Ovarian Masses and O-RADS: A Systematic Approach to Evaluating and Characterizing Adnexal Masses with Ultrasound

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Editor's note: This is the first part of a two-part series. Part II will be presented in the July-August 2021 issue of Applied Radiology.

Clinical presentation and pertinent laboratory analysis often determine the appropriate imaging differential diagnostic considerations in evaluating anyone with ovaries presenting with pelvic symptoms. In patients with a positive pregnancy test, sonography is the modality of choice to evaluate the pregnancy and any complications. Sonography is also the modality of choice for evaluating patients who present with pelvic pain or a mass but are not pregnant. Pelvic sonography is the preferred imaging modality when an obstetrical or gynecologic etiology is suspected under American College of Radiology (ACR) Appropriateness Criteria.[1]

Sonography is useful in evaluating for the presence of an adnexal mass as well as for mass characterization.[2] For example, the sonographic appearance of a retracting clot and/or a reticular pattern without Doppler flow/vascularity is diagnostic of a hemorrhagic cyst (Figure 1).[3] Most adnexal cysts are benign and are easily characterized by ultrasound. However, evaluation of indeterminate adnexal masses by an ultrasound expert is highly valuable.[3] Published data supports the use of pattern recognition by an experienced ultrasound examiner as a highly accurate method of discriminating between benign and malignant adnexal masses without the need for MRI.[3] In particularly challenging cases, contrast-enhanced MRI may be helpful in differentiating between benign and malignant ovarian masses.

This two-part review describes a stepwise approach to evaluating and characterizing adnexal masses in non-pregnant patients. Here in part 1, we will review the utilization of ultrasound in this endeavor. In part 2, we will review the use of MRI.

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Ultrasound Imaging

In evaluating any pelvic mass, the first step is to determine if the mass is arising from the ovaries, the uterus, or another location. Once the anatomical origin is determined, imaging may be extremely helpful in establishing an accurate diagnosis. If the mass is of ovarian origin, for example, identifying its nature—cystic, solid, or complex—and ascertaining the presence of any fat or calcium in the mass will helps narrow the differential diagnoses.

Ultrasound is also invaluable for determining the cystic or solid nature of adnexal masses. Although a comprehensive discussion of all adnexal masses is beyond the scope of this pictorial review, Table 1 provides a list of some common cystic and solid adnexal masses that may be detected, and in most cases diagnosed, with sonography. In 2019, the Society of Radiologists in Ultrasound (SRU) updated its 2010 consensus statement on the management of asymptomatic ovarian and adnexal cysts.[2]

More recently, the ACR convened a consensus panel on risk stratification of ovarian-adnexal masses and management using an O-RADS™ classification system.[3] This system is more

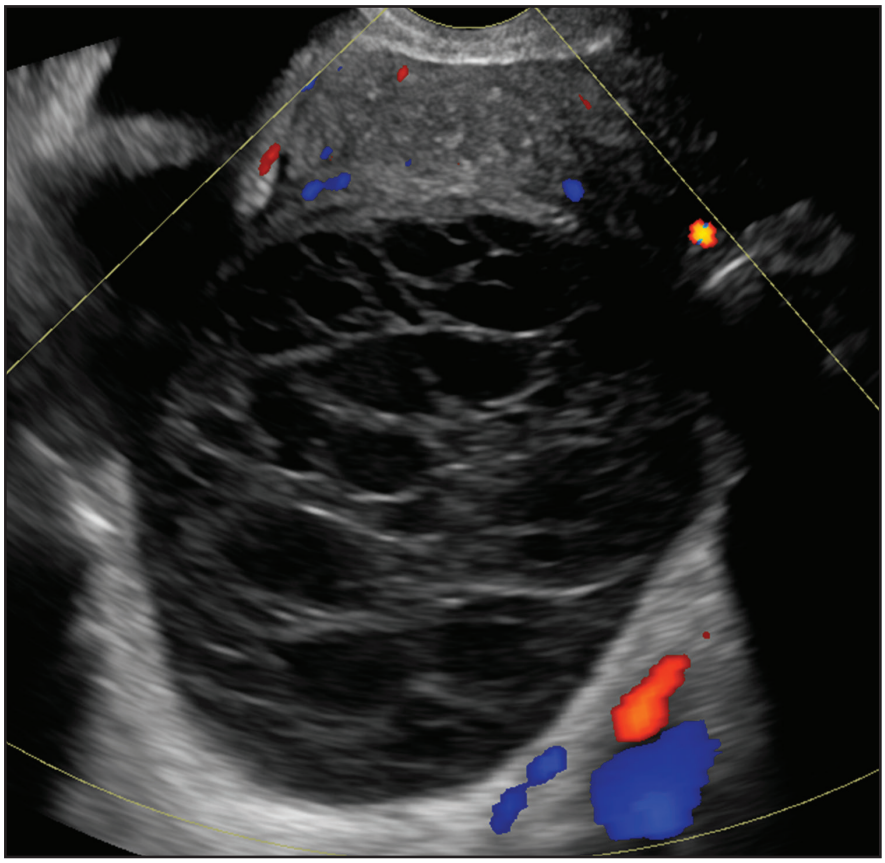

FIGURE 1. *Hemorrhagic ovarian cyst. Typical reticular pattern of fine, thin intersecting lines representing fibrin strands with no central flow is one pattern of a hemorrhagic cyst (O-RADS 2).*

Table 1. Common Differential Diagnoses for Adnexal Masses in Non-pregnant Patients

- Physiologic ovarian cyst/follicle
- Other ovarian cysts
- Hemorrhagic cyst
- Endometrioma
- Tubo-ovarian abscess
- Pyo/hydrosalpinx
- Abdominal abscess
- Paraovarian cyst
- Dermoid cyst/Teratoma
- Serous/mucinous cystadenoma or CA and other epithelial neoplasms
- Fibromas/Thecomas
- Ovarian metastases
- Ovarian torsion
- Pedunculated fibroid
- Peritoneal inclusion cysts

comprehensive than the SRU system in that it not only makes recommendations for classifying simple cysts, but also includes recommendations for risk stratifying more complex adnexal cysts. The O-RADS system also provides a lexicon of ultrasound descriptors to characterize, and ultimately classify, adnexal masses. For simple ovarian cysts in the premenopausal patient, the ACR recommends that 5-10 cm cysts be followed for 8-12 weeks to confirm their functional nature and to reassess for wall abnormalities. In postmenopausal females, simple cysts > 1 cm should be described but do not require follow-up imaging unless they are > 3 cm in size. The ACR O-RADS committee recommends a 1-year follow-up for 3-10 cm cysts in postmenopausal females. The complete review of this most recent SRU update and the O-RADS committee can be found in references 2 and 3.

While other guidelines in the literature are used for ultrasound evaluation of ovarian masses, the O-RADS system has been selected for review for multiple reasons. First, it provides an evidence-based standard lexicon for the use of terms that give a consistent diagnosis. Risk stratification is based upon the application of descriptors that are most predictive of malignancy from a large database, including pathology correlation with the International Ovarian Tumor Analysis (IOTA) group ultrasound rules for ovarian masses.

This system goes well beyond the SRU classification of simple cysts and considers other features of adnexal masses and corresponding management recommendations (Table 2). In addition, it is ultrasound-based, providing risk stratification and management based on imaging appearance of cysts. Descriptors of appearance include pure cysts, multilocular cysts, and multilocular cysts with solid components or solid masses. O-RADS considers diameter of the mass, presence of acoustic shadowing, unilocular versus multilocular cysts, cystic masses with papillary projection or solid component/solid mass appearance, and scoring of mass vascularity.[3] Color flow is graded as follows:

1 – no flow;
2 – minimal flow;
3 – moderate flow; and
4 – very strong flow.

A more detailed lexicon is available in source reference 3.

Risk stratification and management recommendations are based upon some of these parameters (Table 2). The O-RADS working group defined six categories of risk stratification: O-RADS 0, in which the adnexa are incompletely evaluated; O-RADS 1, the normal premenopausal ovary; O-RADS 2, almost certainly benign lesions with < 1% risk of malignancy; O-RADS 3, lesions with a low risk of malignancy (1-9%); O-RADS 4, lesions with an

Table 2. O-RADS Ultrasound Risk Stratification and Management System

O-RADS Score	Risk Category [IOTA Model]	Lexicon Descriptors		Management	
				Pre-menopausal	Post-menopausal
0	Incomplete Evaluation [N/A]	N/A		Repeat study or alternate study	
1	Normal Ovary [N/A]	Follicle defined as a simple cyst ≤ 3 cm		None	N/A
		Corpus luteum ≤ 3cm			
2	Almost Certainly Benign [< 1%]	Simple cyst	≤ 3 cm	N/A	None
			> 3 cm to 5 cm	None	Follow up in 1 year. *
			> 5 cm but < 10 cm	Follow up in 8 - 12 weeks	
		Classic benign lesions	See Table 3 for descriptors and management strategies		
		Non-simple unilocular cyst, smooth inner margin	≤ 3 cm	None	Follow up in 1 year * If concerning, US specialist or MRI
			> 3 cm but < 10 cm	Follow-up in 8 - 12 weeks If concerning, US specialist	US specialist or MRI
3	Low Risk Malignancy [1-<9%]	Unilocular cyst (simple or non-simple) ≥ 10 cm		US specialist or MRI management by gynecologist	
		Typical dermoid cysts, endometriomas, hemorrhagic cysts ≥ 10 cm			
		Unilocular cyst, with irregular inner wall (<3 mm height), any size			
		Multilocular cyst with smooth inner walls/septations, < 10 cm, CS = 1-3			
		Solid lesion with smooth outer contour, any size, CS = 1			
4	Intermediate Risk [10-< 50%]	Multilocular cyst, no solid component	Smooth inner wall, ≥ 10 cm, CS = 1-3	US specialist or MRI Management by gynecologist with gyno-oncologist consultation or solely by gyno-oncologist	
			Smooth inner wall, any size, CS = 4		
			Irregular inner wall ± irregular septation, any size, CS = any		
		Unilocular cyst with solid component	1-3 papillary projections (pp), or solid component that is not a pp, any size, CS= any		
		Multilocular cyst with solid component	Any size, CS = 1-2		
		Solid lesion	Smooth outer contour, any size, CS = 2-3		
5	High Risk [≥ 50%]	Unilocular cyst, ≥ 4 papillary projections, any size, CS = any		Gyno-oncologist	
		Multilocular cyst with solid component, any size, CS = 3-4			
		Solid lesion with smooth outer contour, any size, CS = 4			
		Solid lesion with irregular outer contour, any size, CS = any			
		Ascites and/or peritoneal nodules**			

Table shows ovarian-adnexal reporting and O-RADS risk stratification and management system adapted from American College of Radiology O-RADS for Ultrasound.
CS=color score; GYN = gynecologic; N/A = not applicable
*At least one-year follow-up showing stability or decrease in size is recommended with consideration of annual follow-up of up to 5 years, if stable. However, there is currently a paucity of evidence for defining the optimal duration or interval of timing of surveillance.
**Presence of ascites with category 1-2 lesion, must consider other malignant or nonmalignant etiologies of ascites.

intermediate risk of malignancy (10-<50%); and O-RADS 5, high risk of malignancy (>50%).[3] O-RADS 2 lesions have fairly classic features such as hemorrhagic cysts (Figure 1), dermoid cysts (Figure 2), endometriomas (Figure 3), para-ovarian cysts, peritoneal inclusion cysts (Figure 4) and hydrosalpinx (Figure 5, Table 3). These lesions will be reviewed in detail here. For O-RADS 3 or greater lesions and sometimes in post-menopausal O-RADS 2 lesions, MRI may be valuable.

Germ Cell Tumors

Dermoid cysts and teratomas are classified as germ cell tumors (Table 4), account for 15-20% of all ovarian neoplasms and are rarely malignant. Teratomas may be mature or immature. Dermoid cysts are mature cystic terato-

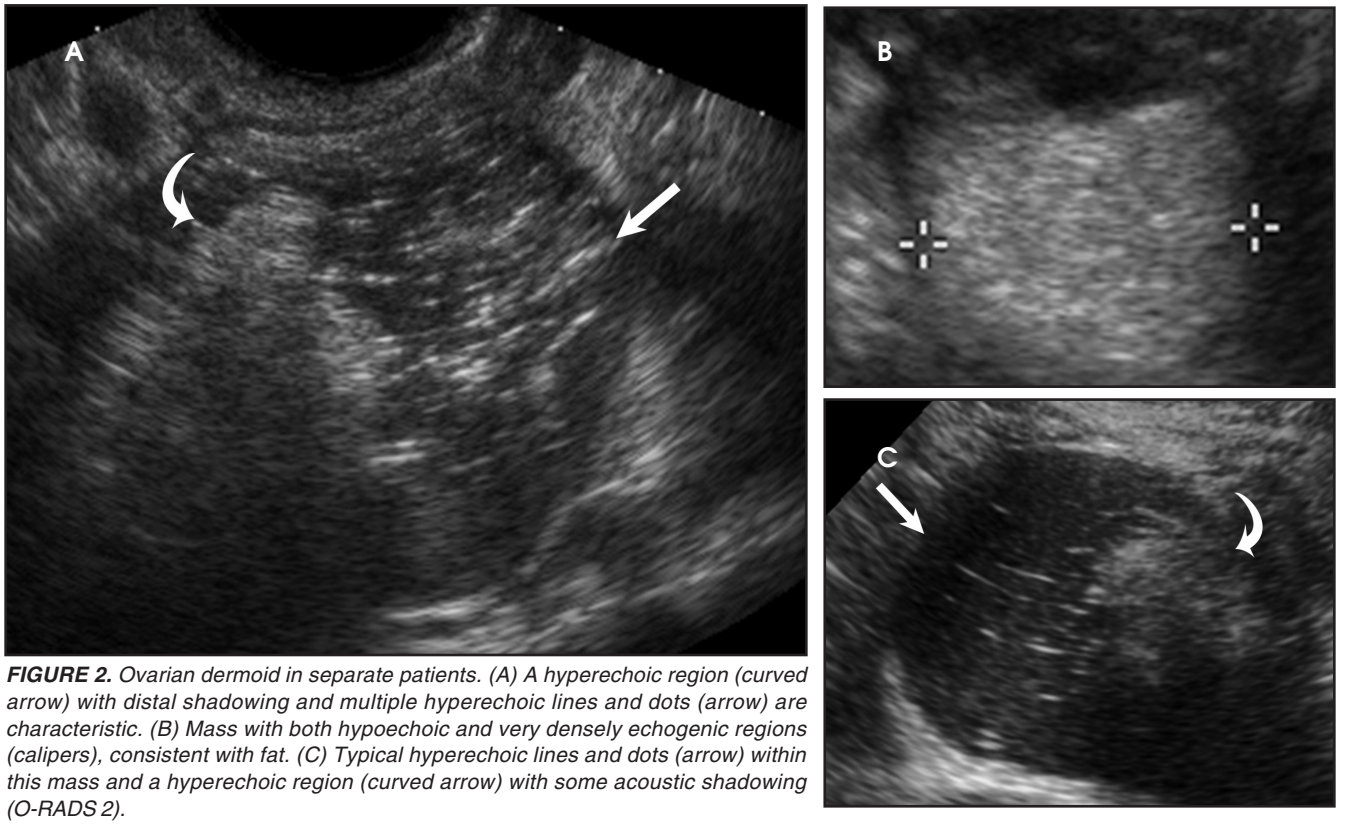

FIGURE 2. *Ovarian dermoid in separate patients. (A) A hyperechoic region (curved arrow) with distal shadowing and multiple hyperechoic lines and dots (arrow) are characteristic. (B) Mass with both hypoechoic and very densely echogenic regions (calipers), consistent with fat. (C) Typical hyperechoic lines and dots (arrow) within this mass and a hyperechoic region (curved arrow) with some acoustic shadowing (O-RADS 2).*

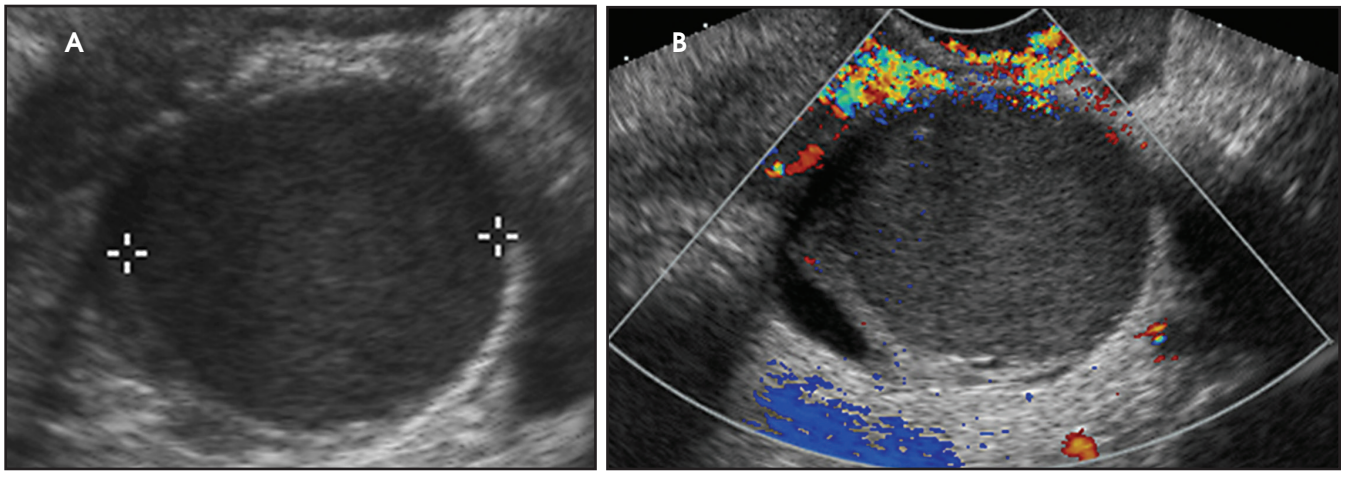

FIGURE 3. *Endometrioma. (A) Initial ultrasound examination demonstrating adnexal mass (calipers) with homogeneous, ground-glass, low-level echoes. (B) Three-month follow-up ultrasound exam demonstrates similar findings with no color flow within the mass, confirming the diagnosis (O-RADS 2).*

mas that may have components from 3 germ-cell layers that predominantly include mature ectoderm elements**.**

Ultrasound and CT features of dermoids include cystic components, fatty elements, hair, and/or calcifications (Figure 2). Thus, a hyperechoic component with acoustic shadowing in a predominantly cystic mass on ultrasound is highly predictive of a dermoid cyst. These cysts can also demonstrate a variety of other sonographic features, including a hyperechoic component with acoustic shadowing, hyperechoic lines and dots, or floating echogenic spherical structures. A Rokitansky nodule is a solid mass of sebaceous material projecting into the lumen of the mass. Most cases require no further evaluation upon identification of classic ultrasound or CT features of O-RADS 2 lesions.

Endometriomas

Endometriomas and hemorrhagic cysts may appear similar on sonography. However, hemorrhagic cysts may have characteristics of a retracting

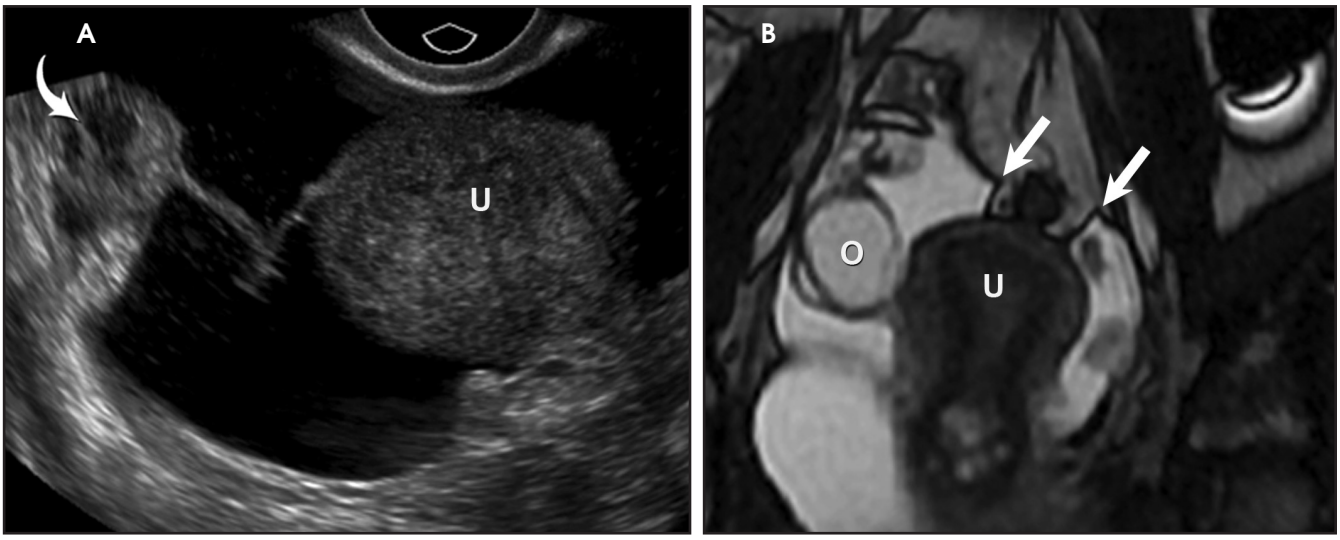

FIGURE 4. *Peritoneal inclusion cyst. (A) A cystic pelvic mass with septations, which may mimic a cystic ovarian neoplasm, but the ovary was separate (curved arrow). Fluid occupies the entire pelvis, following the contour of adjacent organs (U = uterus). (B) Coronal T2 MRI image demonstrates the right ovary with a cyst (O), extra-ovarian free fluid that does not have an oval appearance but acute angles (arrows) following the shape of adjacent organs (O-RADS 2).*

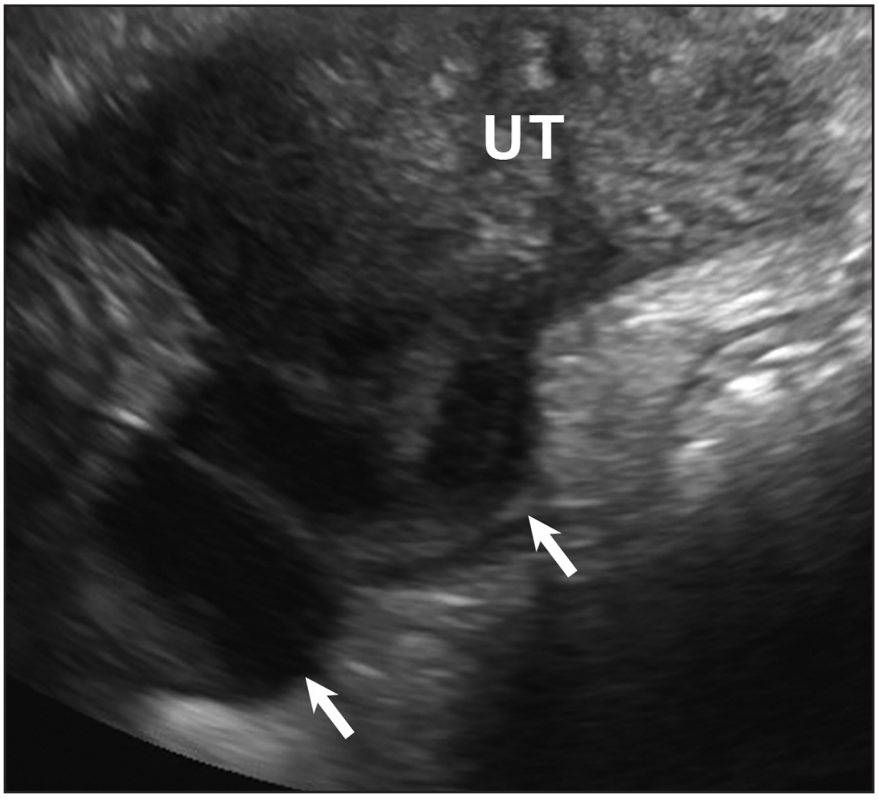

FIGURE 5. *Hydrosalpinx. A parasagittal plane demonstrating a tubular structure (arrows) with incomplete septations posterior to the uterus (UT).*

clot and/or reticular pattern of internal echoes (Figure 1). According to the recent O-RADS classification, masses with this characteristic pattern of a hemorrhagic ovarian cyst and < 5 cm without internal flow require no follow-up imaging. However, follow-up at 8-12 weeks is recommended for masses > 5 cm. Alternatively, endometriomas usually appear with ground glass, homogeneous, low-level, internal echoes with no solid components on ultrasound (Figure 3). Follow-up at 12 weeks is recommended in these cases.[3]

Peritoneal Inclusion Cysts

One mimic of a surface epithelial neoplasm is a benign entity called a peritoneal inclusion cyst, which may be mistaken for a complex cystic ovarian mass. Peritoneal inclusion cysts represent fluid "trapped" within the peritoneal adhesions in patients with previous history of abdominal or pelvic surgery, Crohn disease, or prior pelvic inflammatory process. These "cysts" are not spherical, but they may be oblong with more acute angulations at their margins, as the fluid is interposed between different surfaces within the pelvis (Figure 4). History is helpful in such cases. There should be no mural nodularity. They need only be evaluated with ultrasound or, if detected with CT, they require no further evaluation.

Hydrosalpinx

Diagnostic ultrasound features of hydrosalpinx include visualization of a tubular structure with septations, or an S-shaped cystic mass separate from

Table 3. Classic Benign Lesions (O-RADS 2)

Lexicon Descriptor	Definition	Management	
		Premenopausal	Postmenopausal
Typical hemorrhagic cyst	Reticular pattern: Fine thin intersecting lines representing fibrin strands Retracting clot: An avascular echogenic component with angular, straight, or concave margins	≤ 5 cm None	US specialist, gynecologist, or MRI
		>5 cm but < 10 cm Follow-up in 8-12 weeks If it persists or enlarges, referral to US specialist, gynecologist, or MRI	US specialist, gynecologist, or MRI
Typical dermoid cyst < 10 cm	▪ Hyperechoic component with acoustic shadowing ▪ Hyperechoic lines and dots ▪ Floating echogenic spherical structures	Optional initial follow-up in 8-12 weeks based upon confidence in diagnosis If not removed surgically, annual US follow-up should be considered * US specialist or MRI if there is enlargement, changing morphology, or a developing vascular component	US specialist, gynecologist, or MRI With confident diagnosis, if not removed surgically, annual US follow-up should be considered * MRI if there is enlargement, changing morphology, or a developing vascular component
Typical endometriomas < 10 cm	Ground-glass/homogeneous low-level echoes		
Simple paraovarian cyst/ any size	Simple cyst separate from the ovary that typically moves independent of the ovary when pressure is applied by the transducer	None If not simple, manage per ovarian criteria	Optional single follow-up study in 1 year
Typical peritoneal inclusion cyst/any size	Follows the contour of the adjacent pelvic organs or peritoneum, does not exert mass effect, and typically contains septations. The ovary is either at the margin or suspended within the lesion.	Gynecologist	Gynecologist
Typical hydrosalpinx/any size	▪ Incomplete septation ▪ Tubular ▪ Endosalpingeal folds: Short round projections around the inner wall of a fluid distended tubular structure	Gynecologist	Gynecologist

Table shows O-RADS US risk stratification and management system for classic benign lesions and associated descriptors (O-RADS 2), adapted from source reference No.3 with permission of the American College of Radiology. *There is currently a paucity of evidence for defining the optimal duration or interval of timing for surveillance. Evidence does support an increasing risk of malignancy in endometriomas following menopause

the ovary or uterus (Figure 5). Depending on transducer angulation, this adnexal mass may appear as a more rounded cystic structure. When seen in cross-section, the longitudinal folds produce a characteristic "cogwheel" appearance.

O-RADS 4 and 5 Lesions

Worrisome ultrasound features of O-RADS 4 and 5 lesions include the presence of multilocular cysts, solid components within the lesion, papillary projections, large size, and higher color flow grades (Table II, Figures 6, 7). These features can be present in solid lesions such as sex cord tumors or ovarian metastases, which will be explained in greater detail in Part II of this review (Table 4). Of these lesions, the most worrisome are surface epithelial neoplasms. These tumors constitute approximately

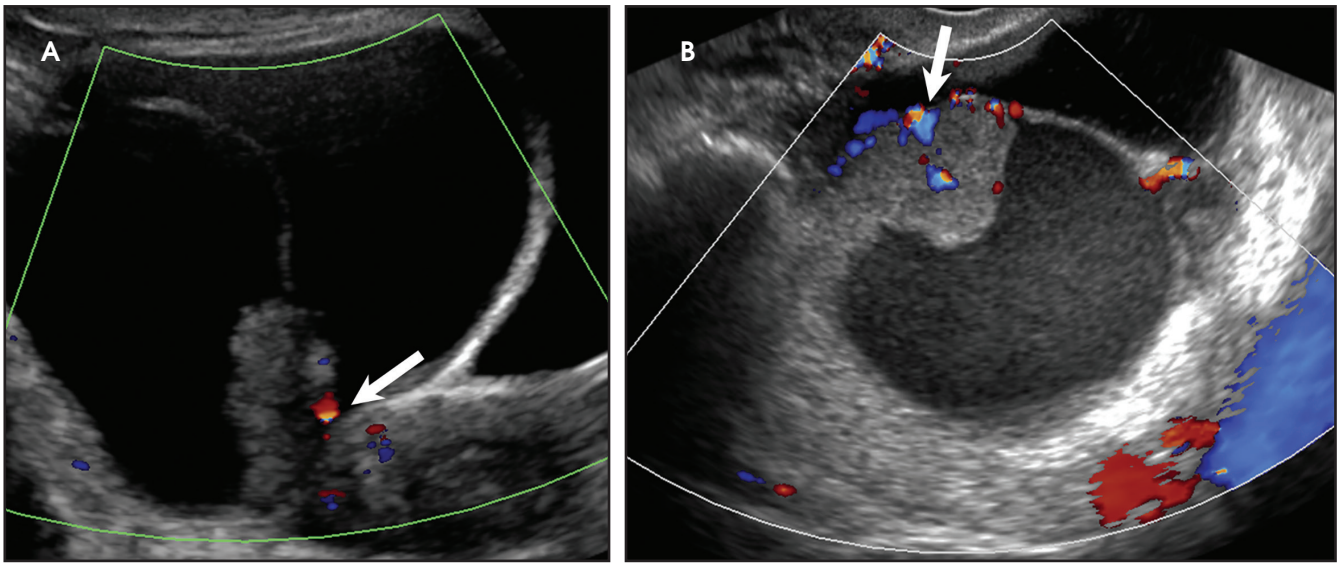

FIGURE 6. *Fallopian tube cancer. (A) Longitudinal view demonstrates a multiseptated mass with mural nodularity and color flow (arrow). (B) Coronal image through the same region demonstrates mural nodularity with strong color flow noted within this mass (arrow) and with thick septations. These findings are strongly indicative of malignancy (O-RADS 4 or 5).*

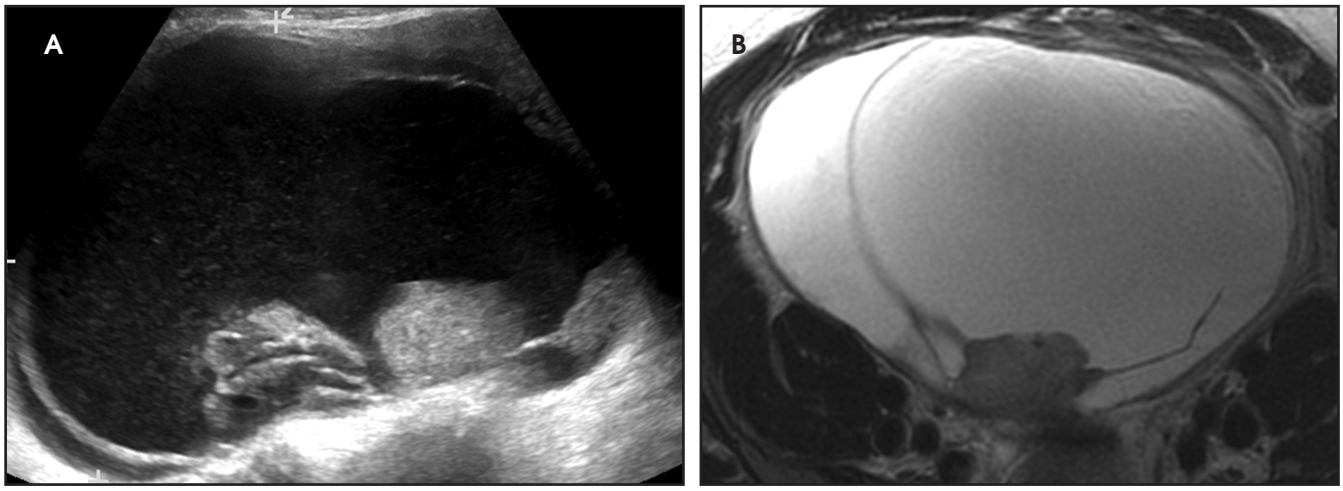

FIGURE 7. *Ovarian mucinous adenocarcinoma. (A) Ultrasound examination demonstrates a >10 cm multilocular cyst with solid components with color flow (not shown). (B) Corresponding T2 MRI shows similar findings of a multilocular cyst with a solid component that enhanced avidly (not shown) (O-RADS MRI 5).*

90% of all malignant ovarian tumors and include serous or mucinous cyst adenocarcinomas. Serous neoplasms have a higher frequency of malignancy than do mucinous neoplasms.

An unusual type of surface epithelial tumor with concerning features is the borderline tumor. These tumors are typically diagnosed pathologically after surgery. They occur in younger patients and have a 10-year survival rate as high as 95% (Figure 8). Surface epithelial neoplasms will be discussed in more detail in Part II.

Conclusion

Ultrasound plays a significant role in diagnosing ovarian and adnexal pathology. It is usually the screening modality of choice in these cases and may be useful in establishing a specific diagnosis in the nonpregnant patient. The SRU and ACR O-RADS™ guidelines may be helpful in classifying simple ovarian cysts and other adnexal masses. In more problematic cases, consultation with an ultrasound expert and the addition of MRI may be warranted.

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Table 4. Ovarian Neoplasms

Origin	Surface epithelium	Germ cells	Parenchyma (sex cord-stroma)	Metastases
Frequency	65 – 70%	15 – 20%	5 – 10%	5%
% of malignant	90%	3 – 5 %	2 – 3%	5%
Age	20+	0 – 25+	All	Variable
Types	Serous	Teratoma	Fibroma	
	Mucinous	Dysgerminoma	Granulosa-theca cell tumor	
	Endometrioid	Endodermal sinus	Sertoli-Leydig cell tumor	
	Clear Cell	Choriocarcinoma	Cystadenofibroma	
	Brenner			

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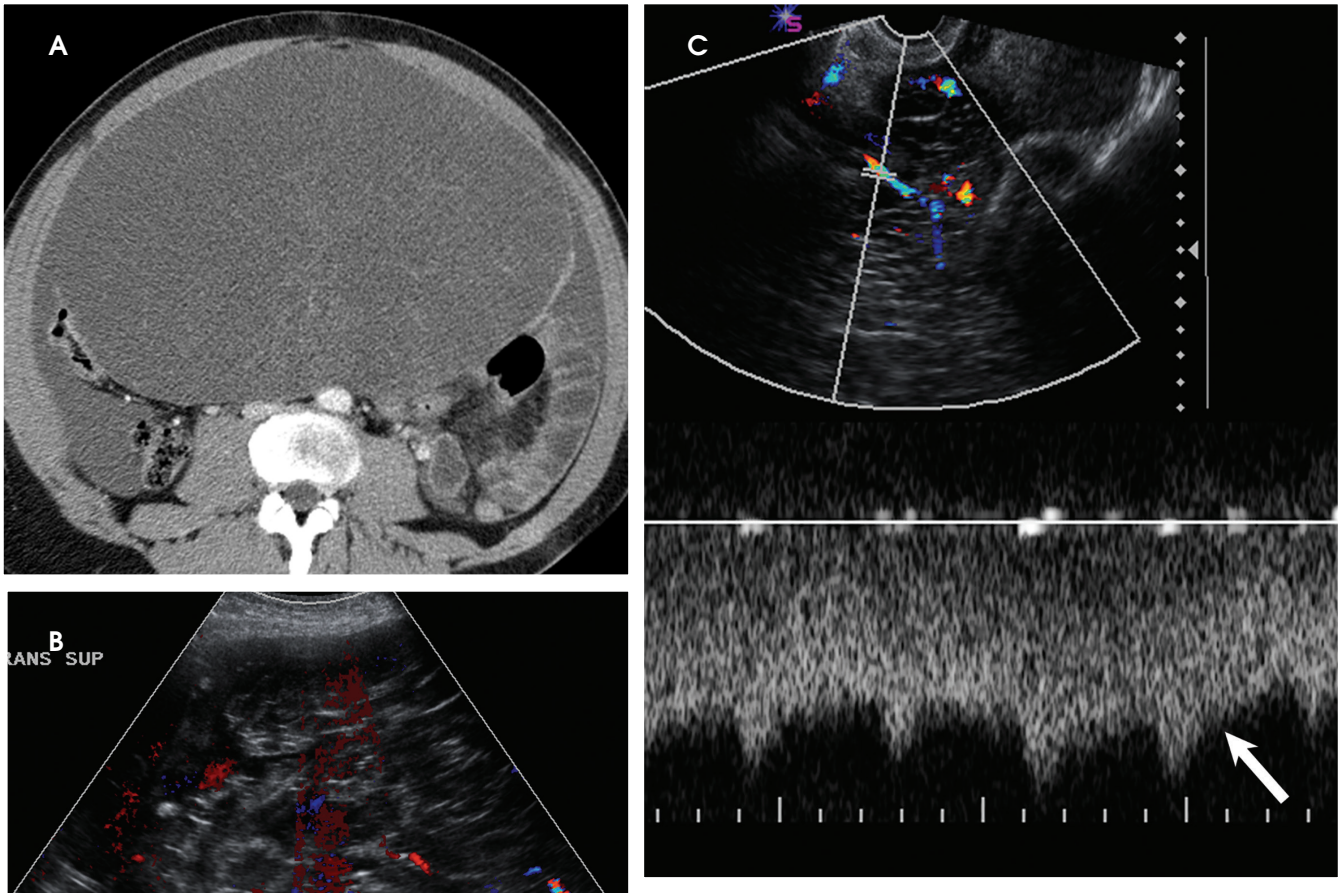

FIGURE 8. *Borderline mucinous cystadenoma. (A) CT scan demonstrating large, predominantly cystic mass arising from the pelvis, with suggestions of septations within the mass. Free fluid was noted within the abdomen/pelvis. (B) Color Doppler image clearly demonstrates the mixed echogenic septations and moderate color flow within them. (C) Doppler tracing of one of the color flow septations demonstrates an arterial waveform with very high diastolic flow within the mass (arrow). Findings are worrisome for malignancy.*