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# Color Doppler Ultrasonography in the Differentiation of Benign and Malignant Ovarian Tumors

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### ABSTRACT

**Objective** To determine the accuracy of color Doppler ultrasonography in the detection of ovarian malignancy on the basis of resistance index.

**Design** Cross-sectional study.

**Setting** Department of Obstetrics and Gynecology, Faculty of Medicine Siriraj Hospital, Mahidol University.

**Subjects** 120 patients who had their ovarian tumors removed surgically between June 2000 and September 2001.

**Method** All patients had color Doppler sonography performed prior to surgery. The Doppler results were compared to the histological diagnosis of the ovarian tumors.

**Main outcome measurement** Sensitivity, specificity, positive predictive value, negative predictive value, false positive rate, false negative rate, and accuracy of the preoperative resistance index.

**Results** Of the 113 patients whose intratumoral blood flow could be evaluated, the resistance index was significantly lower in malignant lesions than in benign lesions ($0.49 \pm 0.14$ vs $0.72 \pm 0.12$, $p < 0.001$). The sensitivity, specificity, and accuracy of the preoperative resistance index ($\leq 0.5$) in detecting malignant ovarian tumors were 71.4%, 93.6%, and 86.7%, respectively; with 83.3% positive predictive value, 88.0% negative predictive value, 6.4% false positive rate, and 28.6% false negative rate.

**Conclusion** Malignant ovarian lesions tended to have low-impedance flow and benign lesions had high-impedance flow. However, some overlap in individual values of resistance index for benign and malignant lesions was found, indicating that color Doppler sonography has limitations in the differentiation of benign from malignant ovarian masses.

**Key words:** Ovarian tumor, color Doppler ultrasonography, resistance index

Ovarian cancer presents an increasing challenge to the physicians. Because it is a silent disease, the overall 5-year survival rate remains low. It is the major lethal gynecological malignancy in Western

countries.[1,2] In Thailand, it comprises about 16% of all gynecological cancers and is the second most common cancer of the female genital tract after cervical cancer.[3] Lack of a reliable diagnostic test at an early stage is a major obstacle for better treatment effect of ovarian cancer. An accurate preoperative diagnosis provides better preoperative and intraoperative management, and the morbidity and even mortality of these patients may be reduced. Conventional ultrasonography is widely used in the diagnosis of ovarian masses by the morphological pattern of the tumors but lacks specificity in distinguishing benign from malignant lesions.[4-6] Serum CA-125 is one of the most useful tumor marker in the management of a patient with ovarian cancer.[7-9] However, the positive and negative predictive values of this marker are generally low.[10,11]

A more recent development in diagnostic ultrasonography is the use of color Doppler ultrasonography (CDS) for the identification of malignant ovarian masses by the detection of low resistance intra-tumoral blood vessels, secondary to angiogenesis and neovascularization in malignant tumors.[12,13] However, the usefulness of CDS is now controversial due to the overlap in the values obtained from benign and malignant lesions[14-16] and their relatively poor correlation.[4,17-19] The purpose of this study was to evaluate whether the resistance index (RI) determined at CDS could be used to distinguish between benign and malignant ovarian tumors.

## Material and method

All patients with suspected ovarian tumor, who were admitted for elective surgery at the Department of Obstetrics and Gynecology Siriraj Hospital between June 2000 and September 2001, were evaluated. The equipment used was a Toshiba (Eccocee) SSA-340A unit. Most patients were scanned transabdominally with a PVF-375 MT, 3.75-MHz transducer. In some patients whose tumors could not be evaluated clearly, transvaginal ultrasound was done with PVF-621 VT, 5-MHz transducer. A pulsed Doppler beam was focused on the intratumoral vessel and flow velocity waveforms were recorded. When internal vessels were absent, vessels in the wall of the tumor were analyzed. A minimum of three waveforms were obtained from any areas of flow within or around the ovary. The RI (systolic peak - diastolic peak / systolic peak) was calculated electronically, with the lowest value taken as representative of the most suspicious pathological characteristic. In accordance with the previous reports of Kurjak and others,[15,20-22] the cutoff point of RI was defined as 0.5. RI greater than 0.5 were considered representative of high-impedance flow (Fig 1), and values of less than or equal 0.5 were considered to indicate low-impedance flow (Fig 2). Tumors were categorized as either benign or suspicious of being malignant by CDS before surgery. The pathological diagnosis was made according to the criteria set by the World Health Organization.[23] We excluded those patients with previous surgery for ovarian cancer, metastatic tumor to ovary, and tumors of nonovarian origin.

The RI was related to the benign or malignant nature of the ovarian tumor by contingency table methods and evaluated for significance by Chi-square analysis. Student t-test was used to compare difference in various parameters between benign and malignant masses, and a difference was considered statistically significant when $p < 0.05$.

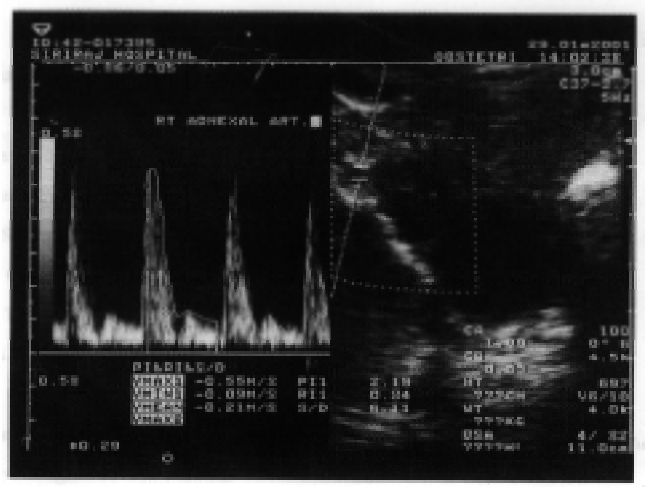

**Fig 1.** Doppler waveform of the lesion demonstrates high-impedance flow (RI = 0.84). Final diagnosis: endometrioma.

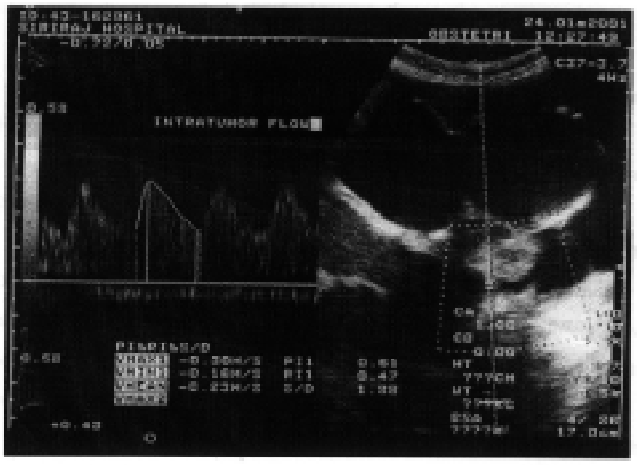


**Fig 2.** Doppler waveform of the lesion demonstrates low-impedance flow (RI = 0.47). Final diagnosis: malignant struma ovarii.

## Results

A total of 120 patients with primary ovarian tumor had CDS performed and underwent laparotomy. The patients' age ranged from 12-81 years with a mean age of 41±14 years. Half of the patients (50.8%) were nulliparous and one-fourth were in postmenopausal period. The most common presenting symptoms were abdominal pain (30.8%) and palpable mass (30%). Common epithelium was the most common histological type, comprising 65.8% and germ cell was the second most common tumor, comprising 19.2%. One-third of the tumors (29.2%) were malignant, and nearly half of the patients (45.7%) had advanced stage of disease. (Table 1)

**Table 1.** Distribution of ovarian tumors according to tumor type, tumor potential and staging (malignant tumor)

| | Number | Percent |
|---|---|---|
| Tumor type | 120 | 100 |
| Common epithelium | 79 | 65.8 |
| Germ cell | 23 | 19.2 |
| Stromal cell | 4 | 3.3 |
| Others (including tumor-like conditions) | 14 | 11.7 |
| Tumor potential | 120 | 100 |
| Benign | 85 | 70.8 |
| Malignant | 35 | 29.2 |
| Staging (malignant tumor) | 35 | 100 |
| Early stage (1 or 2) | 18 | 51.4 |
| Advanced stage (3 or 4) | 16 | 45.7 |
| Undetermined | 1 | 2.9 |

**Table 2.** Contingency table arranged to show the prediction of malignant ovarian tumor by resistance index.*

| Color Doppler ultrasound | HISTOPATHOLOGY | | TOTAL |
|---|---|---|---|
| | Malignant | Benign | |
| RI ≤ 0.5 (positive) | 25 | 5 | 30 |
| RI > 0.5 (negative) | 10 | 73 | 83 |
| TOTAL | 35 | 78 | 113 |

* sensitivity, 71.4% (25/35); specificity, 93.6% (73/78); positive predictive value, 83.3% (25/30); negative predictive value, 88.0% (73/83).

In seven of 120 patients, no flow could be detected within the mass or immediately adjacent to it, and these cases were excluded from the analysis. Of the remaining 113 patients, RI was significantly lower in malignant lesions than in benign lesions (0.49±0.14 vs 0.72±0.12, $p < 0.001$). The RI of advanced ovarian cancer tended to be lower than that of early disease, however, it was not statistically significant (0.44±0.09 vs 0.52±0.15, $p = 0.076$).

Comparison of RI and pathological diagnosis of ovarian tumor is shown in Table 2. The sensitivity and specificity were 71.4% (95%CI, 54.9-83.7) and 93.6% (95%CI, 85.9-97.2), respectively. The positive predictive value was 83.3%(95%CI, 66.4-92.7) and the negative predictive value was 88.0%(95%CI, 79.2-93.3) with a false positive and negative rate of 6.4% and 28.6%, respectively. The accuracy rate of RI was 86.7% (95%CI, 78.7-92.1).

## Discussion

CDS has been widely used in the evaluation of uteroplacental flow in obstetrics during the past decade. It has also been used to detect abnormal intratumoral blood flow in many gynecologic tumors in recent years, especially in differentiating a benign ovarian tumor from ovarian cancer. This idea is based on the premise that malignant masses will have low-impedance flow due to internal neovascularization.[12-14] RI was the most common measurement used in CDS. The value of less than 0.5 was used to indicate malignant tumor, as proposed by Kurjak and others.[15,20-22] Although lesions with no flow have been considered benign, some authors have shown absence of flow in malignant lesions as well.[11,15,22,24] So, we excluded seven patients whose intratumoral blood flow could not be detected from our analysis.

Our results show that malignant lesions tend to have low-impedance flow and benign lesions have high-impedance flow. However, significant overlap in individual values of RI for benign and malignant lesions is found, with 6.4% of our benign lesions showing low-impedance flow and 28.6% of malignant lesions showing high-impedance flow. These findings are similar to those in recent published reports that also show considerable overlap in impedance between benign and malignant adnexal masses.[15,21,22] The reasons for the limited validity of CDS in this study may be attributed to the fact that most of our patients had CDS done transabdominally. Timor-Tritsch et al[25] demonstrated that vaginal approach produce greater image resolution than the abdominal, thus allowing detailed assessment of ovarian masses. Secondly, three-fourths of the patients were premenopausal. The impedance of flow may be influenced by luteal hormones.[26,27] The CDS examinations should be carried out between days 3 and 10 of the menstrual cycle to avoid false positive results as a consequence of increased ovarian flow during the luteal phase. However, this could not be performed in our study because the patients underwent surgery on the day following admission to the hospital. The observation that RI of advanced ovarian cancer tends to be lower than that of early disease in the present study, is similar to that reported by Weiner et al.[24] However, the difference is not statistically significant. This may be attributed to the small number of malignant lesions in our study.

CDS is a useful noninvasive method that can be performed easily without causing discomfort to patients. However, there is a considerable overlap between benign lesions and malignancies, indicating that quality of blood flow described by RI is not enough to distinguish benign from malignant lesions.

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