Current Recommendations for Breast Imaging of the Pregnant and Lactating Patient

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During pregnancy and lactation, the breast undergoes unique changes that manifest as varied clinical and imaging findings. Understanding the expected physiologic changes of the breast as well as recognizing the best imaging modalities for a given clinical scenario can help the radiologist identify the abnormalities arising during this time. Discussion with the patient about the safety of breast imaging can reassure patients and improve management. This article reviews the physiologic changes of the breast during pregnancy and lactation; the safety and utility of various imaging modalities; up-to-date consensus on screening guidelines; recommendations for diagnostic evaluation of breast pain, palpable abnormalities, and nipple discharge; and recommendations regarding advanced modalities such as breast MRI. In addition, the commonly encountered benign and malignant entities affecting these patients are discussed.

Breast imaging during pregnancy and lactation is a commonly encountered diagnostic challenge. Expected hormonal changes acting on the breast result in increased breast volume and fibroglandular density, which can mimic pathologic entities and obscure mammographic findings. Evaluation of the breast can be complicated by the risks of exposing the developing fetus and/or sensitive breast tissue to ionizing radiation, MRI, and gadolinium-based contrast media. In this article, we describe the physiologic changes of the breast induced by pregnancy and lactation; discuss the safety and utility of ultrasound, mammography, and breast MRI in both screening and diagnostic formats; provide up-to-date consensus regarding screening in this patient population stratified by age and risk profile; provide a clinical problem-based approach to diagnostic evaluation; and review typical imaging appearances of commonly encountered gestational and lactational breast abnormalities.

Physiologic Changes of the Breast From Pregnancy to Lactation

Pregnancy is a unique physiologic state in which high levels of estrogen, progesterone, and prolactin exert characteristic changes in the breast [1, 2]. Breast changes are evident beginning as early as the 2nd month of pregnancy [1]. During the 1st trimester, the breast undergoes marked ductal sprouting and branching, initiation of discrete lobular growth, increase in vascularity, and concurrent involution of fibrofatty stroma, which are predominantly due to the effects of rising estrogen [2, 3] (Fig. 1). During the 2nd and 3rd trimesters, the influence of progesterone dominates, with extensive lobular growth and cellular proliferation while the stroma involutes [1, 3] (Fig. 2). Alveolar cells differentiate into colostrum cell epithelium while prolactin stimulates hormone synthesis. Because of the antagonistic effect of progesterone on prolactin synthesis, milk is not yet formed [1].

Lactation is governed predominantly by prolactin. The lactating breast shows lobular gland distention with secretions within the secretory ducts. Milk—a combination of fat, lactose, and proteins—is secreted into mature lobules under the influence of prolactin as well as multiple metabolic hormones such as insulin, thyroid and growth hormones, and corticosteroids [1]. Milk secretion is regulated by oxytocin released from the posterior pituitary gland on initiation of breastfeeding.

Safety of Imaging in Pregnant and Lactating Patients

Ultrasound

Breast ultrasound is safe during pregnancy and lactation because of the lack of ionizing radiation [3–6].

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Mammography

Patients and referring clinicians may be reluctant to use examinations with ionizing radiation because of concerns about spontaneous abortion or the harmful effects on the conceptus; thus, the radiologist must be prepared to address these concerns. Radiation effects can be broadly categorized into two subtypes: stochastic and deterministic effects. Stochastic effects have no threshold level of exposure and are theoretically dose independent [7]. Current consensus maintains that stochastic effects are negligible compared with other risks of pregnancy when fetal dose is less than 50 mGy, and the American College of Radiology (ACR) suggests fetal doses up to 100 mGy are likely "too subtle to be clinically detectable" regardless of gestational age [7–9].

Deterministic effects are dose dependent, with the risk of deleterious effects increasing linearly with dose [7]. Fetuses are most susceptible to dose-dependent teratogenic effects during organogenesis (≈ 2–20 weeks' gestational age), particularly during neuronal development (≈ 8–15 weeks' gestational age) [7, 10–12]. Fetal doses less than 50 mGy are not likely to induce any threshold-related effects [8]. In conventional breast imaging, fetal mammographic doses of 0.001–0.01 mGy are orders of magnitude below the estimated thresholds for either stochastic or deterministic effects [8, 13] (Fig. 3). The radiation that reaches the fetus is primarily from indirect exposure via internal scatter radiation from breast tissue [3, 7, 8, 10, 11, 14]. Scatter radiation dose tends to increase linearly with increased body mass index, although proxy fetal doses remain well below threshold values even at the upper extremes of breast thickness [15]. Direct exposure, although contributing to only a small fraction of total fetal dose, can be further reduced with lead apron shielding [4]. Given the low levels of exposure and our knowledge of radiation effects, mammographic radiation doses to the fetus are essentially of no clinical concern.

Proliferating breast tissue is thought to be more sensitive to radiation effects during pregnancy and lactation, but this theory has not been definitively proven [8, 11, 16, 17]. Generally, mammography is considered safe during pregnancy and lactation because conventional two-view mammography delivers a breast radiation dose of approximately 3 mGy, which is roughly equivalent to 7 weeks' background radiation [4, 8]. However, whether the low dose of mammographic exposure to theoretically more vulnerable breast tissue is clinically significant or not remains unclear [8, 16, 18].

MRI

Unlike the risks associated with ionizing radiation, potential risks of MRI are teratogenic but are not carcinogenic [19, 20]. Proposed risks of MRI include heat deposition into the fetus, altered cell migration and proliferation in the 1st trimester, and damage to developing auditory nerves due to high acoustic noise; however, heat deposition is likely clinically insignificant on magnets that are 3 T or lower in field strength, and risks of altered migration remain theoretic [20]. Acoustic noise causing permanent damage is unlikely because of the brief exposure to MRI as well as maternal body sound attenuation of at least 30 dB insulating and protecting the fetus [20]. A recent study confirmed no statistically significant adverse effects with regard to fetal growth or neonatal hearing in healthy neonates exposed to 3-T MRI for various maternal or fetal indications regardless of gestational age [21].

HIGHLIGHTS

Key Findings

- *Pregnancy and lactation induce characteristic changes in the breast that may mimic or obscure pathologic findings.*
- *Imaging is generally safe for both the mother and the fetus, but the decision to screen requires consideration of underlying risk factors.*
- *Pregnancy-associated breast cancer is a rare but important clinical entity that may be difficult to distinguish from benign entities on imaging alone.*

Opposition to the use of MRI during pregnancy stems primarily from concerns regarding gadolinium-induced fetal toxicity. Although several small retrospective studies determined that there were no adverse fetal effects of chelated gadolinium-based contrast material given during pregnancy, animal studies have shown fetal malformation and death after repeated supraclinical doses [8, 20, 22, 23]. Chelated gadolinium is known to cross the placenta in measurable quantities and may theoretically dissociate into free, nonchelated gadolinium, which is neurotoxic [23]. Despite these considerations, the drug has been deemed "probably safe" during pregnancy by the European Society of Urogenital Radiology because of a paucity of evidence proving teratogenicity [20]. The ACR, on the other hand, recommends against the use dynamic contrast-enhanced MRI (DCE-MRI) in pregnant women regardless of risk profile [24].

Efforts to circumvent the use of gadolinium for DCE-MRI by using DWI sequences are underway. DWI exploits intrinsic differences in tissue contrast based on the random brownian motion of molecules moving into adjacent structures [25]. Normal breast parenchyma and cancerous lesions have been shown to be distinguishable using diffusion-tensor imaging (DTI) parametric mapping techniques [26]. Nissan et al. [27] reported in a recent feasibility study of 10 patients with known pregnancy-associated breast cancer (PABC) that DTI parametric mapping in lieu of gadolinium identified nine of 11 known lesions. Further studies with larger cohorts are needed before the utility of DWI in detecting PABC is established [28].

Screening Modalities

Ultrasound—Physiologic changes of the breast during pregnancy and lactation manifest as progressive ductal and lobular hyperplasia with ductal ectasia, resulting in the sonographic appearance of large hypoechoic ducts and lobules on a background of diffusely decreased breast echogenicity [3, 4]. No studies have been performed evaluating the utility of screening handheld or automated whole-breast ultrasound during pregnancy or lactation regardless of individual patient risk [24, 29]. Studies of supplemental screening ultrasound in women who are not pregnant or lactating have yielded increased rates of cancer detection [30, 31]. Given the potential benefit of ultrasound, current ACR guidelines suggest screening whole-breast ultrasound as a supplemental screening modality in pregnant and lactating wom-

en, particularly those at high risk for breast cancer, regardless of age, along with lactating women at intermediate or high risk [24, 32] (Table 1). Notably, screening ultrasound is associated with increased false-positive rates, which potentially can lead to unnecessary biopsies and associated complications [30, 31].

Mammography—Routine screening mammography is not recommended for average-risk pregnant women younger than 40 years old but should be performed for average-risk women who are 40 years old or older, intermediate- or high-risk women between 30 and 39 years old, and high-risk women younger than 30 years old [24, 32] (Table 1). The combination of increased breast density seen in younger women and the physiologic increase in breast density seen during pregnancy increases the likelihood of concealing small lesions [33]. Digital breast tomosynthesis (DBT) is likely of particular benefit in this demographic group to reduce the masking effect of dense breast tissue. Notably, many studies have shown that mammographic sensitivity remains high during pregnancy, ranging from 74% to 100% [6, 29, 34–37].

TABLE 1: Screening Recommendations for the Pregnant and Lactating Patient

Risk Profile	Pregnancy	Lactation
Mammography (includes tomosynthesis)		
High risk[a]		
≥ 25 y	Recommended	Recommended
Intermediate risk[b]		
< 30 y	Not recommended	Recommended
≥ 30 y	Recommended	Recommended
Average risk[c]		
< 40 y	Not recommended	Not recommended
≥ 40 y	Recommended	Recommended
Supplemental ultrasound		
High risk[a]		
Any age	Can be considered	Can be considered
Intermediate risk[b]		
< 30 y	Can be considered	Can be considered
≥ 30 y	Can be considered	Can be considered
Average risk[c]		
< 40 y	Not recommended	Not recommended
≥ 40 y	Can be considered	Can be considered
Supplemental DCE-MRI		
High risk[a]		
Any age	Not recommended	Can be considered
Intermediate risk[b]		
Any age	Not recommended	Can be considered
Average risk[c]		
Any age	Not recommended	Not recommended

Note—DCE-MRI = dynamic contrast-enhanced MRI.
[a]High risk: 20% or greater lifetime risk of breast cancer, *BRCA* mutation carrier (or patient has not been tested for *BRCA* mutation but first-degree relative has *BRCA* mutation), or history of chest irradiation between ages of 10 and 30 years.
[b]Intermediate risk: 15–20% lifetime risk or personal history of breast cancer, lobular neoplasia, or atypical ductal hyperplasia.
[c]Average risk: less than 15% lifetime risk of breast cancer.

There is no contraindication to mammography during lactation; however, few studies dedicated to evaluating screening mammography in the lactating population have been performed. Several institutions elect to delay screening mammography until after cessation of lactation even in high-risk populations, citing interpretive challenges that may lead to higher false-positive rates, warranting unnecessary biopsies [38, 39]. However, one study found that, of 117 cancers in patients with PABC, nine (7.7%) were subclinical, of which five were detected with only screening mammography [34]. Another small study of 22 cases of PABC determined that two were detected with screening mammography [29]. Given these preliminary data, screening mammography may be of benefit in lactating women, particularly those with higher risk profiles, and should follow screening mammography recommendations for nonlactating women [24]. Sensitivity should be optimized by breastfeeding or pumping before evaluation to reduce breast density, improve compliance of the breast tissue, and allow more uniform compression [4].

MRI—The ACR recommends against the use of DCE-MRI in pregnant women regardless of the patient's risk profile [24]. Limited data exist regarding screening MRI during lactation, but cancers tend to have earlier and more intense initial contrast enhancement compared with physiologic hypervascularity and enhancement often seen in this demographic group [40, 41]. Several studies have shown that enhancing masses and nonmass enhancement can be reliably distinguished from background parenchymal enhancement based on kinetics and morphology [40, 42–45]. A recent study showing the utility of unenhanced DTI mapping techniques found 138% increased tumor conspicuity compared with conventional DCE-MRI in lactating patients, which, although not regularly used in most imaging protocols, offers potential as a future adjunctive modality [46]. Thus, although not the initial screening tool of choice, screening MRI may be considered for high-risk patients during lactation [24] (Table 1).

Lactating women undergoing MRI evaluation should be instructed to pump immediately before imaging to eliminate ductal secretions, reducing fluid and decreasing potentially confounding background T2 signal (Fig. 4C); however, nearly all tumors remain conspicuous even in the context of exuberant background enhancement [4, 47] (Fig. 4B).

Diagnostic Workup

Breast pain or palpable mass—Ultrasound is the mainstay of diagnostic breast evaluation during pregnancy and lactation. Ultrasound lacks ionizing radiation; in addition, mammography is less sensitive in pregnant or lactating women because of the physiologically increased radiodensity of breast tissue during pregnancy and lactation [4]. Ultrasound has shown high sensitivity for both malignant and benign abnormalities including PABC, with sensitivity and NPV near 100% [3, 5, 6, 36, 37]. Thus, ultrasound remains the first-line imaging modality for evaluating a palpable mass or focal pain in pregnant or lactating women regardless of age or risk demographic [1, 6, 24, 35, 48–50] (Fig. 5A).

Any suspicious finding on ultrasound can be promptly evaluated with ultrasound-guided tissue biopsy. Patients who have a palpable breast lesion that persists for 2 weeks or more should undergo targeted ultrasound [3, 51].

Mammography, although not the first-line modality, is a useful adjunct to ultrasound for the evaluation of breast pain or a palpable mass. Studies have shown mammographic sensitivity of 74–100%, which is slightly less than that of ultrasound [6, 24, 29, 35, 36]. Diagnostic mammography should be performed if ultrasound does not show a cause for a palpable mass; specifically, diagnostic mammography should be performed to evaluate for microcalcifications or architectural distortion [1, 24]. Mammography should also be performed in the evaluation of disease extent and in the presence of suspicious calcifications after a highly suspicious ultrasound finding or diagnosis of a new breast cancer has been made.

As we mentioned earlier, DCE-MRI is contraindicated during pregnancy. DCE-MRI is safe and beneficial in lactating patients with a recently diagnosed breast cancer to evaluate for the extent of disease [4]. Breastfeeding can be continued after gadolinium contrast administration because gadolinium excretion via breast milk is negligible, measuring merely 0.0004% of the maternal dose [3, 22]. The ACR does not recommend discontinuation of breastfeeding after gadolinium administration [22]. Unenhanced MRI techniques using DTI sequences remain under investigation.

Nipple discharge—Spontaneous bloody nipple discharge is a nonspecific finding and may suggest either benign or malignant abnormalities. Benign bleeding may occur as a result of physiologic epithelial remodeling and increased vascularity that leave the breast more vulnerable to microtrauma, a phenomenon sometimes referred to as "rusty pipe syndrome" [1, 51, 52]. This type of bleeding is most common during the 3rd trimester, when physiologic changes are most pronounced. Spontaneous bloody secretion not associated with an underlying lesion usually involves more than one duct. False bloody secretions may also occur from nipple trauma from breastfeeding. If cytologic, physical, and sonographic evaluations of the breast are reassuring, the patient may be followed clinically [1, 53] (Fig. 5B). If a pathologic entity is suspected, particularly if bloody secretion is limited to a single duct, galactography can be performed in pregnant patients and MRI in lactating patients to evaluate for an intraductal lesion [1, 53]. Although no studies specifically evaluate diagnostic ultrasound for nipple discharge in pregnant women, retroareolar ultrasound evaluation should remain the first-line modality [1, 53]. Pathologic entities commonly associated with uniductal bloody nipple discharge include intraductal papillomas or ductal carcinoma, including PABC.

Intervention—Ultrasound-guided core needle biopsy (CNB), upright stereotactic or tomosynthesis CNB, and needle localization are safe during pregnancy and lactation, and MRI-guided CNB can be performed safely in lactating patients [4]. An anechoic or hypoechoic mass on ultrasound may be evaluated directly with ultrasound-guided aspiration, particularly in the case of suspected galactoceles, in which case aspiration is both diagnostic and therapeutic [1, 4]. Procedural complication risk is minimal for CNB and generally comparable to that of nonparous women. Radiologists should be aware of the increased risk of bleeding and infection secondary to increased breast vascularization and ductal dilatation [1, 4]. Blood and lidocaine may be found in breast milk after biopsy, but these pose no risk to the breastfed neonate. Milk duct fistula formation is a rare complication associated with CNB and is generally associated with open surgical procedures, but patients should nonetheless be informed of the risk at the time of consent [4, 42, 54]. The risk of fistula formation can be further reduced by allowing patients to pump or breastfeed before the procedure to decrease ductal distention, using the smallest possible needle, selecting the shortest distance to the target, and avoiding crossing of ducts during the biopsy [55].

TABLE 2: Diagnostic Imaging Workup for Common Clinical Symptoms in Pregnant and Lactating Patients

Common Clinical Symptom	Pregnancy	Lactation
Breast pain or palpable mass		
Ultrasound	Recommended	Recommended
Mammography	Recommended	Recommended
MRI	Not recommended	Can be considered[a]
Pathologic nipple discharge		
Ultrasound	Recommended	Recommended
Mammography	Recommended	Recommended
MRI	Not recommended	Can be considered

Note—Based on information in diFlorio-Alexander et al. [24], Mainiero et al. [32], and Lee et al. [53].
[a]Consider MRI when evaluating for extent of disease if a cancer diagnosis is made on initial imaging or core needle biopsy.

Common Benign and Malignant Abnormalities

The following is a review of common entities encountered in the workup of the pregnant and lactating patient (Table 2). Figure 6 is a schematic that describes the imaging features of common clinical entities that occur during pregnancy and lactation. It is important to recognize that multiple benign entities overlap significantly in both temporality and imaging features (Table 3).

Pregnancy-Associated Breast Cancer

PABC is defined as breast cancer that occurs during pregnancy or within 1 year of childbirth, with an estimated incidence of approximately 1 in 3000–10,000 pregnancies [3, 4, 56]. The incidence of PABC is expected to increase with the trend of many women delaying childbearing [1, 4]. Unfortunately, there is a diagnostic delay of approximately 1–2 months for patients with PABC compared with those with nongestational breast cancer [4, 37, 57–60]. Moreover, most patients with PABC present with high-grade tumors and/or lymph node involvement [1, 61, 62]. The combination of diagnostic delay and aggressive biology features results in poor overall prognosis, with multiple studies suggesting poorer outcomes for patients with PABC compared with age- and stage-matched control individuals [13, 45, 63–65].

A recent study of 46 patients with PABC found that PABC was associated with a younger age at cancer diagnosis, older age at first full-term pregnancy, *BRCA* mutation positivity, "non-Caucasian" race, triple receptor–negative status, and higher histologic and pathologic grades when controlled for age at first full-term preg-

TABLE 3: Imaging Findings of Common Breast Abnormalities in Pregnant and Lactating Patients

Abnormality	Findings	
	Ultrasound	Mammography
Hypertrophic fibroadenoma	Oval or round	Oval or round
	Circumscribed	Circumscribed
	Heterogeneous, isoechoic or hypoechoic	Equal density
	With or without cystic spaces with prominent ducts	With or without coarse calcifications (if involuted)
Lactating adenoma	Oval or round	Oval or round
	Circumscribed	Circumscribed
	Homogeneous, hypoechoic	Equal density
		No calcifications
Galactocele	Variable, usually oval or round	Variable, usually oval or round
	Circumscribed	Circumscribed
	Internal cystic spaces	With or without fat-fluid level (diagnostic if present)
Puerperal mastitis	Variable, often irregular	Irregular
	Noncircumscribed margins, often indistinct	Noncircumscribed margins
	Heterogeneous, isoechoic or anechoic	Skin and trabecular thickening
	With or without fluid-debris levels	In cases with abscess, mass may or may not be present and air-fluid levels may or may not be present
	With or without posterior acoustic enhancement	
GM	Variable, usually irregular, noncircumscribed mass with tubular extensions	Variable, may appear normal or asymmetry may be present; with or without a mass
	Parallel orientation	Architectural distortion
	With or without axillary lymphadenopathy	With or without axillary lymphadenopathy
	Stromal edema	
	With or without hyperemia	
	With or without fluid collections	
PABC	Irregular	Asymmetry or mass
	Noncircumscribed	High density
	Hypoechoic	Suspicious microcalcifications
	Posterior shadowing or enhancement	Architectural distortion
	With or without antiparallel orientation	Skin thickening
	With or without cystic spaces	With or without axillary lymphadenopathy

Note—GM = granulomatous mastitis, PABC = pregnancy-associated breast cancer.

nancy [66]. Breast cancer recurrence is common in patients with PABC and usually occurs within 2–3 years of the initial diagnosis [3].

Clinically, patients with PABC commonly present with a palpable breast mass. Sonographic and mammographic features of PABC are identical to those of non-PABC, although imaging findings may be obscured by physiologic changes of the breast tissue [6, 67]. PABC commonly shows sonographic features typically associated with benignancy, with parallel orientation seen in up to 58% of PABC lesions and posterior acoustic enhancement in up to 63% [56]. Aggressive masses may outgrow their vascular supply and develop internally necrotic cystic spaces, potentially mimicking benign cystic masses such as galactoceles or abscesses [56].

Mammographic features of PABC, like those of non-PABCs, include asymmetries or masses, architectural distortion, microcalcifications, skin thickening, or axillary lymphadenopathy, although these features may be partially obscured by the increase in breast density [56] (Figs. 2 and 7). In suspicious cases, mammography is used to evaluate for multifocal disease, multicentric disease, or sonographically occult findings such as microcalcifications [1].

MRI is contraindicated during pregnancy because of concern for gadolinium-induced teratogenic effects on the fetus; however, immediately after delivery or pregnancy termination or during lactation, MRI is recommended to fully evaluate and stage locoregional disease [1, 24]. A retrospective review of 53 patients with PABC who underwent breast MRI determined that 23% of patients had greater extent of disease evident on MRI than was evident on mammography and breast ultrasound [45]. As we previously discussed, PABC tends to have earlier and more intense

enhancement than background parenchymal enhancement on DCE-MRI (Fig. 4).

Pregnancy-induced idiopathic granulomatous mastitis—Idiopathic granulomatous mastitis (GM) is a rare benign inflammatory breast disease associated with pregnancy, lactation, and hyperprolactinemia [1, 68]. GM most commonly occurs within 5 years of pregnancy in women who have nursed from 2 to 36 months. Symptom onset typically occurs between 6 months to 2 years after cessation of breastfeeding. Although the cause of GM is unknown, the most accepted theory suggests an initial insult to ductal epithelial cells results in transit of luminal secretions to lobular breast stroma, stimulating a local inflammatory response within the connective tissue [68, 69]. The hallmark of the disease is the formation of sterile noncaseating lobulocentric granulomas, which have a protracted course and ultimately end in lesion involution [70–72]. The disease typically presents as a unilateral painful palpable mass with or without overlying skin thickening. The clinical features of GM overlap significantly with benign and malignant entities such as infectious mastitis and inflammatory breast cancer.

Sonographic findings of GM are variable, but sonography most frequently shows a large hypoechoic mass with tubular extensions parallel to tissue planes that spare the subareolar breast [68] (Fig. 8). Doppler ultrasound may show peripheral hypervascularity. Fluid collections and abscesses may be present in advanced disease. Additional indirect sonographic findings of GM include skin thickening and stromal edema, obliteration of subcutaneous fat, and axillary lymphadenopathy. Mammographic findings of GM are variable and may show an asymmetry or irregular mass but can be normal. CNB is usually indicated given the nonspecific imaging features, with excisional biopsy reserved for cases of discordant imaging and pathologic findings. Imaging surveillance can be offered to patients with mild disease. For more advanced disease, oral corticosteroids are the first-line treatment, followed by immunosuppressive therapy and/or prolactin inhibitors such as methotrexate or bromocriptine. Wide local surgical excision is reserved for aggressive forms of the disease after failed medical therapy [70].

Puerperal mastitis—Puerperal mastitis specifically refers to mastitis that occurs postpartum or during lactation. It is most often caused by *Staphylococcus aureus* or *Streptococcus* bacteria from the nursing infant's nose and mouth that has infiltrated the nipple-areolar complex through epithelial disruption [1, 73]. The patient usually attests to a history of cracked nipples or skin abrasions. Ceased lactation puts the woman at especially higher risk of infection, because stagnant milk readily encourages bacterial growth [61, 74–76]. Sonographic evaluation typically reveals hypoechoic areas within the parenchyma reflecting edema with ill-defined hyperechoic areas related to inflamed fat lobules, skin thickening, and hyperemia [77, 78]. An abscess, if present, may appear as an ill-defined, irregular, heterogeneously hypoechoic or anechoic mass, occasionally with fluid-debris levels and posterior acoustic enhancement (Fig. 9). Mammography may show skin and trabecular thickening due to edema but is generally not indicated and is uncomfortable for the patient. Treatment is with antibiotics, typically amoxicillin and clavulanate potassium or cloxacillin. Incision and drainage may be required if an abscess is present. Simple needle aspiration, with or without lavage, has also shown to be effective [78, 79]. Notably, inflammatory breast cancer is an important mimic and should be suspected if symptoms are refractory to antibiotic therapy.

Hypertrophic Fibroadenoma

Fibroadenomas are the most common tumors found during either pregnancy or lactation [1, 80–83]. Hormonally sensitive fibroadenomas have a propensity to undergo hypertrophy due to the physiologic hormone elevations characteristic of these periods. Most gestational and lactating fibroadenomas are thought to exist before conception but are clinically undetectable in the prepregnancy period [1]. The typical fibroadenoma appears as a heterogeneous iso- to hypoechoic circumscribed mass. Fibroadenomas may develop cystic spaces and prominent ducts reflecting secretory changes or increased vascularity (Fig. 10). Rarely, infarction may occur due to rapid growth, which may present as a painful palpable mass. Infarcted fibroadenomas may appear suspicious, presenting as lobulated masses with more heterogeneous echotexture and acoustic shadowing, thus necessitating biopsy [1, 81, 82].

Lactating Adenoma

Lactating adenomas are the second most common tumors of pregnancy and lactation [80]. They characteristically develop late in pregnancy or early lactation and present clinically as a firm, nontender, mobile mass that often regresses spontaneously after the cessation of lactation. Imaging features favor benignity: a circumscribed mass with smooth or macrolobulated margins, no calcifications on mammography, homogeneous hypoechoic echo pattern, and an echogenic pseudocapsule [1, 84] (Fig. 11). The imaging appearance of lactating adenoma overlaps significantly with the imaging appearance of fibroadenoma, and the two entities may be indistinguishable [84, 85]. Lactating adenomas may infarct if growth outstrips their blood supply, with resulting imaging findings of posterior acoustic shadowing and irregular margins mimicking malignant entities [86]. Surgical resection may be warranted if there is continued growth after cessation of lactation.

Galactocele

Galactoceles are the most common benign lesions in lactating or recently lactating women [80]. They occur shortly after the cessation of breastfeeding as a result of stagnate milk products but may be formed by any cause that results in obstruction of a lactating duct [1, 40, 61, 87]. Clinically, galactoceles present as slow-growing painless palpable masses. The pathognomonic mammographic appearance is a fat-fluid level within a circumscribed mass; however, more commonly, a galactocele presents as a heterogeneous density that may mimic a hamartoma or a suspicious mass [1, 81, 88]. The sonographic appearance of galactoceles is variable, ranging from a homogeneous mass with low-level echoes and posterior acoustic enhancement to a mass with heterogeneous echotexture and irregular margins. If galactocele is suspected, aspiration may be both diagnostic and therapeutic, and the diagnosis may be confirmed on aspiration of milky fluid and corresponding resolution of the lesion [61] (Fig. 12).

Conclusion

The pregnant and lactating patient presents a unique diagnostic challenge, even more so considering the extensive overlap of

clinical and radiologic findings that often mimic malignant entities. Patients and referring clinicians should feel reassured that mammography with or without tomosynthesis is safe during pregnancy and lactation with negligible fetal doses. Screening mammography based on patient age and individual risk is not contraindicated during pregnancy and lactation. Although some facilities elect to delay screening mammography until after the woman ceases lactation, anecdotal data suggest that screening mammography may be of benefit in the detection of PABC. An algorithm for the diagnostic workup of breast pain, a breast mass, and nipple discharge using ultrasound and mammography will provide timely and appropriate care for the pregnant and lactating patient. MRI has a role in the delineation of disease extent for lactating women with breast cancer. Awareness of the unique pathologic entities that occur during pregnancy and lactation and their hallmark clinical features may reduce unnecessary intervention and may direct the workup toward those with more suspicious features.

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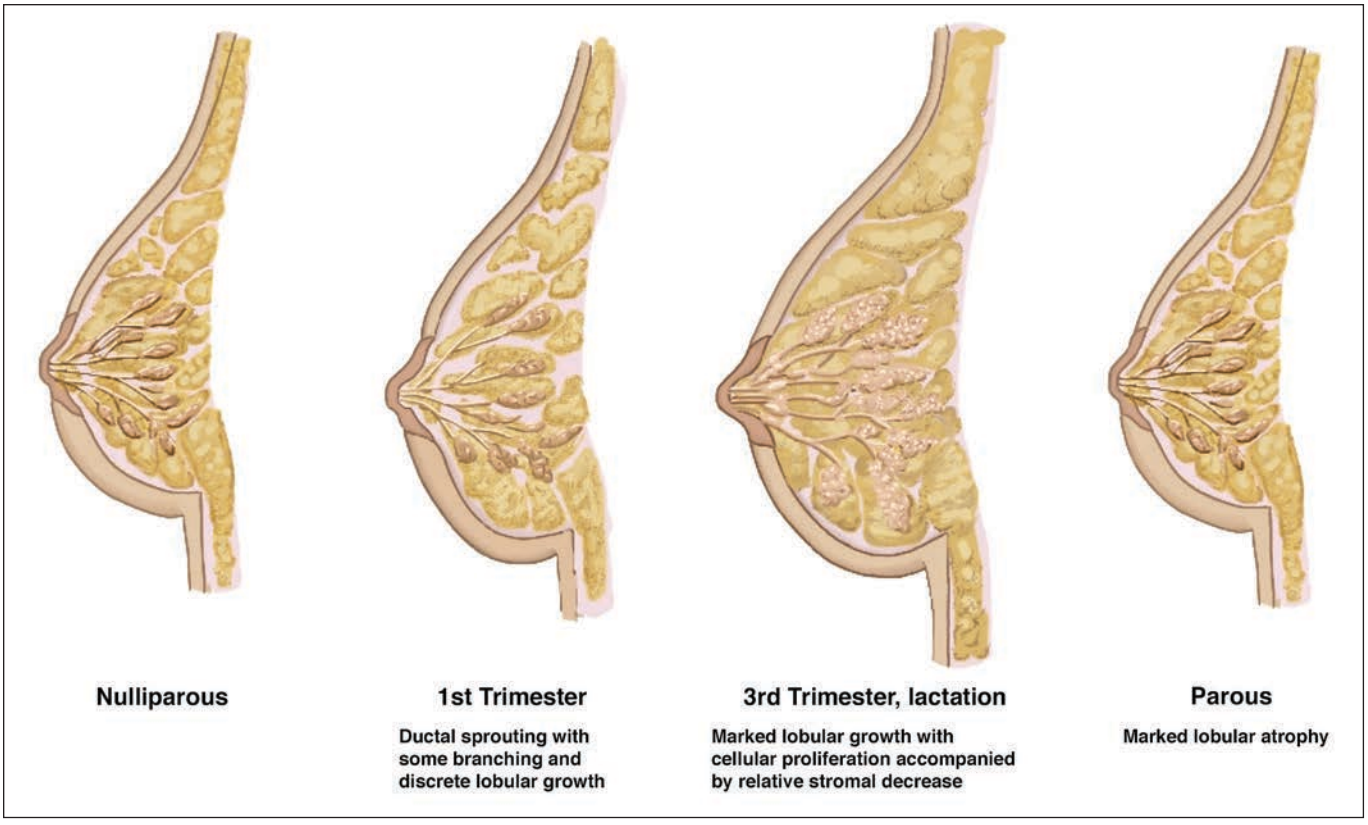


Fig. 1—Drawings show physiologic changes of breast from pregnancy through lactation.

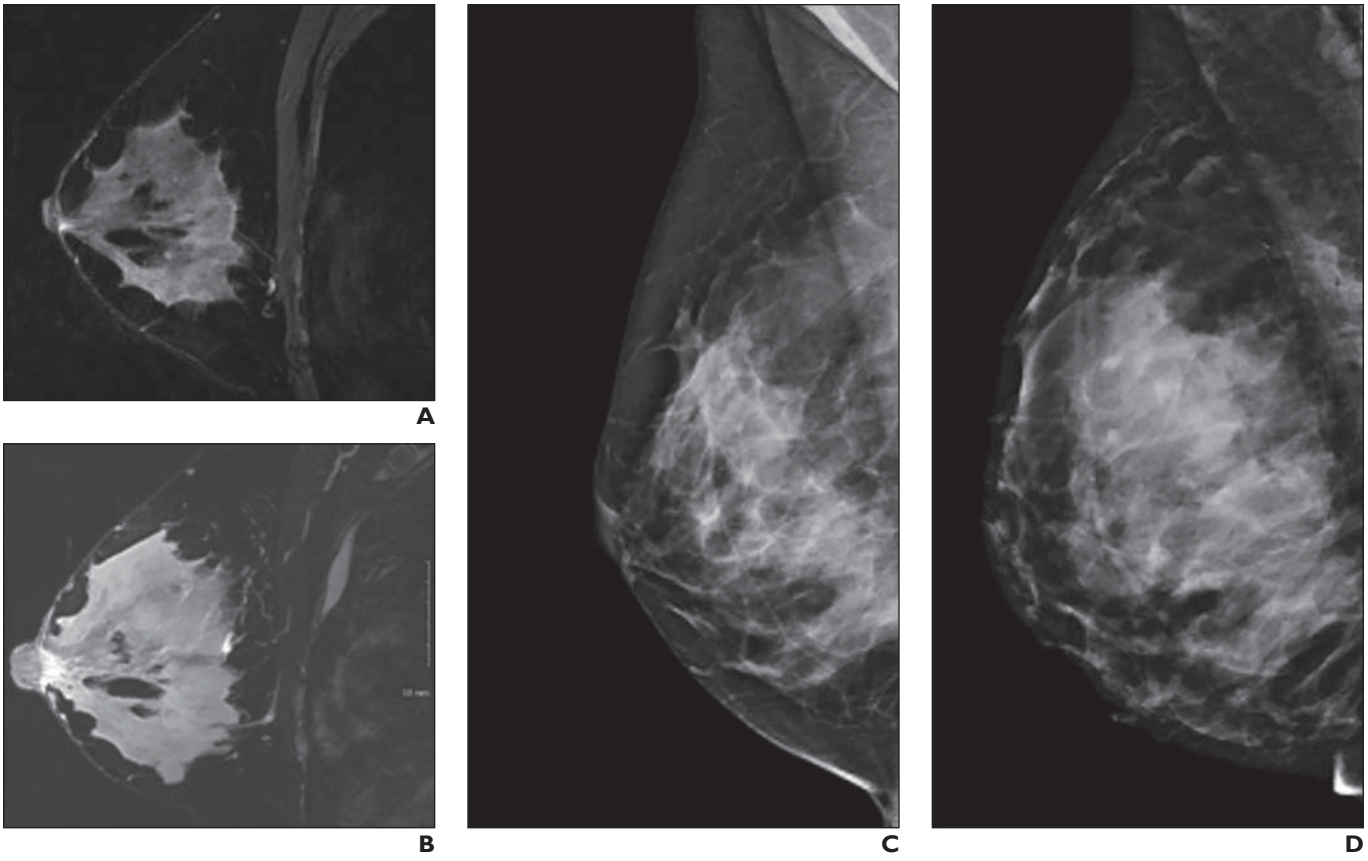


Fig. 2—31-year-old woman who presented for high-risk screening MRI and screening mammography before lactation and during lactation.
A and **B,** T2-weighted MR images of right breast before lactation (**A**) and during lactation (**B**).
C and **D,** Mediolateral oblique screening mammograms of right breast before lactation (**C**) and during lactation (**D**). Notice marked ductal sprouting, lobular growth, and relative decrease in breast fat resulting in overall increase in breast size and density during lactation.

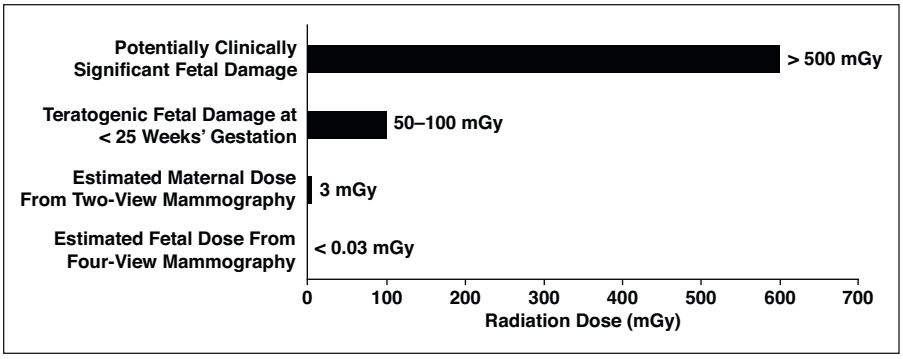


Fig. 3—Bar graph shows deterministic radiation effects of mammography compared with expected thresholds for clinically significant fetal damage.

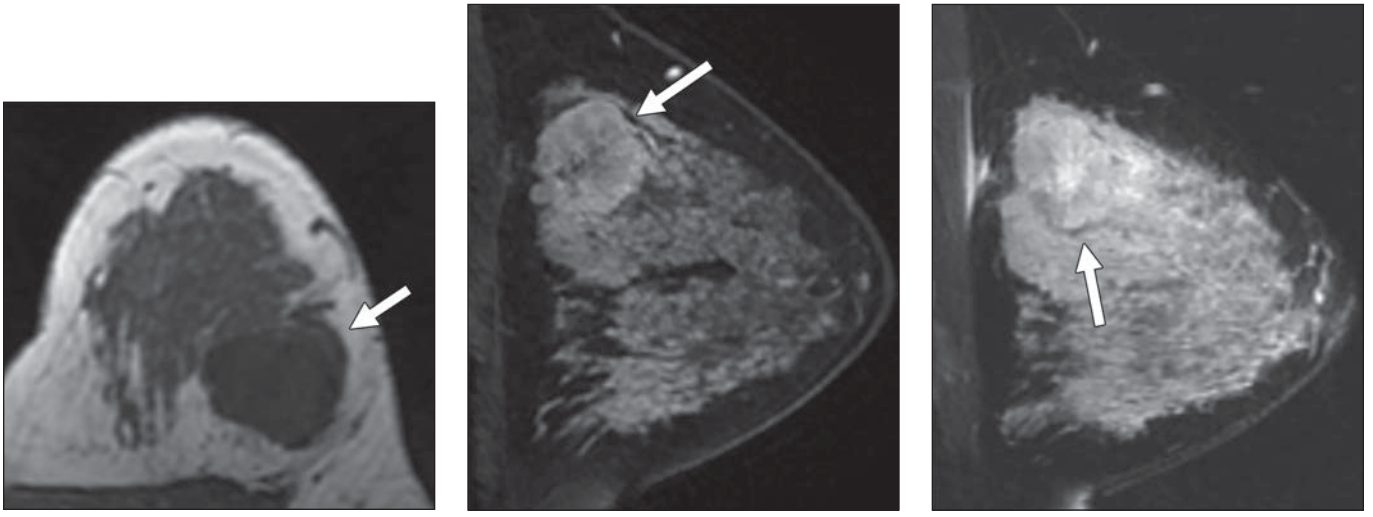


Fig. 4—34-year-old woman 2 months postpartum who presented for staging MRI after diagnosis of invasive ductal carcinoma.
A, Axial T1-weighted image shows large hypointense mass in upper outer breast (*arrow*).
B, Contrast-enhanced fat-suppressed T1-weighted image shows irregular enhancing mass (*arrow*) with rapid washout kinetics and central necrosis.
C, T2-weighted image of left breast shows irregular mass (*arrow*) with centrally increased signal intensity related to necrosis. Exuberant, potentially confounding background T2 signal may account for interpretative challenge.

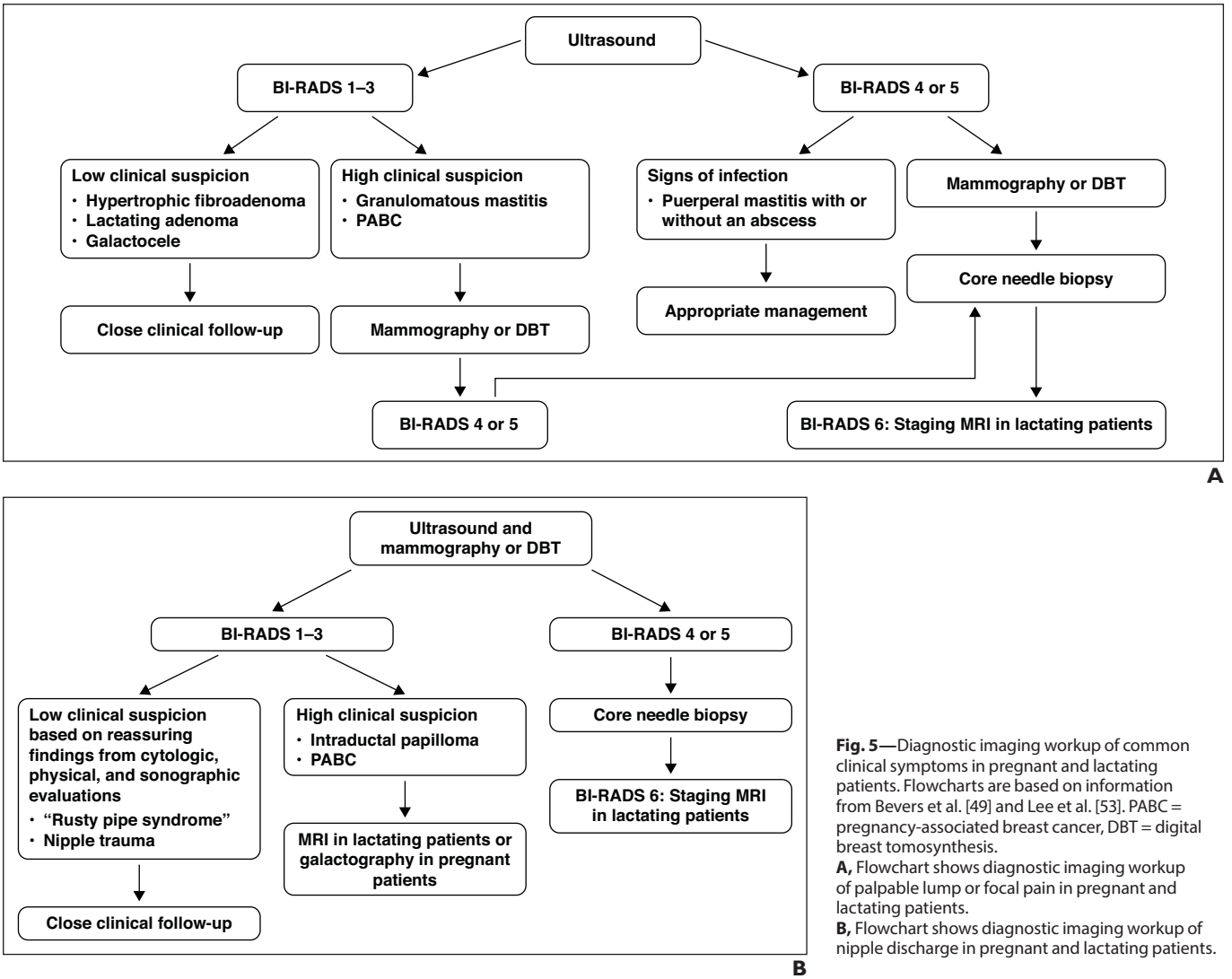


Fig. 5—Diagnostic imaging workup of common clinical symptoms in pregnant and lactating patients. Flowcharts are based on information from Bevers et al. [49] and Lee et al. [53]. PABC = pregnancy-associated breast cancer, DBT = digital breast tomosynthesis.
A, Flowchart shows diagnostic imaging workup of palpable lump or focal pain in pregnant and lactating patients.
B, Flowchart shows diagnostic imaging workup of nipple discharge in pregnant and lactating patients.

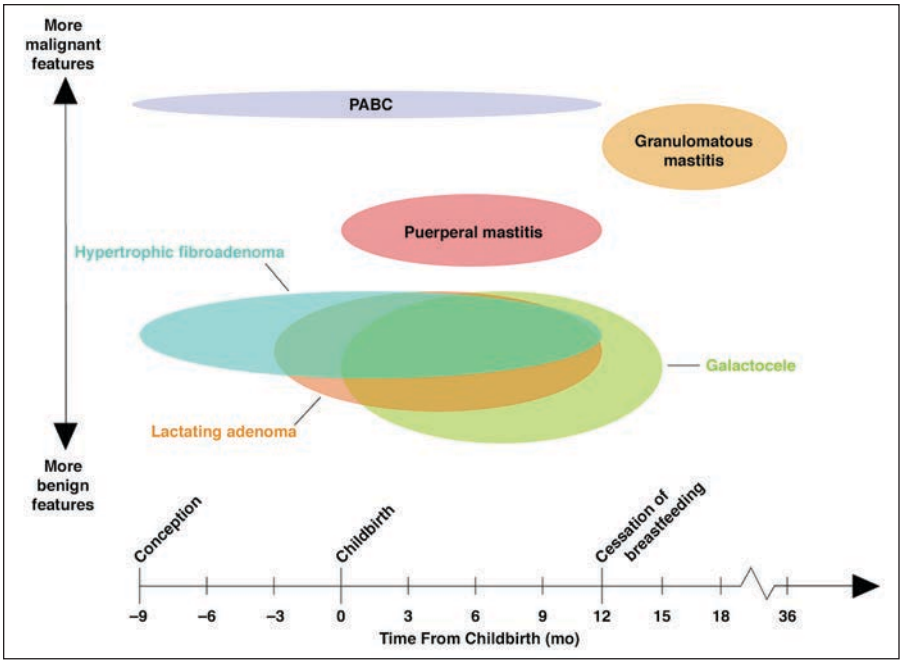


Fig. 6—Schematic shows imaging features of common clinical entities that occur during pregnancy and lactation. PABC = pregnancy-associated breast cancer.

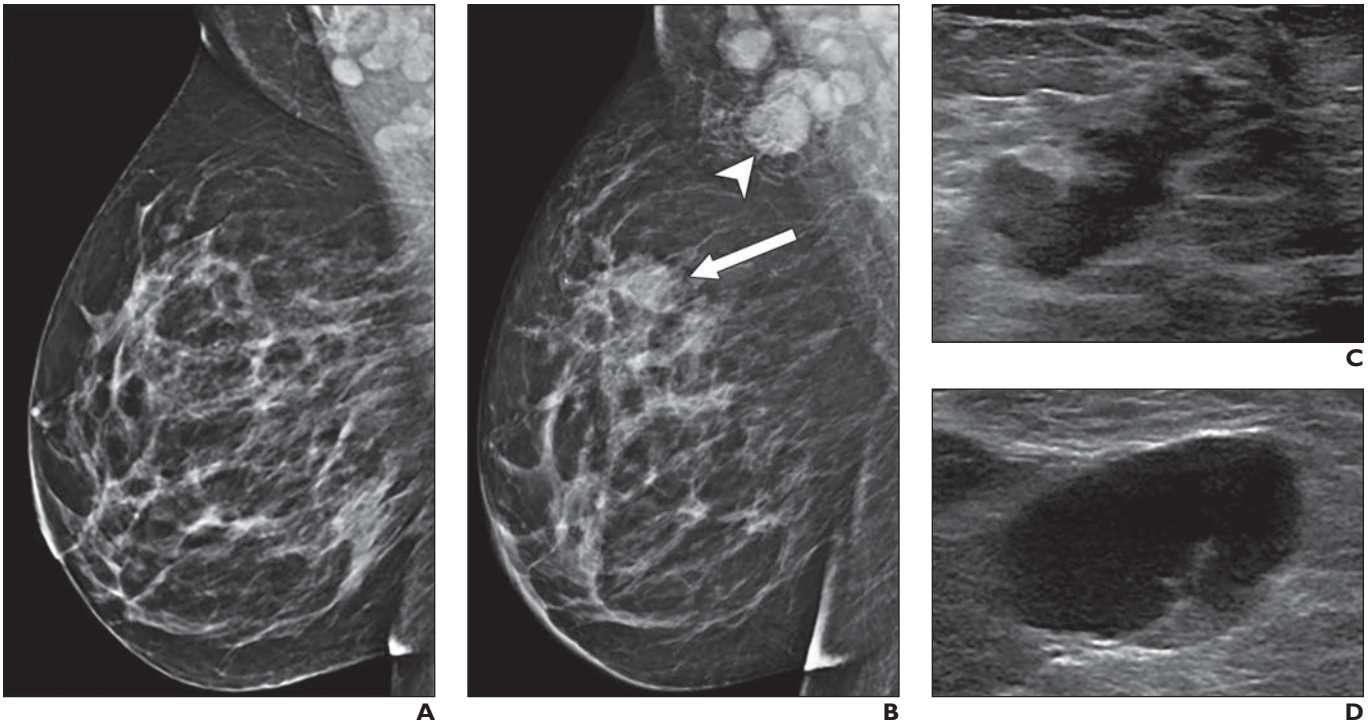


Fig. 7—39-year-old pregnant woman with new palpable lump in right breast.
A, Baseline right mediolateral oblique (MLO) mammogram.
B, Right MLO mammogram obtained 3 months after **A**. Note interval development of mass (*arrow*) in upper middle one-third of breast with associated axillary lymphadenopathy (*arrowhead*).
C, Targeted ultrasound image of mass reveals irregular, ill-defined hypo- to isoechoic mass with posterior shadowing.
D, Targeted ultrasound image of axilla reveals morphologically abnormal lymph node with effaced fatty hilum and cortical thickening. Core needle biopsy revealed invasive ductal carcinoma with metastatic axillary node.

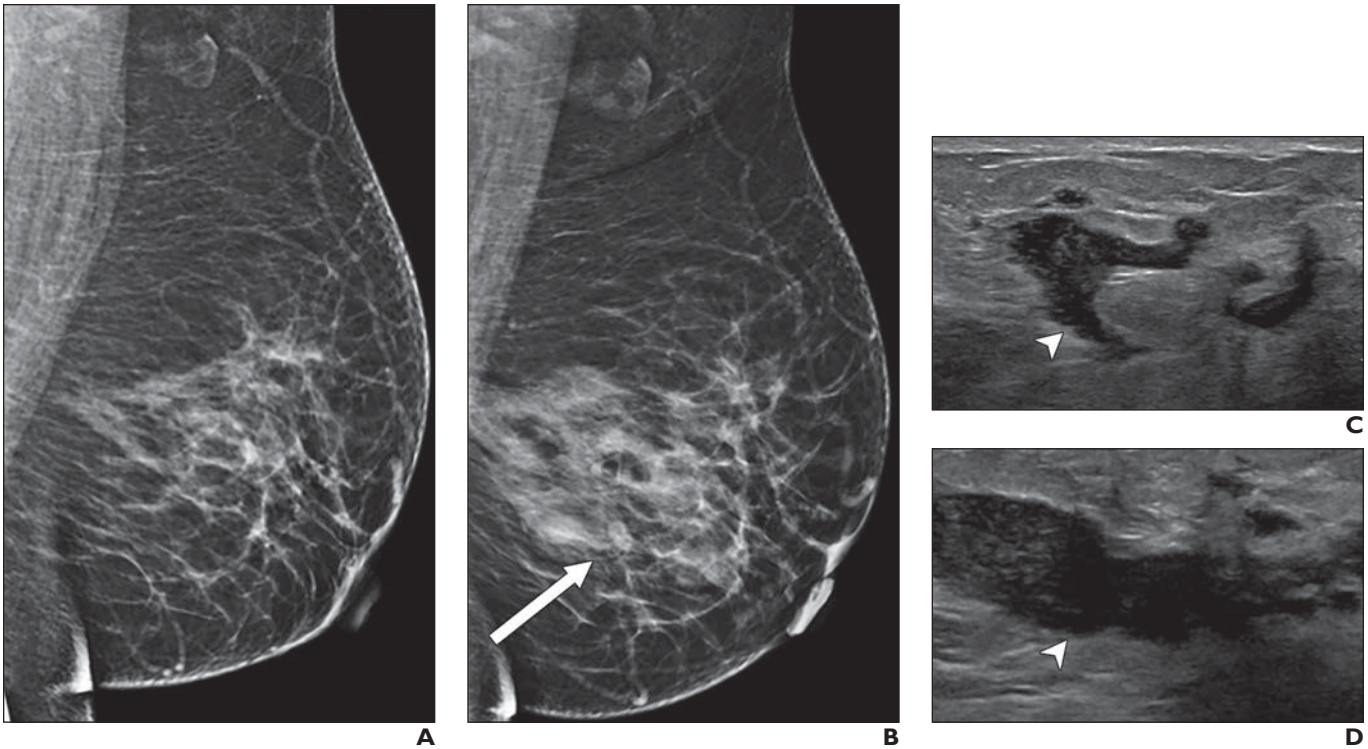


Fig. 8—36-year-old woman who presented with left breast pain 6 months postpartum.
A, Baseline left breast mammogram, mediolateral oblique (MLO) view.
B, Left breast mammogram, MLO view, obtained 8 months after **A** at time of clinical presentation. Note asymmetry in lower middle posterior one-third of breast (*arrow*).
C and **D,** Targeted ultrasound images reveal mixed echogenicity mass with tubular extensions (*arrowheads*). Ultrasound-guided core needle biopsy confirmed granulomatous mastitis.

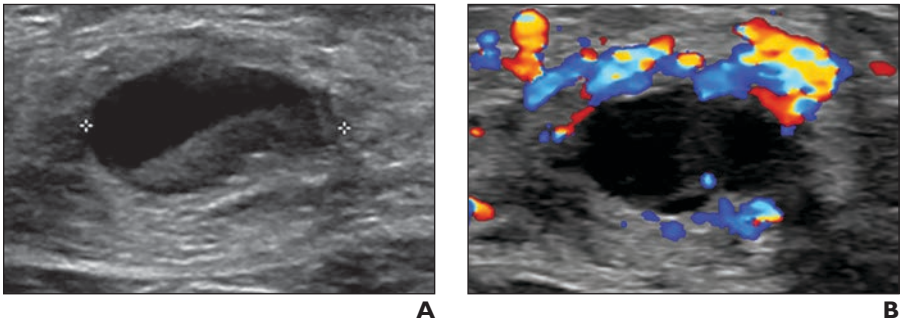


Fig. 9—38-year-old woman who presented with painful breast lump and erythema during lactation.
A, Targeted ultrasound image reveals anechoic mass (*calipers*) with layering isoechoic debris.
B, Color Doppler ultrasound image reveals hyperemia surrounding mass. This finding is consistent with puerperal abscess. Ultrasound-guided aspiration revealed purulent fluid.

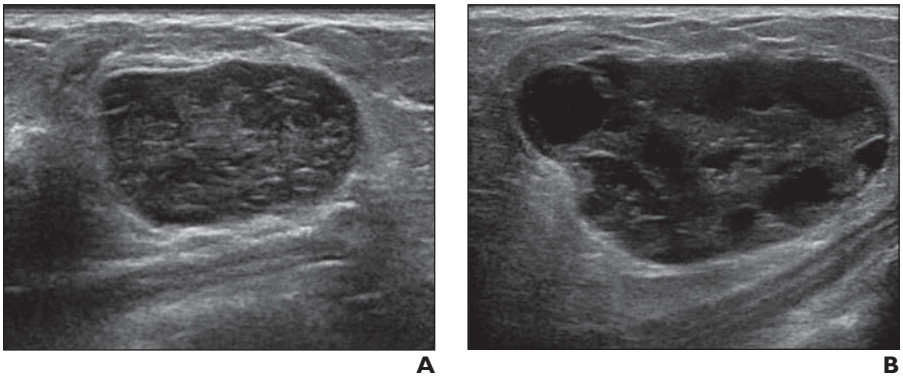
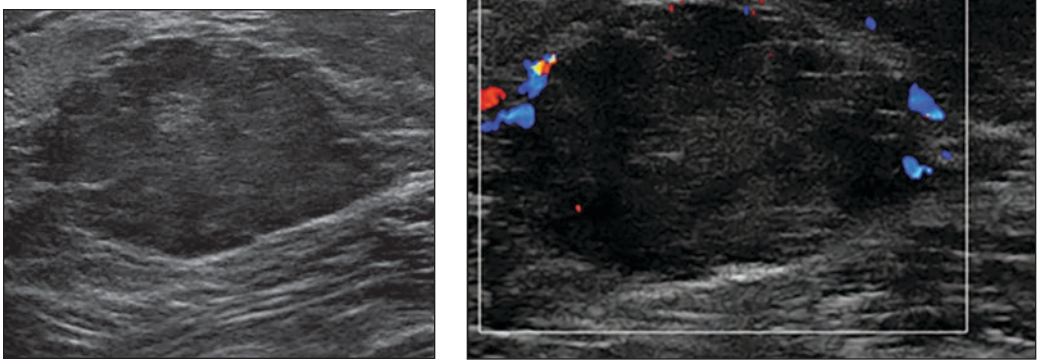
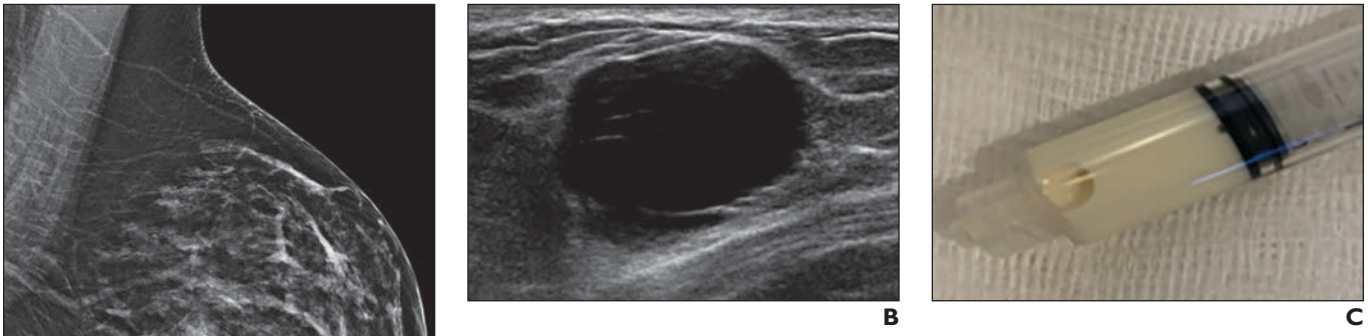


Fig. 10—26-year-old woman who presented with palpable lump at 23 weeks' gestation.
A, Initial ultrasound image shows well-circumscribed, parallel, heterogeneously hypoechoic mass that is most consistent with fibroadenoma.
B, Follow-up ultrasound image obtained 4 weeks postpartum while patient was lactating shows enlargement of mass with interval development of cystic spaces, reflecting secretory changes. Core needle biopsy showed lactational changes in fibroadenoma.



A B

Fig. 11—32-year-old woman who presented with palpable lump in left breast during lactation.
A, Left breast ultrasound image shows heterogeneous hypoechoic mass with well-circumscribed, slightly lobulated margins.
B, Color Doppler ultrasound image shows peripheral vascularity. Ultrasound-guided core needle biopsy result was consistent with lactating adenoma.



A B C

Fig. 12—33-year-old woman who presented with palpable left breast mass 2 months after ceasing lactation.
A, Left mediolateral oblique mammogram shows circumscribed mass (*arrow*) in lower anterior one-third of left breast.
B, Targeted left breast ultrasound image at expected site of mass reveals circumscribed hypoechoic mass with posterior acoustic enhancement.
C, Photograph of syringe containing aspirate obtained at ultrasound-guided aspiration of mass reveals that mass contains milky white fluid, which is diagnostic of galactocele.

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