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Imaging in Adnexal Mass Evaluation: Review Article

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Abstract:

Background: Adnexal lesions are frequently encountered in radiological practice and encompass a broad spectrum of benign, borderline, and malignant conditions. Accurate imaging characterization is essential to prevent unnecessary surgery for benign lesions while ensuring timely referral of patients with suspected malignancy to gynecologic oncology services. Ultrasonography (US) remains the first-line imaging modality because of its accessibility, absence of ionizing radiation, and ability to assess lesion morphology and vascularity. Standardized systems such as O-RADS US and predictive tools such as the IOTA ADNEX model improve risk stratification; however, diagnostic performance may vary according to operator experience, patient population, and the presence of atypical benign features that overlap with malignancy. Magnetic resonance imaging (MRI) provides valuable problem-solving information for indeterminate, large, or complex adnexal lesions by characterizing tissue composition, enhancement, and diffusion features. It can reduce false-positive US findings, improve diagnostic specificity, support histologic subtype prediction, and guide appropriate surgical planning. This narrative review summarizes the current roles, strengths, and limitations of US, the ADNEX model, and MRI in evaluating adnexal lesions, with emphasis on imaging-based risk assessment and their complementary contribution to individualized patient management.

Keywords: Adnexal lesions; Ultrasonography; Magnetic resonance imaging; O-RADS; IOTA ADNEX model; Ovarian neoplasms.

Introduction:

Adnexal lesions are commonly encountered in daily radiology practice with an estimated prevalence of 4–18% in the general population. The management of adnexal lesions varies based on the imaging appearance and clinical picture **(1).**

The importance of accurately characterizing adnexal lesions on imaging is to help avoid inappropriate surgery in benign lesions and triage suspected cancers to a gynecological oncologist. The treatment options for ovarian cancer have expanded given recent morphological and molecular studies which have led to the realization that ovarian cancer is a heterogeneous group of tumors and that treatments need to be tailored to the specific subtype for the best clinical outcomes. For example, preoperative counseling may be needed in younger patients desiring fertility sparing surgery if the lesion is suspected to be a borderline tumor or possible benign ovarian neoplasm **(2).**

US Imaging of Adnexal Lesions

The initial imaging modality of choice for assessing the adnexa in patients of all age groups is US (Table 1). All US-based scoring systems, including the O-RADS US risk score, should only be used in the nonacute setting, as acute processes such as torsion, tubo-ovarian abscess, and decidualized endometrioma can cause false-positive interpretations on US images. At US, simple cysts (Fig 1A), endometriomas (Fig 1B), hemorrhagic cysts (Fig 1C), and dermoid cysts smaller than 10 cm (Fig 1D) are considered very low-risk lesions, with a cancer risk of less than 1%. When lesions are larger than 10 cm, have irregular or thickened septations and/or walls, contain

papillary projections or mural nodules, or are solid, there is an increased risk of malignancy, particularly if there is Doppler flow documented within the solid components **(3).**

Recent large retrospective multicenter studies testing the diagnostic performance of the O-RADS US risk score, in both referral-based practices and nonselected populations, show that the scoring system has sensitivities greater than 90% for the detection of cancer. When a lesion can be characterized as a classically appearing simple cyst, hemorrhagic cyst, dermoid cyst, or endometrioma, the negative predictive values are 99%. These high sensitivities and negative predictive values for cancer have also been documented for other US-based risk assessment algorithms based on US imaging features **(4).**

Table 1: Current Indications, Strengths, Limitations, and Assessment Guidelines for Imaging Adnexal Lesions according to Modality **(1).**

Factor	US	CT	MRI
Indications	Initial assessment of adnexal lesions	Primarily for metastatic disease assessment in suspected or known ovarian cancer; however, can be used to assess some incidentally discovered adnexal lesions	Secondary assessment of adnexal lesions when a more specific diagnosis is required
Strengths	Simple cysts, hemorrhagic cysts, endometriomas, and dermoid cysts have <1% risk of cancer; solid lesions with very strong vascular flow or with irregular borders, as well as lesions with more than four solid components, have ≥50% risk of cancer	Simple cysts and dermoid cysts can be confidently diagnosed	Simple cysts, hemorrhagic cysts, endometriomas, and dermoid cysts have <0.5% risk of cancer; lesions with solid tissue and a high-risk time-intensity curve have >90% risk of cancer
Limitations	Inability to accurately distinguish between solid-appearing blood clot and/or debris and solid tissue within a tumor; operator-dependent, with decreased predictive value for cancer when US is not performed by a physician with expertise in gynecologic imaging	Inability to distinguish high-attenuating material from enhancing solid tissue on a single-phase image	Diagnostic accuracy depends on proper MRI protocols; patients may not be able to undergo MRI due to implanted metal or claustrophobia
Assessment guidelines	O-RADS US risk assessment score	Management of Incidental Adnexal Findings on CT and MRI: A White Paper of the ACR Incidental Findings Committee (24)	O-RADS MRI risk assessment score

Note.—ACR = American College of Radiology, O-RADS = Ovarian-Adnexal Reporting and Data System.

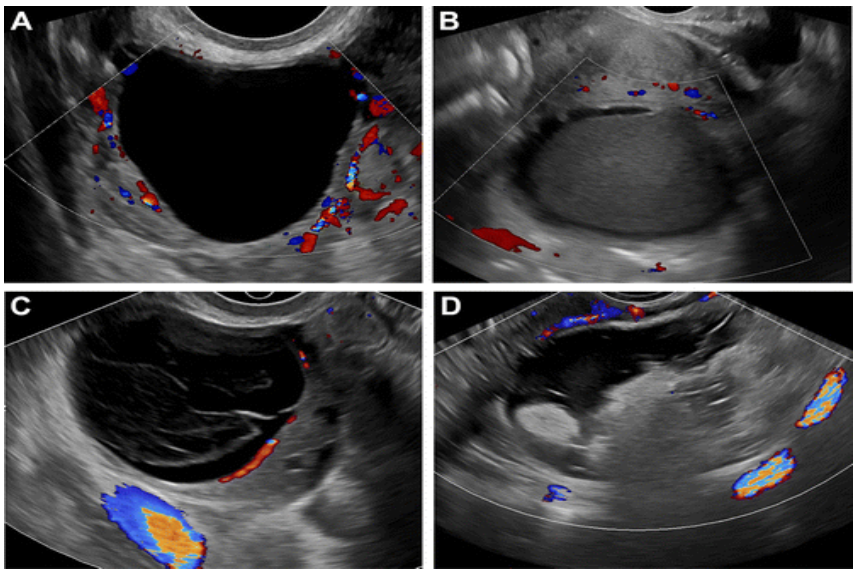


Figure 1: Color Doppler US images of classically appearing adnexal lesions show **(A)** a simple cyst in a 35-year-old patient, **(B)** an endometrioma in a 23-year-old patient, **(C)** a hemorrhagic cyst in a 44-year-old patient, and **(D)** a dermoid cyst in a 29-year-old patient **(1).**

In studies where patients with a known adnexal lesion were referred for surgical consultation and a physician experienced in gynecologic imaging performed and interpreted the examination, the specificities and positive predictive values were at the higher end of the published range, 93% and 84%, respectively. In studies of nonreferral populations, patients scanned in radiology departments by a technologist or a physician with no specialty training, the specificities and positive predictive values of US were at the lower end of the published ranges, 73% and 17%, respectively **(5).**

The factors associated with the decrease in the positive prediction of cancer in patients undergoing examination in the nonreferral setting was due to both the lower incidence of ovarian cancer and a higher number of false-positive interpretations. This increase in false-positive results partially stems from the higher ratio of benign lesions in these populations (eg, cystadenofibromas, dermoid cysts, and endometriomas) that did not have classic benign imaging features and instead were found to have overlapping US imaging features with ovarian cancer, specifically the presence of nodular solid components (Fig 2) **(6).**

This decrease in the predictive value of US in nonreferral practice settings is important when applying any US-based risk assessment system, as a lower predictive value for cancer increases the number of patients referred to surgery with benign lesions. In these settings, lesions that are not classically benign may require further evaluation by a US expert or additional imaging via MRI before referral for surgical consultation. It is important to note that when a benign-appearing lesion is observed with US, the negative predictive value remains high at greater than 99%, regardless of the study population, practice setting, frequency of ovarian cancer, and expertise of the sonographer **(1).**

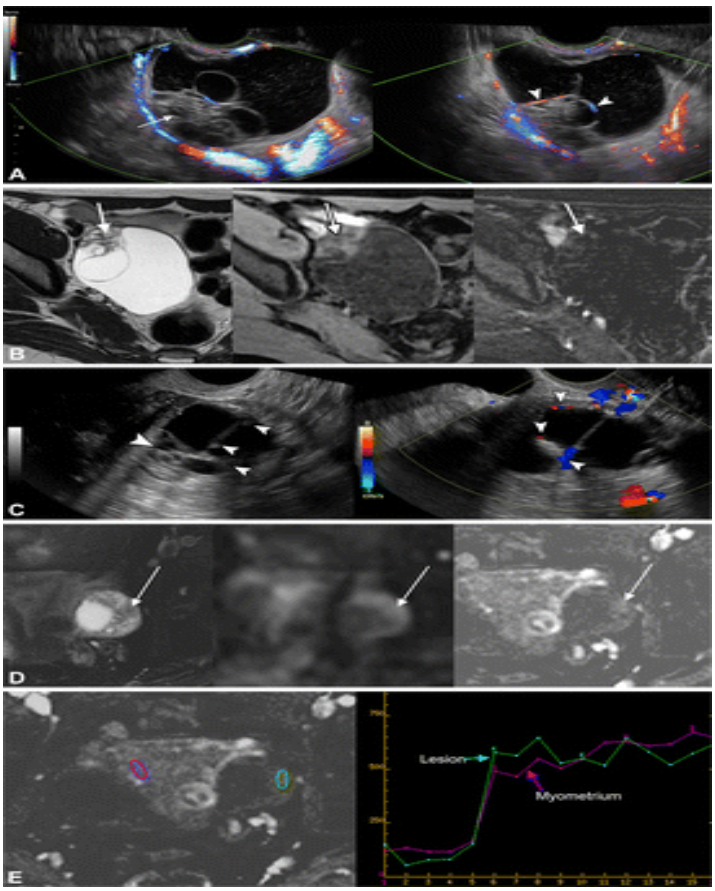


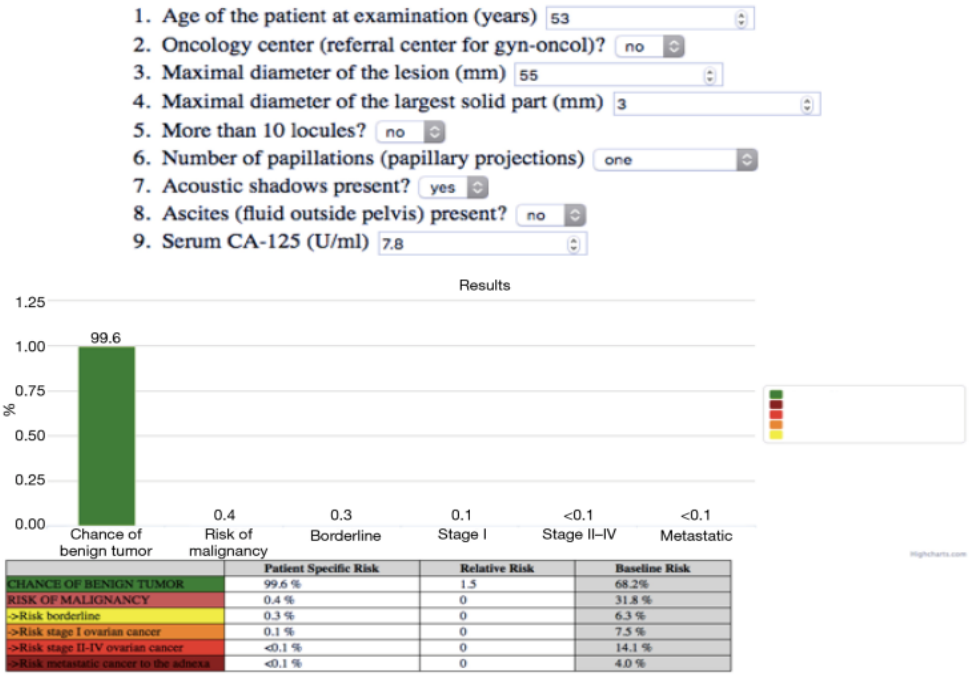
Figure 2: Example images at US and MRI of benign and malignant adnexal lesions that have overlapping imaging features at US and cause increased false-positive rates at US in nonreferral populations. **(A)** Color Doppler US images in a 49-year-old patient show a right adnexal lesion scored as Ovarian-Adnexal Reporting and Data System (O-RADS) US 4. The lesion had low-level echoes in the fluid, a nodular solid component along the wall (arrow), and minimal vascular flow (color score 2) in the solid component (arrowheads). **(B)** MRI scans of the lesion in **A**

show that the right adnexal lesion has a cystic component and grouped septae (arrows). The grouped septae have low signal intensity on the axial T2-weighted image (left), have intermediate signal intensity on the axial precontrast T1-weighted fat-saturated image (middle), and do not enhance on the axial T1-weighted postgadolinium-based contrast subtracted image (right). The lesion meets O-RADS MRI 2 criteria. A general gynecologist removed the lesion and final pathologic analysis determined it to be a serous cystadenofibroma. **(C)** US images in a 50-year-old patient show a left adnexal lesion scored as O-RADS US 4. Gray-scale image (left) and color Doppler image (right) show a multilocular left adnexal lesion with nodular solid components along the septations and wall (arrowheads), with a Doppler color score of 2 indicative of minimal blood flow. **(D)** MRI scans of the lesion in **C** show the left adnexal lesion has cystic and nodular components (arrows). The nodular solid components have intermediate signal intensity on the axial T2-weighted fat-saturated image (left), high signal intensity on the axial diffusion-weighted image (b = 1000 sec/mm^2) (middle), and enhancement on the axial T1-weighted postgadolinium-based contrast subtracted image (right). **(E)** Axial T1-weighted postcontrast subtracted MRI scan (left) and time-intensity curve (right) of the left adnexal lesion depicted in **C** and **D** show that the rise of enhancement within the solid component (green oval) is greater than that of the outer myometrium (pink oval), indicating a high-risk time-intensity curve and meeting O-RADS MRI 5 criteria. A gynecologic oncology surgeon removed this lesion and final pathologic analysis indicated high-grade serous cancer **(1).**

ADNEX Model

To develop a risk prediction model to preoperatively discriminate between benign, borderline, stage I invasive, stage II-IV invasive and secondary metastatic ovarian tumors, the IOTA group introduced the ADNEX model. This model contains 3 clinical (age, serum CA-125 level, type of center (oncology centers vs. other hospitals)), and 6 ultrasound predictors (maximum diameter of lesion (mm), proportion of solid tissue (%), >10 cyst locules (yes/no), number of papillary projections (0,1,2,3,>3), acoustic shadows (yes/no), and ascites (yes/no)) **(7).**

In a multicenter prospective cohort study, the ADNEX model discriminated well between benign and malignant tumors and offered a fair to excellent discrimination between the 4 types of malignancy **(8).**



	Patient Specific Risk	Relative Risk	Baseline Risk
CHANCE OF BENIGN TUMOR	99.6 %	1.5	68.2%
RISK OF MALIGNANCY	0.4 %	0	31.8 %
->Risk borderline	0.3 %	0	6.3 %
->Risk stage I ovarian cancer	0.1 %	0	7.5 %
->Risk stage II-IV ovarian cancer	<0.1 %	0	14.1 %
->Risk metastatic cancer to the adnexa	<0.1 %	0	4.0 %

Figure 3 An example of the mathematical risk prediction IOTA-ADNEX model, showing the average risk of malignancy or benignity of an ovarian tumor, based in clinical and ultrasound criteria **(9).**

MRI of Adnexal Lesions

MRI is performed for assessment of adnexal lesions found at initial imaging when a more specific diagnosis is required prior to initial treatment (Table 1). MRI is helpful when the origin of the lesion needs to be confirmed, the lesion is larger than 10 cm, the lesion contains solid components, or tumor subtyping is required **(10).**

MRI can confirm benignity when there is no enhancement, with a negative predictive value of 99%, and when enhancing solid tissue is present with a high-risk enhancement curve, the risk of cancer is greater than 90%. The specificity and positive predictive value for cancer at MRI is higher compared with US due to the ability of MRI to more accurately characterize the type of fluid and presence of enhancing solid tissue when diffusion-weighted and contrast-enhanced sequences are included in the protocol **(11).**

Furthermore, with the larger field of view at MRI, lesions larger than 10 cm can be evaluated to confirm or exclude enhancing solid tissue. A 2018 study of patients presenting for pelvic US demonstrated a cancer incidence rate of 19% (70 of 370) in lesions larger than 10 cm, suggesting that a significant number of patients could avoid unnecessary or over-extensive surgery if a physiologic cyst or benign lesion is seen at MRI **(12).**

In patients with isolated adnexal lesions with solid components at US, MRI can help decrease the false-positive rate and determine if the patient should be referred to a general gynecologist versus a gynecologic oncology surgeon for surgical evaluation **(13).**

Studies have shown that false-positive lesions at US included atypical appearing follicular cysts, hemorrhagic cysts, endometriomas, cystadenomas, and dermoid cysts. Misclassification of physiologic findings and benign lesions at US occurs when the lesion is not classic in appearance, such as having irregular contours or solid components within the lesion with or without Doppler flow, that cannot be differentiated from malignant tissue on US images **(4).**

In these cases, MRI can help assess for the presence of nonenhancing debris or clot and differentiate it from enhancing solid tissue to distinguish benign from malignant lesions more accurately. There is overlap in the appearance of ovarian cancer and some benign fibrous tumors at US, as both can have irregular borders and shadowing. At MRI, if there is enhancing solid tissue that demonstrates intermediate or high signal intensity on T2-weighted and diffusion-weighted images, a cancer is likely present. If the lesion only contains solid tissue that is low in signal intensity on T2-weighted and diffusion-weighted images, then a benign fibrous tumor is highly likely **(1).**

MRI can be used as a secondary examination to increase the specificity of diagnosis prior to final management. In the case of a lesion suspected to be invasive cancer at MRI, gynecologic oncologists can educate and consent for an appropriate surgery for malignancy, which may include hysterectomy, bilateral salpino-oophorectomy, omentectomy, or lymph node dissection **(1).**

MRI can also help classify lesions by histologic subtypes to determine if the patient should be referred to a general gynecologist versus a gynecologic oncology surgeon for surgical evaluation. For example, if the lesion is found to have well-formed papillary projections at MRI, a serous borderline or low-grade tumor is highly likely and cystectomy or unilateral oophorectomy can be offered. This diagnostic specificity is important as recent studies of a non–referral-based population presenting to radiology departments for pelvic US found that approximately two-thirds to three-quarters of patients were premenopausal **(14).**

Instituting a protocol with all the required sequences, particularly DCE MRI with time-intensity curve analysis, can be a challenge. Where DCE is not possible, analysis of the enhancement of the solid tissue on the 30–40-second postcontrast series can be performed. To characterize adnexal lesions accurately, both the cystic and solid components need to be assessed and enhancing solid tissue must be differentiated from other solid components at MRI. The time investment to develop protocols and acquire adequate interpretive skills can be difficult in a busy clinical practice. Besides the obstacles to instituting proper protocols and obtaining interpretive skills, some patients may not be able to undergo MRI due to implanted metal or claustrophobia. Furthermore,

patient body habitus and other factors (eg, implanted orthopedic hardware) may cause artifacts and, therefore, result in a nondiagnostic examination **(1).**

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