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Breast Masses: Mammographic Evaluation[1]

MAMMOGRAPHY frequently demonstrates masses within the breast, in both symptomatic and asymptomatic women. Occasionally, these masses have characteristically benign radiographic features, causing little difficulty in diagnosis. Even less commonly, masses may demonstrate typically malignant mammographic features that are just as easy to recognize as their clearly benign counterparts. However, most masses exhibit at least some image properties intermediate between benign and malignant, thereby prompting indeterminate mammographic interpretations and leading to further, often invasive diagnostic procedures. Some radiologists are considerably more successful than others in differentiating benign from malignant masses.

The purpose of this article is to provide a systematic and practical approach to the imaging evaluation of noncalcified breast masses. The reader is encouraged to interpret each mass in the step-by-step manner indicated in the text that follows: Establish the presence of a mass and then evaluate its size, location, density, shape, clarity of margins, and interval change.

To a great extent this problem-solving process requires additional images to supplement the standard craniocaudal and side views taken of each breast. Dedicated mammography equipment, especially when used with vigorous breast compression, substantially enhances the radiologist's ability to make more definitive interpretations (1,2), as do the capability to produce fine-detail spot compression magnification mammograms and the interpretive skill to utilize the additional radiographic information provided by these high-resolution images (3,4).

Index terms: Breast, diseases, 00.48, 00.71, 00.72, 00.74 • Breast neoplasms, diagnosis, 00.31, 00.32 • Breast radiography, 00.11 • State-of-Art reviews

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SYSTEMATIC ANALYSIS OF BREAST MASSES

Differentiation of True Masses from Masslike Findings

The first step in any evaluation of breast masses is to define exactly what does and does not constitute a mass, to distinguish true masses both from (benign) asymmetric areas of increased density and from summation shadows produced by fortuitous superimposition of normal fibrous and glandular structures. Masses have an outwardly convex contour, are at least as dense centrally as at the periphery, and are demonstrated on at least two different mammographic projections, preferably orthogonal views. In contradistinction, asymmetric densities characteristically have scalloped concave contours and are interspersed with fatty elements (5,6), while summation shadows cannot be visualized on more than one projection, even with only minor degrees of variation in x-ray beam obliquity (2,7).

Size

The size of a breast mass as measured with mammography is not particularly helpful in predicting either benign or malignant origin, because benign masses substantially outnumber cancers for lesions of all sizes. However, there is a clear trend toward detection of smaller and smaller breast cancers. In the 1970s fewer than 10% of cancers detected at the University of California San Francisco (UCSF) Medical Center were smaller than 1 cm, but since 1985 the median size of screening-detected malignancies has decreased to 1.2 cm and fewer than 20% of our cancers are 2 cm or larger.

The size of a mass does have considerable impact on its subsequent management. For a large mass, especially one greater than 2–3 cm, aspiration or biopsy probably will be done independent of mammographic features, simply because of the increased likelihood that it will be palpable and that the findings of physical examination themselves will prompt a further invasive diagnostic procedure. Similarly, for a small mass, ultrasound (US) examination may not be undertaken even if it otherwise would be indicated, principally because very small nonpalpable lesions often are missed using handheld US units. The smallest size amenable to sonographic study varies from 0.5 cm to 1 cm, depending on the US equipment, the skill of the examiner, the location of the mass (deeper lesions are harder to identify), and the amount of time one is willing to allot for sonographic detection of a mass. There also is a lower limit in size below which most radiologists totally discount the importance of a mass with benign-appearing mammographic characteristics. This limit usually ranges from 0.5 cm to 1 cm, based primarily on one's own personal definition of what constitutes "benign-appearing" features. In establishing such a definition, each radiologist must weigh the opportunity to detect well-circumscribed cancers when they are very small against the morbidity and expense involved in further evaluating lesions for which the likelihood of malignancy is extremely low.

Biopsy Results as a Function of Quadrant Location for Mammographically Visible Noncalcified Masses

Location[†]	Benign	Premalignant[‡]	Malignant[§]
Upper outer	152 (54)	14 (48)	91 (52)
Upper inner	40 (14)	6 (21)	26 (15)
Lower outer	28 (10)	3 (10)	19 (11)
Lower inner	21 (7)	1 (3)	14 (8)
Retroareolar	41 (15)	5 (17)	25 (14)

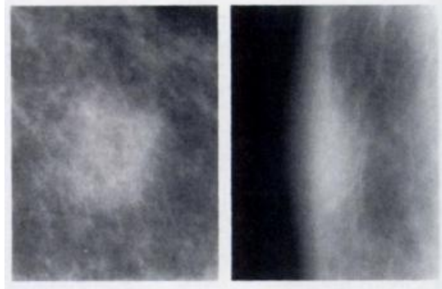
Source.—Data from all UCSF mammography examinations, both symptomatic and asymptomatic women, 1985–1988.

Note.—Numbers in parentheses are percentages.

† Lesion location determined by retrospective review of mammograms. Lesions situated exactly between quadrants allocated half and half to each quadrant. Retroareolar location = more than half of lesion within areolar margins.

‡ Premalignant = lobular carcinoma in situ, epithelial hyperplasia with cellular atypia.

§ Malignant = ductal carcinoma in situ, all invasive carcinomas.



a. b.

Figure 1. Skin lesion mimicking intramammary mass. Diagnosis: infected epidermal inclusion cyst. **(a)** Craniocaudal projection demonstrates poorly defined mass overlying breast parenchyma. There were similar findings on lateral projection (not shown). **(b)** Tangential view of mass indicates its dermal location, thereby eliminating mammographic suspicion of malignancy.

Location

Just as is observed for lesion size, the location of a breast mass usually is not helpful in differentiating benignity from malignancy. Radiologists generally are familiar with the frequency distribution of breast cancers by quadrant location, most common in the upper outer quadrant and least common in the lower inner quadrant (8,9). Less well known are the parallel data for mammographically detectable benign masses, which show an identical quadrant distribution (Table). It may well be that the tendency for both benign and malignant masses to predominate in the upper outer quadrant is due to the disproportionately large amount of residual glandular tissue in that quadrant among women above age 35–40.

Even if quadrant location is not a reliable predictor of the nature of a mass, the location of a mass can be used to guide mammographic decisions in several specific circumstances. First, any mass shown to be located within the skin will not be a primary breast carcinoma. Because skin lesions may project over parenchymal tissues on both of the standard mammographic views (10,11), the radiologist should obtain an additional tangential view of any potentially superficial mass before indicating mammographic suspicion of malignancy (Fig 1). Second, lesion location is important in the mammographic diagnosis of intramammary lymph nodes. Although intramammary nodes are found histologically throughout the breast, virtually all nodes large enough to be visualized with mammography are located in the outer half of the upper outer quadrant (12,13). Therefore, the confident radiographic diagnosis of such a lesion should not be made unless it conforms to this location. Finally, the location of some palpable breast masses may indicate the need for additional mammography. If a palpable lesion is located so peripherally as not to be included on either standard mammographic view, then one must obtain exaggerated craniocaudal, alternative oblique, or "lumpogram" projections to image it satisfactorily (2,7).

Density

Breast masses may be classified by density into either fat, water (fibroglandular tissue), or mixed-density categories. This is an important distinction since virtually all malignant breast masses are of water density, and therefore, any fat or mixed-density mass can be considered benign.

A completely fatty mass surrounded by water-density tissue will be recognized by its relatively lower density and convex margins, whereas when enveloped by fatty tissue such a mass will be identified if its thin fibrous "capsule" is imaged (Fig 2). The differential diagnosis of fat-density masses includes lipoma, fat necrosis, galactocele, and focal collection of normal breast fat that simulates a mass on mammograms. There is no clinical significance in differentiating among these benign lesions, so biopsy is not necessary for the purpose of tissue diagnosis and follow-up is not needed to assess for possible interval change (14–16). However, as an academic exercise, one can often suggest the correct histologic diagnosis: Large (greater than 2-cm) masses tend to be lipomas, the lipid-containing cysts of fat necrosis often are seen at sites of prior surgery or trauma, and galactoceles usually occur during or shortly after lactation.

Mixed-density masses contain both fat and water-density elements. One such lesion is the hamartoma, otherwise known as lipofibroadenoma or fibroadenolipoma (Fig 3). Radiographic diagnosis of this benign lesion requires demonstration of a thin "capsule" at the edge of the mass, permitting one to appreciate that it contains not only water-density but also fatty components (4,17–20). The other, much more commonly en-

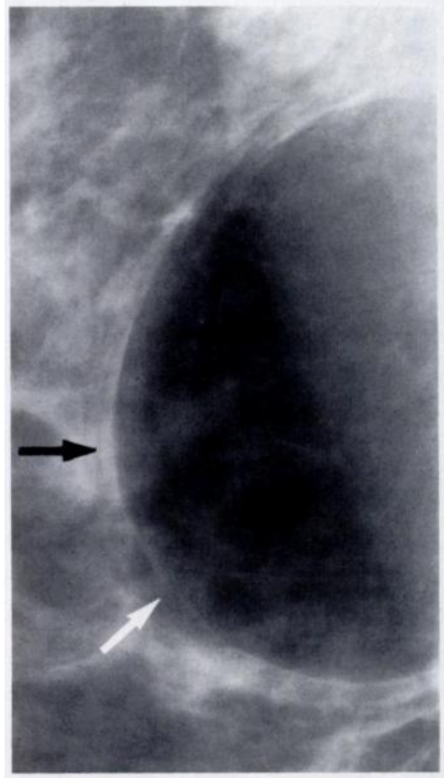


Figure 2. Fat density mass. Diagnosis: lipoma. Thin radiodense "capsule" is readily visible where fatty tissue is immediately adjacent to mass (white arrow). "Capsule" not seen where dense tissue is adjacent to mass (black arrow).

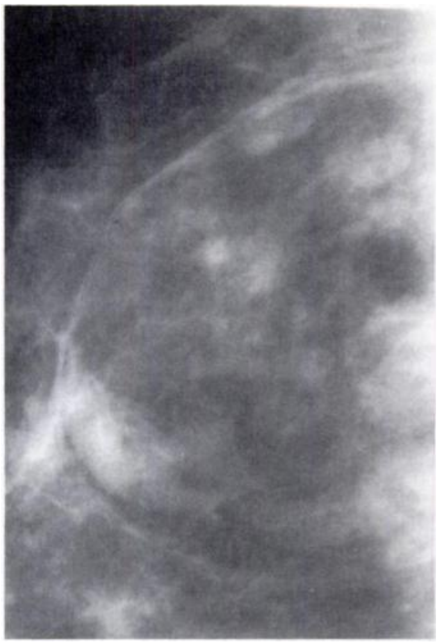
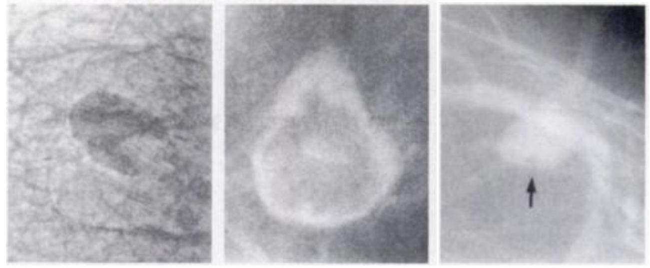


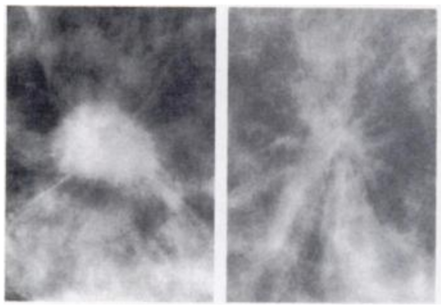
Figure 3. Mixed-density mass. Diagnosis: hamartoma. Note thin radiodense "capsule" demonstrating borders of mass, thereby indicating that it contains fat as well as water-density elements.



a. b. c.

Figure 4. Mixed density masses. Diagnosis: intramammary lymph nodes. **(a)** Fatty hilus imaged tangentially, showing defect in contour of mass. **(b)** Fatty hilus imaged en face, showing central lucency. **(c)** Smallest mammographically visible fatty hilus (arrow) will be recognized only if imaged tangentially.

Figure 5. Water-density mass. Diagnosis: infiltrating duct carcinoma. Cancer (arrow) appears more dense than other water-density structures of similar size.



a. b.

Figure 6. Stellate masses. **(a)** Note dense central area, irregular contour, and numerous fine spiculations radiating out from mass, representing typical mammographic features of malignancy. Diagnosis: infiltrating duct carcinoma. **(b)** Note relative lack of central density and several *radiolucent* lines radiating out from center of mass. Diagnosis: radial scar.

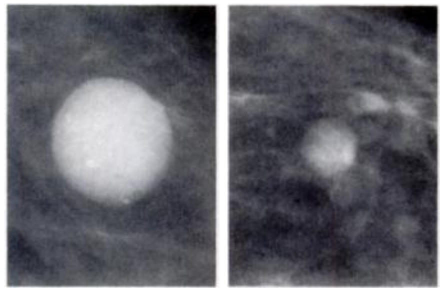
countered, mixed-density mass is the intramammary lymph node. This ovoid or kidney-shaped lesion characteristically displays a radiolucent component of variable size, indicating fatty replacement at its hilus (1,4,13–15,19,21). Demonstration of the fatty hilus is crucial to mammographic diagnosis; the hilus will be seen as a contour defect if imaged tangentially, or as a central lucency if imaged en face (Fig 4). Intramammary nodes, like all other lymph nodes, undergo changes in response to infection, inflammation, or neoplasm. Independent of the underlying cause, the pathologic intramammary node loses its characteristically benign mammographic appearance, becoming more rounded in contour, enlarging beyond 1 cm, and no longer displaying a radiolucent hilus (1).

Water-density masses account for the remainder, and the vast majority, of breast masses. The main differential diagnosis for these lesions involves cyst, fibroadenoma, and carcinoma. When possible, mammographic differentiation is based primarily on those radiographic features discussed later in this article. However, assessment of density can also be helpful occasionally, since some breast cancers appear to be slightly more dense than adjacent areas of fibroglandular tissue, whereas most benign lesions do not (1,4,6,9,19,21) (Fig 5). This observation cannot be explained on the basis of inherently increased density within breast cancer; assessment with computed tomography has demonstrated lack of meaningful difference in x-ray attenuation between benign and malignant water-density tissue (22,23). Rather, the increased density of some malignancies is much more apparent than real, probably resulting from the fact that these cancers contain disproportionately large amounts of sclerotic and fibrous elements (21), causing them to flatten out to a lesser degree when vigorous breast compression is applied (9). The less compressible carcinoma therefore retains greater thickness during mammographic imaging, thereby stopping more x-ray photons and appearing to be denser than adjacent benign tissues. Note that visualization of this subtle difference in apparent density requires the use of a high-contrast screen-film recording system (1,9), vigorous breast compression (6,9), and comparison of breast structures that are approximately equal in volume (21).

Shape

Some breast masses have characteristically benign or malignant shapes. The typical cancerous mass has a stellate or starburst appearance, with an irregular contour often accompanied by fine linear strands (spiculations) radiating out from the edges of the mass (Fig 6a). Most masses with these mammographic features prove to be malignant, but not infrequently a benign lesion will also appear in a similar fashion (1,4,6,19,24), emphasizing the need to establish a tissue diagnosis of malignancy before definitive cancer treatment is begun (6). The most common benign stellate mass is caused by scarring from prior biopsy, but the differential diagnosis also includes radial scar, fat necrosis, abscess, hematoma, and any other mass that contains substantial areas of fibrosis. Careful analysis of accompanying mammographic features may allow the radiologist to suggest one of these benign entities. For example, the radial scar usually lacks central density and has thin radiolucent lines radiating out from its middle (Fig 6b). Past or present medical history and correlative physical findings also may prove helpful, in that prior biopsy at the site of the stellate mass suggests fat necrosis, prior trauma and accompanying ecchymosis favors hematoma, and recent onset of pain, tenderness, and overlying erythema increases the likelihood of abscess. However, as a rule, none of these benign lesions can be distinguished from malignancy with sufficient reliability to avert biopsy (1,4,6,24). On occasion, if clinical suspicion of hematoma or abscess is high, repeat mammography after 1 month may be ordered to document the expected disappearance or substantial resolution of the lesion (4). Also, a stellate mass thought to represent scarring at a *recent* biopsy site may be followed mammographically to demonstrate stability or partial resolution (4,24).

The typical benign mass has a very different mammographic appearance, showing smooth contours and a round or ovoid shape (Fig 7). The great majority of these lesions are cysts or fibroadenomas, but many other solid tumors can also display similar radiographic findings. Occasionally, even a well-circumscribed carcinoma may have a characteristically benign appearance, at least on conventional mammograms (1,4,24). This observation has great significance, since it suggests that the mammographic features of a (water-density) mass should not be the only indicator used to arrive at a benign diagnosis (6). If such a mass is palpable, the findings of physical examination are important and traditionally take precedence in guiding subsequent management should they raise the suspicion of malignancy. On the other hand, when physical findings are benign or normal, the likelihood of carcinoma is very low, probably in the range of 1%–2% (25,26). For these lesions, several additional procedures are available to distinguish solid and complex masses from simple cysts. Palpable masses often undergo aspiration with or without cytologic analysis and/or pneumocystography,



a. b.

Figure 7. Masses with smooth round contour, suggesting benign nature. **(a)** 1.5-cm mass, containing few calcifications. Diagnosis: fibroadenoma. **(b)** 0.5-cm noncalcified mass. Diagnosis: simple cyst, established with US examination.

Figure 8. Mass with indeterminate features by analysis of shape. Some margins are smooth and rounded (arrows), while others are irregular. Diagnosis: infiltrating duct carcinoma.

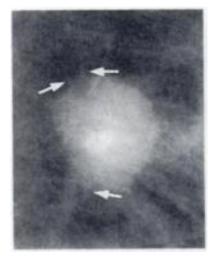


Figure 9. Mass with generally smooth rounded contour, which on close inspection displays few fine radiating spiculations (arrows). Diagnosis: infiltrating duct carcinoma. Medullary and mucinous (colloid) carcinoma often have similar mammographic appearance.

while nonpalpable lesions frequently are examined with US (1,4,6,21,27,28). Uncomplicated cysts do not require further evaluation for purposes of tissue diagnosis, since they always are benign (6). The management of solid benign-appearing masses usually involves periodic clinical and mammographic follow-up rather than biopsy (6,29).

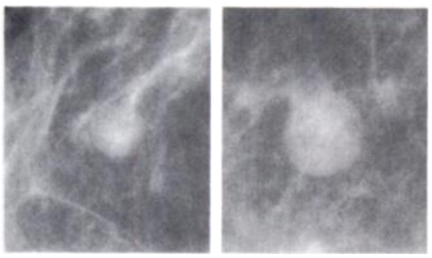
Most mammographically visible masses cannot be classified with confidence into either a typically malignant or benign category. Many of these lesions simply are irregular in shape. Any deformity in contour should prompt further evaluation, even if other portions of the mass have typically benign features (Fig 8). A wide variety of additional mammographic techniques can be applied. Even the most smooth and rounded of carcinomas demonstrate some irregularities in contour on fine-detail images (1,21,24), especially if spot compression magnification technique is utilized (Fig 9).

The presence of lobulations within a mass often complicates interpretation. In general, the likelihood of malignancy increases as does the number of lobulations. Multinodular (knobby) masses frequently prove to be invasive duct carcinomas (Fig 10); these lesions should always undergo biopsy (21). On the other hand, the majority of nodular masses represent fibroadenomas that have only one or two gentle lobulations, often not raising sufficient radiographic suspicion of malignancy to trigger biopsy (4,21). An uncommon lobulated tumor is the cystosarcoma phyllodes (giant fibroadenoma), notable mammographically for its very pronounced although not too numerous lobulations. This potentially malignant lesion usually undergoes biopsy not only because of its prominent lobulations but also due to its large size.

Clarity of Margins

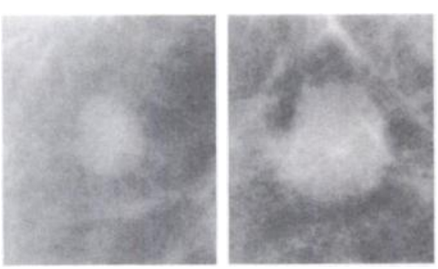
Breast masses also may be classified according to the sharpness with which their margins are visible on mammograms. Such an analysis provides still another parameter to assist in radiographic diagnosis, because benign masses typically have very sharply defined margins (Fig 7), whereas the edges of most breast cancers are poorly defined (Fig 6a). However, many masses display border characteristics intermediate between those that can confidently be evaluated as benign or malignant. Commonly, a benign mass is found adjacent to areas of normal fibroglandular breast tissue, so that, although some of its margins are seen to be very well defined, others are obscured by the adjacent isodense tissue (Fig 11). This usually confounds mammographic interpretation, resulting in an equivocal or indetermi-

Figure 10. Mass with multiple small lobulations, prompting mammographic suspicion of malignancy. Diagnosis: infiltrating duct carcinoma.



a. b.

Figure 13. Water-density mass. **(a)** Conventional mammogram shows somewhat ill-defined margins, suggesting equivocal mammographic interpretation. **(b)** Spot compression magnification mammogram shows margins to be much more sharply defined and contour to be smooth and round, indicating benign mammographic interpretation. Diagnosis: benign, established by lack of interval change on subsequent screening mammograms over 7-year period.



a. b.

Figure 14. Water-density mass. **(a)** Conventional mammogram shows sharply defined margins and smooth contour, except from 8 o'clock to 9 o'clock position, suggesting equivocal mammographic interpretation. **(b)** Spot compression magnification mammogram shows margins to be much less well defined and contour to be much more irregular, indicating increased mammographic suspicion of malignancy. Diagnosis: infiltrating duct carcinoma.

Figure 11. Mass with sharply defined margins, some of which are obscured by adjacent isodense tissue, making mammographic interpretation more difficult. Diagnosis: fibroadenoma.

nate diagnosis. A supplementary spot compression mammogram may prove helpful in this circumstance if it spreads apart nearby dense structures to reveal all the borders of a mass whose silhouette is partially obscured (7,30).

Several radiologists rely heavily on one aspect of border analysis in justifying selected benign interpretations when portions of the margins of a mass are hidden by adjacent dense tissue. To them, benignity is indicated by the "halo sign," the presence of a thin, 1-mm-wide zone of radiolucency immediately external to some of the edges of the mass (1,19) (Fig 12). While the great majority of masses demonstrating this sign indeed are benign, occasional exceptions compromise its clinical value (4,21,31,32). The halo itself appears to represent a Mach band, an optical illusion of enhanced background contrast seen at any sharply defined interface (21,32). Since portions of the borders of both benign and malignant masses can be very well defined, the presence of a peritumoral halo is not pathognomonic for benign lesions (21,31,32).

With the current trend toward expanded utilization of mammography to screen asymptomatic women, we are encountering an increasing proportion of cancerous masses that display less than the fully characteristic radiographic features of malignancy

Figure 12. Mass demonstrating "halo sign." Note thin radiolucent band (arrow) immediately external to one part of border of mass. Diagnosis: fibroadenoma.

(33). As a result, most cancers now do not appear as spiculated masses but simply as nondescript lesions having poorly defined margins or irregular contour. Especially with such indeterminate findings, assessment of the marginal clarity of a given mass should be based on images of the finest detail available. The combination of spot compression and magnification techniques usually is preferred (2,7), permitting definitive interpretation for many benign and malignant masses that otherwise would receive equivocal readings (Figs 13, 14).

Interval Change

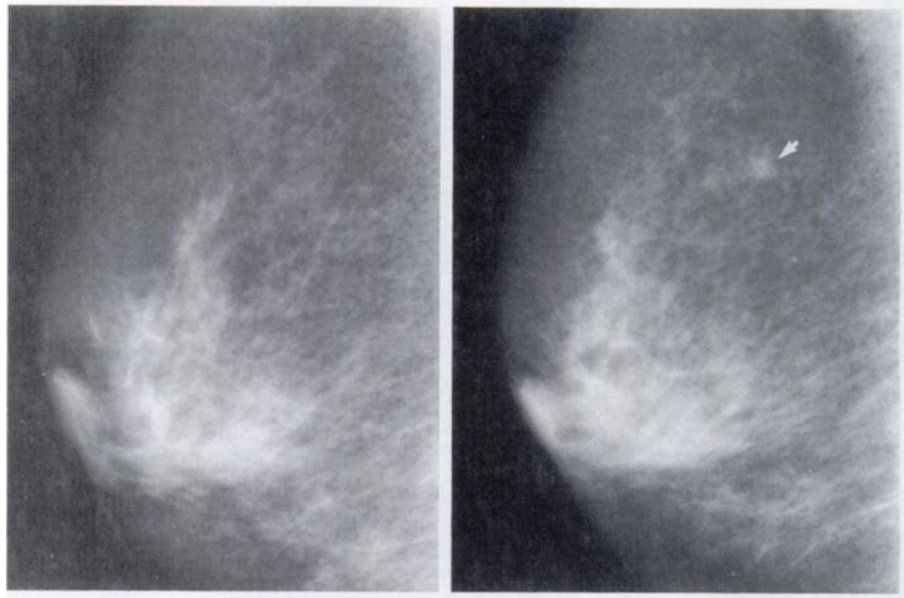
Reasonable attempts should be made to locate and obtain prior mammograms for comparison if a current examination indicates the presence of a mass. The demonstration of mammographic stability reduces the likelihood of malignancy, substantially so if the interval between studies spans several years. Under these circumstances, continued mammographic follow-up usually is the preferred alternative to biopsy. On the other hand, the appearance or growth of a mass after an interval raises some suspicion of malignancy (Fig 15), because the breast is an involuting organ whose natural history involves progressive fatty replacement (34). Indeed, developing densities account for approximately 6% of nonpalpable cancers detected with mammography (33). It is important to realize that the radiographic demonstration of interval change is a nonspecific finding, since benign masses appear de novo and grow just as malignancies do. However, despite the discovery of malignancy in only 10%–15% of such cases (34,35), subsequent management of enlarging masses usually involves prompt performance of further diagnostic procedures (aspiration, US, biopsy) rather than follow-up examinations, because interval change already has occurred (6).

DISCUSSION

In most cases the step-by-step evaluation of the mammographic features of a mass (size, location, density, shape, clarity of margins, interval change) will not give clear-cut indication of benignity or malignancy (1). In fact, for any given mass several of these assessments probably will be indeterminate, perhaps even contradictory. Overall mammographic interpretation involves a synthesis of all these separate analyses, into which one must also factor the findings of physical examination and the woman's breast cancer risk profile (age, personal history of breast cancer, strong family history of breast cancer, etc.) Judicious acquisition of supplementary mammographic images, as described previously, should help convert some initially equivocal interpretations into more definitive radiographic diagnoses.

Not infrequently, several masses will be found on a mammography examination. In the great majority of these cases additional invasive procedures are not indicated, because a multiplicity of (more than two) similar breast lesions argues strongly for benignity (1,4,15,21,36). Indeed, the more masses that are identified, the less chance they represent cancer. The radiologist's task in interpreting such examinations is to seek out the one mass that has mammographic features that differ from the others, and if present, to direct further work-up specifically to the evaluation of this lesion (36). Of course, the possibility of multifocal carcinoma cannot be discounted completely, but discovery of three or more carcinomas with mammography is extremely unusual. If multiple masses having malignant radiographic features are encountered, biopsy of the largest or otherwise most suspicious lesion usually will be done first, with management of the others deferred until a histologic diagnosis is obtained. Much more commonly, multiple masses will display primarily but not entirely benign mammographic features, since portions of their margins probably will be obscured either by each other or by coexisting dense fibroglandular tissue. However, unlike the parallel situation for one or two such lesions, aspiration or US examination often will *not* be done for multiple masses. It is difficult and time-consuming to identify each individual mass, and frequently not all of them are found to be simple benign cysts, resulting in the dilemma of having to decide which of the several mammographic masses represents the solid tumor that may require prompt tissue diagnosis. A more prudent approach to the management of multiple "probably benign" masses is periodic mammographic follow-up to determine whether one of the masses changes disproportionately in comparison with the others (15). One should also remember to add metastases to the differential diagnosis of such lesions, especially if there is a prior history of melanoma, lymphoma, or leukemia (4,37,38).

It is beyond the scope of this article to discuss the evaluation of masses that contain calcifications. Suffice it to say that some calcified masses are characteristically benign (degenerating fibroadenomas, calcified hematomas, and calcified lipid-containing cysts of fat necrosis), while others are highly suggestive of malignancy (tiny clustered linear, curvilinear, or branching calcifications within any mass) (11).



a. b.

Figure 15. Water-density mass showing interval change. **(a)** Normal baseline mammogram. **(b)** Screening mammogram 1 year later demonstrates new 4-mm poorly defined mass (arrow). Diagnosis: infiltrating duct carcinoma.

SUMMARY

The systematic mammographic evaluation of a breast mass involves independent assessments of its size, location, density, shape, clarity of margins, and interval change from prior examination. Additional fine-detail mammograms should be obtained to facilitate this analysis, especially when an equivocal interpretation is planned. Definitively benign masses (those localized to the skin, of fat density, or of mixed density) will not require more attention. Among the remaining water-density lesions, those that have an even slightly stellate appearance should be considered suspicious for malignancy; virtually all of them will undergo biopsy. Well-circumscribed masses should next be evaluated by aspiration or US examination to establish or exclude the diagnosis of simple benign cyst. Only solid and indeterminate lesions will require further evaluation, with the ultimate decision for biopsy versus mammographic follow-up depending on the probability of malignancy determined by the combination of mammographic and physical findings as well as pertinent data from the medical history. ■

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