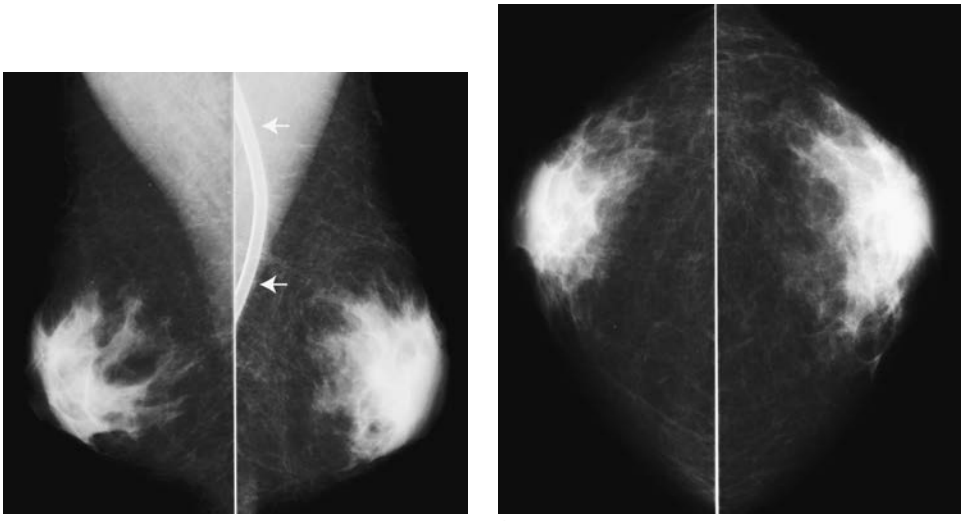



**FIGURE 16-4** Nodular gynecomastia. **(A)** Mediolateral oblique and **(B)** craniocaudal views, left breast. Round area of increased density in the subareolar area, metallic BB used to mark area of clinical concern. Prominent pectoral muscle common in male patients. On ultrasound (not shown) no focal abnormality is seen.



**A** **B**

**FIGURE 16-5** Gynecomastia, asymmetric. **(A)** Mediolateral oblique and **(B)** craniocaudal views. Asymmetric development of dense glandular tissue, right subareolar area. Variable density and scalloping of tissue is noted. Predominantly fatty tissue (pseudo gynecomastia) on the left.



**A** **B**

**FIGURE 16-6** Gynecomastia, symmetric diffuse. **(A)** Mediolateral oblique and **(B)** craniocaudal views. Symmetric, development of glandular tissue centered on nipple. Diffuse glandular pattern. Shunt tubing (*arrows*) is seen on the left mediolateral oblique view posteriorly superimposed on the pectoral muscle.

# MALE BREAST CANCER

## KEY FACTS

- Clinical.

  Less than 0.5% of all breast cancers.

  Older mean age (64) than for female breast cancers.

  Increased incidence in men with Klinefelter's syndrome, mumps orchitis after age 20, Jews, and African Americans.

  Probably unrelated to gynecomastia.

  85% infiltrating ductal carcinomas not otherwise specified; 5% each intraductal or papillary; lobular carcinoma is rare.

  Painless, hard mass in the subareolar area; upper outer quadrant second most common location.

  Approximately 25% of patients have nipple discharge or ulceration.

  Prognosis depends on lymph node status and size of tumor at time of diagnosis.

  Approximately 50% of patients have metastatic disease to the axillary lymph nodes at the time of diagnosis.
- Mammography.

  Mass in subareolar location that has well circumscribed to indistinct to spiculated margins; it may be eccentric to the nipple.

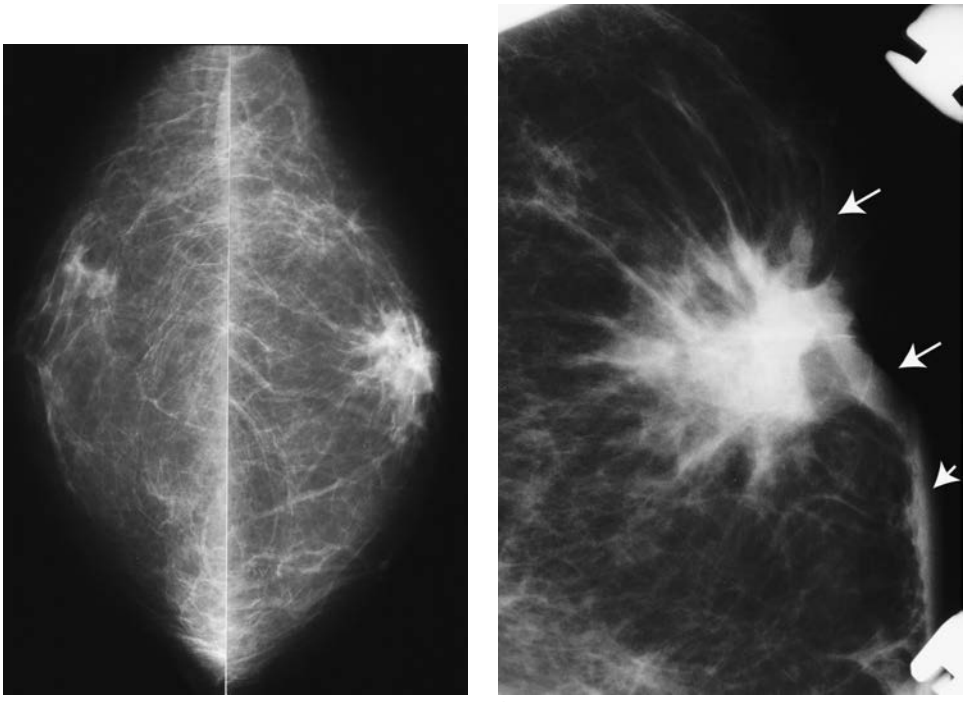
  Distortion.

  Microcalcifications (in up to 30% of male breast cancers).
- Histology.

  No different from findings for female breast cancer types.
- Metastatic disease to the male breast.

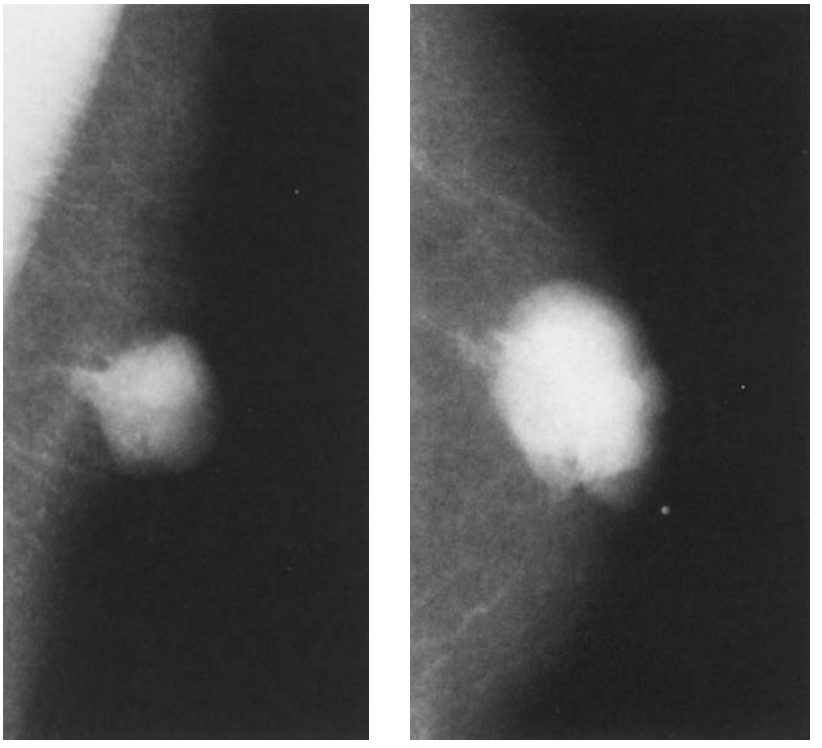
  Prostate cancer most common primary.

  Hematopoietic, lymphoreticular, melanoma, lung.



**A** **B**

**FIGURE 16-7** Invasive ductal carcinoma, not otherwise specified in male patient. **(A)** Craniocaudal views. Mass is present in the left subareolar area. **(B)** Spot compression view. Mass with spiculated margins and associated skin thickening and retraction (*arrows*) corresponding to palpable mass.



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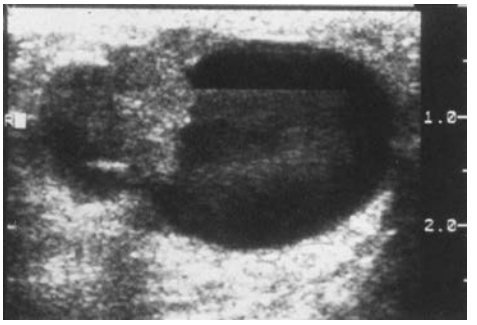


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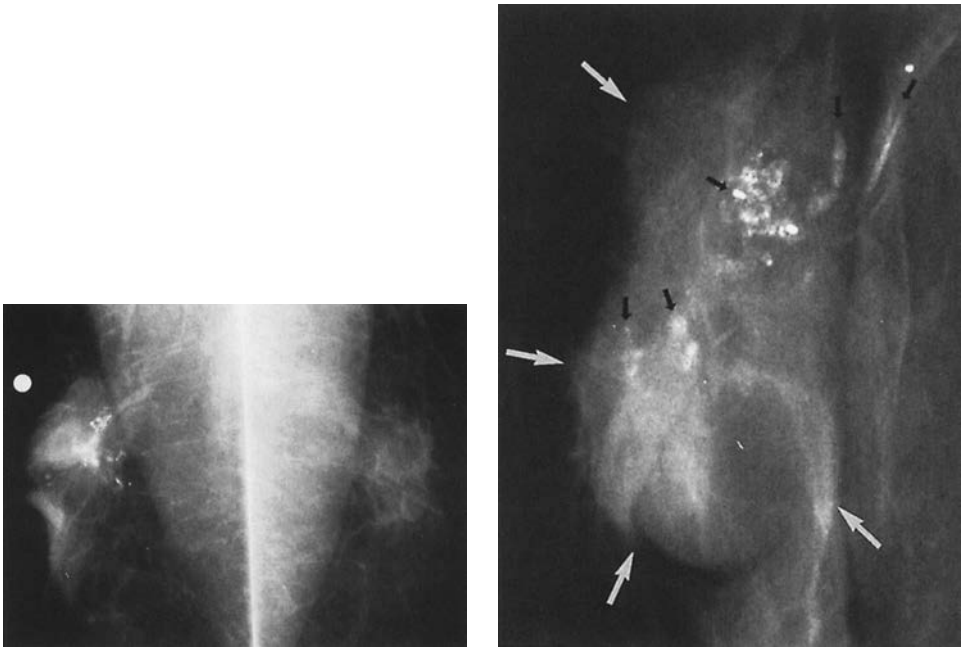
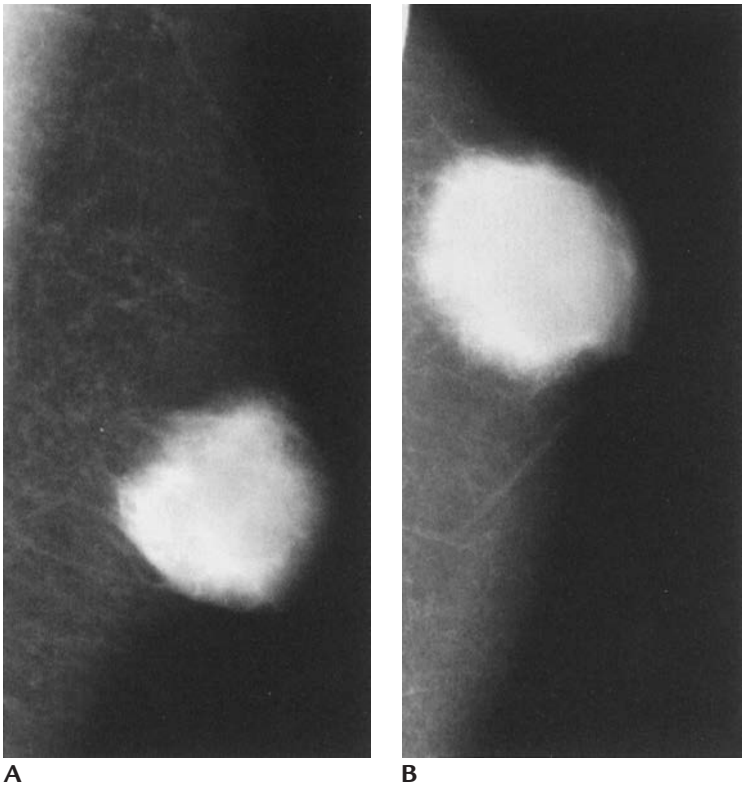
**FIGURE 16-8** Invasive ductal carcinoma, not otherwise specified in male patient. **(A)** Mediolateral oblique and **(B)** craniocaudal views, left breast. Dense, lobular mass with well-circumscribed margins in the subareolar area corresponding to palpable abnormality (metallic BB). **(C)** Lobulated mass with heterogeneous echotexture and necrotic component (fluid-fluid level) and posterior acoustic enhancement.



**A** **B**

**FIGURE 16-9** Invasive ductal carcinoma, not otherwise specified (NOS) with ductal carcinoma in situ (DCIS) in male patient. **(A)** Mediolateral oblique views demonstrating eccentric mass with associated calcifications on the right. Metallic BB indicates presence of a palpable mass. Gynecomastia is present on the left. Prominent pectoral muscles. **(B)** Spot magnification view demonstrating the mass and associated calcifications. The mass (*white arrows*) reflects underlying invasive ductal carcinoma NOS and the calcifications (*black arrows*) represent multifocal DCIS (mixed nuclear grade).



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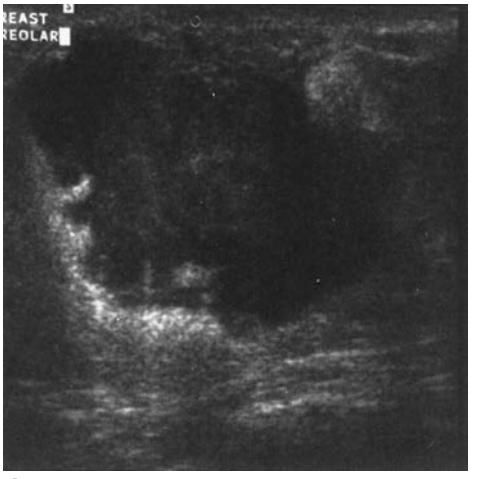



C

**FIGURE 16-10** Metastatic leukemia in 22-year-old male patient. **(A)** Mediolateral oblique and **(B)** craniocaudal views. Round, dense mass with indistinct margins in the left subareolar area. **(C)** Irregular, hypoechoic mass with focal areas of hyperechogenicity and some posterior acoustic enhancement corresponding to mass seen mammographically.

## SUGGESTED READINGS

Appelbaum AH, Evans GFF, Levy KR, et al. Mammographic appearances of male breast disease. *RadioGraphics*. 1999;19:559–568.

Chantra PK, So GJ, Wollman JS, et al. Mammography of the male breast. *AJR Am J Roentgenol*. 1995;164:853.

Cooper RA, Gunter BA, Ramamurthy L. Mammography in men. *Radiology*. 1994; 191:651–656.

Hendrix TM, Tobin CE, Resnikoff LB, et al. Breast imaging case of the day. *Radio Graphics*. 1996;16:452–455.

CHAPTER 17

# INTERVENTIONAL PROCEDURES

## Cyst Aspiration

### Key Facts

- Indications.
  Symptomatic cysts (asymptomatic cysts do not require aspiration).
  Atypical features on ultrasound.
- Ultrasound.
  Cyst is localized.
  Using transducer as guide, skin entry site is selected.
  Lidocaine (1%) is used for skin anesthesia and along the expected needle course in the breast, but not into cyst.
  A 20G spinal needle is used most commonly.
  Can come down directly on the cyst, but because the needle is angled with respect to the transducer it is hard to follow needle trajectory and tip. Also, because the needle is angled toward the chest wall, care must be exercised to minimize the likelihood of a pneumothorax particularly in patients with small breasts.
  Horizontal (e.g., parallel to the transducer and chest wall) needle trajectory used most commonly so that the needle is followed on ultrasound (as done for needle biopsies); particularly helpful for smaller cysts and those close to the chest wall. Eliminates possibility or pneumothorax.
  The cyst is punctured and aspirated using real time guidance: adjustments in needle positioning can be made as needed to aspirate the cyst completely (e.g., if the tip of the needle is up against the cyst wall). In some patients, if the cyst wall is thick, watching during real time helps gauge how much pressure is needed to puncture the wall and to establish if the needle is pushing the cyst out of the way.
  We do not sent fluid for cytology unless it is grossly bloody (following an atraumatic tap) or when the patient insists.

For cysts with atypical features and possible mural lesions, we scan following the aspiration to assure there is no residual abnormality. If a residual abnormality is identified, core biopsies through the area are usually done.

- Mammography.

  CC and 90-degree lateral views are reviewed to establish the shortest skin-to-lesion distance and needle length (see section on the parallel to chest wall approach for preoperative wire localizations).

  Using the shortest distance to the lesion, the alphanumeric fenestrated paddle is used to establish the coordinates for the lesion.

  The needle is advanced slowly as suction is applied. As soon as any liquid is obtained, the needle position is stabilized and suction is continued until the contents of the cyst have been evacuated completely.

  With the needle still in place, films are obtained to ensure there is no residual abnormality.

  If a pneumocystogram is desired (or for therapeutic benefit), air is injected.

## Pneumocystography

- Indications.

  Atypical cyst on ultrasound: helps evaluate potential intracystic or mural lesions.

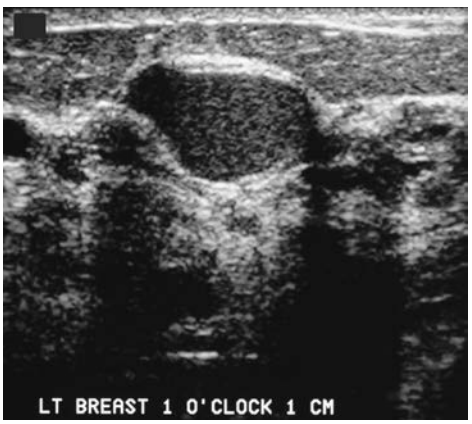
  Some have suggested a therapeutic benefit: air may prevent cyst recurrence.

- Procedure.

  After fluid aspiration, 50% of the aspirated fluid is replaced with air.

  Magnified CC and 90-degree lateral views are done if evaluation of the cyst wall is needed.

  If air is used for potential therapeutic effect, films are not obtained.

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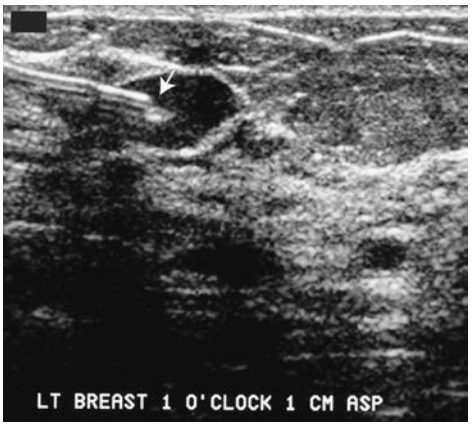
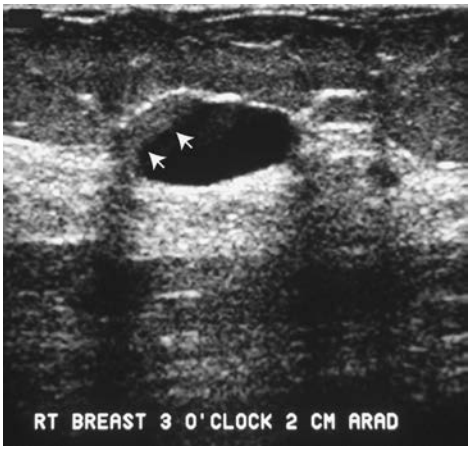



B

**FIGURE 17-1** **(A)** Oval mass with internal echoes, well-circumscribed margins, and posterior acoustic enhancement. This could represent a cyst with "atypical" features or possibly a solid mass. An ultrasound-guided aspiration is attempted; if no fluid is obtained, a core biopsy can be done. An approach is selected so that the needle is parallel to the transducer. With this approach, the needle and its tip can be seen in its entirety at all times. **(B)** Ultrasound-guided aspiration. A spinal needle (20G) is used to puncture the mass. Mass is getting smaller as fluid is aspirated. No residual abnormality is seen following the aspiration of serous fluid; no further intervention is warranted. Notice that the needle tip (*arrow*) appears broken (e.g., bayonet sign) "reflecting" an ultrasound artifact.

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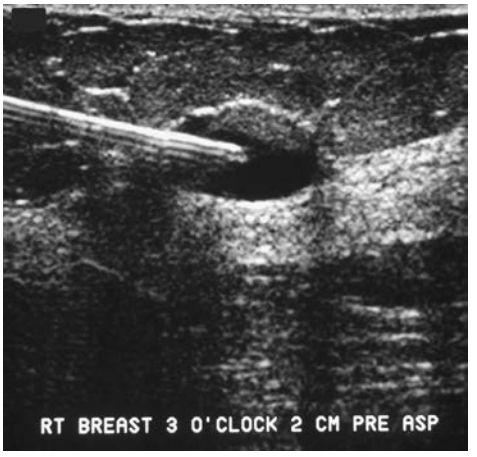


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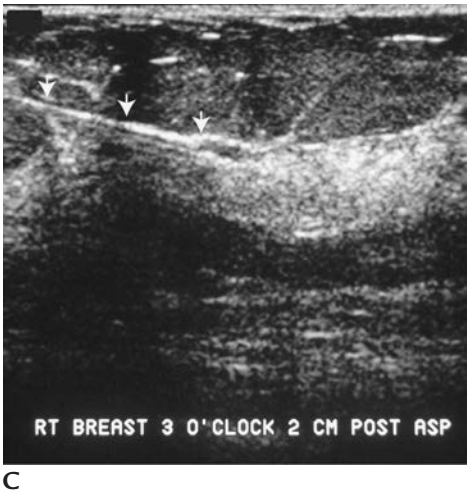


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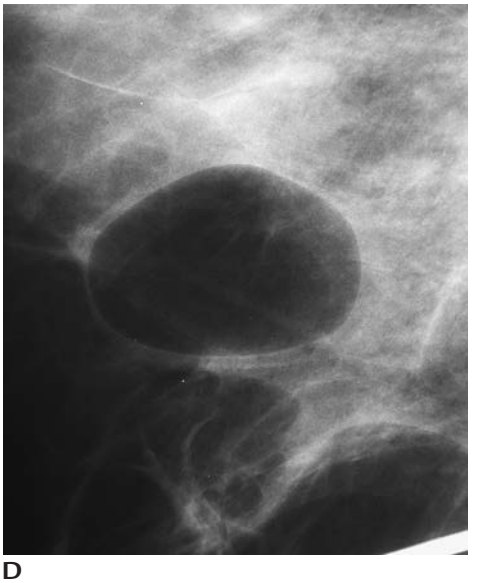


D

**FIGURE 17-2** **(A)** Complex cyst. Because of the presence of echoes along a portion of the cyst wall (*arrows*), a mural lesion is a consideration and as such an ultrasound-guided aspiration with pneumocystography is undertaken for further evaluation. **(B)** Positioning of the needle in the center of the cyst. While observing under real time, fluid is aspirated. **(C)** Postaspiration image demonstrates needle (*arrows*) with no residual abnormality. Needle is stabilized and half of the aspirated volume of fluid is replaced with air. **(D)** Spot compression magnification view demonstrates smooth cyst wall. No mural lesion is identified on the pneumocystogram.

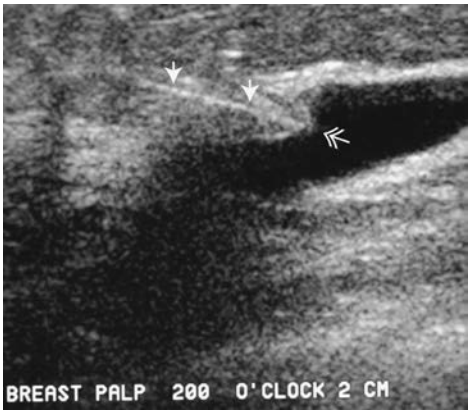



**FIGURE 17-3** When aspirations are done using ultrasound guidance, it is useful to watch the advancing needle under real time to gauge how much pressure is needed to puncture the cyst wall and to make sure the needle is not pushing the cyst out of the way. In this patient, the needle (*arrows*) is indenting the cyst wall (*double headed arrow*) so that more pressure is needed to puncture the wall. When watching under real time, you can stabilize the cyst by increasing compression with the transducer and determine how much pressure needs to be exerted to puncture the wall.

## DUCTOGRAPHY

### KEY FACTS

### General Comments

- Indication.
  Spontaneous, single duct nipple discharge.
- Clinical.
  Discharge intermittent; patients describe red brown to yellowish spots in bra cup or discharge following baths or showers (presumably the hot water relaxes the nipple musculature facilitating manifestation of discharge).
  If the discharge is spontaneous, the character of the discharge (e.g., serous, clear, bloody) does not dissuade us from doing a ductogram. Expressed, multiple, bilateral duct discharge does not warrant ductography.
  Most women with intraductal lesions have normal breast examinations. Some have an identifiable "trigger point," which is a point that when compressed reliably elicits discharge.
  Ductography provides information on the location of lesions within ducts, the number and extent of lesions, and the distribution of the duct within the breast so that minimal-volume breast biopsies can be done removing the lesions causing discharge and sparing normal surrounding tissue.

May avert a biopsy, if fibrocystic changes or duct ectasia are demonstrated.

- Mammography.

  Usually normal.

  Occasionally, dilated duct in isolation or with associated coarse, curvilinear calcifications.

- Contraindications (relative).

  Mastitis, abscess.

- Complications.

  Unusual. We have not had any major complications related to ductography even in patients with a prior history of contrast allergy. Contrast is not injected intravenously or intra-arterial, only small amounts of contrast are used, and if needed most of the contrast can be expressed after the procedure.

  Duct perforation of normal ducts is rare. Patients may describe a sharp pain when perforation occurs and feel a burning sensation as soon as an attempt is made to inject contrast. No long-term sequelae probably result. The patient can be rescheduled for a follow-up study or, if she is willing, the procedure can be tried again following a 20- to 30-minute wait to permit absorption of the extravasated contrast.

- Pitfalls.

  Air bubbles: round, sharply defined lucencies that shift in position between views; care should be exercised when drawing up the contrast to ensure there is no air in the system.

  Over injection of the contrast may obscure small lesions particularly when close to the nipple. It is best to start with small amounts of contrast (0.2 to 0.4 mL), secure the cannula in the duct, and inject additional contrast as needed to opacify the duct.

  Over injection may lead to peripheral extravasation; usually the woman describes a burning sensation when the extravasation occurs. Opacification of lymphatic channels may be seen when extravasation occurs.

  Pseudolesions: uncommon; initial ductogram demonstrates diffuse duct abnormality not confirmed on subsequent (preoperative) studies; cause unknown, postulated to be intraductal debris, possible blood clots, and/or muscular contraction.

  Duct perforation uncommon. When cannulating the duct, do not force or apply significant pressure. If the patient experiences pain, stop and reassess cannula positioning before trying to advance the cannula.

## Procedure

- Comfortable patient: supine position; can be done with patient sitting, but may be more cumbersome and cannulation more difficult.
- Comfortable radiologist: sitting.
- Good lighting (halogen lamp focused on nipple), magnification of nipple surface provided by magnification lenses attached to glasses or safety goggles.

- A 30G straight, blunt-tipped sialography needle with attached tubing connected to a 3 mL Luer lock syringe and undiluted isothalamate meglumine (Conray 60, Mallinckrodt, St. Louis). Air bubbles should be eliminated from the system.

  At the onset, it is important to spend time identifying the secreting duct orifice. On careful inspection of the nipple, the abnormal duct is often slightly patulous and erythematous compared to adjacent duct openings; crusting at the duct opening may be present overlying the duct orifice.

  After inspection of the nipple, elicit a tiny amount of discharge. This is cleared and the process repeated until the orifice has been identified. If too much discharge is elicited, the fluid floods over other duct openings, making isolation of the discharging duct more difficult.

  When the discharging duct opening is identified, the cannula is angled and the tip is placed at the duct opening. The cannula is gently straightened.

  Usually the cannula falls into the duct all the way to the hub; do not apply force.

  If the woman experiences pain during cannulation, stop and reassess the positioning of the cannula. In most women, cannulation is painless.

  After cannulation, wait a few seconds to see if you see contrast refluxing back into the tubing. Also, as you inject contrast you may notice some of the discharge pooling around the cannula. These are indications that you have cannulated the correct duct.

  With the cannula securely in the duct, inject approximately 0.2 to 0.4 mL of contrast and tape the cannula to the nipple using two pieces of paper tape.
- The duct does not need to be dilated prior to cannulation.
- Full paddle orthogonal (CC and 90-degree lateral views) magnification views are obtained and reviewed. Because the cannula remains in the duct, additional contrast can be injected as needed. The cannula also helps tamponade the duct so that injected contrast material is not extruded on compression.
- If difficulty is experienced cannulating duct:

  Apply a hot wash towel over the nipple for several minutes; this presumably relaxes the nipple musculature.

  Use an alcohol wipe on the nipple to clear any keratin plugs partially occluding the duct openings.

  Pull the nipple up gently; this may straighten the subareolar ducts.

  Have the technologist apply traction on the nipple as you cannulate.

  Vary the angle of the cannula.

  Gently twirl the cannula between your thumb and index finger.
- Preoperative ductography.

  If a lesion is found on the diagnostic ductogram, we do preoperative ductography. A 1:1 combination of methylene blue and Conray 60 is used. The methylene blue stains the duct for the surgeon and pathologist and the Conray 60 permits verification that the abnormal duct has been cannulated.

If a lesion is distal to many branch points in the duct or several centimeters from the nipple, a needle localization can be done using the ductogram to direct wire placement.

## Findings

- Duct dilatation: isolated or associated with other findings; obstruction, filling defect, focal or diffuse wall irregularity, expansion and distortion, displacement, or cyst opacification.
- Normal ducts.

  Not much has been written on normal duct anatomy, but it probably varies during different physiologic phases of a woman's life.

  Duct distribution is variable: some ducts diverge to supply large portions (e.g., multiple quadrants) of the breast and others terminate close to the nipple with little if any branching.

  In a few women opacification of lobules is seen ("lobular blush").
- Solitary papillomas.

  Discharge produced by papillomas can be clear, yellow, brown, or bloody in appearance; it is not usually green or white.

  Most common cause of spontaneous nipple discharge. Approximately 50% of women with spontaneous nipple discharge have solitary papillomas.

  Duct containing papillomas are often dilated. Although the dilatation can be diffuse, it most commonly involves the segment of duct between the papilloma and the nipple.

  The papilloma itself can produce complete duct obstruction (a meniscus is usually seen), an intraductal filling defect, an intraductal filling defect with expansion, and apparent distortion of the duct or duct wall irregularity (more sessile-like papillomas).

  With intraductal lesions, biopsy is recommended (cannot distinguish benign from malignant).

  Because the epithelial lining of the duct is contiguous with that of the papilloma, atypical ductal hyperplasia and ductal carcinoma in situ (usually low nuclear grade) can arise in papillomas.
- Fibrocystic changes.

  In women with underlying fibrocystic disease, the discharge is commonly greenish.

  Opacification of cyst or cysts; duct otherwise normal.

  Diffuse duct irregularity: biopsy required (cannot distinguish benign from malignant).
- Duct ectasia.

  Thick, white discharge.

  The duct is dilated in the subareolar area and then assumes an attenuated or pruned appearance.

  No intraductal lesion is identified.

- Breast cancer.

  Filling defect or defects, abrupt duct cut-off: mass at cut-off site, duct wall irregularity, duct displacement (draping around a lesion).

  Extravasation: when this occurs because of an underlying duct lesion, the patient does not experience pain during cannulation or burning when contrast is injected. If on your first try you think you might have perforated the duct, bring the woman back and determine if the extravasation occurs again. It is postulated that abnormal ducts may become "leaky" permitting extravasation without perforation.

  Many of these women have normal physical examinations and mammograms. Generally, the abnormalities on ductography are more extensive with underlying breast cancer than with papillomas. Also, there is less duct distension with malignancy compared to ducts containing solitary central papillomas.
- In some patients presenting with nipple discharge following lumpectomy and radiation therapy, the cannulated duct connects to a seroma cavity.

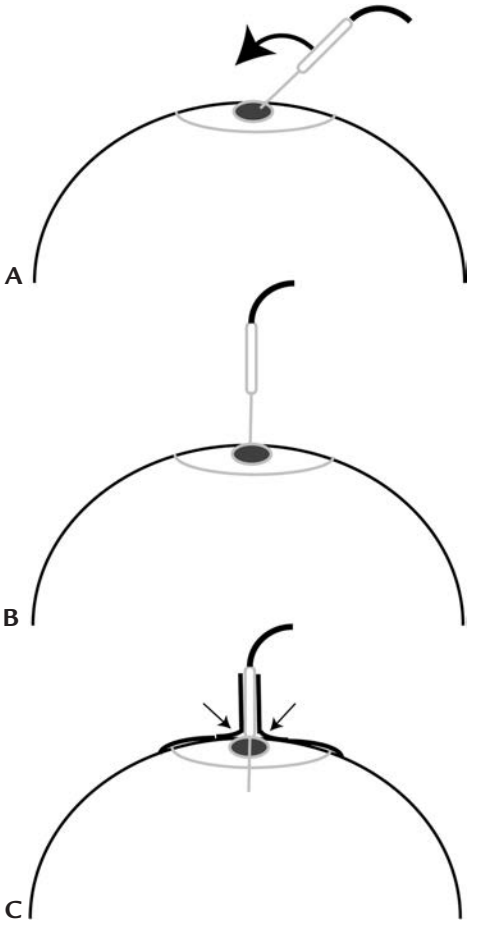



**FIGURE 17-4** Duct cannulation. **(A)** After identifying the duct producing the discharge, angle the cannula and place the tip at the duct opening. **(B)** Gently straighten the cannula. Do not exert any force or pressure. If the patient describes pain, stop and reassess. The tip of the cannula is probably not in the duct opening. **(C)** In most patients, the cannula falls in the duct down to the hub. Because the tubing is now a closed system with the duct, discharge may reflux back into the tubing or, as contrast is injected, discharge may be noted pooling around the cannula. At the onset, inject no more than 0.2 to 0.4 mL of contrast, otherwise small lesions close to the nipple may be masked. Tape the cannula (*arrows*) onto the nipple so that additional contrast can be injected as needed and to tamponade the duct so that the injected contrast is not exuded out as the breast is compressed.

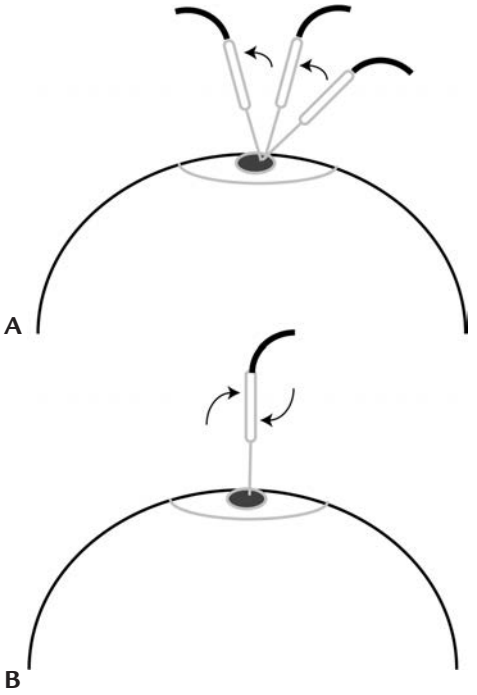
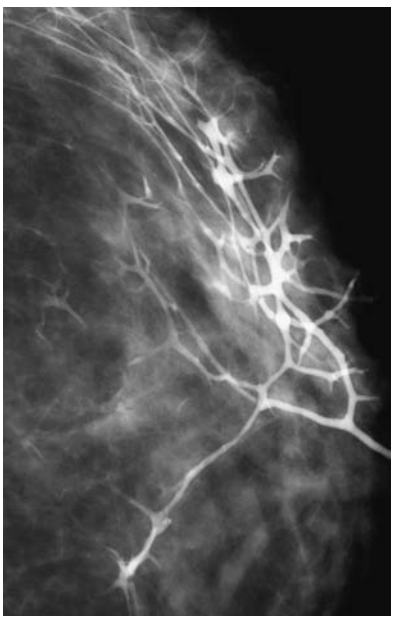
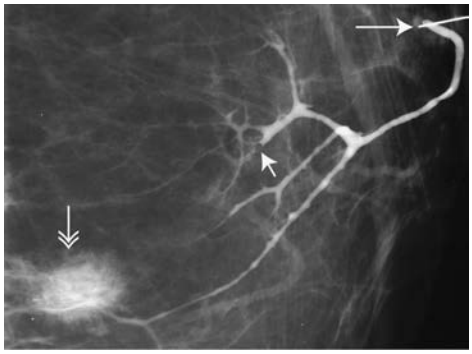



**FIGURE 17-5** Tips for cannulation. **(A)** If the cannula does not fall easily into the duct, gently vary the angle of the cannula. In some patients, a slight change of angle leads to cannulation. **(B)** Alternatively, gently twirl the cannula between your thumb and index finger. Other tips include swabbing the nipple with an alcohol wipe to clear away keratin plugs, applying a warm to hot towel to the nipple for a few minutes (to relax the nipple musculature), lifting the nipple slightly, or having someone apply tension on either side of the nipple.



A

**FIGURE 17-6** Normal ducts. **(A)** Opacified duct is normal in caliber and has multiple branches extending to several quadrants. Arbitrarily, we use the width of the cannula as an approximation of what we consider to be normal duct caliber. No focal abnormality is identified.



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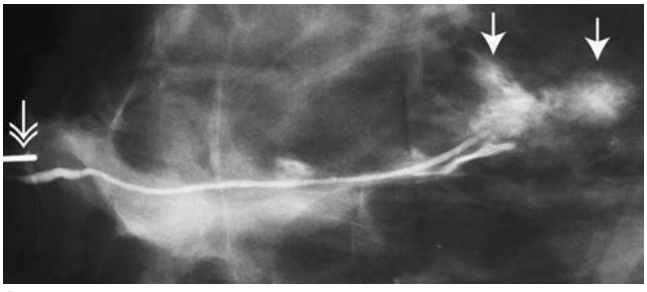


D

**FIGURE 17-6** (*Continued*) **(B)** Different patient. Opacified duct is normal in caliber with less branching and a more limited distribution pattern compared with the prior patient. A small amount of contrast (*double headed arrow*) has extravasated peripherally. When this occurs the patient may describe a burning sensation. A small air bubble (*short arrow*) is present. The only way to distinguish this from a lesion is to obtain follow up images after massaging the breast. Air bubbles shift in position between images, lesions persist. Cannula (*long arrow*) is used to approximate normal duct caliber. **(C)** Different patient. Opacified duct is normal in caliber with limited branching and distribution. Lobular blush at end of duct likely reflects opacification of slightly distended acini. Portion of cannula is seen in the subareolar area. **(D)** Different patient. Opacified duct is hypoplastic. Peripheral extravasation is present (*arrows*). Compare this appearance with that noted for lobular blush in the previous patient. Cannula at nipple (*double headed arrow*).

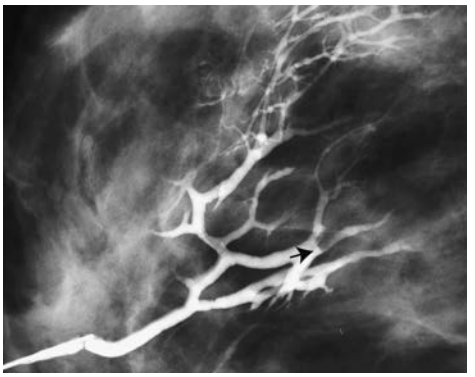


**FIGURE 17-7** Papilloma (*arrow*) is obstructing a side branch of the opacified duct. Mild duct dilatation is present. Cannula is seen in seen in the subareolar portion of the duct.

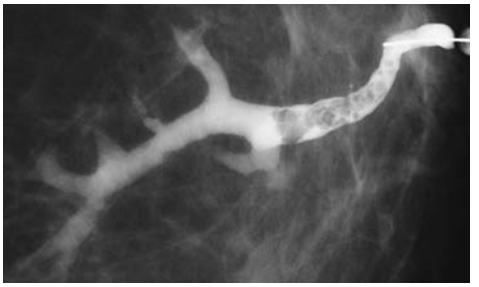


**FIGURE 17-8** Papilloma. Filling defect is present in dilated duct. Microlobulated margins of lesion are apparent as contrast is seen pooling in the interstices of the papilloma. Cannula is seen in the duct.

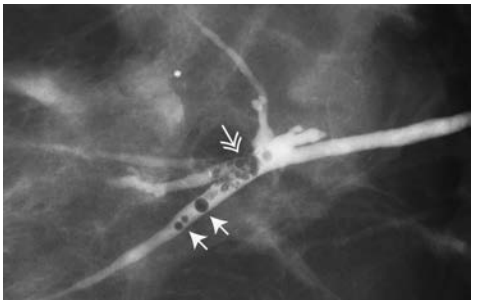


**FIGURE 17-9** Papilloma (*double headed arrow*) producing a filling defect in the opacified duct. Margins are lobulated and there is contrast pooling in the interstices of the lesion. Air bubbles (*arrows*) are noted as round sharply defined lucencies (compare lucency of bubbles with the density of the papilloma). Repeat images can be done to demonstrate a shift in the position of air bubbles and persistence of the papilloma.

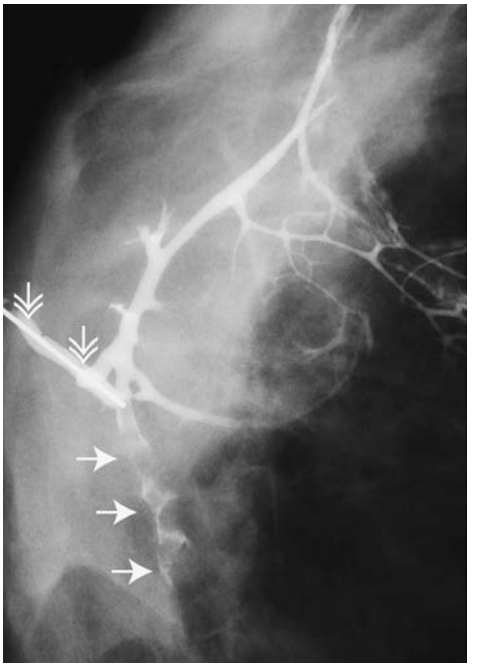
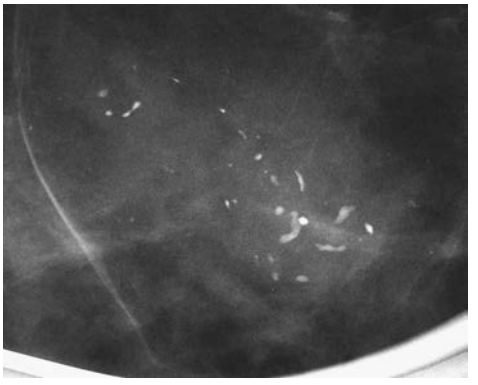


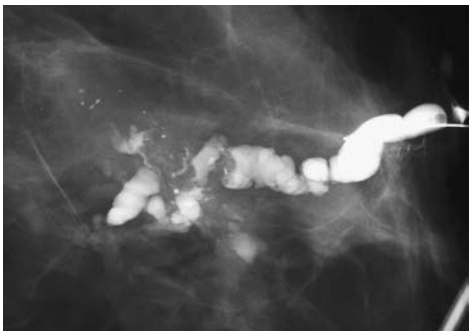
**FIGURE 17-10** Papilloma (*arrows*) producing an irregular filling defect with wall irregularity and obstructing this major side branch of the opacified duct. Cannula (*double headed arrows*) is seen in the subareolar portion of the cannulated duct.

**FIGURE 17-11** Invasive ductal carcinoma. Patient presents with spontaneous nipple discharge. Focal narrowing in the opacified duct ("apple core" lesion).



**A**

**FIGURE 17-12** Ductal carcinoma in situ arising in papilloma. **(A)** Double spot compression magnification view demonstrating a cluster of calcifications with linear, curvilinear and round forms. Because the patient also had spontaneous nipple discharge, a ductogram is done.



**B**

**FIGURE 17-12** (*Continued*) **(B)** An irregular filling defect obstructing some of the branches of the opacified duct is present associated with the calcifications seen in the initial mammogram. At multiple sites, some of the edges of the papilloma are outlined by contrast (creating meniscus) illustrating the irregularity and microlobulation in the margins of many of these lesions. The duct is dilated. An air bubble is seen at the nipple just above the cannula.

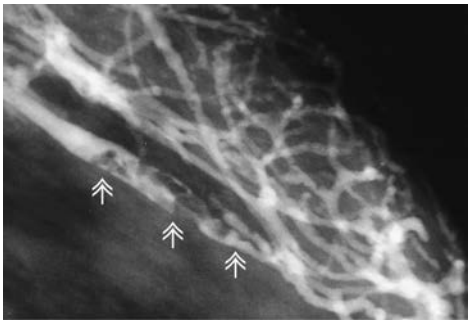


**FIGURE 17-13** Ductal carcinoma in situ. Wall irregularity (*double headed arrows*) diffusely involving the opacified duct. Although the more striking area of abnormality is marked with the arrows, subtle wall irregularities are apparent involving many of the opacified branches of this duct (e.g., the ducts appear "rat-bitten"). Compare the appearance of the duct walls in this patient with the normal ducts shown.

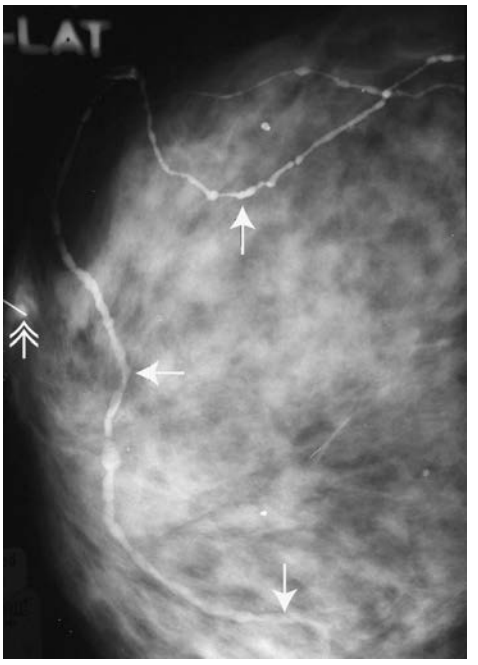



**FIGURE 17-14** Lymphatic channels. Rarely, opacification of lymphatic channels (*arrows*) may be seen. As in this patient, these are characterized by a "beaded" appearance and a non-anatomic distribution for ducts. Cannula (*double headed arrow*) demonstrates non-anatomic relationship of these opacified channels to the nipple.

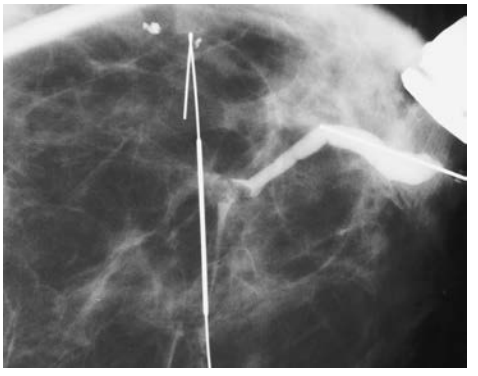


**FIGURE 17-15** Papilloma. On the day of surgery, the ductogram is repeated and used to guide the preoperative wire localization. Mid-portion of reinforced wire segment is at posterior edge of the intraductal lesion. Cannula is seen in the subareolar area.

## Fine Needle Aspiration

### Key Facts

- Aspiration of cellular material from breast lesions for cytologic evaluation.
- Needle placement in the lesion can be guided by palpation, mammography, ultrasound, stereotactically or using magnetic resonance imaging (MRI).
- Lidocaine (1%) is used for local anesthesia.
- Can use an aspiration device combining a 20 mL syringe with the selected needle or a butterfly needle with a syringe attached to the end of the tubing. This may allow for closer control of the needle. During needle excursions, an assistant can be applying suction through the attached syringe.
- Alternatively, a 20G spinal needle is used and directed to the center of the lesion.
- Needle-tip positioning is verified by whichever guidance technology is being used for the procedure.
- With satisfactory needle-tip positioning, suction is applied and small short, quick strokes are made varying the angle of the needle in the lesion.
- Alternatively, methodical movements of the needle in and out of the lesion with slight variations in needle position can yield small "plugs" of tissue that can processed for cell blocks in addition to the cellular material applied on slides.
- Suction is stopped and the needle is pulled out of the breast. The needle and syringe are separated and a small amount of air is sucked into the syringe and reconnected to the needle. The tip of the needle is placed at the leading edge of a glass slide and the plunger on the syringe is compressed so that the material in the needle is gently forced onto the slide.
- A second glass slide is used to smear the material on the slide.
- The slides are allowed to air dry and then processed for staining and microscopic evaluation. However, processing of the material varies among institutions so this should be discussed with the pathologist. Drying, fixing, and staining are the purview of the pathologist.
- Excellent results can be obtained using optimal technique and a well-trained, experienced cytopathologist to establish specimen adequacy and diagnosis.

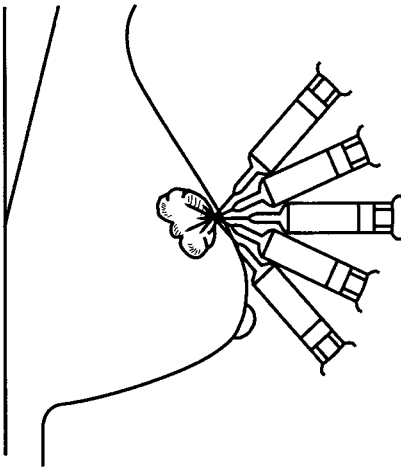


**FIGURE 17-16** One technique for fine needle aspiration involves placing the needle in the center of the mass to be sampled, applying suction, and then making short, quick excursions as the angle of the needle is varied. After sampling, suction is stopped and the needle is withdrawn. It is important to stop suction before pulling the needle out, otherwise aspirated material may be sucked into the syringe.

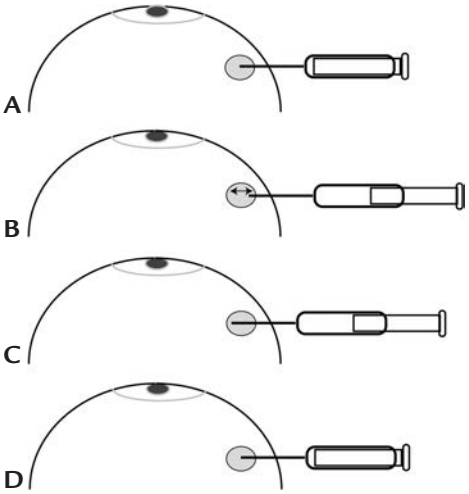
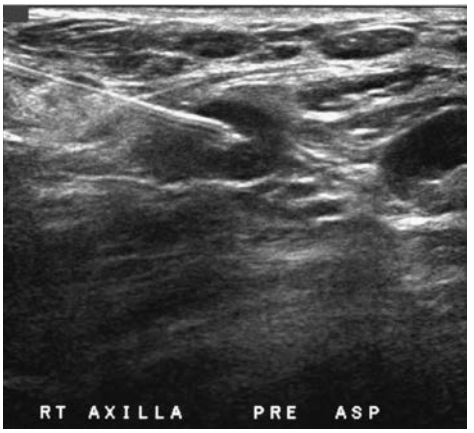
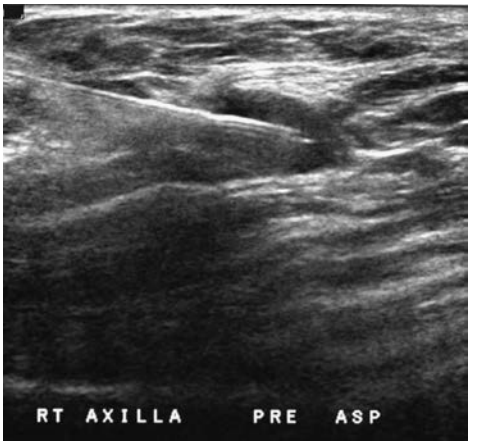


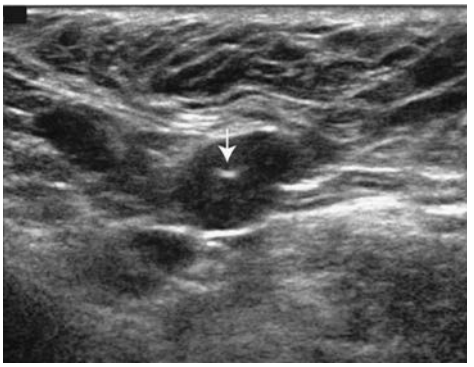

**FIGURE 17-17** **(A)** Another technique for fine needle aspiration involves directing the tip of the needle into the mass being sampled. (**B** and **C**) While applying suction on the syringe, the needle is methodically and slowly moved from one edge of the lesion to the other under real time ultrasound guidance (trying not to come of the mass, otherwise sampling may be limited if the lesion is moved out of the way by the advancing needle). Slight variations in the angle of the needle are made with each excursion. **(D)** After sampling is completed, suction is released on the syringe with the needle still in the lesion. The needle is then pulled out of the breast and the aspirated material is placed on a glass slide. This method is very effective and often yields small tissue plugs in addition to cellular material.




**A**




**B**



**C**

**FIGURE 17-18** Fine needle aspiration of axillary lymph node. (**A** and **B**) With the needle in the mass, suction is applied and the needle is moved methodically from one edge of the mass to the other under ultrasound guidance. Several methodical, slow excursions are done with minor variations in the angle of the needle all under ultrasound guidance. Notice the change in needle position between images. **(C)** Orthogonal ultrasound image is done to confirm appropriate needle (*arrow*) placement in the center of the lesion. Needle is imaged in cross-section surrounded by the lesion being sampled.

# Imaging Guided Needle Biopsy

## Key Facts

### General Comments

- Imaging guided percutaneous biopsies are undertaken on lesions detected on mammography, ultrasound and magnetic resonance (MR); these procedures are an easier and more practical way of arriving at a diagnosis; safer (no anesthesia associated risks), quicker, more cost effective than surgical biopsies (core biopsies average a third the cost of excisional biopsies), less invasive and leave no significant scarring.
- Needle biopsies, however, should not be used to replace or subvert complete diagnostic workups of patients with breast-related findings.
- Caution should be exercised when low nuclear grade ductal carcinoma in situ (DCIS), a radial scar/complex sclerosing lesion or a large papillary lesion (particularly in an older patient) is suspected: sampling errors may preclude an appropriate histologic diagnosis. Discuss findings with pathologist.
- With incongruent radiology/pathology results, atypical ductal hyperplasia (ADH), a radial scar/complex sclerosing lesion, possible phyllodes and papillary lesions with atypical features on core biopsies, excisional biopsy is recommended.

  Approximately, 20% to 56% and 0% to 38% of women with ADH diagnosed on a 14G automated core biopsy or with vacuum-assisted devices, respectively, are found to have malignancy on excisional biopsy.

  Approximately 16% to 35% and 0% to 19% of women with DCIS diagnosed on 14G automated core biopsy or with vacuum-assisted devices, respectively, are found to have invasive cancer on excisional biopsy. (If no sentinel lymph node biopsy is done in these patients at the time of the initial lumpectomy, the sentinel lymph node biopsy is done as a second surgical procedure).

  Epithelial cell displacement has been reported following core biopsies (epithelial cells, including malignant cells, are displaced from the lesion into surrounding tissue, presumably by the advancing needle). Significance unknown, however, the number of identified displaced cells decreases as the time between needle biopsy and excisional biopsy increases. This suggests that displaced cells do not survive. Can cause a problem for the pathologist (e.g., displaced DCIS cells may simulate invasive ductal carcinoma).
- More recently several authors have suggested that excisional biopsy should be recommended with a diagnosis of lobular neoplasia (atypical lobular hyperplasia, lobular carcinoma in situ) following an imaging guided biopsy. Other lesions for which excisional biopsy should be considered following an imaging guided biopsy include mucocele-like lesions and columnar alteration with prominent apical snouts and secretions (e.g., CAPSS) associated with atypia.
- Techniques for stereotactic and ultrasound guidance are well established. Techniques for MRI guidance continue to evolve.

At some facilities, the use of stereotactic equipment is often limited to women with microcalcifications not identified on ultrasound. Lesions (including microcalcifications) seen on ultrasound are sampled using ultrasound guidance.

Most of our core biopsies are done using ultrasound guidance; these are easier on the patient (supine position, no compression or ionizing radiation), quicker and, because orthogonal views of final needle positioning are obtained, confidence in adequate lesion sampling is increased.

Rarely, if there is any question that what is being seen on the mammogram correlates with what is found on ultrasound, a needle (the one we use to deposit lidocaine up to the lesion) can be left in place and a mammographic view (compressing the breast parallel to the orientation of the needle) is done to verify that the ultrasound lesions correlates with that seen on the mammogram.

- Relative contraindications.

  For the larger gauge (11G, 8G) and vacuum-assisted procedures, coumadin or aspirin therapy is stopped for several days before biopsy. (We do not stop coumadin or aspirin therapy when using a 14G spring loaded device; we apply pressure over the skin nick and along the course of the needle for several minutes after each pass.)

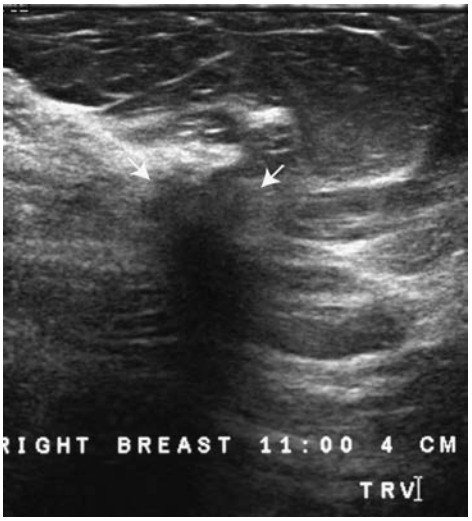
  Lesion location: when the lesion is close to the chest wall, it may or may not be approachable with stereotactic equipment (e.g., cannot get the lesion into the window).

  If patient is unable to lie prone with neck turned for 30 to 60 minutes for stereotactically guided procedures done with the prone unit (not a problem with the add-on devices) or breast compresses to less than 2 cm (preferred needle throw 2.1 to 2.5 cm).

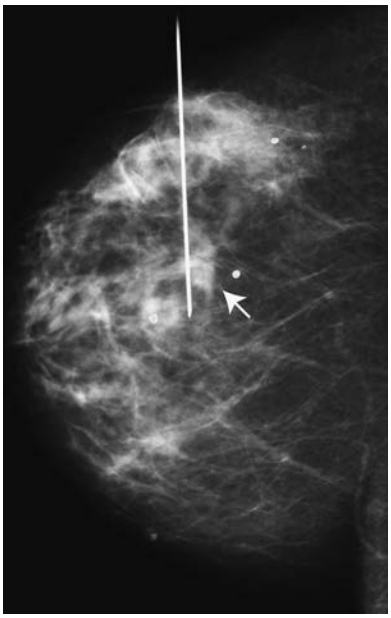
- False negatives.

  Reported range of 0.3% to 8.2% (reported range for excisional biopsies following preoperative wire localizations is 0% to 8%).

  Meticulous targeting of lesions, core specimen radiography when sampling calcifications, ensuring radiology/pathology congruency, and appropriate patient follow-up after biopsies can minimize false negative rates.




A



B

**FIGURE 17-19** Ultrasound-mammographic correlation. **(A)** In evaluating a patient with a spiculated mass in the right breast detected mammographically, an area of intermittent shadowing (*arrows*) is imaged in the right breast on ultrasound. If there is any concern regarding the correlation between mammographic and sonographic findings, the needle used for local anesthesia (25G) is placed through the sonographic finding, and a follow up mammographic image is done. **(B)** Craniocaudal view confirms that what is seen on ultrasound corresponds to the spiculated mass (*arrow*) seen mammographically. The needle is coursing through the anterior edge of the spiculated mass. The patient is returned to the ultrasound room and two cores are done through the mass establishing the diagnosis of an invasive ductal carcinoma.

## Sampling Methods

- Automated gun-needle combinations.

  Different needle gauges are available; 14G recommended for increased accuracy and adequate sampling of lesions.

  Different needle lengths are available: 10, 13, and 16 cm (10 cm used commonly for ultrasound procedures).

  Inner tissue sampling needle: beveled needle tip (4 to 5 mm) and tissue trough. Size of tissue trough determines distance traveled by needle (e.g., needle throw). Short throw (10 to 15 mm) needles are not recommended because of poor tissue samples; we use the long throw (21 to 25 mm) needles almost exclusively.

  Outer cutting cannula.

  In pre-biopsy position outer cannula covers inner needle.

  When the gun is fired, the inner needle advances forward (the tip has downward bevel) followed almost instantaneous by the outer cannula that cuts the tissue, securing a sample in the tissue trough.

  The needle is withdrawn from the breast after each firing to obtain and secure the core samples.

  The guns are spring powered with two sets of springs to move the two sections of the biopsy needles. They all have a cocking mechanism, safety device and trigger.

  Disposable guns and needles are available: use for one lesion and then discard the entire mechanism.

  Most facilities have reusable guns and disposable needles.

- Vacuum-assisted biopsy probes.

  Different needle gauges can be used (e.g., 14G, 11G, 8G).

  Hollow needle with attached vacuum device is placed through or adjacent to the lesion so that as the cutting mechanism advances through the needle, the tissue sample is withdrawn (sucked) into a chamber outside of the breast where it is retrieved (or collected in a small basket).

  In small increments, needle can be rotated 360 degrees, or depending on the relationship of the needle to the lesion, preferentially through a 180-degree arc (e.g., if the needle is below the lesion focus on sampling tissue above the needle); because tissue is being suctioned, targeting accuracy is not as critical compared to nonvacuum-assisted methods.

  Needle does not need to be removed from the breast after each core sample is obtained.

  Larger volumes of tissue are obtained so that with small masses or tight clusters of calcifications it is possible to remove the lesion percutaneously. In this situation, a clip is deployed at the biopsy site: if the lesion is malignant, the clip is localized preoperatively so that a wide excisional biopsy of the area is undertaken as part of the treatment. When there is no chance that the lesion is going to be removed percutaneously, a clip does not need to be deployed.

  Because the clips have been reported to migrate away from the biopsy site, it is helpful to obtain CC and 90-degree lateral views immediately after the

clip is deployed to document the location of the clip at the end of the procedure.

Increasing volumes of tissue are obtained as you go from the 14G gun-needle combinations to 14G and 11G vacuum-assisted biopsy devices to the radiofrequency energy cutting devices.

Equipment and needles are more expensive compared to gun-needle combinations.

- Advanced breast biopsy instrumentation (ABBI).

  Needle sizes up to 2 cm are available.

  Specimen extends from subcutaneous tissue to beyond lesion; small lesions can be removed entirely. Tissue is removed that does not need to be excised (e.g., subcutaneous tissue to lesion) and with malignant lesions, positive margins reported commonly (64% to 100%).

  Increased complication rates.

  More expensive compared to other imaging guided methods.
- Radio frequency energy (Intact) used to cut tissue en-bloc and secure specimen.

  Specimen sizes vary depending on size of cutting "basket" used: 10 mm, 12 mm, 15 mm, and 20 mm.

  Specimen capture takes approximately 10 seconds.

  Mechanism is advanced to lesion using either stereotactic or ultrasound guidance.

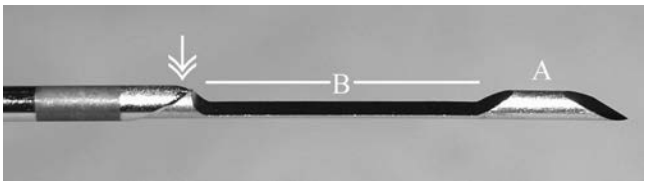
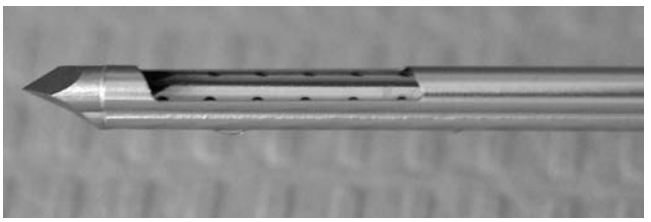
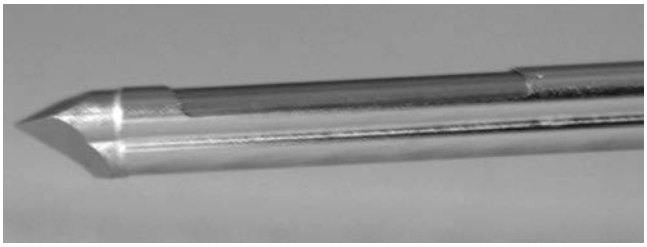



**FIGURE 17-20** Core needle system (14G needle). Inner tissue sampling needle has 5 mm dead space that forms the beveled tip **(A)**. The tissue notch **(B)** is 21 to 25 mm or 10 to 15 mm in size (e.g., long and short throw, respectively). The throw for the needle is adjusted on the gun depending on which needle is used. When the gun is fired, the inner tissue-sampling needle advances into the lesion followed, almost instantaneously, by the outer cutting cannula (*double headed arrow*) such that tissue is cut and secured in the tissue notch.



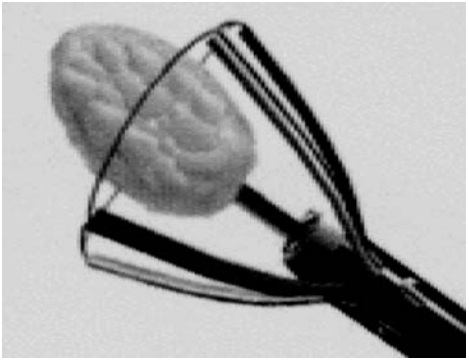
**A**

**FIGURE 17-21** Vacuum assisted needle system (11G needle). **(A)** Specimen chamber in this system contains multiple holes through which suction is applied.



**B**

**FIGURE 17-21** (*Continued*) **(B)** The cutting mechanism advances and closes the specimen chamber thereby entrapping the tissue that has been suctioned into the chamber. Using small increments, the needle can be rotated and tissue samples obtained through a 360-degree radius.

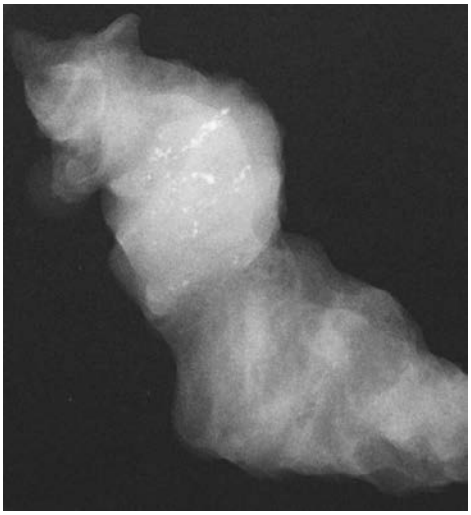


**A**

**B**

**FIGURE 17-22** Radiofrequency cutting system. **(A)** A radiofrequency cutting mechanism is combined with an advancing "basket" to secure en-bloc tissue samples. **(B)** Appearance of (intact) tissue and radiofrequency cutting mechanism after removal from the breast.

C



D

**FIGURE 17-22** (*Continued*) **(C)** En-bloc specimen after removal from the cutting mechanism. **(D)** Specimen radiograph to confirm en-bloc removal of calcification cluster. As with other systems in which complete removal of the lesion is possible, a clip is deployed to mark the location of the lesion in the breast (postclip placement images not shown).

## Procedure—Ultrasound Guidance

- After explaining the procedure to the patient, have her hear the "pop" the gun makes when the needle is fired. This will minimize the likelihood that she is startled at the time of sampling.
- Localize lesion and select approach so that the needle trajectory is parallel to the transducer and chest wall. With this approach, the needle is seen in its entirety and, because it is parallel to the chest wall, the possibility of a pneumothorax is virtually eliminated. If the needle is angled with respect to the transducer, it is harder to image and assessing tip placement is difficult. With this approach the skin entry site is usually a distance away from the transducer minimizing the likelihood of contamination.

  Lidocaine is used at the skin entry site and, using ultrasound guidance, along the expected course of the needle up to the lesion. A generous amount of lidocaine is used (approximately 10 mL starting amount); unlike stereotactically guided procedures with ultrasound, the lesion is not obscured with the lidocaine.

  A #11 scalpel is used to make a skin nick.

  It is best if the radiologist manipulates the transducer (nondominant hand) and the gun-needle combination (with the dominant hand; two hands, one brain). Only one hand is moved at a time (e.g., if transducer is being manipulated, keep needle steady; if needle is being moved, keep transducer steady).

  For deep lesions, particularly in women with small breasts or a prominent abdomen, holding the gun upside down facilitates advancing the needle parallel to the transducer and chest wall.

With the transducer over the lesion (real time-imaging), advance the needle in one movement aiming at the mid-portion of short axis of the transducer (transducer orientation can be used to visually line needle up with lesion); if the needle is not seen advancing toward the lesion, stop moving the needle and move the transducer to one side of the lesion and then the other to localize the needle or move toward the skin entry site with the transducer and trace the needle back toward the lesion.

Use the transducer movements to determine needed adjustment in needle trajectory. If in going from the needle to the lesion the transducer is moved to the left, then the needle needs to be repositioned to the left. This usually does not require you to pull the needle back but rather to angle slightly in whichever direction the lesion is located. As the needle is angled toward the lesion, also angle the transducer so that the transducer and needle are lined up.

With the needle in the pre-fire position, consider where the needle is going after the gun is fired. Rarely (e.g., when doing cores in the axilla or with lesions deep in the breast), it is helpful to estimate the expected trajectory of the needle on the pre-fire image. Extend the course of the needle by measuring a distance of 2.1 to 2.5 cm (e.g., needle throw) on the frozen pre-fire image to estimate where the tip of the needle is likely to end up.

When the needle and lesion are lined up and the trajectory of the needle has been considered, release the safety, verify the relationship of the needle and lesion again (because the needle position may be inadvertently changed as the safety is released), warn the patient of the upcoming "pop," and fire the needle.

Needle movement when the gun is fired is assessed on real time.

Post-fire images are obtained in orthogonal planes to demonstrate the relationship of the needle to the lesion (to verify that the needle has traversed the lesion, images in orthogonal planes are particularly important when targeting lesions under 1 cm in size).

The needle is withdrawn and the sample is teased into 10% buffered formalin. If the target is microcalcifications, radiography of the cores is obtained to document that calcifications are present in the cores. If not, additional samples are obtained.

Before leaving the biopsy room, make sure that the jar with the specimens is closed tightly and labeled with the correct patient's name.

- Prior to doing core biopsies, particularly in the axilla, doppler is used to determine the presence of adjacent vessels. If any are identified, Doppler is used to help determine needle trajectory at the time of the core biopsy (e.g., to avoid any major vessels).

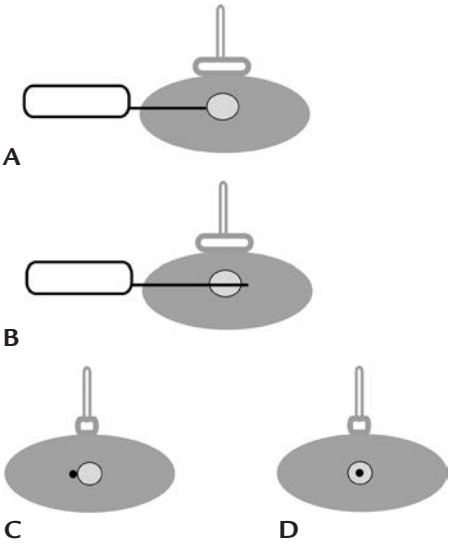



**FIGURE 17-23** Ultrasound-guided core biopsy. **(A)** Pre-fire view. If the needle is advanced parallel to the transducer as shown, it can be imaged in its entirety regardless of the size of the needle; even localization wires can be seen. The possibility of a pneumothorax is made unlikely when needle movements are parallel to the chest wall. **(B)** Post-fire view. Needle is seemingly through the lesion in this plane, however, the relationship of the needle to the lesion is further documented by obtaining an orthogonal view, particularly when sampling smaller lesions (e.g., under 1 cm in size). **(C)** Orthogonal view further documenting needle positioning. In this case the needle is through the edge of the lesion. When this relationship is noted, additional cores are obtained. **(D)** In this case, the needle is through the center of the lesion (e.g., the lesion surrounds the needle). As the tissue is removed from the needle it is inspected. Good cores are characterized by stiff, white segments and sink or dip in the formalin. One or two cores through the lesion with portions that are stiff are almost always diagnostic.

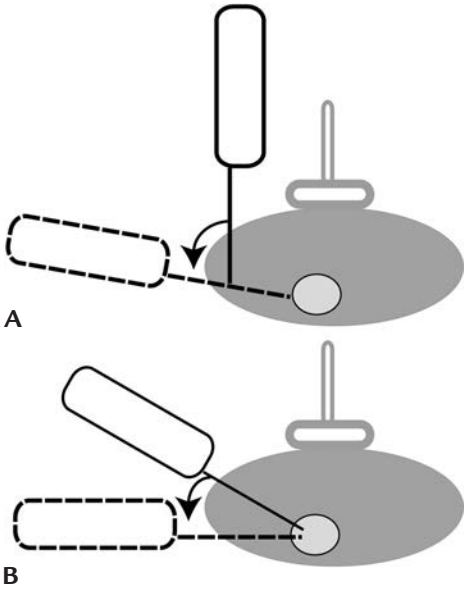



**FIGURE 17-24** Ultrasound-guided core biopsy. Approaches to a lesion deep in the breast. **(A)** After passing through the skin nick, the needle is advanced perpendicularly in a careful, controlled manner. The gun is then moved down so that the needle has a more horizontal trajectory towards the lesion (*dotted line*). **(B)** The needle can be advanced into the lesion. The gun is then moved down so that the lesion is raised and the needle has a more horizontal trajectory when fired (*dotted line*).

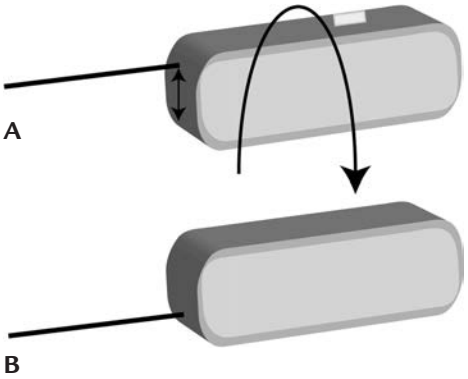



**FIGURE 17-25** Ultrasound-guided core biopsy. **(A)** With the automated gun held upright the needle is towards the top aspect of the gun. The dead space (*double headed arrow*) between the needle and the inferior margin of the gun can lead to an unwanted downward angulation when targeting deeper lesions, particularly in women with small breasts or protuberant abdomens (e.g., the gun comes up against the ribs). The ability to follow needle movements in the breast is compromised if the needle is angled with respect to the transducer (particularly when deep in the breast). **(B)** Holding the gun upside down allows a more horizontal needle trajectory so that it is kept parallel with respect to the transducer and chest wall.

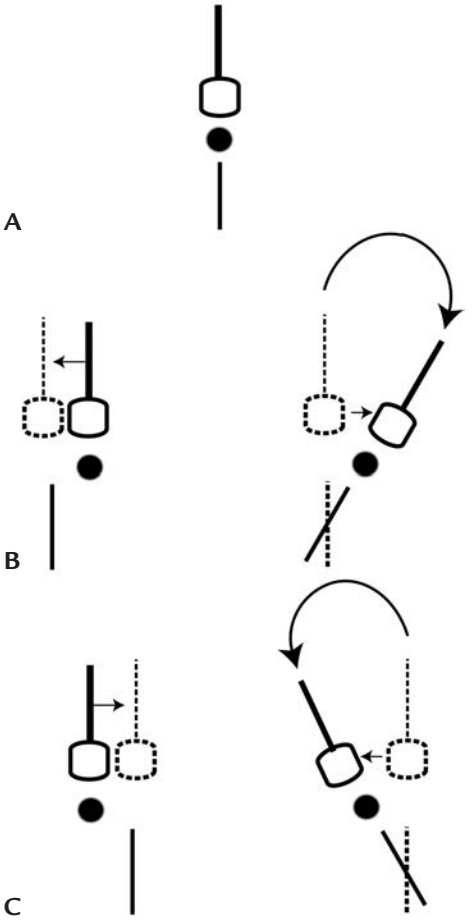
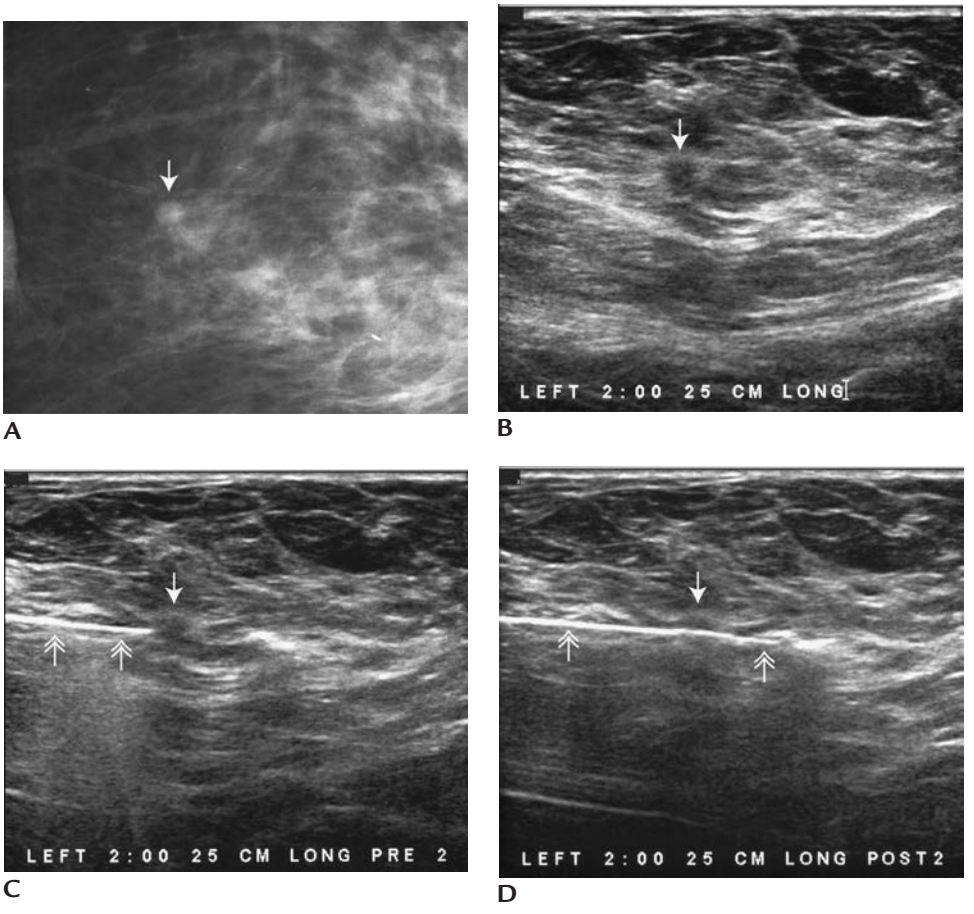
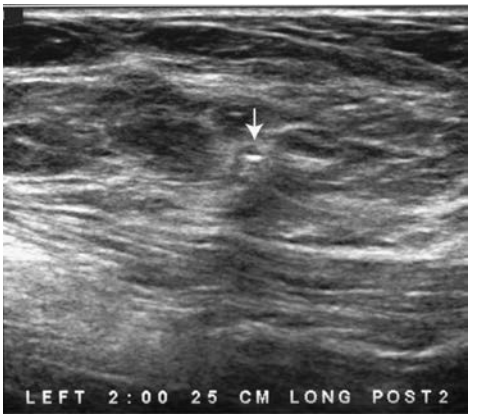



**FIGURE 17-26** Ultrasound-guided core biopsy. **(A)** While holding the transducer in your non-dominant hand, place the lesion in the center of the screen. While looking at the transducer, aim and advance the needle in one movement towards the transducer. After advancing the needle, look at the screen to see if the needle is approaching the lesion. If you do not see the needle in the plane of the lesion, hold the needle steady and slowly, methodically move the transducer to the right and then to left of the lesion until you find the location of the needle. The movement of the transducer as you go from the lesion to the needle and then back tells you how you have to re-adjust the needle. Without pulling the needle out, re-direct the needle. Only one hand is moved at a time. If you are moving the transducer, hold the needle steady. If you are moving the needle, hold the transducer steady (that is your target). **(B)** In this scenario, the transducer is moved to the left (*hashed lines*) to find the needle. In going back towards the lesion, the needle needs to be directed towards the right. As the needle is re-directed the transducer is rotated (*solid lines*) so that the needle and transducer are lined up. **(C)** In this scenario, the needle is moved towards the right (*hashed lines*) to find the needle. In going back to the lesion the needle needs to be directed toward the left. As the needle is re-directed, the transducer is rotated (*solid lines*) so that the needle and transducer are lined up.



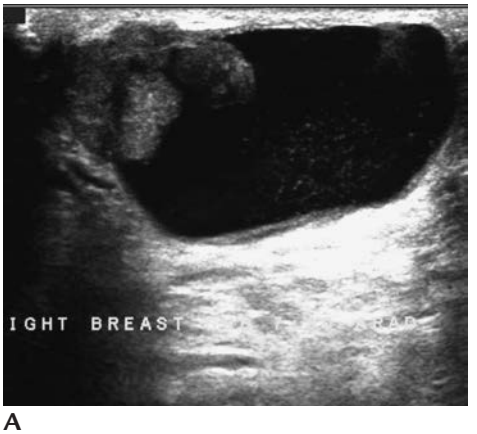

A B C D

**FIGURE 17-27** Ultrasound-guided core biopsy. Invasive ductal carcinoma. **(A)** Spot compression view confirms a 0.5 cm mass (*arrow*) with spiculated margins, laterally in the left breast. **(B)** Vertically oriented, hypoechoic, irregular mass (*arrow*) with echogenic rim and margins that are not well circumscribed corresponding to mammographic finding. Our general rule is: if we can see it with ultrasound, we can obtain tissue for histology. **(C)** Pre-fire image. Needle (*double headed arrows*) trajectory is parallel to the transducer. The tip of the needle is at the leading edge of the mass (*arrow*). We see the tissue beyond the lesion where the needle will end up after the gun is fired (e.g., the gun can be fired safely). The patient is warned she will hear a pop in the room and the gun is fired. **(D)** Post-fire image. Needle (*double headed arrows*) is seen through the mass (*arrow*). The tip is beyond the mass.

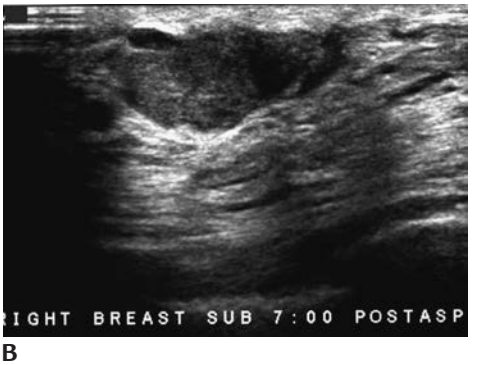



E

**FIGURE 17-27** (*Continued*) **(E)** Orthogonal post-fire image is done for all core biopsies but particularly important when targeting small lesions. The needle is imaged as an echogenic focus through the mass (*arrow*). If a portion of the core is stiff and white, one or two samples (e.g., with this type of needle/lesion relationship on images and gross appearance) are enough to establish a diagnosis. Two cores were done in this patient, both of which had adequate tissue to establish the diagnosis. We do as much as is needed (but not more) to establish an accurate diagnosis.

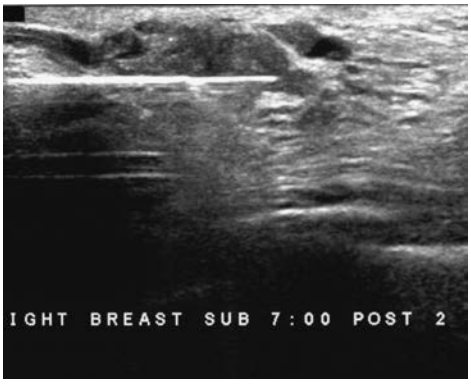


A

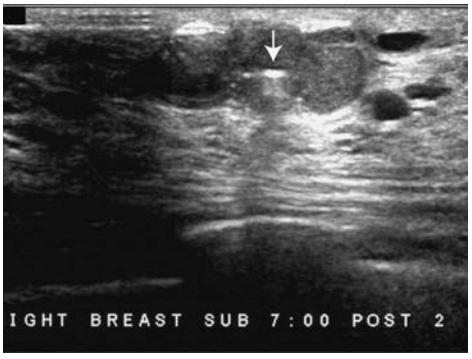



B

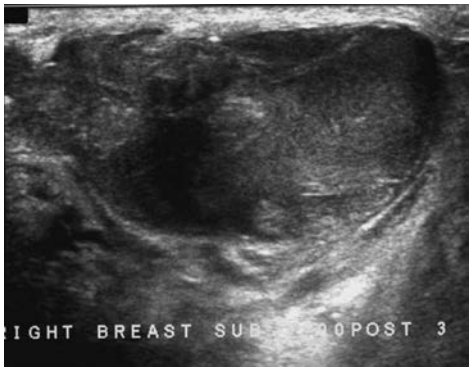
**FIGURE 17-28** Ultrasound-guided core biopsy. Papilloma. **(A)** Complex cystic mass in the right subareolar area. With these types of lesions, our approach is to first aspirate the fluid, however, to establish an accurate diagnosis, core biopsies should be done through the solid component. Fluid alone is not enough to establish a diagnosis in close to 50% of patients with intracystic carcinoma. **(B)** An irregular hypoechoic mass is present post aspiration.




**C**




**D**




**E**

**FIGURE 17-28** (*Continued*) **(C)** Post-fire image demonstrate needle is through the lesion. **(D)** Orthogonal post-fire image. Needle (*arrow*) is seen as echogenic focus surrounded by tumor. **(E)** After a third sample is done, a protruding mass could be seen developing in the subareolar area. When scanned, swirling echogenic material could be seen as the mass enlarged consistent with a developing hematoma. Firm pressure is applied over the area using an ice pack. Subsequent scans were done (same day of biopsy) to document stabilization in the size and appearance of the mass. Hematoma formation is rare, however, when it is suspected clinically and documented sonographically, firm pressure is applied over the area for 15 to 20 minutes (as opposed to the usual 10 minutes).

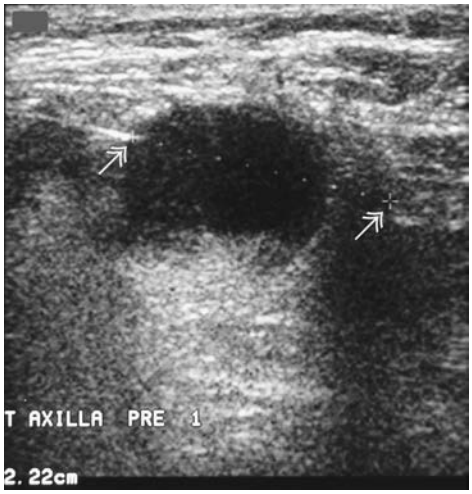
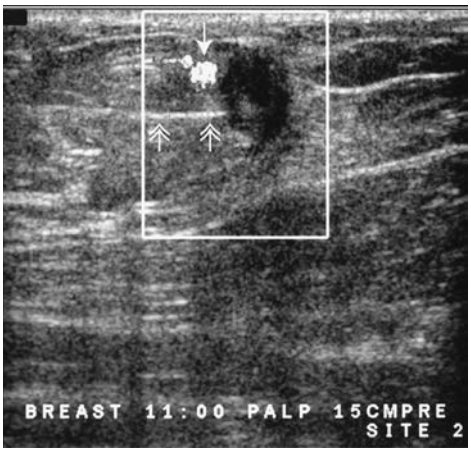
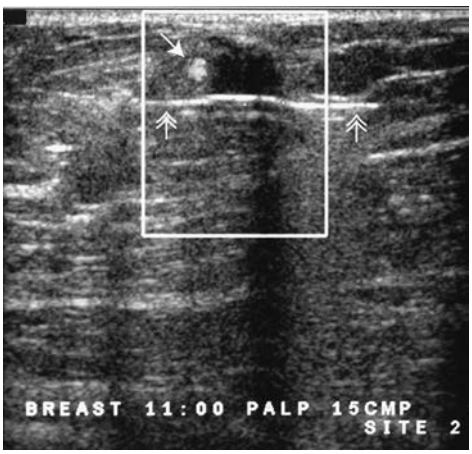



**FIGURE 17-29** Ultrasound-guided core biopsy of an axillary lymph node. Once the gun is fired, there is nothing that can be done to stop the almost instantaneously movement of the advancing needle in the tissue. If there is concern regarding the angle of the needle or adjacent structures, use the length of the needle throw to estimate the expected trajectory of the needle after the gun is fired. In this patient, the expected trajectory of the needle is estimated by extending the needle and its slight angle by 2.2 cm (needle throw) from the tip of the needle on the pre-fire image (*double headed arrows*). Assuming no change in patient or needle positioning, the needle can be safely fired in this patient. Metastatic disease diagnosed on core.

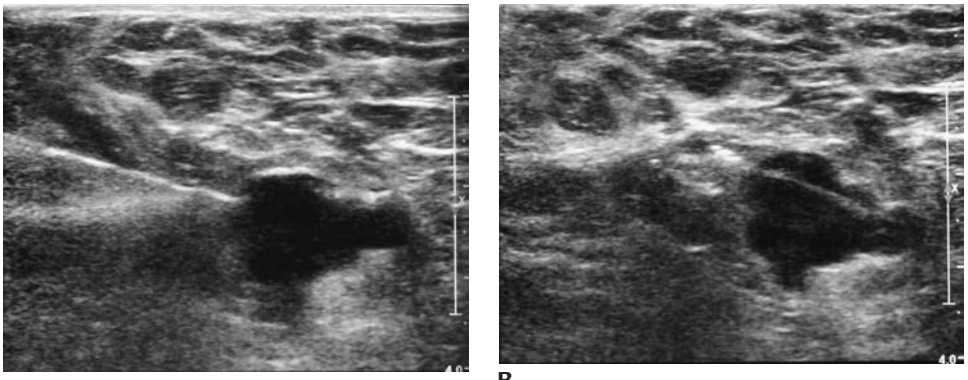



A



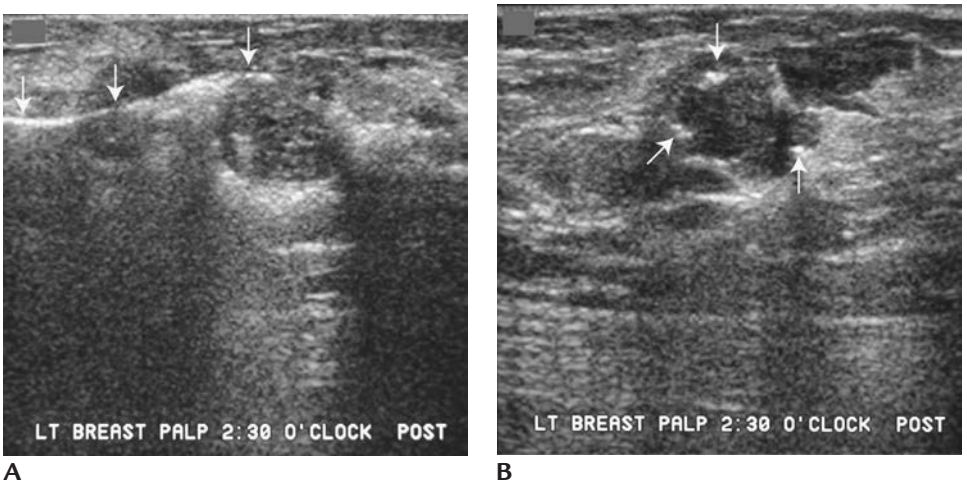

B

**FIGURE 17-30** Ultrasound-guided core biopsy. Invasive ductal carcinoma. **(A)** Pre-fire image demonstrating needle (*double headed arrows*) positioning at the leading edge of a vertically oriented, markedly hypoechoic mass. In this patient, an artery (*arrow*) is seen adjacent to the more superficial aspect of the mass. When arterial structures are seen in close proximity to the area being biopsied, doppler is used to help direct the advancing needle (e.g., to avoid the artery). If the needle is advanced parallel to the transducer as in this patient, it can be seen in its entirety and directed towards portions of the mass away from the adjacent vessel. **(B)** Post-fire image. The needle is seen through the mass (*double headed arrows*) but deep to the artery (*arrow*).



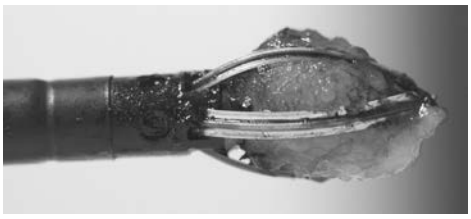
**A** **B**

**FIGURE 17-31** Ultrasound-guided biopsy, suboptimal imaging. **(A)** Inappropriate field of view and inadequate visualization of what is beyond the lesion where the needle will end up after the gun is fired (e.g., the image should have shown the lesion with more tissue to the right of the mass and a smaller amount of needle). When doing ultrasound-guided procedures, adjust the field of view so that you can image the location of the pectoral muscle, ribs and pleural line, particularly if the needle is angled even slightly toward the chest wall and the lesion is deep in the breast. Additionally, when taking the pre-fire images, seeing a large segment of the needle, as done in this patient, is not very helpful. The pre-fire image should document the relationship of the needle tip to the lesion but, most importantly, the tissue, or possible structures beyond the lesion where the needle is going to end up after the gun is fired (e.g., document where you are going rather than where you have been). **(B)** Post-fire image. The needle is only partially imaged in the mass but, most importantly, the location of the needle tip is not shown on this image. This reflects a misalignment between the transducer and the needle. After the gun is fired, there is no rush, so take your time in documenting what was done; specifically final needle positioning (including tip) in orthogonal planes. Also, the field of view is not appropriate, because the location of the pectoral muscle, ribs, and pleural line is not shown.




**A** **B**

**FIGURE 17-32** Ultrasound-guided biopsy. Mucinous carcinoma. **(A)** Radiofrequency cutting device (*arrows*) "entrapping" portions of mass being sample. Posterior acoustic enhancement associated with the mass a common finding with mucinous carcinoma. **(B)** Orthogonal view showing struts (*arrows*) of radiofrequency device in the mass.



C

**FIGURE 17-32** (*Continued*) **(C)** Appearance of tissue and radiofrequency cutting mechanism after removal from the breast. Notice mucoid appearance of specimen characteristic of mucinous lesions.

## Procedure—Stereotactic Guidance

- Basics of procedure are the same regardless of sampling mechanism used; as mentioned previously with gun-needle combinations, the needle is removed from the breast after each core sample; with vacuum-assisted devices, it is not necessary to remove the needle from the breast after each sample is taken.

  Dedicated prone tables and add-on devices (attaching to mammography units) are available.

  Approach is selected using shortest distance from the skin to the lesion (with some units an inferior approach is not possible).

  Breast is positioned, compressed with a fenestrated paddle and a scout view is obtained.

  If the lesion is within the fenestrated portion of the compression paddle, stereo views are obtained.

  Stereo pair: 15 degrees to the right of midline and 15 degrees to the left of midline.

  Reference points are verified and targets are selected on the stereo pairs.

  Computer calculates horizontal, vertical, and depth coordinates (for vacuum-assisted devices, one site is selected initially) for the target(s) selected on the stereo pairs.

  Lidocaine (1%) is used for local anesthesia. Care should be taken to not use too much lidocaine in the breast; the blush that is generated may obscure a mass or calcifications in a cluster can be dispersed. Depending on sampling mechanism being used, some use a lidocaine, epinephrine combination.

  Using a #11 surgical blade, a small skin incision is made that is large enough for a 14G or 11G needle to pass through the skin unimpeded. All passes can usually be made through one skin nick.

  The needle is advanced through the skin nick to the predetermined depth.

  Pre fire films are obtained to establish the relationship of needle to lesion (if needle is on target).

  Depending on the sampling method being used, the needle is withdrawn slightly (to account for the dead space of the needle tip) and the gun is fired.

  Given the suction and rotational capability of the vacuum-assisted devices, with these systems the needle does not need to be fired directly into the lesion.

Post-fire images are obtained to document final needle position.

With gun-needle combinations, several passes are made per lesion (for most lesions an average of 4 to 5 passes); after each pass, the needle is withdrawn and specimen is teased off needle into 10% buffered formalin.

When targeting calcifications, radiographs are obtained to verify adequate sampling of the calcifications; additional cores can be obtained as needed to remove calcifications.

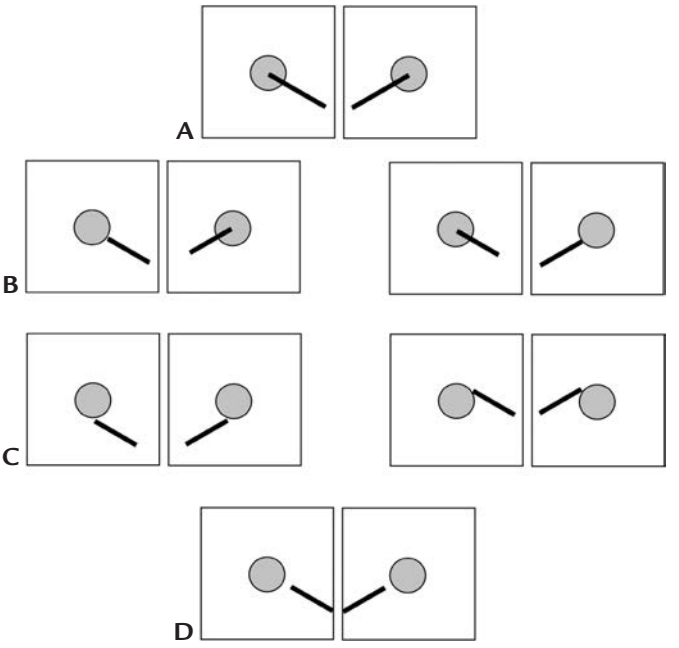
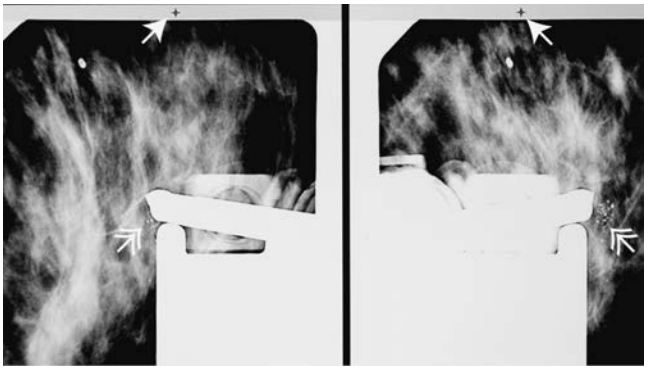
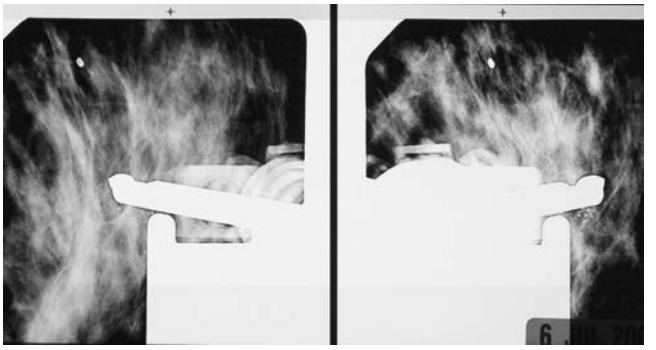


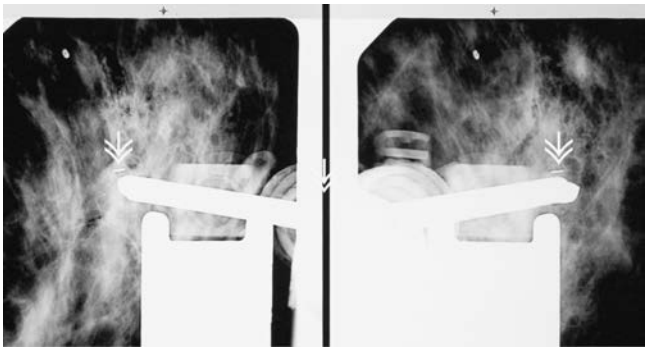

**FIGURE 17-33** Stereotactically-guided biopsy. **(A)** Needle is well positioned on the two stereo (+15 degrees and −15 degrees) images. The needle should be symmetric. **(B)** On these stereo pairs, the needle is off on the x-axis (horizontal axis). In the first set, the needle is to the right of the lesion and on the second it is to the left of the lesion. **(C)** On these stereo pairs, the needle is off on the y-axis (vertical axis). In the first set, the needle is below the lesion and on the second it is above of the lesion. **(D)** On this stereo pairs, the needle is off on the z-axis (depth). The needle is superficial to the lesion.



A

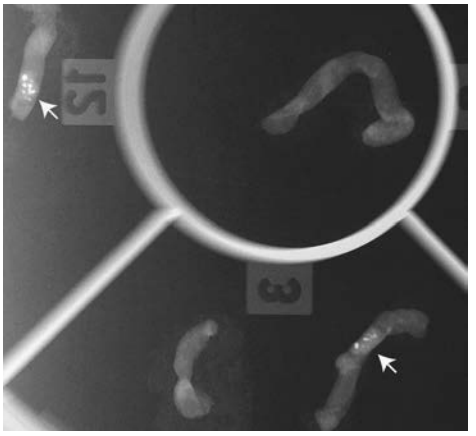


B



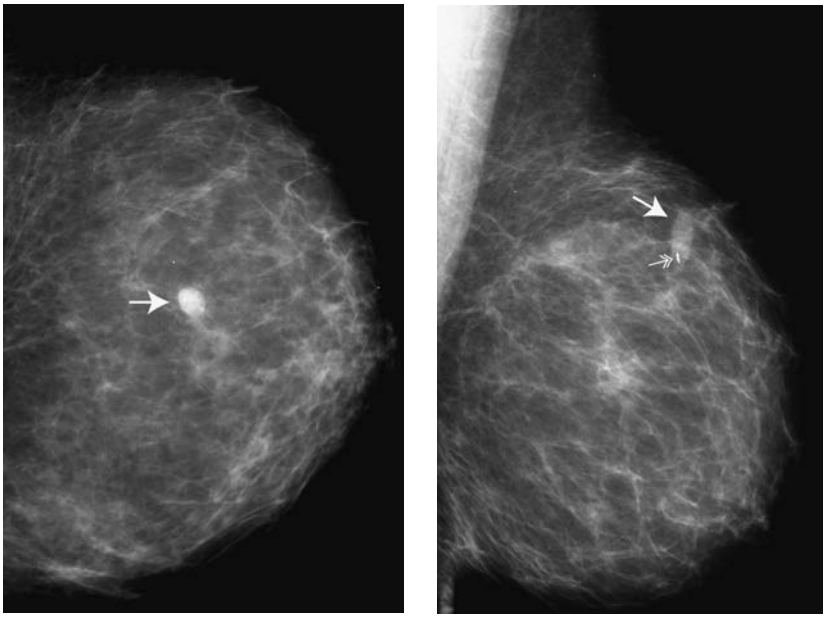
C

**FIGURE 17-34** Stereotactically guided biopsy, vacuum-assisted device. Ductal carcinoma in situ. **(A)** Pre-fire stereo images of needle positioning relative to location of calcifications cluster (*double headed arrows*). Reference cursors (*arrows*) on stereo pairs. **(B)** Post-fire, pre-biopsy image. **(C)** Stereo images demonstrating clip (*double headed arrows*) placement.




D

**FIGURE 17-34** (*Continued*) **(D)** Radiograph of the tissue cores demonstrating calcifications in two of the cores (*arrows*).



A B

**FIGURE 17-35** Linear hematoma post biopsy. Craniocaudal approach used for a stereotactically guided biopsy of a cluster of calcifications in the left breast. **(A)** Round mass (*arrow*) in craniocaudal projection associated with post biopsy clip. **(B)** On the lateral view, a linear density (*arrow*) is present along the needle track. The clip (*double headed arrow*) is seen at the lower edge of the hematoma.

## Procedure—Magnetic Resonance Guidance

- Breast is positioned in coil; lateral quadrants (or medial quadrants, if a medial approach is being used) are cleaned with betadiene and alcohol.

  Compression paddle with multiple evenly spaced square fenestrations and fiducial markers is used to compress the breast. The breast should be adequately immobilized but not over compressed (over compression may affect enhancement).

The breast is scanned in sagittal plane to assure that the grid and fiducial markers are visible and breast is positioned appropriately.

Contrast bolus is given and patient is re-scanned. At this point, we scan in axial and sagittal planes.

If a commercial software system is used for biopsy planning, the type of needle being used as well as the location of the fiducial markers and lesion is marked and the system calculates the square in the compression paddle that overlies the lesion.

Through the square overlying the location of the lesion, lidocaine (or a lidocaine/epinephrine combination) is used for local anesthesia and skin nick is made (some systems do not require a skin nick).

A square insert (needle guide) with multiple holes (e.g., the size of the holes varies depending on the size of the needle/biopsy system being used) is placed in the square fenestration that directly overlies the location of the lesion.

The biopsy software specifically indicates the hole through which the needle should be placed.

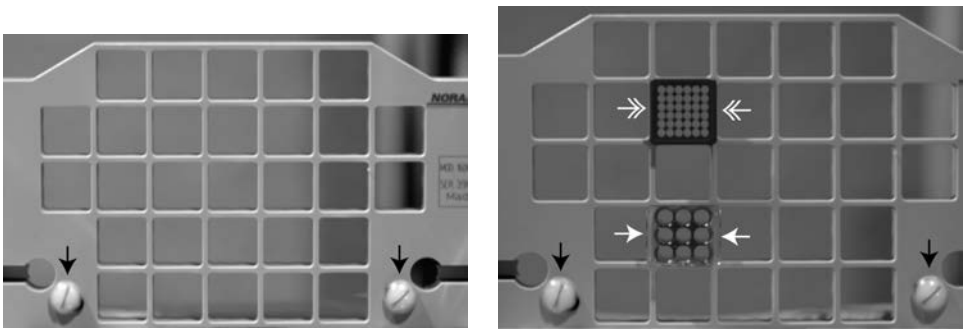
The needle is advanced to the calculated depth and the patient is scanned to establish the relationship of the needle to the lesion.

Sampling is done and a clip is deployed at the biopsy site.

A scan can be done following the biopsy/clip placement.

(If no commercial software is available, the location of the lesion is approximated based on prior MR imaging of the breast. A vitamin E tablet is placed in the square estimated to be over (or close) to the lesion. Contrast is given. Relationship of lesion to vitamin E tablet is established to determine more accurately which square is directly over the lesion.

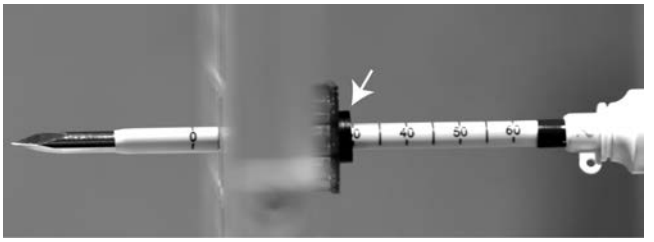
Number of slices from skin to lesion, multiplied by slice thickness plus 2 cm (to account for width of needle guide) approximates lesion depth. Needle is advanced through needle guide to determined depth. Patient is scanned to determine if adjustments are needed).



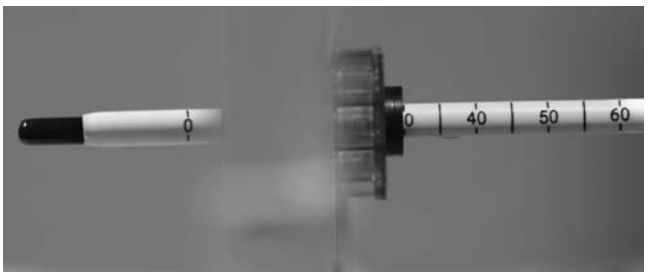
A B

**FIGURE 17-36** **(A)** Compression paddle with multiple square fenestrations used for MRI-guided biopsies. Fiducial markers (*arrows*) used as reference points after patient is scanned, when lesion location is being established. **(B)** After determining which square overlies the lesion to be sampled, a square insert with multiple holes is used to guide the biopsy needle. The size of the holes in the square needle guides varies depending on the size of the needle being used for the biopsy. Two are illustrated in this image: insert with smaller holes (*double headed arrows*) is used for14G needle systems; insert with larger holes (*white arrows*) is used for 12G needle system. Fiducial markers (*black arrows*) used as reference points.

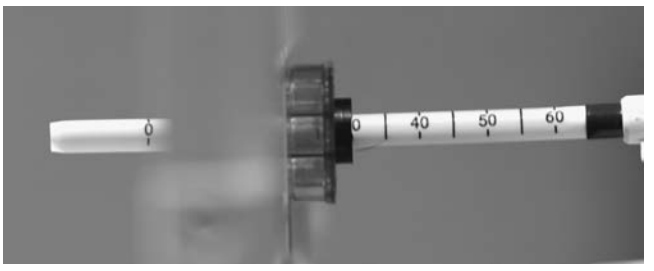
A




B




C




D

**FIGURE 17-37** **(A)** Components in tray for one of the systems available for MRI-guided biopsy. **(B)** White introducer has measurement markings on surface. Black plastic ring (*arrow*) is moved to the marker for the calculated depth of the lesion (at 29 in this example). The trocar is passed through the white introducer to the hub. With this system, no skin nick is needed. The introducer and trocar are advanced through the hole in the square needle guide that is closest to the lesion, into the skin and the breast to the estimated depth for the lesion. **(C)** The trocar is replaced by the black insert and the patient is scanned to establish if the system is correctly positioned at the lesion. **(D)** If the system is at the lesion, the black insert is removed and the sampling, vacuum assisted needle is passed through the introducer. The needle can be rotated at small increments circumferential (360 degrees) or, depending on the relationship of the needle to the lesion, preferentially in a 180-degree radius.

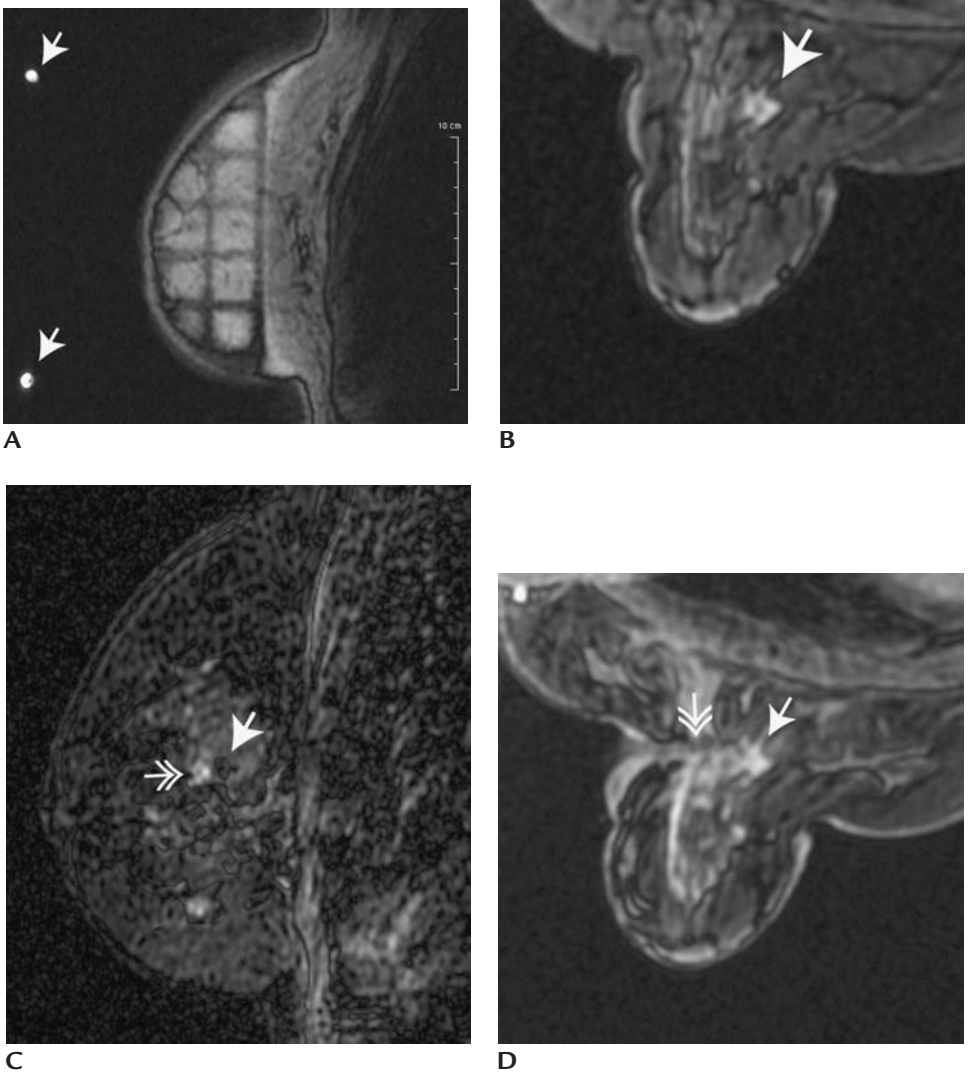
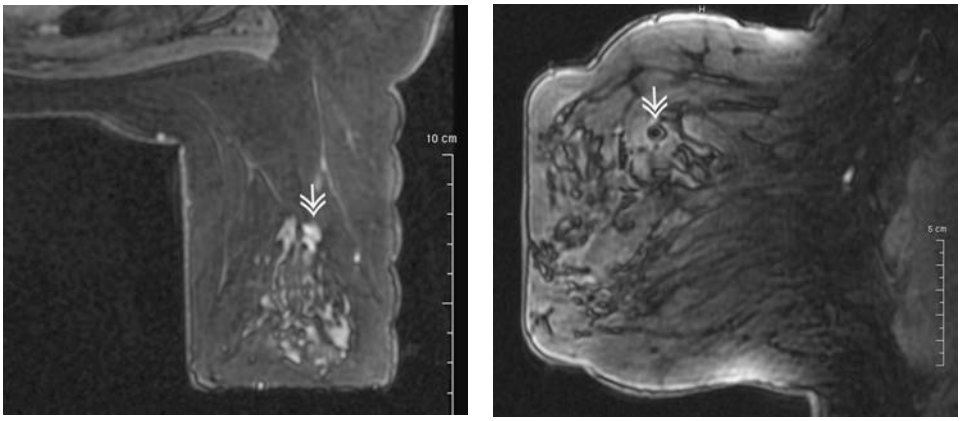



**FIGURE 17-38** MR-guided breast biopsy. MR detected invasive ductal carcinoma. **(A)** Sagittal image demonstrating fiducial markers (*arrows*) and impression of fenestrated compression paddle on the lateral aspect of the breast. **(B)** Axial image demonstrating enhancing lesion (*arrow*) post-contrast and indentations resulting from the compression paddle on the lateral aspect of the breast. **(C)** Sagittal subtraction image demonstrating void from introducer (*arrow*) and lesion (*double headed arrow*). In this patient, the needle is at the deep margin of the lesion so tissue superficial to the needle will be sampled preferentially. **(D)** Axial image demonstrating effects of introducer (*double headed arrow*) on tissue and its relationship to the lesion (*arrow*). Since this lesion could not be seen mammographically or sonographically, a clip is placed to mark the location of the lesion (post clip placement images are not shown) following the MR-guided biopsy.




A B

**FIGURE 17-39** MR-guided breast biopsy. **(A)** Axial image demonstrating enhancing lesion (*double headed arrow*) and indentations caused by compression paddle on the lateral aspect of the breast. **(B)** Sagittal image demonstrating void created by introducer (*double headed arrow*), lesion could be seen in the next slice.

## Post-Procedure

- Regardless of imaging modality/sampling method.

  Pressure is applied along the needle tract for 10 minutes. Two steri-strips are placed at the site of the skin nick and an ice pack is provided for the biopsy site.

  If a clip has been deployed, craniocaudal and lateral views are obtained to document clip positioning.

  The patient is given the radiologist's business card with pager and telephone number should there be any complications, questions or concerns.

  An office visit is scheduled for the following business day at which time, the radiologist checks the biopsy site, discusses the biopsy results with the patient directly, and schedules follow-up appointments as indicated based on results.

  If the results are benign, the patient typically returns to screening. Rarely, is a follow-up diagnostic mammogram scheduled following an imaging guided core biopsy.

  If biopsy results are benign and congruent, the patient is returned to screening.

  If a high-risk lesion is diagnosed, surgical consultation is scheduled for excisional biopsy.

  If a malignancy is described, surgical consultation and MRI of the breasts (to evaluate extent of disease and the contralateral breast) are scheduled. Referring physician is informed.

# Preoperative Localizations

## Key Facts

- Decreasing in frequency as more imaging guided needle biopsies are done for mammographically detected lesions (if lesion is benign no excisional biopsy is usually needed). Most now done for localization of known cancers or high-risk lesions (e.g., atypical ductal hyperplasia).
- Indications.

  Nonpalpable, clinically occult lesions.

  In some women with palpable lesions to ensure excision of the lesion and a one-to-one correlation between mammographic and clinical findings.
- Mammography, stereotactic, ultrasound, and MRI can be used to guide preoperative localizations.
- Methods.

  Skin localizations: unless the lesion is close to the skin surface (within 1 cm), skin localizations are imprecise, which leads to the excision of large amounts of tissue to be sure that the area of concern is excised.

  Dye method (methylene blue, alcian blue): after verifying the position of a needle is in close proximity to the lesion, dye is injected; as the needle is pulled out, a track of dye is left. Some have suggested that diffusion of dye leads to excision of larger amounts of tissue than needed. However, in our own experience, if a minute amount of dye is used (approximately 0.2 mL), not much diffusion is seen. There has been one report of methylene blue affecting estrogen receptor assay.

  Needles and needle-wire combinations; latter is preferred.

  Injection of dye can be combined with wire placement. The dye serves as back-up should anything happen to the wire during surgery; also, because the dye is usually beyond the lesion, it serves to alert the surgeon they are beyond the lesion.

  Methods described for lesions seen in only one view are beyond the scope of this book. See the articles in the bibliography by Kopans, Waitzkin, Linetsky, and colleagues and Pollack for more detailed descriptions of these methods.
- Needle-wire combinations come in different lengths (e.g., 3, 5, 7, 9, 11, and 15 cm).

  Hookwire system: straight wire with hook at the end of the wire.

  Modified hookwire includes a (2 cm long) reinforced wire segment 1.2 cm from the hook.

  J-wire: flexible, J-shaped wire can be retracted back into needle if repositioning is needed.

  Retractable barb: wire can be retracted back into needle if repositioning is needed.
- Four decisions: guidance system, type of needle-wire, needle length, and approach.

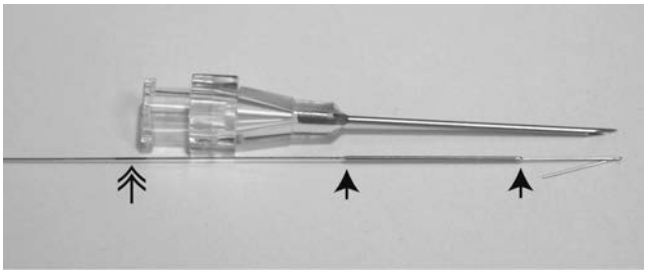
  Also, consider using multiple wires (e.g., bracketing) when localizing an extensive area of microcalcifications.

- Approaches for mammographically guided procedures: anteroposterior and parallel to the chest wall.
- Compression paddles for localizations.

  Regular-sized compression paddle with fenestration and alphanumeric grid most common.

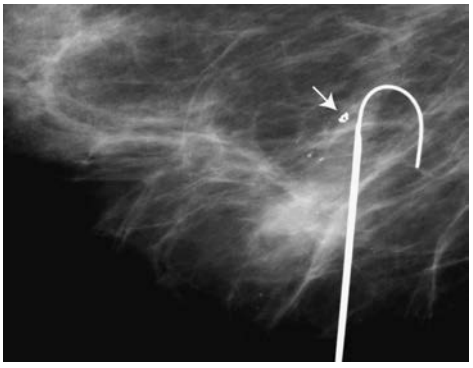
  Regular sized compression paddle with multiple holes; may require repositioning if lesion is not under one of the openings.

  Spot compression paddle with multiple holes or fenestration is particularly useful for localizations in women with small breasts or with a lesion high up in the breast (toward axilla), far posterior, or in the subareolar area. This paddle provides the benefits of a spot compression paddle: maximal compression and ability to reach up or back further (attaining sufficient compression and immobilization) compared to full-sized compression paddle.



**A**

**FIGURE 17-40** Needle wire combinations. **(A)** Modified hookwire system. The wire has a hook and there is a 2 cm portion (*two arrows*) of the wire that is reinforced (e.g., thicker) approximately 1 cm from the hook. When the burnish mark (*double headed arrow*) on the wire is at the hub of the needle the tip of the wire is at the tip of the needle.



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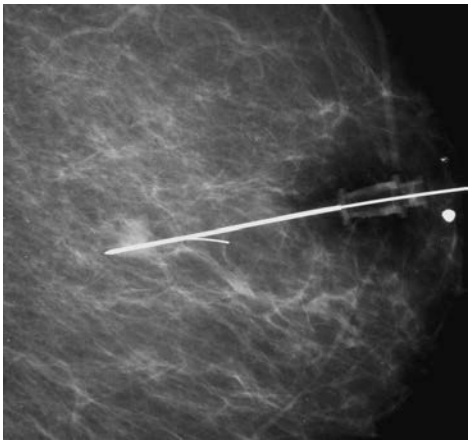
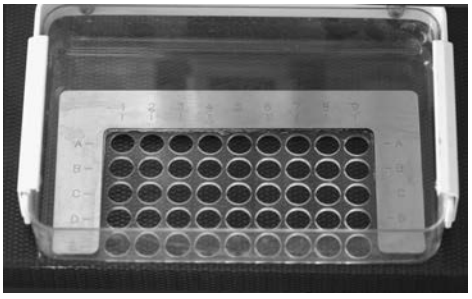


C

**FIGURE 17-40** (*Continued*) **(B)** "J" wire used to localize a post-biopsy clip (*arrow*). With this system, the wire can be retracted back into the needle if repositioning is needed. **(C)** "Retractable barb" wire. This system also permits retraction of the wire back into the needle if repositioning is needed.


A

**FIGURE 17-41** Compression paddles for preoperative wire localizations. **(A)** Compression paddle with fenestration and alphanumeric grid used for most localizations and mammographically guided cyst aspirations.



**B**


**C**

**FIGURE 17-41** (*Continued*) **(B)** Compression paddle with multiple holes. If the lesion is not under one of the openings, repositioning may be necessary. **(C)** Spot compression paddle with fenestration and alphanumeric grid. Particularly useful when optimal immobilization may not be obtainable with the regular-sized compression paddle: specifically, lesions high in the breast (toward axilla), far posterior, or subareolar in location. Also useful in optimally immobilizing the breast when it is small in size.

## Anteroposterior Wire Localization Approach

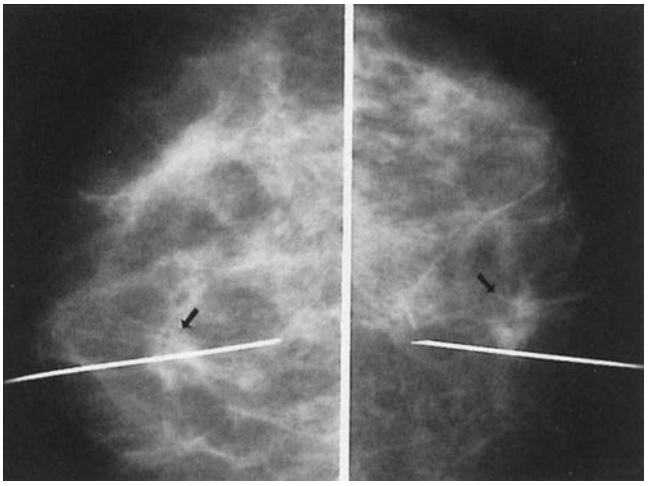
### Key Facts

- Radiologist extrapolates lesion location from images of a compressed breast pulled away from the body to a decompressed breast in its natural position.
- Needle is advanced in breast blindly toward the chest wall.
- Orthogonal images are obtained to determine the relation of the needle to the lesion.
- If the needle is not within 1 cm of the lesion in orthogonal views, you may want to reposition the needle. Use the images to help determine the direction the needle needs to go.
- After the needle is repositioned, orthogonal images are repeated. The needle may need to be repositioned several times before placement is acceptable (within 1 cm of lesion).
- When needle positioning is acceptable, the wire is engaged and orthogonal views are obtained to establish final wire positioning. Because compression for orthogonal views is applied parallel to the wire with this approach, there is no problem compressing the breast after the wire is engaged.
- Although some have suggested a higher complication (primarily pneumothorax, although wire migration may be more common with this approach also) rate with an anteroposterior approach, this has not been studied systematically. If the needle is advanced in the breast carefully, this is a safe and acceptable method of localizing breast lesions.
- Because this method is dependent on serial approximations (the needle may have to be repositioned several times before the lesion is localized appropriately) it may be more time consuming and harder to teach and learn.
- Complications (unusual).

  Bleeding.

  Pneumothorax.

  Migration of wire (in breast or to distant sites).



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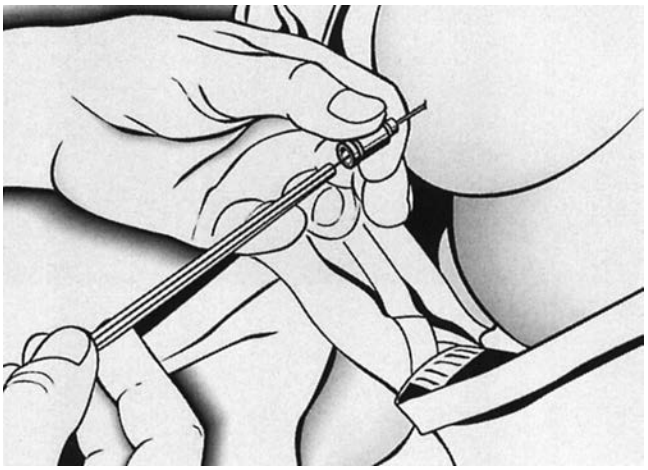

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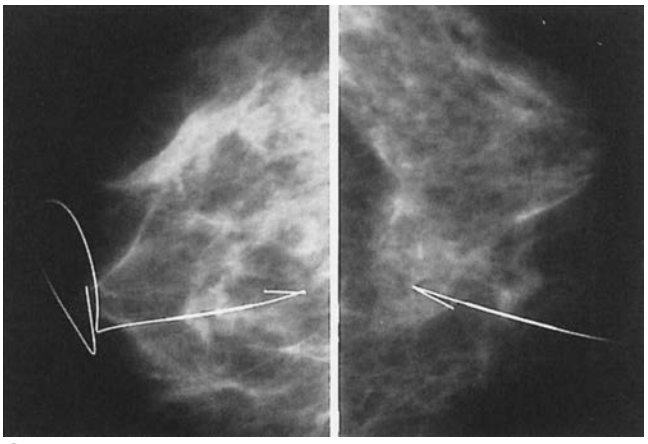
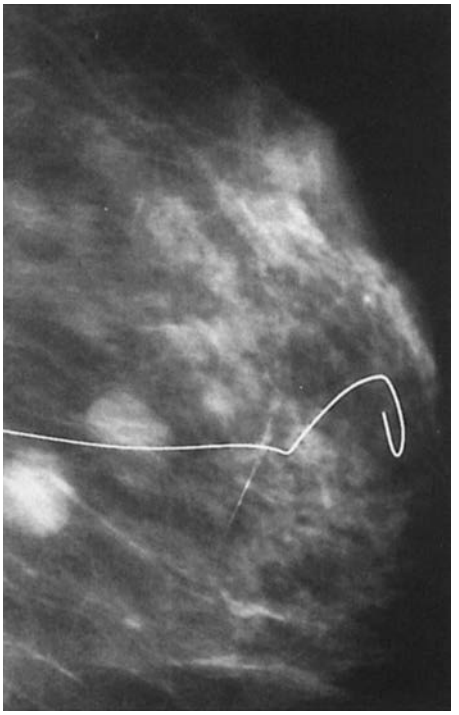


C

**FIGURE 17-42** **(A)** Anteroposterior localization approach. Ninety-degree lateral and craniocaudal (CC) views back to back obtained after needle placement. Acceptable needle placement; needle within 0.5 cm of spiculated mass (*arrows*) on orthogonal views. If at this point needle not within 0.5 to 1 cm of lesion repositioning would be undertaken. **(B)** Wire is passed through the needle. The needle is removed and orthogonal views done to verify final wire positioning. Patient sitting with breast uncompressed. **(C)** Ninety-degree lateral and CC views back to back obtained after wire placement. Reinforced wire segment along side spiculated mass on orthogonal views.



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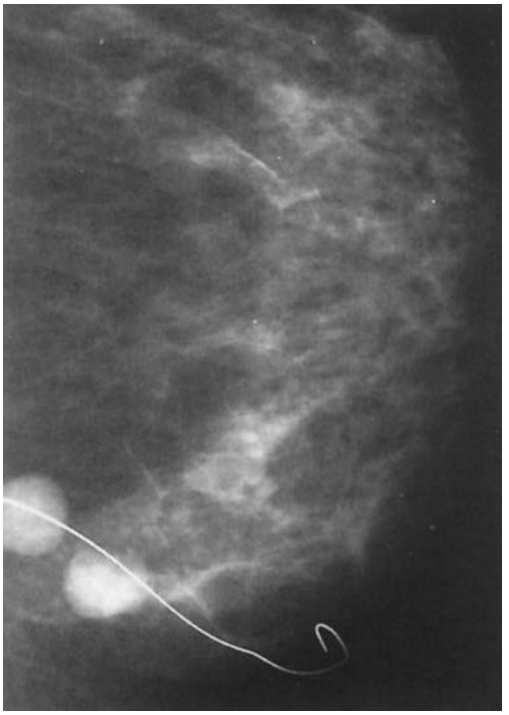

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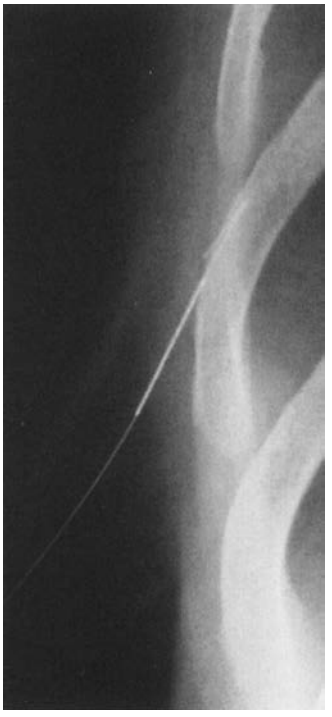


C

**FIGURE 17-43** **(A)** Anteroposterior localization approach. Ninety-degree lateral view after wire placement. Two masses being localized. What is the problem? **(B)** Craniocaudal (CC) view following wire placement. The wire is within 1 cm of both masses in orthogonal views. However, where is the hook of the wire? What can you do at this point (patient is breathing O.K!)? **(C)** Chest wall view. Wire in close proximity to a rib. Care must be exercised as the needle/wire is advanced in the breast. The anteroposterior approach is more difficult to teach and learn, because it requires extrapolation of the lesion location in the breast from CC and 90-degree lateral views (during which the breast is pulled out away from the body and compressed) to the breast in an uncompressed, natural state. In experienced hands, however, this localization approach can be safe and accurate. Fibroadenomas.

# Parallel to the Chest Wall Wire Localization Approach

## Key Facts

### General Comments

- Approach selection.

  Established by reviewing orthogonal views (craniocaudal [CC] and 90-degree lateral views) to determine shortest skin-to-lesion distance:

  If lesion is closest to lateral portion of breast (CC view), the alphanumeric paddle is used to compress the lateral portion of the breast and a 90-degree lateromedial view is done.

  If lesion is closest to medial portion of breast (CC view), the alphanumeric paddle is used to compress the medial portion of the breast and a 90-degree mediolateral view is done.

  If lesion is closest to the top of the breast (90-degree lateral view), then the alphanumeric paddle is used to compress the upper portion of the breast and a craniocaudal view is done.

  If lesion is closest to the bottom of the breast (90-degree lateral view), then the alphanumeric paddle is used to compress the inferior portion of the breast and a from below (FB) view is done.

- Needle length.

  Established by measuring the distance from expected skin entry site to the lesion.

  Needle must be long enough to go beyond the lesion by at least 1 cm. If the needle is too long, it can be pulled out as much as needed before engaging the wire. However, if the needle is short of the lesion, nothing much that can be done other than to start all over. It is always preferable to err on the side of selecting a long needle.

- Pitfalls.

  Selecting the wrong approach; not using the shortest distance to reach the lesion. The surgeon should not have to go across quadrants to remove a clinically occult lesion.

  Using too short a needle. If the wire ends up short of the lesion, the lesion is not localized adequately.

  Vasovagal reactions: this is a stressful time for patients and they are usually fasting, so be prepared to handle vasovagal reactions. Atropine (0.6 mg IM or IV) can be used to prevent vasovagal reactions (contraindicated in patients with glaucoma).

### Procedure

- With approach and needle length selected, the patient is positioned. For purposes of discussion, let us say the lesion to be localized is closest to the superior skin surface on the 90-degree lateral view and we are using a modified hookwire system.

- Using the alphanumeric fenestrated paddle for compression, a CC view is obtained to establish lesion coordinates (patient is sitting during procedure).

  Skin is cleansed with betadiene and alcohol and 1% lidocaine is used to raise a skin wheal. If lidocaine is injected slowly, the stinging sensation described by patients may be minimized. Use of lidocaine is optional.

  Patient remains in compression from the time this view is done until needle is placed and a repeat image with the needle now in place is done. It is critical that the patient not move during this time, otherwise the coordinates selected for the lesion may not be accurate. Marking the patient's skin is helpful in knowing if the patient moves.
- By using the collimator cross hairs, a shadow of the lesion's coordinates is cast on the woman's breast. The needle (we work with the needle alone at this point; the wire is pulled out of the needle and set aside) is angled so that the tip can be placed at the intersection point of the cross hairs and then straightened.
- Holding the needle with your thumb and index finger, spread the other fingers apart away from the needle so that you can see the needle hub shadow and its relationship to the cross hairs. Otherwise, the hand casts a shadow, making it impossible to see the cross hairs. Laser lights are available on some units, but in our opinion these are not ideal; they make some of the described maneuvers difficult, if not impossible.
- Advance the needle all the way into the breast in one rapid motion. Don't worry about depth at this point; the worst that will happen is that you approach and feel the bucky on the contralateral side of the breast. As you approach the contralateral skin, the patient may experience some discomfort.
- The cross hairs are moved out of the way and a film is obtained. If the hub of the needle, needle shaft and lesion are superimposed, and you selected a long enough needle, the lesion is skewered.

  This view is used to define the eventual position of the wire in the initial projection.
- Compression is released, taking care that the needle hub does not become engaged on the edge of the compression paddle because this may result in the inadvertent removal of the needle.
- Using a spot compression paddle, the breast is compressed in the orthogonal direction. In this example, a 90-degree lateral view is obtained to establish where, along the course of the needle, the lesion is located.

  After this view is done, the patient remains in compression until the wire is engaged.
- The tip of the needle should be 1 cm beyond the lesion, ensuring that the reinforced segment of the modified wire is placed within or alongside the lesion.
- If the needle location is appropriate (in this example, the needle superimposed on the lesion in the CC view and the lesion is along the course of the needle on the 90-degree lateral view), methylene blue can be injected as a backup for the surgeon, and the wire engaged.

- The needle is removed ensuring that the wire is not advanced or pulled out with needle removal.
- A follow-up film is obtained to document final wire positioning and compression is released.
- After the wire is engaged, the breast should not be compressed in the direction in which the wire is engaged (e.g., direction of compression is perpendicular to wire) otherwise inadvertent movements of the wire may occur.
- The orthogonal views obtained during localization (CC with needle hub and shaft superimposed on lesion and 90-degree lateral view with wire in place) are reviewed with the surgeon. The amount of tissue and any relevant particulars (e.g., avoid frozen section, multicentricity) can be discussed.
- It is important to document the relationship of the needle and lesion in orthogonal views. If the lesion is not associated with the needle on orthogonal views, stop and reassess the situation before engaging wire. Is the lesion you think you see on the CC view the same lesion as that on the 90-degree lateral view? Might the lesion be on the skin (may happen particularly when localizing calcifications)? Use a bright light and look at the skin directly associated with the needle hub; did you select a long enough needle? Is the lesion you are trying to localize a real lesion or an "imaginoma"?
- When localizing microcalcifications, magnification views during the localization may be needed to visualize calcifications along the needle adequately.

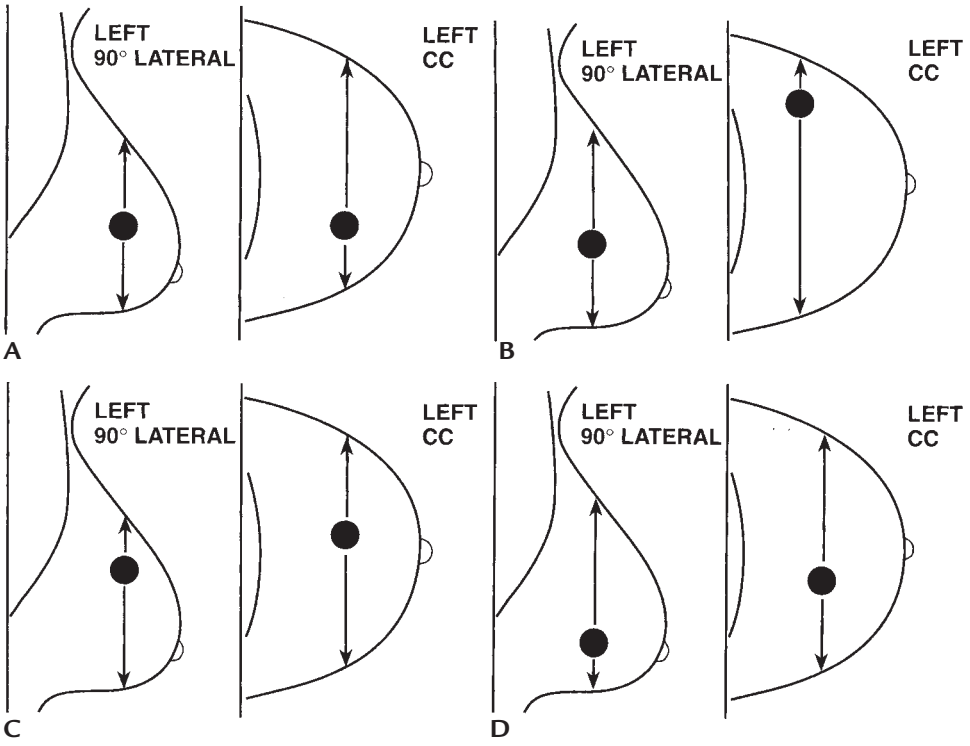
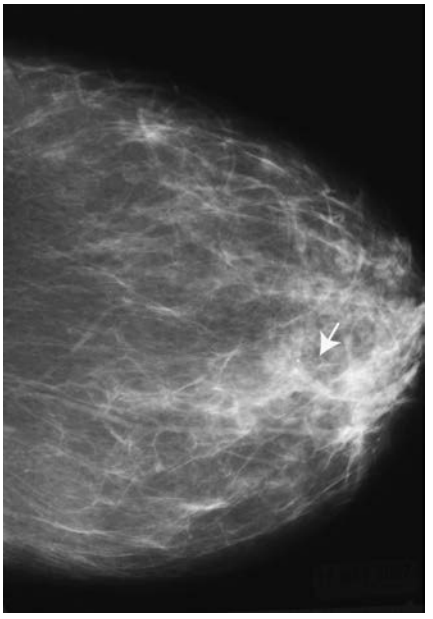



**FIGURE 17-44** Establishing approach and needle length for parallel to the chest wall localizations. **(A)** Ninety-degree lateral and craniocaudal views are reviewed. The various distances (from the top, bottom, lateral, and medial) to the lesion are measured. The shortest distance dictates approach that should be taken. In this case, the lesion is closest to the medial side of the breast. Starting point is a mediolateral view. **(B)** In this case, the lesion is closest to the lateral side of the breast. Starting point is a 90-degree lateromedial view. **(C)** In this case, the lesion is closest to the superior aspect of the breast. Starting point is a CC view. **(D)** In this case, the lesion is closest to the inferior aspect of the breast. Starting point is a from below (FB) view.



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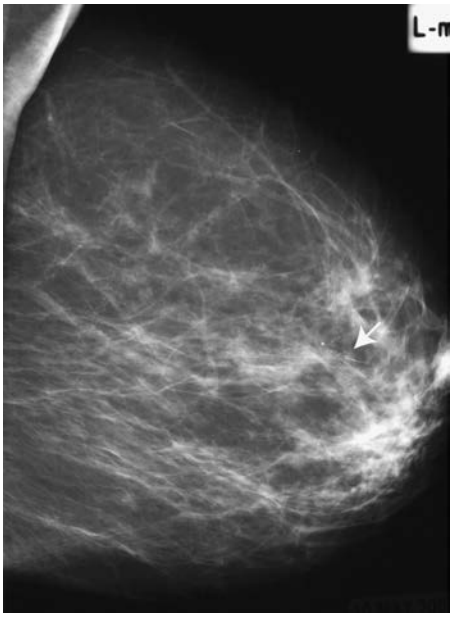


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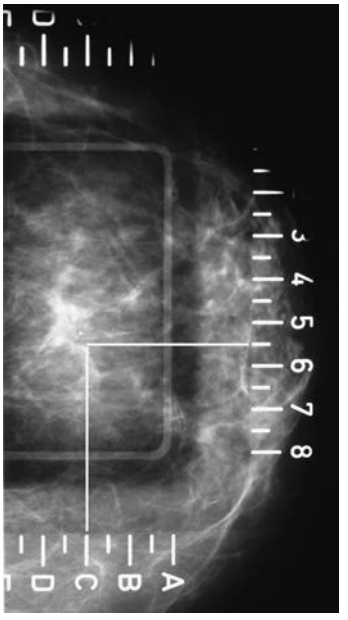
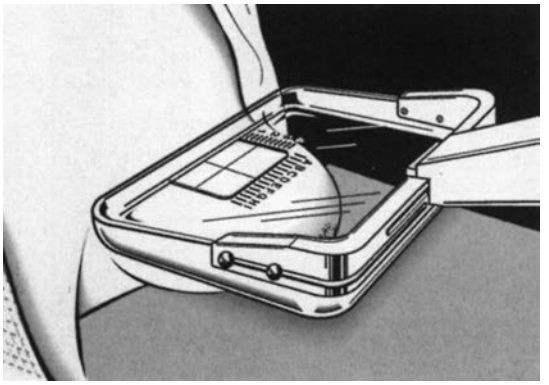



**C**

**FIGURE 17-45** Ductal carcinoma in situ. Preoperative wire localization. **(A)** Craniocaudal (CC) view. The cluster of calcifications (*arrow*) being localized is in the central portion of the left breast. **(B)** Lateral view. Cluster of calcifications (*arrow*) is closest to the superior aspect of the breast. A craniocaudal approach is used and a 7-cm needle is selected so that the tip will go at least 1 cm beyond the lesion. **(C)** CC view done with the fenestrated alphanumeric grid for compression. It is important the patient not move (compression should be firm) from the time this image is taken to the time the needle is inserted; otherwise, the lesion coordinates will change. The technologist should mark the edges of the window on the patient's skin; a shift in the marks relative to the fenestration edges indicates the patient moved. The coordinates for the center of the cluster in this patient are C and 5.5 (*lines*).



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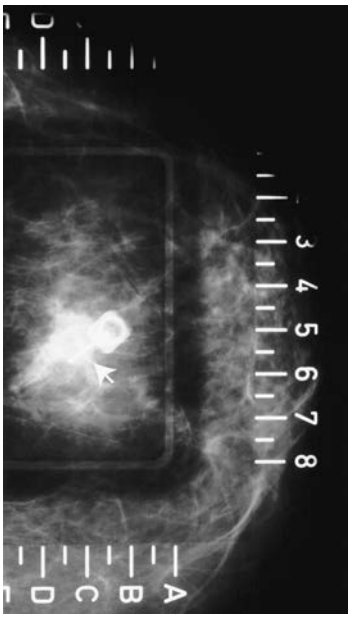


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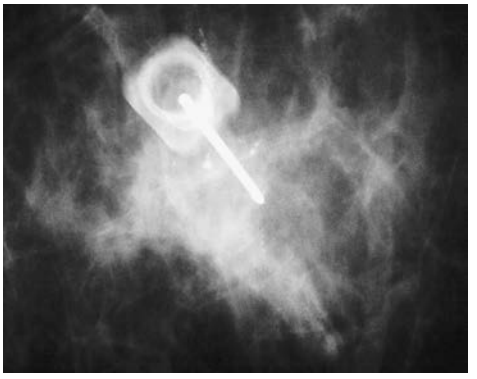
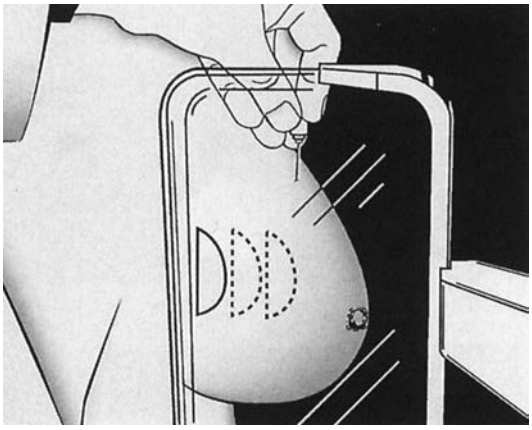


F

**FIGURE 17-45** (*Continued*) **(D)** The collimator cross-hairs are used to cast a shadow on the breast corresponding to the coordinates for the lesion. The tip of the needle is placed at the intersecting point for C and 5.5 and the needle is inserted all the way to the hub in one swift motion or to just short of the bucky. Don't worry about depth at this point. Before taking the next image make sure collimator cross hairs are moved out of the field of view. **(E)** CC view done after needle insertion. Calcifications (*arrow*) are associated with needle shaft. **(F)** Photographic close up of previous image. Needle hub and shaft are associated with some of the calcifications in the cluster. If the needle is long enough, it will be through the center of the calcification cluster. Compression is released slowly. Secure the needle hub so it is not inadvertently dislodged as the compression is released. A 90-degree lateral view is obtained next to demonstrate where the calcifications are along the course of the needle.



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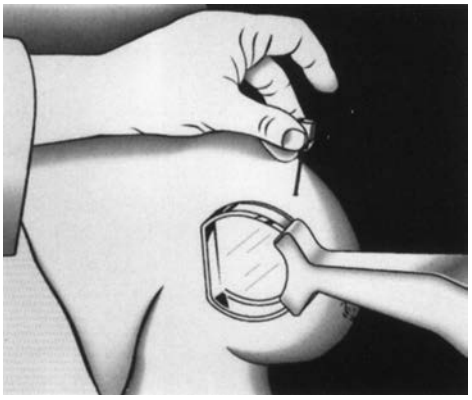

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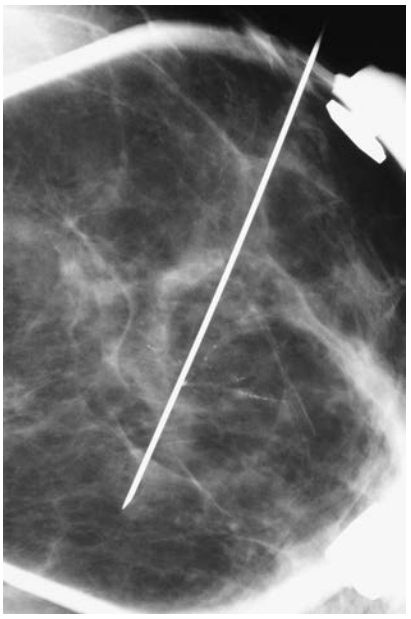
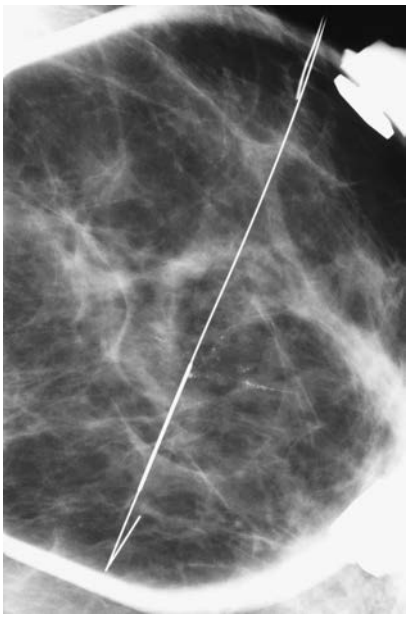


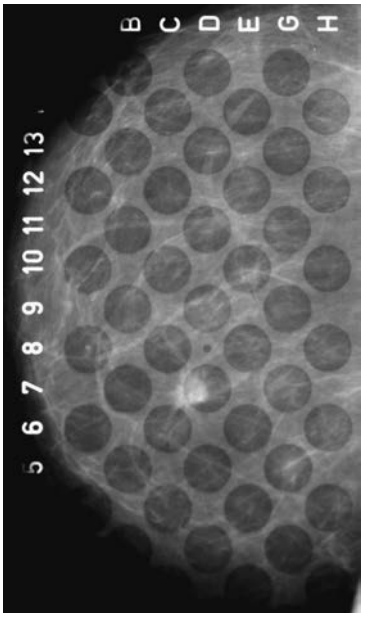
**I**

**FIGURE 17-45** (*Continued*) **(G)** Although the orthogonal view can be done using a regular sized compression paddle, controlled needle manipulation (any needed needle adjustment necessary, and as the wire is passed through needle) is made difficult by the limited space between the paddle and bucky. **(H)** By using the spot compression paddle, there is unimpeded access to the hub of the needle. **(I)** Ninety-degree lateral view using the spot compression paddle. Patient remains in compression from the time this image is done until image is repeated after the wire is deployed. It is on this image that depth is considered. The needle has gone through the cluster of calcifications and the tip is beyond it (by approximately 1 cm). We have now established that the needle is associated with the calcifications in orthogonal views. The wire is passed through the needle until the burnish mark on the wire is at the hub of the needle (indicating tip of hook is at the tip of the needle). The wire is stabilized and the needle is pulled out. Had our needle tip been way beyond the lesion, we would have withdrawn the needle enough to bring the tip to within 1 cm of lesion before engaging the wire.



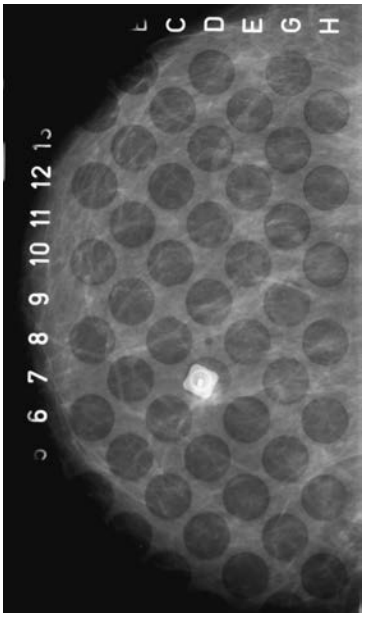
J

**FIGURE 17-45** (*Continued*) **(J)** Ninety-degree lateral view after wire is deployed and needle is removed (compression is released after this image). Superficial portion of reinforced wire segment is in the cluster of calcifications. By placing a portion of the reinforced segment in the lesion true 3D localization has been achieved. As the surgeon approaches the reinforced segment, excision is undertaken.

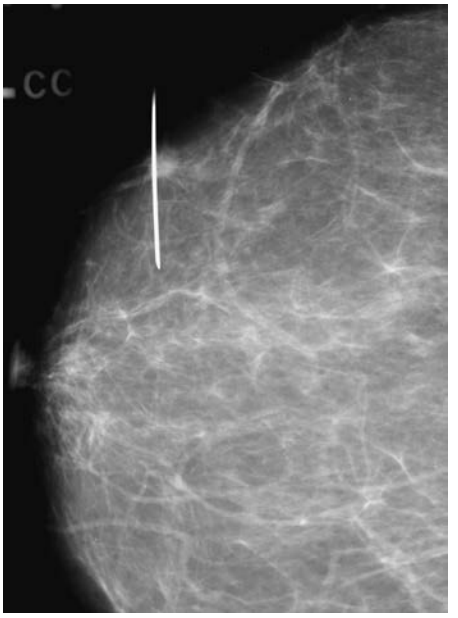



A

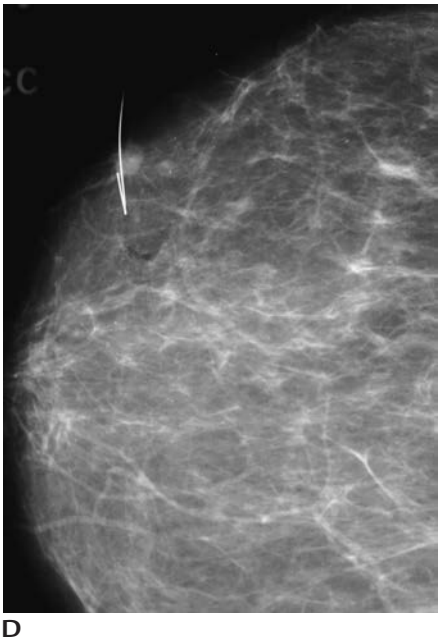
**FIGURE 17-46** Localization using multiple hole paddle. Spiculated mass is closest to the lateral aspect of the right breast on the craniocaudal view. **(A)** Ninety-degree lateromedial view approach using the multiple-hole compression paddle. Lesion is found at the anterior aspect of the D-7 hole.




B




C




D

**FIGURE 17-46** (*Continued*) **(B)** Needle is placed through the anterior aspect of the D-7 hole and advanced as far as it will go (e.g., depth is not assessed on this image). A repeat image done confirms association of needle with the lesion. Because the wire is passed through the needle, this projection also describes eventual trajectory of the wire. It is not necessary to do a 90-degree lateral view after the wire is deployed. Compression is released and the orthogonal view is done. **(C)** Craniocaudal (CC) view demonstrates relationship of needle to lesion in the orthogonal plane. Patient remains in compression after this view is done and until after the wire is deployed. The tip of the needle is approximately 1 cm distal to the mass. If the tip of the needle is more than 1 cm beyond the lesion, it is pulled back before the wire is deployed. At this point, the wire is passed through the needle and the needle is removed. Care is needed to not inadvertently advance the wire or pull the wire out with the needle. **(D)** A follow-up CC view is done to document final wire positioning. Hook of wire is just beyond the mass.

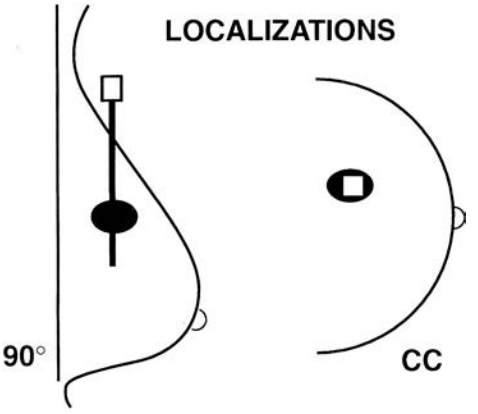



**FIGURE 17-47** It is important to see the needle associated with the lesion in orthogonal views. In this case (lesion approached from the superior portion of the breast), the needle hub and shaft are superimposed on the lesion in the craniocaudal view; if a long enough needle was used the lesion will be skewered. This is confirmed on the lateral view: the needle is seen going through the lesion.

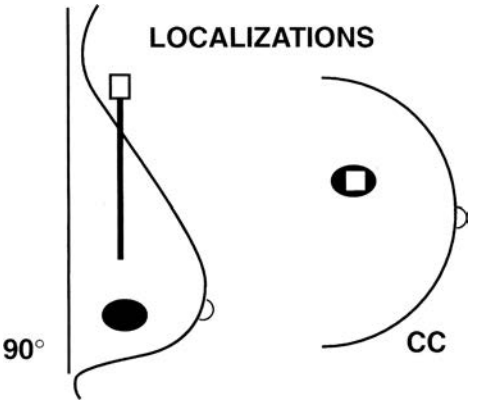
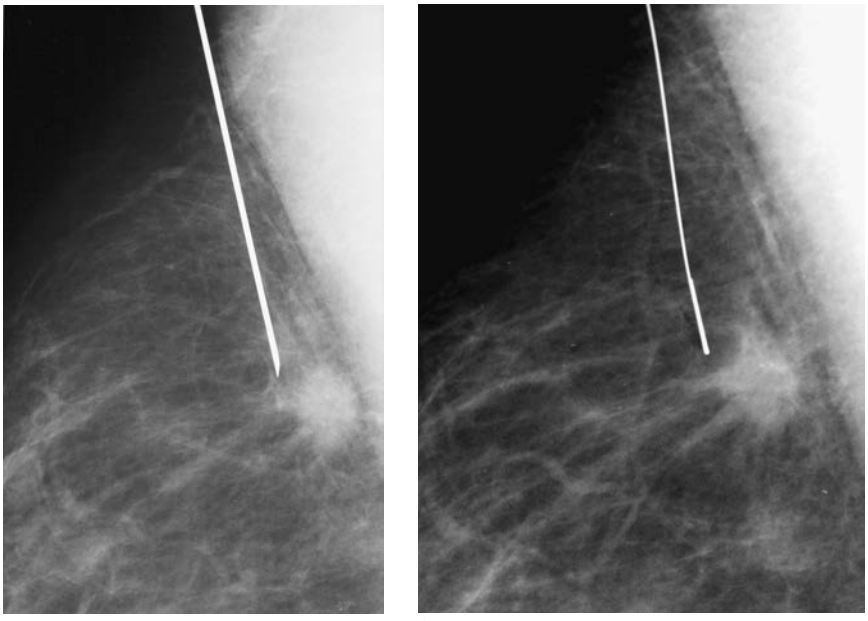
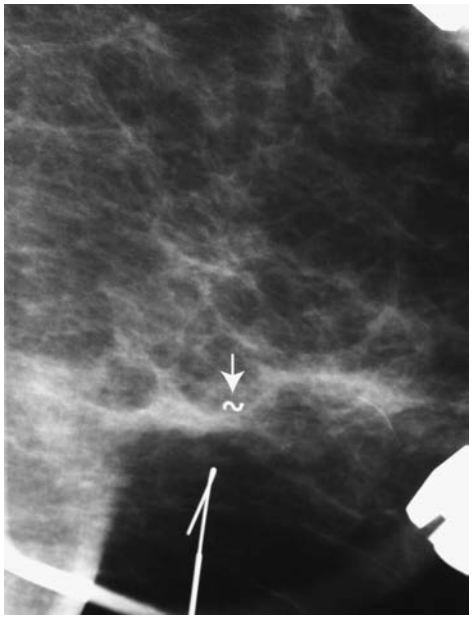



**FIGURE 17-48** In this case, the wrong approach and needle length were selected. The lesion is inferiorly located, so a superior approach is unacceptable. Although the hub and shaft of needle are superimposed on the lesion in the craniocaudal view, the needle is not long enough to reach the lesion. The needle must be associated with the lesion in both views. If not, something is wrong (e.g., approach, needle length, lesion on one view does not correspond to what is being looked at on second view). When the needle is not associated with the lesion on orthogonal views, stop and reassess the situation. Do not engage the hookwire.



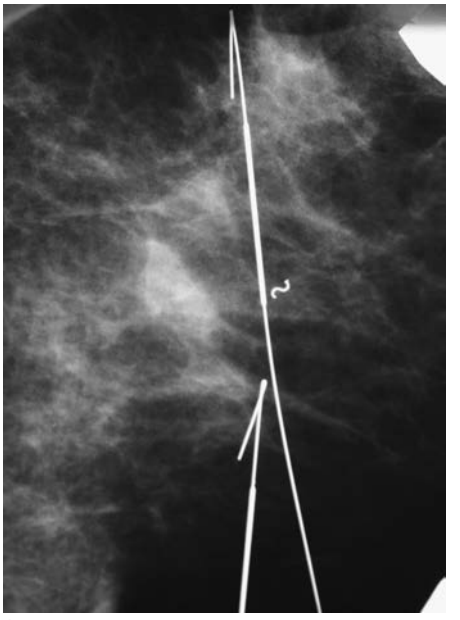
A B

**FIGURE 17-49** **(A)** The needle selected is not long enough to reach the lesion. At this point the procedure should be started over. **(B)** For unclear reasons, the wire was engaged and not surprisingly it is short of the lesion. This is not an acceptable localization.



A

**FIGURE 17-50** Ductal carcinoma in situ. Post-biopsy clip deposited to mark site. A from below approach is used to localize clip closest to the inferior aspect of the left breast on the 90-degree lateral view. **(A)** The wire is short of the clip (*arrow*) having been partially pulled out of the breast as the needle was removed. When the wire is short of the area being localized, we repeat the localization.



B

**FIGURE 17-50** (*Continued*) **(B)** Second wire now adequately localizes the clip. Clip is within 5 mm of the superficial most portion of reinforced wire segment. It is important to tag the wires adequately for the surgeon so there is no confusion regarding which wire extends beyond the localized lesion. In these situations we communicate directly with the surgeon via telephone.

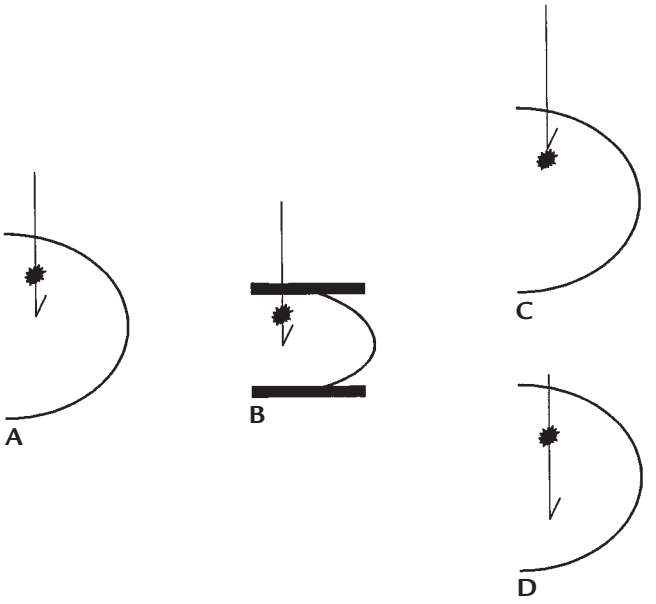



**FIGURE 17-51** Compression perpendicular to the localization wire should be avoided because it can result in inadvertent repositioning of the wire when compression is released. **(A)** Lesion is optimally localized. Wire is through the lesion at the completion of the localization. **(B)** Compression perpendicular to the direction in which the wire is engaged. As compression is released the wire may move inadvertently (accordion effect). **(C)** Wire is short of the lesion. Unacceptable since the lesion is no longer localized. **(D)** Wire is way beyond the lesion. Not optimal, but lesion can still be localized. When localizing lesions using a parallel to the chest wall approach it is not necessary and, as illustrated, not optimal to obtain orthogonal views of the wire after the localization is completed. The initial view with the needle in place and superimposed on the lesion describes the eventual relationship of the wire to the lesion because the wire is passed through the needle. Compression parallel to the wire is not a problem.

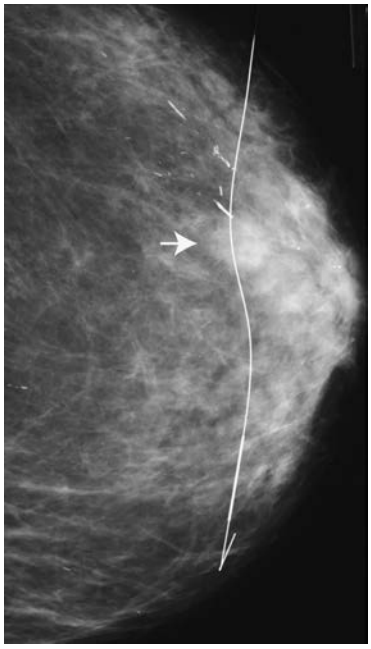


**FIGURE 17-52** In this patient the localization wire is way beyond the mass (*arrow*) being localized. If the breast is compressed perpendicular to the direction in which the hookwire is engaged, inadvertent repositioning of the wire can occur when compression is released (accordion effect). In some patients, the wire is pulled out of the lesion (e.g., wire short of lesion), which is not acceptable or, as in this patient, the wire ends up way beyond the lesion. Although this situation is not ideal, the lesion is still localized.

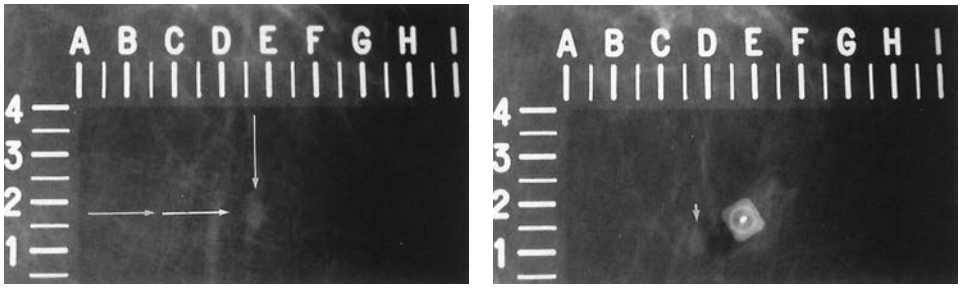



**FIGURE 17-53** **(A)** Mass at D.75 and 1.75 (*arrows*). **(B)** Needle in at D.75 and 1.75 however, needle hub and shaft are not superimposed on mass. Mass (*arrow*) is now at C.5 and 1.25. Patient moved between the time view **(A)** was obtained and needle insertion. Marking the corners of the fenestration on the patient's skin can alert you that the patient moved after the initial image. In this patient, a second needle was inserted at the new coordinates for the lesion.

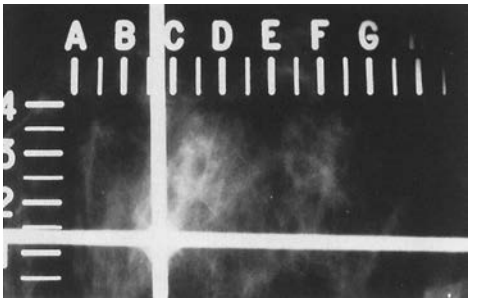



**FIGURE 17-54** If after needle insertion the collimator cross hairs are not moved, evaluation on this orthogonal view is precluded (lesion, needle hub, and shaft are not visualized).

## PREOPERATIVE WIRE LOCALIZATION: ULTRASOUND

### KEY FACTS

- As described for ultrasound-guided biopsies, an approach to the lesion is selected so that as we advance the needle, it is parallel to the transducer. By doing this, we will be able to see the needle and then wire in its entirety.

  Lidocaine (1%) used at skin entry site and along expected course of needle up to but not through the lesion.

  Needle is advanced through the lesion so that the tip is beyond the lesion by approximately 1 cm.

  Wire is deployed and orthogonal ultrasound images of the lesion/wire are taken.

  Using an indelible ink marker, we place an "X" on the skin directly over the lesion/wire and provide the surgeon with the measured distance from the skin (X location) to lesion/wire.

  For mammographically visible lesions, a single mammographic image is done compressing the breast parallel to the wire trajectory; document final wire placement. We do not compress the breast perpendicular to the direction of the deployed wire, because this may result in inadvertent displacement of the wire.

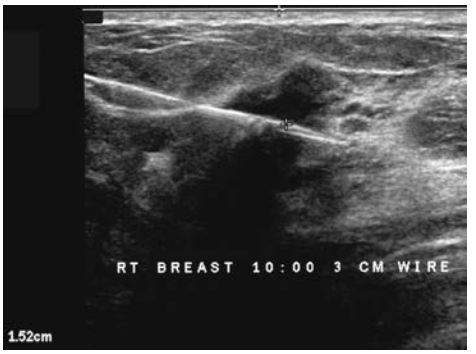



**FIGURE 17-55** Preoperative wire localization, ultrasound guidance. Vertically oriented, hypoechoic mass with angular margins is localized preoperatively using ultrasound guidance. The wire can be seen in its entirety; the hook portion of the wire is partially in the mass. The distance from the skin to the wire (*cross hairs*) in the mass is measured (1.52 cm) and an X is placed on the skin with an indelible marker directly over the lesion and wire. By using the X, the surgeon can cut down to intercept the wire at the location of the mass. A single mammographic view is done compressing the breast parallel to the wire (e.g., is the wire is coming in from lateral to medial a craniocaudal view would be done; if the wire is coming from caudal to cephalad a lateral view would be done).

## Specimen Evaluation

### Key Facts

- Following preoperative wire localizations, specimens are evaluated by doing either radiographs or an ultrasound to determine if the localized lesion (e.g., microcalcifications, masses, areas of parenchymal asymmetry, architectural distortion) has been excised.
- Purposes.

  Verifies that the localized lesion has been excised.

  To guide the pathologist to the location of the lesion in the specimen. We place a needle through the lesion so that we are sure the area of radiologic concern is evaluated histologically. Specimen containers that provide compression and an alphanumeric grid used to localize the lesion for the pathologist are also available.

  To verify that the localization wire has been removed from the breast. If the wire (or a portion of the wire such as the hook) is not seen in the specimen this is discussed with the surgeon while the patient is still in the operating room.

  May be able to assess proximity to margins (remember, however, that a radiograph is a two dimensional representation of a 3D structure).

  To detect additional, unsuspected lesions.

  As learning tool: particularly useful during radiology/pathology correlation sessions in learning about lesion morphology and correlation with histological findings.

- Procedure.

  Done on mammographic unit (lowest possible kV [22 or 23kV], mAs, 4 to 5) or on dedicated specimen radiography unit.

  Specimen is compressed. Care should be exercised to not over compress the specimen since some have suggested that compression may result in positive margins.

  Two magnified (1.6 to 1.8×) views are done (one is placed in the patient's mammography jacket and the other accompanies the specimen to pathology); some of the dedicated specimen radiography units (e.g., Faxitron) allow for approximately 4× magnification providing exquisite detail.

  Communication with the surgeon as to whether the lesion has been excised or not, if there is proximity to margins, and the appropriateness of frozen section. If the wire is not in specimen, ask about the wire.

  Our impressions are also communicated to the pathologist.

## Paraffin Block Radiography

- After a biopsy for microcalcifications, several possible explanations should be considered if the pathologist is unable to locate the calcifications.

  Large calcifications may be lost or sheared off as the tissue is processed.

  Calcium oxalate type calcifications (associated with fibrocystic changes) require polarizing microscopy for visualization (calcifications associated with malignant lesions are usually calcium phosphate).

  The tissue containing the calcifications may not have been sectioned, processed and looked at. If there is unsectioned tissue, it may worthwhile doing a specimen radiograph of the unsectioned tissue: the calcifications may be found in the unsubmitted tissue.

  If all the tissue has been processed, the paraffin blocks can be x-rayed so that the block containing calcifications is identified. This block is then imaged in an orthogonal projection to establish the location (depth) of the calcifications in the block. Calcifications may be deep in the paraffin block, requiring possibly hundreds of slides before the pathologist gets to the calcifications.

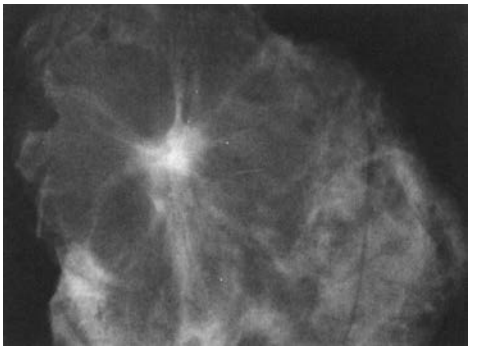


**FIGURE 17-56** Invasive ductal carcinoma, well differentiated. Specimen radiograph. Excision of localized mass with spiculated margins is confirmed. The location of the mass in the specimen is marked for the pathologist. Special specimen containers with localizing grids (alphanumeric) are commercially available.

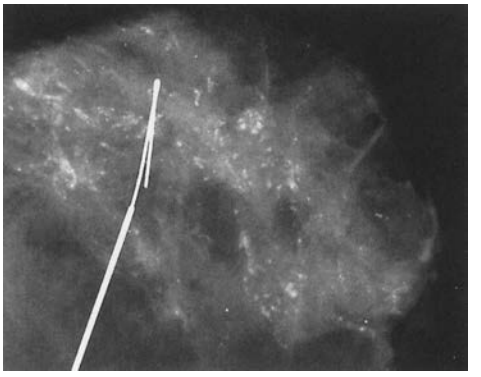
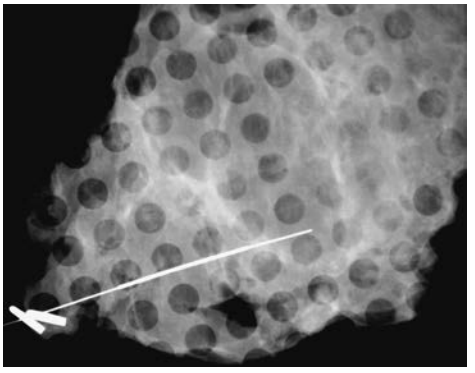
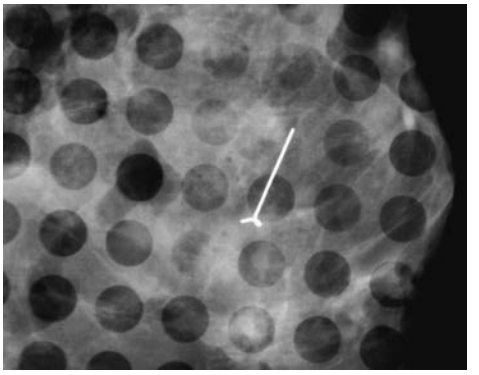


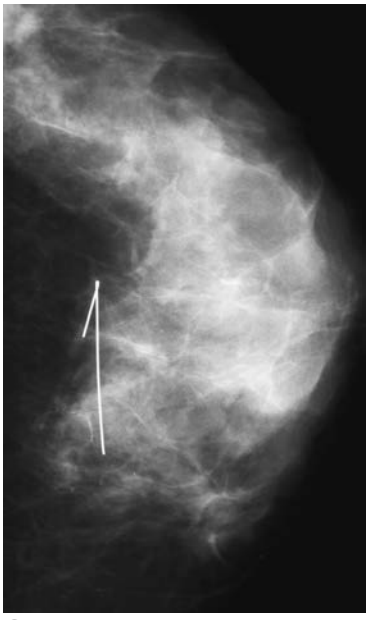
**FIGURE 17-57** Ductal carcinoma in situ, predominantly high nuclear grade. Extensive area of microcalcifications in the specimen. Pleomorphic calcifications including linear, round and punctate forms. What do you want to communicate to the surgeon and pathologist? Since there are calcifications extending to some of the edges of the specimen, it is important to let the surgeon (and pathologist) know that tumor probably extends to the margins (confirmed histologically). Additional tissue can be removed potentially averting a second surgical procedure to clear the margin. Although specimens are a 2D of a 3D structure, if a mass (or calcifications) is present at the edge of the specimen, involvement of the margins is suspected.



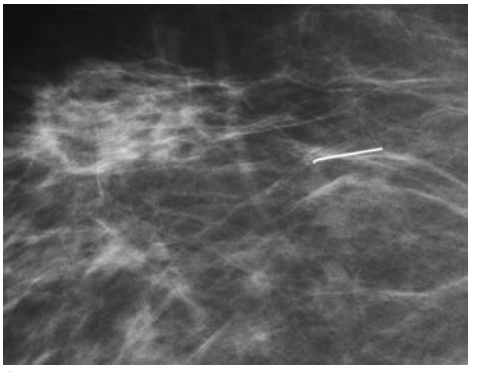
A



B



C



D

**FIGURE 17-58** Papilloma. Wire localization done following a ductogram. **(A)** First specimen submitted. What is the problem? The surgeon is alerted that the hook portion of the wire is missing. **(B)** Second specimen is submitted. The hook of the wire has been excised. The primary purposes of specimen radiography are to confirm excision of the localized lesion and to mark the location of the lesion in the specimen for the pathologist. Additionally, however, it is important to verify that the localization wire has been excised, look for additional unsuspected lesions and to communicate with the surgeon if extension of the lesion to the margins is suspected. **(C)** Different patient. Craniocaudal view 1 year following excisional biopsy demonstrates retained portion of localization wire. **(D)** Different patient. Wire fragment retained following excisional biopsy. These situations can be averted if the specimen is evaluated carefully at the time of surgery to verify removal of entire wire.

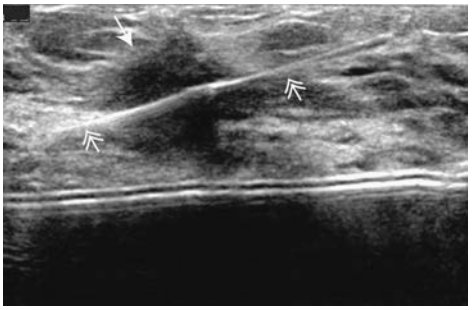
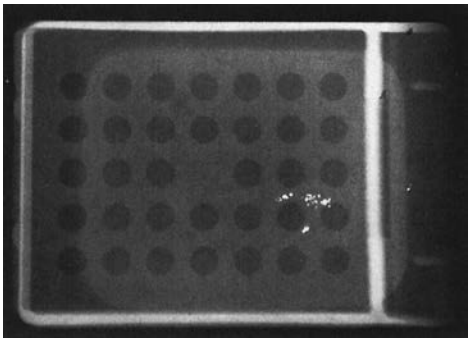
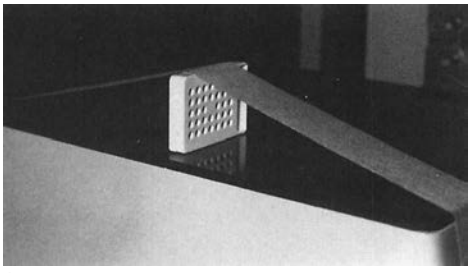


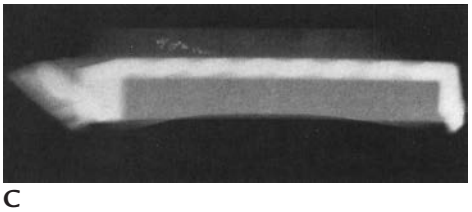
**FIGURE 17-59** Invasive ductal carcinoma. Ultrasound of specimen demonstrates mass (*arrow*) with localization wire (*double headed arrows*). In some patients with dense tissue, ultrasound of the specimen is helpful in verifying excision of the localized mass.



**A**



**B**



**C**

**FIGURE 17-60** **(A)** Paraffin block containing calcifications. In some patients, there may 10 to 20 paraffin blocks per biopsy. Isolating the one or two that contain the microcalcifications can be helpful to the pathologist. **(B)** Block oriented vertically and tapped to the magnification stand for orthogonal view. **(C)** Orthogonal paraffin block view demonstrating the depth of the calcifications in the block. Many slides would have to be prepared and reviewed before the microcalcifications are reached.

## Radiology-Pathology Correlation

### Key Facts

- When making a breast biopsy recommendation, consider what you would accept for a diagnosis and what you will do if the results differ from what is anticipated.
- All breast biopsy results (from excisional and core biopsies) should be reviewed by the radiologists involved. The mammography report, screening and workup films and studies, specimen radiography, and the pathology report are reviewed.
- Data gathering for medical audit.
- Permits determination of radiology/pathology correlation.
- If pathology results are incongruent with radiologic impression, more histopathologic review can be undertaken. If needed the patient can be reevaluated.

  For example, if you have a dense (e.g., not lucent fatty lesion) solid mass and the pathology report concludes "lipoma," something is wrong. Either the area of radiographic concern was not excised or it was not included in the material reviewed histologically.

  If a biopsy was done for microcalcifications and no calcifications are mentioned in the pathology report, you need to go back and establish the whereabouts of the calcifications (presumably seen on specimen radiograph).

  Work with the pathologists and insist that they provide direct correlation for the location of calcifications in their reports. For example, sometimes cancer is described, but the calcifications prompting the biopsy are in adjacent benign tissue.

  For all imaging guided biopsies, we discuss results directly with the pathologist.
- Based on radiology/pathology reviews, needed follow ups are established.

  If the pathology results are not congruent with imaging, immediate evaluation of the patient or further evaluation of the specimen by the pathologist may be recommended.

  If there is a high-risk marker lesion, a 6-month follow-up is recommended to establish a new baseline for the patient (see Chapter 15).

  With needle biopsy results indicating atypical ductal hyperplasia, radial scar/complex sclerosing lesion, phyllodes tumor or papillary lesion with atypical features we recommend excisional biopsy. Some also recommend excisional biopsy with a diagnosis of atypical lobular hyperplasia or lobular neoplasia (lobular carcinoma in situ), mucocelelike lesions, and columnar alteration with prominent apical snouts and secretions with atypia (CAPSS).
- Invaluable learning tool: interpretative abilities can be improved by thorough radiology/pathology reviews.

## SUGGESTED READINGS


Agoff SN, Lawton TJ. Papillary lesions of the breast with and without atypical ductal hyperplasia. *Am J Clin Pathol*. 2004;122:440–443.

Azavedo E, Svane G, Auer G. Stereotactic fine needle biopsy in 2594 mammographically detected non-palpable lesions. *Lancet*. 1989;1:1033–1035.

Berg WA. Image-guided breast biopsy and management of high-risk lesions. *Radiol Clin N Am*. 2004;42:935–946.

Berg WA, Mrose HE, Ioffe OB. Atypical lobular hyperplasia or lobular carcinoma in situ at core-needle biopsy. *Radiology*. 2001;218:503–509.

Brenner RJ, Jackman RJ, Parker SH, et al. Percutaneous core needle biopsy of radial scars of the breast: when is excision necessary? *AJR Am J Roentgenol*. 2002;179:1179–1184.

Carder PJ, Murphy CE, Liston JC. Surgical excision is warranted following a core biopsy diagnosis of mucocele-like lesion of the breast. *Histopathology*. 2004;45:148–154.

Carder PJ, Garvican J, Haigh I, et al. Needle core biopsy can reliably distinguish between benign and malignant papillary lesions of the breast. *Histopathology*. 2004;46:320–327.

Cardenosa G, Eklund GW. Benign papillary neoplasms of the breast: mammographic findings. *Radiology*. 1991;181:751–755.

Cardenosa G, Eklund GW. Paraffin block radiography following breast biopsies: use of orthogonal views. *Radiology*. 1991;180:873–874.

Cardenosa G, Eklund GW. Interventional procedures in breast imaging (part I). In: Taveras JM, Ferrucci JT, eds. *Radiology*. Philadelphia: JB Lippincott; 1993.

Cardenosa G, Eklund GW. Interventional procedures in breast imaging (part II): ductography, cyst aspiration and pneumocystography and fine needle aspiration. In: Taveras JM, Ferrucci JT, eds. *Radiology*. Philadelphia: JB Lippincott; 1993.

Cardenosa G, Doudna C, Eklund GW. Ductography of the breast: technique and findings *AJR Am J Roentgenol*. 1994;162:1081–1087.

Czarnecki DJ, Feider HK, Splittgerber GF. Toluidine blue dye as a breast localization marker. *AJR Am J Roentgenol*. 1989;153:261–263.

Davis PS, Wechsler RJ, Feig SA, et al. Migration of breast biopsy localization wire. *AJR Am J Roentgenol*. 1988;150:787–788.

Dershaw DD. *Stereotactic core needle biopsy*. Breast Imaging: Categorical Course Syllabus. The 99th Annual Meeting of the American Roentgen Ray Society. May, 1999.

Dershaw DD, ed. *Interventional Breast Procedures*. New York: Churchill Livingstone; 1996.

Diaz LK, Wiley EL, Venta LA. Are malignant cells displaced by large-gauge needle core biopsy of the breast? *AJR Am J Roentgenol*. 1999;173:1303–1313.

Fajardo LL, Jackson VP, Hunter TB. Interventional procedures in diseases of the breast: needle biopsy, pneumocystography and galactography. *AJR Am J Roentgenol*. 1992;158:1231–1238.

Farshid G, Pieterse S, King JM, et al. Mucocele-like lesions of the breast: a benign cause for indeterminate or suspicious mammographic microcalcifications. *Breast J*. 2005;11:15–22.

Fasih T, Jain M, Shrimankar J, et al. All radial scars/complex sclerosing lesions seen on breast screening mammograms should be excised. *EJSO*. 2005;31:1125–1128.

Fornage BD, Coan JD, David CL. Ultrasound-guided needle biopsy of the breast and other interventional procedures. *Radiol Clin North Am*. 1992;30:167–185.

Foster MC, Helvie MA, Gregory NE, et al. Lobular carcinoma in situ or atypical lobular hyperplasia at core needle biopsy: is excisional biopsy necessary? *Radiology*. 2004;231:813–819.

Gallagher WJ, Cardenosa G, Rubens JR, et al. Minimal-volume excision of nonpalpable breast lesions. *AJR Am J Roentgenol*. 1989;153:957–961.

Gisvold JJ, Martin JK. Prebiopsy localization of nonpalpable breast lesions. *AJR Am J Roentgenol*. 1984;143:477–481.

Glazebrook K, Reynolds C. Mucocele-like tumors of the breast: mammographic and sonographic appearances. *AJR Am J Roentgenol*. 2003;180:949–954.

Greenstein-Orel S, Evers K, Yeh IT, et al. Radial scar with microcalcifications: radiologic-pathologic correlation. *Radiology*. 1992;183:479–482.

Guerra-Wallace MM, Chistensen WN, White RL. A retrospective study of columnar alteration with prominent apical snouts and secretions and the association with cancer. *Am J Surg*. 2004;188:395–398.

Hall FM, Frank HA. Preoperative localization of nonpalpable breast lesions. *AJR Am J Roentgenol*. 1979;132:101–105.

Hamele-Bena D, Cranor ML, Rosen PP. Mammary mucocele-like lesions: benign and malignant. *Am J Surg Path*. 1996;20:1081–1085.

Hirsch JI, Banks WL JR, Sullivan JS, et al. Effect of methylene blue on estrogen-receptor activity. *Radiology*. 1989;171:105.

Holland R. The role of specimen x-ray in the diagnosis of breast cancer. *Diagn Imaging Clin Med*. 1985;54:178–185.

Homer MJ. Nonpalpable breast lesion localization using a curved-end retractable wire. *Radiology*. 1985;157:259–260.

Homer MJ, Smith TJ, Safaii H. Prebiopsy needle localization. *Rad Clinics NA*. 1992;30:139–153.

Ikeda DM, Helvie MA, Adler DD, et al. The role of fine-needle aspiration and pneumocystography in the treatment of impalpable breast cysts. *AJR Am J Roentgenol*. 1992;158:1239–1241.

Ivan D, Selinko V, Sabin AA, et al. Accuracy of core needle biopsy diagnosis in assessing papillary breast lesions: histologic predictors of malignancy. *Mod Pathol*. 2004;17:165–171.

Jackson VP. The status of mammographically guided fine needle aspiration biopsy of nonpalpable breast lesions. *Radiol Clin North Am* 1992;30:155–166.

Jacobs TW, Chen YY, Guinee DG, et al. Fibroepithelial lesions with cellular stroma on breast core needle biopsy. *Am J Clin Pathol*. 2005;124:342–354.

Jacobs TW, Connolly JL, Schnitt SJ. Nonmalignant lesions in breast core needle biopsies. *Am J Surg Pathol*. 2002;26:1095–1110.

Jacobs TW, Byrne C, Colditz G, et al. Radial scars in benign breast biopsy specimens and the risk of breast cancer. *N Engl J Med*. 1999;340:430–436.

Kalisher L. An improved needle for localization of nonpalpable breast lesions. *Radiology*. 1978;128:815–817.

Kim JY, Han BK, Choe YH, et al. Benign and malignant mucocele-like tumors of the breast: mammographic and sonographic appearances. *AJR Am J Roentgenol*. 2005;185:1310–1316.

Komenaka IK, El-Tmaer M, Pile-Spellman E, et al. Core needle biopsy as a diagnostic tool to differentiate phyllodes tumor from fibroadenoma. *Arch Surg*. 1003;138:987–990.

Kopans DB, Meyer J. Versatile spring hookwire breast lesion localizer. *AJR Am J Roentgenol*. 1982;138:586–587.

Kopans DB, Deluca S. A modified needle-hookwire breast lesion localizer. *AJR Am J Roentgenol*. 1982;138:586–587.

Kopans DB, Lindfors K, McCarthy KA, et al. Spring hookwire breast lesion localizer: use of rigid-compression mammographic systems. *Radiology*. 1985;157:537–538.

Kopans DB,Waitzkin ED, Linetsky L et al. Localization of breast lesions identified on only one mammographic view. *AJR Am J Roentgenol*. 1987;149:39–41.

Kopans DB, Swann CA. Preoperative imaging-guided needle placement and localization of clinically occult breast lesions. *AJR Am J Roentgenol*. 1989;152:1–9.

Kopans DB. The positive predictive value of mammography. *AJR*. 1992;158:521–526.

Leborgne R. Estudio radiologico del sistema canalicular de la glandula mamaria normal y patologica. Montevideo, Uruguay, Impresora Uruguaya S.A., Juncal 1511, 1943.

Leis HP, Cammarata A, LaRaja RD. Nipple discharge: significance and treatment. *Breast*. 1985:11:6–12.

Liberman L, Bracero N, Vuolo MA, et al. Percutaneous large-core biopsy of papillary breast lesions. *AJR Am J Roentgenol*. 1999;172:331–337.

Liberman L, Sama M, Susnik B, et al. Lobular carcinoma in situ at percutaneous breast biopsy: surgical biopsy findings. *AJR Am J Roentgenol*. 1999;173:291–299.

Liberman L. Clinical management issues in percutaneous core breast biopsy. *Radiol Clin North Am*. 2000;38:791–807.

Liberman L. Percutaneous imaging-guided core breast biopsy: state of the art at the millennium. *AJR Am J Roentgenol*. 2000;174:1191–1199.

Liberman L, Evan WP, Dershaw DD, et al. Radiography of microcalcifications in stereotaxic mammary core biopsy specimens. *Radiology*. 1994;190:223–225.

Liberman L, Cohen MA, Dershaw DD, et al. Atypical ductal hyperplasia diagnosed at stereotaxic core biopsy of breast lesions: an indication for surgical biopsy. *AJR Am J Roentgenol*, 1995;164:1111–1113.

Liberman L, Fahs MC, Dershaw DD, et al. Impact of stereotaxic core biopsy on cost of diagnosis. *Radiology*. 1995;195:633–637.

Mercado CL. Hamele-Bena D, Oken SM, et al. Papillary lesions of the breast at percutaneous core-needle biopsy. *Radiology*. 2006;238:801–808.

Meyer JE, Kopans DB, Stomper PC, et al. Occult breast abnormalities: percutaneous preoperative needle localization. *Radiology*. 1984;150:335–337.

Meyer JE. Value of large-core biopsy of occult breast lesions. *AJR Am J Roentgenol*. 1992;158:991–992.

Page DL, Schuyler PA, Dupont WD, et al. Atypical lobular hyperplasia as a unilateral predictor of breast cancer risk: a retrospective cohort study. *Lancet*. 2003;361:125–129.

Parker SH, Lovin JD, Jobe WE, et. al. Stereotactic breast biopsy with a biopsy gun. *Radiology*. 1990;176:741–747.

Parker SH, Lovin JD, Jobe WE, et. al. Nonpalpable breast lesions: stereotactic automated large core biopsies. *Radiology*. 1991;180:403–407.

Parker SH, Jobe WE, eds. *Percutaneous Breast Biopsy*. New York: Raven Press; 1993.

Parker SH, Burbank F, Jackman RJ et al. Percutaneous large-core breast biopsy: a multi-institutional study. *Radiology*. 1994;193:359–364.

Patterson JA, Scott M, Anderson N, et al. Radial scar, complex sclerosing lesion and risk of breast cancer. Analysis of 75 cases in Northern Ireland. *EJSO*. 2004;30:1065–1068.

Pollack AH. Localization of breast lesions identified on one mammographic view: the skin-pinch technique. *Radiology*. 1992;185:278.

Ramsaroop R, Greenberg D, Tracey N, et al. Mucocele-like lesions of the breast: an audit of 2 years at Breast Screen Auckland (New Zealand). *Breast J*. 2005;11:321–325.

Rebner M, Pennes DR, Baker DE, et al. Two view specimen radiography in surgical biopsy of nonpalpable breast masses. *AJR Am J Roentgenol*. 1987;149:283–285.

Rebner M, Helvie MA, Pennes DR, et al. Paraffin tissue block radiography: adjunct to breast specimen radiography. *Radiology*. 1989;173:695–696.

Renshaw AA, Derhagopian RP, Tizol-Blanco DM, et al. Papillomas and atypical papillomas in breast core needle biopsy specimens. *Am J Clin Pathol*. 2004;122:217–221.

Reynolds HE. Core needle biopsy of challenging benign breast conditions: a comprehensive literature review. *AJR Am J Roentgenol*. 2000;174:1245–1250.

Rosen EL, Bentley RC, Baker JA, et al. Image-guided core needle biopsy of papillary lesions. *AJR Am J Roentgenol*. 2002;179:1185–1192.

Rosen, PP. Rosen's Breast Pathology. 2nd ed. Philadelphia: Lippincott Williams and Wilkins; 2001.

Swann CA, Kopans DB, McCarthy KA et al. Localization of occult breast lesions: practical solutions to problems of triangulation. *Radiology*. 1987;163:577–579.

Tabar L, Dean PB. Interventional radiologic procedures in the investigation of lesions of the breast. *Rad Clinics NA.* 1979;24:607–621.

Tabar L, Pentek Z, Dean PB. The diagnostic and therapeutic value of breast cyst puncture and pneumocystography. *Radiology*. 1981;141:659–663.

Tabar L, Dean PB, Zoltan P. Galactography: he diagnostic procedure of choice for nipple discharge. *Radiology*. 1983;149:31–38.

Woods ER, Helvie MA, Ikeda DM, et. al. Solitary breast papilloma: comparison of mammographic, galactographic and pathologic findings. *AJR Am J Roentgenol*. 1992;159:487–491.

Ung OA, Lee WB, Greenberg ML, et al. Complex sclerosing lesion: the lesion is complex, the management is straightforward. *ANZ J Surg*. 2001;71:35–40.

CHAPTER 18

# DOCUMENTATION AND THE MAMMOGRAPHIC REPORT

## General Concepts

### Key Facts

- Mammography reports should be accurate, succinct and directive; as important medical documents reports should be standardized and clear.
- Do not use disclaimers, particularly if they are based on someone else's work; they provide no protection and only serve to discredit your work.
- For screening studies, one question needs to be answered: Is the exam normal or is there an area (or areas) of concern requiring further evaluation?

  On screening studies consider limiting assessment categories used to 1, 2, or 0.
- Diagnostic studies.

  If correlative physical examination and ultrasound are done, consider combining the reports (e.g., diagnostic mammogram, physical exam and ultrasound) in one so that the impression and recommendations reflect the complete workup.

  If done for a potentially abnormal screening study, is anything confirmed on the additional views and ultrasound (e.g., a mass with well-circumscribed margins is confirmed on the spot compression views; a cyst is imaged sonographically correlating to the mammographic finding)?

  If done for clinical findings, specifically address the clinical area of concern (e.g., an oil cyst is imaged correlating to the palpable finding in the right breast).

  Are there findings consistent with breast cancer?

  What is indicated next: return to screening, follow-up, or biopsy? For example, if a mass with spiculated margins is imaged on the spot compression views of the left breast, a biopsy is indicated.

Following complete workups, assessment categories 1, 2, 3, 4, 5, and 6 are used.

On category 4 and 5 diagnostic reports we use suspicious abnormality and highly suspicious abnormality followed by "biopsy is indicated" as opposed to the recommended verbiage in the ACR lexicon of "biopsy should be considered" and "appropriate action should be considered," respectively. In fact, we routinely do the biopsy on the same day as the diagnostic evaluation and see the patient on follow-up to discuss results the following day.

- Before dictating.

  Review films with comparisons (if available).

  Make up your mind about what you are going to say so that you have a clear message with impressions and specific recommendations.

  Do not use your report to make up your mind or shift responsibility.

  On clinically occult lesions, it is the radiologist interpreting the mammogram who should provide guidance and a final recommendation (it makes no sense to say "biopsy if clinically indicated" for a cluster of microcalcifications or a nonpalpable mass).

- Read the report.

  Does it make sense? Is it logical?

  Does it reflect accurately what was done?

  Are the sentences complete and grammatically correct?

  Is the report helpful (e.g., directive) to the referring clinician?

  Eliminate excess verbiage (every word in the reports should be critical to the message).

  Your impression should be a conclusion with specific recommendations (e.g., what is the bottom line?) not a repeat of what you said in the body of the report.

- Report organization.

  Type of study (screening, diagnostic); reason for study.

  Statement regarding comparison with prior studies.

  Tissue type:

    The breast is almost entirely fat (less than 25% glandular).

    There are scattered fibroglandular densities (25% to 50% glandular).

    The breast tissue is heterogeneously dense (51% to 75% glandular).

    The breast tissue is extremely dense (>75% glandular).

  Findings (description), pertinent negatives (if appropriate).

  Lesion location.

    Use clock face preceded by left, right or bilateral (consider providing distance from nipple).

    Usage of quadrants (upper outer quadrant, upper inner quadrant, lower outer quadrant, lower inner quadrant) is an option.

    Subareolar, central, or axillary tail (no clock-face location or depth is needed when using subareolar or axillary tail).

    Depth: anterior, middle, or posterior.

Impression.

Under the Mammographic Quality Standards Act (MQSA) an assessment category (ACR, BI-RADS™) and recommendations are required on all mammography reports.

Category 1: negative.

Category 2: benign finding(s).

Category 3: probably benign finding: short-term follow-up is recommended. Finding placed in this category should have less than 2% likelihood for malignancy.

Category 4: suspicious abnormality, biopsy should be considered.

Can be subdivided into

4A: low suspicion

4B: intermediate suspicion

4C: moderate suspicion

Category 5: highly suggestive of malignancy: appropriate action should be taken.

Category 6: Known, biopsy proven malignancy (e.g., used for outside film consultation or when monitoring patients on neoadjuvant chemotherapy prior to surgery).

Category 0: Need additional imaging evaluation (or prior films for comparison).

- On all biopsy recommendations, make direct contact with the referring physician (document nature of contact and what transpired) and the patient.
- The reader is encouraged to consult the *American College of Radiology (ACR)*. Breast imaging reporting and data system (BI-RADS). 4th edition. Reston, VA: American College of Radiology; 2003. What follows is extracted from this source.

## FOR MASSES...

### KEY FACTS

- A space-occupying lesion seen in two different projections is called a mass; if a potential mass is seen on only one view, the term *asymmetry* should be used until the presence of a mass is established.

  For masses provide: size, morphology (shape, margin, and density), associated findings, location.
- Shape.

  Round.

  Oval.

  Lobular: undulations.

  Irregular: when above three terms don't apply.
- Margins.

  Circumscribed: at least 75% of the margin is well or sharply defined.

  Microlobulated.

Obscured: margins are not well evaluated because of surrounding (potentially superimposed) breast tissue.

Indistinct (ill-defined): margin definition is poor not related to adjacent or superimposed breast tissue.

Spiculated.

- Density.

  X-ray attenuation of mass relative to x-ray attenuation of an equal volume of fibroglandular tissue.

  High density.

  Equal density.

  Low density (but not fat containing).

  Fat (radiolucent) containing density (e.g., lipoma, oil cyst, galactocele, fibroadenolipoma).

- Location.

  Use clock face preceded by left, right, or bilateral.

  Usage of quadrants (upper outer quadrant, upper inner quadrant, lower outer quadrant, lower inner quadrant) is an option.

  Subareolar, central or axillary tail (no clock-face location or depth is needed when using subareolar or axillary tail).

  Depth: anterior, middle, or posterior.

- Associated findings.

  Microcalcifications.

  Architectural distortion.

- Size.

  Provide a measurement; avoid terms such as *large* that provide no useful information and may be misleading (how is small defined? how is large defined?); use greatest dimension.

- Comparison to prior studies.

## For Calcifications...

### Key Facts

- Provide: morphology (type or shape), distribution, associated findings, location.
- Benign.

  Skin.

    Clusters of lucent centered calcifications.

    Tangential view is needed rarely to document skin location.

    Medial and parasternal location common.

    Along scars (e.g. in patients following reduction mammoplasty).

  Vascular.

    Parallel tracks, linear tubular.

  Coarse ("popcorn-like").

    Fibroadenomas.

Large rod-like (benign ductal, secretory).
Duct ectasia.
May branch and have lucent centers.
Typically more than 1 mm in diameter.
Usually a bilateral process, point toward nipple.
Round.
Larger than 0.5 mm.
Punctate may be used when smaller than 0.5 mm.
Lucent centered.
Vary in size from less than 1 mm to over 1 cm.
Thicker than rim or "eggshell."
Fat necrosis.
Eggshell or rim.
Thin, less than 1 mm in thickness.
Wall of cysts.
Milk of calcium.
Differential appearance between craniocaudal and lateral views.
Occur in micro and macro cysts.
When in suspension, amorphous appearance on CC views, "teacup" sharp curvilinear appearance on lateral views.
Suture.
Linear or tubular; may see knots.
Dystrophic.
Irregular in shape.
Usually larger than 0.5 mm.

- Intermediate.

Amorphous or indistinct.
Coarse heterogeneous.

- Higher probability of malignancy.

Fine pleomorphic.
Fine linear or fine-linear branching.

- Distribution.

Diffuse, scattered.
Randomly distributed throughout the breast.
Commonly bilateral.
Regional.
Scattered in a large (>2 cc) volume of tissue.
Do not conform to a duct distribution.
Grouped or clustered (small volume less than 1 cc of tissue).
Linear.
Calcifications define a linear path.
May have branch points.

Segmental.

Suggestive of ductal carcinoma in situ with calcifications outlining the distribution of the duct involved.

- Compare to previous studies.

## Special Cases

### Key Facts

- Tubular density, solitary dilated duct.

  In the absence of other findings (spontaneous nipple discharge) most likely benign.
- Intramammary lymph node.

  Reniform shape with fatty hilum.

  Commonly in upper outer quadrants, but can occur anywhere in the breast.
- Global asymmetry.

  Compared with corresponding area in contralateral breast.

  Greater volume of tissue involving at least one quadrant.

  In the absence of a corresponding palpable abnormality, consider normal variation or hormone effect.
- Focal asymmetry.

  Seen in two projections but lacks the convex borders and conspicuity of a mass.

  Compare with prior studies: if new, and there is no history of surgery or trauma localized to the site of the asymmetry, spot compression views and possibly sonography may be indicated.

## Associated Findings

### Key Facts

- Can be seen in isolation or associated with asymmetries, masses or calcifications.
- Skin or nipple retraction.
- Skin thickening.

  Diffuse.

  Focal.
- Trabecular thickening.
- Skin lesion.
- Axillary adenopathy.

  Enlarged (>2 cm), nonfatty replaced.
- Architectural distortion.

Normal architecture is distorted secondary to prior surgery, trauma, or breast cancer.

Radiating spicules with no central mass.

- Calcifications.

## DOCUMENTATION

### KEY FACTS

- History forms (written or computer based) are helpful and should accompany mammographic studies.

  Part of medical record.

  Medico-legal document.
- Section for patient.

  Suggest limiting questions to those of immediate clinical relevance and that can be verified (e.g., age of menarche, is not something that can be verified independently and recollection is often inaccurate).

  Is there an area of concern to the patient (e.g., "lump" focal tenderness, skin dimpling)?

  Does the patient have spontaneous nipple discharge?

  Is there a history of breast biopsy or other breast related procedure (e.g., augmentation, reduction mammoplasty)?

  Is there a history of breast cancer (personal or first-degree relative)?

  If the patient has had breast cancer, when was it diagnosed and what treatment did she undergo?

  Current medications.

  Current hormone use (include tamoxifen and raloxifene).
- Section for documentation by technologist.

  Technologists should be trained on documentation and the need to be specific.

  A brief, succinct description of any untoward event should be provided.

  Direct quotes from the patient should be used as much as possible.

  No accusatory, judgmental or inflammatory statements.

  Consider having a diagram of the breasts for the technologists to indicate areas of tenderness, palpable mass, prior biopsy, and skin lesions.

  Technologist should specifically review questions related to the presence of breast related symptoms and this should be documented.

  Check off boxes for the technologist to document answers to standard questions on breast related symptoms, or depending on the individual practice, issues such as did the patient tolerate the study?

  Was the patient provided information regarding the possibility of a call back for a diagnostic study?

  Was the patient provided an opportunity to learn about breast self-examination?

  The initials of the technologist involved should be on the form.

- Section for documentation by the radiologist.
  Findings on physical examination: this can also be done using breast diagrams.
  Recommendations made to the patient.
  Communications with referring physicians (time and date).
  Communications with patients (e.g., follow-up phone calls from the patient or follow-up phones calls after imaging guided biopsies).
- The importance of accurate documentation cannot be overstated.

## Patient Notification Letters

### Key Facts

- Required under MQSA for all mammographic studies.
- Under MQSA, all mammographic study results and recommendations must be conveyed to patients in writing using lay language.
- Forms with check off boxes can be used.
- If studies are interpreted while the patient is still in the department, the notification can be handed to the patient directly.
- If screening studies are batch interpreted, notification letters should be mailed within 30 days of study.

### SUGGESTED READINGS

American College of Radiology. *Breast Imaging Reporting and Data System (BI-RADS)*. 4th ed. Reston: American College of Radiology; 2003.

Orsi CJ. Use of the American College of Radiology breast imaging and data system. *RSNA Categorical Course in Breast Imaging Syllabus*. 1995; 77–80.

Orsi CJ, Kopans DB. Mammographic feature analysis. *Semin Roentgenology*. 1993;28:204–230.

CHAPTER 19

# MAMMOGRAPHY AUDIT

## General Concepts

### Key Facts

- Data collection and analysis aimed at evaluating the accuracy of mammography and mammographic interpretation.

  Know statutes governing discovery of records in your particular state before disseminating results; advisable to maintain results as internal audits.
- Why are women screened for breast cancer with mammography?

  Early detection of breast cancer can lead to decreases in breast cancer mortality rates.

  Cancer detection rate and sensitivity: mammography must demonstrate and, we need to detect, a large enough percentage of the breast cancers that exist in the population.

  Rate of minimal, node-negative and node-positive breast cancers detected: the effectiveness of mammography is related to early detection and good prognostic characteristics for the detected breast cancers.
- What does it take to detect breast cancer with mammography?

  Amount of imaging required: recall rates (in finding breast cancers the number of call backs and additional imaging studies done should be kept to a minimum).

  How many biopsies for mammographically detected, clinically occult lesions are recommended (vs. biopsies done) per breast cancer detected? The positive predictive value (PPV) of breast biopsy recommendations is the number of biopsies recommended (vs. biopsies actually done) relative to the number of cancers found.
- Raw data.

  Patient demographics (age, breast cancer history, hormone replacement therapy, previous biopsy, proven high-risk lesions [atypical ductal hyperplasia, lobular neoplasia/LCIS]).

  Audit period dates.

Number of screening studies (asymptomatic women).

Number of diagnostic studies.

Number of first time screens versus number of repeat screens.

Number of recalls (BI-RADS category 0).

Number of biopsy recommendations (BI-RADS categories 4 and 5).

Number of short-interval follow-up recommendations (BI-RADS category 3).

Biopsy results: benign or malignant (track surgical biopsy results separately from needle biopsy and fine-needle aspiration results).

Pathologic tumor staging (tumor size, nodal status, histologic type, and grade).

- Derived data.

  Number of true positives (TP), false positives (FP), false negatives (FN), and true negatives (TN).

  Cancer detection rate.

  Percentage of stage 0, stage 1, and minimal breast cancers detected.

  Percentage of node-positive breast cancer detected.

  Recall rate.

  Prevalent versus incident breast cancer rates.

- When reviewing reports on audit results, be sure that what was done and calculated is defined precisely: some of these terms may be defined differently by different investigators.

## DEFINITIONS

### KEY FACTS

- True positives (TP).

  Breast cancer diagnosed within 1 year after a biopsy is recommended for an abnormal mammogram (BI-RADS categories 4 and 5).

  Required under Mammography Quality Standards Act (MQSA).

- True negatives (TN).

  No known breast cancer diagnosis within 1 year of a normal mammogram (BI-RADS categories 1, 2, 3).

- False negatives (FN).

  Breast cancer diagnosis within 1 year of a normal mammogram (BI-RADS categories 1, 2, 3).

  Probably the least accessible number in an audit. If patients move out of the area or are managed at another institution, the finding of breast cancer may not be communicated to the original institution.

  Under MQSA known FN results must be reviewed for cause.

- False positive (FP).

  Several definitions, so be specific when using.

  FP1: no breast cancer diagnosis within 1 year of an abnormal screening mammogram (recall or biopsy recommendation; BI-RADS categories 0, 4, and 5).

  FP2: no breast cancer diagnosis within 1 year after a biopsy is recommended for an abnormal mammogram.

FP3: biopsy with benign findings within 1 year of a biopsy recommendation for an abnormal mammogram (BI-RADS categories 4 and 5).

Under MQSA, attempts to identify all FP3 results are required.

- Sensitivity.

  Probability of detecting breast cancer when cancer is present (TP/[TP + FN]); how accurate is mammography at detecting breast cancer?
- Specificity.

  Probability of a normal mammogram when no breast cancer exists (TN/[FP + TN]); how accurate is mammography in determining the absence of breast cancer?

  Varies depending on the definition of FP used; the variation, however, is not significant because TN is usually a much larger number than FP.
- Positive predictive value (PPV).

  Several definitions depending on definition of FP used.

  PPV of abnormal findings at screening (PPV 1): percentage of screening studies with abnormal findings (BI-RADS categories 0, 3, 4, and 5) that result in a diagnosis of breast cancer (TP/[TP + FP1]).

  PPV of biopsy recommendations (PPV 2): percentage of patients recommended for biopsy (BI-RADS categories 4 and 5) that resulted in a diagnosis of breast cancer (TP/[TP + FP2]).

  PPV of biopsies done (PPV 3): percentage of all known biopsies done that resulted in the diagnosis of breast cancer (TP/[TP + FP3]); positive biopsy rate.
- Breast cancer detection rate.

  Number of breast cancers found per 1,000 patients examined with mammography.
- Minimal breast cancer.

  Invasive carcinomas 1 cm or less in size or ductal carcinoma in situ.
- Interval breast cancers.

  Breast cancers that become clinically apparent after a negative mammogram but before the next screening mammogram.
- Under MQSA.

  BI-RADS categories 4 and 5 must be tracked (TP and FP results).

  Obtaining FN results is requested but not mandated.

  Lead physician required to oversee QA process including an audit at least yearly (for practice and each interpreting physician) and corrective actions as needed.

## GOALS

### KEY FACTS

- Sensitivity of mammography.

  Should exceed 85%.

  Hard to calculate because in most practice settings, an accurate FN rate is difficult to obtain.

Access to tumor registry helps determine FN results.

- PPV.
  Related directly to the age of the patients in the population being screened.
  Usually varies directly with tumor size.
  Varies depending on the definition of PPV used.
  Range for PPV2 = 25% to 40%.
  For screening facilities, PPV 1 should be used; range for PPV1 = 5% to 10%.
- Tumor size.
  Varies depending on the ratio of screening to diagnostic studies.
  More than 50% of tumors diagnosed by mammography are stage 0 or 1.
  More than 30% of mammographically detected breast cancers are minimal.
- Node positive breast cancers.
  Tumor size should be correlated with positive lymph nodes.
  Less than 25% of screen-detected breast cancers should be node-positive.
- Cancer detection rate.
  Should be calculated for asymptomatic patients (screening population).
  Varies depending on prevalence versus incidence.
  Varies depending on the ages of the patients in the population being screened; breast cancer incidence increases with advancing age.
  Incidence of breast cancer among patients screened for the first time: 6 to 10 cancers in 1,000 women.
  Incidence of breast cancer among repeat screeners: 2 to 4 cancers in 1,000 women.
- Recall rate.
  May decrease directly with experience of mammographer.
  Varies depending on number of first-time screens versus repeat screens.
  Cost-effectiveness and credibility of mammography will be questioned if recall rate is too high; 10% or less has been reported.
- Specificity.
  Must know all TN results, which in turn requires knowing FN results (least accessible number in audit).
  Greater than 90%.

## Benefits of Auditing

### Key Facts

- Measures the success of a mammography program and that of each mammographer in finding breast cancer.
- Invaluable teaching and learning tool.
- Identification of FN studies: review of FN results may lead to an understanding of how these can be avoided in the future (continuous quality improvement).
- Outcome analysis that can be used at the local and national levels.

- If benefit is demonstrated, may improve compliance of referring physicians and patients.
- Calculation of costs per patient screened.
- Medicolegal: a radiologist's profile may be helpful in demonstrating the appropriateness of the steps taken (e.g., follow-up of lesions with a low likelihood of malignancy vs. biopsy).

## SUGGESTED READINGS

Dee KE, Sickles EA. Medical audit of diagnostic mammography examinations: comparison with screening outcomes obtained concurrently. *AJR Am J Roentgenol*. 2001;176:729–733.

Linver MN. Plaudits for audits: the whys, wherefores and therefores. In: Breast Imaging Categorical Course Syllabus. Presented at: the 99th Annual meeting of the American Roentgen Ray Society; May 9–14, 1999; New Orleans, LA.

Linver MN, Osuch JR, Brenner RJ, et al. The mammography audit: a primer for the Mammography Quality Standards Act (MQSA). *AJR Am J Roentgenol*. 1995;165:19–25.

Sickles EA. Auditing your practice. *RSNA Syllabus Categorical Course in Breast Imaging*. 1995:81–91.

Sickles EA. Quality assurance: how to audit your own mammography practice. *Radiol Clin North Am*. 1992;30:265–275.

Sohlich RE, Sickles EA, Burnside ES, et al. Interpreting data from audits when screening and diagnostic mammography outcomes are combined. *AJR Am J Roentgenol*. 2002;178:681–686.

# INDEX