JAOCR
Official Journal of the American Osteopathic College of Radiology

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.

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In this Issue

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One might ask why we need a Women’s Imaging issue of the JAOCR, when two excellent Breast Imaging issues have already been published in January 2013, edited by Michelle C. Walters, D.O., FAOCR, and again in January 2014, edited by Susann E. Schetter, D.O., FAOCR. Unlike many other cancer types that primarily affect older individuals, the potential number of years lost by a young woman diagnosed with breast cancer or gynecologic malignancy places greater importance on the roles of early and high-quality imaging and accurate radiologic interpretation in this group.

The case reviews in this issue by Drs. Gupta and Ahmad, and a Viewbox case by Dr. Mikes, highlight key findings in pelvic imaging. While this issue includes two new breast imaging articles to complement the aforementioned breast imaging issues, a women’s imaging issue need not be limited to examinations tailored to anatomic features of women but may also include articles reflecting differences in predilection between women and men. This difference is illustrated by a Viewbox musculoskeletal case submitted by Drs. Stein and Gogna.

When I hear the recently popularized term sustainability in the context of preserving earth’s limited resources, I am reminded of how the AOCR is also adapting to ensure the sustainability of osteopathic radiology. Along with the privilege of being guest editor of this journal comes the responsibility to mentor radiologists-in-training in scholarly activity. With this objective in mind, most articles in this issue were authored or co-authored by radiology residents. I am especially proud of this issue due to the contributions of radiology residents who will carry the flag long after I have hung up my hat. Our greatest legacy may be to have trained radiologists who will provide high-quality imaging services to women. I hope this issue will help propel you toward that goal.

I would like to acknowledge my colleagues and associates, especially Pauline Germaine, D.O., who rather abashedly called attention to my blind spots, and through whose varied perspectives I have been granted the opportunity to become a better physician. Lastly, I could never forget to thank my wife, Diana, for her endless support and tireless patience while writing and editing this issue.
Breast cancer remains the second leading cause of cancer-related death in women, with an approximately 1 in 8 (12%) chance of developing invasive breast cancer in a woman’s lifetime. Over the past two decades, significant advances in MRI have increased sensitivity in detecting breast cancer. Since then, radiologists, surgeons and oncologists have been utilizing breast MRI for both screening and staging of breast cancer. Numerous studies have shown that breast MRI can identify additional foci of carcinoma within the breasts and that it determines more extensive disease compared to conventional imaging of mammography and ultrasound.

This article will review how radiologists can use breast MRI in detecting additional disease within the breast and surrounding tissues.

Limitations of Mammography and Ultrasound in Breast Cancer Detection

Breast carcinomas are detected via screening and diagnostic evaluations. The workup of abnormalities includes evaluation with diagnostic mammography and ultrasound (US). Tomosynthesis is used as a 3-dimensional (3D) digital mammogram that has been shown to increase detection of invasive carcinomas. Tissue sampling for pathologic diagnosis is then performed depending on the modality in which the abnormality is best visualized, including ultrasound guidance, stereotactic biopsy, and tissue sampling with MRI. Ultrasound-guided biopsies are preferred given the ease of performing and scheduling these cases. The radiologist must then determine whether the pathology result is concordant or discordant with the imaging findings. If discordant, a recommendation for additional tissue sampling via biopsy or surgical excision is then given.

While most primary lesions are found with mammography and ultrasound, these modalities have limitations. The most significant limitation with mammography is increased density of the fibroglandular tissue within the breasts, which may obscure carcinoma. Mammmography has been shown to have decreased sensitivity for detecting masses in extremely dense breasts. Additionally, these women have an increased relative risk for breast cancer compared to the average woman, with approximately a 4- to 6-fold increased risk. For this reason, legislation is now in place to notify women with heterogeneous and extremely dense breasts, and 32 states require patients to be notified regarding their breast density and the possibility of additional screening, including whole-breast ultrasound and breast MRI depending on individual risk. Decreased sensitivity of mammography is also noted in women with breast implants. Breast ultrasound has its own limitations. It is operator dependent, with handheld scanning ultrasound most widely used. Ultrasound is also limited in evaluating or identifying calcifications.

Current Role of Breast MRI

Breast MRI aids with the limitations of mammography and US, and has been shown to have the highest sensitivity of the 3 modalities, helping to detect cancers that are clinically, mammographically and sonographically occult. Indications for screening breast MRI include high-risk patients such as women with a lifetime risk > 20%, women with a BRCA mutation or a first degree relative of a BRCA carrier, history of chest radiation, and women with hereditary syndromes such as Li-Fraumeni. Breast MRI is used to determine the extent of invasive carcinomas and carcinoma in situ prior to treatment; assess response to neo-adjuvant chemotherapy, metastatic carcinoma where the primary is unknown and suspected to be of breast origin; and problem solving for clinical or imaging findings. Breast MRI has also been used for assessment following surgery, as in cases with positive margins post lumpectomy; assessment for recurrence; and in cases with postoperative tissue reconstruction in which recurrence within tissue transfer flaps is suspected.
FIGURE 1. Additional disease on MRI. Axial-subtracted (A) and color-overlay (B) images show a 1.8-cm spiculated mass at the 6 o’clock position in the middle depth of the right breast (arrow) with a central biopsy marker (biopsy confirmed invasive ductal carcinoma). Mixed kinetics are demonstrated on the color overlay image. Axial-subtracted (C) and color-overlay (D) images at an adjacent level reveal nonmass-clumped enhancement anterior to the primary mass. Mixed kinetics are also demonstrated in this region on the color overlay image. The patient underwent a right mastectomy, and pathology confirmed invasive ductal carcinoma with diffuse dermal lymphatic carcinomatosis.

FIGURE 2. Additional disease on MRI. Axial-subtracted image (A) shows a right 1.7-cm retroareolar mass (arrow) with a biopsy marker (biopsy confirmed invasive mucinous carcinoma). Axial-subtracted image inferior to the known mass (B) shows an additional right-sided 2.3-cm mass with irregular margins (arrow), which was confirmed to represent a second site of carcinoma.
FIGURE 3. Additional disease on MRI. Axial-subtracted (A) and color-overlay (B) images demonstrate a dominant mass (arrow) with mixed kinetics within the posterolateral right breast, which was proven to be invasive ductal carcinoma on biopsy. Axial-subtracted image C and color-overlay (D) images reveal additional masses in the same quadrant (arrows, C) with multifocal disease.

FIGURE 4. Osseous metastases. Axial T2 (A), axial T1 postcontrast (B) and sagittal T1 postcontrast (C) images demonstrate an enhancing mass within the right posterolateral breast (yellow arrow, B), consistent with patient’s known invasive lobular carcinoma, as well as abnormal T2 hyperintense signal (white arrow, A) and enhancement (green arrows, B & C) within the sternum, consistent with osseous metastases.
FIGURE 5. Additional and more extensive disease compared to mammography and US. Bilateral mediolateral oblique (MLO) (A) and cranial-caudal (CC) (B) mammograms show global asymmetry involving the left breast (white arrows) with enlarged left axillary lymph nodes (yellow arrow, A). Ultrasound image of the upper outer left breast at the 1 o’clock position in the area of palpable concern (C) demonstrates a 3.1-cm ill-defined hypoechoic mass, suspicious for malignancy. US-guided biopsy (not shown) confirmed invasive ductal carcinoma. Axial-subtracted images (D and E) reveal the biopsy-proven mass (green arrow, D) with biopsy marker placement, along with non-mass enhancement extending from the retroareolar area to the posterolateral left breast involving the upper and lower quadrants (blue arrows, D and E).
BI-RADS for Breast MRI

The 2013 American College of Radiology (ACR) Breast Imaging Reporting and Data System (BI-RADS) lexicon provides terminology that guides radiologists in the evaluation and description of breast MRI findings.11 This includes description of the amount of fibroglandular tissue and background parenchymal enhancement. Abnormalities are further characterized into a focus, mass and nonmass enhancement. A focus is focal enhancement that is <5 mm and considered to be a part of the parenchymal background enhancement. Masses are characterized by shape, margin and internal enhancement with an irregular shape and margin being most concerning. Nonmass enhancement is further characterized by distribution and internal enhancement. Linear and segmental distribution and clumped or clustered ring enhancement are most concerning.11

The morphology of a mass is more important than the enhancement kinetics. In terms of enhancement patterns, washout kinetics are of greatest concern, although many carcinomas are of mixed kinetics, including washout, persistent

FIGURE 6. Multicentric disease in the ipsilateral breast. Axial T1-subtracted (A) and color-overlay (B) images show an enhancing mass in the left retroareolar middle depth (arrows), which was confirmed to represent invasive ductal carcinoma and carcinoma in situ on biopsy. US image through this region (C) shows the mass with relatively circumscribed borders. Axial T1-subtracted (D) and color overlay (E) images through the upper breast demonstrate a second enhancing mass with mixed kinetics in the upper outer left breast (arrows), concerning for malignancy. Dedicated US through this region (F) shows the mass with angular margins. Biopsy confirmed invasive ductal carcinoma, consistent with multicentric disease.

FIGURE 7. Axillary lymph node involvement identified on MRI. Axial T1 postcontrast fat-suppressed image (A) demonstrates a large, spiculated 3.5-cm mass in the right upper outer breast that was palpable and confirmed on US (B). Additional axial T1 postcontrast fat-suppressed image (C) reveals bilateral axillary lymphadenopathy (arrows) with the largest measuring 1.3 cm in short axis. US-guided biopsies of the right breast mass and axillary lymph nodes confirmed invasive lobular carcinoma with metastatic bilateral axillary lymphadenopathy.
FIGURE 8. Chest wall involvement and contralateral disease on MRI. Axial T1 postcontrast fat-suppressed (A and C) and corresponding color-overlay (B and D) images demonstrate a diffuse abnormal shrunken nodular appearance of the entire left breast, consistent with biopsy-proven invasive ductal carcinoma. There is diffuse posterior chest wall involvement and extension through the subcutaneous soft tissues and across midline to the medial margin of the right breast. The abnormal left breast and chest wall have mixed kinetics. Within the middle depth right breast there is a 1.5-cm oval mass at the 9 o’clock position with washout kinetics (arrows), suspicious for an additional site of malignancy in the right breast. Focused ultrasound image of the right breast (E) revealed a mass with angular margins that was felt to correspond with the mass on MRI. Initial and repeat US-guided biopsy demonstrated fibrosis, which was considered discordant. An MRI-guided biopsy was then performed, demonstrating low-grade invasive scirrhous ductal carcinoma with focal low-grade ductal carcinoma in situ. Postbiopsy mammogram (F) showed the rod-shaped MRI biopsy marker to be 1.5 cm from the coil-shaped US-guided biopsy markers.
and plateau. If additional suspicious masses and enhancement patterns are detected that would impact surgical and oncologic management, then a BI-RADS of 4 or 5 is given to obtain a tissue diagnosis.\footnote{Harvey JA, Bovbjerg VE. Quantitative assessment of mammographic density: relationship with breast cancer risk. Radiology 2009;240(1):29-41.}

Breast MRI for Extent of Disease

Preoperative breast MRI is increasingly used in staging newly diagnosed breast cancers. It is primarily utilized to look for evidence of more extensive disease than is noted on conventional imaging with diagnostic mammography and ultrasound. This includes additional disease in the ipsilateral or contralateral breast (\textit{Figures 1-3}).

Location of the cancer in the breast is described in terms of breast quadrant (inner upper, inner lower, outer upper, and outer inner), depth (anterior, middle and posterior), and the o’clock position. Size of the mass or nonmass enhancement is described in all 3 dimensions: anteroposterior, transverse and craniocaudal dimensions. These descriptors are important for localization in terms of surgery and radiation, as well as when comparing the sizes and locations to mammography and ultrasound. If additional suspicious findings are detected, multifocal disease (within the same quadrant) and multicentric disease (within at least 2 quadrants) is described.\footnote{Bi-RADS. In: ACR Atlas, Breast Imaging Reporting and Data System. Reston, VA: American College of Radiology; 2013. http://www.acr.org/-/media/acrorg/-/media/acr médecin/2015/03/10/66b1e1d9-0af0-4180-98d0-3c9c60bca0d1.pdf.}

More extensive disease also needs to be described: extension to the chest wall (\textit{Figure 8}), defined as invasion of the serratus anterior, ribs or intercostal muscles, upgrades tumor stage regardless of tumor size. Invasion of the pectoralis muscle is not considered chest wall invasion and does not change the staging. Pectoralis involvement is defined as enhancement of the pectoralis muscle, which will impact surgical excision. MRI is the imaging modality of choice in assessing pectoralis muscle and chest wall involvement. Distant metastasis is seen in approximately 4\% of breast cancer cases. Osseous, liver and lung metastases may be seen with the breast MRI.\footnote{J Am Osteopath Coll Radiol 2017; Vol. 6, Issue 4
Utilization of Breast MRI for Extent of Disease}

Conclusion

Breast MRI has been shown to be significantly more sensitive in evaluating the extent of disease in breast cancer patients when compared to mammography and US. This includes involvement of the unilateral and contralateral breast, as well as extramammary spread of disease. With a preoperative breast MRI, it is important for the radiologist to appropriately describe the extent of suspected disease in accordance with the BI-RADS lexicon, and make appropriate management and follow-up recommendations.

References

New technologies in mammography, such as 3-dimensional (3D) tomosynthesis and contrast-enhanced spectral mammography (CESM), have a role in increasing the sensitivity and specificity of breast cancer detection. Recently implemented in many breast imaging practices, 3D tomosynthesis has been shown to increase the number of BIRADS 1 and 2 diagnoses and decrease BIRADS 3 category exams, providing a more definitive diagnosis and limiting the cost, time and anxiety of short interval follow-ups associated with BIRADS 3 exams. The number of BIRADS 4 and 5 categories has not significantly changed as reported by Raghu et al.1 Tomosynthesis detects architectural distortion well and clears up focal asymmetries quickly, since most are due to overlapping breast tissue and require no further follow-up. This, in turn, reduces callbacks from screening mammography.

FDA-approved in 2011, CESM is used widely internationally and is gaining popularity – albeit more slowly – in the United States. CESM eliminates breast density as a limiting factor when interpreting 2-dimensional (2D) mammograms by utilizing a dual-energy acquisition system, which then generates a subtracted image to outline areas of enhancement. It serves a role in high-risk screening, diagnostic workup, and cancer staging and restaging.2

Both tomosynthesis and CESM add value to the diagnostic workup of breast lesions in their own way. We review and highlight the role of each modality, including their advantages and disadvantages, followed by an illustrative clinical case in which each modality was used and contributed to the ultimate diagnosis.

Role of 2D, 3D, and Contrast-enhanced Spectral Mammography

In clinical use since the 1970s, 2D screening mammography has provided multiple improvements in technique, image quality, and patient positioning since its implementation. The widespread screening of asymptomatic women has slowly become the standard of care, increasing detection of noninvasive and invasive breast cancers. With changes in technology, digital imaging began to replace screen-film mammography by the early 2000s, reducing length of exposure and radiation dose from the examination.2 Digital mammography also improved assessment of heterogeneously dense and extremely dense breast tissue, providing an additional advantage over screen-film mammography. However, overlap of glandular tissue remains an issue with 2D imaging, resulting in increased recall rates and additional workup with diagnostic mammography, often in combination with ultrasound assessment. The false positive and false negative findings continue to be problematic in everyday practice.

Digital tomosynthesis is a 3D technology that obtains multiple thin sections through each breast. This results in improved assessment of breast parenchyma due to decreased overlap of glandular tissue and a resultant decrease in false positive and false negative findings that are inherent in 2D technology. This technology also enhances characterization of mass margins and triangulation of abnormal findings in the breast, increasing cancer detection rates while lowering recall rates and patient anxiety associated with additional imaging workup.4 Small masses, such as cysts or intramammary lymph nodes, previously concealed by overlapping glandular tissue, are now easily

Role of 2D, 3D, and Contrast-enhanced Spectral Mammography in Diagnosis and Staging of Invasive Ductal Carcinoma: A Literature Review with an Illustrative Case

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Role of 2D, 3D, and CESM in Diagnosis and Staging of Invasive Ductal Carcinoma

detected on tomosynthesis and may be further localized and evaluated with targeted ultrasound for definitive characterization. However, these benefits come at the expense of increased radiation exposure. Three-D tomosynthesis is currently approved in combination with 2D digital mammography, further increasing radiation dose from a single study. Although detection and localization of skin microcalcifications is improved with 3D technology, overall assessment of parenchymal microcalcifications is limited. Detection of microcalcifications is crucial in diagnosing both invasive and in situ cancers.

CESM combines the advantages of digital technology with contrast administration, highlighting neovascularity associated with actively growing malignancy. Simultaneous low- and high-energy exposures are obtained, producing low-energy and subtraction views evaluated by the radiologist immediately following image acquisition to identify areas of concern that may require further workup. This technique is utilized in daily practice for high-risk screening, diagnostic workup, staging of known breast cancer, and assessment of chemotherapy response, particularly in patients with contraindications to MRI.

Although superior in identifying masses, CESM is less sensitive compared to 2D mammography for detecting microcalcifications. CESM low-energy images are not approved to replace 2D mammography; however, they typically provide adequate visualization of microcalcifications, offering an advantage over tomosynthesis. Benign masses such as fibroadenomas or lymph nodes enhance after contrast administration, and careful assessment of mass margins coupled with ultrasound evaluation is needed to avoid false positive results and unnecessary procedures.

As CESM technology relies on iodinated contrast administration, review of patient history and laboratory findings are crucial to avoid allergic reactions to contrast material.

FIGURE 1. 2D digital mammography. 2D mediolateral oblique (MLO) and craniocaudal (CC) images (A) reveal an asymmetry with increased density (white arrow) in the MLO projection of the left breast. (B) also marked by computer-aided detection (CAD) with an asterisk (*) with no definite correlative focal abnormality on the CC projection. Additional areas marked with asterisk on CC projection corresponded to stable mammographic findings. Circular marker identifies a skin lesion. Triangular marker identifies an area of palpable concern. Images of the right breast were noncontributory.

FIGURE 2. 3D tomosynthesis. Mediolateral oblique (MLO) (A) and craniocaudal (CC) (B) tomosynthesis views of the left breast show a mass (white arrows) in the upper outer left breast with spiculations, corresponding to the area of palpable concern and the abnormal finding on the 2D MLO view.
is necessary to avoid the potential risk of allergic reaction or deterioration of renal function. Although the radiation exposure from this technique slightly exceeds that of 2D mammography, it is significantly lower compared to 3D tomosynthesis.

**Illustrative Case**

A 58-year-old woman presented to the breast clinic for assessment of a palpable abnormality in the left lateral breast that was identified 2 weeks earlier by the patient’s gynecologist during a routine annual visit. At the time, she was also past due for her annual mammogram, with her most recent mammogram performed 15 months prior. A marker was placed on the lateral left breast in the location of palpable concern and the workup was initiated.

The workup started with 2D digital mammography, which revealed heterogeneously dense breast parenchyma bilaterally with stable distribution since prior examination. An asymmetry with increased density in the mediolateral oblique (MLO) projection of the left breast was marked by computer-aided detection (CAD) and was in close proximity to the skin marker; however, no focal abnormality could be appreciated on the craniocaudal (CC) projection in the same region on 2D mammography (Figure 1). Due to overall increased density of the breast parenchyma, the suspicious MLO finding, and added palpable concern, further assessment followed with 3D digital tomosynthesis, which highlighted the presence of a 1.4-cm lobulated mass with associated spiculations deep in the lateral superior left breast, in the area of palpable abnormality (Figure 2). Tomosynthesis also revealed several small circumscribed masses in both breasts.

In light of highly suspicious tomosynthesis findings, bilateral staging with CESM immediately followed and confirmed the presence of an avidly enhancing mass in the lateral superior left breast (Figure 3), not marked by CAD on the initial 2D CC projection. No additional areas of suspicious enhancement were identified on either side, resulting in preliminary T1c stage with respect to the size of the index mass.

Ultrasound revealed a hypoechoic mass taller than wide in the left breast at the 2 o’clock position, correlating to the palpable abnormality and the mammographic findings. Ultrasound survey of the left axilla demonstrated small lymph nodes, nonpathologic by size criteria and by sonographic appearance. Several small parenchymal cysts within both breasts correlated with additional circumscribed masses noted on 3D tomosynthesis. Upon completion of the workup, the patient was staged as IA based on TNM classification and was scheduled for percutaneous biopsy for tissue diagnosis.

Ultrasound-guided biopsy of the left breast mass was performed with a 9-gauge vacuum-assisted needle, confirming the presence of infiltrating ductal carcinoma, grade 3, ER, PR and HER-2/neu negative. Due to the aggressive nature of the primary malignancy and despite the normal sonographic morphology of the left axillary lymph nodes, ultrasound-guided biopsy of one of them was performed, revealing no evidence of metastatic involvement and confirming preliminary stage IA breast cancer.

In the illustrative case, all three mammographic techniques were used to diagnose and stage the presumed malignancy. Each study provided a unique piece of information that contributed to the workup, ultimate diagnosis and complete staging. The 2D digital mammogram identified an abnormality on the MLO projection with limited visualization on the CC view, likely in

**FIGURE 3.** Contrast-enhanced spectral mammography (CESM). Mediolateral oblique (MLO) low-energy (A) and subtraction (B) views, as well as craniocaudal (CC) low-energy (C) and subtraction (D) views, depict an enhancing mass (mass depicted by white arrows on all views; enhancement depicted on images B and D) in the upper outer left breast, correlating to 2D and 3D mammography findings. No other areas of enhancement are identified.
Role of 2D, 3D, and CESM in Diagnosis and Staging of Invasive Ductal Carcinoma

part related to overlap of glandular tissue. Subsequent 3D technology accurately localized the mass and improved localization and assessment of the mass margins, highlighting the associated spiculations and architectural distortion. Finally, CESM completed the staging workup revealing no additional suspicious enhancing mass in either breast. Interestingly, the visualization of the primary mass was improved on the low-energy CC and MLO CESM projections when compared to the initial 2D digital mammogram, especially on the CC projection. This observation may be related to the presence of iodinated contrast in the intravenous system and breast parenchyma during CESM image acquisition.

Summary

This case highlights the benefits and advantages of each modality — 2D, 3D, and CESM — particularly when used in conjunction with one another. A diagnostic or high-risk screening technique that could combine 3D and CESM technologies into one unit in a single examination would prove advantageous to many patients in terms of improved lesion detection and characterization, decreased study length, and reduced number of images acquired in a single examination, coupled with significantly decreased combined radiation exposure. Ideally, this unit would also offer percutaneous biopsy capability for tissue diagnosis, further streamlining the workup while lowering the overall radiation exposure.

References

Perivaginal Cysts

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Case Presentation

A 26-year-old nulliparous woman presented to her gynecologist with a nontender lump in the lateral aspect of the vagina. She did not report any dysuria, vaginal discharge, fever, or abdominal pain. Urinalysis was within normal limits. Urine pregnancy test was negative. Transabdominal ultrasound of the pelvis was normal (not shown). An MRI of the pelvis was then performed for further evaluation (Figure 1).

FIGURE 1. Axial (A) and sagittal (B) T2 MR images of the pelvis performed after patient self-administration of water soluble gel in the vagina reveals an eccentrically located cystic lesion in the right anterolateral aspect of the vagina (white arrows). The cyst fluid had intermediate signal fluid on T1 sequences (not shown) and moderately hyperintense T2 signal. The cyst contents are less hyperintense than the intravaginal gel on T2 images (yellow arrowheads). The location of the cyst in the anterolateral vagina at the level of the pubic symphysis (green oval, C) distinguishes it from other perivaginal cystic lesions near the introitus (Skene duct cyst: orange circle, C and D; Bartholin gland cyst: purple oval, C and D).
Key clinical finding(s)
Small lump protruding from the vaginal wall

Key imaging finding(s)
Unilocular cystic lesion in the upper anterolateral wall of the vagina

Differential diagnoses
Gartner duct cyst
Bartholin cyst
Skene gland cyst
Urethral diverticula

Discussion
Perivaginal cysts are usually asymptomatic and may be incidentally discovered during routine pelvic examination. When symptomatic, a small lump protruding from the vaginal wall can cause discomfort. Clinicians may biopsy the lesion or aspirate the fluid to rule out sexually transmitted infection or other pathological processes. Most cysts are benign and remain small, not requiring surgical excision. While these lesions may be detected on ultrasound (US), computed tomography (CT), or MRI, MRI has superior contrast resolution and allows for distinction between the various types of cysts, with location being the most important discriminating factor (Figures C, D).¹

Gartner duct cyst
Gartner duct cysts develop from incomplete regression of Wolffian ducts. They are usually in the upper anterolateral wall of the vagina just above the inferior border of the pubic symphysis (Figure C, green oval). On US, they appear as an anechoic structure in the upper vagina; transvaginal US provides better differentiation than the transabdominal approach. On MRI, the cysts generally appear as well-circumscribed lesions that are isointense to fluid. When these cysts are large enough, they can compress the urethra and cause urinary symptoms, although they are typically < 2 cm.¹

Bartholin gland cyst
Mucin-secreting glands originating from urogenital sinus are referred to as Bartholin glands and are commonly located posterolateral to the vaginal introitus, medial to the labia minora (Figures C, D; purple oval). Obstruction of the gland’s duct by stones or stenosis results in cyst formation. The cysts are typically round and unilocular. A key discriminator from the Gartner duct cyst is its location, found at or below the level of the pubic symphysis. This is most apparent on coronal plane imaging. On MRI, the cysts may have variable T1 signal intensity, while T2 signal intensity is uniformly hyperintense unless there is superimposed infection or proteinaceous content that results in heterogeneous T2 signal intensity. On US, Bartholin gland cysts can be imaged by a transperineal approach. Although these cysts are usually asymptomatic, occasionally infection may necessitate drainage of the cysts.¹

Skene gland cyst
Paired structures near the external urethral meatus with ducts draining into the urethral lumen are referred to as Skene glands. They are distinguished from urethral diverticula, which are usually midurethral. Due to their periurethral location, Skene gland cysts can cause urinary tract infections or urethral obstruction. They are seen lateral to the external urethral meatus (Figures C, D; orange circle). On MRI, they are round with hyperintense signal on T1 sequences due to proteinaceous material. T2 signal intensity will be hyperintense if uncomplicated, and may have a fluid-fluid level if complicated with debris or hemorrhage.¹

Urethral diverticulum
Sac-like outpouchings of the urethra or diverticula may be congenital or result from infection or obstruction. For example, a diverticulum can form when the duct of a paraurethral gland becomes obstructed, which leads to abscess formation that subsequently ruptures into the urethral lumen. The urinary stasis within diverticula predisposes patients to recurrent infections and stone formation. In females, the diverticula commonly extend from the posterolateral wall of the mid-portion of the short female urethra. During voiding cystourethrography (VCUG), they are best portrayed on postvoid images. On transrectal or transperineal US, a cystic mass with complex fluid in proximity to the urethra will be seen anterior to the vaginal wall. Transperineal US may be useful as an initial diagnostic exam; however, transrectal US will have greater specificity for small diverticula. Advantages of US over CT include better localization, lack of radiation, and capacity to differentiate solid from cystic masses. CT will demonstrate a periurethral lesion with low attenuation. On MRI, urethral diverticula will contain T1 hypointense and T2 hyperintense fluid signal intensity. Postcontrast imaging with gadolinium can be used to evaluate for infection or inflammation.²

Diagnosis
Gartner duct cyst

Summary
Perivaginal cysts are not uncommon and are often discovered incidentally. US and MRI are the modalities of choice in evaluating these lesions, with MRI offering superior contrast resolution and localization, which is the most important factor in distinguishing between the diagnostic considerations. The most common perivaginal lesions include Gartner duct, Bartholin, and Skene gland cysts, as well as urethral diverticula.

REFERENCES
Complex Cystic Adnexal Mass Approximating the Uterine Myometrium

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Case Presentation

A 46-year-old G2P2 woman with two prior Cesarean sections presented with several months of pelvic discomfort and urinary frequency. Serum beta human chorionic gonadotropin (hCG) was negative. For initial evaluation, a pelvic ultrasound (US) with transabdominal and transvaginal approach was obtained, which demonstrated a complex cystic mass to the right of the lower uterine segment (Figure 1A). Based on the US findings, follow-up MRI was performed (Figures 1B-D).

**FIGURE 1.** Sonographic image through the pelvis (A) shows a complex solid and cystic mass to the right of the lower uterine segment, which was found to be separate from the right ovary. Color Doppler assessment (not shown) revealed areas of internal vascularity. Axial T2 MR image (B) shows the circumscribed hyperintense mass to the right of the cervix (black arrowhead) with multiple low signal strands (thin black arrows) isointense to smooth muscle. Coronal T1 postcontrast image with fat suppression (C) reveals heterogeneously hypointense signal and regions of enhancement. The mass appears contiguous with the serosa of the right lower uterine segment (white arrow). Coronal T2 MR image (D) again shows heterogeneous hyperintense signal intensity with regions of decreased signal intensity.
**Key Imaging Finding**

Cystic adnexal mass approximating the uterine myometrium

**Differential Diagnoses**

- Epithelial ovarian neoplasm
- Sex cord-stromal cell tumor
- Hemorrhagic ovarian cyst
- Benign multicystic peritoneal mesothelioma
- Cystic degeneration of a pedunculated uterine leiomyoma

**Discussion**

Distinguishing a cystic adnexal mass from a uterine lesion is rarely challenging. Exceptions to this include a pedunculated leiomyoma with cystic degeneration, cystic adenomyosis, and a unicornuate uterus with a rudimentary obstructed horn. In the case presented, cystic degeneration of a pedunculated leiomyoma is an appropriate consideration, in addition to nonuterine (typically ovarian) adnexal pathologies. Since most adnexal masses are initially evaluated by ultrasound, every effort must be made to evaluate the risk of malignancy, as ovarian cancers are responsible for 5% of all cancer deaths in women. MRI is typically performed in situations where this risk cannot be confidently excluded by sonography. Computed tomography (CT) is mainly utilized for staging adnexal malignancies.

**Epithelial ovarian neoplasm**

Epithelial neoplasms account for approximately 70% of ovarian cancers. Subtypes of surface epithelial ovarian neoplasms are serous or mucinous cystadenomas, serous or mucinous cystadenocarcinomas, clear cell carcinomas, Brenner tumors, endometrioid, and undifferentiated epithelial tumors. Epithelial tumors are often primarily cystic with varying proportions of solid components. Another distinctive feature of epithelial tumors is the presence of papillary projections. It is important to identify the imaging features suggestive of malignant cystic ovarian neoplasms, which are a larger size (typically > 4 cm), heterogenous architecture, wall thickness > 3 mm, irregular and/or thick septations with abnormal enhancement, large soft-tissue component with necrosis, and mural nodularity. Blood flow within the septa and papillary projections is usually documented on Doppler ultrasound and helps differentiate from avascular clots adherent to the cyst wall, a common feature of hemorrhagic cysts. In addition, invasion of adjacent structures, peritoneal implants, ascites, and lymphadenopathy are findings that serve as strong evidence of malignancy. Characteristics suggestive of benign epithelial tumors include entirely cystic composition, size < 4 cm, thin walls, and the lack of internal structure.

**Sex cord-stromal tumor**

A less common subcategory of ovarian cancers is the sex cord-stromal tumors. Sex cord-stromal tumors include granulosa cell tumors, fibromas, fibrothecomas, Sertoli-Leydig cell tumors, and sclerosing stromal tumors. Granulosa cell tumors are the most common malignant sex cord-stromal tumor. Adult granulosa cell tumors typically occur in perimenopausal and postmenopausal women, and are much more common than the juvenile type. Endometrial hyperplasia, endometrial polyps, and endometrial cancer are associated with these tumors as a result of hyperestrogenemia commonly produced by these tumors. The appearance on imaging is variable, ranging from solid to cystic with solid components, or purely cystic. Varying degrees of hemorrhagic or fibrotic changes may be present. A feature of ovarian epithelial neoplasms, which is lacking in granulosa cell tumors, is intracyctic papillary projections.

**Hemorrhagic ovarian cyst**

Hemorrhagic ovarian cysts predominately present in premenopausal women and in postmenopausal women taking hormone-replacement therapy. The characteristic ultrasound appearance is that of a thin-walled cystic mass with a web-like pattern of lacy internal echoes and accentuated through transmission. Other diagnostic findings include a fluid-fluid level, prominent blood flow, and acoustic streaming from particulate matter within the hemorrhagic cyst. En-dometriomas may appear identical to hemorrhagic cysts; however, they do not demonstrate acoustic streaming. Often, retracting clots adherent to the wall mimic papillary projections of epithelial tumors, but lack blood flow, which is characteristic of malignant epithelial tumors. Follow-up with pelvic ultrasound may be performed to confirm complete resolution.

**Benign multicystic peritoneal mesothelioma**

Mesothelioma is a tumor of the mesothelial cells that form the lining of several body cavities and organs. Peritoneal mesotheliomas are second only to pleural mesotheliomas as the site of involvement for mesotheliomas. The three commonly recognized subtypes of peritoneal mesotheliomas include malignant mesothelioma, cystic mesothelioma, and well-differentiated papillary mesothelioma, with significant overlap in the pathological appearance of these subtypes. However, grape-like multicystic and multiple unilocular thin-walled cysts favor the diagnosis of cystic mesotheliomas. Cystic mesotheliomas characteristically present with pelvic involvement in young to middle-aged women. An associated history of prior abdominal surgery or pelvic inflammatory disease will often be present. These tumors tend to have a high recurrence rate of approximately 50% after surgical resection. Although once widely believed to have no metastatic potential, malignant transformation of cystic mesothelioma may occur.

**Cystic degeneration of a pedunculated uterine leiomyoma**

Uterine leiomyomas are benign smooth muscle tumors of the myometrium. They are commonly classified as intramural, submucosal, or subserosal based on location. Subserosal leiomyomas may appear predominantly extrauterine when they are peduncu-
lated and project exophytically into the abdomen or pelvis. It is essential to be mindful of the atypical appearances of leiomyomas, which may result from atrophy, internal hemorrhage, cystic degeneration, fibrosis, and/or calcification. Hyaline degeneration is the most common type of degeneration, with hyalinized collagen accounting for the characteristic low signal intensity on T2-weighted MR images. Cystic degeneration is much less common, occurring in approximately 4% of leiomyomas. A pedunculated leiomyoma may mimic an adnexal mass if cystic degeneration is present, especially if it has a very thin stalk or if it is parasitized (receiving blood from nearby structures). Moreover, elevated CA-125 levels have been reported with pedunculated leiomyomas. The bridging vessel sign is definitive in confirming the uterine origin of these exophytic leiomyomas. This sign refers to the presence of a pedicle or a vessel bridging the mass and the myometrium and is demonstrated by flow signal on color and power Doppler ultrasound or unenhanced MRI showing the vessels as curvilinear tortuous flow voids. The vessels represent feeding vessels that arise from the uterine arteries and course through the myometrium to supply the pedunculated leiomyoma.

**Diagnosis**

Cystic degeneration of a pedunculated uterine leiomyoma

**Summary**

Cystic adnexal masses are commonly found on pelvic ultrasound examinations. Because most adnexal masses arise from the ovaries, pelvic cystic lesions that are not of ovarian origin may not routinely be considered in the differential diagnosis. Uterine masses that may present as cystic adnexal masses include a pedunculated leiomyoma with cystic degeneration, cystic adenomyosis, and a unicornuate uterus with a rudimentary obstructed horn. Although cystic degeneration of uterine fibroids is relatively uncommon, the presence of flow signal on color or power Doppler ultrasound or curvilinear continuous flow voids on MRI in a pedicle bridging the mass and the myometrium suggests a uterine origin of these exophytic lesions, as in this case. This is known as the bridging vessel sign.

**References**

Posterior Tibialis Tendinopathy

A 43-year-old woman presented to her primary care physician with medial ankle pain of several weeks. Ankle radiograph revealed an accessory navicular bone (arrow, A). After conservative measures failed to alleviate her pain, she underwent an ankle MRI, which revealed bone marrow edema in the accessory navicular bone (arrow, B) and increased posterior tibialis tendon diameter (arrow, C). These findings are consistent with posterior tibialis tendinopathy.1

Posterior tibialis tendon dysfunction is the most common cause of acquired flatfoot deformity in adults. It typically occurs in overweight, middle-aged women. Additional risk factors include diabetes, hypertension, obesity, rheumatoid arthritis, seronegative spondyloarthopathies, and prior local steroid injections. Importantly, posterior tibialis tendinopathy is strongly associated with accessory navicular bones, which are more common in women. Specifically, women are twice as likely as men to present with increased posterior tibialis tendon sheath fluid.2

Pseudoarthrosis between the navicular bone and accessory ossicle predisposes individuals to reactive changes in the posterior tibialis tendon and tendon sheath. The resulting posterior tibialis tendon dysfunction can lead to chronic ankle pain and acquired flatfoot deformity.

References

Hydrocele of the Canal of Nuck

A 23-year-old woman presented with a palpable lump in her right groin. Physical examination revealed a 3-4 cm fluctuant soft-tissue mass. Targeted sonographic examination revealed an area of fenestration (arrow, A) in the anterior abdominal wall with a small collection of adjacent complex fluid (arrows, B). A computed tomography (CT) scan demonstrated a small, nodular soft-tissue density contiguous with the anteroinferior margin of the right inguinal ligament (arrows, C and D).

The canal of Nuck represents an abnormal evagination of parietal peritoneum into the inguinal canal. During fetal development, the gubernaculum (precursor to the round and ovarian ligaments) attaches to the fetal gonad superiorly and to the skin of the groin inferiorly. A fold of peritoneum called the processes vaginalis forms along the gubernaculum and protrudes into the inguinal canal, creating the canal of Nuck, which normally obliterates. Rarely, the canal persists and can accumulate peritoneal fluid, resulting in a hydrocele. Most hydroceles typically present as a painless, irreducible mass in the inguinolabial region. Since some may communicate with the peritoneal cavity, and many coexist with an inguinal hernia, Valsalva maneuver cannot reliably distinguish a hernia from a hydrocele. Ultrasound findings of a hydrocele of the canal of Nuck include an anechoic or hypoechoic cystic structure in the inguinal region without internal vascularity on color Doppler. Absence of bowel or omentum can help differentiate a hydrocele from an inguinal hernia. A hydrocele of the canal of Nuck is an uncommon entity, which should be included with more common differential diagnoses of groin swelling, such as an inguinal hernia.

References