Accuracy of Diagnostic Mammography and Breast Ultrasound During Pregnancy and Lactation

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OBJECTIVE. The purpose of this article is to determine the accuracy of mammography and sonography in evaluating pregnant, lactating, and postpartum women.

MATERIALS AND METHODS. We retrospectively reviewed diagnostic breast imaging examinations of 155 pregnant, lactating, and postpartum women with 164 lesions presenting to our breast imaging department from 2004 to 2005. Records were reviewed for clinical presentation, reported sonographic or mammographic findings with BI-RADS assessment, histologic results, and clinical outcomes. Examinations rated as BI-RADS categories 4 and 5 were considered positive. One hundred thirty-four (82%) of 164 lesions had pathology results available or longer than 12 months follow-up in our study group. Of these lesions, 12 (9%) were evaluated by mammography alone, 49 (37%) were evaluated by ultrasound alone, and 73 (54%) were evaluated by both techniques.

RESULTS. Of 134 lesions, 87 (65%) were in patients who presented during lactation, 34 (25%) who presented during pregnancy, and 13 (10%) who presented postpartum. The presenting symptom for 86 lesions (64%) was a palpable mass. Biopsies were performed for 40 lesions. Of these lesions, four were malignant and 36 were benign. Mammograms were dense or heterogeneously dense in 88% of patients. All four malignancies were BI-RADS category 4 or 5 according to both mammography and ultrasound. For the 85 lesions evaluated with mammography, there was 100% sensitivity, 93% specificity, 40% positive predictive value, and 100% negative predictive value. For the 122 lesions evaluated with sonography, there was 100% sensitivity, 86% specificity, 19% positive predictive value, and 100% negative predictive value.

CONCLUSION. Among lactating and pregnant women, both mammography and sonography had a negative predictive value of 100% and accurately revealed the few cancers that were present in our study group.

Keywords: breast, lactation, mammography, pregnancy, ultrasound

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During pregnancy and lactation, the breast parenchyma is influenced by a variety of hormones, resulting in glandular proliferation, ductal distention, and stromal involution. These structural changes can make breast physical examination difficult. When women develop breast problems, such as palpable masses, bloody nipple discharge, or focal pain during pregnancy or lactation, they are often referred to breast imaging for evaluation.

The ideal protocol for imaging the breast in a symptomatic pregnant or lactating woman is controversial. In response to the physiologic changes, breast density may increase, compromising the sensitivity of mammography [1, 2]. However, in a small series of patients, Swinford et al. [3] found that the mammographic breast density of lactating and pregnant women did not always change significantly and therefore did not negate the utility of mammography. Although some researchers suggest that mammography should be reserved for pregnant and lactating women in whom malignancy has been proven [4], others argue that mammography is still helpful during lactation and pregnancy [5–8]. In contrast to the controversy that surrounds the utility of mammography, there is a consensus that ultrasound is useful when evaluating a pregnant or lactating woman with a breast problem [1, 2, 4–6, 8–10].

Breast disorders detected during pregnancy and lactation are benign in most cases. Several benign conditions, such as lactating adenomas and galactoceles, are unique to pregnant and lactating women. Fibroadenomas, which are common regardless of pregnancy or lactational status, may increase in size under the influence of estrogen present during the

gravid state. Pregnancy-associated breast cancer, defined as breast cancer occurring during pregnancy or during the first 12 postpartum months, is reported to occur in one in 3,000–10,000 pregnancies. As an increasing number of women are delaying childbearing into, and beyond, the fourth decade of life [11], the incidence of pregnancy-associated breast cancer would be expected to increase. Therefore, the appropriate workup of breast complaints during pregnancy is of increasing importance.

Differences in opinion remain with respect to the appropriate radiologic evaluation of a pregnant or lactating woman with a breast complaint. Therefore, this study was performed as a retrospective review of a large academic institution's experience with the imaging workup of breast problems associated with pregnancy and lactation.

Materials and Methods

Institutional review board approval was obtained before beginning this study, which is HIPAA compliant. The need for informed consent was waived given the retrospective nature of this study.

All diagnostic mammograms and breast ultrasounds performed for pregnant, lactating, or postpartum women at our institution between January 1, 2004, and December 31, 2005, were retrospectively identified by means of a search of the radiology information system. Any woman who was actively breastfeeding at any length of time after delivery was considered to be lactating. For women who were not lactating or whose lactational status was unknown, the postpartum period was defined as 12 months after delivery.

Each patient's electronic medical record was reviewed for the presenting complaint prompting diagnostic imaging, mammographic, or sonographic assessment, or both, at the time of presentation, mammogram density, pathologic results when available, clinical follow-up, and clinical outcomes. Lesions with biopsy-proven pathologic abnormality or more than 12 months of radiographic or clinical follow-up were included in this study; lesions without pathologic diagnosis or with fewer than 12 months clinical follow-up were considered lost to follow-up.

In total, 155 lactating, pregnant, or postpartum women were identified, yielding 164 separate breast lesions. Thirty lesions in 29 patients were lost to follow-up. Hence, 134 (82%) of 164 lesions in 126 women (age range, 19–47 years; mean age, 32.3 years) formed our study population. Eight women were evaluated for bilateral lesions. Of 126 patients, 32 (26%) were pregnant, 81 (64%) were lactating, and 13 (10%) were less than 12 months postpartum (mean, 5.9 months postpartum) but not lactating.

One hundred nineteen (89%) of the 134 lesions presented with symptoms; however, 15 (11%) lesions were identified in asymptomatic women undergoing follow-up or routine breast imaging. Of these 15 asymptomatic patients, nine were being followed for a previously identified BI-RADS 3 abnormality found on screening before pregnancy. Of these nine patients, five were imaged by mammography only (one pregnant and four lactating), three underwent ultrasound only (two pregnant and one lactating), and one pregnant patient underwent both mammogram and ultrasound. Five patients were recalled from screening mammography performed while lactating. Four of these patients underwent mammography only, and one patient underwent both mammogram and ultrasound. One pregnant patient was undergoing routine imaging because of a personal history of breast cancer and was imaged with mammography only.

Mammograms at our institution were performed using either standard film screen or digital techniques (DMR and D2000, GE Healthcare). The standard diagnostic examination included mediolateral oblique, craniocaudal, lateral, and spot compression views with a metallic marker placed over palpable regions of concern, as identified by the patient or the clinical breast examiner. Magnification views were routinely used for the evaluation of calcifications. Of the 134 lesions included in this study, 12 (9%) were evaluated with only mammography, whereas 73 (54%) were evaluated with both mammography and ultrasound.

All breast sonography was performed by the interpreting radiologist (ATL HDI 5000, Philips Healthcare; and GE Logiq 700, GE Healthcare). In cases of a focal problem (i.e., palpable mass or lump, focal thickening, skin dimpling, or erythema), directed sonography was performed. In cases of a generalized problem, sonography of the entire breast was performed. Of the 134 lesions included in this study, 49 (37%) were evaluated with only sonography, whereas 73 (54%) were evaluated with both mammography and ultrasound.

We followed the National Comprehensive Cancer Network's guidelines for the evaluation of symptomatic women. In general, women younger than 30 years were first evaluated with ultrasound; mammography was performed if indicated by clinical symptoms or sonographic findings. Women older than 30 years were generally imaged with both mammography and ultrasound; however, individual physicians had discretion to modify this protocol if indicated by the clinical situation.

A Mammography Quality Standards Act (MQSA)– certified radiologist interpreted each of the examinations included in this study. Each of 11 readers was a dedicated breast imager with more than 6 years of experience. Likewise, all imaging-guided biopsies were performed by an MQSA-certified breast radiologist. Ultrasound-guided biopsies were performed with a 14-gauge spring-loaded biopsy device, routinely retrieving four or five tissue samples. Stereotactic biopsies were performed with an 11-gauge vacuum-assisted biopsy device, routinely obtaining 12 tissue samples. Palpation-guided core biopsies were performed by a breast surgeon in a clinic setting. Open surgical biopsies were performed by a breast surgeon in the operating room. The decision to pursue palpation-guided core biopsy or open surgical biopsy was made by the referring surgeon and was based on the patient's clinical presentation, physical examination, and imaging results. Either open surgical or percutaneous core needle biopsies were obtained in 26 (19%) of the 134 lesions; of these, 12 were open surgical biopsies, and 14 were percutaneous core needle biopsies. Seven of the 14 core biopsies were imaging guided, and seven were palpation guided. Fine-needle aspiration (FNA) was performed in 14 (10%) of 134 lesions.

The BI-RADS [12, 13] assessments rendered prospectively at the time of imaging were used, without a retrospective second interpretation, for both sonographic and mammographic examinations. When a specific sonographic BI-RADS assessment was not included in the report, a single author reviewed the report and assigned an ultrasound BI-RADS category on the basis of standard descriptive criteria. BI-RADS categories 1–3 were considered negative, and categories 4 and 5 were considered positive.

TABLE 1: Clinical History for 134 Breast Lesions

Presentation	No. of Lesions
Symptomatic	
Palpable mass	86
Erythema	12
Pain	7
Thickening	5
Bloody nipple discharge	3
Clear, yellow, or milky discharge	2
Milk rejection	2
Breast firmness	2
Dimpling	1
Asymptomatic	
Short-term follow-up[a]	9
Call-back from screening	5
Personal history of breast cancer	1

Note—Some lesions presented with more than one symptom.
[a]Lesion was previously assigned BI-RADS category 3.

The data were entered into a secure Excel (Microsoft) spreadsheet. Sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV) were calculated.

Results

The clinical presentations of the 134 lesions are recorded in Table 1. One hundred nineteen (89%) of the 134 lesions were associated with symptoms, the most common being a palpable mass in 86 (72%) cases. Bloody nipple discharge was reported in three lactating patients, all of whom had negative imaging results. Two of these patients had spontaneous resolution of the discharge, and a third patient with uniorificial bloody nipple discharge had fibrocystic change on retroareolar duct excision.

All four of the malignancies presented with a palpable mass. Two women were lactating, one was pregnant, and the fourth woman was postpartum. One of the lactating women with cancer reported a history of ipsilateral milk rejection by her infant.

Table 2 summarizes the mammographic findings. Ten (12%) of 85 mammograms were assessed as BI-RADS category 4 or 5; of these 10 mammograms, four (40%) were true-positives and six (60%) were false-positives (Table 3). There were 75 (88%) true-negative mammograms and no false-negative mammograms (100% sensitivity, 93% specificity, 40% PPV, and 100% NPV) (Table 4). All four of the malignancies showed calcifications on mammogram. One cancer was also associated with a mammographic mass (Fig. 1) and one also had architectural distortion. Of the 85 mammograms, breast density was categorized as fatty in 0 patients (0%), scattered in 10 patients (12%), heterogeneous in 46 patients (54%), and extremely dense in 29 patients (34%).

The ultrasound findings are shown in Table 2. Of 122 ultrasounds, 21 (17%) were reported as positive, or BI-RADS category 4 or 5; of these 21 examinations, four (19%) were true-positives and 17 (81%) were false-positives (Table 3). There were 101 (83%) true-negative and no false-negative ultrasounds (100% sensitivity, 86% specificity, 19% PPV, and 100% NPV) (Table 4). Of 17 false-positive ultrasounds, five (29%) were fibroadenomas, four (24%) were normal breast tissue, three (18%) were lactational changes, two (12%) were infectious or inflammatory abnormalities, and three (18%) were other benign pathologic abnormalities. Three of the malignancies were seen on ultrasound as a solid mass and one was identified as dilated ducts with a solid intraductal component.

TABLE 2: Findings for Benign and Malignant Lesions Evaluated With Mammography (*n* = 85) and Sonography (*n* = 122)

Technique, Finding	Benign Lesions	Malignant Lesions	Biopsy Result[a]	
			Benign	Malignant
Mammography[b] (*n* = 81 benign lesions; *n* = 4 malignant lesions)				
Negative	55	0	19	0
Calcification only	10	2	1	2
Mass only	8	0	3	0
Mass and calcification	0	1	0	1
Architectural distortion and calcification	0	1	0	1
Focal asymmetry	7	0	2	0
Dense lymph nodes	0	1	0	1[c]
Other (air-fluid level)	1	0	1	0
Ultrasound (*n* = 118 benign lesions; *n* = 4 malignant lesions)				
Negative	63	0	8	0
Solid mass	24	3	17	3
Simple cyst	9	0	3	0
Complicated cyst	3	0	1	0
Complex cyst	5	0	5	0
Dilated ducts	6	0	0	0
Dilated ducts with solid intraductal component	0	1	0	1
Ill-defined attenuation	3	0	2	0
Subcutaneous edema	2	0	0	0
Sebaceous cyst	2	0	0	0
Intramammary lymph node	1	0	0	0

[a]Biopsy techniques included fine-needle aspiration and core and open biopsy.
[b]Some lesions were associated with more than one finding.
[c]The associated breast mass underwent core biopsy.

TABLE 3: BI-RADS Categories for 85 Lesions Evaluated With Mammography and 122 Lesions Evaluated With Ultrasound Compared With Histologic and Clinical Outcomes

Technique, BI-RADS Category	Cancer	Benign Biopsy	Benign Follow-Up	Total, No. (%)
Mammography				
1 and 2	0	20	44	64 (75)
3	0	1	10	11 (13)
4 and 5	4	4	2[a]	10 (12)
Total, no. (%)	4 (5)	25 (29)	56 (66)	85
Ultrasound				
1 and 2	0	11	73	84 (69)
3	0	11	6	17 (14)
4 and 5	4	14	3[a,b]	21 (17)
Total, no. (%)	4 (3)	36 (30)	82 (67)	122

[a]Two patients were treated with antibiotics for clinical diagnosis of mastitis and had resolution of symptoms.
[b]One patient was managed clinically for pregnancy-related changes, which resolved (see text).

A total of 40 lesions were biopsied—14 with core needle, 12 with open biopsy, and 14 with FNA. Of the 14 core needle biopsies, seven were palpation guided and seven were ultrasound guided. Of the seven palpation-guided core biopsies, five lesions had been

TABLE 4: Mammographic and Sonographic Assessments Versus Outcomes

Technique, BI-RADS Category	Benign[a]	Malignant[a]
Mammography[b]		
1–3 (*n* = 75)	75 (88)	0 (0)
4–5 (*n* = 10)	6 (60)	4 (40)
Ultrasound[c]		
1–3 (*n* = 101)	101 (83)	0 (0)
4–5 (*n* = 21)	17 (81)	4 (19)

Note—Data are no. (%) of lesions.
[a]Outcome was determined by clinical follow-up or pathologic analysis.
[b]Mammography had specificity of 93%, sensitivity of 100%, negative predictive value of 100%, and positive predictive value of 40%.
[c]Ultrasound had specificity of 86%, sensitivity of 100%, negative predictive value of 100%, and positive predictive value of 19%.

assessed as BI-RADS category 1, 2, or 3. The decision to biopsy the BI-RADS category 1, 2, and 3 lesions was made by the surgeons and was based on clinical factors, such as the presence of a clinically significant palpable finding or patient concern. None of the biopsied BI-RADS 1–3 lesions were malignant.

Twenty-two (85%) of the 26 surgical or core biopsies were benign, including lactational changes in eight (36%) cases, fibroadenoma in seven (32%) cases (Fig. 2), fibrocystic changes in three (14%) cases, inflammation or infection in two (9%) cases (Fig. 3), and other in two (9%) cases. Four (15%) of the 26 biopsy specimens were malignant.

Of the 14 FNAs, all had benign cytologic findings and no cancer was found on follow-up. Each of the 14 lesions biopsied with FNA was imaged with ultrasound and 12 were also imaged with mammography. All 12 of these mammograms were assigned BI-RADS category 1. Of the 14 ultrasounds, six were assessed as BI-RADS category 1, one as BI-RADS category 2, six as BI-RADS category 3, and a single lesion was assessed as BI-RADS category 4. As with the palpation-guided core biopsies, the decision to perform FNA on the BI-RADS category 1, 2, and 3 lesions was based on clinical factors, such as the presence of a palpable finding or patient concern.

Four (3%) of the 134 lesions were malignant, with three invasive ductal carcinomas and one poorly differentiated adenocarcinoma. The median size of the malignancies was 2.2 cm, with a mean size of 2.8 cm (range, 0.7–5.0 cm), compared with a mean of 1.8 cm for all lesions (range, 0.4–10.0 cm). All of the malignancies were evaluated with both mammography and sonography. Three of the malignancies were biopsied with core biopsy and one underwent open surgical biopsy. Ninety-four cases did not undergo biopsy or FNA. Of the patients without tissue diagnosis, 64 (67%) had no imaging follow-up, two (2%) had less than 12 months of imaging follow-up, 14 (15%) had 12–23 months of imaging follow-up, and 14 (15%) had at least 24 months of imaging follow-up. Of the 64 patients without imaging follow-up, all had at least 12 months of clinical follow-up: 23 (36%) of these patients had 12–23 months of clinical follow-up, and 41 (64%) had at least 24 months of clinical follow-up. No additional malignancies were identified in the patients who were followed either clinically or radiographically.

Three of the patients whose lesions were not biopsied were categorized as having BI-RADS category 4 lesions. Two of these lesions were clinically mastitis; the patients were treated conservatively with antibiotics,

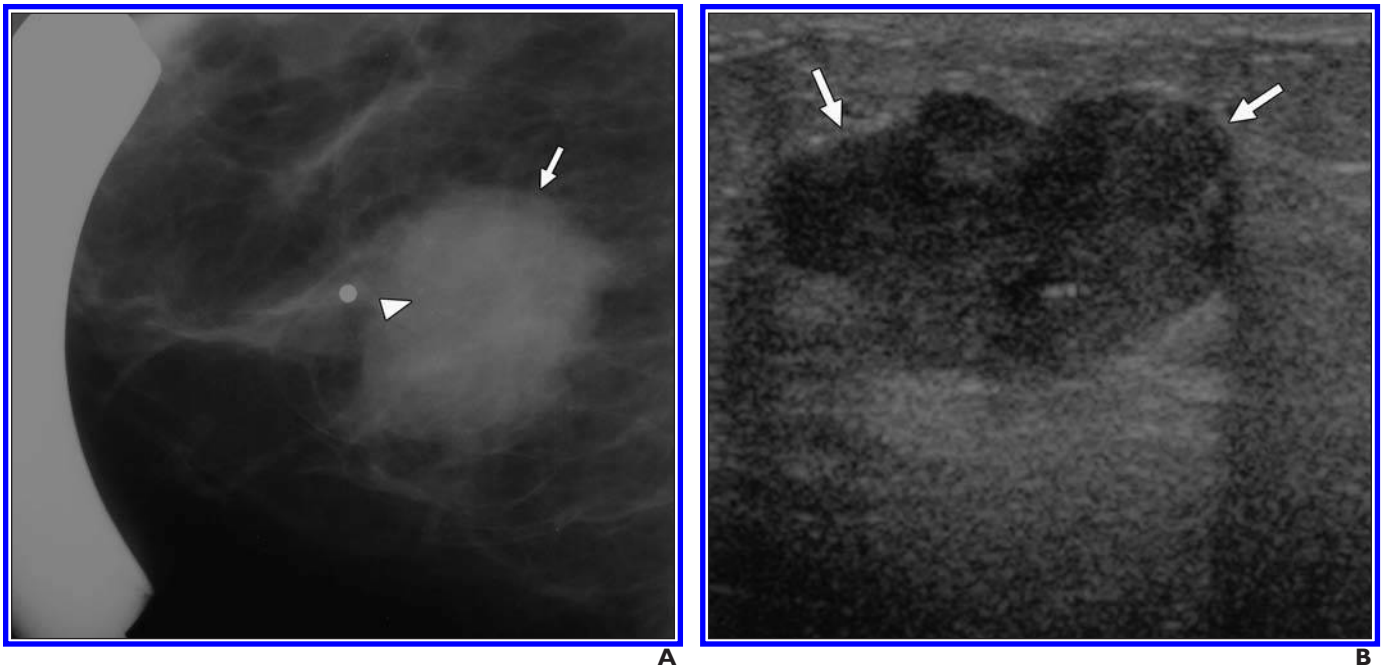

Fig. 1—40-year-old lactating woman who presented with palpable mass.
A, Mammogram shows mass (*arrow*) with spiculated margins and microcalcifications (*arrowhead*).
B, Ultrasound shows corresponding solid irregular hypoechoic mass (*arrows*). Core biopsy was performed and revealed invasive ductal carcinoma.

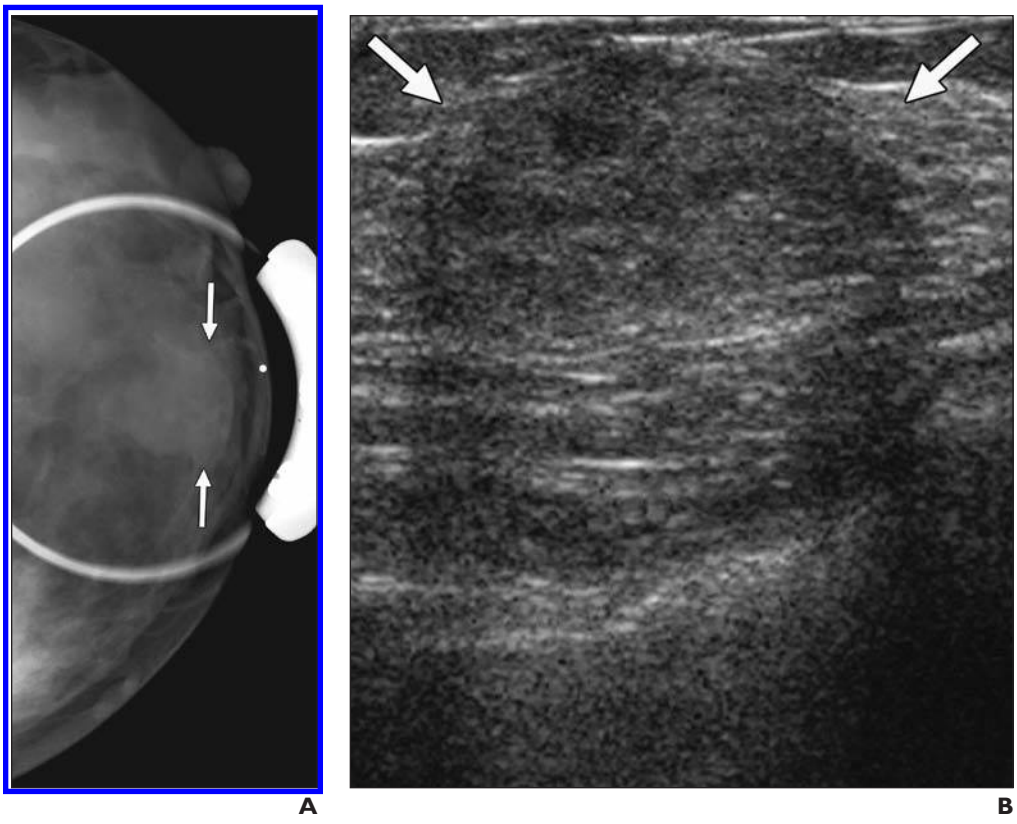

Fig. 2—Fibroadenoma presenting as palpable mass in 28-year-old lactating woman.
A, Mammogram shows lobular mass (*arrows*) with partially obscured borders.
B, Ultrasound shows corresponding solid oval isooechoic mass (*arrows*). Excisional biopsy confirmed diagnosis of fibroadenoma.

had resolution of symptoms, and remained free of disease with 12–23 months of clinical follow-up. The third patient was diagnosed clinically as having pregnancy-related changes and had resolution of the clinical and sonographic abnormality with greater than 24 months of follow-up.

Discussion

A standard breast imaging protocol for the evaluation of pregnant and lactating women has not been formally established, and previous studies that have described the accuracy of breast imaging in this population have included small numbers of patients [1, 3, 5, 6]. In the course of a 2-year period, 155 pregnant, lactating, and postpartum women presented to our breast imaging department for diagnostic evaluation. Therefore, we sought to evaluate the outcomes and accuracy of mammography and ultrasound in those women and to determine the imaging findings, both in patients with cancer and in the majority of patients who present for breast imaging who do not have cancer. The imaging findings in pregnant women with breast cancer have been described, but the outcomes of imaging in symptomatic pregnant and lactating women who do not have cancer have been less well reported.

Previous studies in the literature have included small numbers of patients who were evaluated with prebiopsy imaging. In those studies, ultrasound was more sensitive than mammography for the detection of cancer. In 2006, Yang et al. [6] described 23 pregnant women with 24 cancers that were imaged before surgery and found the sensitivity for mammography to be 90% and that for ultrasound to be 100%. In 1994, Liberman et al. [10] reviewed 88 cases of pregnancy-related breast cancer between 1973 and 1993. Only 23 of those cases were imaged with mammography before biopsy, and only six of the 88 cases were imaged with ultrasound before biopsy. Those authors found a sensitivity of 78% for mammography and sensitivity of 100% for ultrasound [10]. In a 2003 review of the imaging findings in 22 consecutive patients with a diagnosis of breast cancer during pregnancy or lactation, Ahn et al. [5] found that mammography had a sensitivity of 86.7% and ultrasound had a sensitivity of 100%. In a 2007 study of 25 lactating women who underwent breast imaging because of a palpable mass, Obenauer and Dammert [1] found four cancers. One of these cancers was considered suspicious on ultrasound only, one was suspicious on mammography only, one was suspicious on both ultrasound and mammography, and one lesion was considered probably benign on both ultrasound and mammography but was suspicious on MRI [1].

The National Comprehensive Cancer Network publishes guidelines for clinical practice in patients who have breast cancer or are suspected to have breast cancer [14, 15]. These guidelines address cancer detection, workup, and diagnosis yet do not specifically delineate a recommended approach to the breast imaging of pregnant and lactating women. The guidelines do state that, in pregnant women "mammography of the breast with shielding can be done safely" and that "ultrasound of the breast and regional lymph nodes can be used to assess the extent of disease and also to guide biopsy" [14]. There are specific recommendations for the evaluation of symptomatic women younger than 30 years (without regard to pregnancy status), which indicate that ultrasound is the preferred first imaging study and that mammography could be considered if ultrasound does not visualize a lesion or if the lesion seen on ultrasound is indeterminate or suspicious [15]. At our institution, we follow these guidelines, beginning with ultrasound for women younger than 30 years and proceeding to mammography if indicated, with shielding of the abdomen in pregnant patients.

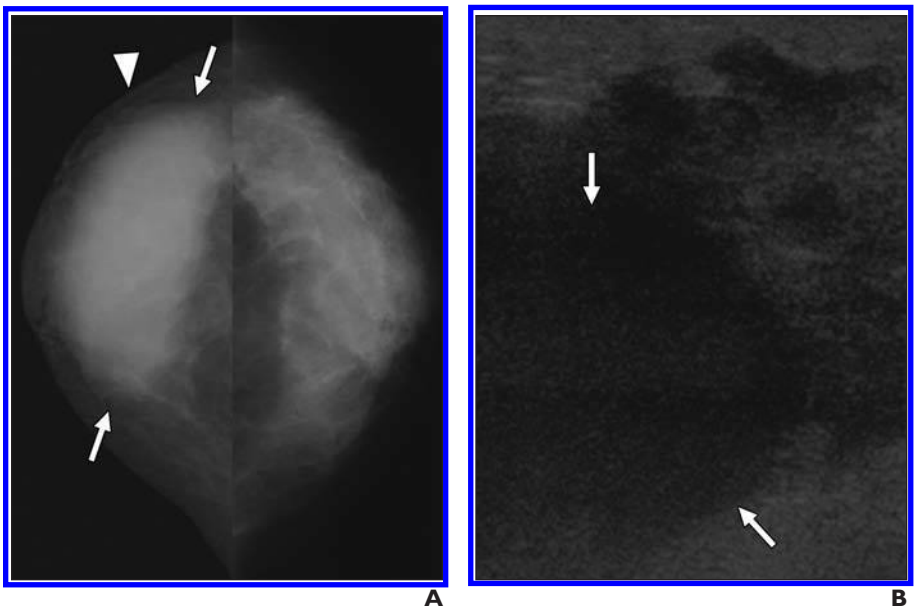

Fig. 3—33-year-old lactating woman presenting with inflammation and palpable mass.
A, Mammogram reveals asymmetric density (*arrows*) within right breast with overlying skin thickening (*arrowhead*).
B, Corresponding ultrasound shows solid irregular hypoechoic mass (*arrows*). Palpation-guided core needle biopsy revealed inflammation consistent with mastitis which resolved with treatment.

All patients with breast cancer in our study presented with a palpable mass. Therefore, it is appropriate that palpable masses in pregnant or lactating women be approached as they would be in nonpregnant women.

Benchmarks for the performance of diagnostic mammography have previously been established from a diverse population of women across the country referred for diagnostic mammography [16]. Although the benchmarks do not account for patient age, pregnancy, or lactational status, the results of our study parallel these values. In our study, 12% of diagnostic mammograms in lactating and pregnant patients were prospectively identified as abnormal (positive), with a PPV of 40%. This finding compares favorably with the benchmark of an abnormal interpretation rate for diagnostic mammography of 8% and a PPV of 31.4% [16]. The overall cancer detection rate in our study population was 3%, which is similar to the benchmark of 25.3 (2.53%) per 1,000 [16]. Shaw de Paredes et al. [17] reported the performance of mammography in women 35 years old and younger and found that 89% of the cancers were detected despite the fact that 52% of the patients had dense breast parenchyma. In our study population, 100% of the cancers were detected mammographically despite breast parenchyma that was characterized as heterogeneously dense or extremely dense in 88%. Although this was a small number of malignancies, the sensitivity of mammography was not hindered by the density of the breast parenchyma. Tissue sampling was obtained in 34% (29/85) of diagnostic mammograms, which includes core biopsies performed by the surgeons because of clinical suspicion. If only the biopsies performed in women with positive imaging studies (BI-RADS 4 and 5) are considered, then 9% (8/85 diagnostic mammograms) of the examinations prompted biopsy, which is slightly higher than the benchmark of 5.4% of diagnostic mammograms undergoing biopsy [16]. Notably, the NPV of both ultrasound and mammography was 100% in our study population. We did not study the direct clinical impact of a negative mammogram and ultrasound in the surgical decision not to proceed with biopsy in the majority of women without cancer. However, it is very possible that surgeons had more confidence to follow low-suspicion clinical findings instead of performing biopsy if both mammogram and ultrasound results were negative.

The performance of ultrasound in our study group had a sensitivity of 100%, which is in keeping with many published reports [5, 6, 10]. Although performance benchmarks for breast sonography have not been established as they have been for mammography, ultrasound was effective in our study group.

Pregnancy-associated breast cancer has been reported to occur with a frequency of one in 3,000–10,000 pregnancies, accounting for 1–3% all breast cancers [2]. However, the prevalence may increase as women are deferring childbearing into the fourth and fifth decades [2, 10]. Approximately 7–14% of newly diagnosed breast cancers in women younger than 40 years are associated with pregnancy [4]. Most breast cancers in young women and pregnant or lactating women present with a palpable mass [4, 17], whereas most cancers in nonpregnant women older than 40 years old are detected by screening mammography before becoming clinically evident [4].

One barrier to the performance of mammography in a pregnant woman is the perceived radiation risk to the developing fetus. Radiation dose to the fetus from a two-view mammogram is minimal. A standard two-view mammogram exposes a fetus to less than 0.03 mrad, which is only a fraction of the average weekly dose of 2 mR (0.02 mGy) from background radiation [7, 18]. Because there is minimal radiation risk to the developing fetus, mammograms can be obtained in a pregnant woman when clinically indicated. A lead shield may be placed over the maternal abdomen and pelvis for maternal peace of mind and for an additional reduction of fetal dose by a factor of two to seven [18]. There have been no published reports of the radiation risk to maternal breast parenchyma from mammography performed during lactation.

Physiologic changes of the breast during pregnancy and lactation may also affect a radiologist's decision to recommend mammographic evaluation. Although breast density may increase during pregnancy and lactation as a result of physiologic alterations of the breast parenchyma, this change in density may not occur in all women [3], and all cancers in our study were identified on mammogram, despite the presence of dense breast tissue in the majority of women.

There are several potential limitations of our study. The average age of our study population is 32.3 years, older than the average age at first birth for U.S. women of 25.2 years, as reported by the Centers for Disease Control and Prevention [11]. Because breast parenchyma is generally denser in younger women [17], our older population of pregnant women may have falsely elevated the sensitivity of mammography. Our study was retrospective; however, we minimized this limitation by using the mammogram and ultrasound

interpretations rendered at the time of examination rather than later independent image review. Because all dictated radiology reports are incorporated into the radiology information system, a comprehensive capture of our patient population was obtained despite the retrospective acquisition of data. Case selection bias exists because our practice is a large tertiary care medical center with both local and referral patients, which may have affected outcomes. Also, all of our ultrasound was performed by a physician, which could have affected sensitivity.

In summary, the standard breast imaging techniques of mammography and ultrasound accurately revealed all four of the cancers in our study group. More importantly for clinical practice is that both techniques had a high NPV (100% in our study group). As always, however, the presence of a clinically significant palpable finding warrants consideration of surgical consultation, even with negative imaging results. The National Comprehensive Cancer Network's guidelines of first using breast ultrasound followed by mammography when the sonographic findings are inconclusive or suspicious in the evaluation of nonpregnant symptomatic women younger than 30 years appears to be an appropriate approach to the evaluation of symptomatic pregnant or lactating women. Neither pregnancy nor lactation should alter the choice of imaging technique for diagnostic breast imaging in symptomatic women of this age group. Because of the extremely low fetal radiation dose, mammography is not contraindicated when suspicious sonographic or clinical findings are present.

References

1. Obenauer S, Dammert S. Palpable masses in breast during lactation. *Clin Imaging* 2007; 31:1–5
2. Sabate JM, Clotet M, Torrubia S, et al. Radiologic evaluation of breast disorders related to pregnancy and lactation. *RadioGraphics* 2007; 27:S101–S124
3. Swinford AE, Adler DD, Garver KA. Mammographic appearance of the breasts during pregnancy and lactation: false assumptions. *Acad Radiol* 1998; 5:467–472
4. Hogge JP, De Paredes ES, Magnant CM, Lage J. Imaging and management of breast masses during pregnancy and lactation. *Breast J* 1999; 5:272–283
5. Ahn BY, Kim HH, Moon WK, et al. Pregnancy- and lactation-associated breast cancer: mammographic and sonographic findings. *J Ultrasound Med* 2003; 22:491–497, quiz 498
6. Yang WT, Dryden MJ, Gwyn K, Whitman GJ, Theriault R. Imaging of breast cancer diagnosed and treated with chemotherapy during pregnancy. *Radiology* 2006; 239:52–60
7. Kopans D. *Breast imaging*, 3rd ed. Philadelphia, PA: Lippincott-Raven, 2007
8. Bock K, Hadji P, Ramaswamy A, Schmidt S, Duda VF. Rationale for a diagnostic chain in gestational breast tumor diagnosis. *Arch Gynecol Obstet* 2006; 273:337–345
9. Son EJ, Oh KK, Kim EK. Pregnancy-associated breast disease: radiologic features and diagnostic dilemmas. *Yonsei Med J* 2006; 47:34–42
10. Liberman L, Giess CS, Dershaw DD, Deutch BM, Petrek JA. Imaging of pregnancy-associated breast cancer. *Radiology* 1994; 191:245–248
11. Martin JA, Hamilton BE, Sutton PD, et al. Births: final data for 2005. *Natl Vital Stat Rep* 2007; 56:1–103
12. American College of Radiology. BI-RADS: mammography, 4th ed. In: *Breast imaging reporting and data system: BI-RADS atlas*. Reston, VA: American College of Radiology, 2003
13. American College of Radiology. BI-RADS: ultrasound, 1st ed. In: *Breast imaging reporting and data system: BI-RADS atlas*. Reston, VA: American College of Radiology, 2003
14. National Comprehensive Cancer Network. *Clinical practice guidelines in oncology: breast cancer.* Vol. 2. Fort Washington, PA: National Comprehensive Cancer Network, 2008.
15. National Comprehensive Cancer Network. *Clinical practice guidelines in oncology: breast cancer screening and diagnosis guidelines.* Vol. 1. Fort Washington, PA: National Comprehensive Cancer Network, 2008.
16. Sickles EA, Miglioretti DL, Ballard-Barbash R, et al. Performance benchmarks for diagnostic mammography. *Radiology* 2005; 235:775–790
17. Shaw de Paredes E, Marsteller LP, Eden BV. Breast cancers in women 35 years of age and younger: mammographic findings. *Radiology* 1990; 177:117–119
18. Sechopoulos I, Suryanarayanan S, Vedantham S, D'Orsi CJ, Karellas A. Radiation dose to organs and tissues from mammography: Monte Carlo and phantom study. *Radiology* 2008; 246:434–443

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1. Kelly S. Myers, Lauren A. Green, Lizza Lebron, Elizabeth A. Morris. 2017. Imaging Appearance and Clinical Impact of Preoperative Breast MRI in Pregnancy-Associated Breast Cancer. *American Journal of Roentgenology* **209**:3, W177-W183. [Abstract] [Full Text] [PDF] [PDF Plus]
2. Janet Szabo, Dairon Garcia, Natalie Ciomek, Laurie Margolies. 2017. Spuriously aggressive features of a lactating adenoma prompting repeated biopsies. *Radiology Case Reports* **12**:2, 215-218. [Crossref]
3. Jocelyne Chopier, Selma Beldjord, Édith Kermarrec, Benjamin Fedida, Isabelle Thomassin-Naggara. 2017. Imagerie diagnostique devant un symptôme en pathologie mammaire du pré- et post-partum. *Imagerie de la Femme* **27**:2, 165-178. [Crossref]
4. Linda Moy, Samantha L. Heller, Lisa Bailey, Carl D'Orsi, Roberta M. DiFlorio, Edward D. Green, Anna I. Holbrook, Su-Ju Lee, Ana P. Lourenco, Martha B. Mainiero, Karla A. Sepulveda, Priscilla J. Slanetz, Sunita Trikha, Monica M. Yepes, Mary S. Newell. 2017. ACR Appropriateness Criteria ® Palpable Breast Masses. *Journal of the American College of Radiology* **14**:5, S203-S224. [Crossref]
5. Harris Carmichael, Cindy Matsen, Phoebe Freer, Wendy Kohlmann, Matthew Stein, Saundra S. Buys, Sarah Colonna. 2017. Breast cancer screening of pregnant and breastfeeding women with BRCA mutations. *Breast Cancer Research and Treatment* **162**:2, 225-230. [Crossref]
6. A. Langer, M. Mohallem, H. Berment, F. Ferreira, A. Gog, D. Khalifa, I. Nekka, P. Chérel. 2015. Masse mammaire chez une femme enceinte. *Journal de Radiologie Diagnostique et Interventionnelle* **96**:5, 496-506. [Crossref]
7. A. Langer, M. Mohallem, H. Berment, F. Ferreira, A. Gog, D. Khalifa, I. Nekka, P. Chérel. 2015. Breast lumps in pregnant women. *Diagnostic and Interventional Imaging* **96**:10, 1077-1087. [Crossref]
8. Constance D. Lehman, Amie Y. Lee, Christoph I. Lee. 2014. Imaging Management of Palpable Breast Abnormalities. *American Journal of Roentgenology* **203**:5, 1142-1153. [Abstract] [Full Text] [PDF] [PDF Plus]
9. F. Kuhn-Beck, L. Foessel, M.-F. Bretz-Grenier, C. Youssef Akladios, C. Mathelin. 2014. Gigantomastie unilatérale gravidique : à propos d'un cas d'hamartome géant. *Gynécologie Obstétrique & Fertilité* **42**:6, 444-447. [Crossref]
10. O. Goetz, C. Burgy, C. Langer, C. Doyen, C. Mathelin. 2014. Allaitement après cancer du sein : enquête auprès des professionnels de santé hospitaliers en Alsace. *Gynécologie Obstétrique & Fertilité* **42**:4, 234-239. [Crossref]
11. A. Langer, M. Mohallem, D. Stevens, R. Rouzier, F. Lerebours, P. Chérel. 2014. A single-institution study of 117 pregnancy-associated breast cancers (PABC): Presentation, imaging, clinicopathological data and outcome. *Diagnostic and Interventional Imaging* **95**:4, 435-441. [Crossref]
12. A. Langer, M. Mohallem, D. Stevens, R. Rouzier, F. Lerebours, P. Chérel. 2014. Étude mono-institutionnelle de 117 cas de cancers du sein associés à la grossesse (CSAG) : données cliniques, radiologiques, histo-pathologiques et évolutives. *Journal de Radiologie Diagnostique et Interventionnelle* **95**:4, 439-446. [Crossref]
13. Surekha Joshi, Vandana Dialani, Jonathan Marotti, Tejas S. Mehta, Priscilla J. Slanetz. 2013. Breast disease in the pregnant and lactating patient: radiological-pathological correlation. *Insights into Imaging* **4**:5, 527-538. [Crossref]
14. Regina J. Hooley, Leslie M. Scoutt, Liane E. Philpotts. 2013. Breast Ultrasonography: State of the Art. *Radiology* **268**:3, 642-659. [Crossref]
15. Iris Krishna, Michael Lindsay. 2013. Breast Cancer in Pregnancy. *Obstetrics and Gynecology Clinics of North America* . [Crossref]
16. Adriana Langer, Marina Mohallem, Pascal Chérel. 2013. Cancer du sein et grossesse : revue de la littérature. *Imagerie de la Femme* **23**:2, 116-118. [Crossref]
17. Sheila S. Lee, Heidi J. Hartman, Cherie M. Kuzmiak, Kenneth L. Crosby. 2013. The Management of Breast Symptoms in the Pregnant and Lactating Patient. *Current Obstetrics and Gynecology Reports* **2**:1, 53-58. [Crossref]
18. Reena Vashi, Regina Hooley, Reni Butler, Jaime Geisel, Liane Philpotts. 2013. Breast Imaging of the Pregnant and Lactating Patient: Physiologic Changes and Common Benign Entities. *American Journal of Roentgenology* **200**:2, 329-336. [Abstract] [Full Text] [PDF] [PDF Plus]
19. Reena Vashi, Regina Hooley, Reni Butler, Jaime Geisel, Liane Philpotts. 2013. Breast Imaging of the Pregnant and Lactating Patient: Imaging Modalities and Pregnancy-Associated Breast Cancer. *American Journal of Roentgenology* **200**:2, 321-328. [Abstract] [Full Text] [PDF] [PDF Plus]
20. C Saunders, D Taylor, A Ives. 2012. The role of breast imaging during pregnancy and lactation in the diagnosis of breast malignancy. *Journal of Medical Radiation Sciences* **59**:4, 119-123. [Crossref]

21. T.W. Stephens. 2012. Accuracy of Diagnostic Mammography and Breast Ultrasound During Pregnancy and Lactation. *Yearbook of Diagnostic Radiology* **2012**, 64-65. [Crossref]