The Breast Imaging Reporting and Data System (BI-RADS) and Imaging of Breast Masses

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Abstract

The Breast Imaging Reporting and Data System (BI-RADS) was developed by the American College of Radiology (ACR) to systematize the format of a mammography report with extension to breast ultrasound and MRI interpretation as well. BI-RADS utilization for standardized reporting helps to manage decision making and serves as a useful tool in collecting data and auditing individual practices. The BI-RADS final assessment categories standardize the reporting of mammographic findings and the recommendations for further management Assessments are either incomplete (category 0) or final assessment categories (categories 1 through 6). A breast mass, also known as a breast lump, is a localized swelling that feel different from the surrounding tissue. Breast pain, nipple discharge, or skin changes may be present. Concerning findings include masses that are hard, do not move easily, are of an irregular shape, or are firmly attached to surrounding tissue. Causes include fibrocystic change, fibroadenomas, breast infection, galactoceles, and breast cancer. Breast cancer makes up about 10% of breast masses. Diagnosis is typically by examination, medical imaging, and tissue biopsy. Tissue biopsy is often by fine needle aspiration biopsy. Repeated examination may be required. Ultrasonography (US) and mammography are the two basic imaging techniques for routine diagnostic imaging of breast diseases. For women over the age of 35 years presenting with a palpable or suspected breast mass, mammography is often the first imaging investigation to be performed. The BI-RADS 5 assessment category is used when the likelihood of malignancy is estimated to be greater than or equal to 95% on the basis of imaging findings. However, according to Yao et al, the actual positive predictive value for a BI-RADS 5 assessment ranges from 78% to 97.5%. Hence, not all BI-RADS 5 lesions are malignant. There are several benign entities affecting the breast that may manifest with highly suspicious imaging features and BI-RADS 5 categorization.

Keywords: BI-RADS,

1. Introduction

The Breast Imaging Reporting and Data System (BI-RADS) was developed by the American College of Radiology (ACR) to systematize the format of a mammography report with extension to breast ultrasound and MRI interpretation as well. BI-RADS utilization for standardized reporting helps to manage decision making and serves as a useful tool in collecting data and auditing individual practices. ***(1)***

BI-RADS final assessment categories:

The BI-RADS final assessment categories standardize the reporting of mammographic findings and the recommendations for further management Assessments are either incomplete (category 0) or final assessment categories (categories 1 through 6). ***(2)***

BI-RADS 0:

Incomplete assessment – Need further imaging evaluation and/or prior mammograms for comparison. Commonly used in screening studies with insufficient data due to incomplete evaluation include technical issues like suboptimal images because of improper positioning or motion. ***(2)***

BI-RADS 1:

This is a totally negative examination. Continue with screening mammography and clinical breast examination is highly recommended. ***(3)***.

BI-RADS 2:

Benign nodules such as fibroadenomas, cysts or benign vascular, parenchymal calcifications. Malignancy is not concerned so any further assessment is not needed. Routine follow-up is recommended. ***(3)***.

BI-RADS 3:

Probably benign finding –used for atypical benign lesions, but the possibility of malignancy is less than 2 percent. Such as a parenchymal asymmetry, calcifications, or a nodule that does not have classic benign imaging features. ***(3)***.

BI-RADS 4:

Suspicious abnormality: Biopsy should be considered for lesion with suspicious features for malignancy. The possibility of malignancy ranges between 2 and 94 percent. The degree of suspicion for malignancy varies both with the lesion and with the interpreter. ***(1)***

BI-RADS 5:

Highly suggestive of malignancy; proper action should be taken – Lesions which have stander worrisome imaging criteria such as speculations pleomorphic calcifications, and skin retraction are placed in this category. The possibility of malignancy is up to 95 percent. ***(3)***.

BI-RADS 6:

Biopsy-proven malignancy; proper action should be taken – This includes patients with biopsy-proven cancers with no surgical intervention who present for further evaluation to of the contralateral breast or assess response to neoadjuvant chemotherapy. As well as second opinion with interpretation of outside imaging studies. ***(2)***

Final Assessment Categories			
Category		Management	Likelihood of cancer
0	Need additional imaging or prior examinations	Recall for additional imaging and/or await prior examinations	n/a
1	Negative	Routine screening	Essentially 0%
2	Benign	Routine screening	Essentially 0%
3	Probably Benign	Short interval-follow-up (6 month) or continued	>0 % but ≤ 2%
4	Suspicious	Tissue diagnosis	4a. low suspicion for malignancy (>2% to ≤ 10%) 4b. moderate suspicion for malignancy (>10% to ≤ 50%) 4c. high suspicion for malignancy (>50% to <95%)
5	Highly suggestive of malignancy	Tissue diagnosis	≥95%
6	Known biopsy-proven	Surgical excision when clinical appropriate	n/a

Figure (1): BI-RADS final assessment categories. ***(3)***.

Pathology And Imaging of Benign Mases

Background:

A breast mass, also known as a breast lump, is a localized swelling that feel different from the surrounding tissue. Breast pain, nipple discharge, or skin changes may be present. Concerning findings include masses that are hard, do not move easily, are of an irregular shape, or are firmly attached to surrounding tissue. ***(4)***

Causes include fibrocystic change, fibroadenomas, breast infection, galactoceles, and breast cancer. Breast cancer makes up about 10% of breast masses. Diagnosis is typically by examination, medical imaging, and tissue biopsy. Tissue biopsy is often by fine needle aspiration biopsy. Repeated examination may be required. ***(5)***

Treatment depends on the underlying cause. It may vary from simple pain medication to surgical removal. Some causes may resolve without treatment. Breast masses are relatively common. It is the most common breast complaint with the women's concern generally being that of cancer. ***(4)***

Basic imaging approach for breast masses:

Ultrasonography (US) and mammography are the two basic imaging techniques for routine

diagnostic imaging of breast diseases. For women over the age of 35 years presenting with a palpable or suspected breast mass, mammography is often the first imaging investigation to be performed. ***(6)***

From our experience, an algorithmic approach based on mammographical features, i.e. Whether a mass is well-circumscribed or not, and the presence of fat density is proposed. US is used to determine whether the mass is a simple cyst, a complex mass, or a solid mass. It should be emphasised, however, that a thorough clinical examination should be performed in conjunction with these imaging studies for a complete breast assessment. ***(7)***

BI-RADS 5: More than Cancer

The BI-RADS 5 assessment category is used when the likelihood of malignancy is estimated to be greater than or equal to 95% on the basis of imaging findings. However, according to **Yao et al,** ***(2)*** the actual positive predictive value for a BI-RADS 5 assessment ranges from 78% to 97.5%. Hence, not all BI-RADS 5 lesions are malignant. There are several benign entities affecting the breast that may manifest with highly suspicious imaging features and BI-RADS 5 categorization ***(8)***.

There are specific imaging features of BI-RADS 5 malignancies depicted at mammography, US. Typical mammographic features that warrant BI-RADS 5 assessment include an irregular mass with spiculated margins with or without associated distortion, fine linear branching or pleomorphic calcifications, segmental pleomorphic calcifications, or some combination of these findings. At US, typical imaging features of a BI-RADS 5 mass include irregular shape, nonparallel orientation, hypoechoic echo pattern, spiculated margin, ductal extension, echogenic halo, or posterior shadowing ***(3)***.

Lesions Possibly Classified as BI-RADS 5:

- ✓ *Fat necrosis.*
- ✓ *Mastitis.*
  - *Inflammatory mastitis.*
  - *Chronic mastitis*
  - *Granulomatous mastitis.*
- ✓ *Complex sclerosing lesion & radical scar.*
- ✓ *Fibromatosis or desmoid tumor.*
- ✓ *Benign Phyllodes Tumor.*
- ✓ *Atypical infection.*

Complex sclerosing lesion and radial scar:

Pathology

A radial scar is a benign hyperplastic proliferative disease of the breast. Proposed possible causes include localized inflammatory reaction and chronic ischemia with subsequent slow infarction ***(9)***.

Histopathologically, radial scars contain hyperplastic tissue cells and a central fibrous core, with a radial extension of tubular structures (the spiculated peripheral borders), mimicking infiltrating carcinoma. This tubular formation has two rows of cells, epithelial and myoepithelial. The malignant potential is two times greater than in the normal population without radial scar ***(10)***

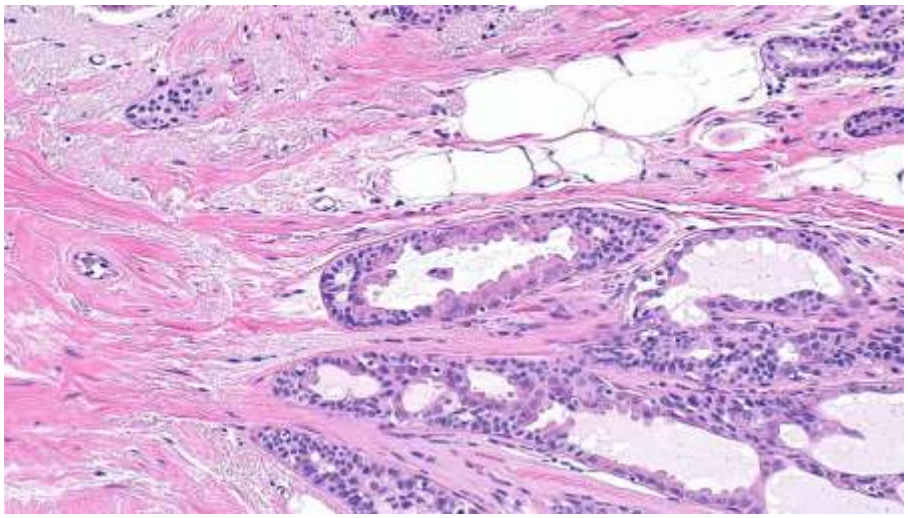


Figure (2).Complex sclerosing lesion ***(10)***

Imaging appearance

Complex sclerosing lesions and radial scars are common benign entities with suspicious imaging features, necessitating biopsy. The most common manifestation is architectural distortion depicted at screening mammography. US usually shows architectural distortion without central mass accompanied by occasional irregular, iso- or hypoechoic mass with or without posterior shadowing. The current recommendation is surgical excision in most cases because of the incidence of associated atypia or malignancy. ***(11)***

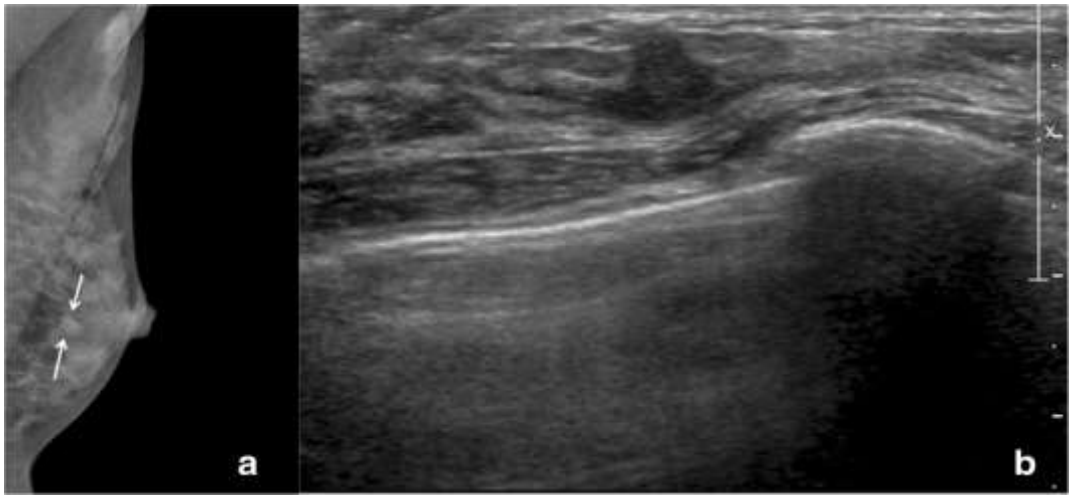


Figure (3): (a) On mammography, there is an irregular, indistinct, hyperdense mass (arrow). (b) On ultrasound, there is an irregular, non-parallel, angular, hypoechoic mass ***(12***).

Fat necrosis:

Pathology

Fat necrosis within the breast is a pathological process that occurs when there is saponification of local fat. It is a benign inflammatory process and is becoming increasingly common with the

greater use of breast-conserving surgery and mammoplasty procedures. At the microscopic level, the initial change is disruption of fat cells, with the formation of vacuoles containing the remnants of necrotic fat cells. The vacuoles are then surrounded by lipid-laden macrophages, multinucleated giant cells, and acute inflammatory cells. Fibrosis develops during the reparative phase, peripherally enclosing an area of necrotic fat and cellular debris. Eventually, fibrosis may replace the area of degenerated fat with a scar, or loculated and degenerated fat may persist for years within a fibrotic scar ***(13)***.

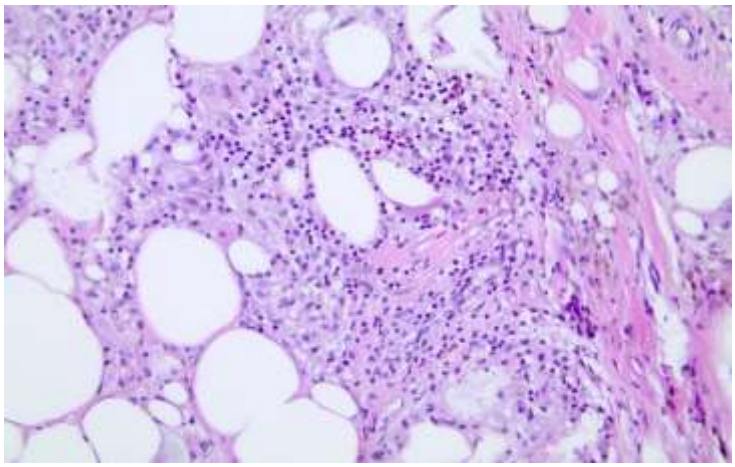


Figure (4) ***Fat necrosis (14)***

Imaging appearance

Fat necrosis is a condition in which the normal fat cells of the breast become round lumps. Symptoms can include pain, firmness, redness, and/or bruising. Fat necrosis usually goes away without treatment but can form permanent scar tissue that may show up as an abnormality on a mammogram. Beyond saponification and calcification, fat necrosis concludes with fibrosis and the formation of grey-yellow scar tissue. On mammography, fat necrosis can present as lipid cysts, calcifications, focal asymmetries, spiculated masses or architectural distortion. It is also possible for calcification to occur around the edges of a fatty necrotic lesion, enclosing the fat in a cyst. These "oil cysts" may persist for months to years without undergoing fibrosis. ***(15)***

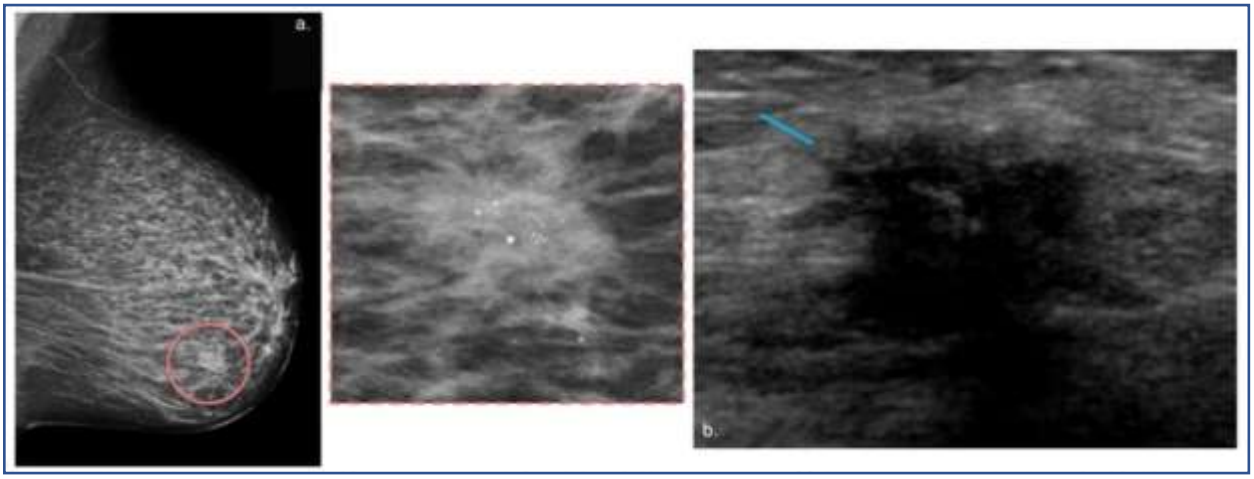


Figure (5): Left mediolateral oblique mammogram (a) shows an irregular spiculated mass (circle) with microcalcifications, which corresponds to a left transverse US image (b) that shows an irregular, spiculated hypoechoic mass (arrow) with posterior shadowing at the 5 o'clock

position. ***(5)***

Fibromatosis or desmoid tumor:

Pathology

Fibromatosis of the breast, also known as an extra-abdominal desmoid tumor of the breast or mammary fibromatosis, is considered a rare breast tumor. It is a non-metastasizing benign but locally invasive stromal tumor. However, it can mimic more sinister types of breast cancer on both imaging and clinical findings ***(16)***.

The entity is pathologically indistinguishable from fibromatosis occurring elsewhere in the body. The tumor has a fibroblastic and myofibroblastic origin. A desmoid tumor appears as a solitary, hard and painless nodule, which sometimes can be attached to the skin or to the pectoral muscle fascia. While it can occur anywhere in the breast, lesions may tend to occur in close proximity to pectoral muscles ***(16)***

Imaging appearance

Fibromatosis or desmoid tumor is a benign locally aggressive spindle cell tumor arising from the aponeurosis overlying the pectoralis muscle or occurs secondary to prior trauma or surgery. ***(11)***

Mammography in these cases usually reveals irregular, spiculated mass arising from aponeurosis overlying pectoralis muscle with or without skin or nipple retraction, however; no lymphadenopathy is found. On the other hand, US shows irregular hypoechoic mass with angular or indistinct margin without posterior features. Variable internal vascularity is sometimes found. ***(17)***

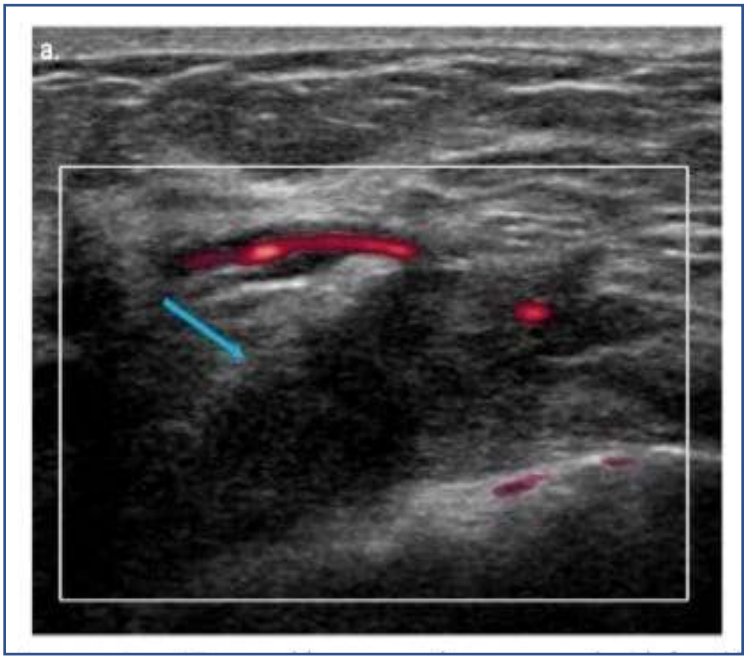


Figure (6): (a) US image shows an irregular hypoechoic mass (arrow) involving the breast and pectoralis muscle with a large feeding vessel (red area in a). ***(5)***

Mastitis :

Pathology

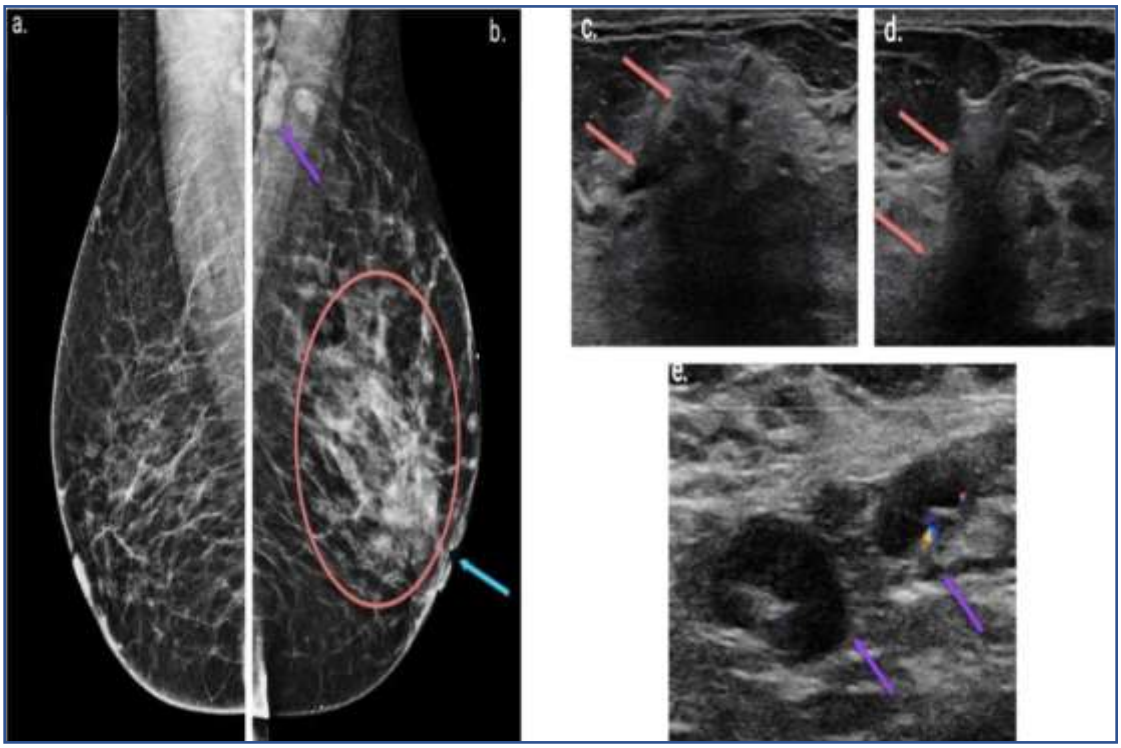
Mastitis refers to inflammation of the breast parenchyma, of which there are a number of

subtypes **(18)**:

- ✓ **Acute mastitis:**
  - puerperal mastitis: occurs usually from infection with Staphylococcus spp. during lactation.
  - non-puerperal mastitis: not related to lactation, and occurs usually in older women.
- ✓ **plasma cell mastitis** (mammary duct ectasia): uncommon subareolar inflammation without associated bacterial infection.
- ✓ **Chronic mastitis**: involves breast unilaterally and may affect every quadrant region except for subareolar area.
- ✓ **granulomatous mastitis:** rare; usually occurs due to tuberculosis or sarcoidosis.

Imaging features:

Mastitis can sometimes manifest with suspicious imaging features and necessitate biopsy. Mammography shows increased breast density, trabecular and skin thickening with or without subareolar ductal dilatation, axillary adenopathy. US demonstrates soft-tissue edema and skin thickening with hyperemia and increased echogenicity with or without ductal debris with ductal wall



thickening. ***(11)***

Figure (7). Right (a) and left (b) mediolateral oblique mammograms show a global asymmetry (oval) involving the upper left breast with associated nipple retraction (blue arrow) and axillary adenopathy (purple arrow in b). (c–e) US images in the left show ill-defined hypoechoic nonmass findings with posterior shadowing (pink arrows) and axillary lymph nodes with thickened cortices (purple arrows). ***(5)***

Inflammatory mastitis:

Pathology:

Breast pain, swelling with or without skin thickening, erythema, induration, peau d'orange appearance sometimes fever are all clinical features of inflammatory mastitis.

Imaging features:

Mammography shows irregular, indistinct mass or asymmetry with or without calcifications with or without skin thickening. US shows irregular, indistinct hypoechoic mass or heterogeneous area with or without calcifications or skin thickening. ***(11)***

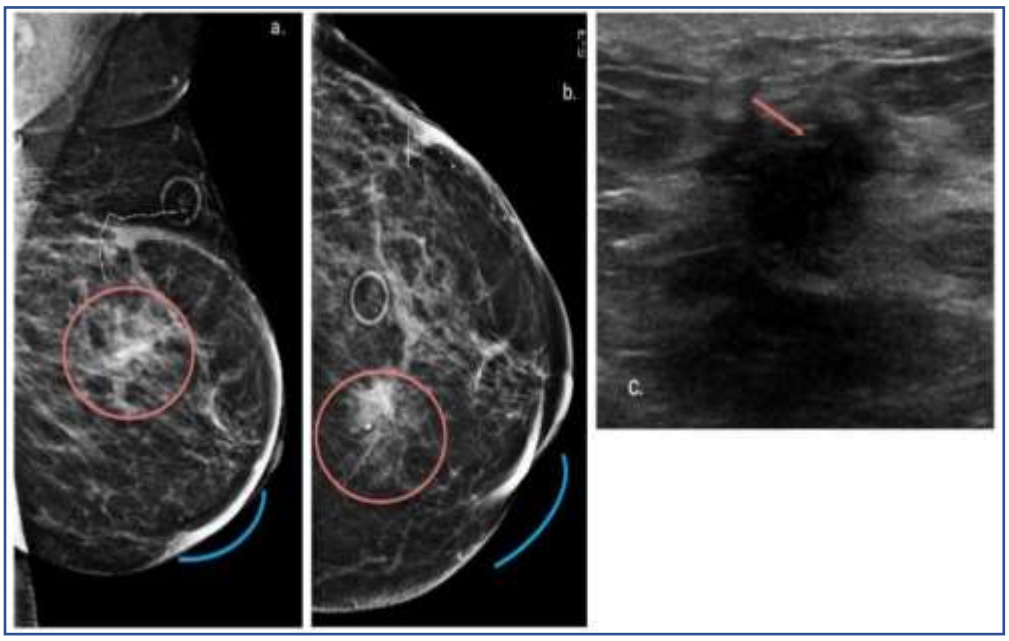


Figure (8): Left mediolateral oblique (a) and left craniocaudal (b) mammograms and US image obtained at the 11 o'clock to 12 o'clock position (c) shows a stable irregular mass (oval and arrow) in the lower inner breast but new skin thickening (curved line. ***(5)***

Granulomatous mastitis:

Pathology

Immunologic factors have been postulated as possible causes; however, the absence of vasculitis or of a prominent lymphocytic component in pathologic specimens favors against this hypothesis.The diagnosis of idiopathic granulomatous mastitis is based on exclusion, since it depends on the demonstration of a particular histologic pattern combined with the exclusion of other granulomatous reactions such as ***(19)***.

- especially tuberculosis
- sarcoidosis
- granulomatosis with polyangiitis
- fungal infections

At pathologic analysis, idiopathic granulomatous mastitis manifests as a non-caseating, non-vasculitic granulomatous inflammatory reaction centered on lobules. Fat necrosis, abscess formation, and fibrosis are commonly associated end-stage features that can disrupt the normal lobular anatomy ***(19)***.

Imaging appearance

Granulomatous mastitis is a benign rare process affecting young women, mimicking inflammatory breast cancer. It is often associated with pregnancy and breast feeding. Management is corticosteroid therapy. ***(11)***

Mammography in these cases shows negative, or asymmetry, irregular, indistinct mass(es), possible architectural distortion with or without trabecular and skin thickening, lymphadenopathy. US shows irregular, indistinct hypoechoic mass or masses with or without edema, complex fluid collections, ductal dilatation or hypervascularity. ***(17)***

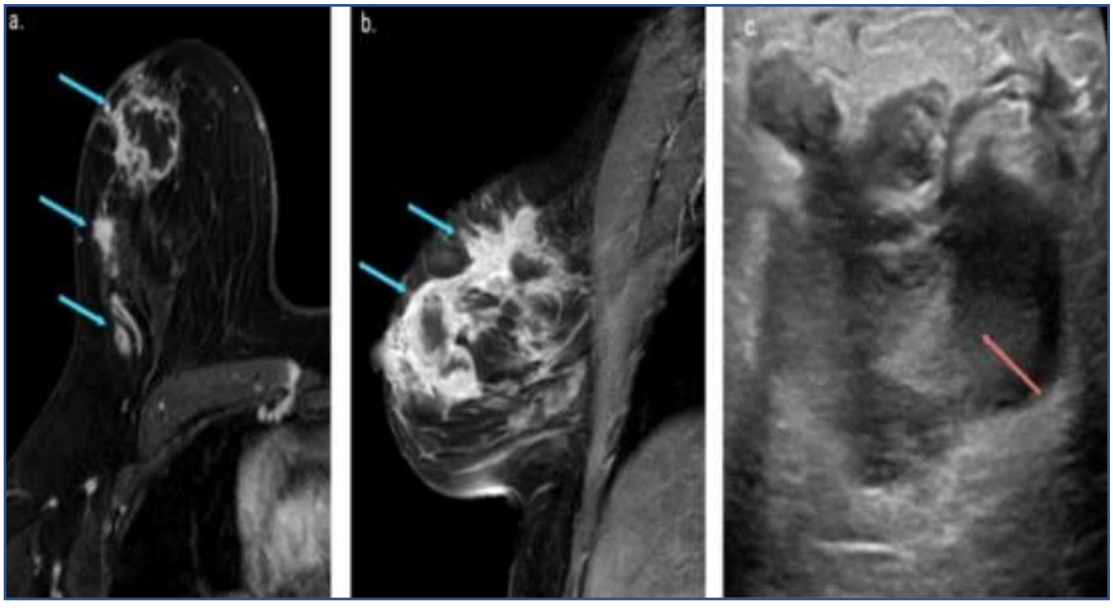


Figure (9): MR images obtained show an irregular mass with rim enhancement and surrounding regional nonmass enhancement (blue arrows) in the right upper outer breast.US image (c) shows irregular, heterogeneously hypoechoic masses (pink arrow) in the upper outer quadrant. ***(5)***

Phyllodes Tumor:

Pathology:

Phyllodes tumor of the breast is a relatively rare fibroepithelial neoplasm, which form well-circumscribed, firm, protruding masses. When cut, the surface is tan or pink to grey and may present as fleshy and mucoid. The characteristic whorled pattern with curved clefts resembling leaf buds is most evident in large lesions, but smaller lesions may have a homogeneous appearance. Phyllodes tumors exhibit leaf-like projections into variably dilated elongated lumina. The epithelial component consists of luminal epithelial and myoepithelial cells stretched into arc-like clefts surmounting stromal fronds. (**20).**

Figure (10); Very low magnification microscopic pathology image showing Phyllodes Tumor of the Breast. (**20).**

Imaging features:

On mammography are typically round lobulated dense mass with partially indistinct or circumscribed margins. Calcifications within the mass are rare, but they can be large. On ultrasound, phyllodes tumor present as a hypoechoic, partially indistinct, or partially circumscribed mass with frequent posterior enhancement.

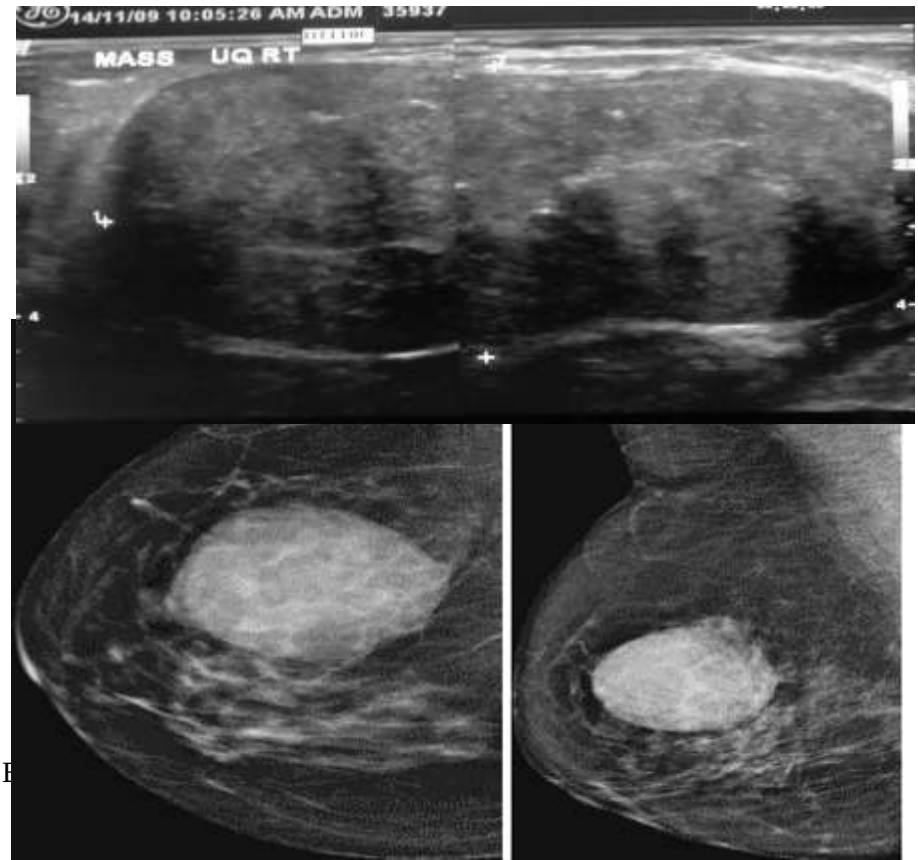


Figure 10; Right breast CC and MLO views on mammogram showing a large dense rounded mass lesion with partly indistinct margins. ***(21)***.

A cystic component is more typical in malignant phyllodes tumors. Frequently phyllodes tumor will show increased vascularity on color or power Doppler**. *(21)***.

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