International Journal of Gynecology and Obstetrics (2008) **103**, 99–104

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International Journal of GYNECOLOGY & OBSTETRICS

REVIEW ARTICLE

Pattern recognition using transabdominal ultrasound to diagnose ovarian mature cystic teratoma

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Received 8 May 2008; received in revised form 6 June 2008; accepted 6 June 2008

KEYWORDS
Adnexal mass;
Color extened-flow mapping;
Echo pattern;
Mature cystic teratoma;
Transabdominal ultrasound

Abstract

Objective: To determine the validity of sonographic pattern recognition in the diagnosis of mature cystic teratoma. *Methods:* Consecutive patients scheduled for elective surgery for adnexal masses were included in the study. All patients underwent transabdominal ultrasound with color extended-flow mapping within 24 hours prior to surgery. Examinations were performed by the same sonographer to identify benign cystic teratoma. The final diagnoses were based on histopathologic findings. *Results:* A total of 329 consecutive patients were recruited; 23 were excluded because the masses were not adnexal masses. Of the remaining 306 patients, 36 masses were found to be mature cystic teratomas and 270 were nonteratomas. Sonographic pattern recognition showed a sensitivity of 94.4% and a specificity of 98.2%. *Conclusion:* Sonographic pattern recognition using transabdominal ultrasound with color extended-flow mapping can accurately diagnose mature cystic teratoma.

1. Introduction

Mature cystic teratoma, one of the common ovarian tumors, affects a younger age group (mean age of 30 years) than epithelial tumors [1] and is the most common ovarian mass observed in children [2]. Ovarian cystic teratomas have a variable appearance on ultrasound because of their heterogeneous histologic structure, typically containing mature tissues of ectoderm (skin, brain), mesoderm (muscle, fat), and endoderm (epithelium) [3]. Sonographic characteristics of ovarian cystic teratomas have been recognized and knowledge about pathognomonic patterns has accumulated. Sonographic morphologic pattern recognition of ovarian cystic teratomas includes: dermoid plug [4], "tip of the iceberg" sign [5], fat-fluid level [6], cyst with pearl-gray appearance [7], dermoid mesh [8], or several tissue components [9].

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0020-7292/$ - see front matter
doi:10.1016/j.ijgo.2008.06.002

The virtually limitless combinations of different tissues in teratomas mean that their patterns can mimic a number of pathologic pelvic masses [3]. Therefore, the interpretation of sonographic data in terms of tissue characterization and ascertainment of a particular pattern can sometimes be confusing. Furthermore, because of its solid components, mature cystic teratoma is one of the most common adnexal masses to simulate malignancy [10—13]. Color flow mapping may be helpful in these confusing cases. Although several studies on the accuracy of sonographic diagnosis of mature cystic teratoma exist, these were often based on sonographic morphology alone and without color flow mapping, which often adds value in differentiating between benign and malignant masses [14]. Although evaluation of color flow mapping is entirely subjective, the results have been shown to be reproducible enough for clinical use [15].

Although in most cases the sonographic patterns in previous reports were obtained transvaginally, with the advancement of high-resolution ultrasound with extended flow and the resulting higher sensitivity to detect blood flow in minute vessels—even during transabdominal examination—we believe that teratoma pattern recognition and vascularization assessment can be performed effectively via a transabdominal approach. Avoiding transvaginal examination may be an advantage of the new ultrasound technology.

The aim of the present study was to determine the accuracy of sonographic diagnosis of mature cystic teratoma based on pattern recognition, including morphology assessment and color flow mapping via a transabdominal approach.

2. Materials and methods

Between April 2006 and March 2008, 329 patients were admitted to Maharaj Nakorn Chiang Mai Hospital, Chiang Mai University, Thailand, for elective surgery owing to detection of an adnexal mass by pelvic examination or ultrasound at another center, or both. Exclusion criteria consisted of known diagnoses of ovarian tumor where the patient was scheduled for a second operation, and patients who underwent surgery more than 24 hours after the ultrasound examination. The women were counseled about the study and were recruited after written informed consent had been obtained.

All patients underwent ultrasound examination within 24 hours prior to surgery by the same experienced sonographer who had no clinical information about the patients. The women were examined with a real-time 3.5—5 MHz transabdominal curvilinear transducer connected to a ProSound Alpha 10 system (Aloka, Tokyo, Japan). After thorough conventional examination, transabdominal color Doppler blood and extended-flow examination were performed.

Evaluation of tumor vascularization was based on a simple scoring system suggested by the International Ovarian Tumor Analysis Group [14]: color score 1, no detectable vascularization; color score 2, minimal vascularization; color score 3, moderate vascularization; and color score 4, abundant vascularization.

The sonographic diagnosis of mature cystic teratoma was based on subjective assessment of pattern recognition including no or minimal detectable vascularization, plus at least one of the morphologic patterns described as follows:

(1) Dermoid plug: a cystic lesion consisting of a densely echogenic and relatively homogeneous mass containing soft

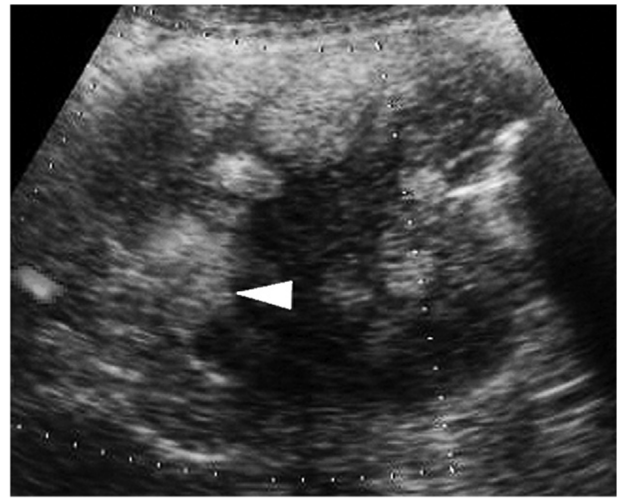

Figure 1 Dermoid plug: solid excrescence arising from cystic wall or septum (arrow head), no detectable vascularization.

Figure 2 Dermoid plug: numerous free-floating balls.

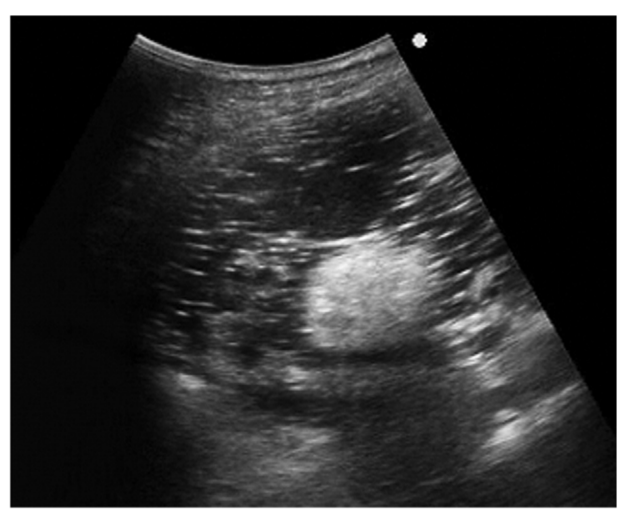

Figure 3 Dermoid plug: fried egg appearance.

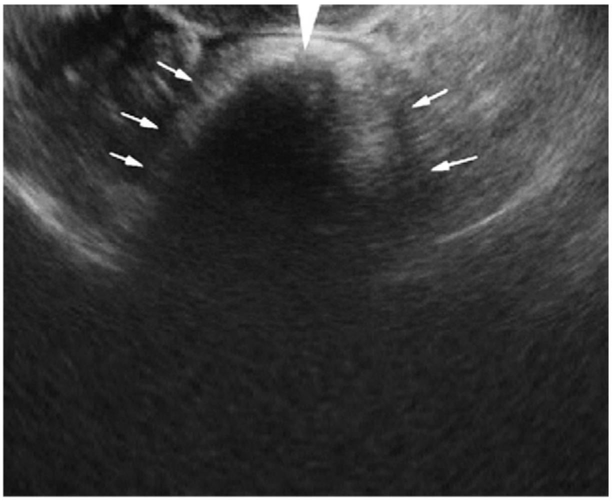

Figure 4 Dermoid plug: "tip of the iceberg" sign (diffusely echogenic mass demonstrating sound attenuation secondary to sebaceous material and hair within the cyst).

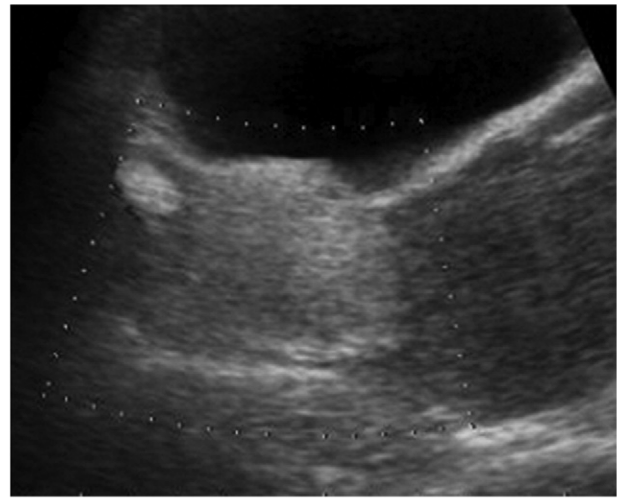

Figure 5 Dermoid plug: pure sebum mass, no detectable vascularization.

tissue or fat mixed with hair, giving a progressive fading shadow of sound beyond the plug mass. A dermoid plug may appear as a solid excrescence arising from the cystic wall or septum (Rokitansky protuberance) (Fig. 1); numerous free-floating balls (Fig. 2); a fried egg appearance (Fig. 3); "tip of the iceberg" sign (a diffuse or partially echogenic mass usually demonstrating sound attenuation secondary to sebaceous material and hair within the cyst) (Fig. 4); or a pure sebum mass (a cyst filled entirely with homogeneous hyper- or hypoechoic mass) (Fig. 5).

(2) Dermoid mesh: multiple thin, echogenic lines and dots caused by hair in the cyst cavity (Fig. 6).
(3) Very bright echogenic focus: casting a well-demarcated sharp acoustic shadow related to the presence of calcified structures such as bone and teeth (Fig. 7).
(4) Fat-fluid level: sebum layered on serous fluid (Fig. 8).
(5) Several tissue components (Fig. 9).

A sonographic diagnosis of mature cystic teratoma recorded at ultrasound examination was subsequently correlated with the final diagnosis based on histopathologic findings after surgery. Data were analyzed using SPSS version 15.0 (SPSS, Chicago, IL, USA) and the sensitivity and specificity were calculated.

3. Results

Between April 2006 and March 2008, 329 patients initially diagnosed with ovarian tumors were recruited to undergo ultrasound examination with color extended-flow mapping.

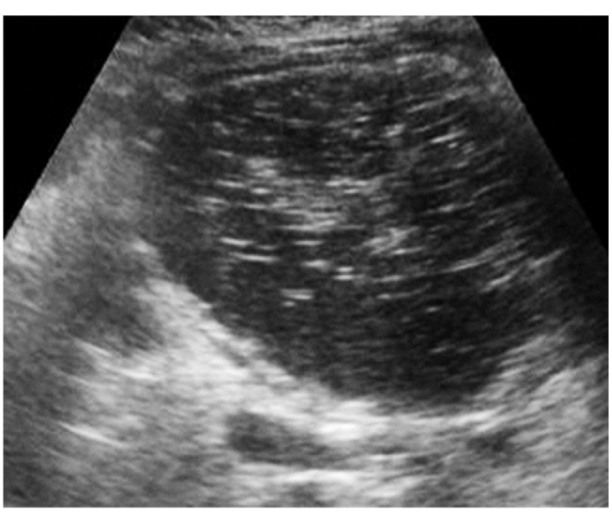

Figure 6 Dermoid mesh: multiple thin, echogenic lines and dots caused by hair in the cyst cavity.

Figure 7 Very bright focus (arrow head) which casts a well-demarcated sharp acoustic shadow related to the presence of calcified structures.

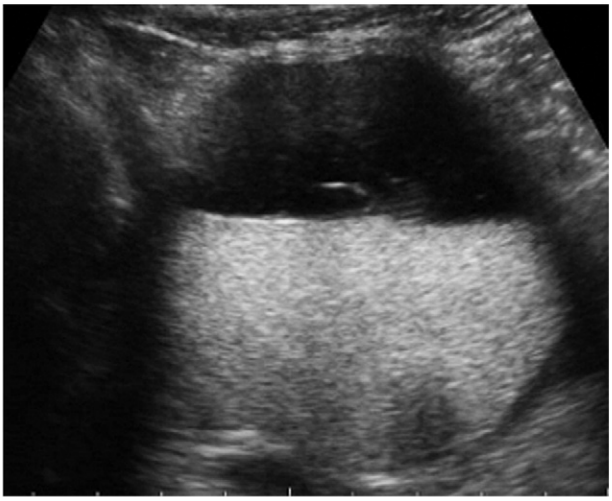

Figure 8 Fat-fluid level: sebum layered on serous fluid.

Figure 9 Several tissue components.

Twenty-three patients were excluded because of pathological diagnoses of nonovarian tumor, including subserous myoma. The remaining 306 patients underwent transabdominal ultrasound prior to surgery. The mean age of the patients was 43.4 ± 14.0 years (range, 13–79 years), 113 (36.9%) were nulliparous, 205 (67.0%) were of reproductive age, 96 (31.4%) were menopausal, and 5 had not begun menarche.

Histopathologic examination revealed 36 (11.8%) mature cystic teratomas and 270 (88.2%) ovarian masses other than mature cystic teratoma.

Of the 36 cases of mature cystic teratoma, 2 cases showing homogeneous hyperechogenic contents with acoustic shadow on ultrasound were mistaken for endometriomas. The remaining 34 cases showed one or more of the sonographic morphologic patterns shown in Table 1.

All 36 cases of mature cystic teratoma showed no or minimal detectable vascularization (score 1 or 2), a resistance index above 0.62, and a pulsatility index higher than 1.2 indicating benign nature. The sensitivity and specificity of the sonographic pattern to diagnose the disease were 94.4% and 98.2%, respectively (Table 2).

Five cases of false negatives (nonteratomas sonographically diagnosed as teratomas) included 2 endometriomas, 1 hemorrhagic cyst, 1 tubo-ovarian abscess, and 1 pedunculated myoma. In contrast, 2 cases of benign cystic teratoma were mistaken for endometrioma and tubo-ovarian abscess.

Table 1 Distribution of sonographic morphologic patterns in the 34 cases of mature cystic teratoma

Morphologic pattern	No.
Dermoid plug	19
Solid excrescence	5
Numerous free-floating balls	2
Fried egg appearance	4
Tip of the iceberg	4
Pure sebum mass	4
Dermoid mesh	14
Very bright focus	5
Fat-fluid level	4
Several components	3

4. Discussion

Using new high-resolution ultrasound technology equipped with extended-flow mapping we were able to effectively evaluate the accuracy of sonographic pattern recognition using transabdominal ultrasound.

A full spectrum of sonographic appearances of ovarian cystic teratoma has gradually become known. Although early publications claimed an accuracy of as low as 50% [16], with advancements in ultrasound technology and increasing experience in the last decade, preoperative diagnostic accuracy has greatly improved, to as high as 100% in a small series using the transvaginal approach [17].

Unlike previous reports, the present study adds the advantage of color extended-flow mapping to the morphologic pattern recognition of teratoma. Although morphologic pattern recognition is accurate, some cases may be confused with malignancy. A dermoid plug is sometimes located at or attached to the cyst wall and mimics excrescence or solid nodules in malignant masses. In such cases, simple color flow mapping or spectral analysis is helpful. In our experience, all dermoid plugs have no or minimally detectable vascularization, unlike excrescences or the solid part of a malignant

Table 2 Diagnostic indices using ultrasound for benign cystic teratomas

Sonographic diagnosis	Pathological diagnosis		Total
	Teratoma	Nonteratoma	
Positive (teratoma)	34	5	39
Negative (nonteratoma)	2	265	267
Total	36	270	306

Sensitivity 94.44% (95% CI, 0.87–1.019); specificity 98.15% (95% CI, 0.965–0.998); positive predictive value 87.20% (95%CI, 0.767–0.977); negative predictive value 99.30% (95% CI, 0.965–1.02).

mass arising from the cystic wall or septae, which have high vascularization.

It is important to differentiate between benign and malignant adnexal masses. Several effective scoring systems or sonographic morphologic patterns have been proposed. However, in all scoring systems the solid part of any mass is usually scored as a malignant component; thus, the solid part in teratomas is commonly interpreted as a high score, leading to a false diagnosis of malignancy. Cystic teratoma is the most common type of benign adnexal mass mistaken for malignancy. A distinct characteristic of the solid area in teratomas is scant vascularization, in contrast to the high vascularization of a malignant mass; therefore all masses with a solid component should be evaluated for feeding vessels, using either color flow mapping or spectral Doppler analysis. The present study shows that simple color flow mapping can effectively differentiate between malignant masses and benign cystic teratomas. No case of teratoma in this study was misinterpreted as a malignant mass, indicating that color flow mapping may be extremely useful in ruling out malignancy in complex masses.

The present study confirms that most mature cystic teratomas manifest a characteristic appearance on grayscale imaging, with minimal or no vascularization by subjective assessment. Although pattern recognition is rather pathognomonic or typical in most cases, as shown in Figs. 1–9, variants may be confused with other conditions and lead to misdiagnosis. All 5 cases with false diagnoses for cystic teratoma were benign, and 2 missed cases of teratoma were diagnosed sonographically as other benign masses. All of these confusing cases showed a homogeneous, highly echogenic pattern without other solid components.

The present study indicates that confusing cases, including ovarian endometrioma and tubo-ovarian abscess or even some cases of pedunculated myoma or fibroma, may be difficult to distinguish from teratomas. In these cases, color Doppler ultrasound examination may also not contribute much to a correct diagnosis because, like teratomas, all such masses have no or minimal detectable vascularization. Notably, these types usually have overlapping ultrasound morphology, especially in the sonographic pattern of homogeneous echogenic fluid without a visible solid part or several tissues, as seen in our 5 misdiagnosed cases. However, although misdiagnosis may sometimes occur, it is unlikely to be mistaken for malignancy and thus has little or no impact on clinical management.

Our experience suggests that common differential diagnosis should include: endometrioma (a cystic mass with internal echoes, nodules in the wall related to fibrosis or desiccated blood, may appear echogenic); bowel (intraluminal gas or fecal material can mimic Rokitansky protuberance, observation of peristalsis helps make the diagnosis); hemorrhagic cyst (lace-like appearance can mimic dermoid mesh); and pedunculated lipoleiomyoma (unusual variant of leiomyoma that contains fat, uterine in origin).

A strength of the present study is that the ultrasound features were interpreted by only one examiner who had no clinical information on the patients, resulting in no interobserver variability. In addition, the examinations were carried out using high-quality equipment with advanced extended-flow technology. However, the accuracy achieved in the study was associated with the subjective assessment of a highly experienced sonographer, which may not be reproducible in general practice. However, this should encourage all sonographers to become familiar with pattern recognition and color flow mapping. This subjective evaluation can almost certainly be learnt by anyone performing gynecological ultrasound examinations on a regular basis, and diagnostic accuracy increases with experience. One limitation of the study is that all recruited patients were scheduled for surgery and nearly all masses could be detected by pelvic examination; the study included only palpable masses, and is therefore not representative of early cases of small sized masses. This may partly explain the successful use of the transabdominal approach in the present study.

In conclusion, subjective evaluation of an adnexal mass by an experienced sonographer is a highly accurate method for diagnosis of cystic teratomas. The data suggest that training should focus on recognizing the constituent morphologic features of a mass, rather than on any particular scoring system. This aim may be achieved using ultrasound videos of different complex adnexal masses so that trainees can establish their own database of experience. Access to stored images or video clips could be implemented into relevant training programs.

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