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To do Elastography or not to do? Comparative study between shear wave Elastography versus Doppler in the Evaluation of O-RADS 3 and 4 Ovarian Lesions

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Abstract

Purpose

Ovarian lesions are common diseases nowadays that should be diagnosed accurately. The Ovarian-Adnexal Reporting and Data System (O-RADS) classification helps to a great extent in categorizing the type of ovarian lesions, whether benign, malignant, or even borderline, that fasten the decision of the treatment plan. The role of Doppler is vital to inform the perfusion of the tissue, thus can predict whether the tumor is benign or malignant. The elasticity of the tissues by shear wave elastography supports the evaluation of ovarian lesions and plays a role as a relatively recent method for diagnosis. This study was done to compare the diagnostic efficacy of Doppler and ultrasonography versus shear wave elastography (SWE) for O-RADS 3 and 4 ovarian lesions.

Methods

Forty-eight female patients were radiologically diagnosed with ovarian lesions, and all of them were included in the final statistical analysis. A pelvic-abdominal ultrasound was performed. Doppler and shear wave elastography techniques were applied for all patients then the findings were correlated to histopathology.

Results

As regards the color Doppler, there were 5 true positive results (10.4%), 32 true negative results (66.7%), 7 false positive results (14.6%), and 4 false negative results (8.3%). Its sensitivity of 55.5%, specificity of 82% and diagnostic accuracy 66%. Regarding the qualitative evaluation of SWE, there was 1 true positive result (2.1%), 32 true negative results (66.7%), 7 false positive results (14.6%), and 8 false negative results (16.7%). Its sensitivity was 11.1%, specificity of 82% and the diagnostic accuracy was 67.8%; however, regarding its quantitative evaluation by measuring the kPa value, the sensitivity of the technique raised to be 66.7% with a significant P value < 0.001.

Conclusion

Color Doppler is an effective diagnostic technique that shows a satisfactory level of agreement with pathology findings when it applies to distinguishing benign from malignant tumors, with (p-value = 0.019) fair agreement (k = 0.33). Regarding the SWE, the quantitative evaluation by measuring the KPA value, which could be used to distinguish between benign and malignant lesions at a cutoff level of > 31 with 66.7% sensitivity, 76.9% specificity, 40% PPV, and 90.9% NPV with a significant P value < 0.001, is much more precise than the qualitative evaluation by elastogram.

Background

Ovarian lesions can be divided into simple cysts, complex cystic and solid or as solid lesions. Cysts are predominately fluid-containing lesions that can be unilocular or multilocular. A solid lesion is composed of at least 80% enhancing solid tissue [1].

The accurate characterization of ovarian lesions is necessary for the best possible patient care. For most benign lesions, conservative and less aggressive treatment is preferable. On the other hand, when malignancy is detected, patients should be referred to a gynecologic oncologist to obtain better outcomes [2].

The Ovarian-Adnexal Reporting and Data System (O-RADS) lexicon for the US provides a standardized lexicon that includes all relevant descriptors and definitions of the characteristic sonographic criteria of normal ovaries and ovarian lesions [3].

The O-RADS US has six categories for risk classification (0–5). Among these, O-RADS 3 includes lesions with a low risk of malignancy (1% to < 10%), whereas O-RADS 4 encompasses lesions with an intermediate risk of malignancy (10% to < 50%) [4].

Adnexal masses categorized as O-RADS 1 and 2 are considered almost certainly benign and generally require little or no further imaging, except in the presence of compelling clinical considerations such as large lesion size (> 10 cm). In contrast, O-RADS 5 lesions carry a high possibility of malignancy and therefore warrant additional imaging and/or surgical intervention. O-RADS 3 & 4 masses with reasonable probability of being malignant may benefit from further evaluation. Such additional assessment aims to minimize misclassification, either by identifying lesions that have been underscored (true O-RADS 5) or overscored (true O-RADS 1 or 2).[5]

In order to better characterize ovarian neoplasms, color Doppler spectral analysis with indices such as the resistive index (RI) and pulsatility index (PI) is valuable.

It is generally accepted that benign tumors are associated with moderate-to-high impedance to blood flow, while low-impedance high velocity blood flow is suggestive of malignancy.[6]

Shear wave elastography (SWE) is a non-invasive imaging technique that quantitatively assesses tissue stiffness by generating and tracking shear waves within the tissue. SWE uses an acoustic radiation force pulse generated by focused ultrasound to create localized perturbations; these perturbations produce transverse shear waves that propagate laterally from the push location. The imaging system then uses ultrafast pulse-echo sequences to detect the resulting shear wave propagation and calculate the shear wave speed, which is directly related to the local shear modulus of the tissue. Because stiffer tissues transmit shear waves at higher velocities, the measured wave speed can be converted into quantitative metrics of elasticity such as shear or Young’s modulus, enabling objective assessment of tissue mechanical properties.[7]

In the current study, we aimed to evaluate the diagnostic performance of shear wave elastography compared to ultrasound and Doppler in the evaluation of unilateral ORADS 3 and 4 ovarian lesions.

Methods

This prospective study was approved by Research and Ethical Committee (MS-448-2023) in accordance with the declaration of Helsinki. Informed consent was obtained from all participants included in the study. The research was carried out at Radiology Department in the period from August 2023 and March 2024.

Population of the study:

The study included forty-eight female patients with unilateral single ovarian lesions (32 right-sided, 16 left-sided). An ultrasound was performed for all patients using a trans-abdominal ultrasound. Color Doppler and shear wave elastography techniques were applied for all patients **(**Fig. 1**).**

Initially, 135 patients referred from the Department of Gynecology and Obstetrics with ultrasound-diagnosed ovarian lesions were considered for inclusion. Of these, 48 patients met the inclusion criteria, namely the presence of a unilateral ovarian lesion classified as O-RADS 3 or 4, and were therefore included in the study. The remaining 87 patients were excluded due to lesions categorized as O-RADS 1, 2, or 5, bilateral ovarian involvement, the presence of collision tumors, or patient's refusal to undergo the examination.

Technique:

All patients underwent B-mode ultrasound with both Doppler and shear wave elastography applications. The ovarian lesions were analyzed according to the O-RADS lexicon. The findings were interpreted and compared accordingly by the gold standard postoperative histopathology.

All patients were examined with B-mode ultrasound (TOSHIBA APLIO 500). Examinations were performed using a curvilinear 5–7 MHz probe. The patient was lying supine in the pelvi-abdominal U/S (PAUS). The scanning protocol included transverse and longitudinal real-time imaging of the ipsilateral side of the lesion as well as the contralateral side.

Doppler application on the lesions was performed to assess the color score according to the Ovarian-Adnexal Reporting and Data System (O-RADS) US v20227 **(Fig. 2).**

Figure 2

Color score categories (1–4) based on the subjective evaluation of vascularity as defined in the O-RADS lexicon. **(A)** Color score 1 indicates absence of detectable blood flow within the cyst wall, septations, or any solid component. **(B)** Color score 2 corresponds to the presence of minimal vascular flow. **(C)** Color

score 3 denotes moderate vascularity. **(D)** Color score 4 describes an adnexal lesion demonstrating pronounced hypervascularity with abundant blood flow.[2]

The elastography was applied while the patient's position was supine with breath control to decrease motion artifact. The transducer was kept stable without pressure for a few seconds perpendicular. Freezing: when we see stable parallel lines. We underwent qualitative and quantitative assessments.

Processing and interpretation of images:

Qualitative measurements: A circular region of interest (ROI) was placed at different lesion sites. The elasticity is qualitatively assessed using color-coded images; red is stiffer, and green or blue is softer.

A shear wave speed image is usually presented as a color overlay on a grayscale B-mode image with either red or blue marking stiff tissues. The color bar on the side of the image relates the colors to either the shear wave speed or the calculated Young's modulus, and usually, the manufacturer identifies which colors are rigid and which are soft. Since the image is quantitative, the technician may place the cursor or define the region of interest and obtain the average SWS or Young's modulus estimation from that location[8].

Quantitative assessment: through measuring the kPa value, by putting the ROI upon the the detected mural soft tissue lesions or hypo-vascular lesions within the ovarian lesions and finally calculating the cutoff value that can discriminate between benign and malignant lesions.

p-SWE only excites the acoustic radiation force at one point and then detects the shear wave velocity in a small region of interest (ROI). The output was expressed in either m/s or kPa, converted by Young's model formula. Because only a small area was measured in shear wave imaging, it was recommended to take at least 5–10 measurements and take the average value. Finally, we calculated the cutoff value of kPa in all examined patients **(**Fig. 3**).**

Imaging analysis, including ultrasound examination with Doppler and shear wave elastography, was under the guidance of two qualified consultants of radiology with more than 10 years of field experience.

The recorded **parameters** included:

1. 1. Shape: cystic, solid, or complex lesions.
2. 2. Inner wall irregularity.
3. 3. Vascularity according to ORADS color score classification.
4. 4. Presence of calcification.
5. 5. Stiffness, whether stiff or soft, is assessed by applied shear wave elastography.
6. 6. Measuring the average of the kPa value.
7. 7. Level of suspicion according to O-RADS classification, the examined ovarian lesions were categorized into O-RADS 3 or 4, depending on the degree of suspicion, according to O-RADS risk

stratification and management system.

Statistical methods:

The data acquired underwent a process of revision, coding, tabulation, and introduction into a personal computer utilizing the Statistical Package for Social Science (SPSS 24).

Descriptive statistics

- The mean, standard deviation (± SD), and range are often used measures for summarizing parametric numerical data. On the other hand, the median represents the middle value of a dataset when arranged in ascending or descending order is more appropriate for summarizing nonparametric numerical data. This study examines the frequency and proportion of non-numerical data.

Analytical statistics

- Kappa statistics in order to determine the level of concordance between two investigative methodologies, it is necessary to calculate the measure of agreement. A kappa value beyond 0.75 can be considered exceptional, while a value ranging from 0.40 to 0.75 can be regarded as fair to good. Conversely, a kappa value below 0.40 is indicative of poor agreement.
- The P value is a measure of the level of significance in statistical hypothesis testing. A P value more than 0.05 is considered nonsignificant (NS), whereas a P value less than 0.05 is considered significant (S).

Results

The final analysis comprised 48 patients with unilateral ovarian lesions, all of whom underwent pelvi-abdominal ultrasonography with Doppler and shear wave elastography.

With a minimum age of 26 years and a maximum age of 52 years, the mean age of all the patients within the study was 38.5 ± 7.8 years. Regarding the affected side, there were 32 right-sided lesions (66.7%) and 16 left-sided lesions (33.3%). There were 19 patients (39.6%) of O-RADS 3 and 29 patients (60.4%) of O-RADS 4 in the study.

Regarding the shape of the lesion, there were 28 patients (58.3%) with a regular shape and 20 patients (41.7%) with an irregular shape in the studied patients. As regards the type of lesion, there were 30 patients (62.5%) with unilocular cysts and 18 patients (18%) with multilocular cysts in the studied patients. There was solid content in 17 patients (35.4%), septation in 26 patients (54.2%), lipid content in 12 patients (25%), and calcifications in 10 patients (20.8%) **(**Table 1**).**

Table 1
Sonographic morphological characteristics of the studied ovarian lesions:

Parameter		Studied patients (n = 48)	
Shape	**Regular**	28	58.3%
	Irregular	20	41.7%
Type	**Uni-locular cyst**	30	62.5%
	Multi-locular cyst	18	37.5%
Solid component	**No**	31	64.6%
	Yes	17	35.4%
Septation	**No**	22	45.8%
	Yes	26	54.2%
lipid contentment	**No**	36	75%
	Yes	12	25%
Calcifications	**No**	38	79.2%
	Yes	10	20.8%

Color Doppler showed that the lesions of 36 patients (75%) were benign lesions and the lesions of 12 patients (25%) were malignant lesions. SWE color showed that the lesions of 39 patients (81.3%) were blue (benign lesions) and the lesions of 9 patients (18.8%) were green/red (malignant lesions).The mean KPA value of all studied patients was 34.1 ± 17.2, with a minimum KPA value of 17 and a maximum KPA value of 82.

There were 9 patients (18.8%) with dermoid cysts (larger than 10 cm), 6 patients (12.5%) with endometrioma (4 cases with soft tissue component, 2 cases were larger than 10 cm), 3 patients (6.3%) with immature teratoma, 5 patients (10.4%) with mucinous cystadenocarcinoma, 19 patients (39.6%) with mucinous cystadenoma, 1 patient (2.1%) with serous cystadenocarcinoma, 4 patients (8.3%) with serous cystadenoma, and 1 patient (2.1%) with hemorrhagic cyst. Total benign lesions were 39 lesions (81.3%), and total malignant lesions were 9 patients (18.8%) in the studied patients **(**Table 2**)**.

Table 2
Comparison between MRI diagnosis and histopathological results of ovarian lesions in the studied patients (n = 48):

Diagnosis	MRI diagnosis n (%)	Histopathology n (%)
Dermoid cyst	9 (18.8%)	9 (18.8%)
Endometrioma	7 (14.6%)	6 (12.5%)
Immature teratoma	3 (6.3%)	3 (6.3%)
Mucinous cystadenocarcinoma	5 (10.4%)	5 (10.4%)
Mucinous cystadenoma	19 (39.6%)	19 (39.6%)
Serous cystadenocarcinoma	1 (2.1%)	1 (2.1%)
Serous cystadenoma	4 (8.3%)	4 (8.3%)
Hemorrhagic cyst	—	1 (2.1%)
Final classification		
Benign	—	39 (81.3%)
Malignant	—	9 (18.8%)

There was statistically significant (p-value = 0.019) fair agreement (k = 0.33) between color Doppler and pathology results. Of the total studied 48 patients, there were 5 true positive results (10.4%), 32 true negative results (66.7%), 7 false positive results (14.6%), and 4 false negative results (8.3%). Thus, Color Doppler had a sensitivity of 55.5%, specificity of 82%, PPV of 41.6%, NPV of 88.9%, and accuracy of 66% about pathology results **(**Table 3**).**

Table 3
Agreement and clinical utility of color Doppler with pathology results:

(n = 48)		**Pathology**				**K**	**P-value**
		Benign		**Malignant**			
Color Doppler	**Benign**	32	66.7%	4	8.3%	**0.33**	**0.019 S**
	Malignant	7	14.6%	5	10.4%		
Clinical utility							
Sensitivity	55.5%			**NPV**		88.9%	
Specificity	82%			**Accuracy**		77%	
PPV	41.6%						

However, there was no statistically significant (p-value = 0.620) poor agreement (k = 0.07) between SWE and pathology results. Of the total studied 48 patients, there was 1 true positive result (2.1%), 32 true negative results (66.7%), 7 false positive results (14.6%), and 8 false negative results (16.7%). Thus, SWE had a sensitivity of 11.1%, specificity of 82%, PPV of 12.5%, NPV of 80%, and accuracy of 68.7% in relation to pathology results (Table 4).

Table 4
Agreement and clinical utility of SWE in relation to pathology results:

(n = 48)		Pathology				K	P-value
		Benign		Malignant			
SWE	**Benign**	32	66.7%	8	16.7%	0.07	0.620 S
	Malignant	7	14.6%	1	2.1%		
Clinical utility							
Sensitivity	11.1%			**NPV**		80%	
Specificity	82%			**Accuracy**		68.7%	
PPV	12.5%						

Using the ROC curve, it was demonstrated that KPA is effective in distinguishing between benign and malignant lesions at a cutoff level of > 31, with 66.7% sensitivity, 76.9% specificity, 40% PPV, and 90.9% NPV (AUC = 0.7 & p-value = 0.017) (Table 5, Fig. 5).

Table 5
Diagnostic performance of KPA value in discrimination of pathology results:

	Cut off	AUC	Sensitivity	Specificity	PPV	NPV	p-value
KPA value	**> 31**	**0.7**	**66.7%**	**76.9%**	**40%**	**90.9%**	**0.017**

Discussion

When an adnexal lesion is found on pelvic ultrasonography, the goal of imaging is to identify if the lesion is benign or possibly malignant. Numerous methods based on ultrasonography have been developed to categorize the likelihood of these lesions by the analysis of imaging attributes, including vascularity and elasticity.[6]

The American College of Radiology (ACR) established the Ovarian-Adnexal Reporting and Data Systems (O-RADS) Committee, a multidisciplinary panel of experts responsible for developing the O-RADS ultrasonography (US) Risk Stratification and Management System[2].

The objective of the current study was to assess the diagnostic performance of shear wave elastography in the evaluation of O-RADS 3 and 4 ovarian lesions in comparison to Doppler and ultrasonography.

A total of 48 female patients with O-RADS 3 and 4 ovarian lesions were enrolled in our study, with a mean age of 38.5 ± 7.8 years (range: 26–52 years). This age distribution is consistent with that reported by Rai et al., who observed that adnexal masses most frequently occur in women of reproductive age (20–49 years)[11]. Similarly, Ahmed et al. reported an age range of 19–67 years (mean 41.8 ± 3.64 years)[12]. In line with these findings, Kodali et al. demonstrated comparable mean ages at presentation for benign, borderline, and malignant adnexal lesions (41.6, 42.5, and 44.5 years, respectively), further supporting the predominance of adnexal masses in this age group[13].

In the present study, benign lesions were detected in 39 lesions (81.3%), and malignant lesions were reported in 9 patients (18.8%) in the studied patients. There were 9 patients (18.8%) with a dermoid cyst, 6 patients (12.5%) with endometrioma **(Fig. 4)**, 3 patients (6.3%) with immature teratoma, 5 patients (10.4%) with mucinous cystadenocarcinoma, 19 patients (39.6%) with mucinous cystadenoma, 1 patient (2.1%) with serous cystadenocarcinoma, 4 patients (8.3%) with serous cystadenoma **(**Fig. 5**)**, and 1 patient (2.1%) with the hemorrhagic cyst .These findings were consistent with those of Zhang et al., who examined 242 individuals with 110 malignant and 153 benign tumors [14].

Figure 4

(**A**) PAUS showed a right cystic ovarian lesion had multiple thin septations inside and an echogenic soft tissue lesion, measuring 14.8cmx 15.8cm **(B)** By applying color Doppler, it showed no vascularity inside, color score 1. It considered O-RADS 3 **(C)** By Shear wave elastography it showed a blue color,with average Kpa value 27.Pathologically confirmed Endometrioma.

Similarly, Prasad et al. evaluated 56 masses and discovered that 24 of them were benign, 4 of them were malignant, and the remainder represented physiological cysts or infectious processes[15]. While Bhagde et al. reported that all examined lesions were of benign etiology[16]. On the opposite side, Rai et al. stated that malignancy etiology was the most prevalent pathology, 70% were malignant, while 15 lesions, 30% were benign[12].

According to O-RADS scoring in the present study, 19 patients (39.6%) were classified as O-RADS 3, while 29 patients (60.4%) were classified as O-RADS 4. In comparison, Tantawy et al. reported that 52.8% of adnexal masses were categorized as O-RADS 3, whereas 47.2% were classified as O-RADS 4 [18]. Additionally, Ahmed et al. found that 13 lesions were assigned an O-RADS 3, while 18 lesions were classified as O-RADS 4 and 19 lesions as O-RADS 5.[13]

In the current study, by using Color Doppler, lesions of 36 patients (75%) were diagnosed as being of benign nature, and 12 patients (25%) were malignant lesions, with statistically significant (p-value = 0.019) fair agreement (k = 0.33) between color Doppler and pathology results. Of the total studied 48 patients, there were 5 true positive results (10.4%) **(**Fig. 6**)**, 32 true negative results (66.7%) **(**Fig. 7**)**

(Fig. 8), 7 false positive results (14.6%), and 4 false negative results (8.3%) (Fig. 9). Thus, Color Doppler had a sensitivity of 55.5%, specificity of 82%, positive predictive value (PPV) of 41.6%, negative predictive value (NPV) of 88.9%, and accuracy of 66% about pathology results .

The study conducted by Kodali et al. reported a sensitivity of 78.5% and a specificity of 94.4%, with a PPV of 84.6%, a NPV of 91.8%, and an overall diagnostic accuracy of 90% when correlated with clinical, serological, and histopathological findings[14]. Similarly, Prasad et al. found excellent sensitivity and NPV (both 100%) for color flow analysis in predicting malignancy, although specificity and PPV were lower (80% and 36%, respectively).[16]

Karimi-Zarchi et al. also reported high diagnostic indices, with sensitivity of 98%, specificity of 85%, PPV of 87.5%, and NPV of 97.6%. [19] Furthermore, Sehgal demonstrated that negligible vascularity was strongly suggestive of benign disease, with an NPV of 90.46%. In his study, vascularity was observed in 92.59% of malignant lesions compared with 42.24% of benign lesions, although vascularity alone showed a limited PPV (64.1%) for malignancy.[20]

In our study, SWE color coding showed that the lesions of 39 patients (81.3%) were blue (benign lesions), and the lesions of 9 patients (18.8%) were green/red (malignant lesions), with no statistically significant (p-value = 0.620) poor agreement (k = 0.07) between SWE and pathology results. Of the total studied 48 patients, there were 1 true positive result (2.1%), 32 true negative results (66.7%), 7 false positive results (14.6%), and 8 false negative results (16.7%).Accordingly, SWE demonstrated a sensitivity of 11.1%, specificity of 82%, PPV of 12.5%, NPV of 80%, and accuracy of 68.7% in relation to pathology results. These results are comparable those reported by Manchanda et al., who found no significant difference in the elasticity values between benign and malignant adnexal masses. Moreover, subgroup analysis of epithelial tumors classified as benign, borderline, or malignant revealed no significant differences in elasticity parameters.[20].

In the current study, the quantitative evaluation of SWE showed the mean KPA value of all studied patients was 34.1 ± 17.2, with a minimum KPA value of 17 and a maximum KPA value of 82. By using the ROC curve, it was shown that KPA can be used to discriminate between benign and malignant lesions at a cutoff level of > 31, with 66.7% sensitivity, 76.9% specificity, 40% PPV, and 90.9% NPV (AUC = 0.7 & p-value = 0.017).

These findings are in agreement with Manchanda et al., who reported a mean elasticity of 45 ± 22.37 kPa for benign masses and 35.58 ± 13.23 kPa for malignant masses. Furthermore, non-neoplastic lesions demonstrated lower mean and maximum elasticity values compared with cystic neoplasms containing solid components. ROC curve analysis identified an E-mean cut-off value of 30.7 kPa, yielding a sensitivity of 66.7% and a specificity of 75%. An E-max threshold of 34.9 kPa showed a specificity of 75% with a sensitivity of 20%.

Limitation:

We had some limitations in our study:

- Single-center study, restricting the generalizability of the results to broader populations and different practice settings.
- Operator dependence, as SWE and color Doppler measurements may vary with probe pressure, ROI selection, and user experience.
- Overlap in elasticity values between benign, borderline, and malignant lesions, potentially reducing the discriminatory capability of SWE.
- Absence of longitudinal follow-up, preventing assessment of SWE utility in monitoring treatment response or lesion progression over time.
- Lack of interobserver variability analysis, which limits evaluation of the reproducibility and reliability of SWE measurements.

Recommendation:

- We do recommend the conduction of a large population-based dataset, and further studies with a higher number of patients in multicenter trials are necessary.
- Future advancements in shear wave elastography (SWE) may be supported by the integration of artificial intelligence–assisted tools, which have the potential to enhance lesion characterization and diagnostic performance while addressing the limitations of stiffness overlap between benign and malignant adnexal masses. AI algorithms could aid in automated ROI placement, standardized stiffness quantification, and recognition of complex elastographic patterns within heterogeneous lesions

Conclusion

Color Doppler is an effective tool for diagnosis that shows a statistically significant degree of agreement with pathology (p-value = 0.019) and fair agreement (k = 0.33) in distinguishing between benign and malignant tumors.

In comparison to the pathology results, the qualitative evaluation by elastogram shows poor agreement (k = 0.07) with a p-value of 0.620 for the SWE.

Although SWE outperforms Doppler in detecting small mural-based soft tissue components or hypovascular solid components, through using the quantitative assessment of SWE by measuring the KPA value, which has 66.7% sensitivity, 76.9% specificity, 40% PPV, and 90.9% NPV with significant P value < 0.001 and can be used to discriminate between benign and malignant lesions at a cutoff level of > 31.

Abbreviations

2D Two-dimensional

ACR American College of Radiology

AUC Area under the curve

KPA Kilopascal

MRI Magnetic resonance imaging

NPV Negative predictive value

O-RADS Ovarian-Adnexal Reporting and Data System

PAUS Pelvi-abdominal ultrasound

PCO Polycystic ovary

PPV Positive predictive value

ROI Region of interest

SWE Shear wave elastography

TE Transient Elastography

US Ultrasound

USE Ultrasound Elastography

WHO World Health Organization

Declarations

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Author Contribution

SA is the guarantor of the integrity of the entire study. SG, HR and SA contributed to the study concepts and design. MH, SA, and HR contributed to the literature research. SG,SA and SD contributed to the clinical studies. All authors contributed to the experimental studies/data analysis. SD and MH contributed to the statistical analysis. SA and HR contributed to the manuscript preparation. SG,SA and MH contributed to the manuscript editing. All authors have read and approved the final manuscript.

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Figures

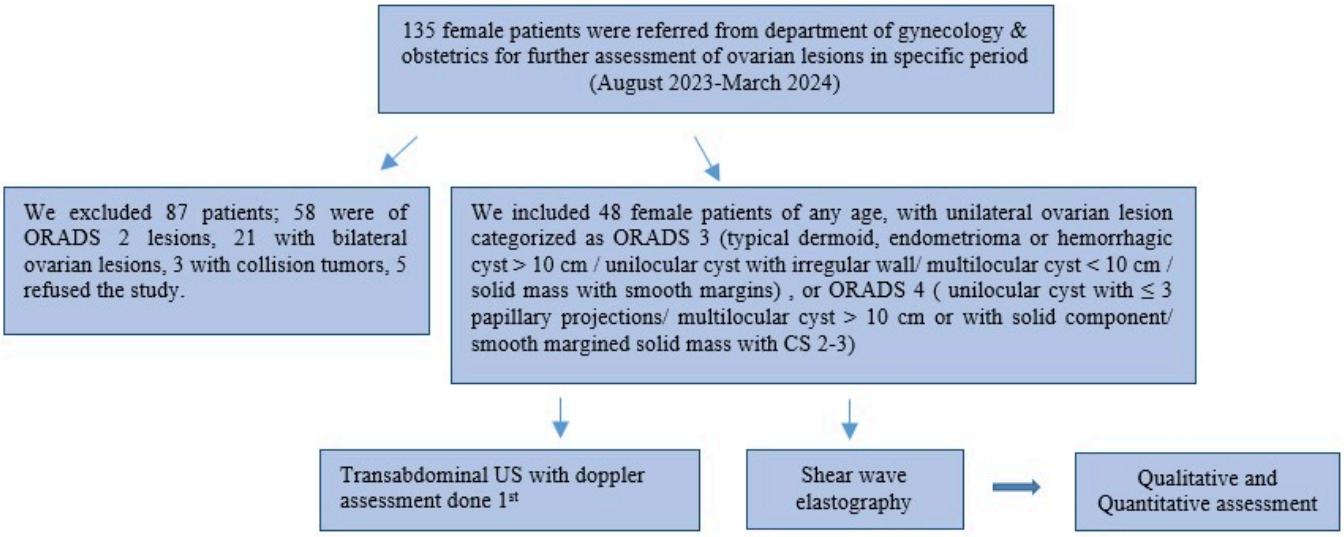


Figure 1

illustrates the flowchart of patient selection and study workflow

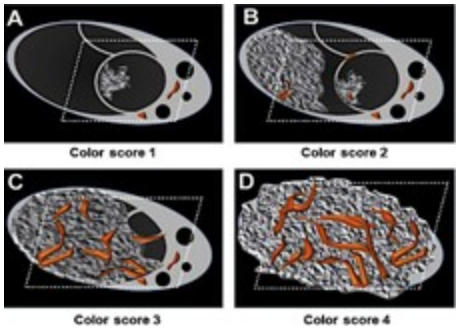


Figure 2

Color score categories (1–4) based on the subjective evaluation of vascularity as defined in the O-RADS lexicon. **(A)** Color score 1 indicates absence of detectable blood flow within the cyst wall, septations, or any solid component. **(B)** Color score 2 corresponds to the presence of minimal vascular flow. **(C)** Color score 3 denotes moderate vascularity. **(D)** Color score 4 describes an adnexal lesion demonstrating pronounced hypervascularity with abundant blood flow.[2]

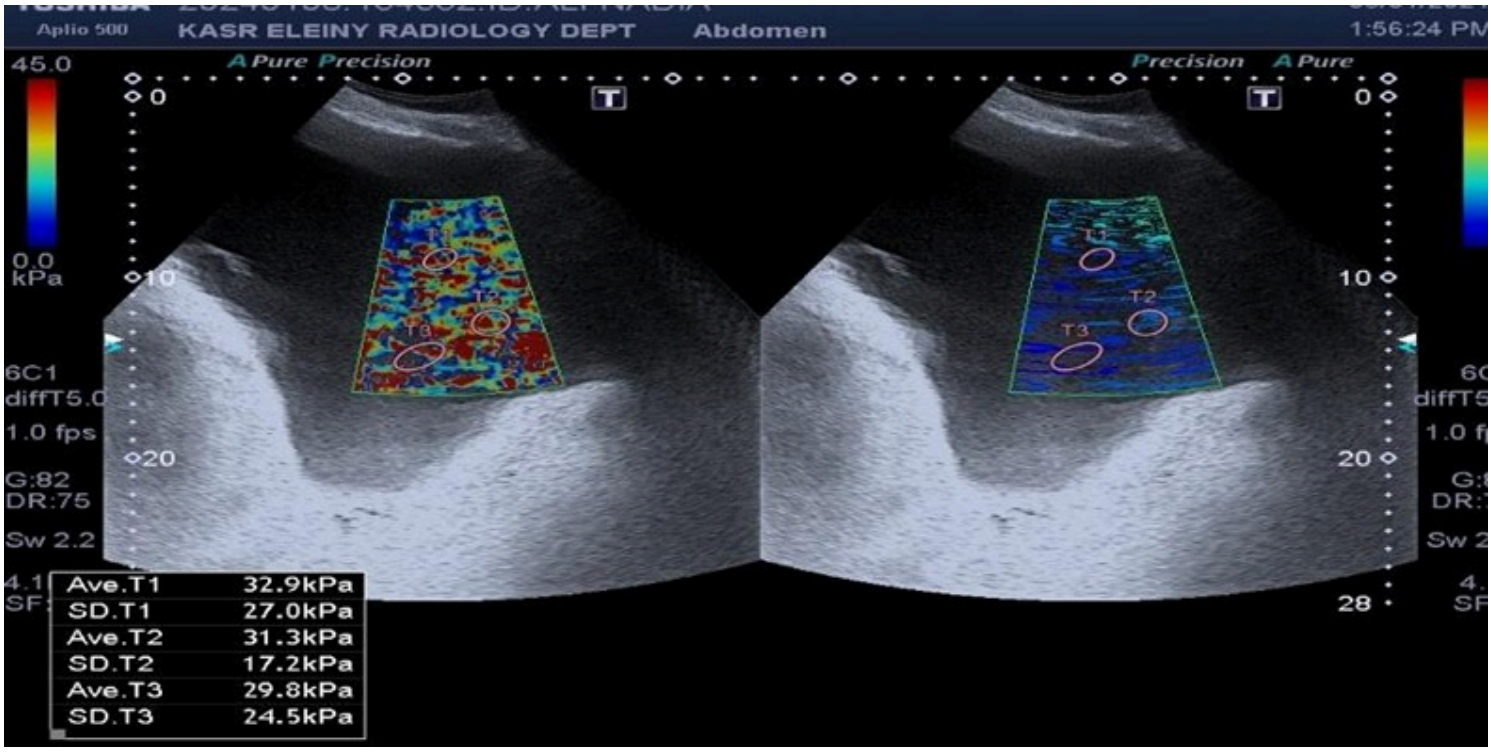


Figure 3

Qualitative (color coded box) and quantitative (kPa value calculated according to the positioned ROI) processing of SWE image.

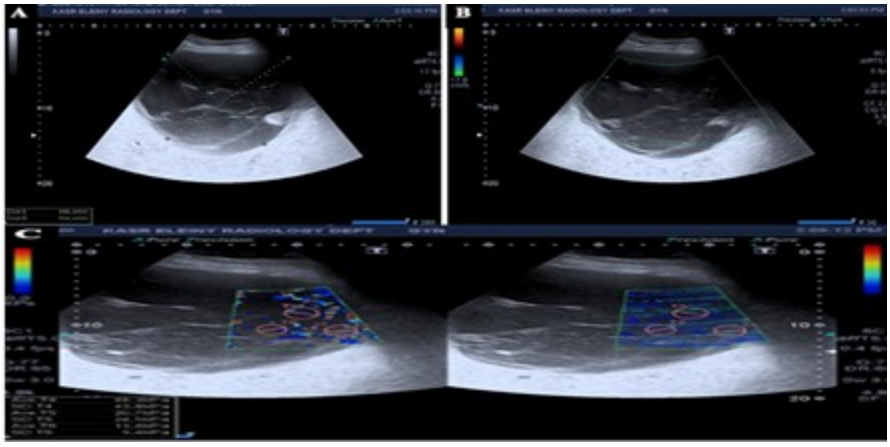


Figure 4

(**A**) PAUS showed a right cystic ovarian lesion had multiple thin septations inside and an echogenic soft tissue lesion, measuring 14.8cmx 15.8cm **(B)** By applying color Doppler, it showed no vascularity inside, color score 1. It considered O-RADS 3 **(C)** By Shear wave elastography it showed a blue color,with average Kpa value 27.Pathologically confirmed Endometrioma.

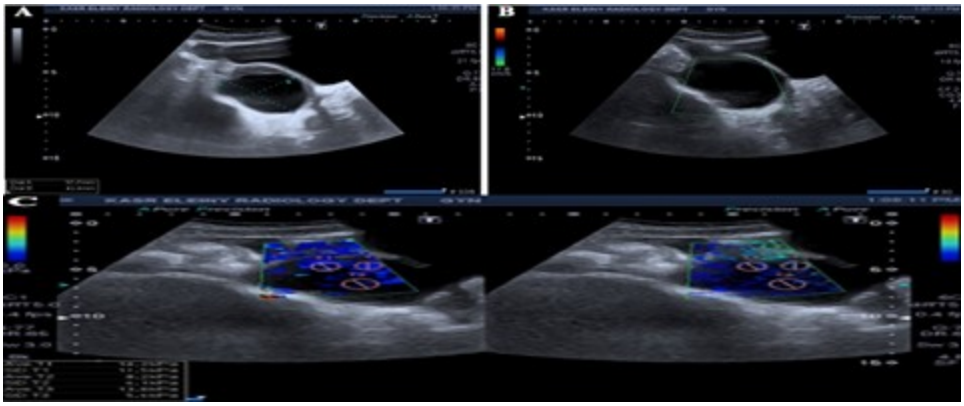


Figure 5

(A(PAUS showed a right cystic ovarian lesion with an irregular inner wall measuring 5.7x4.3 cm **(B)** By applying color Doppler it showed no vascularity, color score 1. it considered ORADS 3 **(C)** By Shear wave elastography it showed a blue color, with average Kpa value 12. Pathologically confirmed serous cystadenoma.

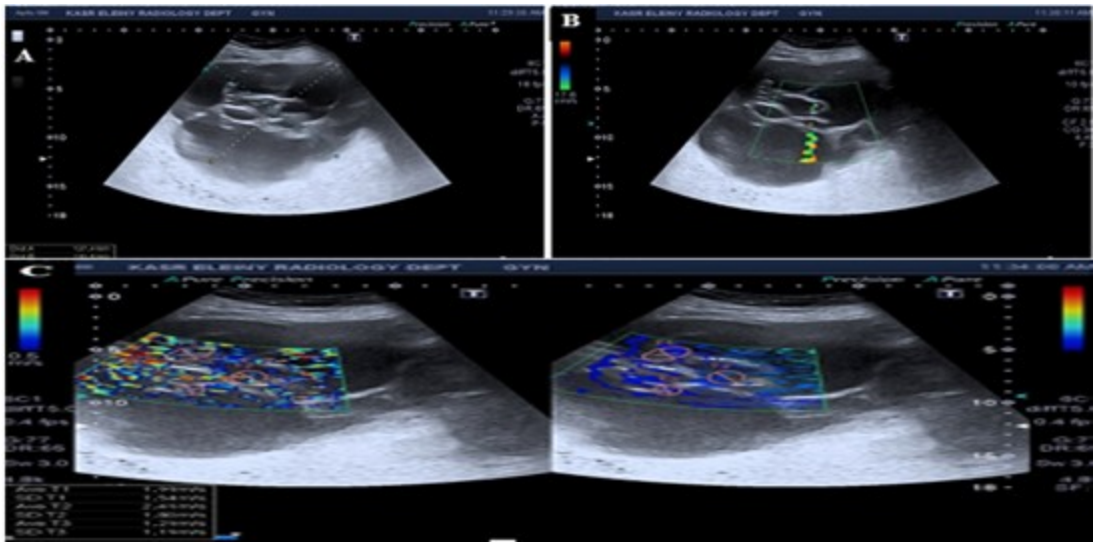


Figure 6

A 45 year old female patient complained of Pelvic pain for 3 months (A) PAUS showed a right complex cystic ovarian lesion with internal thick septations that could be seen inside, measuring 12x13 cm **(B)** By applying color Doppler it showed no internal vascularity, color score 1. it considered ORADS 4 **(C)**By Shear wave elastography it showed a blue color with Kpa value 25. pathologically confirmed mucinous cystadenocarcinoma.

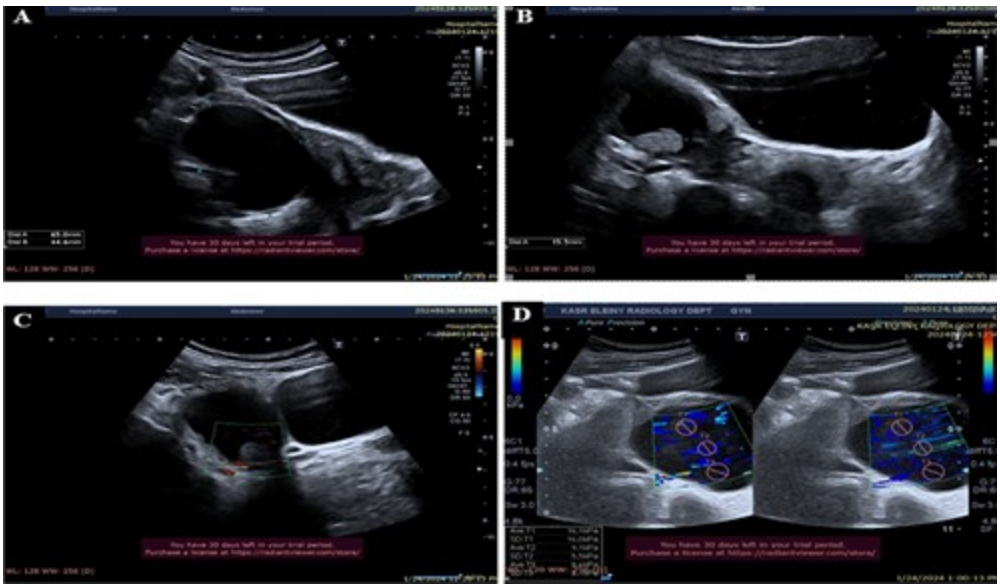


Figure 7

A 29-year-old female patient complained of pelvic pain for 6 months **(A) and (B)** PAUS images showed a right unilocular complex cystic ovarian lesion, measuring 6.5x4.5 cm with two solid nodules could be seen within, the largest one measuring about 1.5 x1.1 cm. (c) By applying color Doppler, it showed no vascularity, color score 1. It is considered ORADS-4. **(D)** By Shear wave elastography, it showed a blue color, with an average kPa value of 12. Pathologically confirmed mucinous cystadenoma.

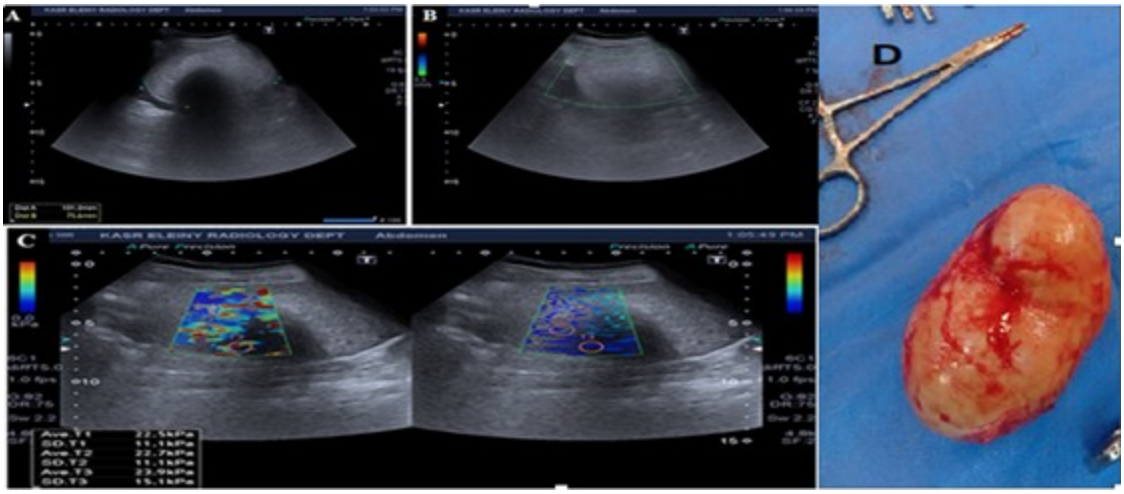


Figure 8

A 38-year-old female complained of pelvic pain with a remittent course for 3 months **(A).** PAUS showed a right unilocular hyperechoic cystic ovarian lesion, with calcific shadowing that could be seen at the center of the lesion, measuring 10.1 x 7.5 cm **(B**). By applying Doppler, it showed no internal vascularity, a color score of 1. It is considered ORADS-3. **(C)**By shear wave elastography, it showed a blue color, with an average kPa of 23. Pathologically confirmed dermoid cyst**. (D)** Post-operative specimen**.**

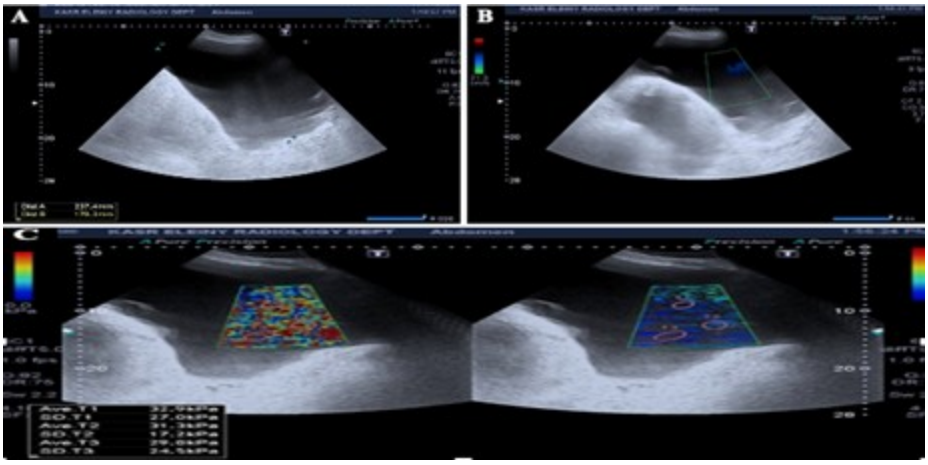


Figure 9

(A) PAUS showed a right cystic ovarian lesion with an irregular inner wall measuring 23 cmx17 cm. (B) By applying color Doppler, it showed internal vascularity, color score 2, it considered O-RADS 4 (c) By shear wave elastography, it showed blue with few areas with green color with average Kpa value 32. Pathologically confirmed mucinous cystadenocarcinoma.