Sonographic Diagnosis of Ovarian Masses

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Abstract: Transabdominal ultrasonography was initially used for the investigation of overt abdominal swellings and much later for the detection of early ovarian cancer in asymptomatic women. The technique was undoubtedly of value for detecting transient, persistent and overt ovarian cysts. Subsequently, the resolving power of pelvic ultrasonography was increased substantially by the advent of transvaginal probes. This revolutionary development was first applied to systemic studies of overt ovarian masses in patients awaiting surgery. Over the past decade, several ultrasound-based morphological scoring systems, color Doppler parameters, logistic regression models have been proposed and tested in order to try to predict the histology of ovarian tumors. On prospective testing, no standard criterion has been published. Therefore, it is important for each operator to establish their own criteria based on individual recognition potential.

Key words: Ultrasonography, ovarian masses, morphological scoring systems, color Doppler imaging with pulsed Doppler spectral analysis, multivariate logistic regression analysis, pattern recognition.

INTRODUCTION

Ovarian lesions are of particular importance in gynecological practice owing to their malignant potential and the limited ability to differentiate between benign and malignant types prior to surgery. Therefore, the preoperative diagnosis of ovarian tumor with B-mode ultrasonography has been very important. As the pelvis contains many soft tissue organs with a similar acoustic impedance, previous studies employing transabdominal sonography could not provide a clear image of the various structures due to low resolution, unacceptable attenuation of the transmitted pulses (and the reflected echoes), and particularly in obese patients, due to the ovaries being well outside the focal region of the transducer. Therefore, the anticipation of ultrasound-derived endpoints which could be used to distinguish malignant from benign cysts proved to be premature.¹ By the advent of transvaginal transducer with high frequency, the better resolution as compared to abdominal transducer, we were able to depict a more detailed imaging of female intrapelvic organs, especially normal ovaries (Figs 1 and 2). This revolutionary development was soon applied to systematic studies of overt ovarian masses in patients awaiting

Fig. 1: Transvaginal sonography of normal ovary (arrows) (A) premenopausal, (B) artificial postmenopausal, (C) postmenopausal, IV: iliac vessel)

A

B

C

Fig. 2: Physiological change of appearance in normal ovary: (A) cumulus oophorus formation (arrow), (B) corpus luteum formation (arrow), (C) polycystic ovary

surgery. Moreover, the introduction of transvaginal color Doppler imaging with pulsed Doppler spectral analysis represented a quantum leap in technical development. This additional facility enabled studies to be undertaken on the vascularity and blood flow within simple and complex forms of ovarian cyst.²

This time, I review the usefulness and limitation of sonographic evaluation of ovarian masses. I hope this review will be useful in clinical practice.

OBJECTIVE EVALUATION

Transvaginal B-mode Diagnosis

Granberg *et al*³ and Rottem *et al*⁴ established sonographic criteria of ovarian tumors, which could be used to classify a tumor as benign (i.e. the cyst must be unilocular and thin-walled with no irregularities in outline or expanding processes or septa, or echogenicity) or malignant (i.e. the ovary must be multicystic, or a single cyst must be multilocular with dense or irregular septa, have a poorly defined border with papillary formation on

the inner surface, or increased fluid in the peritoneal cavity). In our opinion, although the criteria are objective and acceptable, an increase in false-negative results will be inevitable. Only adnexal tumor of unilocular cystic pattern is diagnosed to be benign (Fig. 3). This is the limitation of B-mode ultrasonography with ovarian tumor based on macroscopic pathology. However, the consensus view is that transvaginal B-mode ultrasonography is sensitive to detect nearly all cystic ovarian lesions suggestive of carcinoma (and hence increases false-positive rate).

Several morphological scoring systems have been developed and examined by different centers to improve the accuracy of ultrasound diagnosis⁵⁻⁷ (Fig. 4). Initial results encouraged a systematic examination of a number of different tumor features on ultrasound scan. However, none of these scoring systems has been widely adopted in routine clinical practice. Because, each author had no information regarding the reproducibility of the scoring system, and the relatively small number of subjects precluded a precise estimate of test performance.

Fig. 3: Gray-scale ultrasonographic classification of adnexal tumor

V A L U E	V A R I A B L E S			
	INNER WALL STRUCTURE	WALL THICKNESS (mm)	SEPTA (mm)	ECHOGENICITY
1	Smooth	Thin $\leq$ 3 mm	No septa	Sonolucent

2	Irregularities $\leq$ 3 mm	Thin $>$ 3 mm	Thin $\leq$ 3 mm	Low echogenicity

3	Papiliarities $>$ 3 mm	Not applicable, mostly solid	Thin $>$ 3 mm	Low echogenicity echogenic core

4	Not applicable, mostly solid			Mixed echogenicity

				High echogenicity
5
Max	4	3	4	5

Fig. 4: Scoring system for evaluation of adnexal tumor (quoted from reference 5)

Fig. 5: 'Ovarian crescent sign' (arrows)

Recently, Hillaby *et al*⁸ reported that the presence of normal ovarian tissue (the 'ovarian crescent sign') adjacent to an ovarian cyst (Fig. 5) is a useful morphological feature that may be used to help exclude an invasive ovarian malignancy in women with adnexal masses detected on ultrasound scan. Using this method, i.e. the 'ovarian crescent sign', the differential diagnosis of an ovarian mass is based on the identification of normal ovarian tissue surrounding the tumor, rather than on the detailed morphological examination of the tumor itself. Malignant ovarian lesions could be diagnosed with a sensitivity of 91% and specificity of 84% in 100 women with a preoperative diagnosis of an adnexal mass, which seemed to be relatively proper. However, further prospective work might be necessary to assess the potential value of the 'ovarian crescent sign.'

Transvaginal Color and Pulsed Doppler Diagnosis

The introduction of transvaginal Doppler ultrasonography into gynecologic field has allowed detailed hemodynamic assessment of ovarian tumors. The presence or absence of color and the detection or non-detection of flow velocity waveforms could be used as categorical endpoints (which depend on the presence of high blood velocity). The resistance index (RI) or pulsatility index (PI) was used as continuous variables; these values are highly dependent upon diastolic velocity and are thought to reflect impedance distal to the point of sampling. The use of these endpoints in relation to derived cut-off values gave encouraging results for distinguishing between benign and malignant tumors. Kurjak *et al*⁹ stressed the importance of thorough examination of ovaries with transvaginal color Doppler regardless of their B-mode ultrasound

appearance or size, and found a resistance index (RI) of less than 0.4 in only one of 624 benign tumors, whereas an RI of less than 0.4 was found in 54 of 56 malignant tumors. They set the cut-off value of RI, 0.40. Sequentially, some authors arbitrarily set the cut-off value of RI or PI with excellent sensitivity and specificity.¹⁰⁻¹² However, we were unable to discriminate between the blood flow of a corpus luteum cyst, an endometrioid ovarian cyst and carcinoma, and suggested that we had yet to determine the values that define normal and abnormal blood flow within the ovary.¹³

When ultrasound equipment became more sensitive (in terms of detecting lower blood velocity), more areas of color, flow velocity waveforms and vessels with low RI and PI were found in benign tumors, and the technique did not appear to offer significant advantages over B-mode imaging.^{14,15} Paradoxically, the advance in technology was a contributory factor in momentarily reducing the usefulness of the technique for detecting ovarian cancer. There was renewed interest in the potential use of color Doppler imaging for this purpose; however, when it was found that reproducible measurements could be made of the peak systolic velocity (PSV) in ovarian follicles and corpora lutea,¹⁶ and variety of overt tumors.¹⁷

The accurate measurement of blood velocity is dependent upon the angle of the ultrasound beam to the vessel. Unfortunately, it is not possible to determine the angle of insonation to small intratumoral vessels. However, the volume of tissue under the range gate is large enough to include many vessels, which may be arranged in a tortuous manner. It has been generally accepted that one or more of these small vessels will be at a low or zero angle to measurements can be made. We have shown that the intratumoral PSV is the most useful index for discriminating between overt benign and malignant adnexal masses.¹⁸ This conclusion was reinforced by the findings of Taylor *et al*.¹⁷ that the intratumoral PSV and time-averaged maximum velocity (TAMXV) were better indices than either the RI or PI and that the combined use of one index for velocity and another for impedance was more useful than using either alone.

Now, the situation becomes even more complex when using transvaginal color Doppler imaging with pulsed Doppler spectral analysis. Differences in operator variance and sensitivity contribute to a confusing analysis of variables. In some studies, Doppler ultrasound evaluation is still helpful in the diagnosis of adnexal malignancy.^{19,20} On the other hand, Doppler flow studies did not improve diagnostic accuracy.²¹

Multivariate Logistic Regression Analysis

Multivariate logistic regression analysis is a mathematical procedure for systematically developing an algorithm to assess the probability that a particular event has occurred. This approach has been used to determine the probability of nodal involvement in patients with prostatic carcinoma based on the

patients' age, the serum acid phosphatase level, X-ray findings, tumor grade.²² Tailor *et al*²³ assigned a probability of malignancy for any patient with an adnexal tumor by the application of multivariate logistic regression analysis to variables recorded at the time of pelvic sonography. Multivariate logistic regression analysis enabled the calculation of probability of malignancy for any patient with a known adnexal mass, and ensured reproducibility of diagnosis reduce dependence on operator experience. The accuracy of that prediction appeared to be better than that of morphological or Doppler criteria when the latter were used independently. Another important advantage was the ability to estimate the probability of malignancy that was helpful in both decision making and patient counseling.²³⁻²⁶ However, these published studies were designed using a limited sample size, and therefore must be tested on a large number of women before then can be introduced into clinical practice. Recently, based on the data from 1,066 patients recruited from nine European centers, a more universally useful regression model to distinguish between a malignant and benign adnexal tumor before surgery has been developed.²⁷ Because the model was constructed from multicenter data, it is more likely to be generally applicable. However, I still wonder whether the terms, definition, and qualitative and quantitative endpoints to describe the ultrasonic features of adnexal tumors were being really used in the protocol for those studies with specific objectives. Are internationally agreed terms and definition necessary? I take precautions against these steering studies of mathematical game performed in western countries.

SUBJECTIVE ASSESSMENT

Timmerman *et al*²⁷ stated that most ultrasonographers base their interpretation of ultrasound images on a subjective estimation rather than on the use of decision levels or scoring systems. They concluded that subjective evaluation of the gray-scale ultrasound image, i.e. pattern recognition, for discrimination between benign and malignant tumors can almost certainly be learnt by anyone performing gynecological ultrasound examinations on a regular basis, but diagnostic accuracy increases with increasing experience. Pattern

recognition has been shown to be superior to all other ultrasound methods (e.g. simple classification system, scoring system, mathematical models for calculating the risk of malignancy) for discrimination between benign and malignant extrauterine pelvic masses. Adding Doppler ultrasound examination to subjective evaluation of the gray-scale ultrasound image does not seem to yield much improvement in diagnostic precision, but it may increase the confidence with which a correct diagnosis of benignity or malignity is made.²⁸⁻³⁰ Certain tumors (e.g. endometriosis, dermoid cysts, hydro- pyo- and hematosalpinx, peritoneal pseudocysts, paraovarian cysts, hemorrhagic corpus luteum cysts, myomas, abscesses and ovarian fibromas, thecomas, and Brenner tumors) may manifest a characteristic appearance at gray-scale imaging (Figs 6 to 10). Therefore, an experienced ultrasound examiner can often make a correct specific diagnosis based on the gray-scale ultrasound image by pattern recognition.³¹ However, in some case, the diagnosis with pattern recognition may be confusing and the following observations might be clinically helpful in such case³²⁻³⁴ (Figs 11 and 12).

1. Simple cysts and developing follicles usually exhibit minimal or no flow in their walls.³²
2. The preovulatory follicle presents a large amount of flow in its wall.³³
3. Recent (hemorrhagic) corpus luteum cysts tend to have a very strong peripheral (circular) flow.³²
4. Endometrial cysts most often present a very low and localized flow.³⁴
5. Benign cystic teratoma rarely exhibit internal blood flow.³²
6. Most other benign ovarian tumors present a low or moderate perfusion in their walls and septa.³²
7. Pelvic inflammatory disease (PID) is associated with very strong blood flow in the septa and cyst wall.³²
8. Ovarian cancer commonly exhibits irregular and very strong blood flow in the septa and also in the cyst wall.³²

NEW TRENDS

Three-dimensional power-Doppler imaging (3DPD) has become available. Several studies have shown that 3DPD might improve the diagnostic accuracy for ovarian cancer prediction.³⁵⁻³⁷ On

Fig. 6: Endometriosis with (A) fine granular echo, (B) 'wall nodularity' suggesting coagulation (arrow), (C) adhesion to the uterus, and (D) multilocular cyst

Fig. 7: Typical figures of dermoid cysts

Fig. 8: A fibroma (F) may be confused with a uterine myoma if no connection is seen between the myoma and the uterus (U)

Fig. 9: A granulosa cell tumor presents honey-comb appearance

Fig. 10: A hemorrhagic corpus luteum cyst is easily diagnosed by spider-web-like contents

the other hand, Alcazar *et al*³⁸ reported that 3DPD did not have a better diagnostic performance than 2-dimensional power-Doppler imaging for the discrimination of benign from malignant complex adnexal masses. We have as yet been unable to specify objective parameters in this regard. Further research is seemed to be needed to give 3DPD technique its appropriate role in the diagnostic procedure.

Fig. 11: By gray-scale image, this tumor might be diagnosed to be malignant. Low perfusion within solid part was recorded. This tumor was to be mucinous cystadenoma

Fig. 12: Doppler ultrasonography of serous cystadenocarcinomas. Irregular and very strong blood flow in the solid component was recorded

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