Many perceptual and interpretive factors influence the radiologic detection and assessment of breast neoplasms. Diagnostic problems can be divided into errors of detection and errors of assessment and management. Detection issues may relate to inherent features of the tumor or surrounding tissue, technical problems, or human error. Even when lesions are successfully detected, errors in assessment or management recommendations can cause diagnostic delays. Improper breast imaging-reporting and data system (BI-RADS) usage or failure to integrate mammographic, ultrasonography (US), and magnetic resonance imaging (MRI) findings with clinical findings, all lead to interpretive errors. This article reviews factors affecting the detection and diagnosis of breast cancer, to improve radiologic interpretation, benefit patients by earlier cancer detection, and lessen medicolegal exposure from a missed or delayed cancer diagnosis. Mammography is the primary imaging modality for population-based breast cancer screening, and it is also the usual initial examination performed for diagnostic evaluation of clinical or screen-detected breast abnormalities in women aged 40 years and older. Mammography is supplemented by breast US and/or breast MRI in some cases. This article will, therefore, focus on mammography in reviewing difficulties and errors in cancer diagnosis, with supplemental discussion of breast US and breast MRI.

Department of Radiology, Breast Imaging Division, Brigham and Women's Hospital, Harvard Medical School, Boston, MA.
Address reprint requests to Catherine S. Giess, MD, Department of Radiology, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115. E-mail: cgiess@partners.org

Detection of Breast Cancer
Mammographic Sensitivity
Early detection of breast cancer by mammographic screening decreases breast cancer mortality.1-4 In analyses of randomized controlled trials evaluating mammographic screening, most reviewers conclude that regular mammographic screening lowers breast cancer mortality by approximately 20%-30% overall, with high reductions in older women and somewhat lower reductions in women <50 years.1-4 However, mammography remains an imperfect test, and it does not detect all breast cancer. The Breast Cancer Detection and Demonstration Project, performed in the mid-1970s, reported mammographic sensitivities of 85%-92% in detecting breast cancer.5 A range of mammographic sensitivities for the detection of breast cancer, from 71% to 96%, were reported by the randomized controlled mammographic screening trials.6 In a predominantly community-based study of the New Hampshire Mammography Network, Poplack et al6 reported overall lower sensitivities of 72.4% for screening mammography and 78.1% for diagnostic mammography. Even lower mammographic sensitivities, on the order of 48%-70%, have been reported for patients with dense breast tissue.7-9

Dense Breast Tissue and the Occult Malignancy
It has long been recognized that breast cancer may be obscured by surrounding dense breast tissue. Both malignant masses and normal breast tissue may have similar densities on mammography. Even a large mass may be occult if there is minimal tumor effect on surrounding normal tissue (Fig. 1). In a study of interval cancers (tumors detected between mammographic screenings), Buist et al10 found that breast density accounted for 67.6% of the decrease in mammographic sensitivity. Similarly, a different study found that mammographic sensitivity for detecting breast cancer was only 30% in extremely dense breast tissue, and that increased breast density was a major risk factor for presenting with an interval breast cancer between screenings.11 Carney et al12 studied more than 300,000 women from 7 population-based mammography registries in the United States, reporting mammographic sensitivity for detecting breast cancer to be
only 62.9% in women with very dense breasts. The American College of Radiology Imaging Network (ACRIN) trial compared digital mammography with film-screen mammography and demonstrated improved sensitivity for cancer detection with digital technique in women with dense breasts and younger, pre- and perimenopausal women. However, even in that study, the sensitivity of digital screening mammography in detecting cancer in women with dense breasts was only 70%, compared with 55% sensitivity with film-screen technique. Others have reported even lower mammographic sensitivities for cancer detection in heterogeneously dense or extremely dense tissue, in the range of 50%.7,9

The poor sensitivity of mammography in depicting breast cancer in dense breasts has generated much interest in additional breast imaging modalities. In the diagnostic setting, evaluating clinical or mammographic findings, the addition of a targeted ultrasonography (US) examination to diagnostic mammography has proven helpful in improving cancer detection. In a study by Zonderland et al, targeted US of a clinical or mammographic abnormality was reported to increase diagnostic accuracy by 7.4% over mammography alone. In their study, 12 symptomatic cancers had mammograms that were prospectively considered negative, but targeted USs demonstrated suspicious findings. Another 13 cancers had mammographic findings considered probably benign, but adding a targeted US increased the level of suspicion and led appropriately to biopsy. Similarly, a different group of investigators from the Netherlands reported a 5.4% increase in sensitivity of cancer detection with the addition of US, although that study contained both asymptomatic screening patients as well as diagnostic patients with clinical or imaging findings. Skaane reported a prospective trial evaluating the addition of US to mammography in evaluating malignant masses and found that US upgraded 10% of malignancies with benign or indeterminate mammographic features. Many of the limitations of diagnostic mammography in cancer detection, particularly in the setting of dense breast tissue, can be addressed with diagnostic US. The addition of targeted US to diagnostic mammography is thus the current standard of care in the evaluation of focal mammographic or clinical findings.

Additional Screening Modalities

Whole-Breast US

More recently, there has been scientific interest in using breast US as a screening tool to detect neoplasms that are otherwise mammographically or clinically occult. In this context, breast US is performed as a bilateral, whole-breast examination with a hand-held transducer. In single institution studies, in which reviewers were not blinded to the screening mammogram results, cancer detection rates ranged from 0.3% to 0.46%, a rate comparable with the cancer detection rate of screening mammography.7,16-19 Subsequently in 2008, Berg et al published the results of the ACRIN trial evaluating the addition of whole-breast screening US to that of screening mammography in women at elevated risk for developing breast cancer who had dense breast tissue, demonstrating a US-only cancer detection rate of 4.2/1000. That study had several advantages over earlier work—it was multiinstitutional, and radiologists performing whole-breast US were blinded to the mammography results, thereby eliminating potential bias from equivocal or low suspicion mammographic findings. Although these additional cancer detection rates from screening whole-breast US are promising, researchers also reported that 4.4%-9.5% of USs had findings requiring follow-up or intervention.7,9,16-19 Positive biopsy rates (number of malignancies found per needle intervention) ranged from 7.9% to 11.8% in most of these studies. Crystal et al reported a higher biopsy rate of 18%, but those
authors placed probably benign masses and cysts with internal echoes or septations into surveillance rather than subjecting them to biopsy. These low positive biopsy rates compare poorly with the 25%-40% positive biopsy rate recommended for mammographic findings by the American College of Radiology. Thus, to date, screening whole-breast US, while able to detect small cancers not evident by mammography or clinical breast examination, generates many unnecessary benign biopsies and aspirations. Nearly all the published studies used diagnostic radiologists to perform whole-breast US; one study used a trained US technologist with comparable results. High-quality breast US, especially in the screening setting, is both labor intensive and operator dependent. There is concern that there may be insufficient numbers of trained breast imaging specialists to perform widespread screening breast US. Finally, no randomized controlled trial of screening whole-breast US has been done to evaluate its impact on breast cancer mortality. These issues will need to be addressed with further work to successfully apply screening whole-breast US to a wider clinical setting.

Screening Breast Magnetic Resonance Imaging

The diminished sensitivity of mammography in women with dense breasts has focused research on using screening breast magnetic resonance imaging (MRI) to detect cancer in women at elevated risk of developing breast cancer. The detection of breast cancer with screening MRI in high-risk women has been reported at 3%, which is 10 times higher than the detection rate of mammography in the normal risk population. Although the sensitivity of MRI is higher than mammography with or without US, its specificity is variable, as is the callback rate and the benign biopsy rate. In 2007, the American Cancer Society published guidelines for performing screening breast MRI in women at elevated risk of developing breast cancer. Annual screening breast MRI is recommended for BRCA genetic mutation carriers or first-degree relatives of BRCA mutation carriers with unknown personal mutation status, patients with >20% lifetime risk of breast cancer based on statistical models, those with a history of mantle radiation between 10 and 30 years, and women with Li-Fraumeni, Cowden, Bannayan–Riley–Ruvalcaba syndromes or their first-degree relatives. Women at normal lifetime risk are not recommended to undergo screening MRI because of the variable specificity of MRI and the lower prevalence of disease in this population compared with high-risk women.

Although MRI has high sensitivity, malignancies may go undetected by that modality as well. Several authors have analyzed false-negative MRI studies. In those studies, reasons for false-negative MRI included technical factors such as inadequate contrast administration or suboptimal timing of contrast, location of lesion near the edge of field of view or the breast coil, and artifacts such as motion. False-negative studies also arose from features related to the tumor itself, such as small tumor size, a high degree of background enhancement obscuring the lesion, and nonmass-like growth pattern and/or benign-type kinetics leading to misinterpretation as benign (Fig. 2).

Technical Factors Causing Difficulties in Detection

Scrupulous attention to mammographic technique by the radiologist is necessary to maximize cancer detection. Overall image quality can be affected by breast positioning, tissue compression, and exposure factors during image acquisition; these factors are under the radiologist’s supervision. Image quality is sometimes a factor cited in medical malpractice claims related to failure to diagnose breast cancer. Brenner et al detailed the results of a malpractice claim survey of the Physician Insurers Association of America, finding that image quality was cited as an issue in 10% of screening mammography malpractice claims and 17% of diagnostic mammography malpractice claims. Seventy-five percent of screening cases in which image quality was an issue had an error in diagnosis. In 20% of diagnostic cases in which diagnostic errors were reported, image quality was cited as a problem.

Proper positioning of the breast is necessary for maximum tissue visualization. The pectoral muscle should be seen extending to the level of the posterior nipple line on the mediolateral oblique (MLO) view, the inframammary fold should be open on the MLO view, and the posterior medial tissue should be seen on the craniocaudal view. Because the axillary tail tissue and the tissue along the inframammary fold are often visualized only on the MLO view, neoplasms in these locations may be one-view findings on screening, making their perception by the radiologist challenging.

Inadequate or suboptimal positioning of the posterior tissue increases the challenge of cancer detection in these locations. In an analysis of missed cancers on screening mammography, Bird et al found that one-third of missed lesions were located in the retroglandular tissue. Another series found that missed cancers were more often located outside of the upper outer quadrant than mammographically evident cancers. Other authors reported no statistical difference in lesion location for missed cancers compared with detected cancers.

Poor tissue compression and poor tissue contrast both interfere with lesion detection. Inadequate compression causes excessive scatter radiation and inadequate tissue penetration by the x-ray beam, precluding detection of lesion margins. Inadequate contrast due to suboptimal technique can interfere with cancer visualization, particularly in dense breasts. The higher sensitivity of digital mammography compared with film-screen mammography for breast cancer detection in the ACRIN trial has been attributed to the ability to adjust contrast after image acquisition. Although digital mammography's ability to adjust contrast after image acquisition can compensate for technical problems arising from improper x-ray technique, poor tissue detail because of poor compression or poor positioning is not correctable after image acquisition.

Tumor Characteristics Causing Difficulties in Detection

It is difficult and inherently subjective to determine retrospectively if a breast malignancy visible on an earlier study...
False-negative magnetic resonance imaging (MRI) interpretation may relate to nonspecific imaging features or small tumor size. Contrast-enhanced MRI (A) in a patient with BRCA mutation shows a peripherally located invasive ductal carcinoma (arrow), dismissed due to minimal enhancement. In a different high-risk patient, contrast-enhanced MRI (B-F) shows 2 areas of enhancement (arrows) considered probably benign (B, C). On 6-month follow-up, the more caudal focus (C) had resolved (not shown), but the more superior focus (D, E) had enlarged (arrows). Targeted US (F) showed a small solid round indeterminate mass (arrow); biopsy revealed grade II invasive ductal carcinoma.
that was interpreted prospectively as negative was actually noted but considered benign, or overlooked. In both instances, the lesion is still “missed.” The definition of an interval cancer is a cancer detected clinically between mammographic screening examinations, and it may represent a rapidly growing cancer in which the previous study was a true negative (not showing cancer, even in retrospect) or a missed breast cancer (due to either tumor characteristics or human error). A number of studies have attempted to categorize such “missed” cancers retrospectively according to probable reason for nondetection on the earlier mammograms. Most studies, on retrospective review of previous mammograms, found the majority of previous studies to be true negatives or to have minimal signs of malignancy, considered nonactionable. Those lesions considered nonactionable are particularly interesting because many show only subtle or nonspecific findings on earlier mammograms. In these types of malignancies, the radiologist might well have noted the findings but considered them nonsuspicious. Cancer manifesting as a vague, nonspecific, or focal asymmetric density has been reported as a reason for failure to detect cancer on earlier mammograms by a number of authors. In these instances, the malignancy appears similar to areas of benign breast tissue, making detection challenging. Other reasons for the missed lesions include lesions arising at a site of previous biopsy or lesions found on only 1 mammographic view. 

The one-view finding poses a particular dilemma to the diagnostic radiologist. In a study by Sickles, the one-view finding is reported to have a very low likelihood of malignancy, yet a number of authors have reported that many cancers are visible on previous mammograms as a one-view finding. This is, therefore, the interpretive challenge to the radiologist: although a large majority of one-view findings are not real, a small number represent a manifestation of breast cancer. Further, many of these one-view findings on earlier mammograms are vague asymmetries, which have a low predictive value for malignancy and are frequent benign findings on mammography. As Harvey has pointed out, aggressive evaluation of all asymmetries would result in an excess of benign diagnostic evaluations and benign biopsies. The challenge is to determine which asymmetry represents potential pathology. The likelihood that a global or focal asymmetry represents malignancy increases with a corresponding palpable finding, or associated microcalcifications or architectural distortion, or interval development or growth of the imaging finding. Correlation of a mammographic focal asymmetry with any focal clinical, US, or MRI findings can improve sensitivity and specificity.

The fact that many breast cancers are visible retrospectively on earlier mammograms exposes the radiologist to medicolegal risk of malpractice. In an effort to address the issue of knowledge bias (the reviewing radiologist knows the location of a subsequent cancer diagnosis), several authors have performed retrospective blinded and unblinded reviews of previous mammograms. In the study by Ikeda et al, 169 of 172 previous mammograms would not have been recalled by a majority of 5 blinded reviewers, and 47% would not have been recalled by any of 5 expert blinded reviewers. On unblinded review of the previous mammograms (with knowledge of the subsequent cancer location), 2 expert radiologists felt 20% of previous mammogram cases would have merited recall. In Harvey’s study, blinded review of the previous mammograms resulted in 41% being considered worthy of recall, whereas 59% were considered negative. On retrospective unblinded review, twice as many cases were considered positive and worthy of meriting diagnostic evaluation. Both studies concluded that failure to detect cancer on a previous mammogram, despite visible signs, does not necessarily imply negligence. In a similar fashion, nonblinded retrospective review of mammograms for malpractice cases is neither unbiased nor reflective of actual clinical practice. This observation, while reasonable, is not necessarily applicable to current malpractice litigation, where the most persuasive testimony, rather than the majority opinion, often carries the day.

### Histologic Subtypes Leading to Difficulties in Detection

Certain subtypes of breast cancer are known to pose particular diagnostic challenges. Invasive lobular cancer has a proclivity to grow single file and may fail to elicit a desmoplastic reaction in surrounding tissue, making this malignancy challenging to detect on mammography, US, and MRI. Clinically, it may present with a vague or nondiscrete palpable finding. It may fail to form a mass or manifest as a vague asymmetry on imaging, falling below the detection threshold. False-negative imaging of invasive lobular cancer has been reported on mammography, US, and MRI, although breast MRI has the highest sensitivity of the 3 modalities for this cancer subtype. MRI has also been reported to be more accurate in estimating size and extent of invasive lobular cancer than mammography or US.

### Double Reading and Computer-Aided Detection to Improve Cancer Detection

Double reading of screening mammograms by 2 radiologists, either independently or in consensus, can improve cancer detection. In a review article, Helvie summarized the findings of a number of studies evaluating double reading, with improvements in cancer detection rate ranging from 4.6% to 17%. This increase in sensitivity in some studies was accompanied by a somewhat lower specificity (higher recall rate), particularly for studies in which independent double reading, rather than consensus reading, was performed. Double reading increases health care costs associated with screening mammography because of increased physician time, increased diagnostic imaging, and increased biopsies. Although double reading is used in some European countries, it is not widely performed in the United States.

Computer-aided detection (CAD) can also increase cancer detection. In a summary of the literature on CAD, Birdwell reported that applying CAD to screening mammograms increased cancer detection by 7%–20%, with an increase in the recall rate by 9%-18%. CAD is designed to serve as a type of
Figure 3 Carcinoma arising near a biopsy site. A 44-year-old BRCA mutation carrier with history of contralateral breast cancer; mammogram 6 months after surgical biopsy for atypical ductal hyperplasia revealed a new mass (arrows) adjacent to the biopsy site (A, MLO; B, MLO spot view; C, CC; D, CC spot view). Targeted US (not shown) was negative, and the finding was considered postsurgical. Biopsy 6 months later revealed poorly differentiated invasive ductal carcinoma.
“spell-check” after initial image interpretation, marking areas for the interpreting radiologist to reconsider as potentially abnormal. In another study, Birdwell et al. subjected the previous mammograms of 110 patients with missed breast cancers (as judged by blinded panel review) to CAD analysis. CAD marked 86% of missed calcifications and 73% of missed masses. The authors subjectively assessed possible reasons for prospectively missed or misinterpreted lesions. They found the most common reasons for missed lesions to be other distracting lesions and dense breasts, whereas the most common recorded reasons for lesions misinterpreted as benign were lucent areas within masses and benign-appearing calcifications. CAD successfully marked the majority of these missed cancers. These authors concluded that using CAD in clinical practice may help radiologists to minimize missed lesions.

There are some potential hazards that may arise if CAD is incorrectly applied in the screening setting. Helvie pointed out that the clinical application of CAD to mammographic interpretation can affect human behavior or decision making during image analysis. For example, radiologists may use CAD as a first-line interpretation to select potential abnormalities, rather than as a visual prompt after initial image evaluation. In this setting, overall sensitivity for cancer detection might decline, as reviewers give too much weight to CAD and potentially ignore findings that CAD does not select. In fact, Alberdi et al. found that by decreasing the performance of CAD in a test situation, reader sensitivity decreased significantly, predominantly because of failure to detect cases that were false negative by CAD. They speculated that their findings might be because of “automation bias” (where radiologists using CAD decreased their own vigilance) or “characterization bias” (where radiologists defer to CAD rather than their own findings). These biases may be more common among less experienced radiologists or nonbreast imaging specialists.

**Errors in Assessment and Management**

Detection of a malignant lesion is only half of the challenge in breast cancer diagnosis. Accurate lesion assessment and appropriate management recommendations are equally important for early cancer diagnosis. Breast cancer may occasionally mimic a benign lesion or demonstrate nonsuspicious findings. Even when indeterminate features are present and recognized by the radiologist, the radiologist may err in assessment, misapplying short-term surveillance rather than biopsy. Alternatively, failure to integrate information from all available breast imaging, including mammography, US, and/or MRI, with one other or with any clinical findings can lead to assessment errors. Pertinent information from diagnostic imaging and clinical breast examination must be integrated to maximize cancer detection and diagnosis.

**Benign-Appearing Imaging Features**

It can be difficult on retrospective review to decide if a cancer visible in retrospect was noted, but considered benign, or completely overlooked. A number of authors have attempted to classify cancers visible on earlier mammograms that were prospectively considered negative or benign by performing either blinded or nonblinded review or both. These authors have reported that a number of malignancies on previous mammograms had a benign appearance. In the review of interval cancers in the Malmo trial, 21 patients were considered to have a nonspecific, but slightly abnormal, finding on nonblinded retrospective review of earlier mammograms. These findings included asymmetries, nonspecific calcifications, or benign-appearing masses. The authors noted that no spiculated lesions were present in this group. Spiculated lesions, when visible on previous studies, seem more likely to represent a failure of perception, rather than a misclassification as benign, as spiculation is such a highly suspicious feature. Bird and colleague’s study also reported that a number of cancers visible on previous studies had a benign appearance (including both masses and calcifications); others were stable on the previous mammogram compared with even more remote studies, and the stability may have led to the prospective benign interpretation. Ikeda’s review of 172 subtle cancer findings on previous screening mammograms interpreted as normal involved normal-appearing tissue, benign-appearing or minimal calcifications, or similar-appearing calcifications elsewhere in the breast, or masses with internal lucent areas. Additionally, small size was felt to contribute to a benign interpretation in a small number of cases. Hoff et al. also reported that missed cancers were more often smaller and not spiculated compared with screen-detected cancers. This is not surprising, as malignant characteristics are generally more evident in larger lesions. Further, small masses are quite common on screening mammograms, and recall of all of these cases would lead to very high recall rates.

**Cancer Subtypes with Nonspecific or Benign Imaging Features**

Along with the occasional invasive ductal cancer not otherwise specified, subtypes of invasive ductal cancer often reported to have imaging features overlapping benign masses include mucinous and medullary cancers. Mucinous cancers may pose diagnostic difficulties because of their typically oval or round shape and circumscribed margins on mammography, features typical of benign masses (Fig. 4). On MRI, mucinous cancers may have smooth margins, high T2 signal, and benign-appearing kinetics with gradual and persistent enhancement. On US, medullary cancers may be round or oval circumscribed masses with posterior acoustic enhancement. Papillary cancers and metastatic lesions to the breast can also present as circumscribed masses on mammography. Poorly differentiated breast cancers may appear circumscribed on mammography and cystic on US; scrupulous sonographic technique and strict application of the US breast imaging-reporting and data system (BI-RADS) lexicon can aid the radiologist in avoiding misclassification of such lesions as benign or probably benign (Fig. 5). The imaging overlap of certain uncommon subtypes of breast cancer
with benign lesions poses a challenge to the radiologist striving for early detection while minimizing false-positive biopsies.

Interval growth of a benign-appearing lesion increases the likelihood of malignancy. In Sickles’ landmark article describing short-term surveillance of probably benign findings,\textsuperscript{54} benign-appearing lesions, which underwent biopsy due to interval growth, had an 11% rate of malignancy. Slow-growing malignancies may exhibit little apparent change from 1 year to the next, and therefore, comparing with older studies as well as the most recent previous study is strongly recommended.\textsuperscript{31,43} Lesions demonstrating indeterminate or suspicious features, even if apparently stable or slowing changing, merit biopsy to exclude an invasive malignancy (Fig. 6). In high-risk patients taking tamoxifen as chemoprevention, particular care should be taken with stable or decreasing indeterminate findings, as tamoxifen may slow or arrest tumor growth.\textsuperscript{43}

**Misapplication of BI-RADS Lexicon**

Lesions placed into short-term imaging surveillance should demonstrate imaging features associated with a high likelihood of benignity. By definition, short-term surveillance should generally be applied to lesions on initial evaluation, not to lesions in which interval change has already occurred.\textsuperscript{20,54} In actual clinical practice, this does not always happen. Rosen et al\textsuperscript{55} retrospectively evaluated lesions placed into the probably benign category that ultimately proved to be malignant on follow-up. In that study (performed at an academic center with breast specialists), 80% of malignant lesions placed into short-term surveillance were prospectively described as new or increasing, or had suspicious BI-RADS descriptors prospectively reported. Although none of the malignancies was placed into surveillance without a diagnostic evaluation, the authors found on nonblinded retrospective review that the diagnostic evaluation was often incomplete, sometimes including a failure to perform targeted US evaluation of a mass, asymmetric density, or architectural distortion; or magnification images of calcifications had blur artifact, degrading resolution.\textsuperscript{55} In a different community-based study, Lehman et al\textsuperscript{56} evaluated a group of malignant lesions (cases) and a group of benign lesions (controls), all originally considered probably benign and placed into surveillance. The authors performed a retrospective review of cases and controls and recorded lesion features and patient demographics. This study found that malignant lesions considered probably benign were more likely to occur in older patients, postmenopausal patients, or those with a strong family history of breast cancer or previous biopsy. Imaging findings for lesions in the malignant case group were more often indistinct or spiculated masses or calcifications than imaging findings for lesions in the benign control group. In this study, where the reviewing radiologist was blinded to case-control status, only 20% of the malignant case lesions and benign control lesions met strict criteria for a probably benign lesion. Although the probably benign assessment was given to 2.1% of screening mammograms, cancer was found

![Figure 4](image-url)
in 8.8% of probably benign lesions, higher than the ≤2% cancer yield recommended. This is likely because of failure to adhere to probably benign criteria in using short-term follow-up surveillance. Similar to the findings of Rosen, Lehman et al found that 90.5% of lesions assessed as probably benign, for which there was a comparison study, had already demonstrated an increase at the time of probably benign assessment. In general, lesions demonstrating change on breast imaging are not appropriate for short-term surveillance. They have already demonstrated instability on imaging, and the point of imaging surveillance is to assess stability of lesions considered very unlikely to represent malignancy. However, there are some scenarios in which surveillance of a changing lesion may indeed be reasonable; for example, when evolving dystrophic calcifications are suspected or a lesion’s increased conspicuity is felt to be due to technical factors, rather than true growth. Alternatively, typically benign calcifications, which demonstrate an increase, may also sometimes be placed into short-term surveillance, particularly by less experienced radiologists.

In another study from Italy, breast cancers in which false-negative assessments were made after recall from screening for diagnostic evaluation were retrospectively reviewed. These authors found that masses with circumscribed margins and focal asymmetries were more likely to receive a false-negative assessment at diagnostic evaluation than lesions with more suspicious imaging features, and circumscribed masses and focal asymmetries were the most common find-

**Figure 5** Malignancy misinterpreted as benign. A 64-year-old woman with new mass (arrows) described as high density on screening; diagnostic spot compression view (A) and US (B) were interpreted as a benign cyst. The mass is mammographically dense for its small size, and the US finding has a mildly thickened wall and internal echoes; these are not features of a simple cyst. On 1-year follow-up mammogram (C) and US (D), the mass had considerably enlarged and is now palpable, indicated by the triangle; biopsy revealed poorly differentiated invasive ductal carcinoma.
Figure 6  Slowly growing malignancy manifesting as architectural distortion. (A) The lesion in the upper breast (arrow) was incorrectly attributed to surgical scarring from a biopsy performed in the lower breast. The lesion (arrows) demonstrates gradual progression over 6 years (B, after 2 years; C, D, after 5 years; E, F, after 6 years, at time of diagnosis). This slow rate of mammographic change, coupled with the incorrect identification of a previous biopsy site, delayed diagnosis of this multifocal invasive ductal cancer.
ings recalled from screening for diagnostic evaluation. They suggested their results might indicate a type of “suspicion bias” by the diagnostic radiologist such that these common findings, usually benign, were more often discounted during diagnostic evaluation. Similar to the findings of Rosen,\(^5\) this study also found that cancer cases that received a false-negative assessment at diagnostic evaluation were significantly more likely to have an incomplete diagnostic evaluation, with fewer clinical breast examinations and USs performed in conjunction with diagnostic mammography.

**Integrating Clinical and Imaging Findings to Maximize Detection**

Sometimes a low-suspicion or minimal imaging finding may become more significant when there is an associated clinical finding (Fig. 7) or a corresponding MRI or US finding. Therefore, the radiologist must strive to integrate and weight pertinent clinical and imaging findings with one another to avoid missing or misinterpreting signs of breast cancer. In the screening setting, the presumption is that patients are asymptomatic. However, occasionally, patients presenting for a screening mammogram indicate a clinical symptom on their mammography questionnaire. The interpreting radiologist remains responsible for the information on the mammography questionnaire, even when screening examinations are interpreted in a batch or “off-line” fashion after the patient leaves the facility. Failure to evaluate a clinical symptom reported by a screening patient may expose the interpreting radiologist to medical liability. Additionally, a focal clinical finding might elevate the significance of a subthreshold imaging finding or prompt an US evaluation even with negative mammography.

**Conclusions**

The detection, assessment, and management of breast abnormalities require diligence, skill, and expanding experience with the often subtle features of breast cancer on mammography, US, and MRI. Identifying causes of medical errors and understanding the inherent limitations in cancer detection can help diagnostic radiologists in their efforts to maximize cancer detection. Often the causes of radiologic error are multifactorial; they also tend to fall into certain predictable patterns.\(^5\) Studying these patterns as well as individual cases in which interpretive or perceptive error has occurred can help individual radiologists to improve their diagnostic acumen. Indeed, a departmental policy of reviewing diagnostic errors and cases in which management could have been improved can encourage radiologic colleagues to learn from each other and help to eliminate future errors. As philosopher George Santayana said, “Those who cannot remember the past are condemned to repeat it.”\(^5\)

**References**


**Figure 7** A 48-year-old woman with history of contralateral mastectomy and a new palpable finding on clinical breast examination. Mammography (not shown) showed heterogeneously dense tissue and no suspicious finding. Initial US evaluation by the physician-in-training (A) found no abnormality. Careful correlation of the clinical breast examination with targeted US by the attending radiologist found a subtle corresponding hypoechoic lesion (B, arrows). Standoff pad during US examination improves visualization of the superficial mass. Biopsy showed invasive lobular carcinoma.