Ovarian-Adnexal Reporting Lexicon for MRI: A White Paper of the ACR Ovarian-Adnexal Reporting and Data Systems MRI Committee

Editor's Choice

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Abstract

MRI is used in the evaluation of ovarian and adnexal lesions. MRI can further characterize lesions seen on ultrasound to help decrease the number of false-positive lesions and avoid unnecessary surgery in benign lesions. Currently, the reporting of ovarian and adnexal findings on MRI is inconsistent because of the lack of standardized descriptor terminology. The development of uniform reporting descriptors can lead to improved interpretation agreement and communication between radiologists and referring physicians. The Ovarian-Adnexal Reporting and Data Systems MRI Committee was formed under the direction of the ACR to create a standardized lexicon for adnexal lesions with the goal of improving the quality and consistency of imaging reports. This white paper describes the consensus process in the creation of a standardized lexicon for ovarian and adnexal lesions for MRI and the resultant lexicon.

Key Words: Adnexal lesion, adnexal mass, MRI, ovarian mass, structured reporting

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INTRODUCTION

Ultrasound (US) is widely considered the primary imaging modality in the evaluation of women with suspected adnexal pathology [1-5]. Standardized terms and definitions to describe the sonographic features of adnexal lesions have been proposed, and several US reporting models can aid in differentiating benign from malignant adnexal masses [4,6-11]. However, approximately 20% to 25% of adnexal masses remain indeterminate after the initial sonographic evaluation [4,7,12]. Furthermore, studies have demonstrated variable positive predictive values for the detection of ovarian cancer using US, with some studies showing low positive predictive values in the general population in which the incidence of ovarian cancer is low [6,8,13]. Secondary tests such as MRI could help decrease the number of false-positive lesions when using US in certain settings and avoid unnecessary surgery in benign lesions [6,13-16].

The number of adnexal lesions that remain indeterminate after MRI is 5% to 7%, with high sensitivity and specificity for characterizing both benign and malignant lesions [17-22]. In 2010, the European Society of Urogenital Radiology proposed an algorithmic pathway using standardized MRI morphological descriptors for predicting the risk of malignancy for adnexal lesions [23,24]. Their goal was to improve lesion characterization by MRI to assist in treatment planning. However, a standardized lexicon and risk stratification system was not developed in conjunction with the proposed algorithmic pathway. In 2013, an MR scoring system (AdnexMR score) was developed in a retrospective, single-center French study of 497 sonographically indeterminate adnexal masses on US [25]. The AdnexMR score used a standardized lexicon to describe MRI features and proposed a 5-point score according to the positive likelihood ratio for malignancy derived from features with high positive and negative predictive values in distinguishing benign from malignant masses [25-27].

The ACR Ovarian-Adnexal Reporting and Data Systems (O-RADS) MRI Committee has developed an evidence-based lexicon and risk stratification system for MRI evaluation of adnexal lesions, employing the AdnexMR score as the basis for the lexicon and the results of a subsequent large prospective multicenter study as the foundation of the risk stratification system [28]. The ACR and other partners have led the efforts to standardize imaging reporting in many other anatomical regions, leading to the adoption of uniform reporting descriptors and improved interpretation agreement and providing the basis for structured reporting and best clinical practice [29-33]. Standardized reporting and use of consistent morphologic imaging descriptors and definitions can result in improved accuracy for lesion characterization and improved communication between radiologists and clinicians, as well as allowing for high-impact research [34-38]. The current article describes the formation of a standardized lexicon by the ACR O-RADS MRI Committee and the methodology used in its development.

METHODS

Under the direction of the Commission on US of the ACR headed by Commission Chair, Beverly Coleman, MD, the O-RADS Committee was created in 2015.

Committee Membership

Led by Rochelle F. Andreotti, MD, the multidisciplinary international consortium was first convened in November 2015. The committee includes a diverse, international group of experts that represent specialties and organizations that would be key to developing the O-RADS lexicon and risk stratification systems. The list of committee members is listed in e-only Appendix 1 and the organizations that were represented in the process in e-only Appendix 2.

After the initial meeting in November 2015, the O-RADS committee decided in consensus that the lexicon and stratification systems would be developed for US and MRI, given the important role of both modalities in adnexal mass characterization. Because of the different expertise required for both imaging modalities, two parallel working committees were formed to develop separate but consistent groups of terms specific to each modality (Appendix). The O-RADS MRI Committee is led by Dr. Caroline Reinhold, MD and the O-RADS US Committee is led by Dr. Rochelle Andreotti, MD.

Process

The development of the O-RADS MRI standardized reporting system used a two-step process. The first step was to develop an evidence-based, standardized lexicon using universally accepted terms for describing the imaging characteristics of adnexal masses on MRI. Committee members and nonmember gynecological imaging specialists contributed to this phase. The methodology regarding the development of the standardized MRI lexicon will be described in this article. The second step was to develop the O-RADS MRI risk score, and this is the topic of a separate publication [28].

Literature Search and Development of Lexicon Terms

The development of the MRI lexicon involved a systematic literature search from 1995 through 2019 performed by the ACR with search terms provided by the members of the O-RADS MRI Committee (CR, AR, IT, ES). This list was cross-referenced with bibliographies assembled from the Committee Members' own literature searches. The articles were reviewed independently by the O-RADS MRI Committee via an online questionnaire, and only articles that

Table 1. ACR O-RADS MRI terminology, definitions, and corresponding image for lexicon categories 1 to 7

Category	Term	Subterm	Definition	Comments
1. Major categories				
1a Physiological observations (consistent with normal physiology)				
	Follicle		Simple cyst $\leq$ 3 cm in premenopausal age group; follicle hyperintense on T2WI, hypointense on T1WI, and does not enhance on postcontrast T1WI	Premenopausal women only
	Corpus luteum		Cyst $\leq$ 3 cm, with an enhancing crenulated wall on subtracted postcontrast T1WI, with or without blood clot or hemorrhagic contents	Premenopausal women only
1b Lesions (not physiological)				
	Cystic lesion	Unilocular cyst	Single locule, with or without solid tissue	
		Multilocular cyst	More than one locule, with or without solid tissue	
	Lesion with solid component	Solid tissue	Conforms to one of the following morphologies and enhances: papillary formations, mural nodules, irregular cyst wall or septations, and solid portion	
		Other solid components, not considered solid tissue	Smooth wall or septation, clot or debris, fat	Not considered solid tissue
	Solid lesion		Consists of at least 80% solid tissue with <20% of lesion volume being cystic	
2. Size				
	Maximum diameter		Largest diameter of the lesion or solid component in any imaging plane	
3. Shape or contour of solid lesion or solid tissue				
3a	Smooth		Regular or even margin of a solid lesion or solid tissue	

(continued)

Table 1. Continued

Category	Term	Subterm	Definition	Comments
3b	Irregular		Uneven margin of a solid lesion or solid tissue	
4. Signal intensity				
4a	Homogeneous		Uniform appearance of the signal observed in an adnexal finding	
	Heterogeneous		Nonuniform or variable appearance of the signal observed in an adnexal finding	
4b	T2 hypointense		Adnexal observation with signal intensity lower or equal to iliopsoas muscle	
	T2 intermediate		Adnexal observation with signal intensity higher than iliopsoas and lower than CSF	
	T2 hyperintense		Adnexal observation with signal intensity equal or higher to CSF	
4c	T1 hypointense		Adnexal observation with signal intensity that follows simple fluid	
	T1 intermediate		Adnexal observation with signal intensity similar or higher to iliopsoas and lower than fat	
	T1 hyperintense		Adnexal observation with signal intensity equal or higher to fat	
4d	DWI high B-value low signal		Adnexal lesion with signal similar to urine or cerebral spinal fluid	
	DWI high B-value high signal		Adnexal lesion with signal clearly higher than urine or CSF	
5. Lesion components				
5a Cystic fluid descriptors				
	Simple fluid		Fluid content that follows CSF or urine on all sequences: hyperintense on T2WI and hypointense on T1WI	

(continued)

Table 1. Continued

Category	Term	Subterm	Definition	Comments
	Nonsimple fluid	Hemorrhagic fluid	Content can be variable depending on age	Late subacute hemorrhage hyperintense on T2WI and hyperintense on T1WI
		Endometriotic fluid	Content is hypointense on T2WI and hyperintense on T1WI	
		Proteinaceous fluid	Content is variable in signal on T2WI and variably hypointense on T1WI	
		Fat- or lipid-containing fluid	Hyperintense on T2WI and hyperintense on T1WI, and loses signal on fat-saturated images	If microscopic fat present, there will be signal loss on out-of-phase images and there may not be any signal loss on fat-saturated images
	Additional specific descriptors for nonsimple fluid	Fluid-fluid level	Appearance in which the nondependent fluid component has a different signal intensity from the dependent fluid component with horizontal delineation	
		Shading	Cyst fluid that is hypointense on T2WI; extent of hypointense T2 signal intensity may be homogeneous, variable within the cyst or graduated and dependent	
5b Solid component descriptors				
	Solid tissue: enhances and conforms to one of the listed morphologies			
	Solid tissue descriptors	Papillary projection	Enhancing solid component arising from the inner or outer wall or septation of an adnexal lesion, with a branching architecture	
		Mural nodule	Enhancing solid component, measuring $\geq$3 mm, arising from the wall or septation of an adnexal	

(continued)

Table 1. Continued

Category	Term	Subterm	Definition	Comments
			lesion, with nodular appearance	
		Irregular septation	Enhancing linear strand that runs from one internal surface of the cyst to the contralateral side demonstrating an uneven margin	
		Irregular wall	Enhancing cyst wall demonstrating an uneven margin	
		Larger solid portion	Enhancing component of an adnexal lesion that does not fit into the categories of papillary projection, mural nodule, or irregular septation or wall	
	Other solid components, not considered solid tissue			
		Smooth septations or wall	Even contour or margin with no irregularities, mural nodules, or papillary projections	
		Blood clot, nonenhancing debris, and fibrin strand	Solid-appearing material within a cyst that does not enhance	
		Fat	Lipid-containing material that does not enhance	
		Hair, calcification, and a Rokitansky nodule	Other components of a dermoid not considered solid tissue	
6. Enhancement: T1WI postcontrast				
6a Dynamic contrast enhancement with time intensity curves				
	Low-risk curve		Enhancement of the solid tissue within the adnexal lesion with minimal and gradual increase in signal over time with no well-defined shoulder and no plateau	
	Intermediate-risk curve		Enhancement of the solid tissue within the adnexal lesion with an	

(continued)

Table 1. Continued

Category	Term	Subterm	Definition	Comments
			initial slope less than or equal to myometrium, moderate increase in signal intensity with a plateau	
	High-risk curve		Enhancement of the solid tissue within the adnexal lesion with an initial slope greater than the myometrium, marked increase in signal intensity with a plateau	
6b Nondynamic contrast enhancement at 30-40 s postinjection				
	Less than or equal to the myometrium		Enhancement of the solid tissue within the adnexal lesion that is less than or equal to the outer myometrium at 30-40 s postcontrast injection	
	Greater than the myometrium		Enhancement of the solid tissue within the adnexal lesion that is greater than the outer myometrium at 30-40 s postcontrast injection	
7. General and extra-ovarian findings				
7a	Peritoneal fluid	Physiological	Small amount of fluid inside the pouch of Douglas or cul-de-sac or between the uterus and bladder	
		Ascites	Fluid outside the pouch of Douglas or cul-de-sac or fluid extending beyond the space between the uterus and bladder	
7b	Fallopian tube descriptors	Tubular	Substantially longer in one dimension than in the two perpendicular dimensions	
		Endosalpingeal folds	Incomplete septations or short round projections, orthogonal to the length of the tube	

(continued)

Table 1. Continued

Category	Term	Subterm	Definition	Comments
7c	Peritoneal inclusion cyst		Cyst following contour of adjacent pelvic organs, or normal ovary at the edge of or surrounded by a cystic collection	
7d	Ovarian torsion	Twisted pedicle	Swirling appearance of the broad ligament or ovarian pedicle	
		Massive ovarian edema	Enlarged ovary with edematous central stroma	
		Ovarian infarction	Lack of enhancement of the ovary on T1WI postcontrast	
7e	Peritoneal thickening, nodule	Thickening, smooth	Uniform thickening, without focal nodularity	
		Thickening, irregularity	Nonuniform thickening or focal areas of nodularity	

MRI sequences are specifically noted in the descriptive text only if they are important to the term being defined. For example, the fluid content of a follicle is hyperintense on T2WI; however, unilocular is defined regardless of the imaging sequence. CSF = cerebral spinal fluid; DWI = diffusion- weighted image; O-RADS = Ovarian-Adnexal Reporting and Data Systems; T1WI = T1- weighted imaging; T2WI =T2- weighted imaging.

were hypothesis driven and contained MRI ovarian lesion descriptors were maintained. An online questionnaire was used to (1) document the methodology of each study that provided evidence for all descriptors of ovarian lesions, (2) assess the frequency of usage of the terms, and (3) assess the evidence as pertains to differentiating benign from malignant adnexal lesions.

From this online questionnaire, the O-RADS MRI Committee developed a preliminary set of terms and definitions that could be applied to all adnexal lesions derived from the key articles. For each term, a recommendation to either include or omit the term was undertaken based upon analysis of all available pertinent descriptors and the evidence underlying their usage. Major categories of morphological descriptors were developed, and a list of individual descriptors related to each major category was created. Some of the titles of the major categories, as well as individual descriptors, evolved during ensuing committee discussions to reflect their meaning more accurately or to maintain consistency with the terms proposed by the O-RADS US Committee [10].

The next step involved a modified Delphi process that involved 14 gynecological MR imaging experts, eight of whom were O-RADS MRI Committee members (CR, AR, IT, ES, EAS, KM, RF, AV). The purpose of the modified Delphi process was to rate the usage of descriptor terms using an online survey in which individual descriptors were rated using a 1 to 5 scale (strongly disagree to strongly agree). The committee sought a minimum 80% consensus to determine if a term would be included (rating consensus of 4-5) or excluded (rating consensus of 1-2). Spreadsheets that included the original reference articles from the literature were available to each member for evaluation, to allow evidence-based and usage-driven responses while minimizing individual bias. On occasion, the committee agreed that even a frequently used term should be intentionally excluded when deemed vague or confusing (eg, "complex cyst"). Descriptor terms that did not achieve the minimum 80% consensus on the initial round underwent a rerating and voting process via teleconference, group emails, and online survey. Only those terms that reached the ultimate target of 80% consensus were incorporated into the lexicon.

A lexicon of MRI descriptor terms was derived and organized into seven major categories (Table 1). MRI-specific terms and descriptor terms for the solid and fluid components of adnexal lesions were compiled. This permitted us to go forward with evidence-based standardized terminology for major categories of adnexal lesions, which could then be

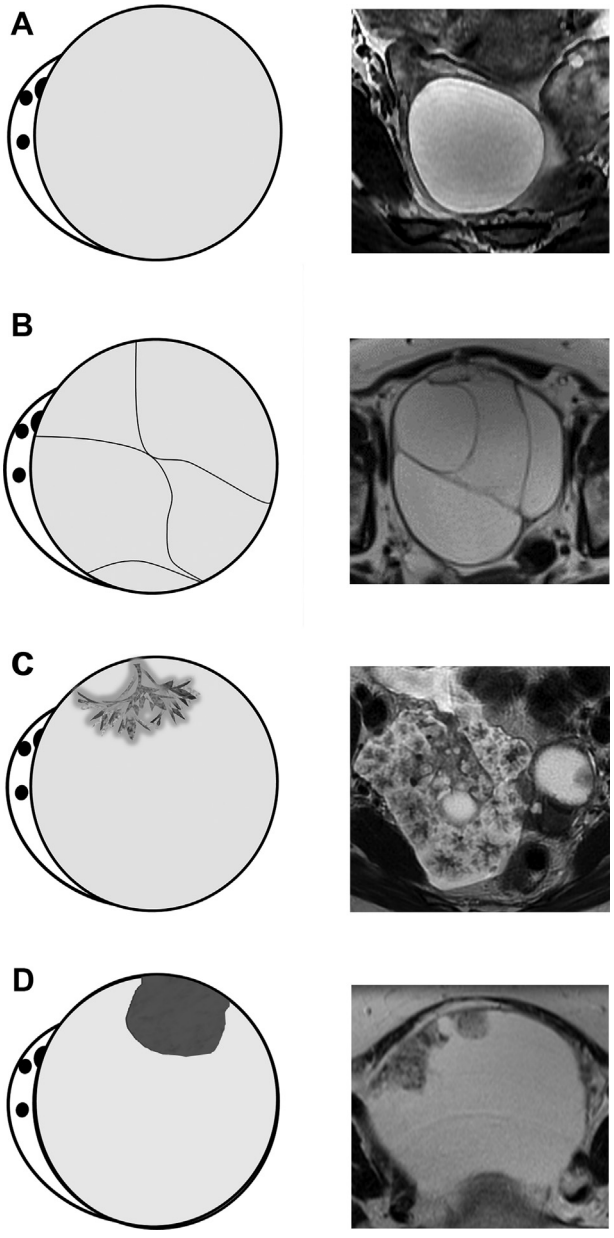

Fig 1. Lesion is a finding in the adnexa that is not normal physiology (ie, not a follicle or corpus luteum cyst). (A) Unilocular cyst without solid tissue. (B) Multilocular cyst without solid tissue. (C) Lesion with solid tissue, papillary projection. (D) Lesion with solid tissue, nodule. (E) Lesion with solid tissue, irregular septation or wall. (F) Lesion with solid tissue, larger solid portion. (G) Solid lesion.

modified by additional MRI-specific characteristics, including T2 signal intensity, T1 signal intensity, diffusion-weighted imaging (DWI), and enhancement characteristics.

O-RADS MRI TERMINOLOGY AND DEFINITIONS

Table 1 provides terms and definitions in the seven lexicon categories, with pictorial representations of the major

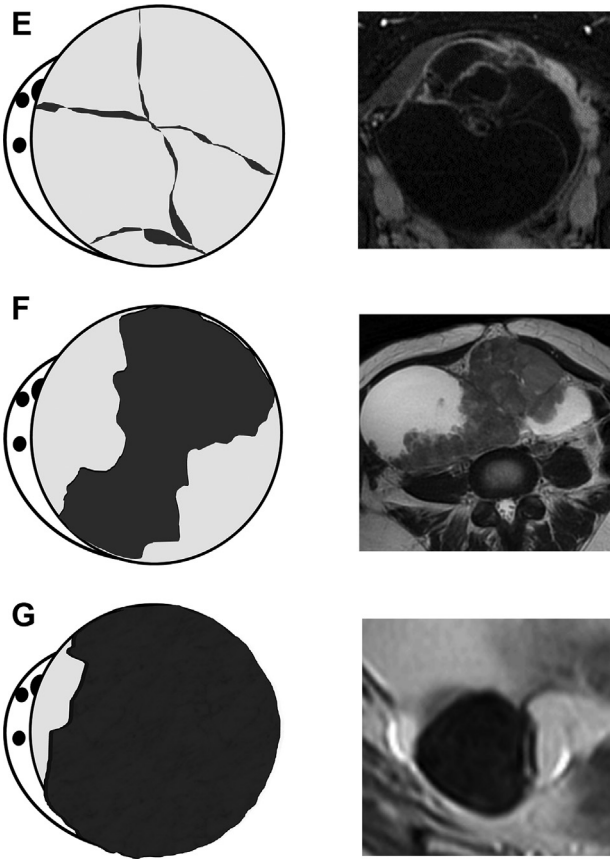

Fig 1. Continued.

concepts in Figures 1 to 4. A general MRI protocol for adnexal mass characterization is provided in e-only Appendix 3.

Category 1: Major Categories

Findings in the ovaries and adnexa can be unilateral or bilateral. When multiple findings are present, a separate process of description and characterization should be performed for each individual observation.

The ovary undergoes substantial morphologic change each month during reproductive life [39]. Therefore, the first fundamental distinction is between physiological observations and nonphysiological observations, known as lesions.

1a: Physiological Observations.

i. Follicles are present in ovaries of premenopausal women and defined as unilocular simple cysts $\leq$3 cm.

ii. Corpus luteum is a transient hormone-producing structure at the site of a follicle that has released an ovum. The wall is thicker than that of a follicle and enhances after contrast administration, often with a characteristic pattern of regular infoldings known as crenulation. If the wall reseals after ovulation, simple or hemorrhagic internal contents may accumulate and form a corpus luteum cyst.

1b: Lesion. Part of an ovary or adnexa that is not normal physiology (ie, not follicles or corpus luteum cysts). Lesions

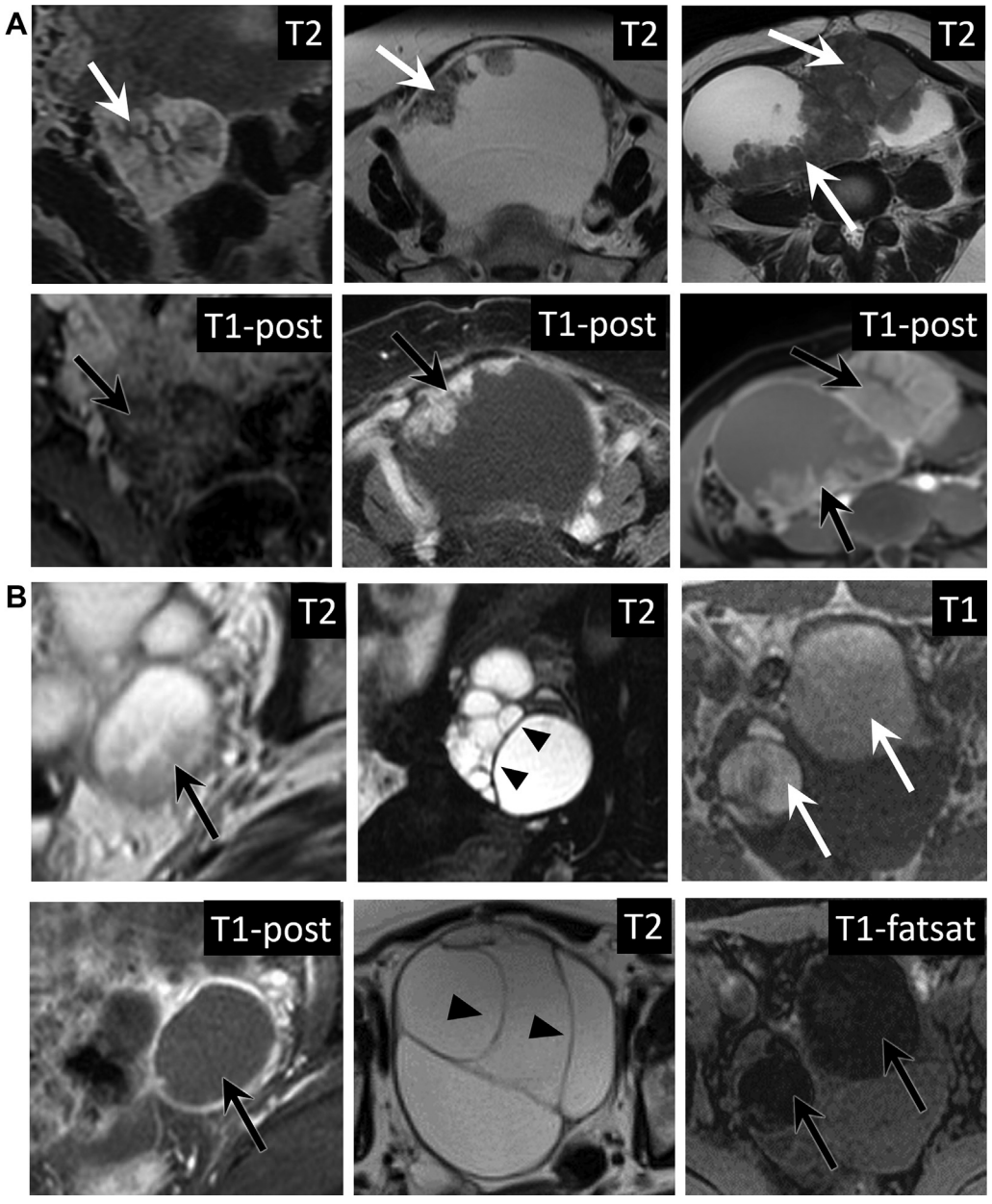

Fig 2. Solid tissue and nonsolid tissue. (A) Solid tissue conforms to one the following morphologies (white arrows) on T2-weighted imaging: papillary formation (left), mural nodules (middle), irregular cyst wall or septation, and solid portion (right). By definition, solid tissue enhances (black arrows) on T1-weighted imaging postcontrast. (B) Nonsolid tissue: debris that does not enhance on T1-weighted imaging postcontrast (black arrows, left), thin septations (arrowheads, middle) that may or may not enhance, and fat (white arrow, top right), which decreases in signal intensity on fat-saturated images (black arrow, bottom right).

may be further characterized as cystic without solid component, cystic with solid component, or solid (Fig. 1).

i. Cystic lesions are fluid-filled structures with or without solid components.
   1. Unilocular cystic lesions contain a single locule, with no complete septations. A complete septation is a linear strand that runs across a cyst cavity, from one internal surface to the contralateral side, and enhances. Unilocular cysts, however, may contain incomplete septations defined as septations that are interrupted or discontinuous.
   2. Multilocular cystic lesions contain one or more complete septations, dividing the lesion into more than one locule.

ii. "Solid component" refers to any nonfluid component of a lesion. There are two types of solid components:

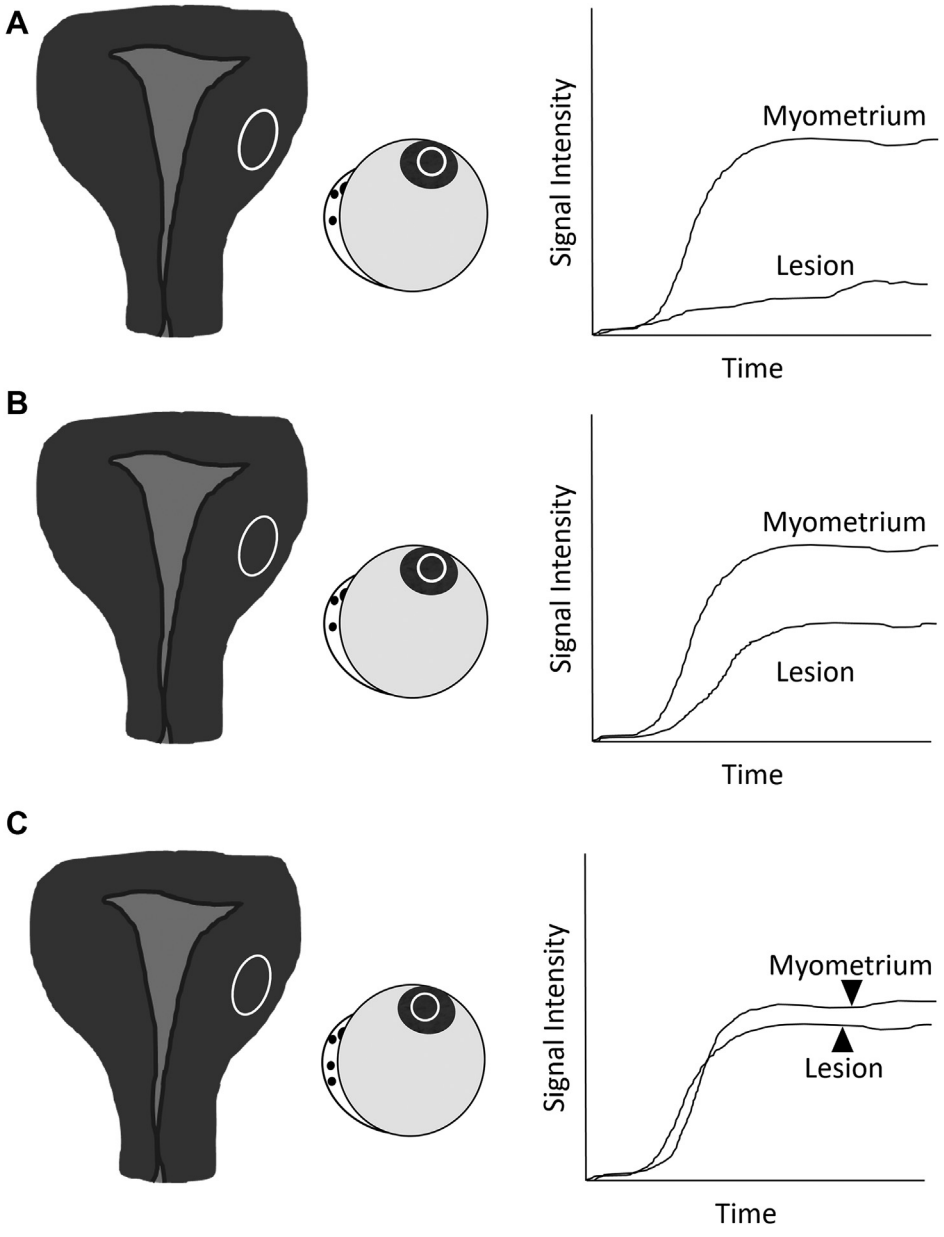

Fig 3. Low-risk (A), intermediate-risk (B), and high-risk (C) time intensity curves are derived from the dynamic postcontrast series. The curves are generated by placing one region of interest on the earliest enhancing region of the solid tissue in the adnexal lesion and one region of interest on the outer myometrium avoiding the arcuate vessels.

solid tissue and other solid components (not solid tissue).

1. "Solid tissue" is defined as exhibiting postcontrast enhancement and conforms to one of the following morphologies: papillary projections, mural nodules, irregular septations or walls, and a larger solid portion (Figs. 2 and 3).
2. Other solid components (not solid tissue) include smooth wall or septation, clot, debris, and fat within a lesion (Fig. 2).

iii. A solid lesion consists of at least 80% solid tissue with <20% of lesion volume being cystic or nonsolid tissue.

Category 2: Size

O-RADS MRI lexicon recommends measuring the maximum diameter of the lesion in any plane as the standard. If there is solid tissue, the maximum diameter of the solid tissue should be measured. The volume obtained from the largest three diameters is not recommended,because no evidence exists that it predicts behavior.

Category 3: Shape or Contour of Solid Lesion or Solid Tissue

Two descriptors categorize the contour of a solid lesion or solid tissue: smooth and irregular. Evaluation of the contour

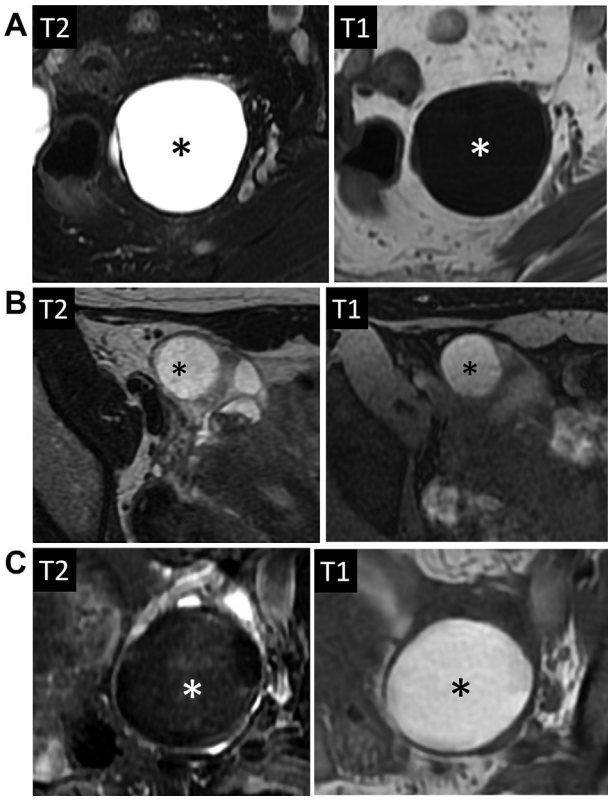

Fig. 4. Fluid descriptors. (A) Simple: fluid content that follows CSF or urine on all sequences; hyperintense on T2-weighted imaging (T2WI) (black asterisk) and hypointense on T1-weighted imaging (T1WI) (white asterisk). (B) Hemorrhagic fluid: variable depending on age; late subacute hemorrhage is hyperintense on T2WI (black asterisk) and hyperintense on T1WI (white asterisk). (C) Endometriotic fluid: hypointense on T2WI (white asterisk) and hyperintense on T1WI (black asterisk). (D) Proteinaceous: variable in signal on T2WI (white and black asterisks; left image) and variably hypointense on T1WI (white and black asterisks right image). (E) Fat or lipid containing: hyperintense on T2WI and hyperintense on T1WI (black asterisk), and loses signal on fat-saturated images (white asterisk).

can be performed with any MR pulse sequence that optimally shows the interface of the solid tissue with the surrounding tissues or adjacent fluid.

3a: Smooth. Regular or even shape or contour of the margin.

3b: Irregular. Uneven shape or contour of the margin.

i. Spiculated: infiltrative appearance to the margin.
ii. Lobular: undulation or scalloped appearance of the margin.

Category 4: Signal Intensity

There are four subcategories of signal intensity described. These categories include homogeneous versus heterogeneous signal intensity and the relative signal intensity on T1, T2, and high B-value diffusion-weighted images.

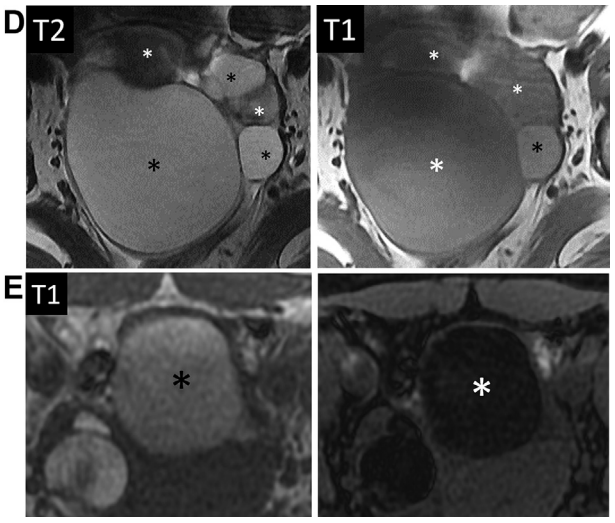

Fig. 4. Continued.

4a: Homogenous Versus Heterogeneous. The signal intensity of the solid and fluid components can be described as homogeneous or heterogeneous. "Homogeneous signal intensity" refers to uniformness of the signal observed, and "heterogeneous signal intensity" refers to nonuniform or variable appearance of the signal observed.

4b: T2 Signal Intensity. T2 signal is subdivided into three categories: hypointense, intermediate, and hyperintense. T2 hypointense observations have similar or lower signal intensity than iliopsoas muscle. T2 intermediate observations have higher signal intensity than the iliopsoas muscle and lower than cerebral spinous fluid (CSF). Hyperintense observations are similar in signal intensity to CSF.

4c: T1 Signal Intensity. T1 signal intensity is subdivided into three categories: hypointense, intermediate, and hyperintense. T1 hypointense observations have signal intensity that follows CSF. T1 intermediate observations have similar or higher signal than iliopsoas and lower signal than fat on non–fat-saturated pulse sequences. T1 hyperintense observations have equal or higher signal intensity to fat on non–fat-saturated pulse sequences.

4e: High B-Value DWI Signal Intensity. Signal intensity on the high B-value ($B \geq 1{,}000$) DWI is subdivided into two categories: low and high. "Low" refers to signal on a high B-value DWI that is relatively similar to simple fluid (urine or CSF). "High" refers to signal that is higher than simple fluid (urine or CSF). The presence of restricted diffusion is not specific for malignancy because hemorrhagic portions of benign endometriomas, infected fluid, and fatty portions of mature cystic teratomas can be high signal on high B-value images and low signal on the corresponding

apparent diffusion coefficient (ADC) maps [40,41]. Solid tissue will enhance, whereas blood, infected fluid, and fat will not enhance.

Category 5: Lesion Components (Cystic and Solid)

5a: Cystic Fluid Descriptors. The fluid within a cystic lesion can be categorized as either simple or nonsimple, based on the observed signal intensity of the fluid on T1-weighted imaging (T1WI) and T2-weighted imaging (T2WI) (Fig. 4).

i. Simple fluid follows the signal intensity of CSF on all sequences.
ii. Nonsimple fluid has signal intensity that does not meet criteria for simple fluid. The signal intensity is variable to CSF and may reflect blood, lipid, or proteinaceous fluid.
    1. Hemorrhagic fluid demonstrates variable signal intensity on T2WI, T1WI, and DWI. The signal intensity depends on the age of the blood [42-44].
    2. Classic endometriotic fluid is homogeneous and T1 hyperintense and demonstrates either hypointense or intermediate T2 signal intensity called shading. Diffusion signal intensity and restriction are variable. In endometriotic cysts or endometriomas, there may be the specific ancillary finding on T2WI of black nodules or linear foci in the wall.
    3. Proteinaceous fluid (mucinous or purulent or colloid) demonstrates variable T2 hypo-intensity, variable T1 signal intensity, and variable DWI signal intensity.
    4. Fat- or lipid-containing fluid (eg, dermoid or benign mature teratoma) is T2 hyperintense and T1 hyperintense with signal dropout on fat-saturated imaging. Microscopic or intravoxel fat can be identified by loss of signal intensity on out-of-phase images and may not exhibit signal loss on fat-saturated images.
iii. Additional specific descriptors for nonsimple fluid:
    1. "Fluid-fluid level" describes an appearance in which the nondependent portion has a different signal intensity from the dependent portion with horizontal delineation. This may be seen when there is a mixture of two fluid types of different intensity within the same lesion.
    2. "Shading" is characteristic of endometrioma and older hemorrhagic fluid [45]. This describes cyst fluid that is hypointense or intermediate T2 signal intensity; the signal intensity may be homogeneous, variable within the cyst, or graduated and dependent.

5b: Solid Component Descriptors. Cysts are delineated by a wall and may contain septations or solid components, all of which may be seen to enhance on postcontrast T1WI. The cyst wall and any septations may be described as smooth or irregular, depending if there are any irregularities, papillae, or mural nodules present. The presence of an enhancing irregular wall or septations or papillary projections or mural nodules indicates the presence of solid tissue (Figs. 2 and 3).

i. "Solid tissue" is defined by the presence of enhancement and conforms to one or more of the following morphological appearances listed below (1-4) (Figs. 1 and 2). If solid tissue is present in a lesion, the lesion may be further characterized by evaluating the time intensity curve (TIC) within the solid tissue (see Category 6) (Fig. 3).
    1. Papillary projection has a distinct appearance on MRI that is defined by a protrusion with a stalk, an acute angle with the cyst wall, septation or surface of the ovary, with typically a visible branching architecture. A papillary projection may lie within a cyst, arise from a septation (endocystic), or may arise on the external surface of the ovary or cyst (exophytic).
    2. Mural nodule is a focal protrusion along the wall or septation of a cystic lesion that has a height of $\geq$3 mm and has outward convex borders and a more obtuse angle in relation to the cyst wall or septation than a papillary projection.
    3. Irregular septation or wall demonstrates uneven margin that varies in thickness along its length.
    4. Larger solid portion enhancing component of an adnexal lesion that does not fit into the categories of papillary projection, mural nodule, or irregular septation or wall. A solid lesion consists of at least 80% solid tissue.
ii. Other solid components not defined within the term "solid tissue" include any components of the lesion that are not fluid and do not conform to the definition of solid tissue described previously (Fig. 2). Other solid components may or may not enhance. For solid components such as thin septations or Rokitansky nodules that enhance, comparisons to the enhancement of the myometrium should not be performed or reported as part of the O-RADS MRI risk score [28].
    1. Smooth septation or wall has an even contour. Smooth septations may enhance after contrast administration.
    2. Blood clot can be variable in signal intensity depending on the age of the clot and does not enhance post-contrast. Debris and fibrin strands are lacelike or cobweb-type strands seen in hemorrhagic or proteinaceous cysts and do not enhance after contrast administration.
    3. Fat, hair, and calcifications as part of a dermoid cyst. Fat, hair, and calcifications do not enhance after contrast enhancement. A Rokitansky nodule is a solid component within a dermoid cyst and it may

enhance; however, it is not termed solid tissue. A Rokitansky nodule usually contains fat and may be associated with multiple septations.

Category 6: Enhancement

In an adnexal lesion, it is important to identify the presence of any enhancement. If there is no enhancement (no increase in signal on T1WI after intravenous gadolinium-based contrast injection), the lesion is almost certainly benign [15,16,25,28]. To evaluate for the presence of enhancement, especially in a lesion that contains any high T1W signal, subtracted images are optimal. Any portion of the lesion may enhance, including the wall, septations, and solid tissue.

The recommended method for assessing enhancement is performing a dynamic contrast enhancement (DCE) MRI acquisition (e-only Appendix 3). Alternatively, a nondynamic contrast MR acquisition is acquired precontrast and at 30 to 40 seconds after contrast injection (e-only Appendix 3). A DCE MRI acquisition is a postcontrast 3-D T1WI fat-saturated sequence with a minimal spatial resolution of 3 mm and a temporal resolution of 15 seconds and allows complete coverage of the lesion. A TIC can be obtained by placing one region of interest on the earliest enhancing region of the solid tissue in the adnexal mass and one region of interest on the outer myometrium avoiding the arcuate vessels (as an internal reference standard). If DCE MRI is not available, the analysis of relative enhancement on the 3-D T1WI at 30 to 40 seconds after contrast injection of the solid tissue related to outer myometrium may be used.

6a: Dynamic Enhancement With TICs.

i. "Low-risk TIC" is defined as a gradual increase in the signal of solid tissue, slower than the myometrium, without a well-defined shoulder and no plateau (corresponds to TIC type 1) [28].
ii. "Intermediate-risk TIC" is defined as a moderate initial rise in the signal of solid tissue, slower than or equal to the myometrium, followed by a plateau (corresponds to TIC type 2) [28].
iii. "High-risk TIC" corresponds to an initial rise in the signal of solid tissue that is faster (steeper) than myometrium, followed by a plateau (corresponds to TIC type 3) [28].

6b: Nondynamic Enhancement Visual Analysis at 30 to 40 Seconds After Contrast Enhancement.

i. Less than or equal to the outer myometrium
ii. Greater than the outer myometrium

In the absence of a uterus, a low-risk TIC can be recognized by its progressive enhancement (no plateau), whereas intermediate- and high-risk TICs cannot be distinguished. The level of enhancement should be estimated according to the expertise of the radiologist. The committee agreed to change the name of TICs to low, intermediate, or high risk rather than using a number as in previous publications to be more descriptive and avoid potential confusion with O-RADS MRI risk score assignment [28].

Solid tissue may be encountered in benign lesions as well as in borderline or malignant lesions. The nature of the enhancement may help to differentiate benign from malignant lesions, which is the purpose of the O-RADS MRI score for risk score of adnexal lesions [28].

Category 7: General and Extra-Ovarian Findings

Several general findings are relevant to the description of adnexal lesions on MRI that we include in the lexicon.

7a: Peritoneal Fluid. Physiological fluid should be used to describe a small amount of fluid inside the pouch of Douglas (ie, cul-de-sac) or fluid in the space between the uterus and bladder. "Ascites" is defined as abdominal or pelvic fluid outside of the pouch of Douglas (ie, cul-de-sac) or fluid extending beyond the space between the uterus and bladder.

7b: Fallopian Tubes. These may be visualized on MRI, particularly when fluid filled (ie, hydrosalpinx). The morphologic descriptor "tubular" is defined as a structure that is substantially longer in one dimension than in the two perpendicular dimensions. Endosalpingeal folds may also be visualized on MRI and are orthogonal to the length of the tube (short axis), typically appearing as incomplete septations or short round projections. Fallopian tubes should have thin walls measuring <3 mm and the wall is considered thickened when it measures ≥ 3 mm.

7c: Peritoneal Inclusion Cyst. These cysts occur in women with a history of pelvic surgery, trauma, or chronic pelvic inflammation from various causes including endometriosis. The term should be used to describe a cyst that follows the contour of the peritoneal cavity and adjacent pelvic organs or in the presence of a normal ovary at the edge of or surrounded by a cystic collection of fluid.

7d: Ovarian Torsion. Ovarian torsion can mimic ovarian malignancy on other imaging modalities, particularly when it is chronic in nature. Ovarian torsion occurs when the blood flow to the ovary is impeded by "twisting" of the vascular pedicles. If the twisting is not reversed, ovarian infarction can occur. Chronic ovarian torsion may result in the appearance described as "massive ovarian edema," defined by an enlarged ovary with edematous central stroma and peripherally displaced follicles.

7e: Peritoneal Thickening or Nodules. Peritoneal thickening describes prominence of the peritoneal surfaces that become discretely visible on MRI and should be

categorized as "smooth" when thickening is uniform or "irregular" when there is nonuniform thickening or there are focal areas of nodularity.

DISCUSSION

The added value of MRI lies in its ability to accurately characterize adnexal lesions that are deemed sonographically indeterminate, despite the use of advanced analytics and high-level sonographic expertise [18,25,46,47] Studies support the use of MRI as a secondary test to (1) decrease the number of false-positive diagnoses of cancer when using US and (2) to potentially reduce the number of unnecessary surgeries performed for benign lesions [6,13,14]. Recently, Thomassin-Naggara et al found that the O-RADS MRI score achieved a sensitivity of 93% and specificity of 91%, for diagnosing malignant adnexal lesions that were sonographically indeterminate. In addition, the same study found that a lesion without any enhancement has a positive likelihood of malignancy of <0.01 [28].

In a continued effort toward global standardization of radiological reporting, the ACR O-RADS committee was established, an international multidisciplinary working committee for ovarian-adnexal mass characterization using US and MRI. This process included the development of a universally accepted set of standardized terms and definitions. Such a lexicon would provide the basis for a standardized reporting and risk stratification system of adnexal or ovarian masses. The ACR O-RADS US lexicon and risk stratification system has recently been published by Andreotti et al [10,11]. In keeping with the use of MRI as a secondary modality in adnexal lesion evaluation, the O-RADS US management schema includes the recommendations for MRI lesion characterization in multiple risk categories.

The ACR O-RADS MRI lexicon presented in this article encompasses seven categories of descriptors of adnexal masses that were derived by consensus of expert radiologists in the field of female pelvic MRI using a modified Delphi process. These categories include general descriptors, as well as morphological and functional MRI properties of fluid and tissue. The combination of these descriptors allows for specific characterization of adnexal masses. Although categories 2 to 6 include descriptions of the lesion, category 7 summarizes secondary findings important for tumor dissemination as well as cystic lesions that can be specifically characterized by imaging (eg, fallopian tube dilation, ovarian torsion, and peritoneal inclusion cyst). Despite its common use in the literature, the nonspecific term "complex adnexal lesion" was eliminated and replaced by concise descriptors of the lesion morphology. This is in keeping with the approach taken by the O-RADS US lexicon [10].

Characterization of adnexal lesions is mainly based on the combination of morphologic features with its functional properties on DWI and DCE. Contrast dynamics compared with the myometrium using TIC have been shown as a pivotal feature for predicting malignancy [22,48]. Of note, this can only be applied to the solid tissue within an adnexal mass. This warranted clarification of the term "solid tissue," which conforms only to papillary projections, mural nodules, irregular cyst wall and septations, and larger solid portions within an adnexal mass. In contrast, other solid components (smooth enhancing cyst wall or septations, nonenhancing debris, clot, fat or Rokitansky nodule) are not considered solid tissue.

The ACR O-RADS MRI lexicon was developed to provide a comprehensive set of terms and definitions for the broad spectrum of adnexal findings ranging from physiological to malignant entities. Its widespread implementation as a standardized lexicon will improve reporting and interdisciplinary communication by eliminating uncertainties in term usage and thus help optimize patient management. The consistent use of these descriptors may also provide a basis for future research and serve as a means for multi-institutional collaborations.

TAKE-HOME POINTS

- The O-RADS MRI lexicon is a multidisciplinary international initiative with the goal of developing standardized terminology for the evaluation of ovarian and adnexal lesions with MRI.
- Consistent application of the O-RADS MRI lexicon terms in a standardized report has the potential to increase accuracy of lesion characterization, improve interdisciplinary communication, and promote optimized patient management of adnexal and ovarian lesions.
- This lexicon is used in the O-RADS MRI risk stratification system to assign a malignancy risk to adnexal lesions and provide actionable information in the imaging report.

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ADDITIONAL RESOURCES

Additional resources can be found online at: https://doi.org/10.1016/j.jacr.2020.12.022

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