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Original Article

Radiology Section

Sonoelastographic Evaluation of Pelvic Adnexal Masses and its Association with Clinicopathological Findings at a Tertiary Care Centre in Western Uttar Pradesh, India

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ABSTRACT

Introduction: Despite advancements in cross-sectional aging techniques, ultrasonography continues to remain the first-line imaging modality for the preoperative assessment of pelvic adnexal masses. Ultrasound strain elastography is a novel technique that can characterise adnexal lesions based on their tissue stiffness and when used in conjunction with conventional USG, it may increase the precision of diagnosis and can act as a cost-effective viable ancillary tool.

Aim: To assess the role of strain sonoelastography in characterising the adnexal lesion as benign or malignant.

Materials and Methods: This cross-sectional study was conducted in the Department of Radiodiagnosis, Teerthankar Mahaveer Medical College and Research Centre (TMMC&RC), Moradabad, Uttar Pradesh, India, for a period of 18 months from January 2020 to June 2021 and consisted of 110 patients with clinical suspicion of adnexal mass, who were evaluated on SIEMENS Acuson S 3000 scanner (from the total of 130 cases). Various morphological features of mass (size, laterality, consistency, echogenicity and internal contents) were assessed on Gray scale and vascularity was assessed on colour doppler Ultrasonography (USG). Subsequently, real time strain elastography (eSie touch) was performed to assess the tissue stiffness. Elasticity was indicated on a colour-coded elastogram map, with blue areas denoting hard tissue, green areas suggesting intermediate tissue, and red portions denoting soft tissues. The sonographic findings were compared with histopathological diagnosis. Sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) were calculated for Gray scale sonography in combination with Doppler (conventional ultrasound techniques) and in conjunction with elastography. The Chi-square test was applied for comparing the frequency and p-value less than 0.05 was considered to be significant.

Results: The youngest patient was 16-year-old and eldest was 70 years and the mean age of study population was 36.35±14.82 years. On histopathology out of 110 patients, 95 (86.36%) had benign adnexal lesions and 15 (13.64%) had malignant adnexal lesions. When conventional ultrasound technique was used alone for differentiating benign and malignant adnexal masses the sensitivity was 96.7%, specificity was 83%, PPV was 96.7% and NPV was 83% while on addition of sonoelastography the sensitivity increased to 98.9%, specificity increased to 93%, PPV increased to 98.9% and NPV increased to 93.7%.

Conclusion: Conventional ultrasound techniques should be combined with sonoelastography in a diagnostic system to achieve better characterisation and differentiation of benign and malignant adnexal masses.

Keywords: Benign adnexal lesion, Elastography, Strain elastography, Ultrasonography

INTRODUCTION

Adnexal lesions are fairly common in women of various age groups. It is the fourth most common gynaecologic reason for hospitalisation [1]. In addition to being congenital, adnexal masses can be functional, inflammatory, or malignant in origin [2]. Ectopic pregnancy, polycystic ovaries, tubo-ovarian abscess and luteal cysts are the benign causes and endothelial carcinoma, sarcoma, and borderline tumours are malignant causes of adnexal mass [3]. Urinary, gastrointestinal, or metastatic lesions can also present as adnexal lesions [4].

Despite recent advancements in cross-sectional imaging techniques like Magnetic Resonance Imaging (MRI) and Computerised Tomography (CT) for confirmation of origin and nature of mass, Ultrasound is still the first-line imaging modality [5]. There is a significant overlap between benign and malignant lesions when morphologic parameters alone are used to predict malignancy. Hence, using colour doppler in conjunction improves the characterisation of adnexal lesions [6]. However, it has been discovered that colour Doppler merely provides an overview of the presence of vascularity and depicts its direction in a defined location in a broader sense [7,8].

Ultrasound Elastography (USE) is a novel imaging technology sensitive to tissue stiffness that was first described in the 1990s and is validated as an important additional tool in the diagnostic armamentarium [9]. Elastography techniques make use of changes in soft tissue elasticity caused by pathological or physiological processes and hence can be used to differentiate diseased from normal tissue for diagnostic applications [10,11]. Various techniques of USE have been described in Literature. Strain elastography is one of the first methods developed and tried clinically [12,13]. Strain elastography evaluates differences in tissue strain using manually applied compression or physiologic changes in pressure [14]. Strain is an indirect measure of tissue stiffness that is based on local tissue strain measurements. Relative stiffness of the tissue is shown on a gray scale or a colour spectrum ranging from red, green to blue. The elastographic features of ovarian lesions can be used to characterise them as malignant or benign similar to the lesions of thyroid or breast [15].

Although gray scale sonography is sensitive in detecting ovarian carcinoma, its reliability has not been sufficient to obviate more invasive surgical procedures. Colour doppler imaging have been investigated as possible means of improving the specificity of gray scale sonography in differentiating benign from malignant masses [3,4]. However, colour doppler has its own limitations as it only indicates the absence or presence of vascularity, its direction and quantification. Furthermore, it has technical limitations such as being prone to aliasing and angle dependency [7,8]. To overcome these limitations and for better characterisation and differentiation of benign and malignant lesions, a newer sonoelastographic technique was introduced. With this background, the present study was undertaken to examine various pelvic adnexal lesions using Gray scale and Doppler ultrasound, as well as strain elastography, and to relate the overall findings with clinicopathological diagnosis.

MATERIALS AND METHODS

This cross-sectional study was conducted after due approval from the Institutional Ethical Committee (TMMC&RC/IEC/19-20/029 dated 19/12/2019) in Department of Radiodiagnosis, Teerthankar Mahaveer Medical College and Research Centre, Moradabad, Uttar Pradesh, India, from January 2020 to June 2021.

Inclusion criteria: Patients who were referred to Radiodiagnosis Department with clinical suspicion of pelvic adnexal mass and patients who were incidentally detected having pelvic adnexal masses on routine abdominopelvic scan were included in the study.

Exclusion criteria: Patients with gravid uterus (except ectopic gestation), midline uterine lesions and masses due to non gynaecological causes were excluded. Patients in whom there were technical difficulties in performing sonoelastography such as morbidly obese patients or patients with surgical bandaging were also excluded from the study.

Sample size calculation: This formula was used for calculating sample size:

$n=(Z_{\alpha/2})^2 \{S_P(1-S_P)\}/(1-P)E_2$

$Z_{\alpha/2}=1.96$ ($Z_{\alpha/2}$)=Standard normal variable

$S_p=0.61$ (S_p)=Specificity [3]

P=12% (P)=Prevalance [3]

E=10% (E)=Error $n=(1.96)^2 \{0.61\times(1-0.61)\} (1-0.12).1^2$

=103.85

After rounding off the figure, final sample size considered for the study was 110.

Convenience Sampling technique was used.

Study Procedure

Transabdominal ultrasonography was performed using B-mode, Colour and Power Doppler mode, and elastography mode on a Siemens Accuson S 3000 scanner (Germany) with an Elastography compatible 6C1 curvilinear and 9L4 linear probes. The patient was made to lie in supine position with a distended bladder and all the pelvic adnexal structures i.e., uterus, cervix, fallopian tube, and ovaries were examined. MC9-4 transvaginal probe was used to do transvaginal examination in patients, in lithotomy position with an empty bladder, unless contraindicated or refused by the patient.

The various morphological features of individual adnexal lesions were assessed in multiple planes and findings were recorded as follows: size, echogenicity, wall thickness, inner wall border, locularity, septations, presence or absence of any solid component and if present, whether regular or irregular, external contour, and ascites [16-20]. The presence or absence of colour flow in the different portions of the mass and the site of colour flow (central or peripheral) was also analysed [16-20].

Tissue stiffness was encoded by colour code pattern on elastogram (eSie Touch) with the colour spectrum ranging between Blue-Green-Red (BGR) in the equipment used. The red colour denoted the softest part and blue colour denoted stiffer tissue parts. The components with average strain were displayed as green [21].

According to tissue stiffness, sonoelastograms were divided into five colour-overlay patterns as described in literature [22,23]:

- Pattern-I: Red and green (includes shades of blue- BGR pattern) representing low stiffness indicating absent or very small hard area.
- Pattern-II: predominantly green (BGR pattern) representing intermediate tissue stiffness with hard areas representing less than half of the lesion.
- Pattern-III: Mixed blue and green representing intermediate tissue stiffness with hard areas appearing more than 50%.
- Pattern-IV: predominantly blue- representing increased tissue stiffness, but not entirely hard with few central soft tissue parts.
- Pattern-V: blue- representing the lesion to be stiff entirely and having hard component with or without soft rim.

Lesions with elastogram colour code Pattern-I and II were labelled as benign while those following Pattern-III were labelled essentially benign and the lesion showing elastogram Pattern-IV and V were mostly labelled as malignant [24,25].

Based on the morphologic and sonoelastographic characteristics, the lesions were categorised as malignant/benign and whenever possible, a specific histologic diagnosis was suggested. A benign mass was diagnosed when the mass did not present any of the findings of malignant tumours or when it had typical pattern of a benign ovarian mass [26] which includes: 1) unilocular cyst; 2) acoustic shadows; 3) no detectable blood flow on doppler examination [26-28]. A malignant tumour was diagnosed in the presence of any of the following morphologic features on conventional ultrasound technique [26-28]: irregular multilocular solid tumour; hypoechoic solid content; papillary projection; thickness of septa (≥3 mm); thickness of wall (≥3 mm); central vascularity. The patients were followed-up and histopathological findings were obtained which was considered gold standard diagnostic modality.

STATISTICAL ANALYSIS

The data was entered in Microsoft Excel sheet and statistical analysis was performed using latest Statistical Package for the Social Sciences (SPSS) software, version 24.0. For comparing the frequency, Chi-square test was applied and p-value less than 0.05 was considered to be significant. Sensitivity, specificity, PPV and NPV were calculated for Gray scale sonography in combination with colour and spectral doppler (conventional ultrasound techniques) and in conjunction with elastography.

RESULTS

Out of total 130 cases, 110 cases were enrolled in the study in accordance with inclusion and exclusion criteria. The mean age of study population was 36.35±14.82 years. The maximum number of benign lesions was found in 26-35 years age group (31.5%) while maximum number of malignant adnexal masses was found in 56-65 years age group (26.67%). In benign category 81.05% masses occurred in premenopausal women while in malignant category 66.67% masses were found in postmenopausal women [Table/Fig-1].

On histopathology out of 110 patients, 95 (86.36%) had benign adnexal lesion and 15 (13.64%) had malignant adnexal lesion [Table/Fig-2]. The ovary 93 (83.64%), was the most common source of origin of adnexal lesions.

The demographic characteristics such as age more than 55 years and postmenopausal status and sonographic features such as size of the lesion >10 cm, solid consistency, thick wall, irregular inner wall, multilocularity, thick septations, presence of irregular solid

Variables	Benign masses n (%)	Malignant masses n (%)
Age group (in years)		
15-25	25 (26.3)	00
26-35	30 (31.5)	02 (13.33)
36-45	22 (23.2)	03 (20)
46-55	12 (12.6)	03 (20)
56-65	03 (3.2)	04 (26.67)
>65	03 (3.2)	03 (20)
Total	95 (100)	15 (100)
Parity		
Nulliparous	28 (29.47)	2 (13.33)
Primiparous	31 (32.63)	6 (40)
Multiparous	36 (37.89)	7 (46.66)
Total	95 (100)	15 (100)
Menstrual status		
Premenopausal	77 (81.05)	5 (33.33)
Postmenopausal	18 (18.95)	10 (66.67)
Total	95 (100)	15 (100)

[Table/Fig-1]: Distribution of benign and malignant adnexal masses according to the various demographic characteristics.

Histopathological diagnosis of adnexal masses	Number of masses	Percentage
Benign ovarian neoplasms	**23**	**20.90**
Serous cystadenoma	06	05.45
Mucinous cystadenoma	02	01.80
Brenner's tumour	01	00.90
Dermoid cyst	08	07.27
Ovarian thecoma	02	01.80
Ovarian fibroma	01	00.90
Mature solid teratoma	03	02.72
Malignant ovarian neoplasms	**15**	**13.63**
Serous cystadenocarcinoma	04	03.63
Mucinous cystadenocarcinoma	01	00.90
Endometroid carcinoma	02	01.80
Dysgerminoma	02	01.80
Choriocarcinoma	02	01.80
Ovarian metastatic tumour (Krukenberg)	02	01.80
Malignant immature teratoma	02	01.80
Non neoplastic lesions of ovary	**49**	**44.54**
Simple ovarian cyst	15	13.63
Haemorrhagic cyst	10	09.09
Endometrioma/Chocolate cyst	06	05.45
Polycystic ovaries	12	10.90
Complex cyst	06	05.45
Parovarian and paratubal cysts	**04**	03.63
Hydrosalpinx	**05**	**04.54**
Pyosalpinx	**02**	01.80
Tubo-ovarian abscess	**05**	**04.54**
Broad ligament fibroid (leiomyoma)	**04**	03.63
Ruptured ectopic	**03**	02.72
Total	**110**	100

[Table/Fig-2]: Distribution of adnexal masses according to specific histopathological diagnosis.

areas or nodules, irregular external contour, ascites, presence of central vascularity in the mass and blue or predominantly blue elastographic pattern were found to have statistically significantly association with malignancy with p-value <0.05 [Table/Fig-3].

Feature	Benign n (%)	Malignant n (%)	p-value
Age >55 years	6 (6.4%)	7 (46.67%)	0.004
Postmenopausal status	18 (18.95%)	10 (66.67%)	0.000081
Size >10 cm	3 (3.2%)	7 (46.60%)	<0.001
Solid consistency	15 (15.80%)	10 (66.70%)	<0.0001
Anechoic lesion	61 (65.30%)	00	<0.0001
Thick wall*	21 (26.20%)**	4 (80%)***	<0.01
Irregular inner wall*	8 (10%)**	4 (80%)***	0.000013
Multilocularity*	25 (31.25%)**	4 (80%)***	0.025
Thick septations*	10 (12.50%)**	3 (60%)***	0.005
Presence of irregular solid areas or nodules*	2 (02.50%)**	4 (80%)***	0.00001
Irregular external contour^	1 (4.80)^^	14 (93.30%)^^^	0.00001
Ascites	18 (18.90%)	14 (93.33%)	0.00001
Presence of vascularity in mass	37 (38.90%)	15 (100%)	0.000011
Central vascularity	5 (5.20%)	13 (86.66%)	0.00001
Peripheral vascularity	32 (33.68%)	02 (13.33%)	0.001
Blue or predominantly blue colour code	10 (10.50%)	14 (93.40%)	0.00001

[Table/Fig-3]: Summary of salient gray scale, doppler and sonoelastographic features assessed in differentiation of benign and malignant adnexal masses. *Assessed in cystic and mixed solid cystic lesions; **Total no. of benign masses- 80; ***Total no. of malignant masses- 5; ^Assessed in solid and mixed solid cystic lesions; ^^Total no. of benign masses- 21; ^^^Total no. of malignant masses- 15; p-value <0.05 considered significant

[Table/Fig-4] shows that majority of benign lesions (85 out of 95, 89.47%) showed Pattern-I, Pattern-II and Pattern-III tissue stiffness on sonoelastography [Table/Fig-5]. The majority (14 out of 15, 93.33%) of malignant masses showed Pattern-IV and Pattern-V elastogram indicating relatively higher tissue stiffness [Table/Fig-6,7]. However, one malignant mass (serous cystadenocarcinoma) showed Pattern-II elastogram [Table/Fig-8].

Colour coding	Number of benign lesions	Percentage	Number of malignant lesions	Percentage
Pattern-I	24	25.26	00	0
Pattern-II	34	35.78	01	06.67
Pattern-III	27	28.42	00	0
Pattern-IV	10	10.50	04	26.67
Pattern-V	0	0	10	66.67
Total	95	100	15	100

[Table/Fig-4]: Distribution of benign and malignant adnexal masses according to colour coding on elastography.

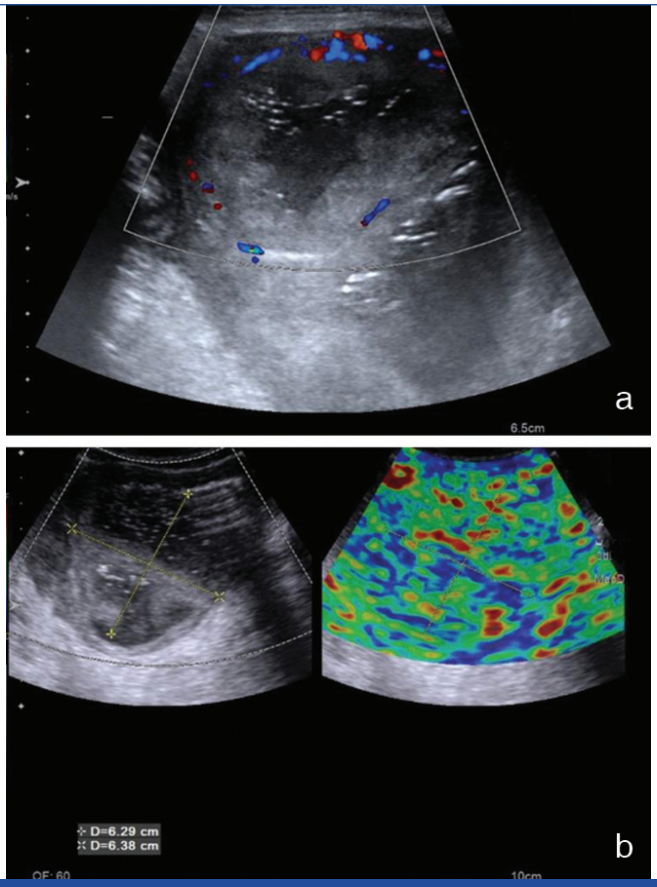
The conventional ultrasound technique correctly diagnosed in 92 out of 95 (96.85%) benign adnexal masses and 12 out of 15 (80%) malignant adnexal masses [Table/Fig-9]. When conventional ultrasound was combined with sonoelastography, 94 out of 95 (98.94%) benign adnexal masses and 14 out of 15 (93.33%) malignant adnexal masses were correctly identified [Table/Fig-10].

When conventional ultrasound technique was used alone for differentiating benign and malignant adnexal masses the sensitivity was 96.7%, specificity was 83%, PPV was 96.7% and NPV was 83% while on addition of sonoelastography, the sensitivity increased to 98.9%, specificity increased to 93%, PPV increased to 98.9% and NPV increased to 93.7% [Table/Fig-11].

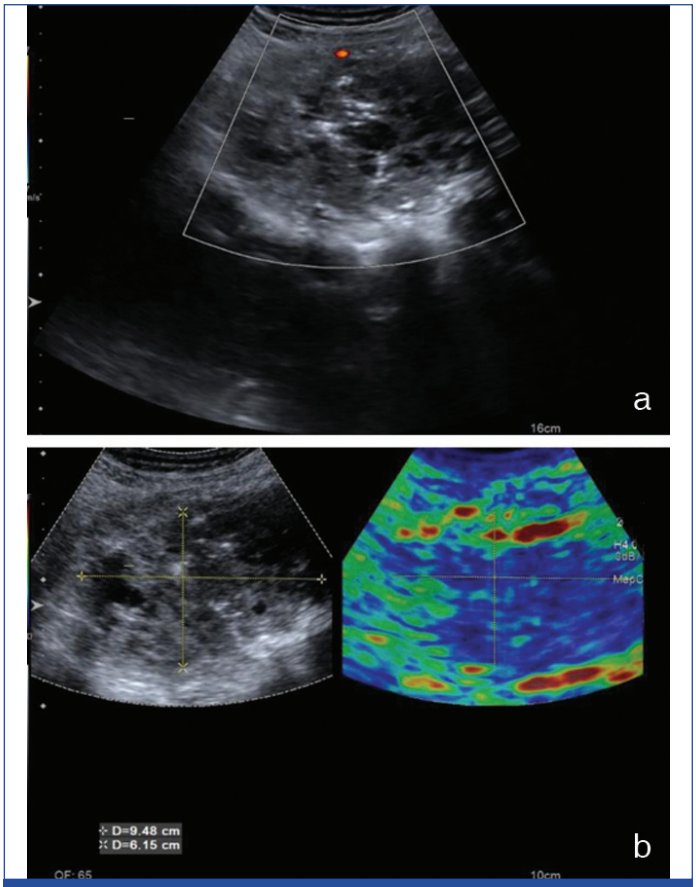
DISCUSSION

In the present study, for adnexal masses, ovary (83.64%) was the most common source of origin which is consistent with the findings of Khandelwal S et al., as 167 out of 180 (92.77%) adnexal masses in their study were of ovarian origin [27].

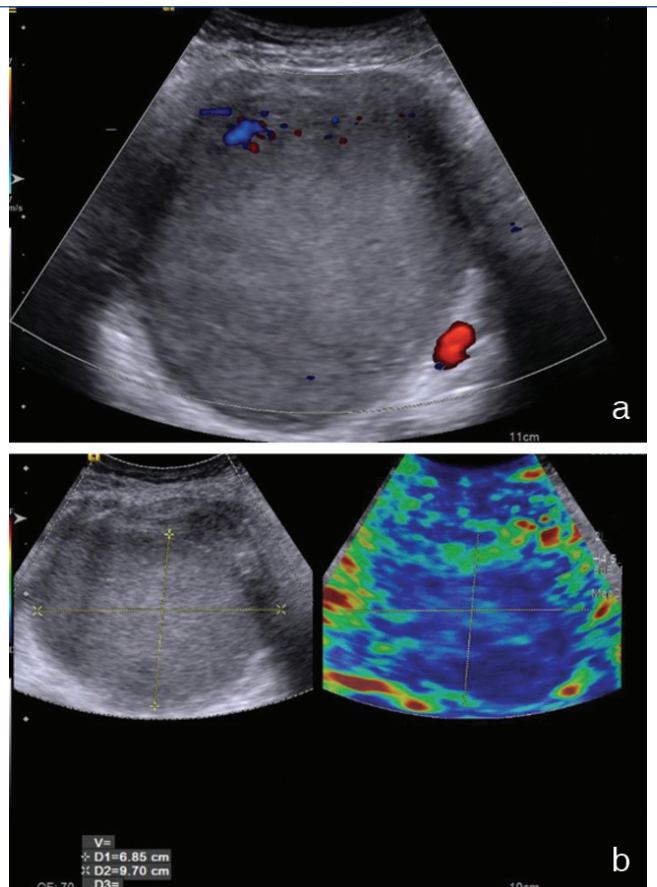
The highest occurrence of benign adnexal masses was seen in 26-35 years age group (31.50%) while maximum number of malignant



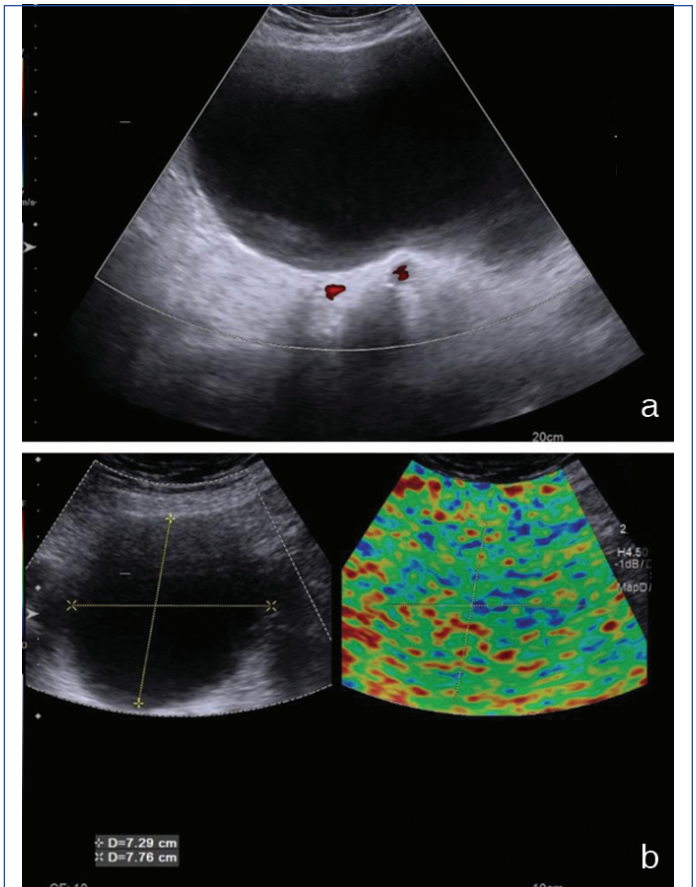
[Table/Fig-5]: a) Shows the gray scale USG image of mixed solid cystic lesion showing presence of vascularity in solid component on USG colour doppler, suggesting malignancy; b) Corresponding sonoelastogram image showing mixture of green and blue with impurities of red (corresponding to Pattern-III) suggesting lesion to be having intermediate tissue stiffness and hence, suggesting benign lesion. Histopathologically, the lesion turned out to be benign teratoma.



[Table/Fig-7]: Shows the histologically proven case of Endometroid carcinoma: a) Shows gray scale USG image of a mixed predominantly solid lesion with minimal peripheral vascularity on USG colour doppler, suggesting the lesion to be benign; b) Shows corresponding sonoelastogram revealing blue colour corresponding to elastogram Pattern-V indicating hard lesion and was correctly diagnosed as malignant on elastogram.



[Table/Fig-6]: Shows case of histologically proven serous cystadenocarcinoma: a) shows gray scale image of a large cystic lesion with internal echoes and peripheral vascularity on USG colour doppler and was labelled as benign; b) However, it showed predominantly blue colour on corresponding sonoelastogram (Pattern-IV) and was correctly labelled as malignant.



[Table/Fig-8]: a) shows a large cystic lesion with peripheral vascularity on USG gray scale and colour doppler; b) which showed predominantly green colour on sonoelastogram (Pattern-II) indicating predominantly soft lesion and was labelled as benign on both conventional and sonoelastographic techniques. However, on histopathology the lesion turned out to be malignant (serous cystadenocarcinoma).

Diagnosis on conventional ultrasound techniques	Histopathological diagnosis				Total
	Benign		Malignant		
	No. of masses	Percentage	No. of masses	Percentage	
Benign	92	96.85	03	20	95
Malignant	03	03.15	12	80	15
Total	95	100%	15	100%	110

[Table/Fig-9]: Correct prediction of the nature of adnexal mass in terms of benign and malignant on conventional ultrasound techniques alone (correlated with histopathology).

Diagnosis on conventional USG and sonoelastography	Histopathological diagnosis				Total
	Benign		Malignant		
	No. of cases	Percentage (%)	No. of cases	Percentage (%)	
Benign	94	98.94	01	06.67	95
Malignant	01	01.06	14	93.33	15
Total	95	100	15	100	110

[Table/Fig-10]: Correct prediction of the nature of adnexal mass in terms of benign and malignant on conventional ultrasound techniques combined with sonoelasography (correlated with histopathology).

Techniques	Sensitivity%	Specificity%	PPV%	NPV%
Conventional ultrasound techniques alone	96.7	83	96.7	83
Conventional ultrasound combined with sonoelastography	98.9	93	98.9	93.7

[Table/Fig-11]: Relative value of conventional ultrasound alone and in conjunction with sonoelastography in characterising benign and malignant adnexal masses.

47 malignant masses were characterised prospectively as suggestive of malignancy [31]. The possible reason could be difference in geographical distribution of prevalence because of varying lifestyle habits in South-east Asian population.

The size of the lesion >10 cm, solid consistency, thick irregular wall, multilocularity, thick septations, presence of irregular solid areas or nodules, irregular external contour and central vascularity in mass favoured malignancy (p-value <0.05). These findings are consistent with the findings of the previous studies [Table/Fig-12] [1,19,32-33].

Tissue stiffness by colour coding on elastography: The authors found higher tissue stiffness in malignant adnexal masses and conversely softer tissue elasticity was associated with benign lesions and the difference found to be statistically significant (p-value <0.00001). Fedorova A et al., in a study of 37 patients, found that, majority of the malignant lesions (98%) showed blue colour on elastogram and majority of the benign lesions (96%) showed predominantly green with impurities of red and blue on elastogram [34]. Similar results were reported by Ciledag N et al., in their study of 26 ovarian lesions, where malignant lesions such as clear cell carcinoma showed elastographic Pattern-V corresponding to very high tissue stiffness, while most of the benign lesion showed hetergenous mosaic pattern of BGR on elastogram [23].

Cystic lesions: In the present study, 24 out of 95 (25.26%) benign lesions with purely cystic content showed red and green pattern on elastogram, corresponding to lesser stiffness of the tissue while none of the malignant lesion showed this pattern on elastogram. Marfani GM and Pathak SV; and Stasiv ID et al., reported that essentially anechoic cystic lesion shows BGR pattern indicating very

Feature	Predictors of malignancy in present study (% of malignant masses)	Timmerman D et al., [33] (2010)	Khurana I and Satia MN [32] (2016)	Khalaf LMR et al., [19] (2020)	Isgandarova A et al., [1] (2020)
Size	>10 cm (46.6%)	>7 cm	>10 cm	-	-
Consistency	Solid (66.70%)	Solid (48.3%)	Solid (77.8%)	Solid hypoechoic component (92.2%)	Solid (90%)
Wall	Thick (80%)	Thick (58.4%)	-	Thick ill-defined (81%)	-
Inner wall	Irregular (80%)	Irregular (72.22%)	-	Poorly defined inner wall (81%)	-
Locularity	Multilocularity (80%)	Multilocularity (99% predictive value)	Multilocularity (77.8%)	-	-
Septations	Thick and irregular (60%)	-	-	Thick (53.8%)	Present (60%)
Solid areas or nodules	Present (100%) Irregular (80%)	Presence significantly associated with malignancy	No solid component in majority benign lesions (92.2%)	-	-
External contour	Irregular (93.3%)	Irregular (95.52%)	Irregular solid tumour favours malignancy	-	-
Vascularity	Central (86.66%)	Moderate to strong vascularity (76.4%)	Vascularity present (100% malignant masses)	Central neovascularity (73.6%)	-

[Table/Fig-12]: Comparison of various gray scale and doppler USG predictors of malignancy in adnexal masses in the present study with previous studies [1,19,32-33].

adnexal masses was found in 56-65 years age group (23.08%). Thus, malignant adnexal masses were more prevalent in older age groups (p-value=0.004). The mean age of the patients with malignant adnexal masses was 50.48 years in study by Mohan L et al., [28]. Garg S et al., in their study also found that among 50 patients, 64.29% cases of ovarian malignancies were in age group between 56-70 years, while age group 26-40 years had maximum benign lesions 63.89% [29].

About 66.67% malignant adnexal masses were found in postmenopausal women, in comparison to only 18.95% of benign adnexal masses which occurred in postmenopausal women and the association of postmenopausal status with malignancy was found to be statistically significant (p-value=0.000081). Mohan L et al., also reported almost three times higher occurrence (53.3%) of malignant adnexal tumours in postmenopausal women [28]. However, the findings in the present study differ from Ong C et al., as they reported majority of the malignant lesions in premenopausal women [30]. In a study by Stein SM et al., also reported 46 of the less stiffness on elastogram [21,24]. Thus, our findings are coherent with the findings of these authors.

Predominantly cystic lesions: A 35.78% benign predominantly cystic lesions with impurities of soft tissue component showed predominantly green pattern on elastogram corresponding to intermediate tissue stiffness. Ciledag N et al., reported similar elastogram findings (Pattern-II) in these types of lesions [23]. Stasiv ID et al., also found that cystic lesion such as haemorrhagic cyst shows predominantly green colour with admixture of blue of elastogram corresponding to intermediate high tissue stiffness [24].

Mixed solid cystic lesions: A 28.42% benign lesions such as polycystic ovaries dermoid cyst and ruptured ectopic and some solid appearing benign neoplasms showed mixed blue and green pattern corresponding to slightly higher tissue stiffness. Marfani GM and Pathak SV; and Çıracı S et al., showed that dermoid cysts and polycystic ovaries shows green and blue colours (corresponding to slightly stiffer tissue) with some stiff areas on elastogram due to variegated tissues [21,35].

Predominantly solid lesions: Some of the solid appearing benign lesions (10.50%) such as few teratoma, thecoma and broad ligament fibroids and 80% of predominantly solid malignant lesion showed Pattern-IV on elastogram corresponding to relatively higher tissue stiffness. Marfani GM and Pathak SV; Stasiv I et al., and Ryo E, reported similar findings in some of the benign solid lesions such as broad ligament fibroids and teratomas which showed relatively increased tissue stiffness due to presence of smooth muscle component and majorly stained blue on elastogram [21,25,36].

Solid lesions: A 66.67% malignant adnexal lesions in this study showed blue colour on elastogram corresponding to elastogram Pattern-V, indicating very stiff tissue. Marfani GM and Pathak SV; Ciledag N et al., Fedorova A et al., Khalmukhamedova AE et al., Baig F et al., Marfani G et al., all in their respective studies, found that that malignant ovarian lesions show elastographic Pattern-V corresponding to very high tissue stiffness [21,23,34,37-39]. Thus, our findings are in close agreement with the previous literature.

Prediction of Nature of Adnexal Mass in Terms of Benign and Malignant

Out of 110 adnexal masses, on histopathology 95 (86.36%) masses were found to be benign and 15 (13.63%) were found to be malignant.

Benign Adnexal Masses

Gray scale and doppler USG: A 92 (96.80%) out of 95 histopathologically confirmed benign adnexal masses were correctly diagnosed on conventional ultrasound techniques. Three benign adnexal masses were wrongly labelled as malignant by conventional gray scale ultrasound techniques which included one case of mucinous cystadenoma and two cases of teratoma.

Conventional USG combined with elastography: On subsequent elastography, 94 (98.90%) out of total 95 histopathologically confirmed benign adnexal masses, were correctly diagnosed. Of the two benign teratomas which were wrongly diagnosed as malignant on conventional gray scale techniques. Elastography showed mixed pattern of blue and green on elastogram indicating lesion to be having intermediate stiffness and hence suggested the lesion to be benign. However, one case of benign teratoma was still diagnosed as malignant even on elastography as it showed blue colour pattern on elastogram indicating the lesion to be having harder tissue property and hence was labelled malignant. Ciledag N et al., also misdiagnosed teratoma as malignant using sonoelastography in their study [23]. Mucinous cystadenoma which was wrongly labelled as malignant on conventional ultrasound techniques was correctly labelled as benign on addition of elastography as it displayed mixed blue and green pattern on elastogram with green representation more than 50%.

Malignant Adnexal Masses

Gray scale and doppler USG: A 12 (80%) out of total 15 histopathologically confirmed malignant adnexal masses were correctly diagnosed on conventional gray scale ultrasound techniques alone while three malignant adnexal masses were wrongly labeled as benign. Out of the three cases, two cases of serous cystadenocarcinoma were misdiagnosed as benign. One endometroid carcinoma appeared as well-defined predominantly solid mass with regular borders and minimal central vascularity so was misdiagnosed as benign.

Conventional USG combined with elastography: A 14 (93.33%) out of total 15 histopathologically confirmed malignant adnexal masses were correctly diagnosed by combining elastography with conventional ultrasound techniques. Out of the two cases of serous cystadenocarcinoma which were labelled as benign on conventional ultrasound techniques one was correctly diagnosed as malignant as it showed predominantly blue colour pattern corresponding to harder elasticity pattern on elastogram. Xie M et al., reported that, real-time qualitative USE was a feasible technique for the discrimination of ovarian low and high-grade serous ovarian carcinoma on the basis of tissue elasticity pattern [40]. Ciledag N et al., also stated that transvaginal real-time ultrasonographic elastography has the potential to aid in the distinction of benign from malignant cystic lesions [23]. However, one case of serous cystadenocarcinoma was still misdiagnosed as benign as it showed mixed blue and green pattern. The possible reason could be the absence of solid component in the central portion of the lesion and hence the majority cystic component stained green on elastogram. Stasiv I, found that the large anechoic predominantly cystic lesions (>40 mm in size) cannot be assessed adequately and posed a limitation of elastography [25]. One case of endometroid carcinoma that was misdiagnosed as benign on conventional ultrasound techniques was correctly suggested to be malignant on addition of elastography as it showed blue colour (Pattern-V) corresponding to hard stiffness on sonoelastogram. Marfani G et al., and Onur MR et al., were able to detect malignant ovarian lesions on addition of elastography by identifying stiffer tissues within the lesion [21,41].

The combination of conventional USG techniques and sonoelastography performed better than conventional USG alone in differentiating benign from malignant adnexal masses. [Table/Fig-13] shows comparison of diagnostic performance of combined USG and elastography in the present study with various other studies [22,34,35,37,42]. The present findings are comparable with the results of most of these studies, except for Batur A et al., who reported lower sensitivity, specificity and NPV than the present study [22]. The possible reason for this discrepancy could be due to varied demographic profile of patients and differences in sample size. The authors used strain elastography technique only, to assess the adnexal lesions in the present study, hence, future studies using combination of strain and shear wave elastography can help in adding new dimension for diagnosing adnexal lesions using these novel technologies.

Authors	Sensitivity%	Specificity%	PPV%	NPV%
Fedorova A et al., [34] (2011)	94.8	93	-	-
Vorontsova NA et al., [42] (2013)	84	81	-	-
Cıracı S et al., [35] (2015)	87.50	85.42	85.7	87.2
Khalmukhamedova AE et al., [37] (2013)	94.8	93	-	-
Batur A et al., [22] (2016)	82.1	79.2	-	-
Present study	98.7	93	98.7	93

[Table/Fig-13]: Comparison of diagnostic performance of conventional USG techniques combined with elastography in differentiating benign and malignant adnexal masses with other studies [22,34,35,37,42].

Limitation(s)

The relatively small sample size may limit generalisation of study results and thus, further multicentric studies on larger series is required. Real-time ultrasonographic elastography is an operator and machine dependent modality and hence, requires an experienced operators to apply adequate pressure for elastographic evaluation because either too low or too strong pressure may lead to erroneous diagnosis.

CONCLUSION(S)

Conventional ultrasonography combined with sonoelastography can characterise various adnexal masses and can differentiate between benign and malignant adnexal masses. Gray scale and doppler USG used in conjunction with sonoelastography performed better than conventional ultrasound techniques, alone in distinguishing malignant and benign adnexal masses. Thus, conventional ultrasound techniques should be combined with sonoelastography in a diagnostic system to achieve better characterisation and differentiation of benign and malignant adnexal masses. Added major advantage of sonoelastography (in comparison to conventional ultrasound techniques) is, its improved ability to characterise mixed solid-cystic and predominantly solid lesions, as benign or malignant.

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