RadioGraphics

US of the Ovary and Adnexa: To Worry or Not to Worry?[1]

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CME FEATURE

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LEARNING OBJECTIVES FOR TEST 2

After completing this journal-based CME activity, participants will be able to:

- List three US features of the most commonly encountered benign ovarian lesions.
- Identify three pelvic US findings that are worrisome for malignancy.
- Describe three pelvic US findings that indicate follow-up US should be performed in lieu of surgical intervention.

INVITED COMMENTARY

See discussion on this article by Goldstein (pp 1640–1642).

TEACHING POINTS

See last page

Ultrasonography (US) is typically the first study to be requested in patients with clinical findings that may suggest pelvic disease. The evaluation of adnexal masses is a common component of the sonologist's workload, and US has been shown to be accurate for both detecting and characterizing these masses, most of which are either insignificant or benign and therefore require little or no follow-up. Recognition of the most common benign ovarian and extraovarian adnexal masses should help avoid additional or unnecessary imaging. US features that suggest malignancy include thick septations, vascularized solid components, or areas of focal wall thickening, and identifying these features will result in timely management. Indeterminate-appearing masses demonstrate atypical features and cannot easily be classified as definitely either benign or malignant. Proper reporting and management recommendations serve to alleviate both patient anxiety and physician misinterpretation. Knowledge of these recommendations and of the characteristic US features of benign, malignant, and indeterminate adnexal masses can serve as important guidelines for patient management.

Introduction

In most patients with clinical findings that may suggest pelvic disease, ultrasonography (US) is typically requested for further evaluation. This modality is noninvasive and has been shown to be highly accurate for both detecting and characterizing adnexal masses (1–5). Fortunately, because so many adnexal processes are either clinically insignificant or benign, when they are asymptomatic they can often be followed up with serial US or even ignored. In a few cases, additional imaging with magnetic resonance (MR) imaging or occasionally computed tomography (CT) may be indicated. As a result of this evolving approach, surgical intervention is no longer commonly used for diagnosis, but rather is most often reserved for therapeutic purposes.

In this article, we describe a practical US approach to evaluation of the female pelvis that will allow the radiologist to *(a)* optimize US imaging techniques to recognize ovarian mimics and allow confident visualization of the ovary; *(b)* recognize US features that characterize the "Big Six" ovarian entities, which are those most often seen in a general US laboratory; *(c)* recognize US features that often characterize

Abbreviations: BI-RADS = Breast Imaging Reporting and Data System, GI-RADS = Gynecology Imaging Reporting and Data System, PCOM = polycystic ovarian morphology, PCOS = polycystic ovarian syndrome, PIC = peritoneal inclusion cyst, SRU = Society of Radiologists in Ultrasound

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three other commonly seen extraovarian pelvic cystic lesions; *(d)* recognize US features of cysts that are indeterminate but most likely benign, as well as US findings that are worrisome for malignancy; and *(e)* generate a report that provides clinically meaningful information with respect to diagnosis and follow-up.

Initial Considerations

Before a pelvic US examination is begun, relevant clinical information should be obtained, including the indication for the study, findings from any available prior imaging studies, and laboratory results. It is also helpful to determine the date of the patient's last menstrual period and to inquire if the patient is on hormonal therapy, in the form of either birth control or (in postmenopausal patients) hormonal replacement therapy.

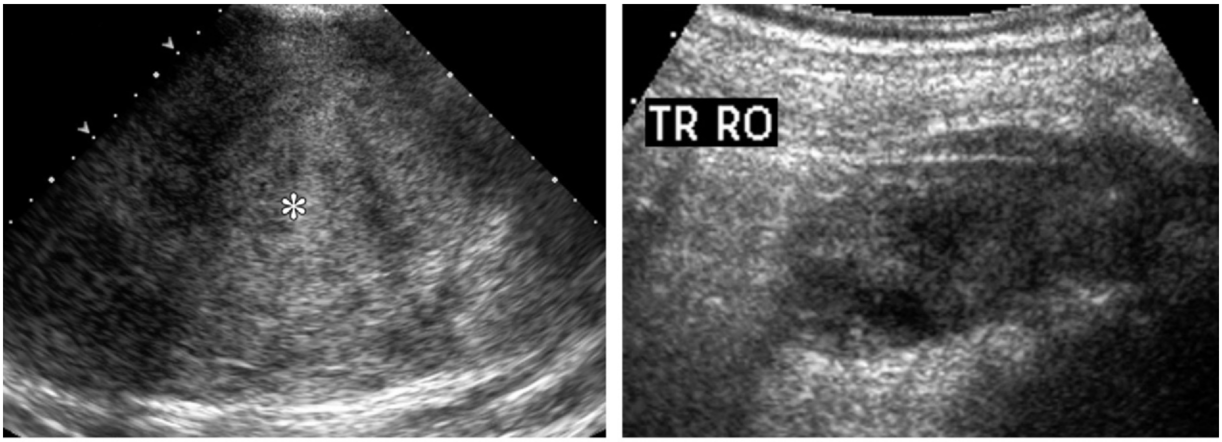
Unless the study is a follow-up examination, it is usually beneficial to begin with a quick transabdominal overview of the pelvis. The position and size of the uterus should be documented, and any visible adnexal disease should be evaluated. In the interest of improving both patient throughput and patient comfort, distending the urinary bladder is no longer considered necessary and is not routinely done (6).

Transvaginal images should be obtained when the patient's urinary bladder is empty; the transducer frequency should be at least 5 MHz, and harmonic imaging should be used if deemed beneficial. Although various approaches can be used to locate the ovary, we prefer to start our search by imaging in the coronal plane at the level of the uterine fundus. With use of mild to moderate pressure, the transducer is gradually angled toward one of the adnexa. Often, there is visible thickening of soft tissues that are in continuity with the uterine fundus, likely representing a combination of the fallopian tube, mesosalpinx, and ovarian ligament. This tissue serves as a useful anatomic landmark that can be followed as it leads toward the ovary. In most pre- and postmenopausal women, the ovaries are located immediately adjacent to the internal iliac vessels. In multiparous women, as well as in those with uterine or ovarian masses, the position of the ovaries is more variable. If overlying bowel precludes their visualization, either the sonographer or the patient can place a hand over the region of the ovary and apply mild to moderate compression. Once the ovary is identified, images should document its appearance in both coronal and sagittal planes. Ideally, video clips should be used to show the ovary in its entirety. Although some US laboratories routinely document both arterial and venous flow in each ovary, doing so should be optional when the ovary appears normal. If the ovary is not seen transvaginally, a second attempt should be made to locate it using a transabdominal approach. This is especially important if there is a large uterine fibroid or other space-occupying pelvic mass. In such cases, the ovary is often displaced into a superolateral superficial position. We prefer to attempt localization using a curved-array transducer of at least 6 MHz in conjunction with harmonic imaging (Fig 1). If the patient is obese, it may be helpful to ask her to assist by placing her hands on the soft tissues of the lower pelvis and applying gentle traction in a superior direction.

Possible Mimics

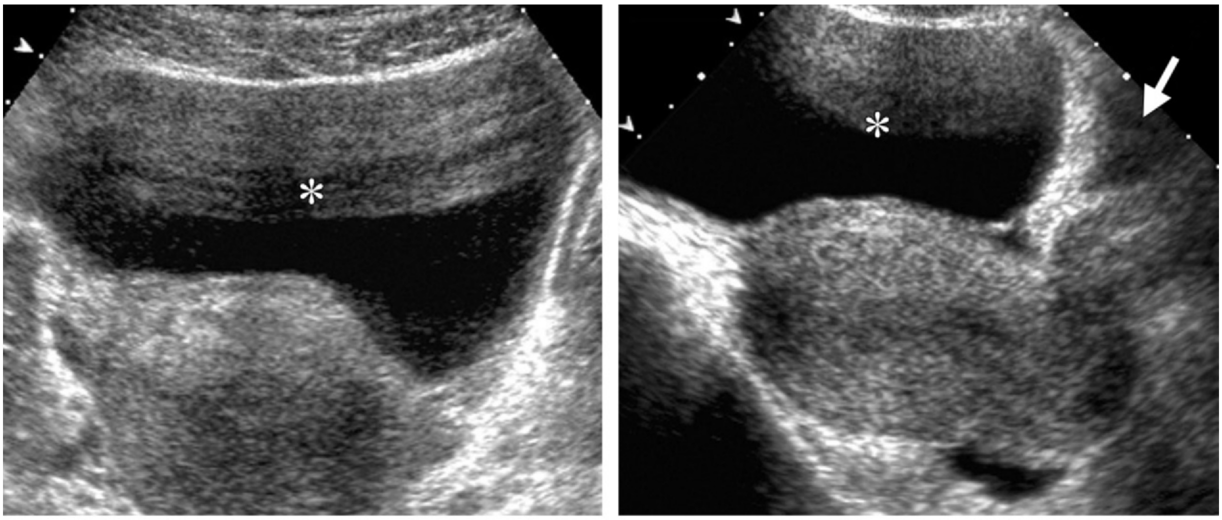
Occasionally, a large simple pelvic cyst can have an atypical configuration and can even mimic the appearance of a distended urinary bladder (Fig 2). In these cases, the clinical history of a palpable mass and patient denial of a full bladder should provide tips that further investigation is necessary. The easiest way to solve this dilemma is to determine the location of the bladder by slowly advancing a vaginal transducer beyond the introitus and observing the urethra and the point at which it enters the bladder base (Fig 2c). A Foley catheter can also be used to determine bladder location, but this approach is not recommended, since it is invasive and is relatively uncomfortable.

On static images, several anatomic structures can mimic a normal-appearing ovary, including bowel, blood vessels, and small subserosal fibroids (Fig 3). To avoid misinterpretation, close attention to detail is required during the real-time transvaginal examination. When transducer pressure is applied over the presumed ovary, bowel will compress and often demonstrates peristalsis. Vessels (typically engorged veins) will also compress and show slowly moving internal echoes when the gain setting is increased, or demonstrate color with low-flow adjustments to Doppler settings. A subserosal fibroid can be suggested when a "push-pull" maneuver of the transducer is gently and repeatedly applied over the presumed ovary, and the fibroid remains fixed to the uterine surface during this maneuver. Occasionally, to convincingly demonstrate that the subserosal



a. b.

Figure 1. Displaced ovary. **(a)** Sagittal transabdominal US image shows the uterus (*), which is enlarged and heterogeneous due to fibroids. **(b)** On a transverse transabdominal US image obtained with a 6-MHz curved-array transducer and harmonic imaging, the right ovary is displaced superior and lateral to the uterus in a superficial location. The left ovary (not shown) was similarly located.



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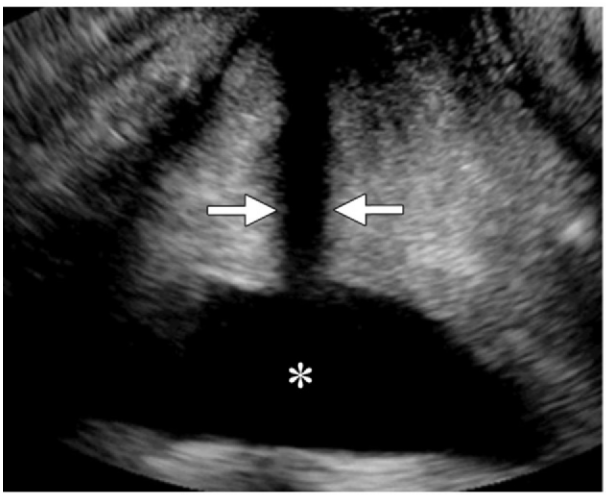

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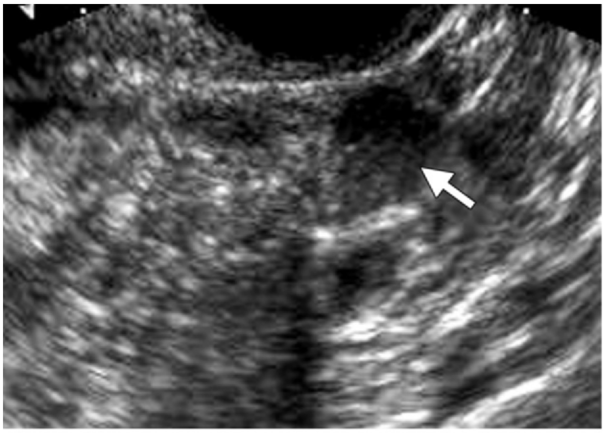
Figure 2. Pelvic cyst mimicking the bladder. **(a)** Transverse transabdominal US image of the pelvis demonstrates a cystic structure (*) anterior to the uterus that was originally misidentified as the bladder. **(b)** Sagittal transabdominal US image shows the same cystic structure (*) in the expected location of the bladder. A portion of the bladder (arrow) is seen caudad to the cyst. **(c)** Sagittal transvaginal US image obtained with the transducer placed just beyond the introitus demonstrates the urethra (arrows) and the point at which it enters the bladder base (*), findings that allow confident identification of the bladder.



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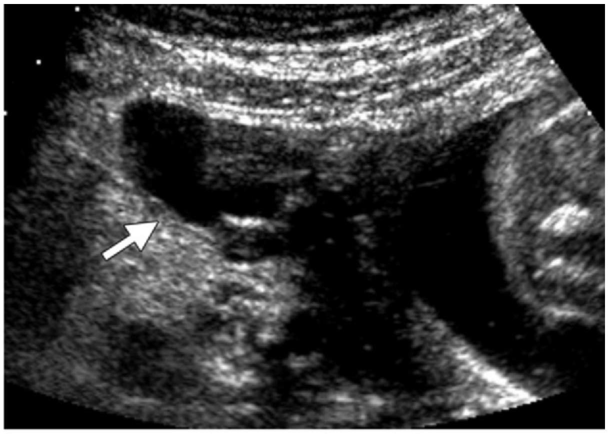

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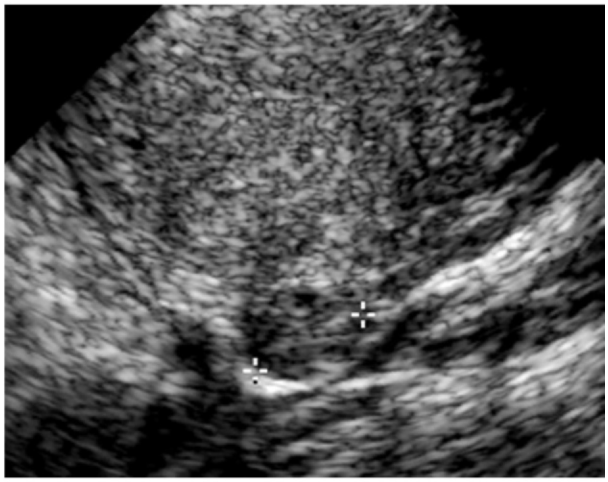
Figure 3. Ovarian mimics. **(a)** Coronal transvaginal US image of the left adnexa shows a well-defined hypoechoic structure (arrow) that appears similar to the left ovary but demonstrates peristalsis in real time, a finding compatible with bowel. **(b)** Transverse transabdominal US image of the right adnexa in a different patient demonstrates a cystic structure (arrow) that appears similar to the right ovary. Doppler US demonstrated flow due to prominent blood vessels mimicking follicles. **(c)** Coronal transvaginal US image obtained in a third patient demonstrates a well-defined structure (calipers) posterior to the uterus that appears similar to the left ovary. Gentle compression with the transducer revealed a fixed attachment to the uterus, thereby confirming the diagnosis of a subserosal fibroid.



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fibroid or “pseudo-ovary” is inseparable from the uterus, a bimanual US examination can be performed; this is done with the examiner’s hand palpating the overlying abdominal soft tissues while the transducer push-pull maneuver is applied over the presumed ovary.

Extraovarian cystic lesions, including a paratubal cyst, hydrosalpinx, or peritoneal inclusion cyst (PIC), can also sometimes create a diagnostic dilemma. Identifying a separate ipsilateral ovary is the simplest and most effective way to resolve this issue. Anatomic shape and configuration, as well as patient history, can also be helpful. In cases in which the mass is large or a separate ovary is not visible, additional cross-sectional imaging may be necessary.

Ovarian Lesions: Pattern Recognition of the Big Six

A variety of US approaches have been used to evaluate and characterize ovarian masses. These range from sophisticated analyses using statistically derived scoring systems, probability-based logistic regression analysis, and mathematically derived neural networks (7) to a much simpler subjective method that makes use of a pattern recognition approach (1,3–5). Studies verify that subjective evaluation of the ovary, when done by experienced examiners, is at least as good as if not superior to other methods for accurately analyzing ovarian and adnexal masses, with a sensitivity of 88%–100% and a specificity of 62%–96% for predicting malignancy (5,8,9). Obviously, any mass with findings suggestive of malignancy must be identified and distinguished from masses with benign features. Fortunately, in most clinical practices, the overwhelming majority of ovarian masses are benign, are easily recognizable, and can be classified as one of six entities. Known as the Big Six, these entities include physiologic and functioning follicles, corpora lutea, hemorrhagic cysts, endometriomas, polycystic ovaries, and benign cystic teratomas (dermoids).

Physiologic and Functioning Follicles

In healthy premenopausal women whose ovaries are not hormonally suppressed, monthly dynamic changes initially occur due to preovulatory devel-

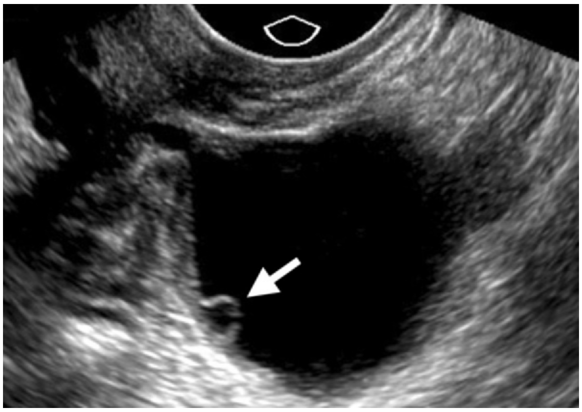
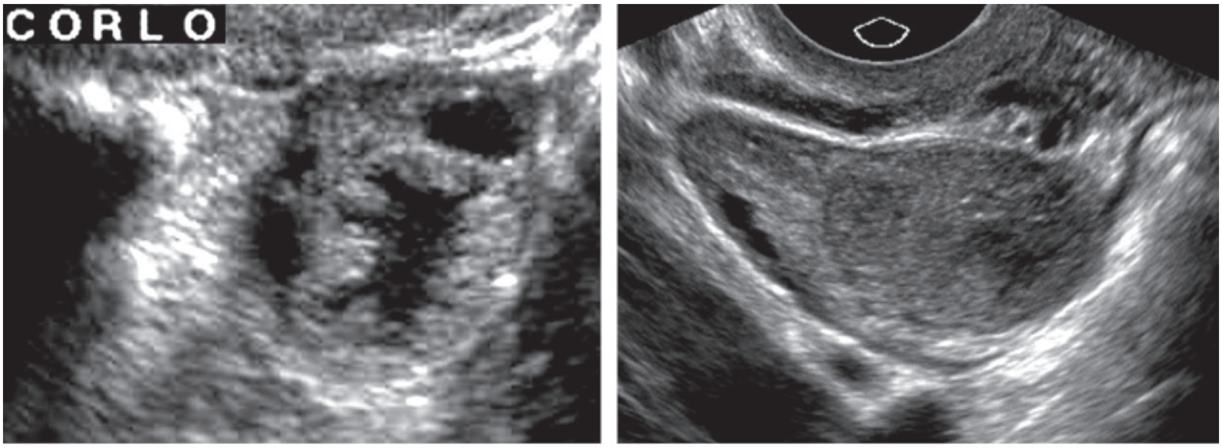


Figure 4. Mature follicle. Coronal transvaginal US image of the left ovary demonstrates a simple cyst with a peripheral curved structure (arrow) that represents the cumulus oophorus. This finding should not be mistaken for a septum in a complex cyst.



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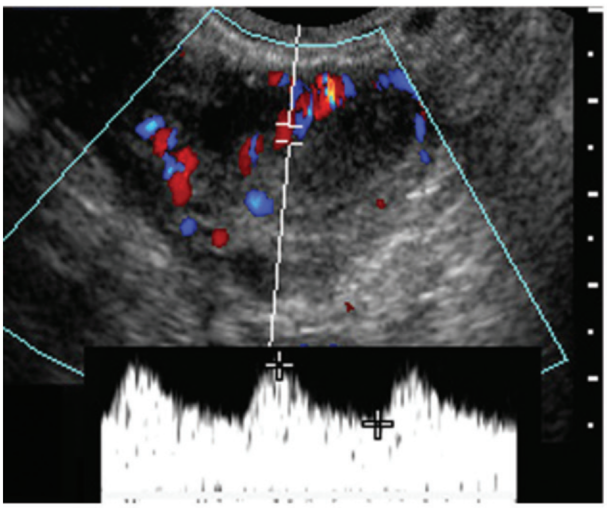

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Figure 5. Corpus luteum cysts. **(a)** Coronal transvaginal US image of the left ovary demonstrates a postovulatory corpus luteum with a thick irregular wall. **(b)** Sagittal transvaginal US image of the ovary in a different patient demonstrates a collapsed corpus luteum with a more solid appearance. **(c)** Coronal transvaginal duplex US image of the left ovary in a third patient demonstrates peripheral flow with a low-resistance waveform.

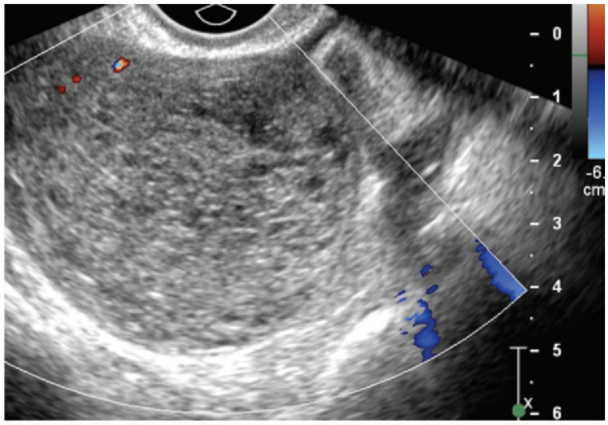
Teaching Point

opment of a dominant follicle. During this phase of the cycle (variably referred to as the follicular, proliferative, or preovulatory phase), transvaginal US depicts a developing follicle as a thin-walled, round to oval, avascular simple-appearing cyst. At ovulation, its diameter ranges from 1.7 to 2.8 cm (10,11), but a diameter of up to and including 3.0 cm is considered normal (12). Immediately before ovulation, a tiny peripheral curved line may be visible, which indicates that the ovum is surrounded by a cumulus oophorus within the mature follicle (Fig 4). A functional follicle develops when ovulation fails to occur, and the follicle continues to enlarge but remains simple in its US appearance.

Corpora Lutea

A postovulatory corpus luteum can also measure up to 3.0 cm, but its gray-scale appearance is more varied and ranges from a thick-walled cyst with an irregular crenulated margin, to a cyst that appears more collapsed, giving it a relatively solid appearance. In all cases, however, Doppler US demonstrates prominent peripheral blood flow with a low-resistance waveform (Fig 5). Typically, physiologic cysts resolve within a few weeks.

Figure 6. Hemorrhagic cysts. **(a)** Coronal transvaginal color Doppler US image of the ovary demonstrates echogenic, avascular, heterogeneous nonshadowing material compatible with acute blood clot. **(b)** Coronal transvaginal color Doppler US image of the right ovary in a different patient demonstrates a cyst with a solid-appearing mural nodule. The nodule is avascular with concave edges, findings that are characteristic of a retracting clot. At real-time imaging, the clot, which was relatively soft, "jiggled" with transducer ballottement. **(c)** Sagittal transvaginal color Doppler US image of the left ovary in a third patient demonstrates a cystic structure with avascular irregular fine linear echoes that represent fibrin strands in a resolving hemorrhagic cyst.



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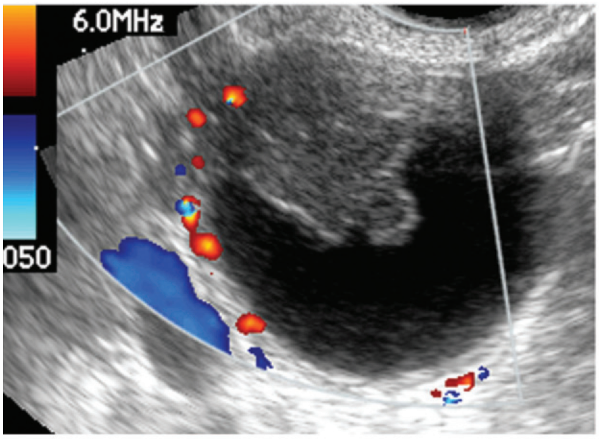

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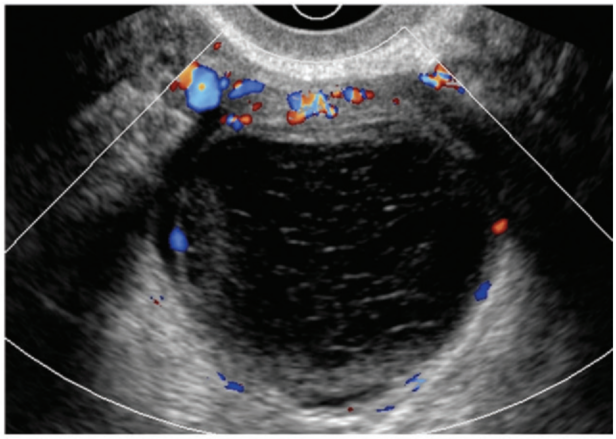

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A functioning corpus luteum develops when the corpus luteum fails to resorb following ovulation. It, too, often enlarges, and, given its inherent vascular wall, it often evolves into a hemorrhagic cyst.

Clinically, functioning follicles and corpora lutea are often asymptomatic, typically resolving in 8–12 weeks. If large, however, they can cause pressure effects or pain, and if significant hemorrhage, cyst leakage, rupture, or torsion occurs, acute symptoms develop.

Hemorrhagic Cysts

Hemorrhagic cysts typically develop in premenopausal women and are due to hemorrhage within a corpus luteum. Their US appearances are well described in the literature (13) and vary depending on whether it is an acute or a resolving process. Given that hemorrhage is common, resolves, and is not associated with malignant neoplasms (4,14,15), it is imperative to recognize the characteristic US features of hemorrhagic cysts. Acutely, a hemorrhagic ovarian cyst contains clotted blood, which at US manifests as intensely echogenic, avascular, homogeneous or heterogeneous nonshadowing material (Fig 6a). The ovary is often tender to transducer palpation, and echogenic free fluid may be present if blood is leaking into the pelvis. In its subacute state, the clot may retract, remain avascular, and pull away from the cyst wall; its surface is often undulating (Fig 6b), and it has a characteristic concave contour. Importantly, since clot is relatively soft and gelatinous, it will jiggle with transducer ballottement. In contrast, a neoplastic mural nodule is vascular and has a convex surface contour, and because it is firm, it will not jiggle with transducer ballottement. Another very common feature that heralds the diagnosis of a resolving hemorrhagic cyst is the presence of US findings that are consistent with fibrin strands (Fig 6c). A variety of descriptive adjectives can be used effectively to report the appearance of this avascular material. Acceptable terms include "cobweb," "reticular," "lacy," "fishnet," and "spongy," each of which "paints a picture" of somewhat irregular fine lines that typically do not completely traverse the cyst. In contrast, the word *septation* should be avoided, since it implies thicker, often vascularized, more substantial linear echoes that typically traverse the entire cyst and are associated with a neoplasm. An ovarian cyst that demonstrates classic features consisting of fibrin strands, no septa-

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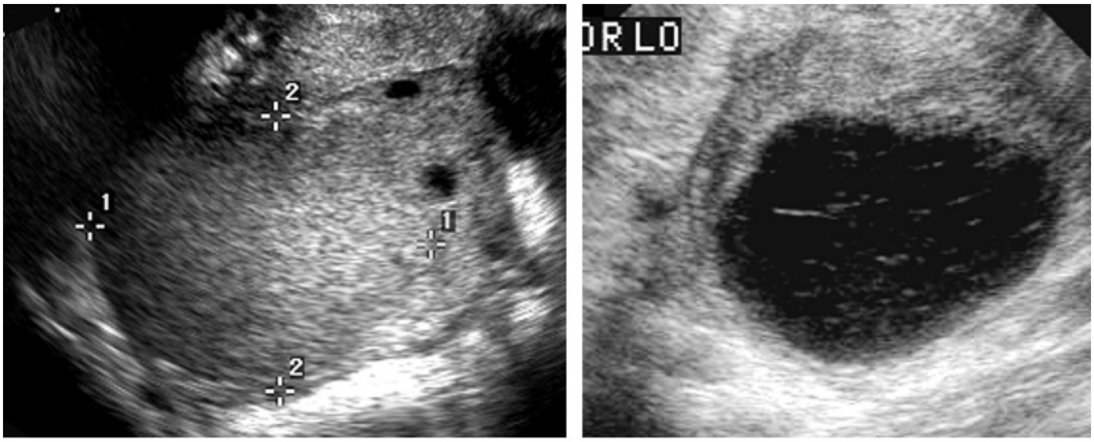


a. b.

Figure 7. Endometriomas. **(a)** Coronal transvaginal US image of the right ovary demonstrates a homogeneous structure (calipers) with low-level echoes, a finding that is characteristic of an endometrioma. **(b)** Coronal transvaginal US image of the left ovary in a different patient demonstrates a cystic structure containing fine linear echoes similar to those seen in a hemorrhagic cyst. The cystic structure proved to be an endometrioma.

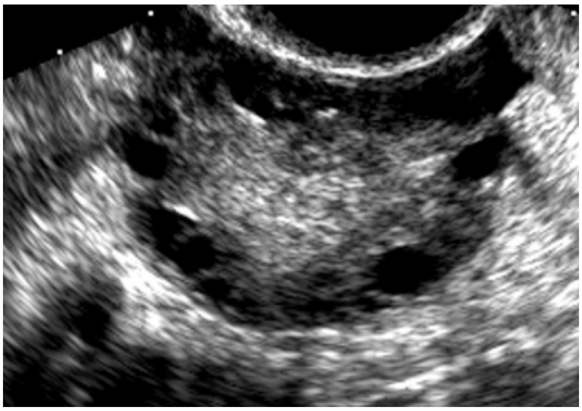


Figure 8. Polycystic ovary in a 35-year-old woman with amenorrhea and hyperandrogenism. Sagittal transvaginal US image demonstrates the right ovary with multiple (~20) follicles, each measuring less than 9 mm in diameter.

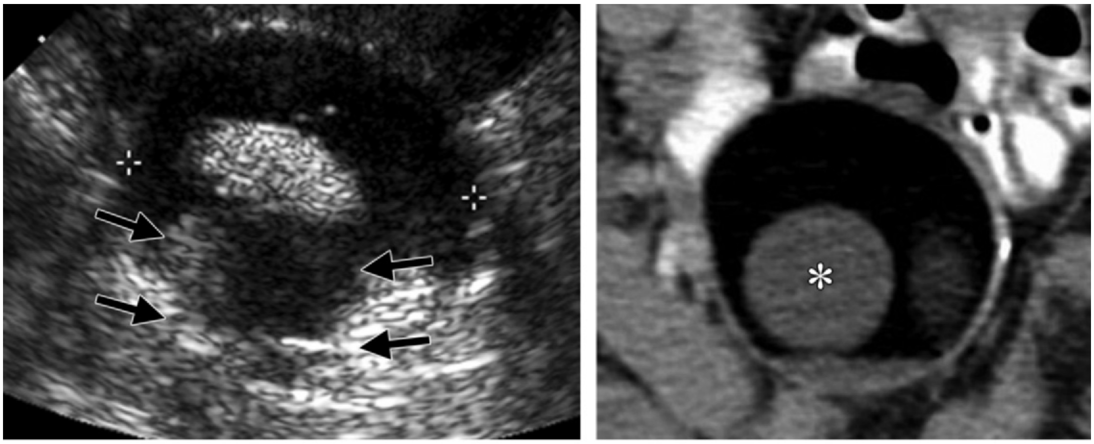
tions, and a smooth wall has been shown to be a hemorrhagic cyst with a likelihood ratio of 200, a sensitivity of 90%, and a specificity of 100% (13).

Endometriomas

The ovary is the most common site for extrauterine endometrial tissue deposition, and most endometriomas have a characteristic US "signature." This signature consists of a well-defined, smooth-walled uni- or multiloculated cyst that contains homogeneous low-level echoes, which impart a characteristic "ground-glass" appearance (Fig 7a) (16). In approximately 15% of cases, however, atypical findings may be visible (1,16–18), including mural irregularities, which are usually avascular and are likely due to adherent mural clot or fibrin. Rarely, endometriomas may have flow due to the presence of endometrial tissue (3); thus, it is not surprising that occasionally the appearance of an endometrioma can overlap with that of other conditions, including hemorrhagic cyst (Fig 7b), dermoid, and even ovarian carcinoma (4). Furthermore, malignant transformation to endometrioid or clear cell carcinoma has been reported in approximately 1% of endometriomas (19); this typically occurs with endometriomas larger than 9 cm and in women over 45 years of age (20).

Polycystic Ovaries

Polycystic ovarian morphology (PCOM) is one of the features used to evaluate women who present with clinical and endocrinologic dysfunction consistent with polycystic ovarian syndrome (PCOS). Extraovarian aspects of this condition vary considerably but classically include menstrual disturbances (oligo- or amenorrhea), obesity, and hyperandrogenism. Because of the varied clinical presentation, the definition of what actually constitutes PCOS has been debated, but most authorities agree that ovarian dysfunction is central to the diagnosis (21). Accordingly, in 2003 a consensus report was published that included the following description of morphologic ovarian changes consistent with PCOM: An involved ovary should demonstrate 12 or more follicles measuring 2–9 mm in diameter (Fig 8), increased ovarian volume (>10 cm^3), or both. Neither the distribution of



a. b.

Figure 9. Mature cystic teratoma (dermoid) in a 28-year-old woman in whom an asymptomatic right pelvic mass was palpated at routine physical examination. **(a)** Transverse transabdominal US image of the right ovary demonstrates a cystic structure (calipers) with a focal hyperechoic component that gradually attenuates sound (arrows). **(b)** Pelvic CT scan shows an adnexal cystic structure containing peripheral fat and a central nodule (*) that corresponds to the echogenic nodule seen in **a**.

follicles nor the appearance of the stroma was included in this definition (21). In part because this ovarian morphology is common, especially in adolescent girls without menstrual dysfunction or hyperandrogenism, questions were raised as to what criteria should constitute PCOM (22,23). Recently, a follow-up consensus statement was published that suggested the number of follicles used to suggest PCOM should be increased from 12 to a threshold of 19, since smaller follicles can now be visualized with the improved US technology (24).

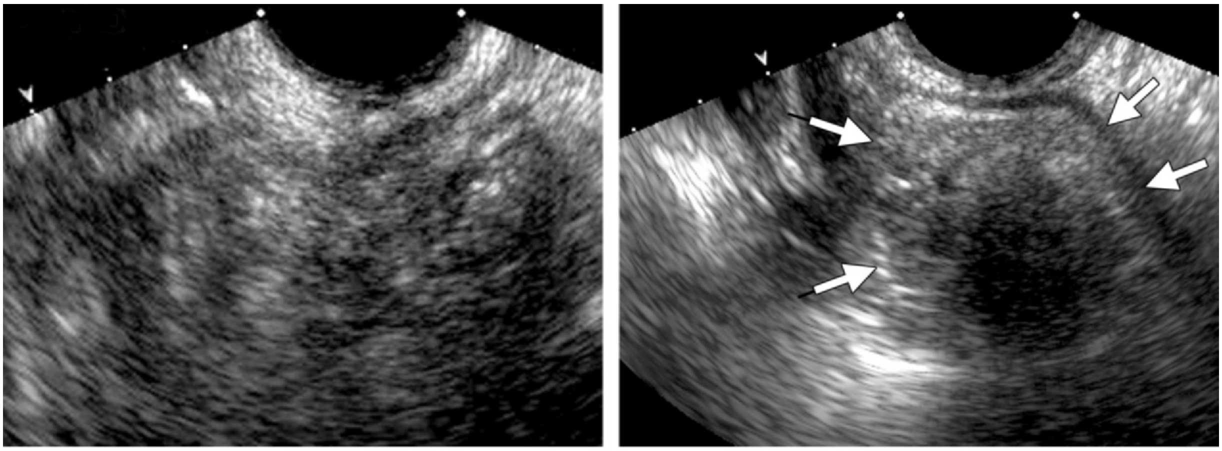
The management of women in whom PCOM is visible at US depends on whether the accompanying clinical and endocrinologic manifestations are consistent with PCOS.

Mature Cystic Teratomas

Mature cystic teratomas (dermoids) are common benign avascular ovarian neoplasms with a variety of characteristic US features, which in most cases may be used to make a confident and accurate diagnosis (25). Most dermoids contain a clump of hair, which both absorbs and reflects sound at US. The net effect is a focal hyperechogenic area that gradually attenuates sound and results in a characteristic gradual acoustic shadow (Fig 9). Another prominent histologic component is sebum, which at body temperature is often in a liquefied state and manifests at US as fluid with variable internal echoes (26). If the "hair ball" floats in the sebum, US findings can be subtle, and the appearance has been called the "tip of the iceberg" sign (27). This results in prominent acoustic shadowing that closely mimics the sound attenuation seen with bowel (Fig 10a). In questionable cases, especially if there is a clinically palpable mass and the ovary is not seen, the transducer can be used for ballottement of the suspect region in an effort to see if it moves as a cohesive focal mass (bowel should compress and demonstrate peristalsis) (Fig 10b).

Teaching Point

Occasionally, hair in a dermoid disperses into the surrounding fluid. At US, this is seen as bright, undulating, hyperechoic fine lines and dots and has been termed the "dermoid mesh" sign (Fig 11) (28). Although this finding can mimic fibrin strands associated with an evolving hemorrhagic cyst, careful scrutiny often reveals additional characteristic findings such as gradual acoustic shadowing, which permits an accurate diagnosis. To determine the ability of US to help detect the various characteristic features that can be used to diagnose a dermoid, a study was



a. b.

Figure 10. Dermoid with the tip of the iceberg sign in a 35-year-old woman with a palpable right adnexal mass and a nonvisualized right ovary. **(a)** Coronal transvaginal US image of the right adnexa shows nondescript shadowing echogenic material but no defined mass, findings that could represent bowel. **(b)** Coronal transvaginal US image obtained with compression of the region with the transducer shows a cohesive mass (arrows) with gradual acoustic shadowing, findings that are characteristic of a dermoid.

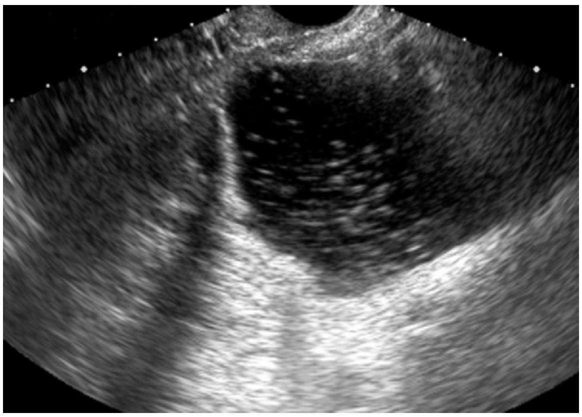


Figure 11. Dermoid mesh sign in a 42-year-old woman with a palpable left adnexal mass and mild tenderness. Sagittal transvaginal US image of the left ovary demonstrates a cystic structure containing hyperechoic lines and dots representing hair in a dermoid that has dispersed into the surrounding fluid. Other images revealed characteristic findings of a dermoid, including an echogenic mass with gradual acoustic shadowing.

conducted that analyzed more than 250 adnexal masses (including 74 dermoids). In 74% of the dermoids, at least two characteristic features were detected, allowing experienced sonologists to make the correct diagnosis with a positive predictive value of 100% (25).

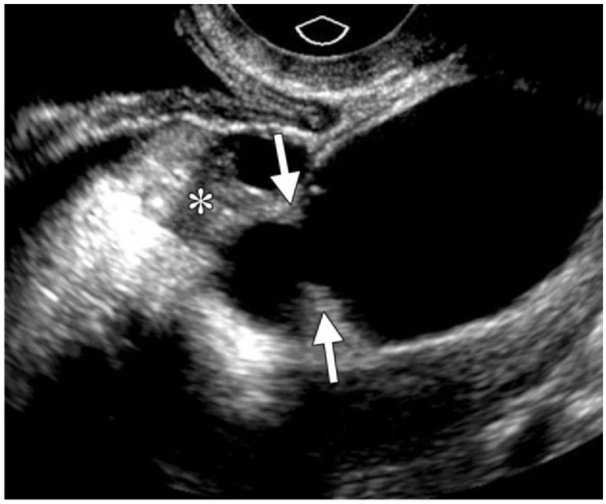
Extraovarian Lesions: Three Common and Recognizable Entities

Although most adnexal masses originate in the ovary, the surrounding tissues should also be examined to detect extraovarian lesions. Common and recognizable extraovarian lesions include hydrosalpinges, paraovarian cysts, and PICs. These are typically benign entities, and the correct diagnosis can often be made on the basis of characteristic US findings. In some cases, patient history can also provide etiologic clues.

Hydrosalpinges

Findings that help differentiate a hydrosalpinx from other adnexal masses include an elongated tubular mass with indentations of its opposing walls (“waist” sign) (Fig 12a) (29). Another common finding is an incomplete septation, likely due to infolding of the tube on itself (Fig 12b) (30). Wall changes can also be used to help differentiate acute from chronic disease: A thick wall with a “cogwheel” appearance is common with acute inflammation, whereas small mural nodules akin to the appearance of beads on a string suggest chronic dilatation (Fig 12c) (30). Entities that may mimic a hydrosalpinx include distended

Figure 12. Hydrosalpinges. **(a)** Sagittal transvaginal US image of the left ovary (*) shows an adjacent elongated cyst with indentations of its opposing walls (arrows), findings that represent the waist sign seen with hydrosalpinx. **(b)** Sagittal transvaginal US image of the left adnexa in a different patient demonstrates a convoluted tubular structure adjacent to but separate from the left ovary (*). The structure contains incomplete internal septations due to infolding of the tube on itself and represents a fallopian tube. **(c)** Coronal transvaginal US image of the left adnexa in a third patient demonstrates a dilated left fallopian tube (calipers) that is folded in on itself and contains tiny mural nodules (arrows) representing endosalpingeal folds within a chronically dilated tube. When the tube is less dilated and thickened, the folds are more prominent, creating a cogwheel appearance.



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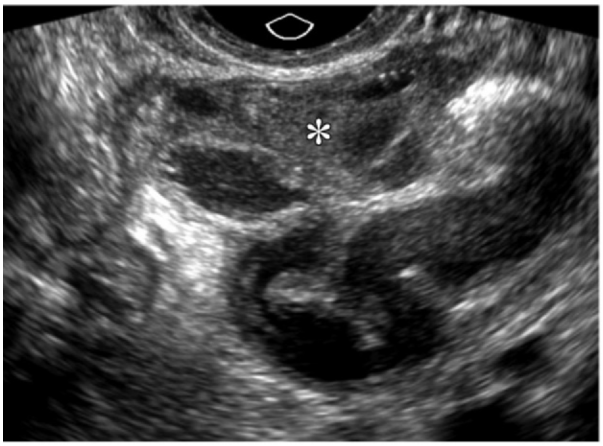

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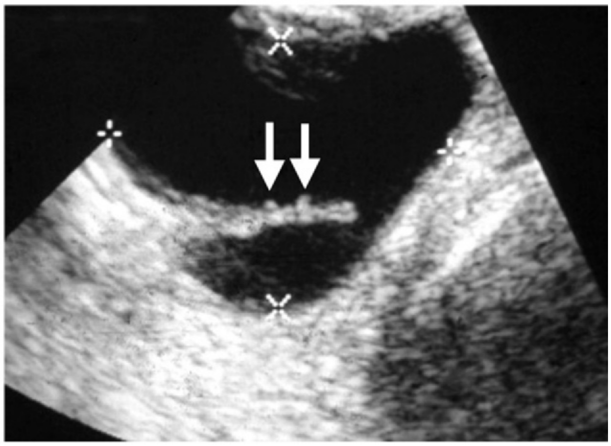

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tortuous veins and bowel; increasing the gain settings to look for slow flow and using transducer compression are usually effective in differentiating these entities from a hydrosalpinx.

Paraovarian Cysts

Paraovarian cysts are congenital remnants that arise from the wölffian duct in the mesovarium. They vary greatly in size and are reported to account for 10%–20% of adnexal masses (31). Paraovarian cysts are typically round to oval, simple in appearance, and abut but do not distort the adjacent ovary (Fig 13). Occasionally, however, they can indent the ovary and mimic an exophytic ovarian cyst; in such cases, a transvaginal transducer can be used to apply pressure and separate these two contiguous structures (Fig 14). The key to making the diagnosis is to identify the ipsilateral ovary as a separate structure. In a study of 42 patients with surgically proved paraovarian cysts who were imaged transabdominally, the ovary was detected 76% of the time, and the paraovarian cyst had an average size of 8 cm (31). Given that transvaginal imaging is currently the preferred technique, many more ovaries and smaller paraovarian cysts can now be identified.

Peritoneal Inclusion Cysts

PICs represent a type of pseudocyst, with fluid accumulation entrapped by peritoneal adhesions. The fluid, which is produced by the ovary, occurs following an insult to the peritoneum; consequently, PICs are encountered in association with endometriosis, pelvic inflammatory disease, or prior surgery. PICs can be recognized on the basis of two key features.

Teaching Point

1. Lack of a wall. PICs typically have an irregular passive shape that conforms to and is defined by the contours of surrounding structures (Fig 15a).

2. Entrapment of the ovary either within or at the periphery of the fluid collection (Fig 15b) (32,33).

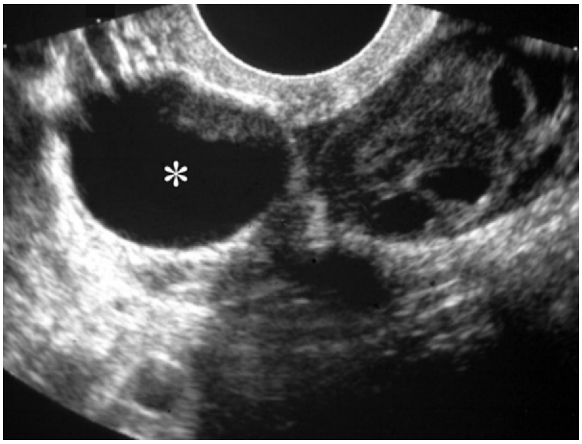
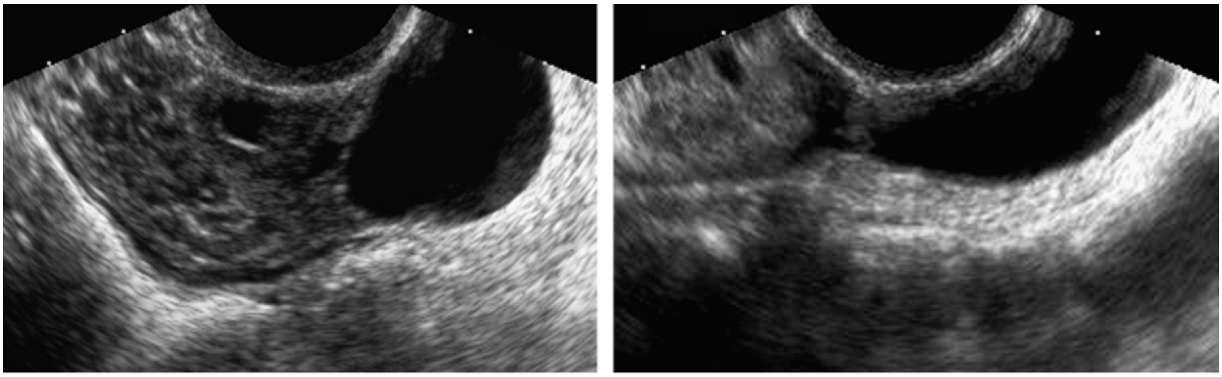
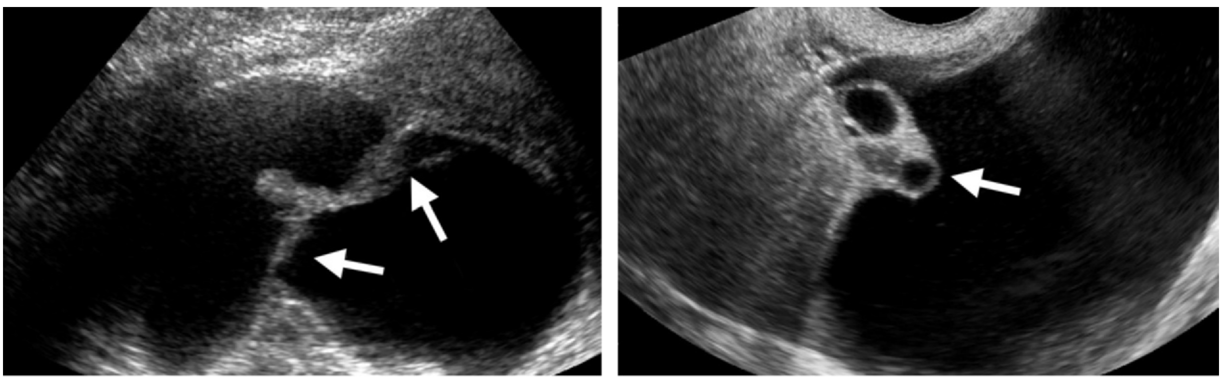


Figure 13. Incidentally discovered paraovarian cyst in a 23-year-old woman with irregular menses. Sagittal transvaginal US image of the left adnexa demonstrates a simple cyst (*) contiguous with, but clearly separate from, the ovary. Echoes in the near field of the cyst are due to reverberative artifact.



a. b.

Figure 14. Paraovarian cyst in a 28-year-old woman with vague right-sided discomfort. **(a)** Sagittal transvaginal US image of the right ovary demonstrates what appears to be an exophytic ovarian cyst. **(b)** On a sagittal transvaginal US image obtained as transducer pressure was applied to the right ovary at the level where the cyst and ovary merge, the two structures are separate and distinct, thereby allowing characterization of the cyst as paraovarian.



a. b.

Figure 15. PIC in a 42-year-old woman with a history of endometriosis. The patient underwent pelvic US for pain and bloating. **(a)** Oblique transabdominal US image of the left adnexa demonstrates a cystic structure that appears to conform to the surrounding structures. A peritoneal adhesion (arrows) is seen traversing the cyst. **(b)** Sagittal transvaginal US image of the left adnexa demonstrates the passive nature of the cystic structure, which surrounds or encases the left ovary (arrow).

If the adhesions within a PIC become thick and vascularized, a PIC may be misconstrued as an ovarian neoplasm. However, this error should not occur when there is an appropriate history and when the two aforementioned key features are present.

Reporting and Managing Typical-appearing Ovarian and Extraovarian Lesions

Given the pivotal role of US in evaluating pelvic masses, it is critical for the sonologist to accurately and succinctly describe relevant findings in the body of the report, and to then generate an impression that permits the clinician to appropriately manage the patient. With regard to the readily recognizable benign ovarian and extraovarian conditions described earlier, several groups have published criteria that can serve as management guidelines.

The American College of Radiology Appropriateness Criteria, in their updated 2009 report entitled "Clinically Suspected Adnexal Mass," concluded that physiologic cysts should resolve spontaneously in asymptomatic premenopausal women. Also, because benign-appearing simple cysts, endometriomas, dermoids, and hydrosalpinges (each <6 cm in diameter) remain unchanged during long-term follow-up, they should be managed with follow-up US rather than surgical intervention (34).

The following year, the Society of Radiologists in Ultrasound (SRU) published a detailed consensus statement that set forth specific management guidelines for asymptomatic ovarian and extraovarian masses imaged at US (12). A major concern was management of simple-appearing cysts that were not physiologic or functional. The panelists concurred with published findings that adnexal cysts up to 10 cm are highly likely to be benign (35–37), and that up to 84% of these lesions are histologically benign serous cystadenomas (38). Genetic analysis of this benign neoplasm reveals that it does not contain the mutational genes seen in its malignant counterpart. Therefore, the SRU group emphasized a less aggressive approach to this type of lesion in both pre- and postmenopausal women.

The four sections that follow summarize the conclusions reached by the SRU's panel of experts.

Guidelines for Premenopausal Women

1. Simple or hemorrhagic cysts 3 cm or less in size do not require follow-up and, at the discretion of the interpreting physician, may be omitted entirely from the report.

2. Simple or hemorrhagic cysts greater than 3 cm and less than or equal to 5 cm do not require follow-up but should be mentioned in the report.

3. Simple cysts greater than 5 cm and less than or equal to 7 cm should be followed up with US annually to ensure lesion stability.

4. Simple cysts greater than 7 cm should be the target of further imaging (eg, MR imaging) or surgical intervention.

5. Hemorrhagic cysts greater than 5 cm and less than or equal to 7 cm should undergo a 6–12-week follow-up US examination to ensure resolution.

Guidelines for Pre- or Postmenopausal Women

1. Classic-appearing endometriomas should undergo a 6–12-week follow-up US examination to ensure stability. This is because hemorrhagic cysts and endometriomas may share common US features. If an endometrioma is not surgically removed, follow-up US should be performed annually to ensure stability with respect to size and appearance.

2. Classic-appearing dermoids do not require additional imaging for confirmation, but they should be reevaluated with US at 6–12 months to ensure stability with respect to size and appearance. Subsequently, an annual US examination is recommended.

3. Classic-appearing hydrosalpinges and PICs do not require additional imaging or follow-up to confirm the diagnosis. Subsequent studies depend on the patient's age and clinical symptoms.

4. Paraovarian cysts are followed up with the same criteria that are used for premenopausal simple-appearing ovarian cysts.

Guidelines for Women in Early Menopause (1–5 Years after Last Menstrual Period)

Because ovulation may occasionally occur during early menopause, hemorrhagic cysts can occur. A classic-appearing hemorrhagic cyst should be described in the report, and follow-up US should be performed in 6–12 weeks to ensure resolution.

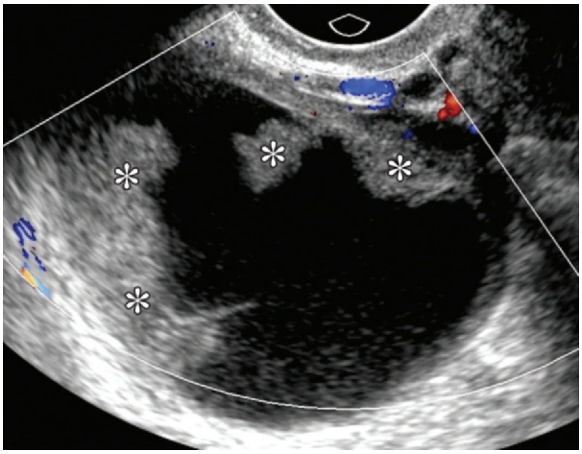


Figure 16. Atypical hemorrhagic cyst in a 27-year-old woman who presented to the emergency department with right lower quadrant pain. Coronal transvaginal color Doppler US image of the right adnexa demonstrates a cystic structure in the right ovary containing solid-appearing material that simulates malignant mural nodules (*); however, the nodules are avascular.

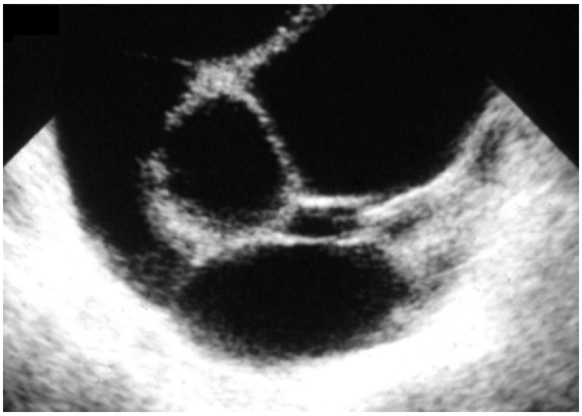


Figure 17. Atypical endometrioma in a 36-year-old woman who presented with right-sided pelvic pain. Coronal transvaginal US image of the right adnexa demonstrates a cystic structure with multiple thick irregular septations and some wall irregularity. Doppler US did not demonstrate flow within the septations. Surgery was performed, and pathologic analysis confirmed that the cystic structure was an endometrioma.

Guidelines for Postmenopausal Women (>5 Years after Last Menstrual Period)

1. Simple cysts less than or equal to 1 cm do not require follow-up and, at the discretion of the interpreting physician, may be omitted entirely from the report.

2. Simple cysts greater than 1 cm and less than or equal to 7 cm should be described in the report and should initially be imaged with US annually to ensure stability with respect to size and appearance. Once stability is documented, or if cyst size decreases, the follow-up interval may be lengthened. The report should emphasize that these are almost certainly benign lesions.

3. Simple cysts greater than 7 cm should be the target of further imaging (eg, MR imaging) or surgical intervention.

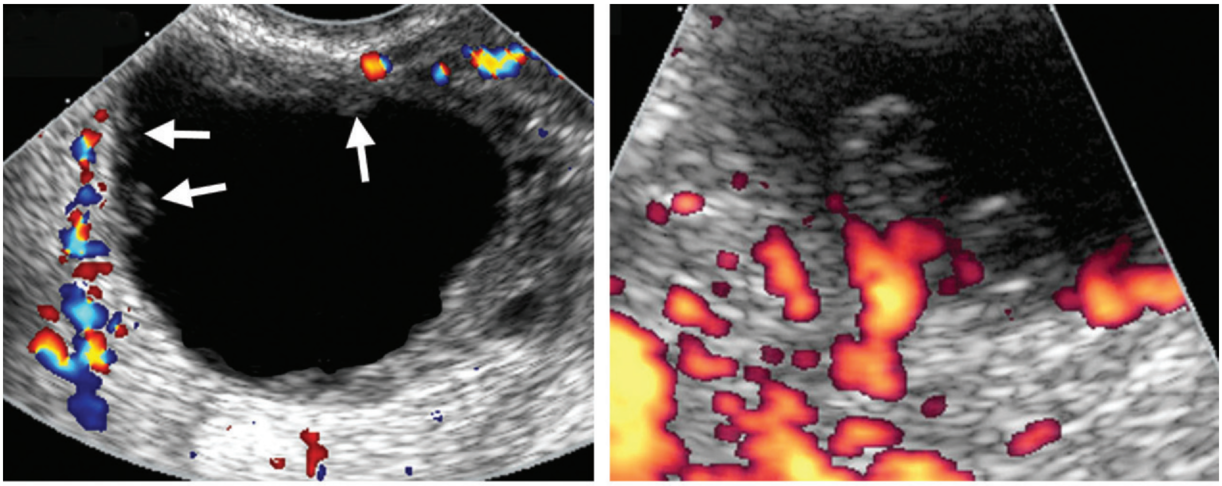
4. A hemorrhagic cyst should not occur, since the patient is anovulatory. Any cyst with this appearance is likely neoplastic, and surgery should be considered.

If CT was performed initially and the findings were classic for a follicle, corpus luteum, or mature cystic teratoma, US need not be performed (39–42).

Other Lesions

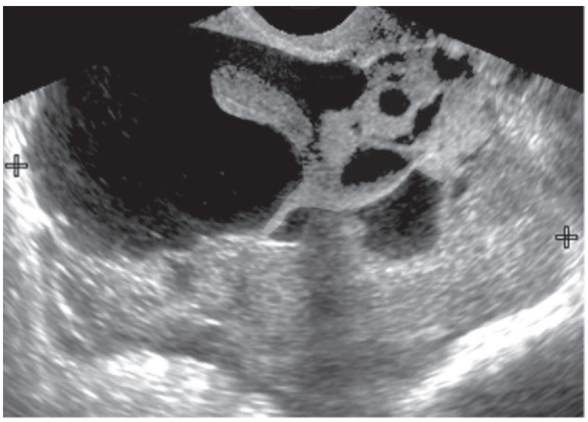
The preceding discussion should allow experienced sonologists to identify characteristic-appearing ovarian or extraovarian lesions and provide management guidelines when these lesions are encountered. Nonetheless, given the large number of cases imaged with US, a wide and divergent spectrum of appearances may be encountered. Occasionally, benign lesions may appear slightly atypical, in which case they should be classified as indeterminate but likely benign. In contrast, other lesions may have a clearly worrisome appearance, in which case they should be classified as indeterminate but likely malignant.

Even some lesions that typically have a classic appearance and are described as one of the Big Six may have atypical features (Fig 16). For example, a hemorrhagic cyst may contain a retracting clot that simulates a mural nodule, or fibrin strands may be misinterpreted as septations (13). Both hemorrhagic cysts and endometriomas may have wall irregularity (Fig 17), heterogeneously

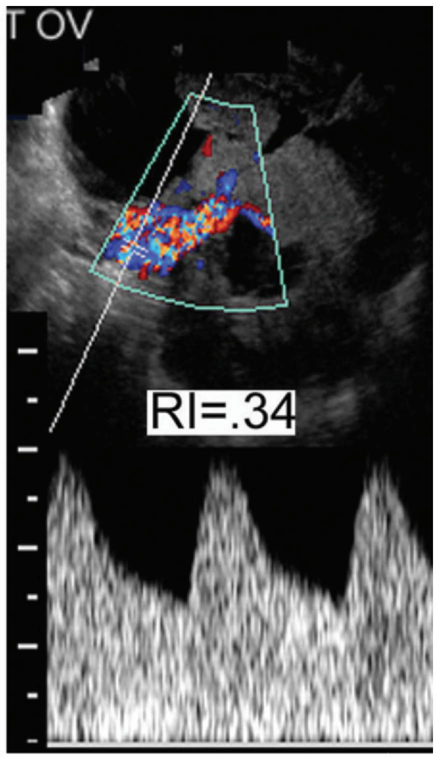


a. b.

Figure 18. Indeterminate adnexal lesions in a 32-year-old woman who presented with right-sided pelvic pain. **(a)** Sagittal transvaginal color Doppler US image of the right ovary demonstrates a cystic lesion with mild wall irregularity (arrows). **(b)** Coned-down coronal transvaginal power Doppler US image of the right ovary demonstrates the absence of flow within the mural irregularities. The cystic lesion was categorized as an indeterminate but likely benign lesion and resolved within 3 months.



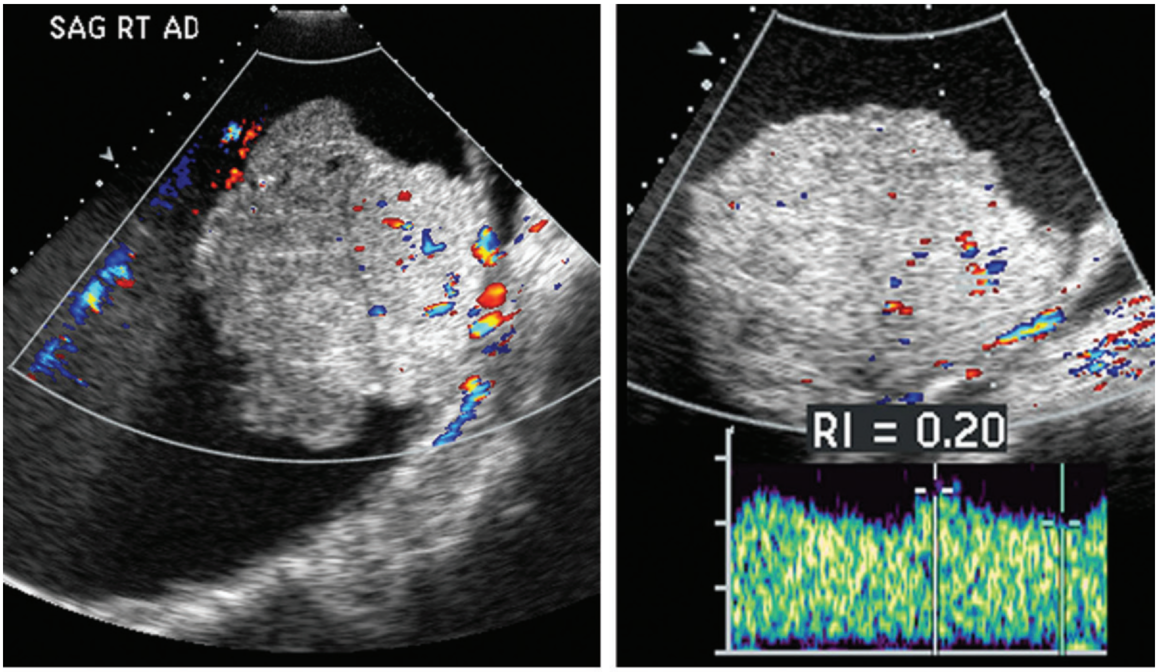
a.



b.

Figure 19. Primary epithelial ovarian malignancy in a 65-year-old woman with a pelvic mass. **(a)** Sagittal transvaginal US image of the right adnexa demonstrates a cystic mass (calipers) with an irregular solid component and septations. **(b)** Sagittal transvaginal duplex US image of the right ovary demonstrates low-resistance vascularity in the solid portions of the lesion, a finding that is characteristic for a primary epithelial ovarian malignancy and requires surgical evaluation rather than imaging follow-up. *RI* = resistive index.

echogenic material suggestive of a solid component, or a fluid-debris level (16–18). With the rare exception of an unusual endometrioma that contains a vascularized mural nodule (3), endometriomas and hemorrhagic cysts are always avascular (Fig 16). To differentiate between these two entities, premenopausal women or those in early menopause should undergo follow-up US in 6–12 weeks to confirm resolution and establish a hemorrhagic process as the cause. If the lesion



a. b.

Figure 20. Large malignant pelvic mass in a 68-year-old woman. **(a)** Sagittal transabdominal color Doppler US image of the right adnexa demonstrates a cystic structure with a large, solid vascularized component. **(b)** Sagittal transabdominal duplex US image demonstrates low-resistance vascular flow. This feature has been found to be most predictive of malignancy. *RI* = resistive index.

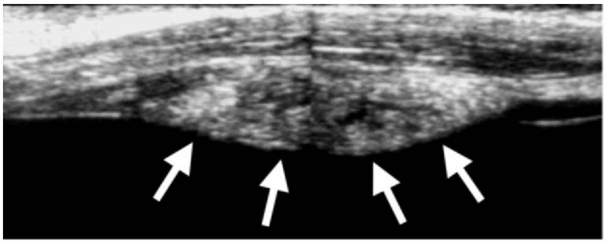
persists or the patient is postmenopausal, MR imaging should be considered, and, depending on the results, surgical evaluation may become necessary. With dermoids, difficulties can arise if *(a)* the tip of the iceberg sign (27) is misconstrued as bowel (Fig 10a); or *(b)* the lesion is predominantly cystic, making differentiation from other cystic masses difficult. Also, the appearance of dermoids has been confused with that of endometriomas and other benign cystic ovarian neoplasms (43). In questionable cases, CT can be used to look for fat and, if present, coarse calcifications. MR imaging can also be helpful for confirming intralesional fat.

If a cyst contains either a thin (<3-mm) septation or a small mural calcification, it is very likely benign and should be managed in a similar fashion as a simple-appearing cyst (12). If it contains multiple avascular thin septations or has a solid avascular mural nodule or wall irregularity, it will most likely be a benign neoplasm and should be characterized as indeterminate but likely benign. In such a case, the patient should undergo short-term follow-up US in 6–12 weeks (Fig 18); if the patient is premenopausal, US should ideally be performed at a different time of the cycle to avoid interpretive errors associated with a newly developing cyst. If the lesion persists or the patient is postmenopausal, contrast material–enhanced MR imaging should be considered to help determine if the mural abnormality is vascularized. If it is, surgical evaluation should be considered (12).

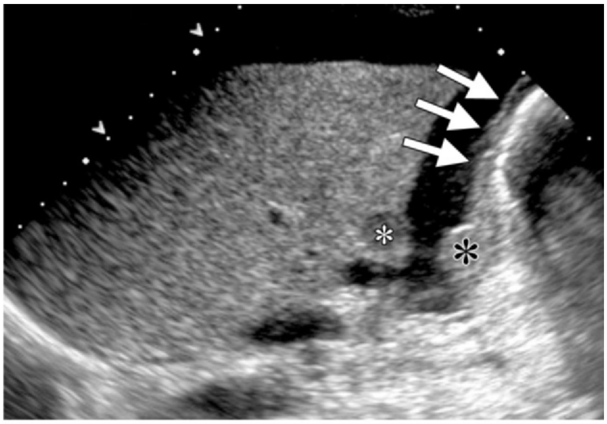
Teaching Point

Features that are worrisome for primary epithelial ovarian malignancy include cysts with thick septations or vascularized areas of focal wall thickening (each ≥3 mm) (Fig 19). In a statistical study conducted to determine features that could help discriminate malignancy from benignancy, the most predictive malignant feature was a solid mass with centrally located flow (Fig 20). When a cyst has these features, follow-up imaging should not be performed; rather, the patient should be referred for surgical evaluation. Ascites (when present) is also worrisome and often permits visualization of omental or peritoneal implants (Fig 21) (12,44). Once malignancy is confirmed, CT can be used to evaluate for disease spread.

RadioGraphics



a.



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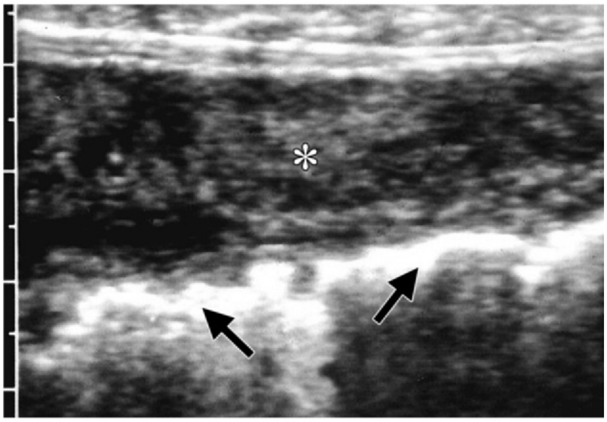

c.

Figure 21. Ovarian cancer metastases. **(a)** Superficial US image obtained with a 7-MHz linear transducer demonstrates a soft-tissue nodule (arrows) on the peritoneal surface outlined by ascites, findings that are compatible with a peritoneal implant. **(b)** Sagittal transabdominal US image of the right upper quadrant obtained in a different patient shows ascites with peritoneal thickening (arrows) and nodularity (black *), as well as a surface implant on the liver (white *). **(c)** Superficial US image obtained with a 7-MHz linear transducer in a third patient demonstrates superficial soft-tissue thickening (*) due to omental metastases. Note the posterior bowel displacement (arrows).

Although low-resistance Doppler flow is considered worrisome for malignant neovascularity, this spectral waveform may also be seen with various benign conditions, including a physiologic corpus luteum. Furthermore, with malignancy, the resistive index can vary from relatively low to relatively high (45,46). Therefore, findings related to spectral Doppler cannot be used in isolation to differentiate benign from malignant lesions. Instead, the diagnosis should rely on the gray-scale appearance of a lesion in conjunction with the presence of flow.

Solid adnexal masses may be either extraovarian or ovarian. One relatively common extraovarian lesion that may sometimes cause diagnostic confusion is a pedunculated fibroid. Visualizing the ipsilateral ovary and detecting uterine blood flow into the pedicle of the fibroid are helpful in differentiating this entity from a solid ovarian mass. Solid ovarian masses are most often neoplasms; consideration should be given to either a sex cord stromal tumor or metastatic disease (~10% of ovarian neoplasms). Sex cord stromal tumors constitute approximately 8% of ovarian neoplasms (47) and include hormonally active neoplasms such as granulosa cell tumors (symptoms of hyperestrogenism and low malignant potential) and Sertoli-Leydig cell tumors (symptoms of virilization and either benign or grade 1) (Fig 22). Also included in this group are fibroma-thecoma neoplasms, benign tumors that can sometimes be suggested when US demonstrates dramatic sound attenuation (Fig 23). Rarely, these benign tumors may be associated with Meig syndrome, which consists of ascites and pleural effusions. Metastases to the ovary, which account for up to 15% of all ovarian malignancies, are most often due to spread from the gastrointestinal tract, breast, or endometrium (48). Bilateral ovarian involvement is typical, and the US appearance of these tumors varies considerably. In most cases, they are smaller than primary epithelial malignancies, and they often have significant solid components with interspersed cysts.

Without question, malignant ovarian neoplasms are extremely worrisome and require prompt diagnosis and therapy. Nonetheless, it is important to understand that the overwhelming majority of ovarian and adnexal lesions imaged with US are benign. On the basis of the characteristic US pat-

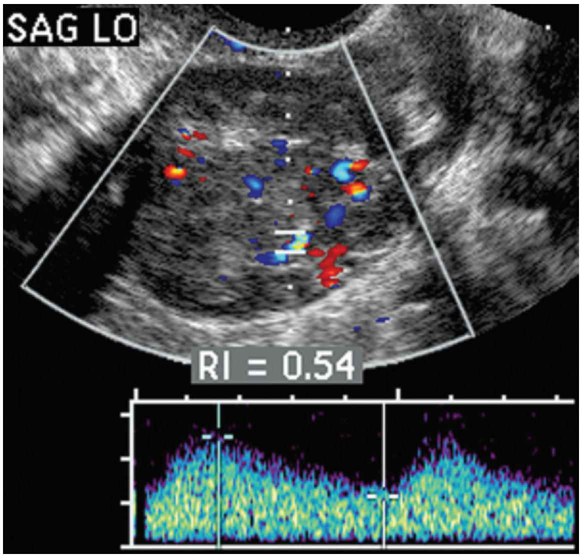

Figure 22. Virilization in a 55-year-old woman. Sagittal transvaginal duplex US image of the left ovary demonstrates a solid mass with low-resistance intralesional vascularity. Pathologic analysis showed the mass to be a Sertoli-Leydig cell tumor. *RI* = resistive index.

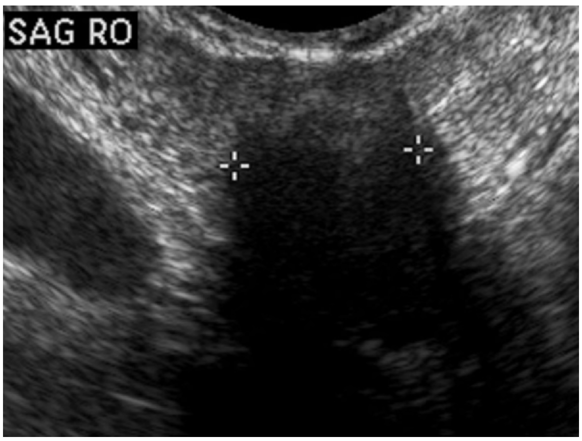

Figure 23. Incidentally discovered right ovarian mass in a 23-year-old woman with menorrhagia. Sagittal transvaginal US image of the right ovary (calipers) demonstrates a solid ovarian mass with dramatic attenuation of sound, findings that are characteristic of an ovarian fibroma, which was surgically proved.

terns or appearances of ovarian and adnexal lesions, experienced sonographers can assess masses in a subjective manner and can use this method to appropriately classify 93% of lesions as benign or malignant (5). Indeterminate lesions should be relatively few and in most cases can be followed up with US; persistent questionable findings may often be resolved with MR imaging.

Future Considerations

Accurate and uniform reporting is extremely important. In the late 1980s, uniform reporting for breast imaging was introduced by the American College of Radiology, and the acronym BI-RADS (Breast Imaging Reporting and Data System) was adopted (49). This dynamic lexicon, which has followed a logical and evidenced-based path from its inception, has evolved over the years and is currently in its fourth edition. Furthermore, this structured reporting system has been modified to incorporate both breast US and breast MR imaging interpretation. The hope is that other imaging domains will use the BI-RADS concept as an example of a highly successful application of standard terminology. In accordance with this philosophy, in 2009 the American College of Radiology convened a committee to develop LI-RADS (Liver Imaging Reporting and Data System), a standardized reporting system for patients with end-stage liver disease (50). Also in 2009, a group of gynecologic sonologists introduced GI-RADS (Gynecology Imaging Reporting and Data System), which uses pattern recognition analysis to evaluate adnexal masses and then classifies the findings into one of five graded categories. Grade 1 masses are considered to be definitely benign, whereas grade 5 masses are considered to be very probably malignant (51). Masses in grades 2–4 are categorized as very probably benign, probably benign, and probably malignant, respectively. Recently, these investigators reported the results of their prospective evaluation of 432 pelvic masses using the GI-RADS system (52). The study was performed independently at two institutions, and, with this lexicon, there was only a single error. This error involved a lesion categorized as grade 3 (probably benign) that was histologically a stage 1a serous ovarian carcinoma. Furthermore, 103 of 116 masses (89%) categorized as grade 5 (very probably malignant) proved to be malignant. The sensitivity of the GI-RADS reporting system in predicting malignancy was 99%, with a specificity of 86%. Also, interobserver agreement for this classification system was very good, and there was universal agreement among referring clinicians that this reporting system was "useful" (52).

It appears, therefore, that the GI-RADS classification system has the potential to influence clinical decision making and patient management. Hopefully, further research will confirm the usefulness of this approach. Also, it remains to be seen whether these findings can be reproduced by individuals who are less skilled in US performance and image interpretation.

Conclusions

The evaluation of an adnexal mass is a common task faced by sonologists. Assimilating and applying the information presented in this article will hopefully permit accurate classification of adnexal masses into one of three categories: benign, indeterminate, or malignant. Recognition of the six most common benign ovarian lesions and the three most common benign extraovarian adnexal lesions should help avoid additional or unnecessary imaging. Conversely, identifying features that strongly suggest malignancy will result in timely management rather than a delay caused by additional follow-up imaging. Finally, proper reporting and management recommendations serve to alleviate anxiety and misinterpretation on the part of the patient and physician.

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US of the Ovary and Adnexa: To Worry or Not to Worry?

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During this phase of the cycle (variably referred to as the follicular, proliferative, or preovulatory phase), transvaginal US depicts a developing follicle as a thin-walled, round to oval, avascular simple-appearing cyst. At ovulation, its diameter ranges from 1.7 to 2.8 cm (10,11), but a diameter of up to and including 3.0 cm is considered normal (12).

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Acutely, a hemorrhagic ovarian cyst contains clotted blood, which at US manifests as intensely echogenic, avascular, homogeneous or heterogeneous nonshadowing material (Fig 6a).

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Most dermoids contain a clump of hair, which both absorbs and reflects sound at US. The net effect is a focal hyperechogenic area that gradually attenuates sound and results in a characteristic gradual acoustic shadow (Fig 9).

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PICs can be recognized on the basis of two key features.

1. Lack of a wall. PICs typically have an irregular passive shape that conforms to and is defined by the contours of surrounding structures (Fig 15a).
2. Entrapment of the ovary either within or at the periphery of the fluid collection (Fig 15b) (32,33).

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Features that are worrisome for primary epithelial ovarian malignancy include cysts with thick septations or vascularized areas of focal wall thickening (each ≥3 mm) (Fig 19). In a statistical study conducted to determine features that could help discriminate malignancy from benignancy, the most predictive malignant feature was a solid mass with centrally located flow (Fig 20).