

# Sonomorphological, gray scale and color Doppler flow imaging evaluation of ovarian lesions

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## ABSTRACT

**Background:** Ultrasonography (USG) is considered the primary imaging modality for confirmation of the ovarian origin of the mass and characterization of the nature of the mass as benign or malignant. However, when morphologic features alone are applied to the prediction of ovarian malignancy, there is a tendency to over diagnose malignant tumors because of a substantial overlap between malignant and benign-appearing masses. Transvaginal color Doppler imaging with pulsed Doppler spectral analysis improves the characterization of ovarian masses by means of quantitative blood flow measurements obtained from tumor vessels. Color Doppler ultrasound helps identify solid, vascularized components in a mass. **Objectives:** To evaluate prospectively the relative usefulness of color Doppler, spectral Doppler, and gray scale sonography in differentiating benign from malignant adnexal masses. **Materials and Methods:** Patients with abdominal lump were screened for sonography. If on sonography patient having ovarian lesion then detailed study was carried out by gray scale, color, power Doppler and by spectral waveform analysis. Morphologic indexing of the adnexal masses was performed using the Sassone score. Flow results were recorded as being absent or present and further characterized as normal or increased, vessel location, and arrangement. **Results:** A total of 50 patients with 53 adnexal masses were enrolled into the study. Benign lesions were common in premenopausal age (30 [81%]) and malignant lesions (10 [77%]) were more common in the postmenopausal state. 23 out of 49 masses were considered suspicious of malignancy (Sassone score = 9), of which, 18 were malignant (including bilateral ovarian metastasis as a separate lesion) and 8 were benign. The somomorphologic evaluation following Sassone scoring system had a sensitivity of 90%, specificity 75%, positive predictive value (PPV) 69% and negative predictive value (NPV) 92%. The sensitivity, specificity, PPV, and NPV of gray scale USG alone were 70%, 72.22%, 58.33%, and 81.25% respectively. While for gray scale with combined color and spectral Doppler USG the values were 90%, 91.66%, 85.71%, and 94.28%, respectively. **Conclusion:** Adding color Doppler to conventional sonography produced a specificity and PPV higher than those of conventional sonography alone and so gray scale USG in combination with Color Doppler and Spectral Doppler is proposed as the first and foremost diagnostic modality in patients with ovarian lesions.

**KEY WORDS:** Adnexal Mass; Color Doppler Ultrasound; Real Time Grey Scale Ultrasound; Ovarian Lesions

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## INTRODUCTION

Adnexal masses are frequently found in both symptomatic and asymptomatic women. In premenopausal women, physiologic follicular cysts and corpus luteum cysts are the most common adnexal masses. Other masses in this age group include endometriomas,

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polycystic ovaries, tubo-ovarian abscesses, and benign neoplasms.<sup>[1,2]</sup>

The presence of an ovarian mass is one of the leading indications for gynecologic surgery. The determination of a degree of suspicion for malignancy is critical and is based largely on imaging appearance. Ultrasonography (USG) is considered the primary imaging modality for confirmation of the ovarian origin of the mass and characterization of the nature of the mass as benign or malignant.<sup>[3]</sup> The introduction of high-frequency transvaginal USG in the mid-1980s, has allowed detailed morphologic evaluation of ovarian lesions.<sup>[4]</sup> Transvaginal sonography unquestionably provides excellent depiction of the pelvic organs. It has been used as a routine technique as a part of the gynecological examination.

However, when morphologic features alone are applied to the prediction of ovarian malignancy, there is a tendency to over diagnose malignant tumors because of a substantial overlap between malignant and benign-appearing masses.<sup>[4]</sup> In addition, transvaginal color Doppler imaging with pulsed Doppler spectral analysis improves the characterization of ovarian masses by means of quantitative blood flow measurements obtained from tumor vessels. Color Doppler ultrasound (US) helps identify solid, vascularized components in a mass. Spectral Doppler waveform characteristics correlate well with malignancy, but generally add little information to morphologic considerations.<sup>[4,5]</sup> Computed tomography can help assess the extent of disease in patients before and after primary cytoreductive surgery. Magnetic resonance imaging is better reserved for problem solving when US findings are nondiagnostic or equivocal because, although it is more accurate for diagnosis, it is also more expensive.

The objective of the study was to compare morphologic findings on sonograms with the resistive index (RI) of benign and malignant lesions and to find out the best RI cut-off value for the discrimination between benign and malignant ovarian masses. Furthermore, the objective was to evaluate prospectively the relative usefulness of color Doppler, spectral Doppler, and gray scale sonography in differentiating benign from malignant adnexal masses.

## MATERIALS AND METHODS

This was a prospective observational study carried out at the Department of Radiodiagnosis, Medical College & S. S. G. Hospital, Vadodara, over a period of 2-year. The study was conducted in coordination with Department of Obstetrics & Gynecology. Prior permission from Human Research Ethics Committee was taken before starting the study.

Patients were selected from the outpatient department and from admissions in ward. Patients with abdominal lump were screened for sonography. If on sonography patient

having ovarian lesion then detailed study was done by gray scale, color, power Doppler and by spectral waveform analysis. Informed written consent was taken from each participants before enrolment into the study. All patients were examined on Esaote AU5 color Doppler machine with 6.5 MHz transvaginal transducer and with gray scale, power and spectral Doppler. A 3.5-7 MHz convex transducer was utilized sometimes assess large lesions and in unmarried patients.

## Method of Examination

The bladder was emptied before examination to bring the pelvic organs into the focal zone of the transvaginal transducer. The patient was explained about examination and verbal consent was obtained before beginning the examination. The transducer was prepared with US coupling gel and then covered with a protective sheath and lubricant. The transducer was inserted into the vagina with the patient supine, knees gently flexed and hips elevated slightly on a pillow. The elevated hips allow free movement of the transducer. With gentle rotation and angulation of the transducer both sagittal and coronal images are obtained. Extreme angulation is applied to visualize the entire adnexae. In patients with narrow introitus or vagina who experience discomfort at attempted insertion of the transducer the examination was discontinued and transabdominal examination was done. All adnexal masses were subjected to sonomorphological evaluation followed by blood flow analysis using color, spectral, and power Doppler sonography (PDS). The examination was performed during the follicular proliferative phase of the menstrual cycle in premenopausal women.

Morphologic indexing of the adnexal masses was performed using the Sassone score based on the visualization of inner wall structure and wall thickness, septae, solid parts and echogenicity. A mass with a score of 9 and above was classified as a high risk mass (suspicious for malignancy).<sup>[6]</sup> Subsequently, power and color Doppler flow imaging and spectral analysis were performed. Doppler parameters were optimized for detection of flow and calculation of impedance indices. Flow results were recorded as being absent or present and further characterized as normal or increased, vessel location (peripheral, central, septal) and arrangement (regular/random).

On spectral Doppler, the lowest RI, pulsatility index (PI) and maximum peak systolic velocity (PSV) detected at any point in the mass was used for analysis. The Doppler findings were considered being suggestive of malignancy when:  $RI < 0.6$ ,  $PI < 1$  and  $PSV_{max} > 15$  cm/s. Measurements are obtained from three consecutive waveforms and the smallest sample volume should be used.

When PDS was used, the Doppler setting was optimized for detecting small vessels:

- High sensitivity
- Low wall filter
- Pulsed repetition frequency (prf): 700 Hz
- Medium persistence
- The color gain was initially increased to a level which shows color noise.

The sonographic findings were compared with intraoperative observations/gross and cytohistopathological analysis/ follow-up scans.

**RESULTS**

Over 2-years from 50 patients with 53 adnexal masses were enrolled in the study. Among these 53 adnexal masses 3 cases were bilateral ovarian metastasis.

The present study included 50 patients, the youngest being of 12 years and oldest being, 70 years. The peak age of incidence was in the 21-40 years of age group with 34 subjects falling in this age group. There was a total of 36 benign lesions and 17 malignant lesions noted (Table 1). Benign lesions were more common in the age group below 40 years (31 [86.11%]). Malignant lesions were common in age group above 40 years (11 [64.7%]).

Abdominal pain was the chief complaint which was present in 39 (78%) out of 50 patients. Anorexia and weight loss were second common complaint seen specifically in malignant lesions (10 [52%]). Other was infertility (8), abdominal lump (8) and distension of abdomen (5) (Table 2). Benign lesions were common in premenopausal age (30 [81%]). In contrast to this, in the postmenopausal state malignant lesions (10 [77%]) were more common. In this study, 36 (64.28%) of the

56 masses were benign and 20 (35.71%) were malignant. Of these benign lesions, hemorrhagic cyst was the most common benign lesion presenting 12 (33.33%) of cases. The second most common lesion is the mature teratoma making 22.22% of cases. While the mostcommon malignant lesion was serous cystadenocarcinoma (17.64%) and ovarian metastasis (17.64%). Ovarian metastasis was seen in both side and the primary malignancies in case of metastasis were breast carcinoma in 2 patients and gastric malignancy in 1 patient (Figures 1 and 2).

23 out of 49 masses were considered suspicious of malignancy (Sassone score = 9) of which 18 were malignant (including bilateral ovarian metastasis as a separate lesion) and 8 were benign. High scoring(=9) benign lesions were endometriomas, cystic teratomas, mucinous cystadenomas, hemorrhagic cyst and fibromas. Non-suspicious sonomorphology (score <9) was noted in 27 mass lesions - 25 were benign and 2 were malignant (1 borderline serous tumor and 1 serous cystadenocarcinoma). The sonomorphologic evaluation following Sassone scoring system had a sensitivity of 90%, specificity 75%, positive predictive value (PPV) 69% and negative predictive value (NPV) 92% (Tables 4 and 5).

The presence of tumor neovascularization was seen in 95% of malignant tumors in contrast to 22.22% benign tumors. The site of tumor vascularity did not affect the diagnosis in cystic neoplasm, as the tumor vascularity was encountered almost equally in the wall and septae. However, in solid malignant neoplasms; the central vascularity was encountered in 83.33% cases while peripheral vascularity was present in 16.66% of cases (Table 6). As shown in Table 7, 80% of malignant tumors had PI < 0.8 in contrast to only 8.03% of benign tumors. Similarly, 95% of malignant tumors showed RI < 0.6 in contrast to only 11.11% of benign tumor. PSV was more than 15 cm/s in 17 (85%) malignant tumors as compared to only 5.55% of benign tumors (Table 2). The data show slightly more specific (100%) and less sensitive (16.66%) with RI < 0.4 and slightly more sensitive (100%) and less specific (88.88%) with PI < 1. With using cut-off criteria for PI < 0.8 we got sensitivity of 80%, specificity of 91.66%, PPV of 84.21% and NPV of 89.18%. While using <0.6 as a cut-off for RI we got 95% sensitivity, 88.88% specificity, 82.60% PPV and 96.96% NPV (Table 8).

Out of a total of 36 patients with benign tumors, 26 (72.22%) patients were correctly diagnosed on gray scale USG alone, while 33 (91.66%) patients were correctly diagnosed when color and spectral Doppler were used along with the gray

**Table 1:** Age distribution of benign and malignant lesions

Age group (years)	Number of benign lesions (%)	Number of malignant lesions (%)	Total Number of lesions (%)
0-10	-	-	-
11-20	2 (5)	1 (5)	3 (5)
21-30	21 (58)	1 (5)	22 (41)
31-40	8 (22)	4 (23)	12 (22)
41-50	3 (8)	2 (11)	5 (9)
51-60	2 (5)	7 (41)	9 (17)
61-70	-	2 (11)	2 (3)
Total	36	17	53

**Table 2:** Symptomatic distribution

Lesions	Abdominal pain	Distension	Abdominal lump	Infertility	Anorexia and weight loss
Benign	20	0	3	7	0
Malignant	16	5	5	1	10
Others	3	0	0	0	0

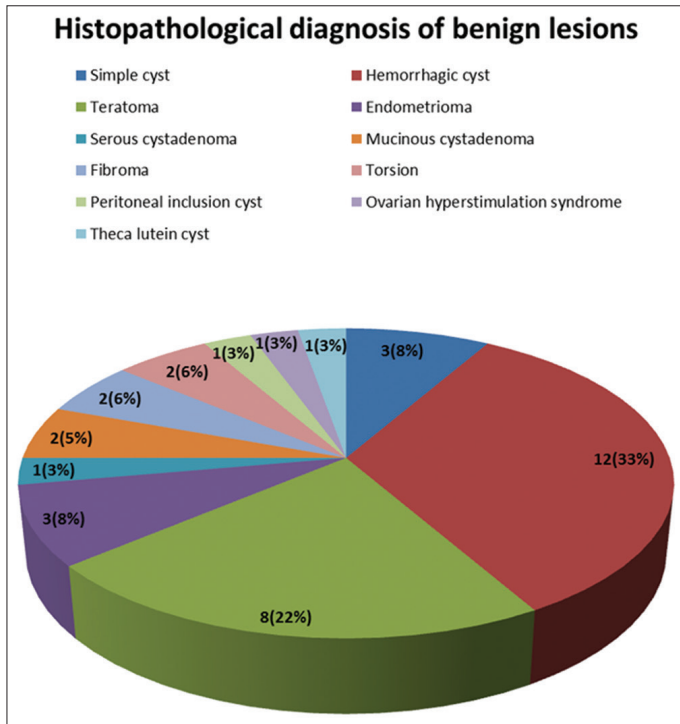


Figure 1: Distribution of benign lesions according to histopathological diagnosis

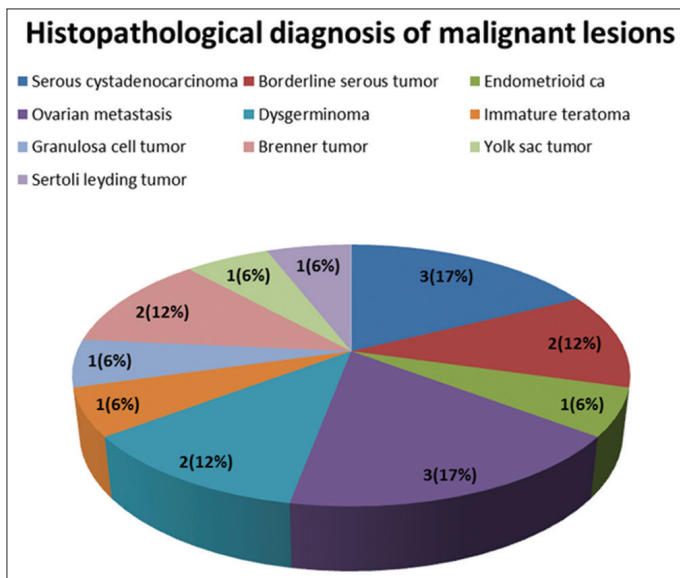


Figure 2: Distribution of malignant lesions according to histopathological diagnosis

scale USG. Out of a total of 20 patients with malignant tumors, 14 (70%) patients were correctly diagnosed on gray scale USG alone, whereas 18 (90%) patients were correctly diagnosed when color and spectral Doppler were used along with the B-mode USG (Table 9). The sensitivity, specificity, PPV, and NPV of gray scale USG alone were 70%, 72.22%, 58.33%, and 81.25%, respectively. While for gray scale with combined color and spectral Doppler USG the values were 90%, 91.66%, 85.71%, and 94.28%, respectively (Table 10).

Table 3: Correlation of the lesion with menopausal status

Lesions	Menopausal status	
	Pre-menopausal n=37 (%)	Post-menopausal n=13 (%)
Benign	30 (81)	3 (23)
Malignant	7 (19)	10 (77)

Table 4: Correlation of lesion with Sassone score

Final diagnosis	Range of sassone scores	Masses with sassone score ≥9
Simple cyst	4	-
Hemorrhagic cyst	5-9	2
Endometrioma	4-9	1
Teratoma	6-9	2
Fibroma	9-10	2
Peri. Inc. cyst	4	-
Serous cystadenoma	6	-
Mucinous cystadenoma	8-9	1
Malignant tumors	8-16	18

Table 5: Two-by-two table for the comparison of sassone positive score (that is suspicious for malignancy) with the pathological malignant and benign lesions

Sassone score	Pathological diagnosis	
	Malignant	Benign
Test positive (≥9)	18	8
Test negative (<9)	2	25

## DISCUSSION

USG remains the study of choice in the initial evaluation of suspected adnexal masses because it is relatively inexpensive, noninvasive, and widely available. Transabdominal US, endovaginal US performed for the evaluation of adnexal masses.<sup>[7]</sup> Among ovarian lesions benign lesions were noted to be more common in the age group below 40 years making 31 (86.11%) out of 36 cases. Malignant lesions were noted in much older patients with 11 out of 17 (64.7%) cases seen in patients with more than 40 years of age. In this study, 36 (64.28%) of the 56 masses were benign and 20 (35.71%) were malignant. Of these benign lesions, hemorrhagic cyst was the most common benign lesion presenting 12 (33.33%) of cases. The second most common lesion is the mature teratoma making 22.22% of cases.

Abdominal pain was the chief complaint that the patient presented with in this series with 39 (78%) out of 50 patients with this complaint. It was the commonest complain in both the benign and malignant lesions. Anorexia and weight loss is also a common complaint in malignant lesions with 10 out of 19 patients (52%) experiencing it. Abdominal lump is

**Table 6:** Correlation of lesion with the presence and site of neovascularity

Lesions	Presence of neovascularity (%)	Site of neovascularity			
		Septal	Central	Peripheral	Central+peripheral
Benign (n=36)	8 (22.22)	5	3	1	0
Malignant (n=20)	19 (95)	2	15	1	3
Total (n=56)	26 (46.42)	7	18	2	3

**Table 7:** Correlation of lesions with spectral flow analysis

Lesions	PI<0.8	RI<0.6	PI<1	RI<0.4	PSV>15
Benign (n=36)	3	4	4	0	2
Malignant (n=20)	16	19	20	4	17
Total (n=56)	19	23	24	4	19

PI: Pulsatility index, RI: Resistive index, PSV: Peak systolic velocity

**Table 8:** Sensitivity, specificity, PPV and NPV of RI and PI

Spectral flow	Sensitivity %	Specificity %	PPV %	NPV %
PI<0.8	80	91.66	84.21	89.18
PI<1	100	88.88	83.33	100
RI<0.6	95	88.88	82.60	96.96
RI<0.4	16.66	100	100	64.28
PSV 15 cm/s	85	94.44	89.47	91.89

PI: Pulsatility index, RI: Resistive index, PPV: Positive predictive value, NPV: Negative predictive value, PSV: Peak systolic velocity

**Table 9:** Comparison of pathological diagnosis and US findings

Pathological diagnosis	Number of lesions	Correctly diagnosed at gray scale (%)	Correctly diagnosed at gray scale and color Doppler (%)
Benign lesions	36	26 (72.22)	33 (91.66)
Malignant lesions	20	14 (70)	18 (90)
Total	56	40 (71.42)	50 (89.28)

US: Ultrasound

also a common complaint in malignant lesions that 5 out of 19 (26%) complaint of it.

In the present study, Sassone scoring system had a sensitivity of 90%, specificity 75%, PPV 69% and NPV 92%. 23 out of 49 masses were considered suspicious of malignancy (Sassone score = 9) of which 18 were malignant (including bilateral ovarian metastasis as a separate lesion) and 8 were benign. High scoring (=9) benign lesions were endometriomas, cystic teratomas, mucinous cystadenomas, hemorrhagic cyst, and fibromas. Non-suspicious sonomorphology (score <9) was noted in 27 mass lesions - 25 were benign and 2 were malignant (1 borderline serous tumor and 1 serous cystadenocarcinoma). Madan et al.<sup>[8]</sup> used the Sassone scoring system for sonomorphologic evaluation of ovarian mass had a sensitivity of 92.3%, specificity 55.3%,

PPV 54.3%, NPV 92.8%. Forty-six out of 74 masses were considered suspicious of malignancy (Sassone score = 9) of which 25 were malignant and 21 were benign. High scoring (=9) benign lesions were inflammatory adnexal masses, endometriomas, cystic teratomas, mucinous cystadenomas, and thecoma. Non-suspicious sonomorphology (score <9) was noted in 28 mass lesions- 26 were benign and 2 were malignant. Thus, sonomorphology has higher specificity in differentiating malignant from benign ovarian neoplasms if dermoids, inflammatory masses and endometriomas are excluded by recognizing their specific sonographic characteristics. Morphologic assessment by transvaginal sonography yielded additional information, especially small papillary projections (<3 mm), thick septae, and the relationship of the mass to surrounding structures. Papillary protrusions and abnormalities of the inner wall structure were the most reliable findings associated with ovarian carcinoma.

In the present study, there was presence of tumor neovascularization in 95% of malignant tumors in contrast to 22.22% benign tumors. Vascularization in benign lesions tended to be peripheral and in malignant lesions it was central. Taori et al.<sup>[9]</sup> showed presence of tumor neovascularization in 92.59% of malignant tumors in contrast to 42.24% benign tumors. Vascularization in benign lesions tended to be peripheral and in malignant lesions it was central. In the study by Madan et al.<sup>[8]</sup> 92.5% (25/27 masses) malignant masses were vascularized as compared to 68.08% (32/47 masses) benign adnexal masses. Vascularization in benign lesions tended to be peripheral and in malignant lesions it was central. Absent blood flow in a solid tumor almost always ruled out the possibility of malignancy.

With using cut-off criteria for PI < 0.8 we got sensitivity of 80%, specificity of 91.66%, PPV of 84.21% and NPV of 89.18%. While using <0.6 as a cut-off for RI we got 95% sensitivity, 88.88% specificity, 82.60% PPV, and 96.96% NPV. Brown et al.<sup>[10]</sup> used PI cutoff value of 1.0, with any value less than this considered indicative of malignancy, and determined the sensitivity and specificity to be 100% and 46%, respectively. For the proposed RI = 0.6, sensitivity and specificity were 100% and 65%, respectively. The RI cutoff value with the highest accuracy in their population was 0.40 or 0.45; each had slightly different sensitivity and specificity. Thus by comparison it can be stated that, the present study yielded fairly good specificity and sensitivity with PI and RI values of <0.8 and <0.6 respectively, despite some overlap in the values between benign and malignant lesions. For PSV,

**Table 10:** Relative values of gray scale USG alone and in combination with color and spectral Doppler in differentiating benign and malignant ovarian neoplasms

USG	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Gray scale USG	70	72.22	58.33	81.25
Gray scale with combined color and spectral Doppler USG	90	91.66	85.71	94.28

PPV: Positive predictive value, NPV: Negative predictive value, USG: Ultrasonography

15 cm/s was considered as the cutoff value in present study and the sensitivity and specificity detected for malignant adnexal tumors were 85% and 94.44%, respectively. Hata et al.<sup>[11]</sup> demonstrated the sensitivity and specificity of PSV in detecting malignant adnexal tumors were 83.3% and 91.6%, respectively. The findings confirm those of most previous reports: Malignant ovarian tumors tend to have lower PI and RI than do benign tumors. Relatively high values of PI and RI usually indicate benignity. The PI value above which a mass will always be benign has been variably reported but, as in our study, usually has been found to be 0.8 or less. The RI value above which a mass will always be benign has been reported as ranging from 0.4 to 0.6. The PSV obtained from intratumoral abnormal morphologic features provides a superior means for differentiating malignant from benign adnexal tumors.

The sensitivity, specificity, PPV, and NPV of gray scale USG are 70%, 72.22%, 58.33%, and 81.25%, whereas the same values for gray scale USG with combined color and spectral Doppler USG are 90%, 91.66%, 85.71%, and 86.11%, respectively. Taori et al.,<sup>[9]</sup> in their study demonstrated that out of a total of 33 patients with benign tumors, 25 patients (69.44%) were correctly diagnosed on B mode USG alone, while 31 patients (93.93%) were correctly diagnosed when color and spectral Doppler were used along with the B-mode USG. Out of a total of 27 patients with malignant tumors, 14 patients (51.85%) were correctly diagnosed on B mode USG alone, whereas 22 patients (81.48%) were correctly diagnosed when color and spectral Doppler were used along with the B-mode USG. Fleischer et al. <sup>[12]</sup>, in their study demonstrated that the combined gray scale and color Doppler sonography had sensitivity of 85%, specificity of 93%, and NPV of 98% in the detection of malignant tumors. It indicates that the color Doppler sonography was highly accurate in excluding malignancy. Kurjak et al. <sup>[13]</sup> in their study demonstrated that, morphology alone had poor sensitivity, but when combined with Doppler indices, the sensitivity improved to 90% and the positive and NPVs were 90 and 96%, respectively. The results of this study suggest that, transvaginal gray scale imaging, color flow, and Doppler indices satisfy criteria as tests that may be sensitive and specific enough for application in a screening program. Thus, by comparison it can be stated that, color Doppler and spectral Doppler tremendously increased the reliability in diagnosing a malignant ovarian tumor.

The data from this study will help to get idea about ovarian lesions in particular this geographical area, as there are no any data available in this particular geographical area about gray scale and color Doppler sonography. However, data with more subjects might give good and more reliable results.

## CONCLUSION

In conclusion to the present study, there is considerable overlap in the morphologic patterns of various adnexal masses and hence, a multiparameter analysis incorporating morphologic scoring, vessel location, vessel arrangement and spectral waveform analysis is helpful in determining those patients in whom early intervention is necessary. Adding color Doppler to conventional sonography produced a specificity and PPV higher than those of conventional sonography alone. Gray scale USG in combination with color Doppler and spectral Doppler is proposed as the first and foremost diagnostic modality in patients with ovarian tumor, so as to establish the definite diagnosis of malignancy early in the course of the disease.

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