O-RADS MRI After Initial Ultrasound for Adnexal Lesions: *AJR* Expert Panel Narrative Review

Elizabeth A. Sadowski, MD[1,2], Erica B. Stein, MD[3], Isabelle Thomassin-Naggara, MD, PhD[4], Andrea Rockall, MBBS, MRCP[5], Stephanie Nougaret, MD, PhD[6], Caroline Reinhold, MD, MSc[7,8], Katherine E. Maturen, MD, MS[9,10]

Genitourinary Imaging · *AJR* Expert Panel Narrative Review

Keywords

adnexal lesions, MRI, O-RADS, ovarian cancer, ovary, ultrasound

Submitted: Jun 1, 2022
Revision requested: Jun 13, 2022
Revision received: Jul 15, 2022
Accepted: Aug 4, 2022
First published online: Aug 17, 2022
Version of record: Nov 9, 2022

I. Thomassin-Naggara receives support from GE Healthcare, Siemens Healthineers, Hologic, Canon Medical, Guerbet, Bracco, and Bayer. The remaining authors declare that there are no other disclosures relevant to the subject matter of this article.

Supported in part by Cancer Research UK Imperial Centre and the National Institute for Health Imperial Biomedical Research Centre (A. Rockall).

The Ovarian-Adnexal Reporting and Data System (O-RADS) ultrasound (US) and MRI risk stratification systems were developed by an international group of experts in adnexal imaging to aid radiologists in assessing adnexal lesions. The goal of imaging is to appropriately triage patients with adnexal lesions. US is the first-line imaging modality for assessment, whereas MRI can be used as a problem-solving tool. Both US and MRI can accurately characterize benign lesions such as simple cysts, endometriomas, hemorrhagic cysts, and dermoid cysts, avoiding unnecessary or inappropriate surgery. In patients with a lesion that does not meet criteria for one of these benign diagnoses, MRI can further characterize the lesion with an improved specificity for cancer and the ability to provide a probable histologic subtype in the presence of certain MRI features. This allows personalized treatment, including avoiding overly extensive surgery or allowing fertility-sparing procedures for suspected benign, borderline, or low-grade tumors. When MRI findings indicate a risk of an invasive cancer, patients can be expeditiously referred to a gynecologic oncologic surgeon. This narrative review provides expert opinion on the utility of multiparametric MRI when using the O-RADS US and MRI management systems.

The goal of imaging in the assessment of adnexal lesions is to triage patients appropriately, thereby avoiding unnecessary or overly extensive surgery and expediting the evaluation of patients with potential ovarian cancer. Previously published algorithmic risk stratification systems exist and have used ultrasound (US) features to classify adnexal lesions; these guidelines include the International Ovarian Tumor Analysis simple rules, the Gynecologic Imaging-Reporting and Data System, and the Society of Radiologists in Ultrasound guidelines [1–3]. The American College of Radiology (ACR) Ovarian-Adnexal Reporting and Data System (O-RADS) US and MRI committees have published lexicons and risk stratification systems partially based on previously published systems in order to standardize terminology and provide a data-driven risk score for assigning a probability of malignancy based on large population studies [4–8]. The overarching goal of these risk assessment and management systems is to triage patients appropriately.

US is the first-line imaging modality when there is a clinical concern for an adnexal lesion or when an adnexal lesion is identified on another imaging examination, and it has a sensitivity greater than 90% and specificity greater than 80% for the diagnosis of ovarian cancer [1, 3, 5, 9–17]. An adnexal lesion may also be discovered incidentally on US when a patient is undergoing pelvic imaging for a variety of indications from abnormal bleeding to pelvic pain. Most adnexal lesions seen on US can be accurately characterized as physiologic or benign. When imaging shows characteristic features of a simple cyst, hemorrhagic cyst, endometrioma, or dermoid cyst, a benign diagnosis can be assigned, and the

ARRS is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education activities for physicians.

The ARRS designates this journal-based CME activity for a maximum of 1.00 AMA PRA Category 1 Credit™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

To access the article for credit, follow the prompts associated with the online version of this article.

doi.org/10.2214/AJR.22.28084

AJR 2023; 220:6–15

ISSN-L 0361–803X/23/2201–6

[1]Department of Radiology, University of Wisconsin School of Medicine and Public Health, 600 Highland Ave, E3/372, Madison, WI 53792-3252. Address correspondence to E. A. Sadowski (ESadowski@uwhealth.org).

[2]Department of Obstetrics and Gynecology, University of Wisconsin School of Medicine and Public Health, Madison, WI.

[3]Department of Radiology, University of Michigan, Ann Arbor, MI.

[4]Service d'Imagerie, Hôpital Tenon, Assistance Publique—Hôpitaux de Paris, Sorbonne Université, Paris, France.

[5]Division of Surgery and Cancer, Imperial College London, London, UK.

[6]Department of Radiology, Institute of Cancer Research of Montpellier INSERM, Montpellier, France.

[7]Department of Radiology, McGill University Health Centre, McGill University, Montreal, QC, Canada.

[8]Augmented Intelligence & Precision Health Laboratory of the Research Institute of McGill University Health Centre, Montreal Imaging Experts, Montreal, QC, Canada.

[9]Department of Radiology, University of Michigan, Ann Arbor, MI.

[10]Department of Obstetrics and Gynecology, University of Michigan, Ann Arbor, MI.

frequency of cancer in these lesions is less than 1% [5, 18, 19]. When an adnexal lesion does not have the appearance of a classic benign lesion, the risk of malignancy ranges from 1% to more than 50% according to the O-RADS US risk score [5]. The variability in cancer risk on US is partly because of overlapping imaging features of benign and malignant entities and reader experience level [5]. In such lesions, MRI has been shown to increase the specificity for malignancy by decreasing the false-positive rate [13, 20–31]. A multicenter prospective study found the O-RADS MRI risk score performed well, with sensitivity of 93%, specificity of 91%, PPV of 90%, and NPV of 98% for the diagnosis of cancer when certain imaging features were present, such as a high-risk time-intensity curve [8]. Currently, no large multicenter studies have been performed to evaluate when MRI is most helpful after US, and the available literature focuses on the use of MRI for sonographically indeterminate adnexal lesions. The new O-RADS US lexicon and risk stratification systems do not include a classification of adnexal lesions as "indeterminate" but rather place adnexal lesions into risk categories: almost certainly benign and low risk, intermediate risk, and high risk for cancer (Fig. 1). In all of these O-RADS US categories, MRI can play a role in guiding management by further assessing the lesion using the O-RADS MRI risk stratification schema (Fig. 2 and Table 1). This narrative review provides expert opinion on the utility of multiparametric MRI when using the O-RADS US and MRI management systems.

Why Is MRI Valuable?

Multiparametric MRI allows more accurate characterization of both the fluid and solid components of an adnexal lesion compared with US, accounting for MRI's increased specificity for the diagnosis of malignancy. The presence of solid tissue with a high-risk enhancement curve has a PPV for cancer of approximately 90% [8]. Conversely, the absence of enhancement in an adnexal lesion has an NPV that exceeds 98% [8]. Furthermore, MRI can accurately predict the underlying pathology when certain characteristic imaging findings are present (e.g., papillary projections suggest a benign, borderline, or low-grade serous tumor; solid tissue that is hypointense on both T2-weighted MRI and high b-value DWI, referred to in O-RADS MRI as "dark T2/dark DWI," indicates a benign fibrous tumor) [21, 32–34]. Recognizing these characteristic findings is crucial, particularly when triaging a lesion to a gynecologist versus a gynecologic oncologist for surgical evaluation or when considering fertility-sparing surgery [21, 35–41]. Appropriate adnexal lesion characterization by imaging allows patients with benign lesions to avoid unnecessary or overly extensive surgery and allows patients with ovarian cancer to be promptly referred to a gynecologic oncologist. Avoiding surgery or overly extensive resection decreases stress on the patient, strain on hospital resources, and complications [42]. Referring patients with ovarian cancer to a gynecologic oncologist for the initial evaluation and surgery improves clinical outcomes [43].

When Is MRI Helpful?

MRI is helpful in further characterization and risk assessment of lesions discovered on US when there is a clinical need for improved specificity for malignancy or for differentiation between benign or borderline/low-grade tumor and invasive ovarian cancer [9, 10, 21,

TABLE 1: Clinical Scenarios Where Referral to MRI May Be Helpful After Ultrasound (US) for an Adnexal Lesion

Reason for Referral to MRI	O-RADS US Category	Role of MRI	Possible Outcomes on MRI and Clinical Benefit
Clinical need for improved specificity for malignancy or tumor subtype	3, 4, or 5	Assessment of the morphology, signal intensity, and enhancement of any solid tissue	MRI can increase the PPV for cancer and suggest the histopathologic subtype when certain imaging features are present. MRI can help in the following scenarios: • Patient with an isolated adnexal lesion and no signs of metastatic disease, where there is a clinical need for a specific diagnosis • Patient who desires a fertility-sparing surgery to differentiate among benign, borderline, low-grade tumors and invasive cancers • In a poor surgical candidate, to support surveillance if the lesion has an O-RADS MRI category of 2 or 3 and nonsurgical assessment and treatment of cancer if the lesion has an O-RADS MRI category of 4 or 5
Incompletely visualized lesion on ultrasound	0	Complete visualization of the lesion to assess the risk of malignancy	Classification of the lesion as O-RADS MRI category 1 through 5 to guide further management
Nonsimple unilocular cyst in postmenopausal patient	2	Assess for any solid tissue to exclude malignancy because postmenopausal patients should not have hemorrhagic or proteinaceous cysts and the risk of a neoplasm in this scenario is increased	Classification of O-RADS MRI category 2 or 3 supports continued surveillance or nononcologic surgical consultation Classification as O-RADS MRI category 4 or 5 supports gynecologic oncologic surgical consultation for further management
O-RADS US category 3 and 4 adnexal lesions	3 or 4	Assessment of fluid content and of any solid tissue	Classification as O-RADS MRI category 2 or 3 supports conservative management Classification as O-RADS MRI category 4 or 5 supports gynecologic oncologic surgical consultation for further management

Note—O-RADS = Ovarian-Adnexal Reporting and Data System.

38–40]. This need for specific assessment depends on the patient's age, clinical scenario, and desire for a nonsurgical or limited surgical resection for fertility preservation or other health reasons. Even when a lesion is assessed as O-RADS US category 5 (PPV, > 50%), MRI may be helpful, particularly in young patients and in patients who would like to avoid surgery. In a multicenter study, investigators noted that although 62% of O-RADS US category 5 lesions were cancer, 22% of lesions were physiologic findings or endometriomas and 16% were benign neoplasms (dermoid cysts or cystadenomas) [44]. MRI can potentially downgrade the lesion if the lesion has no enhancement or has classic benign features (e.g., fat or endometriotic fluid). This added information helps the referring physician decide to continue to monitor the lesion by imaging in the case of a lesion with benign features versus potentially consider surgery if cancer is suspected. In addition to specific clinical scenarios, MRI may be helpful when an adnexal lesion is incompletely visualized on US, is a nonsimple unilocular cyst in a postmenopausal patient, or is scored as O-RADS US category 3 or 4.

These patients may benefit from evaluation by MRI, because MRI may downgrade the lesion to an O-RADS MRI category 2, allowing conservative management, or may upgrade the lesion to having a higher PPV for cancer, prompting referral to a gynecologic oncologist. Table 1 describes specific scenarios in which this expert panel considers MRI an appropriate next step after US in the evaluation of an adnexal lesion.

Incompletely Visualized Lesion on Ultrasound

When an adnexal lesion is not well seen on US, it is scored as O-RADS US category 0. Inadequate evaluation of the adnexa may occur as a result of artifacts from bowel or a leiomyomatous uterus or in the setting of a large adnexal lesion (> 10 cm). MRI can be helpful in these cases because of the modality's large FOV and multiplanar capabilities (Fig. 3). Furthermore, MRI can assess the composition of the fluid (e.g., simple, lipid, endometriotic, hemorrhagic, or proteinaceous) as well as the presence of enhancing solid tissue. This assessment of the lesion's fluid and solid components allows classification of the lesion into O-RADS MRI categories 2 through 5. In the setting of a large lesion, the multiplanar capabilities of MRI allow examination of the entire lesion. Lastly, approximately 10% of adnexal lesions referred for MRI from US are found to be nonovarian, and MRI can classify the lesion origin with an accuracy of 93% [8].

Nonsimple Unilocular Cyst in Postmenopausal Patients

When a lesion discovered on US is diagnosed as benign (O-RADS US category 2), the referring physician and, more importantly, the patient can be reassured that the risk of malignancy is less than 1% [5]. In these patients, correlation should be made with clinical history and laboratory assessment, and the management recommendations provided in the O-RADS US risk score table should be followed [8]. However, MRI may be considered for further evaluation of an O-RADS US category 2 lesion when assigned in a postmenopausal patient with a nonsimple unilocular cyst that has a smooth inner margin. In this scenario, MRI can potentially upgrade or downgrade the lesion, which would help the referring clinician and patient decide between following the lesion versus proceeding with surgical evaluation. If MRI shows no enhancement of the lesion, there is essentially no chance of cancer; if MRI shows wall enhancement or tiny internal papillary projections, then the chance of cancer will depend on the lesion's O-RADS MRI category (O-RADS MRI category 3: 5%; category 4: 50%; category 5: 90%).

O-RADS Ultrasound Category 3 and 4 Lesions

MRI can also be used to further assess lesions assigned O-RADS US category 3 (PPV, < 10%) or category 4 (PPV, 10–49%). The diagnosis is uncertain for lesions assigned these O-RADS US categories given the overlapping appearance of benign and malignant lesions on US. A lesion that is not clearly benign or is at high risk for malignancy on US may be a benign neoplasm, such as a cystadenoma, dermoid cyst, or fibroma, or may be a follicle, corpus luteum, or proteinaceous or hemorrhagic cyst [13, 14, 18, 44] (Figs. 4 and 5). In a multicenter study of more than 900 patients evaluated by US in radiology departments, 68% of O-RADS US category 3 lesions and 48% of O-RADS US category 4 lesions were physiologic findings or endometriomas on follow-up imaging [44]. Superior characterization of fluid and soft tissue and the use of contrast media increase the specificity of MRI for benign diagnoses such that MRI may downgrade O-RADS US category 3 and 4 lesions to a physiologic finding or other classic benign lesion. MRI may also upgrade an O-RADS US category 3 or 4 lesion when the lesion on MRI shows solid enhancing tissue with intermediate or high signal on T2-weighted imaging or DWI. Furthermore, MRI can be specific in the diagnosis of the underlying histopathology when certain features are present (Fig. 5). In a patient of childbearing age, this information from MRI can be used to decide to pursue surveillance for a lesion suspected to be benign, possible fertility-sparing surgery for a lesion suspected to be a benign neoplasm or a borderline or low-grade tumor, or complete oncologic surgical resection for a lesion suspected to be invasive cancer. In a patient who is a poor surgical candidate, the information from MRI can be used to decide to pursue surveillance for an O-RADS MRI category 2 or 3 lesion versus nonsurgical assessment and treatment of cancer for an O-RADS MRI category 4 or 5 lesion.

How to Evaluate Adnexal Lesions on MRI After Ultrasound

MRI of an adnexal lesion should be performed on a 1.5-T or 3-T scanner using a multiparametric approach. Optimizing MR images includes both patient preparation and technical considerations. Patient preparation includes fasting for 4–6 hours before the examination, use of an antiperistaltic agent, and instruction to void within 30 minutes before imaging. Technical considerations include selection of sequences to properly assess an adnexal finding for fluid and solid components. Required sequences include axial in- and opposed-phase T1-weighted images, T2-weighted images in two planes (e.g., axial and sagittal), postcontrast T1-weighted images, and DWI (using b ≥ 1000 s/mm^2) (Table 2). Protocols should include a fat-saturated and non–fat-saturated set of either T1-weighted or T2-weighted sequences to depict macroscopic fat within lesions. This set of sequences is in addition to the in- and opposed-phase T1-weighted sequences that depict microscopic fat. Lesion size should be considered when prescribing the sequence's slice orientation and FOV to ensure complete lesion coverage. The T2-weighted and postcontrast T1-weighted sequences should use a slice thickness of 3 mm or less to depict small papillary projections within ovarian neoplasms.

TABLE 2: MRI Protocol for Adnexal Mass Characterization at 1.5- or 3-T MRI

Sequence	Dimensions	Plane	Fat Saturated	Contrast Media	Comments
T2W	2D	Sagittal	No	No	Slice thickness: 4 mm or less
T2W	2D	Axial	No	No	Slice thickness: 3 mm or less
T1W	2D	Axial	No	No	In phase and opposed phase Slice thickness: 4 mm or less
T1W	3D[a] (dynamic)	Optimal plane for coverage of lesion and visualization of the uterus	Yes	Yes	Multiple phases for a total imaging duration of approximately 4 min Begin the scanning and inject at 30 s without interruption of scan acquisition Slice thickness: 3 mm or less
T1W	3D[a] (not dynamic)	Optimal plane for coverage of lesion and visualization of the uterus	Yes	Yes	Precontrast and single postcontrast phase scanned at 30–40 s after the end of the contrast material injection Slice thickness: 3 mm or less
DWI	2D	Axial	Yes	No	Similar location as T2-weighted image Section thickness: 4 mm or less b = 0–50 and 1000 s/mm^2 or greater

Note—Scanning parameters should be adjusted according to field strength and vendor for optimum image quality. FOV may vary according to patient-related considerations and size of the adnexal lesion. T2W = T2-weighted imaging, T1W = T1-weighted imaging.

[a]Three-dimensional dynamic dynamic contrast-enhanced T1-weighted image series is recommended for optimal evaluation and increased specificity. A nondynamic scan can be used in place of the dynamic scan; however, specificity for cancer will decrease.

A dynamic contrast-enhanced perfusion sequence is recommended for the postcontrast imaging to allow evaluation of time-intensity curves and assist in risk stratification [31]. This dynamic sequence requires a temporal resolution per phase of 15 seconds or less. From the dynamic contrast-enhanced acquisition, time-intensity curves for the lesion and the myometrium can be generated using commercially available software, including the software packages used for kinetic analysis in breast or prostate MRI. If the dynamic contrast-enhanced series is not performed, then a precontrast sequence and a single postcontrast sequence acquired at 30–40 seconds after the end of the contrast material injection can be performed. However, without a dynamic series, lesions with nonfibrous solid tissue components can only be classified as O-RADS MRI category 4 or 5 because of the inability to show a low-risk time-intensity curve (O-RADS MRI category 3) [31]. Subtraction sequences should be routinely generated to assess for enhancement in lesions with T1-hyperintense content.

Future Direction

The potential value of performing MRI after US for the assessment of adnexal lesions provides numerous opportunities for further investigation. First, quantitative analyses of DWI data may show the role of ADC thresholds or other quantitative DWI parameters in substratifying adnexal lesions [30]. Second, although time-intensity curves have been shown to improve the stratification of lesions as having a low, intermediate, or high risk for cancer, future studies could address how this stratification affects patient referral patterns [31]. Third, large cohort studies could explore the impact of using the O-RADS risk stratification systems to select between surveillance and surgery and how this stratification affects patient outcomes and costs. Such additional data will provide evidence to guide the further refinement of the O-RADS US and MRI risk stratification systems and better understand the benefit of performing MRI after US for the evaluation of adnexal lesions.

Consensus Statements

- MRI is valuable in the characterization and risk assessment of adnexal lesions discovered on US when there is a clinical need for improved specificity for malignancy and a need to differentiate benign and borderline/low-grade tumors from high-grade cancer (e.g., patients considering fertility-sparing surgery or who are poor surgical candidates).
- In addition to O-RADS US category 0, 3, and 4 lesions, O-RADS US category 2 and 5 lesions may also benefit from MRI evaluation in certain settings, including potentially downgrading or upgrading the risk category in a patient who is a poor surgical candidate or excluding high-grade tumor in a patient seeking fertility-sparing treatments.
- MRI of an adnexal lesion should be performed on a 1.5-T or 3-T scanner using a multiparametric protocol that includes a precontrast axial in- and opposed-phase T1-weighted sequence, precontrast T2-weighted sequence in two planes, fat-saturated and non–fat-saturated T1- or T2-weighted sequences, DWI with a b value of 1000 s/mm^2 or greater, and a postcontrast dynamic contrast-enhanced T1-weighted series with subtraction images and time-intensity curve analysis.

Provenance and review: Solicited; externally peer reviewed.

References

1. Levine D, Brown DL, Andreotti RF, et al.; Society of Radiologists in Ultrasound. Management of asymptomatic ovarian and other adnexal cysts imaged at US Society of Radiologists in Ultrasound consensus conference statement. *Ultrasound Q* 2010; 26:121–131
2. Timmerman D, Ameye L, Fischerova D, et al. Simple ultrasound rules to dis-

tinguish between benign and malignant adnexal masses before surgery: prospective validation by IOTA group. *BMJ* 2010; 341:c6839

3. Amor F, Alcázar JL, Vaccaro H, León M, Iturra A. GI-RADS reporting system for ultrasound evaluation of adnexal masses in clinical practice: a prospective multicenter study. *Ultrasound Obstet Gynecol* 2011; 38:450–455
4. Andreotti RF, Timmerman D, Benacerraf BR, et al. Ovarian-adnexal reporting lexicon for ultrasound: a white paper of the ACR Ovarian-Adnexal Reporting and Data System committee. *J Am Coll Radiol* 2018; 15:1415–1429
5. Andreotti RF, Timmerman D, Strachowski LM, et al. O-RADS US risk stratification and management system: a consensus guideline from the ACR Ovarian-Adnexal Reporting and Data System Committee. *Radiology* 2020; 294:168–185
6. Reinhold C, Rockall A, Sadowski EA, et al. Ovarian-adnexal reporting lexicon for MRI: a white paper of the ACR Ovarian-Adnexal Reporting and Data Systems MRI committee. *J Am Coll Radiol* 2021; 18:713–729
7. Sadowski EA, Thomassin-Naggara I, Rockall A, et al. O-RADS MRI risk stratification system: guide for assessing adnexal lesions from the ACR O-RADS Committee. *Radiology* 2022; 303:35–47
8. Thomassin-Naggara I, Poncelet E, Jalaguier-Coudray A, et al. Ovarian-Adnexal Reporting Data System Magnetic Resonance Imaging (O-RADS MRI) score for risk stratification of sonographically indeterminate adnexal masses. *JAMA Netw Open* 2020; 3:e1919896
9. Atri M, Alabousi A, Reinhold C, et al.; Expert Panel on Women's Imaging. ACR Appropriateness Criteria clinically suspected adnexal mass, no acute symptoms. *J Am Coll Radiol* 2019; 16(5S):S77–S93
10. Forstner R, Thomassin-Naggara I, Cunha TM, et al. ESUR recommendations for MR imaging of the sonographically indeterminate adnexal mass: an update. *Eur Radiol* 2017; 27:2248–2257
11. Glanc P, Benacerraf B, Bourne T, et al. First international consensus report on adnexal masses: management recommendations. *J Ultrasound Med* 2017; 36:849–863
12. Kaijser J, Vandecaveye V, Deroose CM, et al. Imaging techniques for the pre-surgical diagnosis of adnexal tumours. *Best Pract Res Clin Obstet Gynaecol* 2014; 28:683–695
13. Maturen KE, Blaty AD, Wasnik AP, et al. Risk stratification of adnexal cysts and cystic masses: clinical performance of Society of Radiologists in Ultrasound guidelines. *Radiology* 2017; 285:650–659
14. Patel-Lippmann KK, Sadowski EA, Robbins JB, et al. Comparison of International Ovarian Tumor Analysis simple rules to Society of Radiologists in Ultrasound guidelines for detection of malignancy in adnexal cysts. *AJR* 2020; 214:694–700
15. Suh-Burgmann E, Flanagan T, Osinski T, Alavi M, Herrinton L. Prospective validation of a standardized ultrasonography-based ovarian cancer risk assessment system. *Obstet Gynecol* 2018; 132:1101–1111
16. Basha MAA, Abdelrahman HM, Metwally MI, et al. Validity and reproducibility of the ADNEX MR scoring system in the diagnosis of sonographically indeterminate adnexal masses. *J Magn Reson Imaging* 2021; 53:292–304
17. Cao L, Wei M, Liu Y, et al. Validation of American College of Radiology Ovarian-Adnexal Reporting and Data System Ultrasound (O-RADS US): analysis on 1054 adnexal masses. *Gynecol Oncol* 2021; 162:107–112
18. Gupta A, Jha P, Baran TM, et al. Ovarian cancer detection in average-risk women: classic- versus nonclassic-appearing adnexal lesions at US. *Radiology* 2022; 303:603–610
19. Hack K, Gandhi N, Bouchard-Fortier G, et al. External validation of O-RADS US risk stratification and management system. *Radiology* 2022; 304:114–120
20. Adusumilli S, Hussain HK, Caoili EM, et al. MRI of sonographically indeterminate adnexal masses. *AJR* 2006; 187:732–740
21. Anthoulakis C, Nikoloudis N. Pelvic MRI as the "gold standard" in the subsequent evaluation of ultrasound-indeterminate adnexal lesions: a systematic review. *Gynecol Oncol* 2014; 132:661–668
22. Kaijser J, Sayasneh A, Van Hoorde K, et al. Presurgical diagnosis of adnexal tumours using mathematical models and scoring systems: a systematic review and meta-analysis. *Hum Reprod Update* 2014; 20:449–462
23. Kinkel K, Lu Y, Mehdizade A, Pelte MF, Hricak H. Indeterminate ovarian mass at US: incremental value of second imaging test for characterization—meta-analysis and Bayesian analysis. *Radiology* 2005; 236:85–94
24. Nunes N, Ambler G, Foo X, Naftalin J, Widschwendter M, Jurkovic D. Use of IOTA simple rules for diagnosis of ovarian cancer: meta-analysis. *Ultrasound Obstet Gynecol* 2014; 44:503–514
25. Pereira PN, Sarian LO, Yoshida A, et al. Improving the performance of IOTA simple rules: sonographic assessment of adnexal masses with resource-effective use of a magnetic resonance scoring (ADNEX MR scoring system). *Abdom Radiol (NY)* 2020; 45:3218–3229
26. Aslan S, Tosun SA. Diagnostic accuracy and validity of the O-RADS MRI score based on a simplified MRI protocol: a single tertiary center retrospective study. *Acta Radiol* 2021 Nov 29 [published online]
27. Assouline V, Dabi Y, Jalaguier-Coudray A, et al.; EURAD study group. How to improve O-RADS MRI score for rating adnexal masses with cystic component? *Eur Radiol* 2022; 32:5943–5953
28. Bang JI, Kim JY, Choi MC, Lee HY, Jang SJ. Application of multimodal imaging biomarker in the differential diagnosis of ovarian mass: integration of conventional and molecular imaging. *Clin Nucl Med* 2022; 47:117–122
29. Basha MAA, Abdelrahman HM, Metwally MI, et al. Validity and reproducibility of the ADNEX MR scoring system in the diagnosis of sonographically indeterminate adnexal masses. *J Magn Reson Imaging* 2021; 53:292–304
30. Hottat NA, Badr DA, Van Pachterbeke C, et al. Added value of quantitative analysis of diffusion-weighted imaging in Ovarian-Adnexal Reporting and Data System magnetic resonance imaging. *J Magn Reson Imaging* 2022; 56:158–170
31. Wengert GJ, Dabi Y, Kermarrec E, et al.; EURAD Study Group. O-RADS MRI classification of indeterminate adnexal lesions: time-intensity curve analysis is better than visual assessment. *Radiology* 2022; 303:566–575
32. Taylor EC, Irshaid L, Mathur M. Multimodality imaging approach to ovarian neoplasms with pathologic correlation. *RadioGraphics* 2021; 41:289–315
33. Li K, Song F, Yu L, Shi H, Wang J, Cheng X. Role of MRI in characterizing serous borderline ovarian tumor and its subtypes: correlation of MRI features with clinicopathological characteristics. *Eur J Radiol* 2022; 147:110112
34. Togashi K, Nishimura K, Kimura I, et al. Endometrial cysts: diagnosis with MR imaging. *Radiology* 1991; 180:73–78
35. Shim SH, Kim SN, Jung PS, Dong M, Kim JE, Lee SJ. Impact of surgical staging on prognosis in patients with borderline ovarian tumours: a meta-analysis. *Eur J Cancer* 2016; 54:84–95
36. Zhou J, Wu SG, Wang J, et al. The effect of histological subtypes on outcomes of stage IV epithelial ovarian cancer. *Front Oncol* 2018; 8:577
37. Trimbos JB. Surgical treatment of early-stage ovarian cancer. *Best Pract Res Clin Obstet Gynaecol* 2017; 41:60–70
38. McEvoy SH, Nougaret S, Abu-Rustum NR, et al. Fertility-sparing for young patients with gynecologic cancer: how MRI can guide patient selection prior to conservative management. *Abdom Radiol (NY)* 2017; 42:2488–2512
39. Morice P, Denschlag D, Rodolakis A, et al. Recommendations of the Fertility Task Force of the European Society of Gynecologic Oncology about the conservative management of ovarian malignant tumors. *Int J Gynecol Cancer* 2011; 21:951–963
40. Rockall AG, Qureshi M, Papadopoulou I, et al. Role of imaging in fertility-sparing treatment of gynecologic malignancies. *RadioGraphics* 2016; 36:2214–2233
41. Stein EB, Hansen JM, Maturen KE. Fertility-sparing approaches in gynecologic oncology: role of imaging in treatment planning. *Radiol Clin North Am* 2020; 58:401–412
42. Baack Kukreja J, Bathala TK, Reichard CA, et al. Impact of preoperative prostate magnetic resonance imaging on the surgical management of high-risk prostate cancer. *Prostate Cancer Prostatic Dis* 2020; 23:172–178
43. Mercado C, Zingmond D, Karlan BY, et al. Quality of care in advanced ovarian cancer: the importance of provider specialty. *Gynecol Oncol* 2010; 117:18–22
44. Jha P, Gupta A, Baran TM, et al. Diagnostic performance of the Ovarian-Adnexal Reporting and Data System (O-RADS) ultrasound risk score in women in the United States. *JAMA Netw Open* 2022; 5:e2216370

(Figures start on next page)

O-RADS Ultrasound Risk Stratification and Management System

O-RADS Score	Risk Category [IOTA Model]	Lexicon Descriptors		Management: Pre-menopausal	Management: 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 on next page 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-<10%]	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 gyn-oncologist consultation or solely by gyn-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		Gyn-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**			

CS=color score; GYN = gynecologic; IOTA = International Ovarian Tumor Analysis; N/A = not applicable
* At a minimum, 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 for surveillance.
**Presence of ascites with category 1-2 lesion, must consider other malignant or non-malignant etiologies of ascites

Fig. 1— Ovarian-Adnexal Reporting and Data System (O-RADS) ultrasound (US) guidance. Material is reproduced without modification with permission from American College of Radiology (©American College of Radiology; www.acr.org/-/media/ACR/Files/RADS/O-RADS/O-RADS_US-Risk-Stratification-Table.pdf), pursuant to Creative Commons BY-NC-ND license and terms contained therein (creativecommons.org/licenses/by-nc-nd/4.0/legalcode), including disclaimer in Section 5.
A, Image shows official O-RADS US risk stratification table.

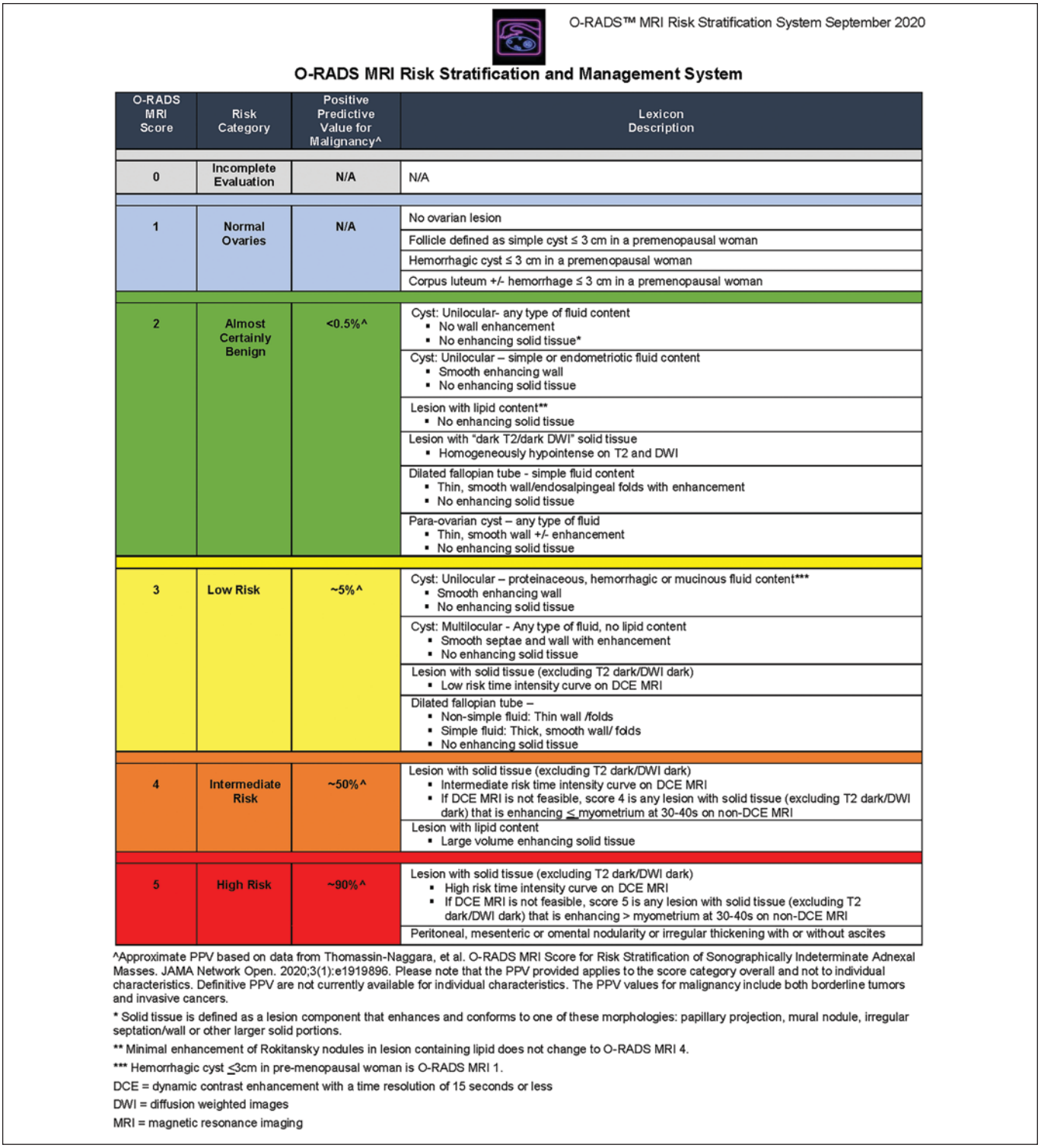
(Fig. 1 continues on next page)

O-RADS Ultrasound Risk Stratification and Management System
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 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 then 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 then 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

*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.

Fig. 1 (continued)— Ovarian-Adnexal Reporting and Data System (O-RADS) ultrasound (US) guidance. Material is reproduced without modification with permission from American College of Radiology (©American College of Radiology; www.acr.org/-/media/ACR/Files/RADS/O-RADS/O-RADS_US-Risk-Stratification-Table.pdf), pursuant to Creative Commons BY-NC-ND license and terms contained therein (creativecommons.org/licenses/by-nc-nd/4.0/legalcode), including disclaimer in Section 5.
B, Image shows supplementary table for classic benign lesions.



O-RADS™ MRI Risk Stratification System September 2020

O-RADS MRI Risk Stratification and Management System

O-RADS MRI Score	Risk Category	Positive Predictive Value for Malignancy^	Lexicon Description
0	Incomplete Evaluation	N/A	N/A
1	Normal Ovaries	N/A	No ovarian lesion
			Follicle defined as simple cyst ≤ 3 cm in a premenopausal woman
			Hemorrhagic cyst ≤ 3 cm in a premenopausal woman
			Corpus luteum +/- hemorrhage ≤ 3 cm in a premenopausal woman
2	Almost Certainly Benign	<0.5%^	Cyst: Unilocular- any type of fluid content ▪ No wall enhancement ▪ No enhancing solid tissue*
			Cyst: Unilocular – simple or endometriotic fluid content ▪ Smooth enhancing wall ▪ No enhancing solid tissue
			Lesion with lipid content** ▪ No enhancing solid tissue
			Lesion with "dark T2/dark DWI" solid tissue ▪ Homogeneously hypointense on T2 and DWI
			Dilated fallopian tube - simple fluid content ▪ Thin, smooth wall/endosalpingeal folds with enhancement ▪ No enhancing solid tissue
			Para-ovarian cyst – any type of fluid ▪ Thin, smooth wall +/- enhancement ▪ No enhancing solid tissue
3	Low Risk	~5%^	Cyst: Unilocular – proteinaceous, hemorrhagic or mucinous fluid content*** ▪ Smooth enhancing wall ▪ No enhancing solid tissue
			Cyst: Multilocular - Any type of fluid, no lipid content ▪ Smooth septae and wall with enhancement ▪ No enhancing solid tissue
			Lesion with solid tissue (excluding T2 dark/DWI dark) ▪ Low risk time intensity curve on DCE MRI
			Dilated fallopian tube – ▪ Non-simple fluid: Thin wall /folds ▪ Simple fluid: Thick, smooth wall/ folds ▪ No enhancing solid tissue
4	Intermediate Risk	~50%^	Lesion with solid tissue (excluding T2 dark/DWI dark) ▪ Intermediate risk time intensity curve on DCE MRI ▪ If DCE MRI is not feasible, score 4 is any lesion with solid tissue (excluding T2 dark/DWI dark) that is enhancing ≤ myometrium at 30-40s on non-DCE MRI
			Lesion with lipid content ▪ Large volume enhancing solid tissue
5	High Risk	~90%^	Lesion with solid tissue (excluding T2 dark/DWI dark) ▪ High risk time intensity curve on DCE MRI ▪ If DCE MRI is not feasible, score 5 is any lesion with solid tissue (excluding T2 dark/DWI dark) that is enhancing > myometrium at 30-40s on non-DCE MRI
			Peritoneal, mesenteric or omental nodularity or irregular thickening with or without ascites

^Approximate PPV based on data from Thomassin-Naggara, et al. O-RADS MRI Score for Risk Stratification of Sonographically Indeterminate Adnexal Masses. JAMA Network Open. 2020;3(1):e1919896. Please note that the PPV provided applies to the score category overall and not to individual characteristics. Definitive PPV are not currently available for individual characteristics. The PPV values for malignancy include both borderline tumors and invasive cancers.

* Solid tissue is defined as a lesion component that enhances and conforms to one of these morphologies: papillary projection, mural nodule, irregular septation/wall or other larger solid portions.

** Minimal enhancement of Rokitansky nodules in lesion containing lipid does not change to O-RADS MRI 4.

*** Hemorrhagic cyst ≤3cm in pre-menopausal woman is O-RADS MRI 1.

DCE = dynamic contrast enhancement with a time resolution of 15 seconds or less

DWI = diffusion weighted images

MRI = magnetic resonance imaging

Fig. 2—Image shows Ovarian-Adnexal Reporting and Data System (O-RADS) MRI risk stratification table. Terms "dark T2/dark DWI" and "T2 dark/DWI dark" indicate solid tissue that is homogeneously hypointense on T2-weighted imaging and DWI. N/A = not applicable. Material is reproduced without modification with permission from American College of Radiology (©American College of Radiology www.acr.org/-/media/ACR/Files/RADS/O-RADS/O-RADS-MR-Risk-Stratification-System-Table-September-2020.pdf), pursuant to Creative Commons BY-NC-ND license and terms contained therein (creativecommons.org/licenses/by-nc-nd/4.0/legalcode), including disclaimer in Section 5.

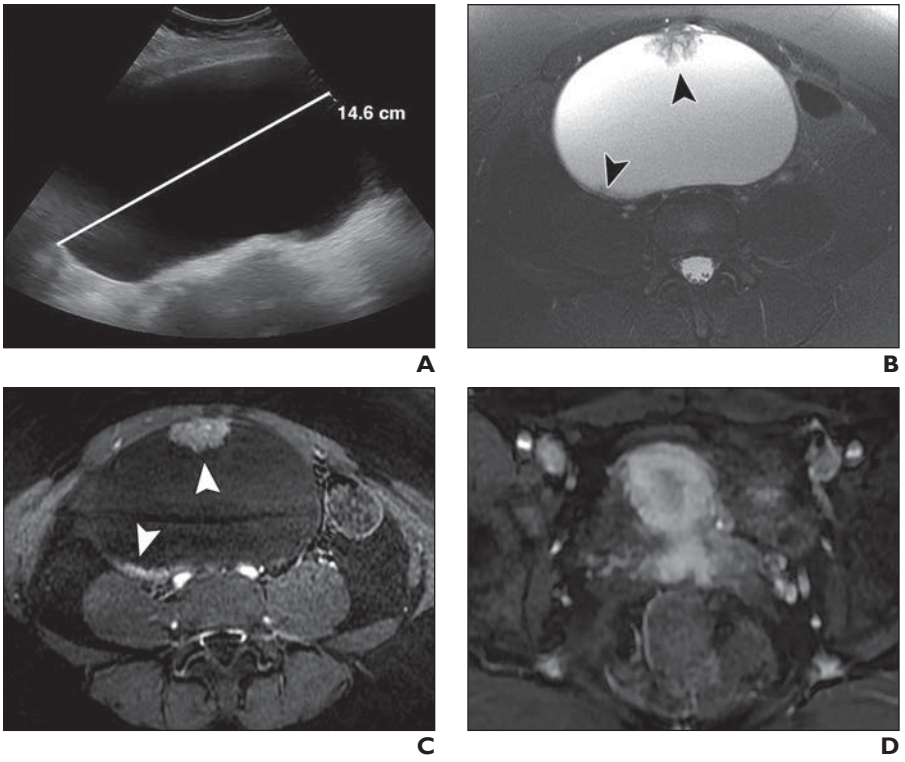


Fig. 3—25-year-old woman with adnexal lesion.
A, Transabdominal gray-scale ultrasound (US) image shows simple-appearing cyst measuring 14.6 cm (*line*). Visualized portions show no obvious solid components. Cyst was classified as Ovarian-Adnexal Reporting and Data System (O-RADS) US category 0 because of size and reverberation artifact along right lateral and anterior portions of lesion. MRI was performed 2 weeks after ultrasound.
B, Axial T2-weighted MR image shows papillary projection along anterior wall and smaller papillary projection along posterior wall (*arrowheads*).
C, Axial postcontrast T1-weighted MR image shows enhancement of papillary projections (*arrowheads*).
D, Axial postcontrast T1-weighted MR image shows enhancement of myometrium. Enhancement of papillary projection was less than or equal to enhancement of myometrium. Lesion was classified as O-RADS MRI category 4. Final surgical pathology was serous borderline tumor.

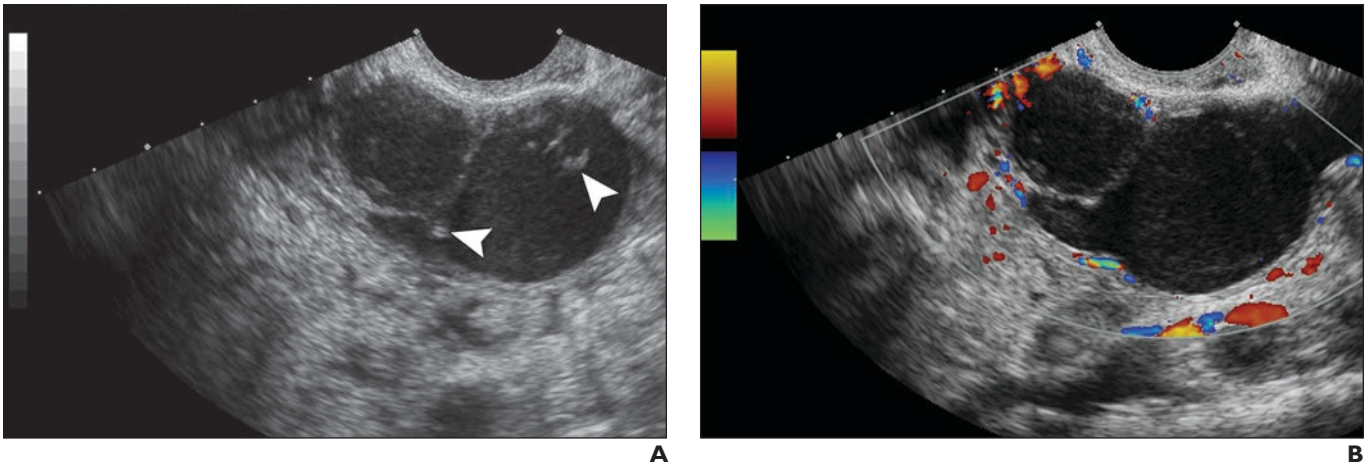
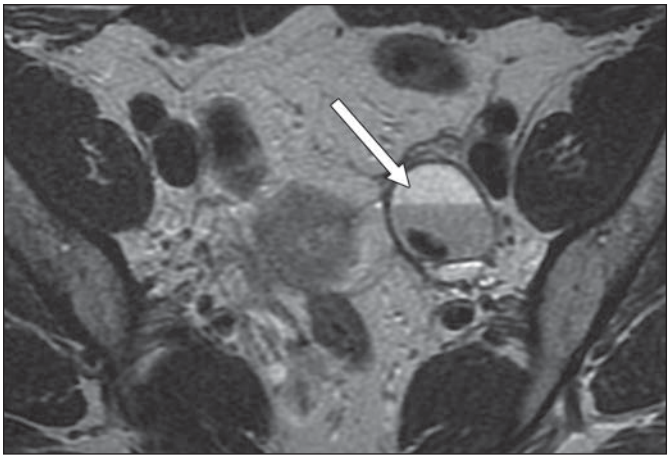
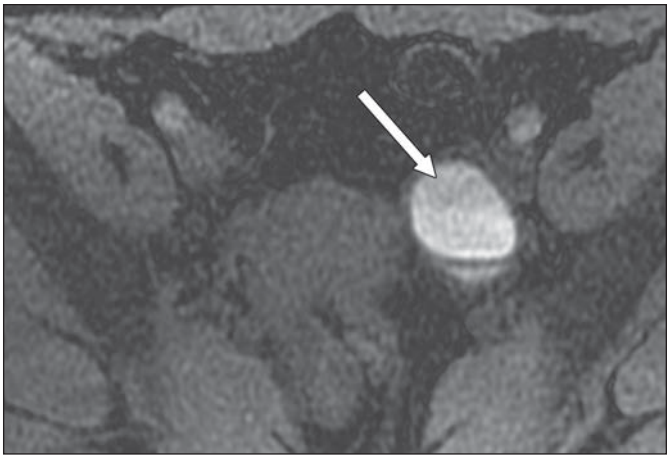


Fig. 4—52-year-old woman with left adnexal lesion.
A, Gray-scale ultrasound (US) image shows multilocular cyst with irregular septation and nodules (*arrowheads*).
B, Color Doppler US image shows no flow in irregular septation or in any other portion of lesion. Ovarian-Adnexal Reporting and Data System (O-RADS) US category was 4. MRI was performed for further evaluation.

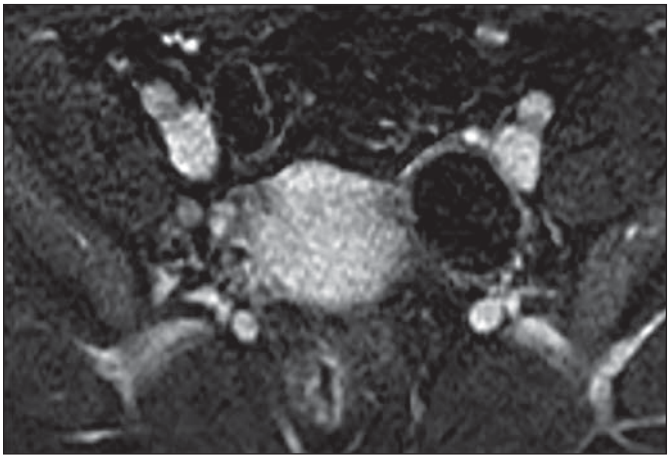
(Fig. 4 continues on next page)



C

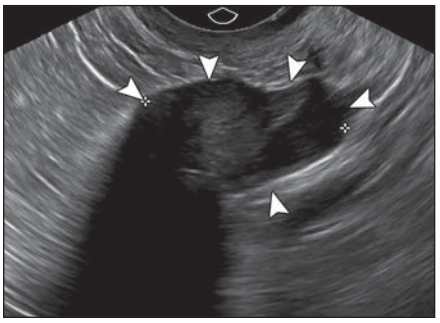


D

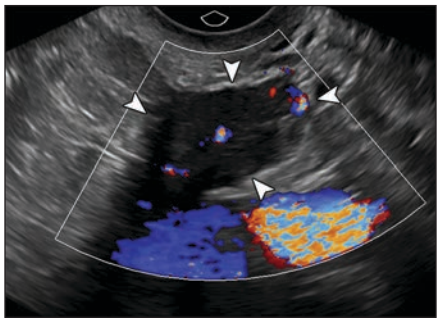


E

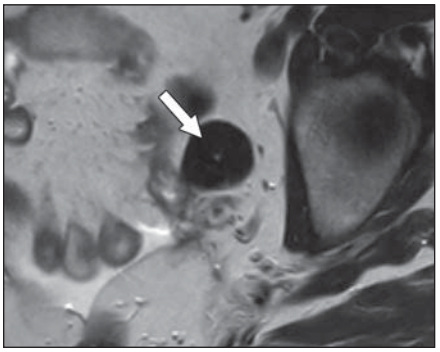
Fig. 4 (continued)—52-year-old woman with left adnexal lesion.
C, Axial T2-weighted MR image shows layering blood products of varying signal intensity in lesion (*arrow*).
D, Axial fat-saturated T1-weighted MR image shows layering blood products of varying hyperintense signal intensity in lesion (*arrow*).
E, Subtracted axial postcontrast T1-weighted MR image shows no internal enhancement in left adnexal lesion. O-RADS MRI category was 2. Final surgical pathology was endometrioma.



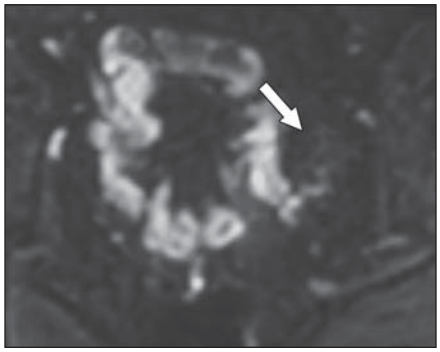
A



B



C



D

Fig. 5—50-year-old woman with right adnexal lesion.
A, Gray-scale ultrasound (US) image shows solid lesion (*arrowheads*) with lobular outer contour. Crosses indicate edges of lesion.
B, Color Doppler ultrasound image shows flow in solid lesion (*arrowheads*). Ovarian-Adnexal Reporting and Data System (O-RADS) US category was 5. MRI was performed for further characterization.
C, Axial T2-weighted MR image shows homogeneous hypointensity of lesion (*arrow*).
D, Axial DWI (b = 1200 s/mm^2) shows homogeneous hypointensity of lesion (*arrow*). Lesion is likely fibroma and consistent with description of hypointensity on T2-weighted imaging and DWI ("dark T2/dark DWI") in O-RADS MRI. Such lesions are assessed as O-RADS MRI category 2, and enhancement-related findings do not contribute to category assessment. Patient was managed nonoperatively.