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Breast Imaging

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Breast cancer is the most frequent non-skin cancer diagnosis in women, with an estimated 192,370 new cases in 2009[1]. Knowing what diagnostic imaging tests are available, which test to order when, and what to do with the results presents a challenge to the primary care practitioner. This chapter reviews three key concepts regarding breast imaging:

1. There are certain relatively widely accepted rules about how to screen asymptomatic women, and how to image symptomatic women.
2. Mammography is the mainstay of diagnosis, frequently supplemented by ultrasound, with MR playing a minor role.
3. Careful follow-up and handoff of the patient is critical for optimal patient care.

RULES TO GUIDE BREAST IMAGING

There are a few relatively widely accepted rules regarding breast imaging that are helpful to know when ordering imaging studies. Breast imaging studies may be divided into screening and diagnostic exams, and the rules differ for these two categories of exams. This chapter first covers screening studies, done on asymptomatic patients to detect possible breast cancer. It then discusses diagnostic studies.

Screening studies

Screening studies are usually chosen for a combination of factors including relatively low cost and high sensitivity: the screening test should pick up as much disease as possible, with the idea that subsequent studies will provide more specificity regarding the diagnosis.

Screening mammography

Mammography remains the king of breast imaging (Figure 1). It has been shown in multiple trials to reduce mortality in the screened population by about 30%[2]. It's the best screening test we have. That being said, it has problems as a screening test: it is relatively insensitive, it involves ionizing radiation, it is at least somewhat painful for most women, and it can be inconvenient. It also results in a fair number of false positives, causing a lot of needless worry on the part of patients and driving up the costs of medical care. If we had some alternate method of early diagnosis – for example, a serum test for tumor markers – this would be a great advantage. This may happen, but it hasn't yet, so we continue to do mammography.

General recommendations are that women have screening commencing at age 40, and continue as long as life expectancy is at least ten years[3]. For

patients who have had a mother, sister, grandmother, or aunt diagnosed at a young age (prior to 40) with breast cancer, it is generally accepted that screening should begin at an age earlier than 40. One commonly used rule is to start screening at 5 years prior to the age of diagnosis of cancer in the relative.

Note that a screening mammography report will usually contain one of two recommendations: 1) a recommendation to return for an annual screening mammography in one year, if the study is normal; or 2) a recommendation for additional imaging studies if the screening study is abnormal (see below). Usually, the additional imaging study is either additional mammography, with, for example, spot compression or magnification views, or ultrasound evaluation. It is uncommon to proceed directly to biopsy on the basis of a screening study.

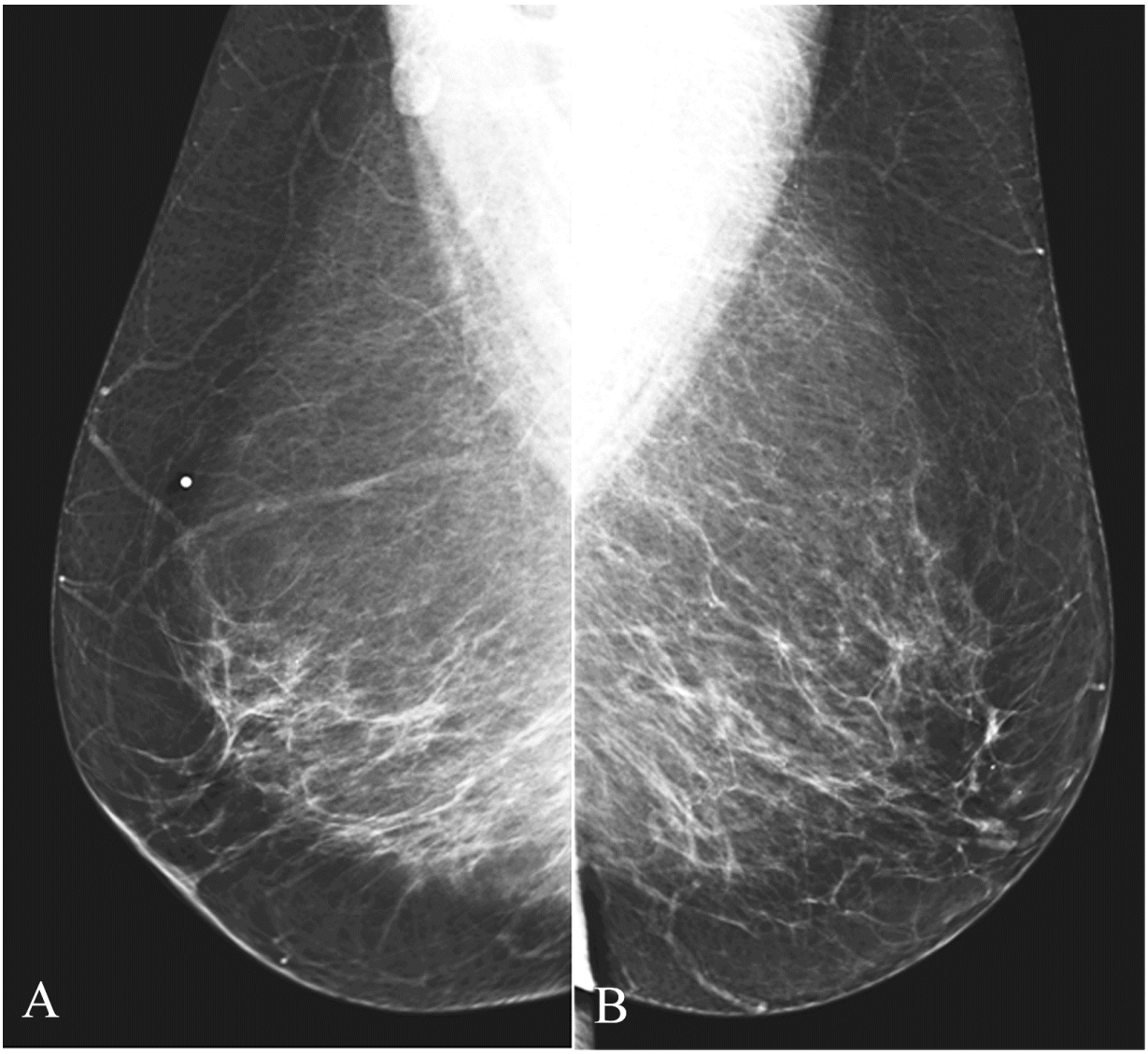

Figure 1. Normal digital screening mammogram, mediolateral oblique (MLO) views. Modern digital mammography technique shows exquisite detail of breast tissue allowing screening for malignancy. Note the inclusion of the pectoralis muscle along the posterior margin of the study. Screening mammography usually includes both bilateral mediolateral oblique views (shown) and craniocaudal views (not shown).

Screening MRI

MR is more sensitive than mammography in the detection of breast cancer. The generally accepted sensitivity for MRI is over 90%, but it will miss small cancers or areas of DCIS[4]. There are two major problems with breast MR, however: 1) specificity is only in the 50-70% range secondary to false positives from fibroadenomas and other benign lesions, and 2) cost. The false positives necessitate either biopsy or follow-up MR, both of which are also costly. However, because of the increased sensitivity of MR compared to mammography, there are multiple organizations, including the American Cancer Society, that advocate screening MRI for patients with a 20 – 25% lifetime risk of breast cancer[5]. Patients will generally fall into this high risk category if they have a breast cancer gene (BRCA1 or BRCA2), or if they have close relatives with breast cancer. There are several online calculators which will allow precise determination of cancer risk, for example at: http://www.cancer.gov/bcrisktool/.

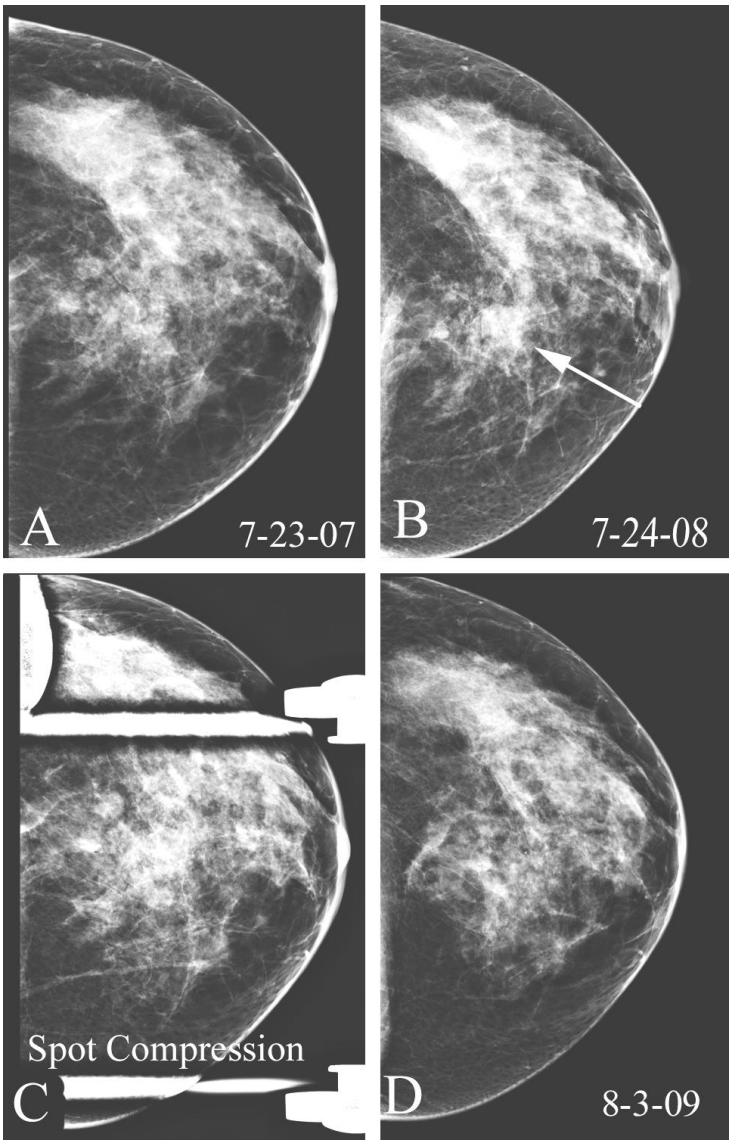

Figure 2. Abnormal screening mammogram, prompting recall of the patient for a diagnostic mammogram with additional views showing normal tissue. A. Screening mammogram from 7-23-07 is normal. B. The patient's left craniocaudal view from 7-24-08 shows an apparent developing mass in the inner aspect (arrow). C. Spot compression study shows no discrete mass but normal, although dense, breast tissue. D. Follow-up mammogram study of 8-3-09 is normal.

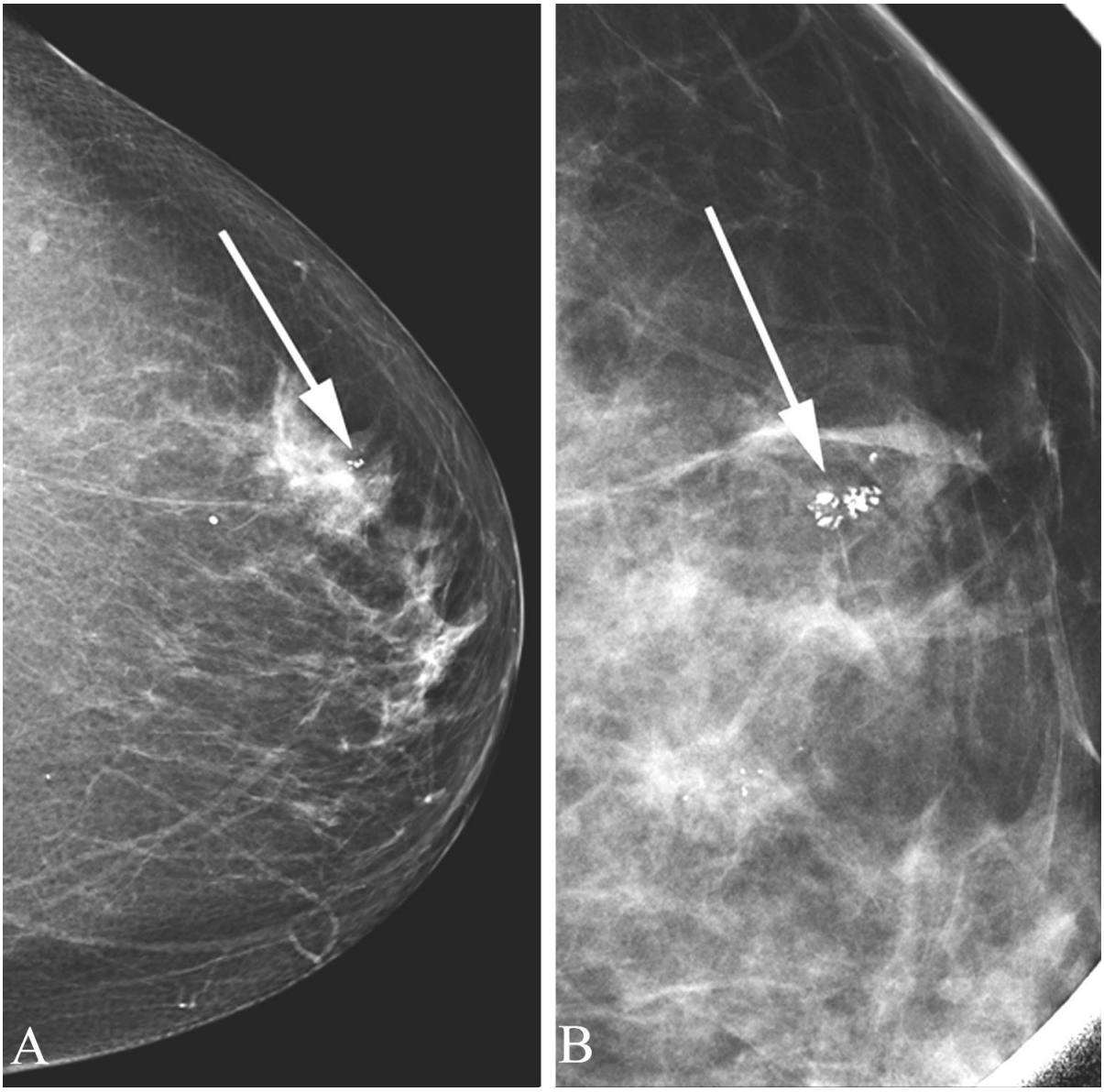

Figure 3. Abnormal screening mammogram, prompting recall of the patient for a diagnostic mammogram with additional views prompting biopsy. A. Screening cradiocaudal mammogram shows a small, dense cluster of calcifications (arrow). The patient was recalled for a diagnostic mammogram. B. Spot magnification craniocaudal mammogram better shows these calcifications (arrow), which demonstrate variable size. Stereotactic needle biopsy was performed, and the pathology interpretation was an involuted fibroadenoma and focal ductal hyperplasia without atypia.

Screening ultrasound

Ultrasound is presently not routinely used as a screening study, although the modality is undergoing evaluation as an adjunct (or possible replacement) to mammography, particularly in patients with dense breasts[6] [7].

Diagnostic Studies

Screening mammography is done on asymptomatic patients with no known imaging abnormality. *Diagnostic mammography* is performed when there is either an abnormality on a screening examination (also known as a callback) or the patient has symptoms. Ultrasound and MR may also be used as

diagnostic studies, and again this usually occurs either because of an abnormal screening examination or patient symptoms.

Abnormal screening studies resulting in diagnostic studies

Nowadays, most radiology departments handle callbacks internally, with the department notifying the patient that additional evaluation is necessary. If the results of that additional evaluation are clearly benign (Figure 2), then the patient returns to a yearly screening schedule. If the results of the additional evaluation are not clearly benign, it may be necessary to proceed with biopsy (Figure 3). Ordering of studies and the decision to proceed with biopsy should generally follow the radiologist's recommendations.

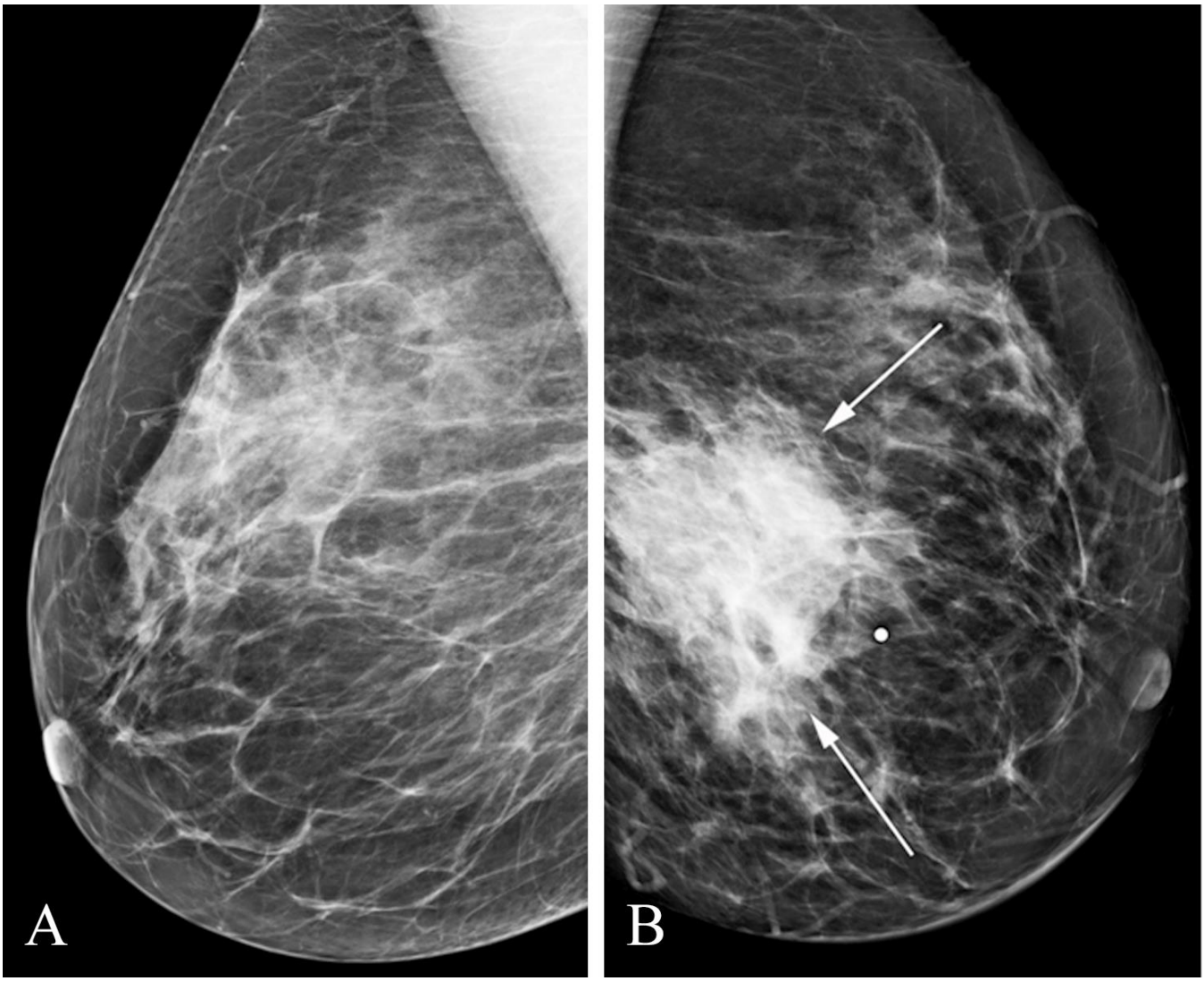

Figure 4. Infiltrating ductal carcinoma in a 39 year old woman with a breast mass found at breast self examination. A. Right mediolateral oblique (MLO) diagnostic mammogram is normal. B. Left MLO diagnostic mammogram demonstrates a large, dense mass (arrow).

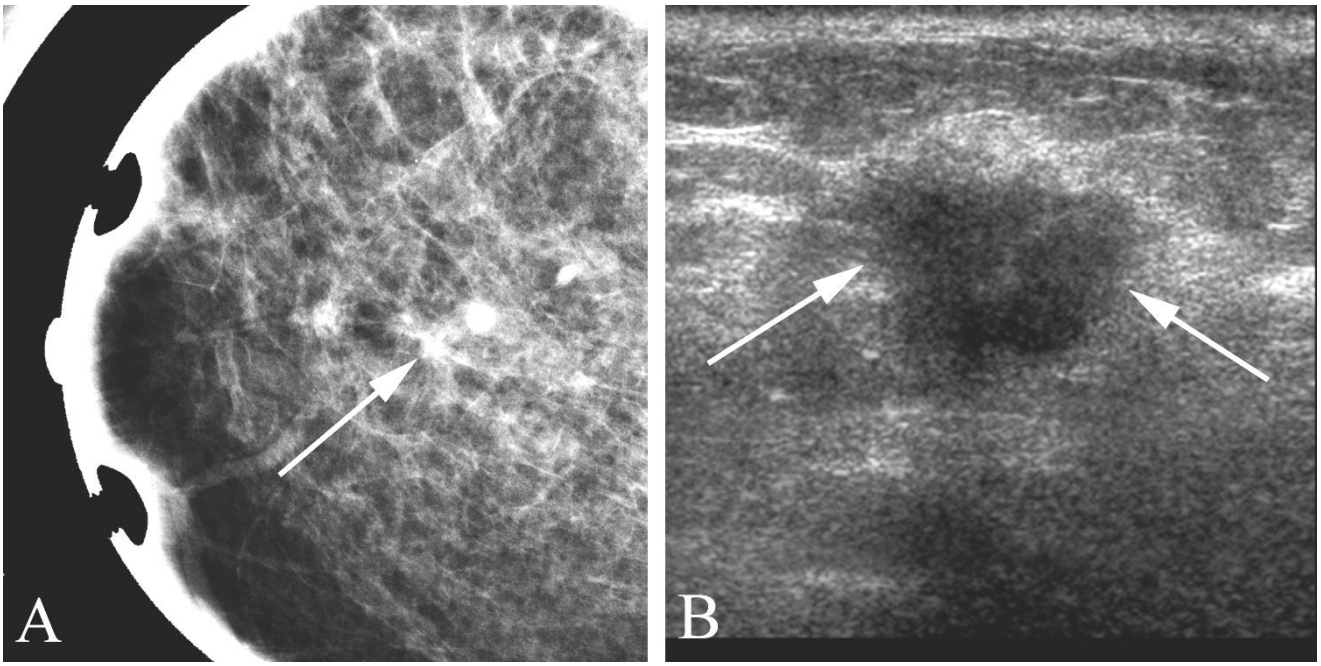

Figure 5. Infiltrating ductal carcinoma in a in a 75 year old woman with a palpable lesion found at clinical breast examination. A. Craniocaudal mammogram spot compression views (following initial full field exam) shows a subtle lesion of the right breast by the radio-opaque marker. B. Breast ultrasound demonstrates a hypodense, shadow-casting, irregular lesion (arrows) worrisome for malignancy. Biopsy revealed infiltrating ductal carcinoma.

Breast lump or focal pain, age > 35

Generally speaking, lumps and focal pain should be worked up in a similar fashion. Lumps found at clinical breast examination (CBE) or breast self examination (BSE) are both evaluated using the same algorithm, although lumps found at CBE are more likely to be malignant than those found at BSE[3].

For patients over the age of 35 with a lump or focal pain, mammography should be performed first (Figure 4), with ultrasound to follow if necessary (Figure 5)[8]. The mammogram should be scheduled as a "diagnostic" (not a "screening") study, and the technologist will typically put a radiographic marker at the location of the palpable lump or area of maximum pain. If the palpable abnormality is subtle on clinical exam, particularly if the patient cannot feel the abnormality herself, it is best to mark the patient's breast at the time of the physical examination, prior to sending the patient for imaging. This way, the technologist will know where to place the radiographic marker. The mammogram should include both breasts if the asymptomatic breast has not undergone mammography in the past year.

If the mammogram fails to show, or does not adequately characterize, an explanatory lesion at the location of the palpable abnormality or focal pain, the patient will typically proceed to ultrasound (Figure 5). The ultrasound study is done because ultrasound will demonstrate some malignant lesions that escape detection on mammography, and ultrasound may better demonstrate some lesions which are poorly demonstrated on mammograms.

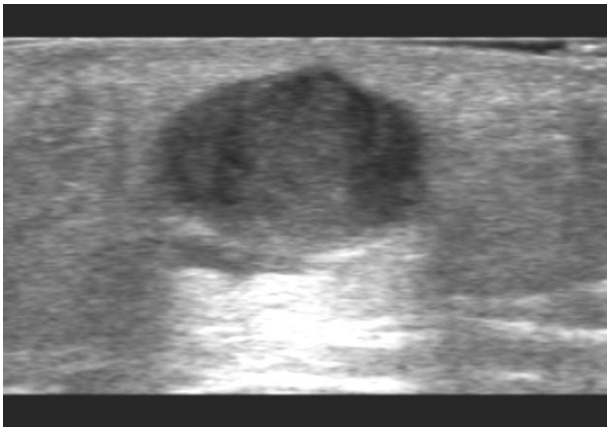

Figure 6. Ruptured epidermal inclusion cyst in a 23 year old woman with a palpable abnormality. The ultrasound exam demonstrates a hypoechoic lesion. Since the abnormality did not represent a simple cyst or a prominent but normal ridge of breast tissue, it was surgically excised, and the pathologic diagnosis was a ruptured epidermal inclusion cyst.

Breast lump or focal pain, age < 35

For patients under the age of 35, ultrasound should be performed first, followed by mammography if necessary[8] (Figure 6). These women have denser breasts and a lower pretest probability of having a malignancy with a higher likelihood that the palpable lesion is a cyst or benign but prominent ridge of breast tissue. Therefore, it makes sense to perform ultrasound first, followed by mammography if the ultrasound provides no explanation but there is still a strong suspicion of a lesion.

Breast discharge

Multipore, blood-negative, expressed-only discharge is best categorized as benign physiologic discharge, and is not worrisome for malignancy. Such discharge may require medical evaluation and medical work-up[9].

Unilateral, single pore discharge, particularly if bloody, is worrisome and needs further evaluation[10]. The first imaging step in evaluation is usually ultrasound, particularly in patients under 30, to detect dilated ducts and focal masses. This may be followed by mammography, and if these tests do not provide a definitive answer, then a ductogram (also known as a "galactogram") may provide a diagnosis (Figure 7). The ductogram is performed by cannulating the nipple pore that shows the discharge with a small, specially designed blunt catheter and injecting contrast material into the duct in a retrograde fashion.

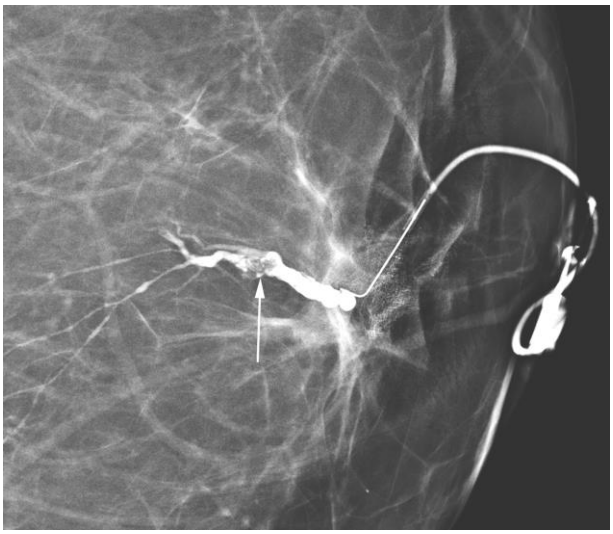

Figure 7. Intraductal papilloma in a 55 year old woman with bloody single pore nipple discharge. A standard mammogram (not shown) failed to demonstrate any cause of discharge. The catheter tip is at the nipple, and contrast material fills the dilated duct which has a filling defect (arrow), found at pathology to represent a benign intraductal papilloma.

What NOT to image

For patients with diffuse pain, or with bilateral, multipore discharge, no imaging beyond standard, age-appropriate screening mammography is useful.

MAMMOGRAPHY IS THE PRIMARY IMAGING MODALITY, SUPPLEMENTED BY ULTRASOUND, WITH A SMALL ROLE FOR MRI

As noted above, mammography is the screening modality of choice, and is the most frequently used diagnostic modality as well. Since mammography is the primary method of breast evaluation in both the screening and diagnostic roles, how do radiology departments know that they are doing a good job?

Mammography quality assurance

Mammography quality assurance has evolved through the years in part because of work done by

the American College of Radiology (ACR), and in part because of legislation known as the Mammography Quality Standards Act (MQSA).

ACR Lexicon and BI-RADS

In response to complaints about the variability of mammography reports, the American College of Radiology developed a lexicon of mammography terms[11]. As it turns out, this lexicon has not been universally adopted although the ACR publishes an excellent handbook illustrating these terms[12]. At the same time they developed the lexicon, the ACR also developed the Breast Imaging Reporting and Data System or BI-RADS (Table 1). BI-RADS is a quality assessment tool, but it is also directly clinically relevant, because it forces the radiologist to reduce the mammogram result to a single number which determines the next step in patient care. As noted by Sistrom and Langlotz writing on the topic of improving radiology reporting "One of the greatest benefits of the entire BI-RADS initiative arises from the mandated forced choice between clinically diagnostic categories".[13] Each BI-RADS category is linked to a specific next step, making management unambiguous (Table 1)

BI-RADS Category	Description	Next Step
0	Incomplete assessment	Return for additional imaging or obtain prior comparison studies
1	Negative	Return for routine screening
2	Benign findings	Return for routine screening
3	Probably benign findings	Return for initial short term follow-up (usually 6 months)
4	Suspicious abnormality	Biopsy should be considered
5	Highly suggestive of malignancy	Appropriate action should be taken
6	Known malignancy	Appropriate action should be taken

Table 1. BI-RADS categories with descriptions and resulting actions.

Screening mammography metrics

The BI-RADS categories allow relatively easy evaluation of large amounts of data. The United States Department of Health and Human Services has created benchmarks or metrics for community radiologists which may be calculated with the use of these categories[14]. Of these metrics, the most useful are probably recall rate, biopsy rate, biopsy yield, and cancer detection rate*. Note that these metrics can be calculated from the BI-RADS codes given to the screening studies and follow-up on those specific studies where biopsy was recommended (which should represent about 1% of the screening exam results). Also note that the cancer *prevalence* rate is different in those women undergoing screening mammography for the very first time than the cancer *incidence* in patients undergoing annual screening. While the general recall rate is set at 10%, the recall rate is also different between women undergoing their first study (where 10% is a reasonable figure) versus women undergoing repeated screening (where 3% or 4% is probably more reasonable[15]). However, the prevalence data (exams for first-time screening mammograms) and incidence data (exams with prior studies for comparison) are often pooled in evaluating mammography quality assurance. An example for data in one small community hospital is presented in Table 2. Note that in the "Analog" column, the data represents a two year period and demonstrates adequate performance with respect to the recall rate, biopsy yield, and cancer detection rate. The biopsy rate is higher than the benchmark (1.6% versus 1.0%), but given that the biopsy yield is still significantly above the benchmark, this is acceptable.

* Other benchmarks or metrics include: sensitivity of at least 85%, prevalent cancer detection rate of 0.6 – 1.0%, incident cancer rate of 0.2 – 0.4%, less than 25% with positive lymph node metastases at the time of diagnosis, mean tumor size of less than 1.5 cm, at least 30% DCIS or invasive cancer < 1 cm; at least 50% stage 0 or 1 cancer.

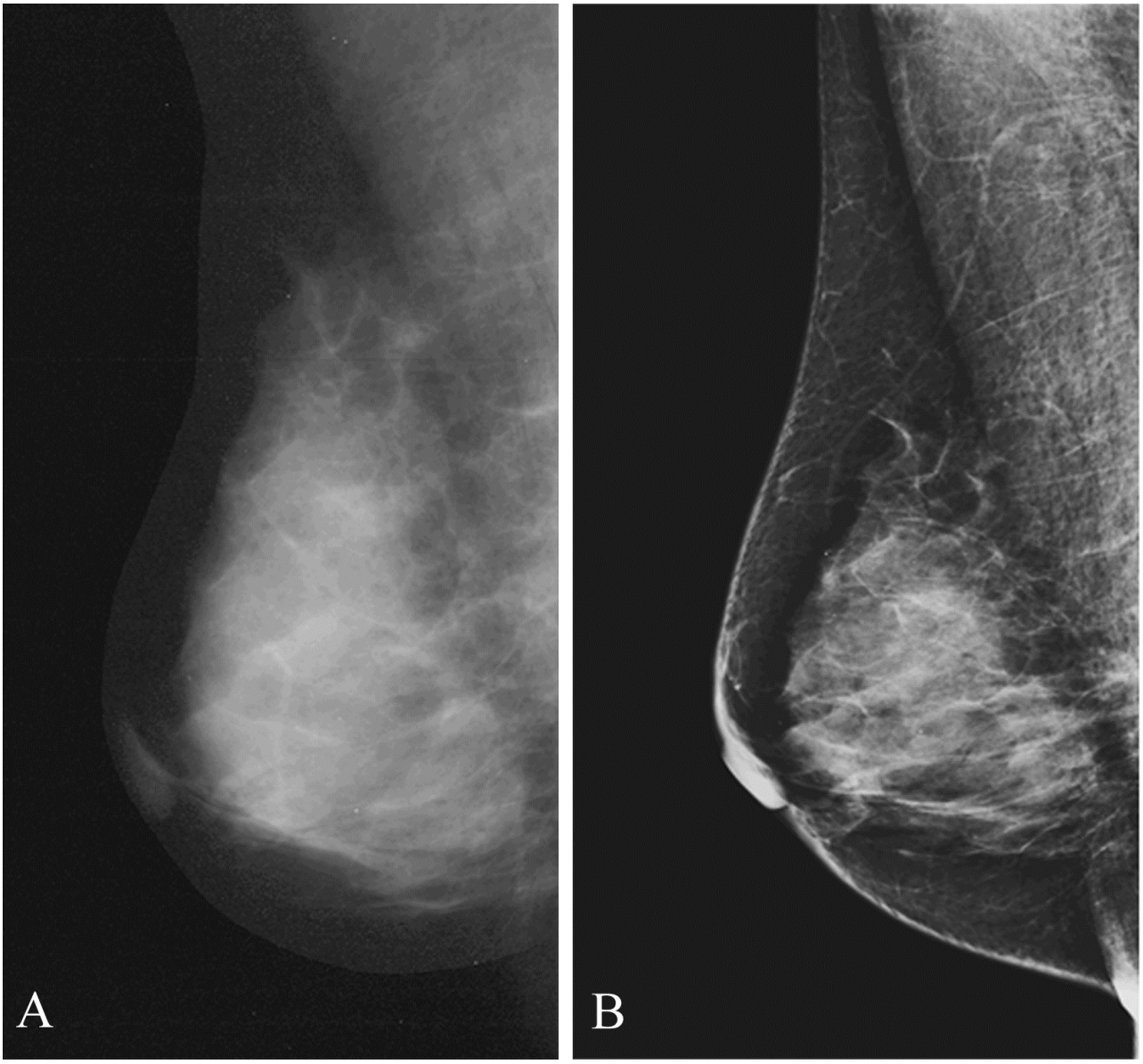

Figure 8. Superior detail with digital mammography. Film-screen (A.) versus digital (B.) normal screening mammogram. Note the superior visualization of both the central, dense parenchymal tissue, and also the peripheral, predominantly fatty breast tissue, with digital mammography.

Digital mammography

Digital mammography uses different technology than analog mammography, and provides greater detail, particularly in the superficial tissues and in dense breasts (Figure 8). Image data is collected, stored, and displayed electronically rather than with film. Digital mammography shows greater sensitivity for detection of cancer in women with dense breasts, as seen in women under the age of 50 or women who are premenopausal and perimenopausal[16]. In addition, Sala et al demonstrated a significant reduction of the call-back rate for digital mammography versus film mammography in return patients (2.4 % versus 3.6%)[15], without a decrease in the rate of malignancy detection. This reduction in call-back rate is important, since women being recalled for additional views may experience significant, ongoing anxiety[17]. When comparing the data at the same small community hospital (Table 2 again), note that following implementation of digital mammography, there was a decrease in the recall rate (in this table, both initial and return recall rates

are pooled), similar to the Sala et al study, while the biopsy *rate* (the percentage of screening patients eventually undergoing biopsy) fell, while the biopsy *yield* (the likelihood that a given biopsy demonstrated cancer) increased. The cancer detection rate showed a statistically insignificant, small decrease.

Wherever mammography is done, these metrics should be available. If, as is often the case, there is more than one available location for mammography service, these metrics provide a handy way to compare the locations.

Metric	Benchmark	Analog (5742)	Digital (6128)
Recall Rate	<10%	6.3%	4.6%
Biopsy Rate	<1%	1.6%	1.1%
Biopsy Yield	>25%	30.4%	40.6%
Cancer Detection Rate	0.2 – 0.5%	0.49%	0.46%

Table 2. Mammography data from Door County Memorial Hospital, Sturgeon Bay, WI. Rates are for screening mammograms performed in a community hospital, with historical comparison between Analog and Digital examinations.

Ultrasound is used frequently and MR is used occasionally for problem solving

Ultrasound is used to distinguish normal tissue and cysts from solid masses. Ultrasound can be used to evaluate palpable lesions, focal tender spots, or lesions seen on mammography or MRI requiring further work-up. Lesions seen on ultrasound may be placed into one of four basic categories, two of which typically require no further evaluation or work-up. If a normal ridge of breast tissue or a cyst explain the abnormality, then no further evaluation is necessary (Figure 9). If a solid lesion is identified, this typically requires biopsy, although some solid lesions are relatively typical of benign lesions such as fibroadenomas (Figure 10),

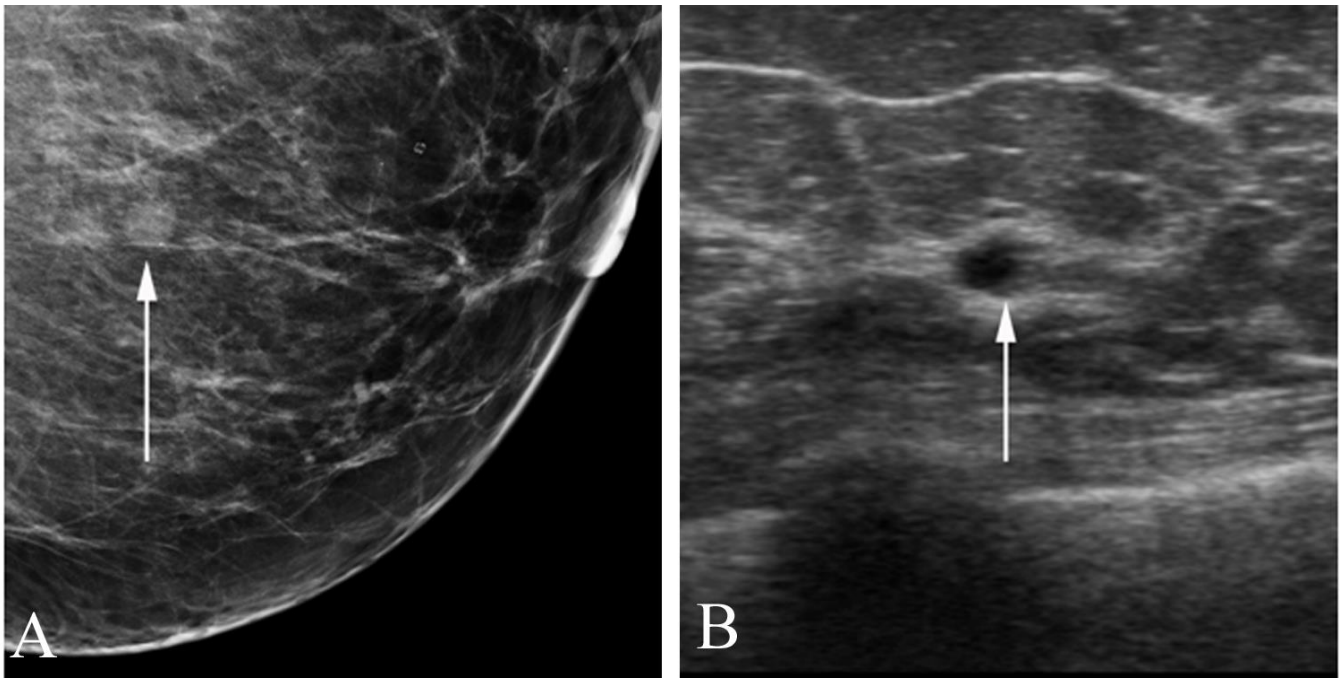

Figure 9. Cyst in a 47 year old woman with an abnormal screening mammogram, with ultrasound demonstrating a benign cyst at the location of the new lesion. A. Craniocaudal screening mammogram (cropped) shows a circumscribed hypodense lesion of the inferior right breast (arrow). B. Ultrasound (right) demonstrates a simple cyst at the location of the lesion (arrow), and no further work-up required.

while others are quite suspicious for malignancy (Figure 5). Some women would rather have even benign appearing solid lesions removed rather than followed, whereas other women would rather avoid biopsy. Malignant appearing solid lesions should certainly undergo biopsy.

MRI shows malignancy as a mass or enhancing tissue

In addition to its role as a screening tool in patients with a high risk of breast malignancy, MR may be used to evaluate the ipsilateral breast for mammographically occult disease, the contralateral breast in a patient with known malignancy (Figure 11), and, on occasion, to better characterize a lesion seen on mammography or ultrasound[18].

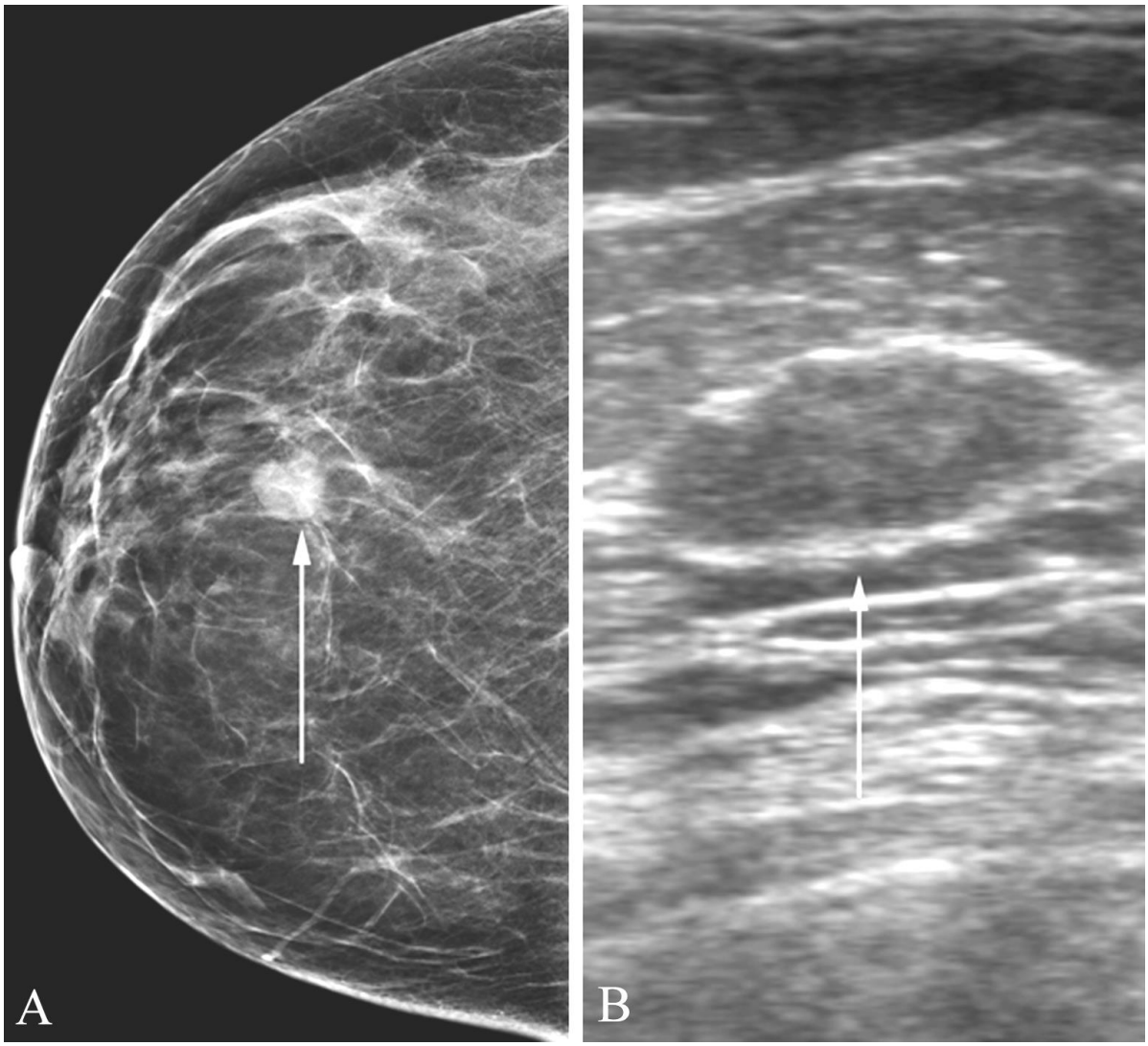

Figure 10. Fibroadenoma in a 48 year old woman with an abnormal screening mammogram, with ultrasound demonstrating a solid, benign appearing lesion at the location of the abnormality. A. Screening mammogram shows a circumscribed isodense mass (arrow) in the right breast. B. Breast ultrasound (with a different magnification) shows an oblong, sharply marginated, isodense solid mass without shadowing (arrow), characteristic of a fibroadenoma. The patient wanted the lesion removed despite its benign appearance, and pathology confirmed a fibroadenoma.

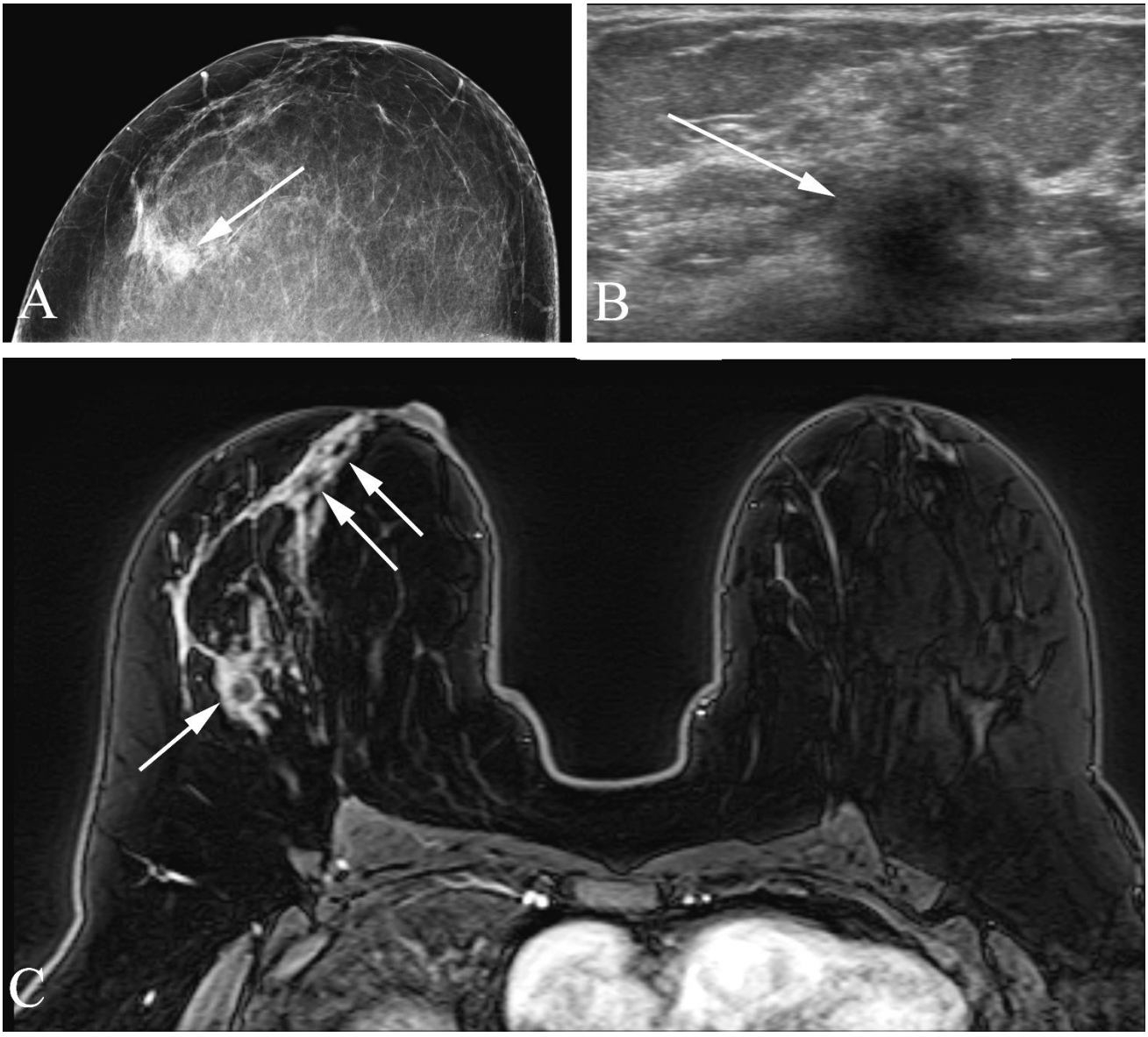

Figure 11. Infiltrating ductal carcinoma in a 41 year old woman with MRI demonstrating additional disease not detected at initial surgery. A. Right craniocaudal screening mammogram shows a mass in the lateral breast (arrow). B. US of the breast confirms a malignant appearing mass (arrow). C. Contrast enhanced MR examination of the breasts done following excision of an infiltrating ductal carcinoma demonstrates the operative site (arrow). Abnormal tissue extends from the biopsy site to the nipple (double arrow). Imaging directed biopsy of this region demonstrated multifocal high-grade DCIS beyond the margins of the initial surgery.

CAREFUL HANDOFFS ENSURE THE BEST PATIENT CARE

Careful handoffs from practitioner to practitioner prevent the tragic mistakes that can happen because of missed reports "falling through the cracks". With the development of BI-RADS, the responsibility to notify the patients to return for additional views or ultrasound examination largely shifted from the referring physician to the radiology department. Many of these same departments also schedule and

perform ultrasound-directed biopsy or stereotactic biopsy, whereas at other locations biopsies are performed by surgeons. Local referral patterns, as well as preference for ultrasound directed biopsy, core needle biopsy with mammographic guidance, and biopsy using needle localization techniques vary with locations as well as patient circumstances[18]. Regardless of the local distribution of duties, it is imperative that all involved physicians know the pathway the patient is taking. In the unfortunate event of a bad outcome, all parties will likely be held liable, so it is good to have redundancy built into the system in those instances when a patient is sent to biopsy. There are various mechanisms to achieve this, such as keeping a list of patients you know are going to biopsy *and* setting up automated forwarding of pathology results to you from the laboratory. Making sure the patient knows who to call, and that she *should* call someone, if she does not hear about her results, adds an additional layer of security. Do *not* assume the patient will call if she hears nothing: there are patients who, hoping for the best, will assume that "no news is good news".

SUMMARY

Breast imaging usually follows several widely accepted rules about when and how to screen patients, and when and how to image the breast symptoms of a palpable mass or focal breast pain. Mammography remains the mainstay of diagnosis, frequently supplemented by ultrasound with MR typically playing a minor role. Careful follow-up and handoff of the patient are critical for optimal patient care.

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