Egyptian Journal of Radiology and Nuclear Medicine

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The impact of using ovarian-adnexal reporting data system magnetic resonance imaging (O-RADS MRI) score on risk stratification of sonographically indeterminate adnexal masses

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Abstract

Background Adnexal masses (AMs) are prevalent, leading to a substantial clinical effort including imaging for diagnosis, surgery, and pathology.

Aim of the study The goal of this research was to evaluate the reliability of the Ovarian-Adnexal Reporting Data System Magnetic Resonance Imaging (O-RADS MRI) scale for diagnosing the sonographically indeterminate adnexal masses and to discriminate between malignant and benign ones using the O-RADS MRI scoring system.

Methods This study included 72 cases with indeterminate adnexal masses in any age group. We excluded patients with previous history of operated adnexal lesion and patients who had contraindications for MRI as pacemakers or iron clips.

Results Based on O-RADS MRI score, 44.4% of masses were diagnosed as O-RADS II indicating that they were almost certainly benign, 11.1% as O-RADS III indicating low risk malignancy, 8.3% as O-RADS IV indicating intermediate risk malignancy and 36.1% were diagnosed as O-RADS V indicating high risk malignancy. O-RADS MRI score for malignancy gave sensitivity of 92.31% (95%CI 63.97–99.81), specificity of 82.61% (95%CI 61.22–95.05), PPV of 75% (95%CI 54.84–88.11) and NPV of 95% (95%CI 74.12–99.21) with an overall accuracy of 86.11% (95%CI 70.50–95.33).

Conclusions The O-RADS MRI score has excellent accuracy and validity in determining whether an AM is malignant or benign. Using this score in clinical practice may enable a tailored, patient-centered approach for masses that are sonographically indeterminate, avoiding unnecessary surgery, and in certain cases allows less extensive surgery, or even fertility preservation when appropriate.

Keywords O-RADS, MRI, Adnexal masses

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Background

Adnexal masses are frequent, which leads to a heavy clinical workload for pathology, surgery, and diagnostic imaging. The majority of adnexal masses are benign, and ultrasonography can reliably classify the majority of masses as benign or malignant. However, after ultrasonography utilizing the ultrasound scoring system

simple rules or other ultrasonography scoring systems, between 18 and 31% of adnexal masses remain ambiguous [1, 2].

In order to accurately characterize adnexal lesions, which is crucial for effective patient care, A lexicon and risk classification system for adnexal lesions have been published by the Ovarian-Adnexal Reporting and Data System (O-RADS) MRI committee of the American College of Radiology (ACR) (Fig. 1) [3, 4].

The primary goal of the O-RADS MRI risk classification system is to standardize the communication between radiologists and referring physicians, thereby reducing the number of unnecessary or overly extensive surgical procedures performed on women with benign lesions or borderline tumors, while referring the women with suspected malignancy for oncologic surgical evaluation [5, 6].

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

Fig. 1 O-RADS MRI risk stratification and management system [7, 8]

Methods

Ethical consent

Academic and Ethical Committee granted permission for this research (IRB Approval No. ZU-IRB#9240/12-1-2022). All participants agreed to participate in the research after signing an informed written permission form. The Declaration of Helsinki, a global standard for the ethical conduct of medical research involving human participants, has been followed throughout this project.

Population and study design

Between February 2022 and February 2023, Seventy-two patients were included in this prospective trial after being sent to the MRI unit at the radio-diagnosis department for evaluation of a possible adnexal mass lesion by a radiologist with 11 years' experience.

Inclusion criteria

Female with sonographically indeterminate adnexal masses (O-RADS US 3 and O-RADS US 4) and any age group.

Exclusion criteria

Contraindication to MRI (i.e., patients with pace makers or metallic clips), patient refusal despite of informed discussion with the sonographer, and patients with previous history of operated adnexal lesion.

The following were applied to all patients:

1. Complete clinical history and personal history, which should include name, date of birth, sexual history, past gynecological sickness, and family history of gynecological malignancy.
2. Current medical history, including illness progression, treatment, duration, menstrual history, and pregnancy status.
3. Patients are evaluated clinically through PV, speculum, and palpation (when sedated).
4. Ultrasound examination were done using transducers with frequencies ranging from 2.5 to 8 MHz (a transabdominal ultrasound was performed with a full bladder, or a transvaginal ultrasound was performed after UB evacuation). The vascularity of the lesion was evaluated using power or color Doppler US, and to ensure the presence or absence of a solid component.
5. Magnetic resonance imaging.
6. Histopathological correlation with the imaging results (O-RADS MRI 4 & 5).

MRI protocol and technique

(a) The a-MRI was performed on a conventional pelvic coil in a 1.5 Tesla super conducting MR scanner (Philips Achieva). During the whole examination, the patient lay supine, face up. Methodology placement patients were told to lie supine and remain still during the duration of the test. The pelvic region was surface-coiled.
(b) Images of the axial, coronal, and sagittal localizers.
(c) Fast spin echo T1-weighted echo (FSE) was performed with slice thicknesses of 3 to 4 mm, an interslice gap of 1–2 mm, a field of view (FOV) of 240 mm, and a flip angle of 90 (TR 500 ms, TE 10 ms, matrix 320 512).
(d) (TR 3000 ms, TE 100 ms, matrix 256×512, slice thickness: 3–4 mm with an interslice gap of 1–2 mm, FOV 240 mm, flip angle 90) Axial, oblique, and sagittal fast spin echo (FSE) T2-weighted images.
(e) Gadolinium diethylenetriamine pentaacetic acid (GD-DPTA), 0.1–0.2 mmol/kg body weight, was administered intravenously to all patients having MR imaging with contrast. The following parameters were employed for an axial oblique and sagittal T1 spin echo with fat suppression after contrast administration: Axial oblique T1-weighted fat-suppressed images with dynamic contrast enhancement are typically acquired at 30, 60, and 120 s after the administration of contrast material, followed by a delayed phase at 3–4 min later along the axis of the uterus. Malignant tissue's dynamic curve, as compared to normal tissue, exhibits an abrupt, powerful amplification followed by a relatively quick washout.
(f) Acquired on an identical magnetic resonance imaging (MR) system with the exact same settings (Time of recurrence "TR" 2900 ms, Echo time "TE" 70 ms, matrix 512×512, slice thickness 4 mm with an interslice gap of 1–2 mm, and field of view (FOV) 240 mm) as the axial spin echo sequence, but with the patient breathing freely.
(g) f-MRI using a diffusion-weighting gradient. Every patient was subjected to diffusion-sensitizing gradients that had a b factor ranging from 0 to 500 s/mm [2] and a b factor ranging from 0 to 1000 s/mm^2. For each and every image with diffusion weighting, ADC maps were mechanically reconstructed and used in the calculation of ADC value.

Table 1 Baseline characteristics of the studied patients

		Total patients (n = 72)
Age (years)	Mean ± SD	42.92 ± 13.01
	Range	16 – 62
Marital status	Unmarried	6 (8.3%)
	Married	66 (91.7%)
Menstrual state	Pre-menopausal	44 (61.1%)
	Post-menopausal	28 (38.9%)

Data are presented as frequency (%) unless otherwise mentioned

Table 2 Symptoms of the studied patients (N = 72)

Symptomatology		
	N	%
Pain	72	100.0
Constipation or diarrhea	46	63.9
Fever	32	44.4
Palpable mass or increased abdominal volume	30	41.7
Vaginal bleeding	16	22.2
Urinary symptoms	14	19.4

Table 3 Origin of lesions detected in the studied patients (n = 72)

	N	%
Adnexal		
Ovarian	46	63.9
Tubo-ovarian	14	19.4
Broad ligament	6	8.3
Non adnexal		
Uterine	6	8.3

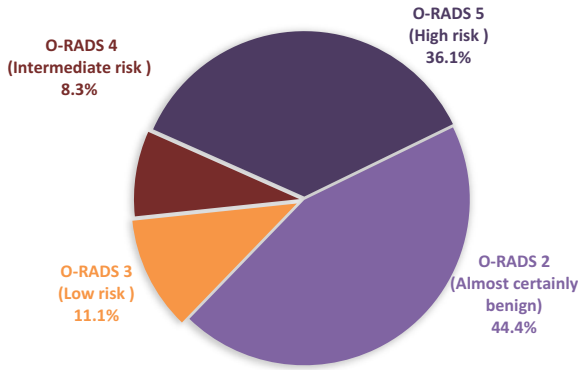

Fig. 2 O-RADS MRI score of the studied patients

Reference standard

The final diagnosis for every patient relied on histopathology in O-RADS MRI 4 & 5 or clinical follow-up in O-RADS MRI 2 & 3 for six to twelve months of observation was performed (clinical follow-up for O-RADS 2 and follow-up by MRI for O-RADS 3 cases)

Statistical analysis

The data were analyzed using SPSS version 28 (IBM Co., Armonk, NY, USA). The parameters' quantitative mean, standard deviation (SD), and range were given. The percentage and frequency distributions of the qualitative variables were shown.

The diagnostic accuracy of several tests was compared using ROC curves with area under the curve (AUC) (where AUC > 50% indicates acceptable performance and AUC 100% indicates the greatest performance for the test). The cutoff for statistical significance was set at a two-tailed P value of less than 0.05.

Results

This cross-sectional study included 72 females with sonographically indeterminate adnexal masses, with ages ranging between 16 and 62 years (a mean age of 42.92 ± 13.01 years). Most patients (91.7%) were married. Out of 72 patients, 61.1% were pre-menopausal as shown in Table 1.

As shown in Table 2, all 72 patients suffered from pain, more than half patients (63.9%) suffered from constipation or diarrhea, 44.4% had fever, 41.7% had palpable mass or increased abdominal volume, 22.2% had vaginal bleeding and 19.4% had urinary symptoms.

As regards the origin of the studied lesions, 66 were adnexal (out of which, 46 were ovarian, 14 were tubo-ovarian and six were in broad ligament) and 6 were non adnexal (uterine lesions) as shown in Table 3.

Figure 2 shows the outcomes of O-RADS MRI assessing, which indicated that 44.4 percent of masses were categorized as O-RADS 2, which means they were probably benign; 11.1 percent were classified as O-RADS 3, which meant they had a low risk of being cancerous; 8.3 percent were classified as O-RADS 4, which meant they had an intermediate risk of being cancerous; and 36.1 percent were classified as O-RADS 5, which meant they had a high risk of being cancerous.

Based on pathology results which were the reference standard, 26 cases (36.1%) of the total adnexal masses were malignant and 46 cases (63.8%) were benign. Regarding MRI O-RADS classification in relation to pathology, out of 32 lesions categorized as O-RADS

Table 4 O-RADS classification by US and MRI in relation to pathology results

	US			MRI		
	Malignant	**Benign**	**Total**	**Malignant**	**Benign**	**Total**
O-RADS 1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
O-RADS 2	0 (0%)	0 (0%)	0 (0%)	2 (2.8%)	30 (41.7%)	32 (44.4%)
O-RADS 3	12 (16.7%)	26 (36.1%)	38 (52.8%)	0 (0%)	8 (11.1%)	8 (11.1%)
O-RADS 4	14 (19.4%)	20 (27.8%)	34 (47.2%)	4 (5.6%)	2 (2.8%)	6 (8.3%)
O-RADS 5	0 (0%)	0 (0%)	0 (0%)	20 (27.8%)	6 (8.3%)	26 (36.1%)

Data are presented as frequency (%)

Table 5 Pathology results of different age groups

	Age groups			
	(19–30 yrs)	**(31–40 yrs)**	**(41–50 yrs)**	**(51–62 yrs)**
Benign	0 (0%)	12 (60%)	12 (75%)	4 (12.5%)
Right hydrosalpinx	0 (0%)	0 (0%)	4 (25%)	0 (0%)
Tubo-ovarian abscess	0 (0%)	4 (20%)	4 (25%)	4 (12.5%)
Ovarian mucinous cystadenoma	0 (0%)	0 (0%)	4 (25%)	0 (0%)
Ovarian dermoid	0 (0%)	4 (20%)	0 (0%)	0 (0%)
Ovarian fibroma	0 (0%)	4 (20%)	0 (0%)	0 (0%)
Malignant	4 (100%)	8 (40%)	4 (25%)	28 (87.5%)
Pedunculated subserous leiomyosarcoma	0 (0%)	0 (0%)	0 (0%)	4 (12.5%)
Ovarian mucinous cystadenocarcinoma	0 (0%)	0 (0%)	0 (0%)	8 (25%)
Clear cell carcinoma	0 (0%)	0 (0%)	0 (0%)	4 (12.5%)
Serous cystadenocarcinoma	0 (0%)	0 (0%)	4 (25%)	8 (25%)
Granulosa cell tumor (malignant sex cord stromal tumor)	0 (0%)	8 (40%)	0 (0%)	0 (0%)
Dysgerminoma	4 (100%)	0 (0%)	0 (0%)	0 (0%)
Endometrioid adenocarcinoma	0 (0%)	0 (0%)	0 (0%)	4 (12.5%)

Data are presented as frequency (%)

2 by MRI, two were diagnosed as malignant by pathology while 8 lesions were O-RADS 3 by MRI which was consistent with pathology being benign. Out of 6 lesions categorized as O-RADS 4 by MRI, 2 lesions were diagnosed as benign by pathology. Out of 26 lesions categorized as O-RADS 5 by MRI, 6 were diagnosed as benign by pathology as summarized in Table 4.

As shown in Table 5, the four patients aged 19–30 years old had malignant lesions of dysgerminoma type. Twelve patients out of 20 aged 31–40 years old had benign lesions (tubo-ovarian abscess, ovarian dermoid and ovarian fibroma) and eight had malignant ones (all of granulosa cell tumor type). Out of 16 patients aged 41–50 years old, 12 had benign lesions (right hydrosalpinx, tubo-ovarian abscess and ovarian mucinous cystadenoma) and four had malignant ones (all of serous cystadenocarcinoma type). The 51–62 years age group included four patients with benign lesions (tubo-ovarian abscesses) and 28 with malignant ones (ovarian mucinous cystadenocarcinoma and serous cystadenocarcinoma, and pedunculated subserous leiomyosarcoma, clear cell carcinoma and endometrioid adenocarcinoma).

Table 6 Diagnostic performance of O-RADS MRI score for malignancy according to pathology results

	Value	**95%CI**
Sensitivity	92.31	63.97 to 99.81
Specificity	82.61	61.22 to 95.05
PPV	75	54.84 to 88.11
NPV	95	74.12 to 99.21
Diagnostic accuracy	86.11	70.50 to 95.33

True positive = 24 cases

True negative = 38 cases

False positive = 8 cases

False negative = 2 case

At cut off ≥ 4, O-RADS MRI score for malignancy gave sensitivity of 92.31% (95%CI 63.97–99.81), specificity of 82.61% (95%CI 61.22–95.05), PPV of 75% (95%CI 54.84–88.11) and NPV of 95% (95%CI 74.12–99.21) with an overall accuracy of 86.11% (95%CI 70.50–95.33) as summarized in Table 6.

As summarized in Table 7, MRI showed 44.4% upgrading in O-RADS scoring when compared to US O-RADS (six out of 38 lesions categorized as O-RADS 3 by US were classified as O-RADS 4 by MRI and 12 were O-RADS 5, while 14 of 34 O-RADS 4 by US were O-RADS 5 by MRI (Fig. 3)), and there was 50% downgrading in scoring (16 of 38 O-RADS 3 by US were classified as O-RADS 2 by MRI (Fig. 4), while 16 of 34 O-RADS 4 by US were O-RADS 2 and four were O-RADS 3 by MRI); moreover, MRI kept the same grading of 4 lesions (O-RADS 3) as US (Fig. 5).

Discussion

One of the most prevalent reasons for gynecologic imaging is the detection of adnexal masses (AM), which are a common gynecological issue. In order to prevent needless laparotomies for benign lesions, it is crucial to adopt an accurate imaging approach for differentiating between benign and malignant AMs. In addition, it allows evaluation of the malignancy risk of masses, which aids in treatment planning [9, 10].

Recently, Thomassin-Naggara et al. [4, 7, 8] prospectively assessed an updated version of this grading method using a large multicenter patient population to develop the O-RADS MRI score. The diagnostic accuracy of the new scoring system, which is likewise based on MRI results, is very high (99%) and almost as high (78%). However, both scoring systems have limitations that make them less than ideal. The fundamental problem is that PWI is not often utilized in clinical practice or generally understood by the general public.

In the current study, we found that all 72 patients suffered from pain, more than half patients (63.9%) suffered from constipation or diarrhea, 44.4% had fever, 41.7% had palpable mass or increased abdominal volume, 22.2% had vaginal bleeding and 19.4% had urinary symptoms. This was in agreement with Bhagde et al. [11] found that many adnexal masses are asymptomatic, although abdominal discomfort was present in roughly 92% of patients.

In the current study, we demonstrated that as regards the origin of the studied lesions, 66 were adnexal (out of which, 46 were ovarian, 14 were tubo-ovarian and 6 were in broad ligament) and six were nonadnexal (uterine lesions).

Determining whether a pelvic tumor is adnexal or nonadnexal is crucial for effective treatment. According to Thomassin-Naggara et al. [4, 7, 8], MRI may be used to confirm or refute the ultrasonographic diagnosis of an adnexal mass. 10% of the MRI-described masses in a group of 802 women with a single mass were outside of the adnexa. This is especially crucial for malignant nonadnexal tumors, where a poor prognosis might result from improper first treatment. Nonadnexal lesions of uterine, colorectal, urothelial, nonepithelial peritoneal, or lymph node origin accounted for 5.4% of malignant tumors in their population (15/277).

The present research found that the O-RADS MRI score accurately classified 44.4% of masses as O-RADS 2, indicating that they were almost certainly benign; 11.1% of masses were classified as O-RADS 3, indicating low risk malignancy; 8.3% of masses were classified as O-RADS 4, indicating intermediate risk malignancy; and 36.1% of masses were classified as O-RADS 5, indicating high risk malignancy.

The findings of our research are consistent with those of the Hottat et al. [12, 13] study which discovered that among 402 women, those with ambiguous adnexal masses detected using transvaginal ultrasonography (TVUS) were evaluated via MRI. There were 32 lesions with a score of 2 in 27 patients, 88 lesions with a score of 3, 32 lesions with a score of 4, and 39 lesions with a score of 5 in 31 individuals. There were 201 lesions, 58 (or 28.9%) of which were cancerous and the rest were benign.

In the current study, we demonstrated that based on pathology results which were the reference standard, 36.1% of the total adnexal masses were malignant.

Pereira et al. [14, 15] identified a significant malignancy rate, with 90 (47.37%) of those 190 masses being designated as malignant in the histological investigation, which is consistent with our study's findings.

Table 7 Change in O-RADS classification by MRI in comparison with US scoring

US	MRI					Total
	O-RADS 1	O-RADS 2	O-RADS 3	O-RADS 4	O-RADS 5	
O-RADS 3	0 (0%)	16 (22.2%)	4 (5.6%)	6 (8.3%)	12 (16.7%)	38 (52.8%)
O-RADS 4	0 (0%)	16 (22.2%)	4 (5.6%)	0 (0%)	14 (19.4%)	34 (47.2%)
Total	0 (0%)	32 (44.4%)	8 (11.1%)	6 (8.3%)	26 (36.1%)	72 (100%)

Data are presented as frequency (%)

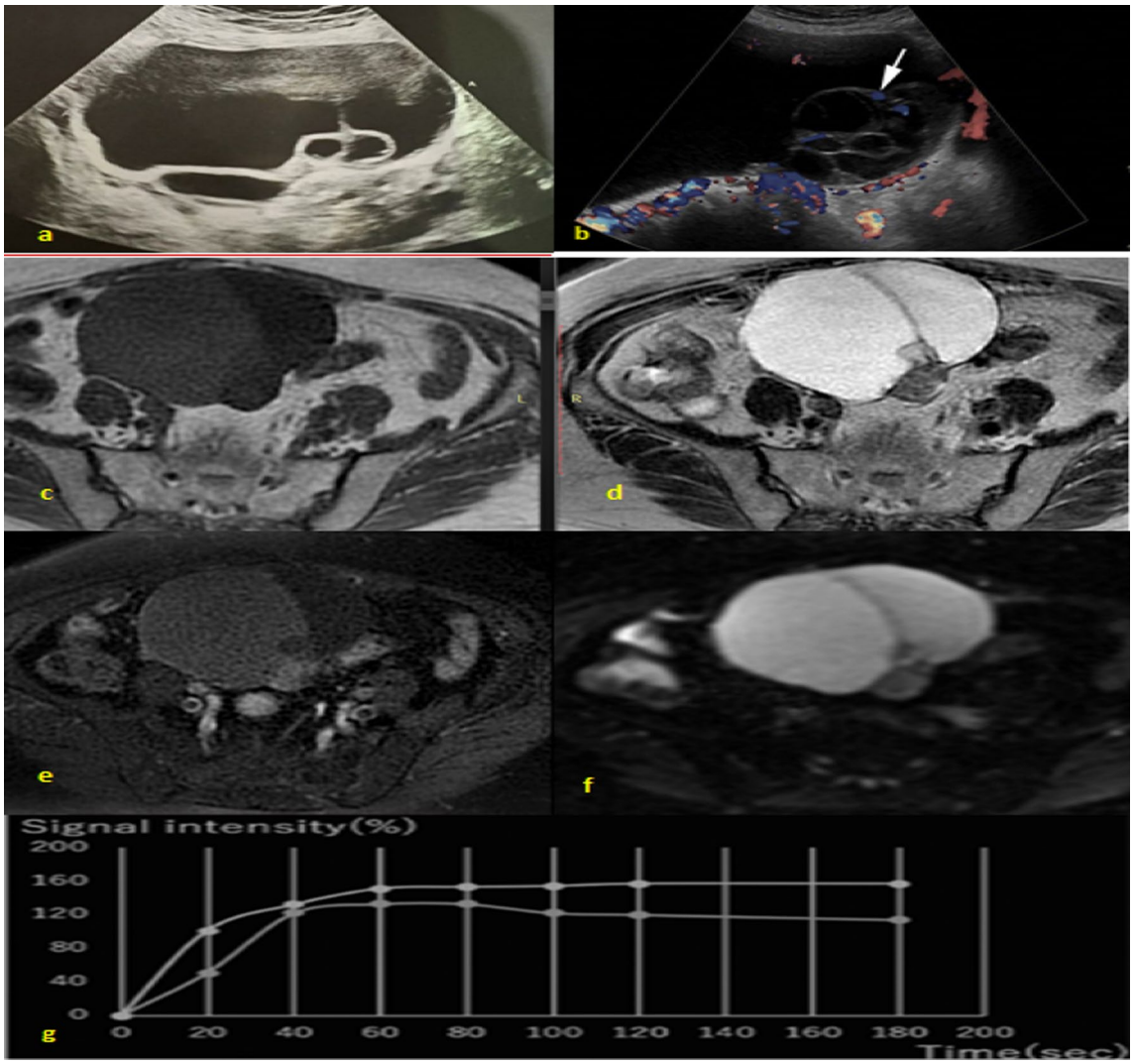

Fig. 3 A 62-year-old married female patient, complaining of abdominal pain and distention, and nausea. **a** Transabdominal ultrasound reveals right adnexal well-defined anechoic Complex cystic lesion measuring about 11 × 9 cm with thick nodular internal septations **b** Transabdominal ultrasound shows moderate flow on color Doppler. **c** Axial T1-weighted image reveals right ovarian well-defined bilocular cystic lesion measuring about 12 × 10 cm with mural nodules, inseparable from the sigmoid colon and uterus. The lesion displays low signal in T1WI small mural nodules displaying low signal intensity **d** Axial T2-weighted image shows intermediate signal intensity of the mural nodules **e** Axial T1 post contrast shows mild post contrast enhancement of the lesion. **f** Diffusion-weighted image shows restricted diffusion of the mural nodule (**g**) DCE-MRI, dynamic contrast-enhanced MRI Curve type 3: Initial rise steeper than that of myometrium. Scoring: O-RADS US 4, CS 2, and O-RADS MRI 5, the lesion was diagnosed as right ovarian mucinous cystadenocarcinoma by histopathology

In the current study, we illustrated that regarding MRI O-RADS classification in relation to pathology, out of 32 lesions categorized as O-RADS 2 by MRI, two were diagnosed as malignant by pathology, while eight lesions were O-RADS 3 by MRI which was consistent with pathology being benign. Out of six lesions categorized as O-RADS 4 by MRI, two were diagnosed as benign by pathology. Out of 26 lesions categorized as O-RADS 5 by MRI, six were diagnosed as benign by pathology.

Pereira et al. [14, 15] confirmed our findings. Wrong diagnosis was made due to the false-positives and false-negative result, as well as the major image abnormalities. Three out of the eight false-negative cases were cancerous masses with a solid part but a relatively safe (type 1) time-intensity curve, and they got a score of 3. 5 of the eight false-negative cases involved cancerous masses that did not have a clear solid part. These cases got an O-RADS MRI grade of 2 or 3, and the other three cases involved malignant masses that got a score of 3. All ten

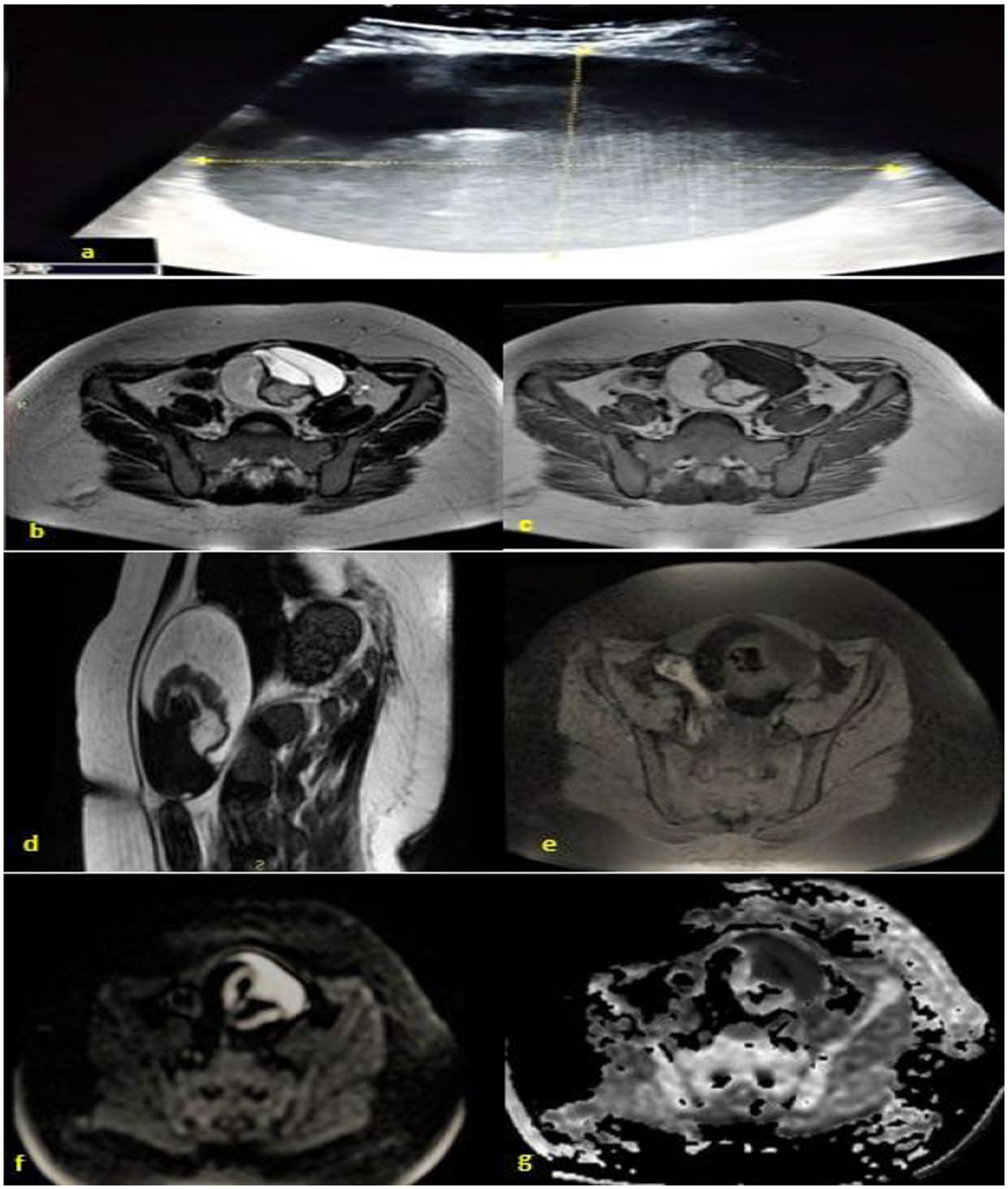

Fig. 4 A 32-year-old female patient complaining of pain and fullness in lower abdomen. **a** transabdominal ultrasound reveals left adnexal well-defined cystic lesion of mixed echogenicity measures about 13 × 11 cm with calcification, no vascular activity on color Doppler **b** Axial T1-weighted image shows well-defined left adnexal lesion measures about 11 × 13 × 8 cm, T1WI display mixed high signal (cystic) and isointense (fatty element) with evidence of low signal calcification inside. **c** axial T2-weighted image with isointense fatty element and low signal (cystic element) **d** sagittal T1Post contrast no pathologically enhanced lesions. **e** Axial STIR shows suppression of the fatty element. **f** Diffusion-weighted image and (G) ADC map: the lesion shows no areas of restricted diffusion. Scoring: O-RADS US 3, COLOR SCORE 1, and O-RADS MRI 2, the lesion was diagnosed as left ovarian dermoid by histopathology

masses that were wrongly thought to be cancer had an O-RADS MRI score of 4, which points to a type 2 (average risk) time-intensity curve. There was not a single piece of data to suggest that any of the masses followed a time-intensity curve typical of high risk type 3.

Except for the cases with an O-RADS MRI score of one, our results are the same as the ones found by

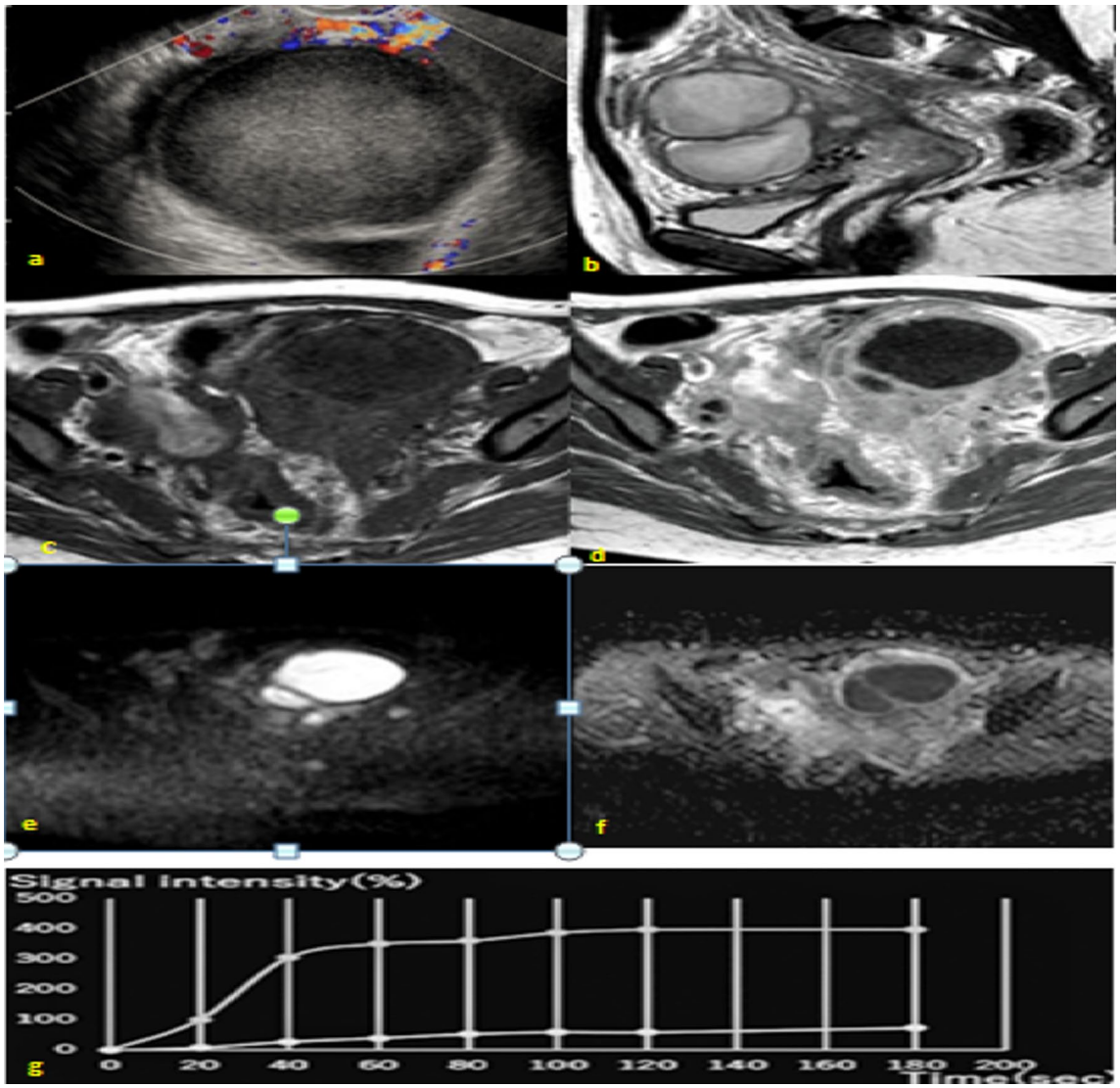

Fig. 5 A 37-year-old female patient presented with pelvic pain, fever and leukocytosis **a** transvaginal ultrasound shows left adnexal well-defined bilocular cystic lesion of turbid content measures about 5 × 3 cm with preipheral vascular activity on color Doppler study **b** sagittal T2-weighted image shows well-defined left adnexal bilocular mixed signal intensity lesion displays high signal intensity on T2WI **c** axial T1-weighted image shows heterogeneous low and intermediate ground glass stain signal lesion **d** axial T1 post-contrast image shows intense post-contrast enhancement of its thick walls and incomplete septae. The internal septations reach 3 mm in thickness. **e** Diffusion-weighted image **f** ADC map shows diffusion restriction of the cyst contents with no restriction in wall nor septae, **g** Dynamic contrast enhancement, Curve type 1: Gradual increase without a well-defined shoulder findings are suggestive of ovarian abscess. Scoring: O-RADS US 3, COLOR SCORE 2, and O-RADS MRI 3, the lesion was diagnosed as left tubo-ovarian complex by histopathology

Thomassin-Naggara et al. [4, 7, 8] (10.9%, 0.3%, 5.6%, 55.5%, and 89.5%, respectively, for O-RADS MRI values of 1, 2, 3, 4, and 5). This disparity in the O-RADS MRI score 1 category may be explained, according to our analysis, by the greater sample size and higher percentage of nonadnexal masses seen in the study conducted by Thomassin-Naggara et al. [4, 7, 8]. In spite of this, research on a massive scale and involving several centers are required in order to further draw out the ramifications of these discoveries.

In addition, Aslan et al. [16, 17] show that the sensitivity, specificity, and accuracy rates of the O-RADS MRI score in differentiating between benign and malignant AM are all fairly high. The sensitivity rate was 96.3%, the specificity rate was 95.2%, and the accuracy rate was 95.8%.

According to BASU et al. [18, 19], the O-RADS MR scoring technique has a high sensitivity and specificity, with respective values of 92.3% and 87.8%.

We also demonstrated that there was a positive correlation between the O-RADS MRI score and an increased likelihood of developing cancer, with a likelihood ratio (LR) of 0.01 for score 2, 0.27 for score 3, 4.42 for score 4, and 38.81 for score 5. These results are in line with what was discovered in a study carried out by Wong et al. [2, 20]. For the experienced readers, the sensitivity was 93%, the specificity was 91%, and the area under the receiver operating characteristic curve was 0.96. This was in conjunction with the good inter-rater agreement.

Conclusions

Our results demonstrated that the O-RADS MRI score accurately and validly differentiates between indeterminate benign and malignant AMs. Clinical use of this score for sonographically ambiguous masses might lead to tailored, patient-centered approach for masses that are sonographically indeterminate that avoids needless surgery and, in certain cases, allows for less invasive procedures or even fertility preservation.

Abbreviations

ADC	Apparent diffusion coefficient
ADNEX	Assessment of Different neoplasias in the adnexa
AM	Adnexal masses
DCE	Dynamic contrast-enhanced
DCE-MRI	Dynamic contrast-enhanced MRI
DWI	Diffusion-weighted imaging
FSE	Fast spin echo
MRI	Magnetic resonance imaging
O-RADS	Ovarian-Adnexal Reporting and Data System
T2-W	T2-weighted
TAUS	Transabdominal ultrasound
TICs	Time-intensity curves
TSE	Turbo spin echo
TVUS	Transvaginal ultrasound
ACR	American College of Radiology
CS	Color score
AUC	Area under curve
PWI	Perfusion-weighted image

Acknowledgements

The author thanks all the study participants for their patience and support.

Author contributions

Study concepts and design were done by RH, HT and SE. Literature research was done by RH and MK. Clinical studies were carried out by MK. Experimental studies/data analysis were done by RH and MK. Statistical analysis was done by MK and SE. Manuscript preparation was done by RH and MK. Manuscript editing was done by HT. All authors read and approved the final manuscript.

Funding

No funding was obtained for this study.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board (IRB) of Zagazig University (IRB Approval No. ZU-IRB#9240/12-1-2022). A written informed consent from the patient before the study.

Consent for publication

All patients included in this research gave written informed consent to publish the data contained within this study.

Competing interests

The authors declare that they have no competing interests.

Received: 15 July 2023 Accepted: 6 April 2024
Published online: 18 April 2024

References

1. Ahmed H (2021) The usefulness of the ultrasound diagnosis of suspicious ovarian masses based on the O-RADS classification system. Al-Azhar Int Med J. https://doi.org/10.21608/aimj.2021.90943.1551
2. Thomassin-Naggara I, Poncelet E, Jalaguier-Coudray A, Guerra A, Fournier LS, Stojanovic S, Millet I, Bharwani N, Juhan V, Cunha TM, Masselli G, Balleyguier C, Malhaire C, Perrot NF, Sadowski EA, Bazot M, Taourel P, Porcher R, Darai E, Rockall AG (2020) Ovarian-adnexal reporting data system magnetic resonance imaging (O-RADS MRI) score for risk stratification of sonographically indeterminate adnexal masses. JAMA Netw Open 3(1):e1919896. https://doi.org/10.1001/jamanetworkopen.2019.19896
3. Phillips CH, Guo Y, Strachowski LM, Jha P, Reinhold C, Andreotti RF (2023) The ovarian/adnexal reporting and data system for ultrasound: from standardized terminology to optimal risk assessment and management. Can Assoc Radiol J 74(1):44–57. https://doi.org/10.1177/08465371221108057
4. Sadowski EA, Thomassin-Naggara I, Rockall A, Maturen KE, Forstner R, Jha P, Nougaret S, Siegelman ES, Reinhold C (2022) O-RADS MRI risk stratification system: guide for assessing adnexal lesions from the ACR O-RADS committee. Radiology 303(1):35–47. https://doi.org/10.1148/radiol.204371
5. Sasaguri K, Yamaguchi K, Nakazono T, Mizuguchi M, Aishima S, Yokoyama M, Irie H (2019) External validation of ADNEX MR SCORING system: a single-centre retrospective study. Clin Radiol 74(2):131–139. https://doi.org/10.1016/j.crad.2018.10.014
6. Reinhold C, Rockall A, Sadowski EA, Siegelman ES, Maturen KE, Vargas HA, Forstner R, Glanc P, Andreotti RF, Thomassin-Naggara I (2021) Ovarian-adnexal reporting lexicon for MRI: a white paper of the ACR ovarian-adnexal reporting and data systems MRI committee. J Am Coll Radiol 18(5):713–729. https://doi.org/10.1016/j.jacr.2020.12.022
7. Stein EB, Hansen JM, Maturen KE (2020) Fertility-sparing approaches in gynecologic oncology. Radiol Clin North Am 58(2):401–412. https://doi.org/10.1016/j.rcl.2019.10.006
8. Basha MAA, Abdelrahman HM, Metwally MI, Alayouty NA, Mohey N, Zaitoun MMA, Almassry HN, Yousef HY, el Sammak AA, Aly SA, Algazzar HY, Farag MAEM, Mosallam W, Abo Shanab WS, Ibrahim SA, Mohamed EA, Mohamed AEM, Afifi AHM, Harb OA, Azmy TM (2021) Validity and reproducibility of the <scp>ADNEX MR scoring</scp> system in the diagnosis of sonographically indeterminate adnexal masses. J Magn Reson Imaging 53(1):292–304. https://doi.org/10.1002/jmri.27285
9. Biggs WS, Marks ST (2016) Diagnosis and management of adnexal masses. Am Fam Physician 93(8):676–681
10. Hermans AJ, Kluivers KB, Wijnen MH, Bulten J, Massuger LF, Coppus SF (2015) Diagnosis and treatment of adnexal masses in children and adolescents. Obstet Gynecol 125(3):611–615. https://doi.org/10.1097/AOG.0000000000000665
11 Bhagde AD, Jani SK, Patel MS, Shah SR (2016) An analytical study of 50 women presenting with an adnexal mass. Int J Reprod Contr Obstet Gynecol 6(1):262. https://doi.org/10.18203/2320-1770.ijrcog20164671

12. Hottat NA, van Pachterbeke C, vanden Houte K, Denolin V, Jani JC, Cannie MM (2021) Magnetic resonance scoring system for assessment of adnexal masses: added value of diffusion-weighted imaging including apparent diffusion coefficient map. Ultrasound Obstet Gynecol 57(3):478–487. https://doi.org/10.1002/uog.22090
13. Zhang X, Meng X, Dou T, Sun H (2020) Diagnostic accuracy of transvaginal ultrasound examination for assigning a specific diagnosis to adnexal masses: a meta-analysis. Exp Ther Med 20(6):1–1. https://doi.org/10.3892/etm.2020.9395
14. Pereira PN, Yoshida A, Sarian LO, Barros RHO, Jales RM, Derchain S (2022) Assessment of the performance of the O-RADS MRI score for the evaluation of adnexal masses, with technical notes. Radiol Brasil 55(3):137–144. https://doi.org/10.1590/0100-3984.2021.0050
15 Torre LA, Trabert B, DeSantis CE, Miller KD, Samimi G, Runowicz CD, Gaudet MM, Jemal A, Siegel RL (2018) Ovarian cancer statistics. CA 68(4):284–296. https://doi.org/10.3322/caac.21456
16. Aslan S, Tosun SA (2023) Diagnostic accuracy and validity of the O-RADS MRI score based on a simplified MRI protocol: a single tertiary center retrospective study. Acta Radiol 64(1):377–386. https://doi.org/10.1177/02841851211060413
17 Froyman W, Landolfo C, de Cock B, Wynants L, Sladkevicius P, Testa AC, van Holsbeke C, Domali E, Fruscio R, Epstein E, dos Santos Bernardo MJ, Franchi D, Kudla MJ, Chiappa V, Alcazar JL, Leone FPG, Buonomo F, Hochberg L, Coccia ME et al (2019) Risk of complications in patients with conservatively managed ovarian tumours (IOTA5): a 2-year interim analysis of a multicentre, prospective, cohort study. Lancet Oncol 20(3):448–458. https://doi.org/10.1016/S1470-2045(18)30837-4
18. Basu A, Pame M, Bhuyan R, Roy DK, James VM (2022) Diagnostic performance of O-RADS MRI scoring system for the assessment of adnexal masses in routine clinical radiology practice- a single tertiary centre prospective cohort study. J Clin Diagn Res. https://doi.org/10.7860/JCDR/2022/54998.16240
19. Timmerman D, Planchamp F, Bourne T, Landolfo C, du Bois A, Chiva L, Cibula D, Concin N, Fischerova D, Froyman W, Gallardo Madueño G, Lemley B, Loft A, Mereu L, Morice P, Querleu D, Testa AC, Vergote I, Vandecaveye V, Fotopoulou C (2021) ESGO/ISUOG/IOTA/ESGE Consensus Statement on pre-operative diagnosis of ovarian tumors. Int J Gynecol Cancer 31(7):961–982. https://doi.org/10.1136/ijgc-2021-002565
20. Wong VK, Kundra V (2021) Performance of O-RADS MRI score for classifying indeterminate adnexal masses at US. Radiol Imaging Cancer 3(3):e219008. https://doi.org/10.1148/rycan.2021219008

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