Doppler Ultrasound: A Good and Reliable Predictor of Ovarian Malignancy

Shah Dharita · Shah Sandip · Parikh Jay · Bhatt C. J. · Vaishnav Kavita · Bala D. V.

Abstract

Aims The aim of the present study was to prove the efficiency of Color Doppler and Spectral Doppler in evaluation and characterization of the ovarian neoplasm.

Materials and Methods In total, 104 patients with adnexal masses were examined sonographically to evaluate for morphologic characteristics, as well as pulsatility indices (*PI*), and resistance indices (*RI*) over a period of 2 years, of which 20 were excluded as the masses were not finally proven to be adnexal, and thus 84 patients with ovarian neoplasm were retained as the study subjects. The final diagnosis was based on histopathologic confirmation.

Result Out of 84 cases, 44 were benign and 40 were malignant. Color Doppler showed vascularity in 97.5 % of malignant tumors in contrast to only 68.1 % of benign tumors. The present study showed that, 87.5 % of malignant tumors had *PI* less than 0.8 in contrast to only 4.54 % of benign tumors. Similarly, 82.5 % of malignant tumors had *RI* less than 0.6 in contrast to only 6.81 % of benign tumors.

Conclusion Multiparameter analysis utilizing B-mode USG along with Color Doppler and Spectral Doppler is the mainstay in diagnosis of patients with ovarian tumors. A good specificity (84.1 %) and sensitivity (97.5 %) with *PI* and *RI* values of <1.0 and <0.6, respectively, was achieved with the present study which is highly significant in differentiating between malignant and benign ovarian tumours.

Keywords Doppler indices · Ovarian malignancy

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Introduction

Adnexal masses pose a special diagnostic challenge and suspicion for malignancy is based largely on imaging appearance. The ovarian malignancy is the third leading cause of cancer in females in population based cancer registry of Ahmedabad district (year 2009). Therefore early diagnosis and management of ovarian tumors has significant clinical importance. Effective evaluation of ovarian malignancy using Color and Spectral Doppler has been a subject of challenge as its implication. The present study aimed at assessing and differentiating benign and malignant ovarian neoplasms with the help of B-mode ultrasonography in conjunction with Color Doppler and Spectral Doppler and to correlate the imaging findings with histopathologic findings. The newly formed tumoral vessels are devoid of muscular layer, have low impedance-high

velocity flow, and thus the resistance measured by color flow indices such as resistance indices (RI) and pulsatility indices (PI) are low, which can be used as predictors of ovarian malignancy.

Study Design

In a study period of 2 years, a total of 104 patients were prospectively evaluated by B-mode ultrasonography, Color and Spectral Doppler study using a TOSHIBA NEMIO XG real-time Ultrasound and Doppler Scanner through a transabdominal approach, using a 3.75-MHz sector transducer. If required, transvaginal sonography was also performed with a 6.0-MHz endovaginal transducer. The study included the patients who were referred with an adnexal mass with age group between 40 and 60 years. Patients excluded from the study were those having anechoic cyst which resolved on follow-up study, patients with pelvic mass of uterine origin determined either per-operatively or on histopathology report, and those who were lost to follow-up. Written informed consent was taken from all of these patients. Initially, the patients were subjected to B-mode USG. Color Doppler study with no aliasing along

Table 1 Comparison of cutoff criteria for PI value of the present study between criteria of $PI < 0.8$ and $PI < 1.0$ to diagnose ovarian malignancy

	$PI < 0.8$ (%)	$PI < 1.0$ (%)
Sensitivity	87.5	93
Specificity	95.4	93
Positive predictive value	94.5	93
Negative predictive value	89.3	93

Table 2 Comparison of cutoff criteria for RI value of the present study between criteria of $RI < 0.6$ and $RI < 0.4$ to diagnose ovarian malignancy

	$RI < 0.6$ (%)	$RI < 0.4$ (%)
Sensitivity	83	20
Specificity	93	98
Positive predictive value	92	89
Negative predictive value	85	58

with pulsed Doppler at the lowest pulse repetition frequency and at high sensitivity settings was then undertaken. The pulsed Doppler waveform analysis was done. The lowest values of PI and RI were recorded from three different readings that were measured. These indices were correlated with histopathologic reports.

The sensitivity and specificity of various cutoff levels of PI and RI were calculated, and the proper values of PI and RI for differentiating the tumors were determined by calculation of area under each receiver operator characteristic curve.

Results

Out of a total of 104 patients examined over a period of 2 years, 20 were excluded from the study group as six patients were diagnosed to have mass of uterine origin on B-mode USG; seven patients with adnexal masses did not undergo histopathology examination and thus were not followed up; two patients had mass of uterine origin on HPE; and five patients were having unilocular ovarian cysts, which resolved on follow-up USG. Thus, the study group was composed of 84 patients with ovarian neoplasms. Color Doppler showed neovascularity in 97.5 % of malignant tumors in contrast to only 68.1 % of benign tumors (Table 1). Absent blood flow in a solid tumor almost always ruled out the possibility of malignancy. In the present study, 87.5 % of malignant tumors had $PI < 0.8$ in contrast to only 4.54 % of benign tumors. Similarly, 82.5 % of malignant tumors had $RI < 0.6$ in contrast to only 6.81 % of benign tumor (Table 2). B-mode USG alone correctly diagnosed benign tumors in 20 patients, while B-mode along with Color Doppler and Spectral Doppler helped us to diagnose 37 benign tumors out of a total of 44 patients having benign neoplasms. Similarly, 35 patients with malignancy were correctly diagnosed on B-mode USG alone, while with help of Color and Spectral Doppler in conjunction with B-mode USG, 39 patients were correctly diagnosed to have malignant ovarian tumors (Table 3).

Discussion

USG, because of being relatively inexpensive, noninvasive, and widely available, is considered to be the method of

Table 3 Sensitivity, specificity, positive predictive value, and negative predictive value of B-mode only and B-mode with color flowmetry and pulse wave study for patient with malignant ovarian tumor

Diagnosis of malignant ovarian tumor	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
B-mode scan	87.5	45.45	61.4	80
B-mode with color flowmetry and pulse wave study	97.5	84.1	84.78	97.4

choice of investigation in the initial evaluation of suspect adnexal masses. Transabdominal USG, and/or endovaginal USG, should be performed for the evaluation of adnexal masses [1, 2]. Color Doppler with spectral analysis using indices such as *PI* and *RI* is of immense value in yielding better characterization of ovarian neoplasm. It is factually correct that low impedance to blood flow with high velocity is suggestive of malignancy, whereas moderate-to-high impedance to blood flow is correlated to benign tumors. Resistive indices less than 0.4–0.8 [3, 5] and pulsatility indexes less than 1.0 are generally considered to be suspicious for malignancy [3–6]. In the present study, *PI* < 0.8 and *RI* < 0.6 were considered for analysis. B-mode features suggestive of malignancy were also studied using a morphologic scoring system described earlier [7].

Color Doppler evaluation of the tumor showed the presence of neovascularity in 97.5 % of malignant tumors in contrast to 68.1 % benign tumors. Vascularity in cystic lesions was seen equally in septae as well as in wall, but in solid malignant tumors, the central vascularity was observed in 87.5 % cases and peripheral vascularity in 37.5 % cases. These findings were correlated well with the study by Valentin et al. [8] and Kurjak et al. [7], but the study by Sharon Stein et al. [9] suggested that internal color flow cannot be used as a predictor of malignancy (PPV 49 %), but the absence of color flow suggested benignity (NPV 94 %).

Neovascularization in tumor always offers lower resistance to blood flow in malignant neoplasm (Figs. 1, 2, 3). The present study was based on a pre-established cutoff criterion of *PI* < 0.8 and *RI* < 0.6 as described by Jonathan Carter et al. [10].Using the cutoff criterion of *PI* < 1.0 and *RI* < 0.4, Kurjak et al. [7] achieved high sensitivity and specificity as the study group comprised only postmenopausal women.
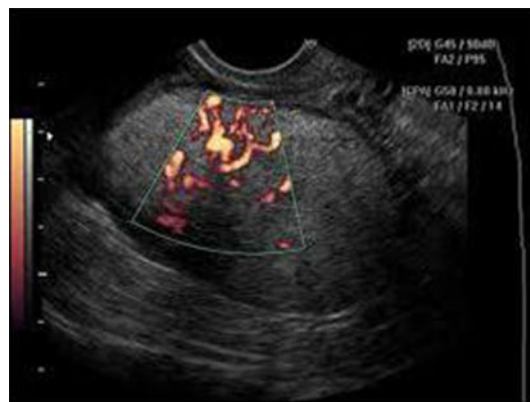

Fig. 2 30-year-old woman with dysgerminoma

The present study, with *PI* < 0.8, observed 87.5 % of malignant tumors in contrast to only 4.54 % of benign tumors (Table 1). Similarly, with *RI* < 0.6, it observed 82.5 % of malignant tumors in contrast to only 6.81 % of benign tumors (Table 2). Extrapolating the data of the present study using the criterion *PI* < 1.0 and <0.4 proposed by Kurjak et al. [7] and Buy et al. [11], 92.5 % of malignant tumors and 6.82 % of benign tumors showed *PI* < 1.0, while only 20 % malignant tumors and 2.27 % of the benign tumors showed *RI* < 0.4. As elucidated previously by many authors [12, 13], the absence of vascularity is always indicative of benignity (Fig. 4).

In the present study, B-mode USG achieved a sensitivity of 87.5 %, a specificity of 45.45 %, and a PPV of 61.4 %, but when the pulsatility and resistance index was included, more acceptable levels of sensitivity at 97.5 %, specificity at 84.1 %, and positive predictive value at 84.78 % were obtained. These results correlate well with a study by Timor-Tritsch et al. [14].
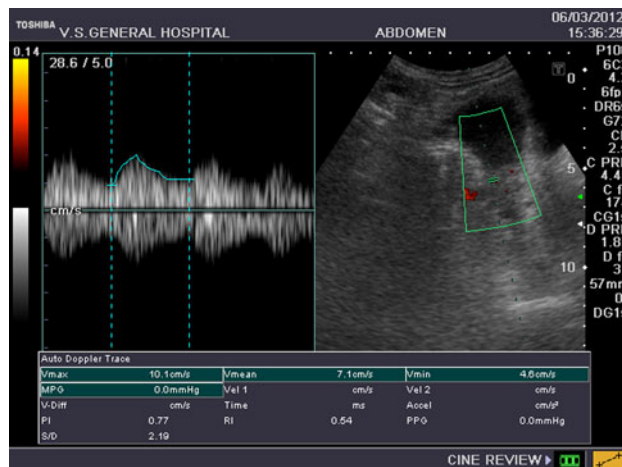

Fig. 1 45-year-old woman with serous cyst adenocarcinoma

Fig. 3 Spectral Doppler analysis showing *PI* 0.77 and *RI* 0.54 in 60-year-old woman with mucinous cystadenocarcinoma

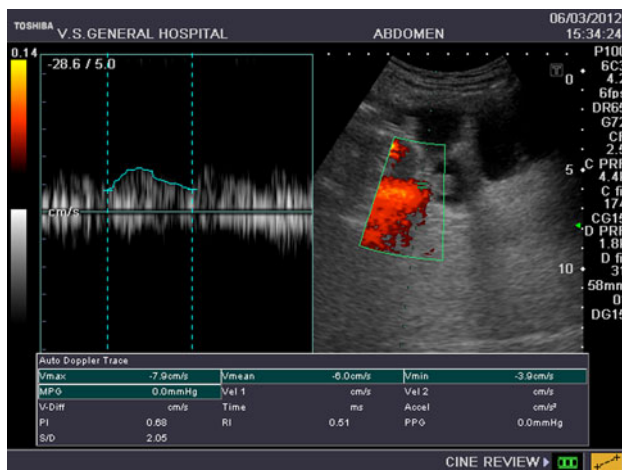**Fig. 4** 38-year-old woman with hemorrhagic cyst

Fig. 5 Spectral Doppler analysis showing *PI* 0.68 and *RI* 0.51 in 58-year-old woman with serous cystadenocarcinoma

Thus, the present study data were rendered slightly more specific and less sensitive with $RI < 0.4$ and more sensitive and specific with $PI < 1.0$, and hence, to optimize sensitivity and specificity, $PI < 1.0$ and $RI < 0.6$ should be taken. In the present study, B-mode USG along with Color Doppler and Spectral Doppler offers reliable prediction of benignity of tumor as only 4.54 % benign tumors were misdiagnosed in contrast to 17.5 % of malignant tumors. This feature correlates well with the study by Stein et al. [9]. Only after when Color Doppler showed intratumoral vascularity (mainly central) and Spectral Doppler showed low resistance velocity waveforms in intratumoral vessels, the definite diagnosis of malignancy in solid tumors was made (Fig. 5). Fairly good specificity and sensitivity (Table 3) with *PI* and *RI* values of <1 and <0.6, respectively, were achieved in the present study [15].

Thus, multiparameter analysis utilizing B-mode gray scale USG along with Color and Spectral Doppler offers good sensitivity, specificity, and positive predictive value. It should always be the diagnostic modality of choice for the patients with adnexal masses to establish the diagnosis of ovarian malignancy.

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