Aims and Scope
The *Journal of the American Osteopathic College of Radiology* (JAOCR) is designed to provide practical up-to-date reviews of critical topics in radiology for practicing radiologists and radiology trainees. Each quarterly issue covers a particular radiology subspecialty and is composed of high quality review articles and case reports that highlight differential diagnoses and important teaching points.

Access to Articles
All articles published in the JAOCR are open access online. Subscriptions to the journal are not required to view or download articles. Reprints are not available.

Copyrights
Materials published in the JAOCR are protected by copyright. No part of this publication may be reproduced without written permission from the AOCR.

Guide for Authors
Submissions for the JAOCR are by invitation only. If you were invited to submit an article and have questions regarding the content or format, please contact the appropriate Guest Editor for that particular issue. Although contributions are invited, they are subject to peer review and final acceptance.

Editor-in-Chief
William T. O'Brien, Sr., D.O.
San Antonio, TX

Design Editor
Jessica Roberts
Communications Director, AOCR

Managing Editor
Tammam Beydoun, D.O.
Farmington Hills, MI

Editorial Board
Susann Schetter, D.O.
Daniel J. Abbis, D.O.
Les R. Folio, D.O.
Michael W. Keleher, D.O.
Rocky Saenz, D.O.
Kipp A. Van Camp, D.O.
John Wherthey, D.O.
# Table of Contents

## Breast Imaging

Editor: Michelle C. Walters, D.O., FAOCR

<table>
<thead>
<tr>
<th>Title/Author(s)</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>From the Guest Editor</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Review Articles</strong></td>
<td></td>
</tr>
<tr>
<td>MRI Breast Clinical Indications: A comprehensive Review</td>
<td>2</td>
</tr>
<tr>
<td><em>Michelle C. Walters, D.O., FAOCR, and Lennard Nadalo M.D., FCR</em></td>
<td></td>
</tr>
<tr>
<td>High-Grade Ductal Carcinoma In Situ: An Overview for the Radiologist</td>
<td>18</td>
</tr>
<tr>
<td><strong>Case Reports</strong></td>
<td></td>
</tr>
<tr>
<td>Peripherally Enhancing Breast Lesion With Central Fat</td>
<td>26</td>
</tr>
<tr>
<td><em>Sharon Kreuer, D.O., and Rocky C. Saenz, D.O.</em></td>
<td></td>
</tr>
<tr>
<td>Unilateral Axillary Lymphadenopathy</td>
<td>29</td>
</tr>
<tr>
<td><em>Shannon Gaffney, D.O.</em></td>
<td></td>
</tr>
<tr>
<td><strong>JAOCR at the Viewbox</strong></td>
<td></td>
</tr>
<tr>
<td>Mondor’s Disease</td>
<td>32</td>
</tr>
<tr>
<td><em>Amy Argus, M.D., and Arthur Ballard, M.D.</em></td>
<td></td>
</tr>
<tr>
<td>Ductal Carcinoma In Situ</td>
<td>33</td>
</tr>
<tr>
<td><em>Mary C. Mahoney, M.D., and Arthur Ballard, M.D.</em></td>
<td></td>
</tr>
</tbody>
</table>
The controversy surrounding breast imaging is astounding. We have heard that we are over-diagnosing – and thus over-treating – breast cancer in a recent *New England Journal of Medicine* article. Then we are told that we are under-diagnosing breast cancer in patients with dense breast tissue and now must inform patients about the density of their breast tissue and that additional screening tests, such as US and MRI, may be useful. It would come as no surprise to me if breast imagers were as confused as our patients.

As breast imagers, we have to remember that early detection of breast cancer does indeed save lives. It has been shown that screening mammography decreases breast cancer deaths in up to 25-30% of women. These results have been reaffirmed in multiple well designed, prospective, controlled studies. Nowadays, we must be cognizant of the issues surrounding breast imaging, as our patients often read about these issues in the Wall Street Journal or in the local newspaper. We have to arm ourselves with the scientific knowledge of proven research and technology. Breast imagers are direct patient advocates in the fight against breast cancer, and it takes special effort and fortitude to maintain that fight and keep our patients in the fold of our screening efforts. However, I believe it is well worth the time and energy that this requires.

I hope that the articles in this section of the JAOCR will help you in your practice. I was honored to be asked by Dr. William O’Brien to be the guest editor for the breast imaging section of the JAOCR. It is exciting to see this journal grow and even more exciting to be a part of this growth. You have to understand how much time Dr. O’Brien puts into each edition of the JAOCR. His expertise is astounding. I thank him and the JAOCR staff for all that they do.

Thanks also to the contributors to this edition of the JAOCR, to include Drs. Rocky Saenz, Luke and Geneva Ballard, Shannon Gaffney, and the breast imaging faculty at the University of Cincinnati. Without their time and energy, this edition would not have been possible. Special thanks to Dr. Lennard Nadalo for his help in editing my MRI breast article. He made it actually readable. Finally, thanks to my staff for helping me sift through almost 3,200 MRI breast cases and picking out the “great” ones (albeit slowly) for the article.

For those who know me, breast MRI is (and has been for awhile) a passion of mine. I enjoyed putting pen to paper and looking over my cases for the past 5 years, and I am especially excited to share this information with you. I hope you find it useful.

I hope everyone has a wonderful 2013. There are a lot of changes coming to healthcare. I can only hope that there are some beneficial changes amidst all of the controversy and craziness that seems to be part of the process. I hope that radiology – and more specifically breast imaging – will flourish, that research will continue to direct us, and that compassion will continue to drive us. Don’t lose sight of the reason you became a physician and specifically a radiologist. Ours is truly one of the great specialties.
Introduction

Breast cancer is the second most common cancer in women, following skin cancer. It accounts for 1 in 3 cancers diagnosed in women and is one of the leading causes of mortality in the United States. The average relative lifetime risk of breast cancer in women is about 1 in 8 (12%).

MRI of the breast has become an important imaging modality in the detection, evaluation, staging, and management of breast cancer. MRI has proven value in numerous clinical settings, including screening for breast cancer in select high-risk patients with the wider use of genetic testing; evaluation for multicentricity or bilaterality of a known cancer; determining the efficacy of neoadjuvant chemotherapy; differentiation of scar tissue versus recurrent tumor in patients who have undergone breast-conservation surgery; and evaluation of patients with metastatic axillary adenopathy with an unknown primary. MRI may also be very useful in problem solving for patients with dense breast tissue, a difficult physical exam, equivocal mammogram and ultrasound findings, or discordant pathology results. This review offers guidelines and indications for breast MRI as represented in the literature.

Technique

Although there is no standardized technique for breast MRI, the American College of Radiology (ACR) has established minimum standards for breast MRI accreditation. The standards include a T2-weighted sequence, and most importantly, a multi-phase T1 weighted sequence. In accordance with the ACR standards, both breasts must be examined simultaneously. Acquisition during pre and post-contrast T1 weighted sequences must have a slice thickness ≤ 3.0 mm. There should be no gap, and the maximum in plane pixel dimension for phase and frequency should be ≤ 1.0 mm. T1 weighted GRE imaging should be performed quickly with dynamic enhancement and delayed imaging performed. Computer aided detection may be beneficial in interpretation of the exam. Subtraction images may prove useful as well. Diffusion weighted imaging (DWI) along with ADC evaluation has been shown to be useful for the differentiation of benign vs. malignant tumors. Figure 1 shows normal pre and post-contrast T1 weighted images, along with a normal subtraction image.

Evaluation of images and lesions should be based on several factors, most importantly enhancement characteristics and morphology. Delayed imaging may be beneficial, especially with low grade DCIS (Figure 2). In our practice, we also include T1 and T2 weighted open field of view (FOV) sequences to evaluate the chest wall and other surrounding soft tissues. We have discovered lung and liver metastases (Figure 3), as well as associated adenopathy (Figure 4), with open FOV sequences.

Reporting

The most commonly accepted reporting system for breast imaging is Bi-Rads classification. Bi-Rads for MRI is identical to the Bi-Rads classification in mammography.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 0</td>
<td>Incomplete: need for additional imaging</td>
</tr>
<tr>
<td>Category 1</td>
<td>Negative</td>
</tr>
<tr>
<td>Category 2</td>
<td>Benign findings</td>
</tr>
<tr>
<td>Category 3</td>
<td>Probably benign findings</td>
</tr>
<tr>
<td>Category 4</td>
<td>Suspicious abnormality</td>
</tr>
<tr>
<td>Category 5</td>
<td>Highly suggestive of malignancy</td>
</tr>
<tr>
<td>Category 6</td>
<td>Known cancer</td>
</tr>
</tbody>
</table>

For full lesion features and descriptions for MRI, the ACR website has a MRI Lexicon Classification Form which may be used as a guideline.
Breast Cancer Screening With MRI

Recommendations.

MRI of the breast is increasingly used to screen for breast cancer in the high-risk patient. There are many factors used in the determination of a patient’s overall relative lifetime risk of breast cancer. Breast cancer risk factors include a family history of breast and ovarian cancer, high risk pathology such as lobular carcinoma in situ (LCIS), atypical ductal hyperplasia (ADH), radial scar, and women who have a history of radiation treatment for Hodgkin disease, etc. [4-6]

Mammography remains the gold standard for breast cancer screening; however, for women with increased risk of breast cancer, other screening modalities, including US and MRI, have been shown to contribute to early the detection of breast cancer. The American Cancer Society (ACS) issued recommendations for breast MRI screening in March 2007:

**Recommend Annual MRI Screening**

Patients with BRCA mutation; first-degree relative of BRCA carrier, but untested; or lifetime risk ≥ 20-25% as defined by BRCAPRO or other models that are largely dependent on family history.

(Based upon evidence from nonrandomized screening trials and observational studies)
**Recommend Annual MRI Screening**

Patients with radiation to the chest between the ages of 10 and 30 years or a personal history or first-degree relative with Li-Fraumeni, Cowden, and Bannayan-Riley-Ruvalcaba syndromes.

(Based upon expert consensus opinion/lifetime risk for breast cancer)

**Insufficient Evidence to Recommend For or Against MRI Screening**

Patients with a lifetime risk of 15-20% as defined by BRCAPRO or other models that are largely dependent on family history; LCIS, ADH, or atypical lobular hyperplasia; heterogeneously or extremely dense breast on mammography; or a personal history of breast cancer, including DCIS. Screening decisions should be made on a case-by-case basis, as there may be particular factors to support MRI. Payment should not be a barrier. More data on these groups is expected to be published soon.

**Recommend Against MRI Screening**

Patients with <15% lifetime risk of breast cancer.

(Based upon expert consensus opinion)

BRCA1 and BRCA2 mutations are responsible for 40-50% of all familial cancers. The BRCA mutation increases the average lifetime risk of breast cancer to approximately 60-80% and 40% for ovarian cancer (BRCA1). The ACS Guidelines recommend “intensified surveillance” as an alternative to bilateral mastectomy. BRCA1 associated breast cancers tend to have benign morphological appearances (round shapes and minimal asymmetry) but an aggressive biological nature. Thus, screening should start at a younger age and occur more frequently in the case of BRCA mutations. These women are younger at presentation when average breast density is high. Earlier and more frequent screening in this population will result in a substantial cumulative lifetime ionizing radiation dose. With the additional increased risk of breast cancer associated with mammographic screening (albeit minimal), potentially dense breast

---

**Figure 4.** T2W axial image reveals mediastinal adenopathy.

**Figure 5.** Dense breast tissue in a BRCA positive patient. Bilateral CC views (A) show dense breast tissue bilaterally, which limits the sensitivity of mammography. US (not shown) demonstrated several hypoechoic masses and patchy areas of shadowing. Axial T1W post-contrast image with fat-suppression (B) demonstrates benign bilateral fibrocystic changes, Bi-Rads 2.
tissue in the younger patient, and the need for increased sensitivity in the evaluation of these patients, MRI has become accepted as an integral part of surveillance in the high risk population (Figure 5).

For women with an average risk of breast cancer, there is no data that supports breast MRI for screening at this time. Although MRI does have increased sensitivity in the detection of breast cancer, the positive predictive value (PPV) is much lower than in the high risk population; therefore, the cost of routine MRI screening is not justified. Long-term studies and further surveillance may change this perspective in the future.

Third Party Reimbursement

Insurance companies tend to follow the above guidelines for reimbursement. For the lower risk patient with dense breast tissue, a difficult physical exam, or significant fibrocystic changes, there are less objective recommendations and MRI of the breast may not be covered by insurance. Most insurance companies utilize a calculation of risk factors using one of several methods: BRCAPRO - Claus model - Gail model – Tyrer-Cuzick. The major carriers have policy guidelines for breast MRI.

Sensitivity and Specificity in MRI Breast Screening

Sensitivity of mammography alone decreases in proportion to the increased density of the breast tissue. However, breast density does not affect the sensitivity of MRI (Figure 6).11 There are numerous literature references for sensitivity and specificity of mammography, US, and MRI. The references vary but all clearly state that MRI is by far more sensitive than mammography and US in the detection of breast cancer for high-risk patients, dense breast tissue,

Figure 6. Patient with personal and family history of breast cancer. Bilateral MLO views (A) demonstrate findings of prior lumpectomy on the left for invasive ductal carcinoma; right breast is very dense. US (not shown) demonstrated several hypoechoic masses bilaterally with patchy areas of shadowing. T1W pre (B), post-contrast (C), and MIP (D) images reveal a cobblestone enhancement pattern in the right breast at the 9-10 o’clock position. Biopsy revealed high-grade DCIS with central necrosis.
patients on hormone replacement therapy (HRT), and in the younger population.\textsuperscript{12,13} According to the National Cancer Institute (NCI) Breast Cancer Surveillance Consortium (BCSC), the sensitivity of screening mammography in the detection of breast cancer (starting at age 40) ranges from as low as 64% to as high as 100% based upon age and time from prior mammogram. Specificity was as low as 78% to as high as 94%.\textsuperscript{14}

MRI breast does not replace screening mammography or diagnostic mammography with US evaluation. Rather, MRI is used in conjunction with these modalities (Figure 7). Although breast MRI is more sensitive in the detection of breast cancer when compared to mammography and US, it has been reported as less specific overall.\textsuperscript{15} It should be noted, however, that in a recent ACRIN trial, the specificity of MRI breast was as high as 88%.\textsuperscript{16} MRI’s imperfect sensitivity comes from its inability to detect low grade DCIS due to the lack of enhancement. Mammography, on the other hand, may detect low grade DCIS as amorphous calcifications or small foci of architectural distortion, which may not be detected or be very subtle on breast MRI. Overall, however, MRI has been shown to be superior to mammography in detecting cases of unsuspected DCIS.\textsuperscript{17} Contrast-enhanced MRI of the breast has shown relatively high sensitivities, ranging from 94-99% for invasive cancer and 50-80% for in situ cancers.\textsuperscript{18}

**MRI Breast in the Newly Diagnosed Breast Cancer Patient**

**Clinical Indications and Applications of Breast MRI.**

The National Comprehensive Cancer Network (NCCN) discussion of breast MRI recommends the use of MRI for the following clinical indications and applications:

- Staging evaluation to define extent of cancer or presence of multifocal or multicentric cancer in the ipsilateral breast.
- Screening for contralateral breast cancer at time of initial diagnosis.
- Evaluation before and after neoadjuvant therapy to define extent of disease, response to treatment, and potential for breast conserving therapy.

**Figure 7.** Complimentary role of mammography and MRI. Bilateral MLO views (A) demonstrate suspicious calcifications in the posterior left breast (biopsy proven DCIS), as well as faint, scattered calcifications in the upper, posterior right breast; the calcifications on the right could not be seen well or biopsied on stereotactic technique. Pre (B) and post (C) contrast MR images reveal very minimal nodular enhancement in the far posterior, lateral right breast. Due to the faint calcification in this area, the patient underwent biopsy with the pathologic diagnosis of low-grade DCIS. Patient also had lumpectomy changes on the left for intermediate grade DCIS. She subsequently opted for bilateral mastectomies.
Detect additional disease in women with mammographically dense breasts.

Identify primary cancer in women with axillary nodal adenocarcinoma or Paget’s disease of the nipple (Figure 8) with a breast primary not identified on mammography, ultrasound, or physical examination.

The utility of MRI in follow-up screening of women with prior breast cancer is undefined. It should generally be considered only in those whose lifetime risk of a second primary breast cancer is greater than 20% based on models largely dependent on family history, such as in those with a risk associated with inherited susceptibility to breast cancer.

There is no data demonstrating that the use of MRI to affect choice of local therapy improves outcomes (local recurrence or survival). Although breast MRI is more sensitive than mammography or US, false positive findings on MRI are common. Therefore, surgical decisions should not be based solely on MRI findings. Tissue sampling of areas of concern identified by breast MRI is recommended prior to treatment planning.

Staging.

Treatment options for breast cancer are based upon staging. Breast cancer staging is determined by the extent of disease in the breast and axilla, as well as metastatic disease determination. The current TNM staging of breast cancer is outlined in the 7th Edition of the American Joint Committee on Cancer. Key staging components include tumor size; involvement of overlying skin or chest wall; involvement of local or regional lymph nodes, to include mobile or fixed, conglomerate, or extracapsular spread; and presence or absence of distant metastases.

MRI has been shown to increase the sensitivity in the evaluation of local-regional disease involving the breast and axilla. When combined with mammography, US, and clinical exam, the sensitivity of MRI is as high as 99% in cases of newly diagnosed breast cancer (Figure 9). The reported low sensitivity of clinical exam (50%), mammography (60%), and US (83%) alone substantiate the use of MRI in the preoperative staging of breast cancer patients. Breast MRI has been shown to detect both multicentric and bilateral breast cancers with increased sensitivity over clinical exams, mammography, and US (Figures 10 and 11). Ipsilateral multicentric disease detected with MRI has been reported in 10-27% of patients. MRI detects occult contralateral breast cancer in about 3% of patients with invasive ductal carcinoma and in 6% of patients with invasive lobular carcinoma. Bilaterality has been reported in up to 10% in selected series.

Overall tumor size is more accurately depicted on MRI compared to mammography when correlated with pathology specimens (Figure 9). Although it was thought that this may decrease the need for reexcision due to unclear margins, this has recently...
Figure 9. Patient presents with palpable mass on right. Bilateral MLO views of the breast (A) demonstrate a mass in this region with an US correlate (B). Biopsy revealed invasive ductal carcinoma. MRI breast (C and D) demonstrates more anterior and superior lateral extension than is perceived by mammogram or US.

Figure 10. Bilateral/contralateral breast cancer. MLO (A) and CC (B) views demonstrate a mass in the upper outer left breast, which was confirmed as suspicious on US (not shown). Post-contrast (C), MIP (D), and color-coded (E) images reveal the known breast cancer on the left, as well as an unsuspected enhancing mass in the right breast. Second look US was performed with subsequent biopsy; pathological diagnosis was invasive ductal carcinoma.
Figure 11. Bilateral/contralateral breast cancer in a patient with a palpable mass on the right. MLO (A) and CC (B) views reveal an asymmetry in the mid-lower, inner right breast, similar to prior studies. US was performed (not shown), and biopsy demonstrated invasive ductal carcinoma. Color-coded (C) and MIP (D) post-contrast images better delineate the breast cancer on the right and identify an additional suspicious mass in the left breast. Second look US of left breast was performed with biopsy; pathological diagnosis was invasive ductal carcinoma.

been shown not to be true. The COMICE trial performed in the UK demonstrated similar need for reexcision in patients who had pre-operative MRIs versus those who did not. However, further study with long-term evaluation and follow-up is needed.26

In the clinical setting of DCIS, MRI is useful to rule out underlying invasive carcinoma. This can be accomplished with MRI due to its high negative predictive value (NPV) in the diagnosis of invasive breast cancer. MRI and mammography compliment each other in the diagnosis of DCIS. Although MRI has greater overall sensitivity, it does not detect all DCIS cases, especially those which are non-enhancing and are only seen as calcifications on mammography. Mammography is similarly limited in the detection of DCIS, especially in the absence of calcifications where lesions are only detected as abnormal enhancement on MRI. Research has shown that the overall sensitivity of MRI for high-grade DCIS is higher than that of mammography.27

Controversy.

Breast surgeons have concerns regarding MRI causing a delay in treatment and/or increasing mastectomy rates. In most cases, the delay in treatment is minimal, since an MRI can be performed quickly after biopsy with the diagnosis of cancer. As for the increase in mastectomy rates related to breast MRI and the opinion that radiation therapy eradicates or delays progression of residual disease, these are not proven. While there have been reports of unnecessary mastectomies based upon false-positive MRI exams, this emphasizes the point that surgical management of breast cancer should be based upon confirmed histology, i.e. MRI-guided biopsy.28

With breast conservation therapy, the rate of recurrence is low but not zero. The statement that outcomes in women who undergo breast conservation
are equivalent to the outcomes in women who undergo mastectomy is debatable. The trials that have been performed to date have shown that women who undergo breast conservation have a higher risk of local recurrence. Thus, disease free survival is not equivalent.\textsuperscript{29} It was previously thought that local recurrence did not affect overall survival. However, it is now well accepted that local relapse does affect overall survival. Therefore, preventing local recurrence is considered as important as the early diagnosis of the primary breast cancer. The ability to prevent local recurrence requires more accurate staging and subsequent treatment; this is where MRI can play a critical role.\textsuperscript{30-32}

The threshold of radiation therapy to eradicate any residual disease has not been established. Each patient should be offered the best treatment for long-term survival. In essence, a staging MRI examination which demonstrates only one focal cancer site allows the patient, surgeon, and oncologist to explore the option of conservation therapy, since the likelihood of any residual disease will be low. It should also be clarified that multicentricity does not necessarily require mastectomy.

It must be stated clearly that there are no published randomized, prospective trials that have assessed the impact of breast MRI on mastectomy rates, or the impact on the recurrence rates or mortality. The long-term determination of this controversy will only come from controlled studies with long-term follow-up. Until that time, MRI should be used in the context of staging and improved pathologic confirmation of local regional disease. Treatment plans in tumor boards can be discussed and implemented with better knowledge of the patient’s disease extent and the treatment needed.

**Neoadjuvant Chemotherapy Follow-Up**

Neoadjuvant chemotherapy has been increasingly used over the past several years for patients with locally advanced breast cancer (LABC). LABC typically refers to breast cancer lesions that are larger than 5 cm with or without spread to lymph nodes. The primary advantage of neoadjuvant chemotherapy is to reduce the size of the overall tumor burden. This allows for a higher percentage of patients to undergo breast conservation therapy, while still offering significant reduction in local recurrence rates and improved overall survival.\textsuperscript{33,34}
Diagnostic imaging is performed to monitor the tumor response to chemotherapy as early as possible and to identify any residual tumor. Information regarding tumor response during the early stages of neoadjuvant chemotherapy is useful for treatment optimization. Tumor size may not necessarily decrease immediately in the early phase of treatment; therefore, evaluation of metabolic response becomes important. PET scanning and MRI have established roles in the early assessment of metabolic “functional” response. MRI demonstrates a positive response to chemotherapy as a decrease in the enhancement characteristics of the tumor (Figures 12 and 13). The enhancement curve changes and typically flattens with a diminished wash-out pattern. Wash-in changes occur as well; the wash-in will be slower. A decrease in tumor size typically occurs later.35 MR Spectroscopy and diffusion-weighted (DWI) MRI have been shown to help evaluate “responders” versus “non-responders” as early as 24 hours after the first cycle of chemotherapy. DWI detects cytotoxic effects of the chemotherapy by the change in the free interstitial water diffusion rates. There are standard protocols for DWI and ADC mapping; the literature provides suggestions for protocols and visual and numerical references. As protocols become standardized and controlled studies are performed, DWI and ADC may become standard in the evaluation for initial response to chemotherapy.36

After neoadjuvant chemotherapy, MRI is often used to evaluate for any residual tumor. A recent ACRIN study (Protocol 6657) concluded that tumor response to chemotherapy as measured volumetrically by MRI was a much stronger and early predictor of pathologic response than clinical or tumor diameter. Several studies have demonstrated similar findings, indicating that MRI is superior to conventional mammography, US, and clinical exam.37,38 However, MRI correlation with tumor response is not 100%. It has been shown in some cases, particularly with chemotherapeutic agents that demonstrate antivascular effects, that residual vital tumor may be identified in up to 30% of patients whose MRI showed no residual abnormal enhancement. The accuracy of MRI in post-neoadjuvant chemotherapy evaluation also appears to vary with tumor subtype. It appears to be more accurate in ER-/HER2+ and triple negative and less accurate in luminal tumors.39,40

Problem Solving

MRI can be used for problem solving in clinical scenarios such as discordant pathology results (Figures 14 and 15), markedly dense breast tissue with multiple palpable lumps (Figure 16), or complex mammographic findings (Figure 17). MRI is also useful in cases with equivocal or inconclusive findings on mammograms or US. Patients who have undergone breast conservation therapy may benefit from MRI if there is clinical concern of recurrent tumor versus developing scar tissue.

If there is a single abnormality on either US or mammogram, then US-guided or stereotactically biopsy is more efficient. These two biopsy techniques are readily available, relatively safe, easy to perform, and provide a histologic diagnosis.

In the patient with multiple areas of asymmetry on a mammogram (without calcification) and no US abnormality; a mammographic abnormality seen only on one view; or for the patient with multiple round, smooth masses that are equivocal on mammogram and US (i.e. breast cancer vs. multiple sclerotic fibroadenomas or multiple complex cysts), MRI has a very high negative predictive value (NPV). Some institutions may put these patients in short-term 6 month follow-up, Bi-Rads 3, diagnosis; however, rather than short-term follow-up or biopsy, MRI may also be considered. A 3-year consecutive study recently reported that breast MRI should be used in the diagnostic work-up of non-calcified Bi-Rads 3 lesions. It was stated that malignancy is ruled out with a very high level of confidence in the majority of patients, thus avoiding invasive diagnostic procedures.41

Abnormal nipple discharge is most often caused by benign etiologies, such as ductal ectasia or solitary or multiple papillomas.42 Mammogram and US are performed initially to evaluate for the underlying cause and to rule out associated or causative breast cancer. Mammography and US are complimentary in evaluating abnormal nipple discharge. However, in the majority of cases, both exams will often be normal. Galactography may be performed and can be helpful; however, oftentimes (up to 10% of cases) a galactogram cannot be performed due to technical reasons (i.e. intermittent discharge, discharge from more than one orifice, etc). Also, the diagnostic information obtained with a galactogram is limited.
**Figure 14.** Problem solving with discordant results. Bilateral CC views (compressed and magnified on the left) (A) demonstrate suspicious calcifications within the outer, posterior left breast, as well as a mass in the posterior right breast. Right breast US (B) reveals a suspicious, lobulated, hypoechoic mass with posterior shadowing. Left breast biopsy demonstrated invasive ductal carcinoma. Right breast US-guided biopsy demonstrated sclerosing adenosis, which was felt to be discordant with the imaging findings. Post-contrast color-coded MR image (C) reveals extensive tumor in the left breast and findings highly suggestive of malignancy (abnormal rapid enhancement as well as irregular margins) on the right. MRI-guided right breast biopsy revealed infiltrating carcinoma with apocrine features.

**Figure 15.** Problem solving with discordant results. Initial bilateral MLO analog images from 6 months earlier (A) are normal. Follow-up MLO (B) and CC (C) digital images of the left breast demonstrate an area of spiculation (best seen on the MLO view) underlying the palpable marker. Left breast US (D) reveals an ill-defined area of low level echoes. Biopsy was performed with US guidance and the pathology results were fibrosis and chronic inflammation, which was felt to be discordant. Post-contrast MR images demonstrates two irregular suspicious enhancing masses in the left breast (E), as well as a very large enhancing mass in the inferior left lateral axilla (F). Biopsy under MR guidance revealed infiltrating ductal carcinoma with axillary metastasis.
**Figure 16.** Young woman with dense breast tissue and palpable mass on the right. MLO (A) and CC (B) views demonstrate a mass in the mid, posterior right breast. US (C) with biopsy revealed mucinous carcinoma. Post-contrast MR image (D) is beneficial in determining size and extent of tumor, especially in the setting of markedly dense breast tissue and difficult US and physical exams.

**Figure 17.** Problem solving with complex mammogram. Bilateral MLO views (A) reveal numerous silicone injection granulomas, greatly reducing the sensitivity of mammography. Post-contrast color-coded MR image (B) demonstrates normal enhancement of underlying breast tissue. There may be normal rim enhancement of some of the silicone granulomas.
Sensitivity for detection of a malignant lesion has been reported as very low (0-55%). MRI can help detect intraductal lesions not seen on mammogram and/or US and allows for localization of the lesion (Figure 18); subsequent image-guided biopsy may be performed.

**Axillary Adenopathy With Unknown Primary**

Few women diagnosed with breast cancer initially present with metastatic axillary adenopathy. Historically, mastectomy was the treatment of choice in a patient with adenocarcinoma metastasis to the axillary lymph nodes in which the clinical exam, conventional mammogram, and/or US were unable to detect an abnormality, as it was usually thought to originate from a primary breast cancer in the ipsilateral breast. MRI can detect the primary tumor in up to 70% of these patients (Figure 19). This effectively changes their staging from T0 (unknown primary) to a defined TNM classification. The patient can then undergo more appropriate and focused surgical and oncologic therapy.

Due to the negative predictive value of MRI in the detection of invasive breast cancer, a negative MRI can be used to suggest that a mastectomy is not needed. Some oncologists advocate the use of radiation therapy alone in women with a negative MRI.

**Ongoing Screening Debate**

Recent controversial opinions concerning the value of breast cancer screening have challenged the very basis of why we offer mammography and by extension, breast MRI. It is critical that breast imagers base their practice on the firm conviction that mammography - and by extension MRI of the breast - saves lives. Nearly 20% of cancers which are detected with screening mammograms are found in women 40-50 years old. Recent negative opinions have been the products of retrospective analysis by physicians who do not directly treat or diagnose breast cancer. The mantra that “early detection saves lives” is still as true as ever before. Breast MRI allows very early detection of cancers in women who are at high risk. Breast MRI also allows for a less invasive means of follow-up for those women at moderate risk. It is important to support prospective studies related to breast cancer detection while we continue to offer the safest means possible to detect and manage breast cancer in our patients.
Summary

In summary, breast MRI has proven to be a valuable tool in the diagnosis, work-up, and management of breast cancer. Common indications include screening for breast cancer in select high-risk patients, problem solving in cases of dense breast tissue or equivocal or discordant findings on mammogram or US, evaluation for multicentricity or bilaterality of a known cancer, determining the efficacy of neoadjuvant chemotherapy, differentiation of scar tissue versus recurrent tumor, and evaluation of axillary adenopathy with an unknown primary. The clinical indications will likely continue to expand as clinical trials demonstrate additional benefits of MRI in breast imaging. When used in conjunction with mammogram and US, this useful tool will assist in decreasing morbidity and mortality associated with breast cancer.

Figure 19. Axillary adenopathy with unknown primary. Bilateral MLO views performed at an outside institution (A) were read as benign and unchanged from an exam two years prior. Patient felt a mass in her right underarm one week after the mammogram. A surgeon performed a biopsy in his office, and the pathology came back as cancer. Post-contrast MR images demonstrate a mass far lateral posterior right breast at the 7 o’clock position with abnormal enhancement and abnormal morphology (B), as well as an enlarged right axillary lymph node (C) which was previously biopsied. MRI-guided biopsy demonstrated invasive lobular carcinoma.
References


2. ACR Breast Magnetic Resonance Imaging Accreditation Program Requirements.


High-Grade Ductal Carcinoma In Situ: An Overview for the Radiologist


1Division of Breast Imaging, Wilford Hall Ambulatory Surgical Center, San Antonio, TX
2Department of Radiology, San Antonio Military Medical Center, San Antonio, TX

Introduction

Ductal carcinoma in situ (DCIS) is a common pre-invasive malignancy of the breast, representing approximately 20% of all breast cancer diagnoses. It is widely believed that DCIS is a precursor lesion to invasive ductal carcinoma, but the exact biologic nature is not completely understood and debated by some. DCIS is unarguably a heterogeneous disease with variable malignant potential. Evidence shows that high-grade DCIS is an aggressive subtype with an overall poorer prognosis than non-high-grade disease. There have been many studies evaluating the role of the radiologist in the diagnosis of high-grade DCIS with emphasis on radiologic-pathologic correlation using standard mammography and magnetic resonance imaging. Our current understanding of the clinical importance of high-grade DCIS from the perspective of a radiologist and characteristic imaging features are discussed in detail.

Clinical Implication of DCIS

The diagnosis of DCIS has increased dramatically over the last several decades from an incidence of less than 2 per 100,000 in the early 1970’s to 32.5 in 2004. Much of this increase has been attributed to the advent of screening mammography. Some advocates of screening see this as a victory, achieving one of the goals of a screening program: the prevention of life threatening invasive cancer by detection and treatment at the in situ stage. Detractors, however, believe the detection of DCIS leads to a substantial number of patients being over-diagnosed and overtreated for a non-life threatening condition. While large scale trials have shown survival benefit of screening mammography in the range of 30 percent, the screening debate goes on and is beyond the scope of this discussion.

Much of the controversy regarding the increase in diagnosis of DCIS over the years lies in our limited knowledge of the natural history of the disease. There is little argument that DCIS is likely a precursor to invasive ductal carcinoma. However, it is very clear that some - but not all - of DCIS will progress over the lifetime of a patient. The evidence well summarized by Erbas et al. showed that 14-53% of DCIS misdiagnosed as benign will progress to invasive carcinoma over a 10-15 year interval. In a study by Sanders et al., low-grade DCIS progressed in 11 of 28 patients with most occurring within 10 years; 3 were diagnosed between 23 and 42 years after the initial biopsy; and 5 of 11 died of breast cancer.

Autopsy studies suggest that a substantial number of DCIS cases may remain subclinical, although the interpretation and significance of these findings is debated. Papers such as these underscores the concept that some DCIS is effectively benign, but it remains evident that there is no way to prospectively determine if and when DCIS will progress to invasive disease. Moreover, the available data are not representative of the full spectrum of DCIS and largely exclude high-grade lesions. High-grade DCIS is rarely misdiagnosed pathologically and is routinely surgically excised, owing to the perceived malignant potential. This has allowed for very limited long-term observations.

In spite of the unknown, the overall prognosis for DCIS is excellent with appropriate surgical and oncologic management (approximately 98% long-term survival). DCIS is typically treated with wide surgical resection with or without radiation therapy; there is an evolving role for hormonal therapy. With a breast cancer specific mortality of less than 2%, it has proven difficult to demonstrate significant survival benefit with more advanced treatment options, such as radiation or hormonal therapy. This has led to considerable effort to stratify patients with a diagnosis of DCIS, based on the risk of local recurrences, as invasive recurrence (either local or systemic) appears to be the primary source of breast cancer specific mortality in these patients. Approximately half of patients with recurrence after breast conservation.
surgery are diagnosed with invasive disease, and 12-15% of these patients ultimately die of breast cancer.\textsuperscript{17,18} While the overall prognosis for conservation therapy is good, the risk of recurrence or death is relatively negligible when DCIS is treated with mastectomy.\textsuperscript{18,19}

The pathologic evaluation of DCIS is one of the primary considerations in stratifying patients and has shifted from a purely architectural classification, which offered little prognostic information, to a focus on the nuclear grade and degree of cellular necrosis. This is reflected in the Van Nuys system which simply divides DCIS lesions into high-grade and non-high-grade; the latter group is further divided into those with or without necrosis.\textsuperscript{20} Moreover, the Consensus Conference on Classification of Ductal Carcinoma In Situ (1997) recommends stratifying DCIS first by nuclear grade (high, intermediate, and low) and then determining the presence or absence of necrosis due to the potential treatment implications.\textsuperscript{16} The consensus reflects the current understanding of high-grade DCIS as an aggressive subtype of DCIS with an overall poorer prognosis than non-high-grade disease. Analysis of the data has shown that a high nuclear grade may increase the risk of local recurrence after breast conservation therapy, shorten the time to recurrence, increase the rate of distant metastases, increase the rate of recurrence with invasion, and increase mortality with recurrent invasion.\textsuperscript{17,19-25} High-grade DCIS at core needle biopsy also appears to be a significant risk factor for underestimation of invasive breast cancer, a phenomena which occurs in approximately 25% of all DCIS diagnoses.\textsuperscript{26}

High-grade DCIS represents the majority of screening detected in situ lesions in multiple series, further emphasizing the importance of this diagnosis.\textsuperscript{27,29} Diagnosing high-grade DCIS represents a relatively frequent opportunity for radiologists to impact patient care. Thorough knowledge of the characteristic imaging features of high-grade DCIS, as well as the limitations of imaging, is imperative.

\textbf{Figure 1.} Examples of linear and branching calcifications in three cases of high-grade ductal carcinoma in situ. (\textbf{A}) shows classic casting type calcifications within a long ductal segment that has one major branch. (\textbf{B}) reveals a cluster of fine pleomorphic calcifications with several linear forms. (\textbf{C}) demonstrates casting calcifications forming branching shapes with additional adjacent pleomorphic calcifications.
Mammography of High-Grade DCIS

Microcalcifications are found in an estimated 50-75% of all DCIS diagnosed on mammography and in approximately 90% of clinically occult DCIS. Radiologic-pathologic correlation has shown that these calcifications develop as a consequence of calcified intraluminal cellular debris secondary to a high concentration of calcium in adjacent necrotic cells and from ductal secretions, such as mucin or other calcific products.

Many studies have demonstrated a correlation between the type of mammographic calcification and the pathologic diagnosis, suggesting that certain calcification types are more likely to be associated with high-grade lesions at histopathology. Specifically, linear branching calcifications are generally predictive of high-grade DCIS (Figure 1). These result from extensive intraluminal necrosis and calcifications which form “casts” of the ducts, yielding the characteristic linear branching pattern. A variety of mammographic descriptors have been used that with nuanced differences appear to be synonymous to linear branching calcifications, including “fine linear branching,” “casting,” and “comedo” calcification. The range of non-standardized microcalcification descriptors in the literature may indicate a measure of subjectivity in the analysis, although generally the differences can be reconciled.

While linear branching calcifications are characteristic of high-grade DCIS, the significance of this finding as a histologic predictor of disease is debated. High-grade DCIS appears to present with this finding in a majority of cases. In one study by Lee et al., 15 of 16 high-grade DCIS lesions presented with linear calcifications and showed excellent correlation. In another study by Dinkel et al., 14 of 18 high-grade DCIS lesions showed linear calcifications. This pattern represented high-grade DCIS 56% of the time. Though this is the majority, compared with intermediate and low-grade DCIS, this was not a statistically significant result. The remaining 32% and 12% of linear calcifications represented intermediate and low-grade DCIS, respectively. First evaluated by Tabar et al., multiple studies have provided evidence that casting calcifications import a poor prognosis when associated with small invasive cancers. Analysis shows that these casting calcifications consistently represent the presence of extensive high-grade DCIS (Figure 2).

Unfortunately, as the Dinkel study illustrates, there remains considerable overlap in the imaging appearance of not only different grades of DCIS but also between DCIS and benign processes, as high-grade DCIS is not confined to the linear branching pattern of calcifications. While this morphology has shown good positive predictive value for high-grade DCIS, other calcification patterns have not produced

**Figure 2.** Ectopic Casting type calcifications. (A) shows casting calcifications in a segmental distribution, correspond to extensive high-grade DCIS. (B) MRI reveals corresponding clumped segmental non-mass-like enhancement (white arrows) in the right breast in association with a circumscribed 2 cm invasive malignancy posteriorly (black arrowheads), which was mammographically occult. This patient presented with bloody nipple discharge, corresponding to the linear ductal fluid signal (white arrowhead). A benign fibroadenoma was visualized in the medial right breast (open black arrow).
significant negative predictive values or correlation with low-grade disease that might be used to confidently reduce biopsy rates. Indeed, high-grade DCIS is seen with varying degree in all of the ACR BI-RADS suspicious calcification types, including amorphous or indistinct, coarse heterogeneous, and fine pleomorphic forms, though less frequently (Figure 3).\textsuperscript{30,36,37} The challenge for radiologists is most evident in early stages when high-grade DCIS lesions are small and more confined; the appearance of associated calcifications is often non-specific. Appropriate biopsy technique and sampling provide an opportunity to limit under-diagnosis in these situations.\textsuperscript{26}

When not calcified, DCIS presents in numerous ways on mammograms, including masses, asymmetries, architectural distortion, and even as a negative exam.\textsuperscript{32} DCIS may present as a mass, either palpable or screen detected in up to 10\% of cases of DCIS; this presentation is seen more commonly in low-grade lesions, rather than high-grade DCIS.\textsuperscript{42,43} Presentation as a focal asymmetry may be especially challenging to radiologists when the finding is questionable, not seen with ultrasound, or difficult to localize stereotactically. Moreover, a negative mammogram may harbor DCIS, as demonstrated by occult cases identified only with the use of MRI. While such presentations are less common, it remains important to be aware that high-grade DCIS may present as a non-calcified mammographic abnormality.

\textbf{Magnetic Resonance Imaging of High-Grade DCIS}

The overall sensitivity of breast MRI for the detection of all grades of DCIS was previously considered to be relatively low with authors reporting various sensitivity data for DCIS as low as 77\%.\textsuperscript{44} However, with improved MRI techniques and high spatial resolution, as many as 98\% of DCIS cases are now detectable by MRI with an additional 6-23\% of mammographically occult DCIS lesions detectable only

\textbf{Figure 3.} Examples of high-grade ductal carcinoma of varying morphologies and distributions. (A) shows extensive amorphous calcifications in a regional distribution. (B) reveals a relatively innocuous looking cluster of pleomorphic calcifications with some round and punctuate forms. (C) demonstrates an example of fine pleomorphic and amorphous calcifications without clear linear forms.
by MRI.\textsuperscript{44,45} This is largely attributed to the enhancement of non-calcified DCIS which cannot be identified with a mammogram.\textsuperscript{45}

The most common MR imaging finding in DCIS falls under the category of “nonmasslike enhancement” (NMLE) and is demonstrated in 60-80\% of cases.\textsuperscript{47,48} Though there is some variability in the literature regarding the exact descriptors, the NMLE seen with DCIS is typically in a segmental or linear distribution. Morakkabati-Spitz et al. demonstrated a positive predictive value of 34\% and specificity of 96\% for segmental and linear enhancement patterns.\textsuperscript{49} The most commonly seen internal enhancement pattern among NMLE lesions associated with DCIS is clumped or heterogeneous enhancement (Figure 4).\textsuperscript{48} Less commonly, purely DCIS lesions manifest as a mass (14-34\%) or focal enhancement (1-12\%).\textsuperscript{44}

The kinetic characteristics of pure DCIS lesions are more heterogenous and less predictive than those of invasive cancers, which are more likely to demonstrate early enhancement followed by rapid washout kinetics. The majority of pure DCIS lesions have rapid initial phase of enhancement in up to 77\% of cases.\textsuperscript{46,48,50} The type of delayed enhancement is variably reported, but most commonly described as plateau or washout. Less often, DCIS lesions may demonstrate slow, progressive delayed enhancement (Figure 5). As with enhancing masses, a suspicious morphology, such as unilateral segmental or linear enhancement, will trump an associated benign appearing dynamic enhancement curve.

While one might expect that enhancement morphology and kinetics would reflect biologic behavior and by extension nuclear grade, there is no definitive evidence to suggest that either can be used to predict the presence of high-grade DCIS.\textsuperscript{46,48} When morphologic features of high-grade versus non-high-grade DCIS are compared, there is simply no statistical difference that would separate these categories.\textsuperscript{51,52} However, some potentially significant observations have been made regarding features of high-grade DCIS on MRI. High-grade DCIS appears to be more easily detected than low-grade, suggesting MRI may have a significant benefit in excluding high-grade disease with a negative exam.\textsuperscript{49} Additionally, high-grade DCIS is significantly more likely to be detected with MRI than conventional mammography, with as many as 48\% of high-grade cases detected with MRI alone.\textsuperscript{45}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure4}
\caption{Clumped non-mass-like enhancement (NMLE) of high-grade DCIS. (A) Sagittal MR post-contrast subtraction image shows clumped, segmentally distributed NMLE in the mid to lower breast. (B) Craniocaudal and (C) axial post-contrast MIP images in a different patient with mammographically occult high-grade DCIS reveal asymmetric, clumped segmental enhancement (white arrows) in the upper inner breast. The orientation of the affected breast was positional, as it did not persist on the subsequent MRI guided biopsy.}
\end{figure}
Enhancement features of pure high-grade DCIS, including a focal branching pattern or irregular contour, may also be helpful in prospectively differentiating from pure invasive disease.\textsuperscript{52}

**Summary**

Overall, pure DCIS has an excellent prognosis; however, high-grade DCIS is an aggressive subtype with significantly greater morbidity and risk of mortality with recurrent invasive disease. Appropriate use of mammography and MRI affords radiologists an opportunity to identify this population and guide the most appropriate surgical and oncologic management based upon our current understanding of the disease. Research has extensively evaluated mammographic and MRI features of high-grade DCIS, and its appearances are well documented. Unfortunately, imaging currently shows little prospective value in cases of pure high-grade DCIS beyond the ability to make the initial diagnosis. Future research is necessary to determine the full impact of imaging patients with high-grade disease and to further define the best clinical treatment strategies.

The views expressed in this material are those of the author, and do not reflect the official policy or position of the U.S. Government, the Department of Defense, or the Department of the Air Force.
References


Case Report, Kreuer et al.

Peripherally Enhancing Breast Lesion With Central Fat

Sharon Kreuer, D.O., and Rocky C. Saenz, D.O.
Department of Diagnostic Radiology, Botsford Hospital, Farmington Hills, MI

Case Presentation

67-year-old female presents with a palpable mass within her right breast. Review of systems revealed a breast procedure approximately 2 years prior. Physical exam demonstrated nipple inversion with confirmation of a deep palpable mass in the upper breast. Patient then underwent breast MRI imaging (Figures A - C).

Figure. Axial T1 image (A) demonstrates a triangular shaped lesion within the upper breast posterior depth with central high T1 signal. Sagittal dynamic post-gadolinium T1 subtraction image with fat saturation from the sub-peak phase (B) shows peripheral enhancement with central hypointense signal. Sagittal dynamic post-gadolinium T1 subtraction image with fat saturation with color overlay (C) demonstrates the lesion to have mixed kinetics, including type III washout.
Key clinical finding

Palpable mass with history of prior surgical procedure or trauma.

Key imaging finding

Peripherally enhancing breast lesion with central fat signal on T1.

Differential diagnoses

- Fat Necrosis
- Infiltrating Ductal (IDC) Carcinoma
- Radial Sclerosing Lesion (RSL)

Discussion

A key component in the evaluation of a breast lesion seen on mammography or ultrasound is obtaining a thorough patient history. Answers regarding personal and familial cancer history, as well as prior surgeries and trauma, should be elicited and may guide differential considerations. In indeterminate cases when the discrimination between benign and malignant processes cannot be made, MRI may be an invaluable diagnostic tool, even though there is overlap in the MR appearance of many benign and malignant breast lesions.

Fat necrosis.

Fat necrosis most commonly is a consequence of surgery or accidental trauma but may also result from prior radiation therapy to the breast.\(^1\) Patients may or may not have grossly visible or palpable evidence of fat necrosis depending on the depth and size of the lesion.

On imaging, the varied appearances of fat necrosis is ascribed to various amounts of histiocytic infiltration, hemorrhage, fibrosis, and calcification present after breast insult and is dependent on the stage of evolution.\(^1\) Lesion morphology can range from a well-marginated appearance of an oil cyst to a spiculated appearance of robust fibrosis. This wide gamut of tissue changes produces a constellation of MRI signal abnormalities and enhancement patterns.

T1 sequences are the most useful in evaluating suspected fat necrosis, which typically has signal characteristics consistent with fat elsewhere in the breast.\(^2\) Occasionally, necrotic fat may demonstrate low T1 signal secondary to the presence of hemorrhage and inflammatory content.\(^3\) Post-contrast images show variable amounts of enhancement depending on the amount of inflammation present, although a thin rim of enhancement is common.\(^2\)

When increasing amounts of inflammation and fibrosis are present, imaging findings can be easily confused with malignancy. Fibrosis may have hyperintense, intermediate, or hypointense signal on T1, and areas of thick nodular enhancement may persist for several years after the initial insult.\(^2\) Washout kinetics are as variable as the morphology and signal characteristics; therefore, they are typically not very helpful.\(^3\)

Infiltrating ductal carcinoma (IDC).

IDC is the most common histologic variant of breast cancer and often progresses from ductal carcinoma in situ. Patients presenting with IDC may be asymptomatic, or may have a palpable mass, nipple discharge/inversion, or overlying skin findings.

MRI is a valuable tool in diagnosing IDC with a sensitivity of 90-100%.\(^3\) Its main uses in the setting of IDC include evaluating tumor extent and assessing for multicentric involvement and contralateral disease in patients with biopsy proven carcinoma.

The classic pre-contrast T1 and T2 MRI appearance of IDC is signal intensity equal to or lower than that of fibroglandular tissue.\(^4\) Post-contrast images typically reveal an irregular, spiculated, enhancing mass with early enhancement with delayed washout kinetics.\(^5\) Less common enhancement patterns include heterogeneous mass-like or rim enhancement; rim-enhancement is highly suggestive of malignancy when not otherwise consistent with fat necrosis.\(^4\)

Radial sclerosing lesion (RSL):

RSLs, otherwise known as radial scars, are not truly scars and are not associated with prior surgery or trauma. They are typically asymptomatic and found incidentally. There is a known increased incidence of breast cancer when a radial scar is present; atypical
ductal hyperplasia and carcinoma are found in up to 50% of cases. In many cases it may be difficult or impossible to distinguish sclerosing lesions of the breast from ductal carcinoma, even with MRI. Morphologically, these lesions have spiculated margins and secondary architectural distortion; post-contrast enhancement patterns are similar compared to IDC.

Percutaneous biopsy of these lesions remains controversial. One study suggests that core needle biopsy alone is sufficient if at least 12 tissue samples are obtained and there is no histologic evidence of atypical hyperplasia. Otherwise, excisional biopsy is recommended due to the lesion’s high association with carcinoma and heterogenous histology.

**Diagnosis**

Fat Necrosis

**Summary**

Imaging findings of fat necrosis of the breast are varied and have several overlapping imaging characteristics with other benign and malignant breast lesions, making it a particularly challenging diagnosis. However, when characteristic features are present, such as fat signal intensity, thin peripheral enhancement, superficial location, history of trauma or surgery, oil cysts, or benign calcifications, short-term follow-up may be preferred to biopsy. In the absence of these classic findings, however, tissue sampling should be a consideration.

**References**

Unilateral Axillary Lymphadenopathy

Shannon Gaffney, D.O.
Department of Diagnostic Imaging, Wilford Hall Ambulatory Surgical Center, San Antonio, TX

Case Presentation

A 37-year-old woman presented with pain and tingling underneath and behind her left breast for the past two weeks intermittently. She denied trauma or any inciting event. Past medical history and review of systems were noncontributory. Physical exam of the breasts and left chest wall is negative. The patient was subsequently referred for diagnostic mammogram, ultrasound, and MRI breast (Figs A-D).

Figure. Bilateral MLO (A) and magnified ML view of the left breast (B), demonstrate asymmetric left axillary adenopathy. Targeted ultrasound of the left axilla (C) confirms enlarged axillary lymph nodes with irregular, thickened cortex and loss of the fatty hilum. Sagittal T1 post-contrast fat suppressed MR image (D) reveals an enhancing mass in the middle depth left breast that is mammographically occult. Left axillary adenopathy is again demonstrated.
Key imaging finding

- Unilateral axillary lymphadenopathy

Differential diagnoses

- Breast carcinoma with axillary spread
- Reactive lymphadenopathy
- Metastases/Lymphoma
- Systemic disease
- Granulomatous disease

Discussion

Unilateral axillary adenopathy can present a diagnostic and therapeutic dilemma. Differentiating benign versus malignant causes can be a challenge. Features of axillary lymph nodes that may be considered abnormal include increased size (greater than 2 cm), homogeneously increased density, loss of normal architecture, and occasionally internal calcifications. When detected, a thorough history and physical exam may aid in excluding benign causes, such as reactive adenopathy or granulomatous disease. In most cases, further imaging and often biopsy are performed to determine the etiology. A typical workup for unilateral axillary adenopathy detected on mammogram includes bilateral axillary ultrasound and tissue sampling. Additionally, MRI and nuclear medicine imaging may be contributory in the diagnostic and therapeutic approach.

Breast carcinoma with axillary spread

Although primary breast carcinoma presenting as axillary adenopathy is relatively uncommon (some authors suggesting ranges of 4-12%), it must considered in the differential diagnosis of unilateral axillary adenopathy. Most women with axillary adenopathy due to metastatic disease have an obvious primary tumor. In fact, unilateral axillary adenopathy with an otherwise normal mammogram is a rare presentation of breast cancer, occurring in less than 1% of cases. Axillary nodes in the setting of metastatic breast cancer can appear dysmorphic with increased size and density and rarely have internal pleomorphic microcalcifications. If a mass is not seen on mammogram, an ultrasound can be performed but is often low yield without a suspicious mammographic finding. In such cases, lymph node biopsy is typically performed. Imaging with MRI is a another alternative to further evaluate for a mammographically occult mass.

Reactive Adenopathy

Radiographic appearance of reactive adenopathy is nonspecific but typically consists of enlarged lymph nodes that maintain normal architecture (i.e. reniform shape and preserved fatty hilum). Clinical evaluation for infection or inflammation in the ipsilateral breast, axilla, arm, and hand is recommended. Common causes of unilateral reactive adenopathy include mastitis, breast abscess, an infected skin lesion, and cat scratch disease.

Metastases/Lymphoma

Metastases and lymphoma may present with axillary adenopathy, which is more often bilateral but may be unilateral as well. Some of the more common extramammary malignancies that may present with axillary adenopathy include thyroid, lung, gastrointestinal, and pancreatic cancers. Ovarian metastases can also present with unilateral axillary adenopathy, but this is quite rare. Past medical history and prior imaging may be beneficial in these cases.

Granulomatous disease

Axillary adenopathy can be seen in patients with granulomatous diseases, such as tuberculosis or sarcoidosis. Imaging features include enlarged axillary lymph nodes with coarse internal calcifications. If granulomatous disease is suspected, prior chest radiographs or chest CTs can confirm pulmonary granulomas and/or calcified mediastinal/hilar lymph nodes.
Collagen vascular disease.

Systemic diseases, such as systemic lupus erythematosus, rheumatoid arthritis (RA), and scleroderma can present with unilateral axillary adenopathy. The imaging characteristics of axillary nodes in systematic diseases are often nonspecific. One rare but unique imaging feature is gold deposits within the lymph nodes, which mimic internal calcifications; this feature is seen in RA patients treated with gold therapy.6

Diagnosis

Invasive ductal carcinoma with axillary spread.

Summary

Unilateral axillary adenopathy detected on imaging should be regarded as suspicious and warrants further investigation. Workup should include, at a minimum, diagnostic mammogram and axillary ultrasound (to confirm unilateral adenopathy); biopsy is often necessary. MRI may be contributory to detect mammographically occult breast masses, as in the case presented here, and is widely being used in the diagnostic approach for malignant axillary adenopathy in the absence of a mammographic abnormality. Nuclear medicine studies (such as PET and BSGI) may also have some benefit in evaluating for underlying breast malignancies.7 Although the diagnostic workup of unilateral axillary adenopathy remains variable, a prudent approach should make every effort to exclude a primary breast malignancy as the cause.

References

2. Leibman J, Kossoff M. Mammography in women with axillary adenopathy and normal breasts on physical examination: value in detecting occult breast carcinoma. AJR 1992 Sep; 159: 493-495

The views expressed in this material are those of the author, and do not reflect the official policy or position of the U.S. Government, the Department of Defense, or the Department of the Air Force.
Mondor’s Disease.

Can you tell why this patient presented?

The arrow on the mammogram points to an acutely painful, palpable, superficial tubular mass coursing toward the nipple. The ultrasound image demonstrates a superficial, anechoic, tubular structure with multiple areas of narrowing and intraluminal echogenicity (arrowhead). Color Doppler analysis shows absence of flow within the tubular structure. These findings are consistent with superficial thrombophlebitis, also known as Mondor’s disease.

Mondor’s disease is a rare, self-limiting, generally benign condition of thrombophlebitis of the superficial veins of the breast and anterior chest wall. This entity is often idiopathic; however, known causes include trauma, breast augmentation, breast biopsy, breast cancer, inflammation, and infection. The classic presentation of a painful, palpable, cord-like structure often aids in avoiding misdiagnosis of the enlarged vein as a dilated duct. Also, thrombosed veins are longer, have a beaded appearance, and do not terminate at the areola. Since there have been occasional cases of associated breast cancer, imaging is warranted to exclude underlying malignancy. Management includes warm compresses and pain relievers (NSAIDS) with a 6-month follow-up examination. If findings are unresolved on follow-up, surgical excision may be considered.
JAOCR at the Viewbox

Mary C. Mahoney, M.D., and Arthur Ballard, M.D.
Breast Imaging Department, University of Cincinnati Health/University Hospital, Cincinnati, OH

Ductal Carcinoma in situ (DCIS).

Can you name the disease associated with this classic distribution of enhancement on the sagittal breast MRI?

The arrows on the breast MR subtraction image point to clumped, non-masslike enhancement in a ductal distribution, directed toward the nipple. These findings are most compatible and concerning for ductal carcinoma in situ (DCIS).

DCIS is malignancy confined to the ducts of the breast. It is considered to be a preinvasive form of cancer. Mammographic screening has led to an increased frequency in the detection of DCIS, which now accounts for approximately 20% of all detected breast cancers. Early detection of this preinvasive form of breast cancer is one of the factors contributing to the decrease in breast cancer mortality. Most DCIS is detected mammographically in the form of pleomorphic microcalcifications. However, recent studies have shown that MRI is capable of detecting not only calcified DCIS, but uncalcified DCIS as well. In fact, the sensitivity of MRI for DCIS is higher than that of mammography, especially for high grade lesions which are thought to be more prone to progress to invasive carcinomas.