

B-mode and Power Doppler Ultrasound in Adnexal Masses

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Abstract

Adnexal masses can be classified in ovarian, paraovarian or tubal. In the present review we analyzed the diagnostic performance of transvaginal ultrasonography in identifying simple ultrasonographic findings of benign adnexal pathology but also the role of color Doppler in the differential diagnoses between benign and malignant masses and in the preoperative triage. Because of many kinds of adnexal masses have usually a typical ultrasound appearance, the results of the studies present in literature showed a good and sufficient diagnostic accuracy. Unfortunately some cases with uncertain findings are present and in these cases the addition of color Doppler can be useful as demonstrated by several authors. Using the location of flow evaluated using color Doppler as main parameter a mass should be graded as malignant if flow is shown centrally within the excrescences or solid areas. The same approach should be used to triage the patients with adnexal masses to the most appropriate surgical approach with an increase of less invasive surgery.

Keywords: B-mode ultrasonography, power Doppler, adnexal masses, ovary, ovarian cancer, transvaginal ultrasonography.

INTRODUCTION

Adnexal masses can be classified in ovarian, paraovarian or tubal. Several papers have been published in these last 20 years about ultrasonographic differential diagnosis of the different kinds of pelvic masses and different authors have described simple findings at B-mode evaluation that characterize benign adnexal masses.¹⁻²¹ An improvement in the diagnosis of ovarian cancer can be obtained using Doppler evaluation in those masses suspected to be malignant at B-mode evaluation.

We analyzed in the present review the diagnostic performance of transvaginal ultrasonography in identifying simple ultrasonographic findings of benign pelvic pathology but also the role of color Doppler in differential diagnoses between benign and malignant masses and in the preoperative triage.

OVARIAN LOCALIZATION

Functional or Simple Cyst

At ultrasonographic evaluation the follicular cyst appears as unilocular, anechoic smooth walled cyst without endocystic

vegetation (Fig. 1).¹ This morphology is not specific and similar sonographic findings may be found in serous cystadenomas.² Ninety-three percent of follicular cysts was anechoic and septa were present in 14% of the cases while a vegetation was present only in 3% of the cases.³ When these B-mode findings are present and the CA125 value is lower than 25 IU/ml, the probability of the presence of functional follicular cysts is high (75%).³ In addition, other authors correctly suggest that is necessary an observation over a period of 1 to 3 months to make a diagnosis of functional cyst.⁴

Corpus-Luteum Cyst

This kind of functional cyst, represent approximately 30% of all persistent ovarian masses in reproductive age submitted to surgery.³ The sonographic appearance of a corpus luteum can mimic many other lesions, also malignant tumors. Brown⁵ in a recent review describes hemorrhagic cysts as often having internal echoes with a pattern of fine interdigitating lines that have been variously described as “reticular”, “fishnet”, “lace-



Fig. 1: The B-mode findings of follicular cysts: an unilocular, anechoic smooth walled cyst without endocystic vegetation

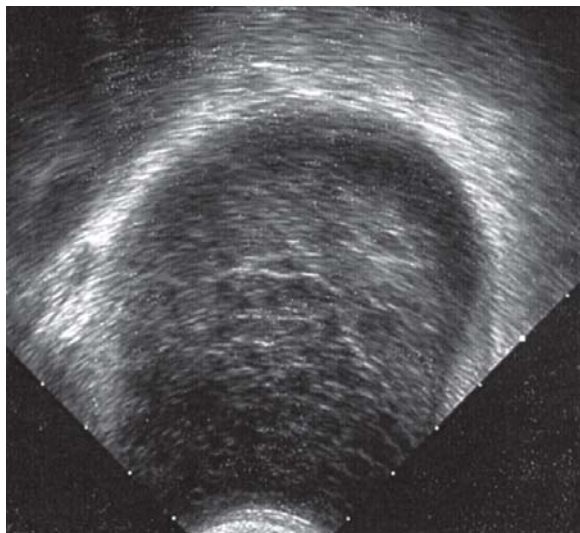


Fig. 2: B-mode finding of luteal hemorrhagic cyst: a mass with internal echoes with a “jelly-like” appearance

like” or “jelly-like” and are believed to be caused by fibrin strands that result when clot hemolyzes (Fig. 2).⁵ In the literature contradictory results are present. As a matter of fact Yoffe et al⁶ observed that transvaginal ultrasonography seems to lack specificity in diagnosis of luteal hemorrhagic cyst. On the contrary, Guerriero et al³ found that B-mode findings show a good specificity (86%).

Endometriomas

The incidence of endometriomas among ovarian masses in premenopausal populations ranged between 45 to 58% when functional cysts are excluded.⁷ The most common transvaginal sonographic feature of an endometrioma is the presence of homogeneous low-level echoes (“ground glass”) in a cystic pelvic mass with a clear demarcation from the parenchyma (Fig. 3). This pattern is present in at least 80% of cases of endometriomas.⁷⁻⁸ Also the presence of hyperechoic wall foci (punctate peripheral echogenic foci) described by Patel et al,⁹ on ultrasonographic examination is very specific to endometriomas. Unfortunately all these characteristics are not always pathognomonic. In an interesting review, Moore et al¹⁰ conclude that transvaginal ultrasound appears to be a useful test both in making and excluding the diagnosis of an ovarian endometrioma, with positive likelihood ratios ranging from 7.6 to 29.8, and the negative likelihood ratios ranging from 0.1 to 0.4 with wide confidence intervals. Recently, Clarke et al¹¹ proposed the “acoustic streaming” as a useful tool for differentiating endometriomas from other benign cystic lesions. “Acoustic streaming” is defined as the bulk movement of fluid due to a sound field caused by energy transfer from a US wave to a fluid.¹¹ Practically, the energy of the US beam “pushes” the fluid in the direction of insonation (away from the



Fig. 3: B-mode findings of endometrioma: a round homogeneous hypoechoic “tissue”, of a low-level echoes, with a clear demarcation from the parenchyma and without papillary proliferation

transducer).¹¹ Movements of fluid particles in the direction of the beam away from the transducer result in acoustic streaming. This study demonstrates that endometriomas do not show acoustic streaming, whereas 63% of other cysts shows acoustic streaming.¹¹

Mature Cystic Teratomas

Mature cystic teratomas, or dermoids, can contain tissue derived from ectodermal, mesodermal, and endodermal elements. This origin is responsible for the ultrasonographic findings. Teratomas may be cystic, with hyperechoic regions, areas of “dots and lines” (Fig. 4), or hyperechoic densities with an acoustic “shadowing” (Fig. 5). Mais et al¹² prospectively, performed a study in which the presence of dermoid cyst was

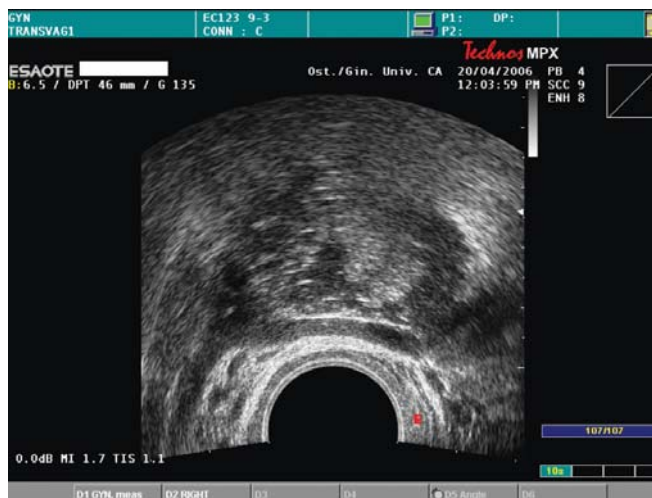


Fig. 4: B-mode findings of cystic teratoma: echogenic thin band-like echoes; a dense echo pattern with or without a cystic component

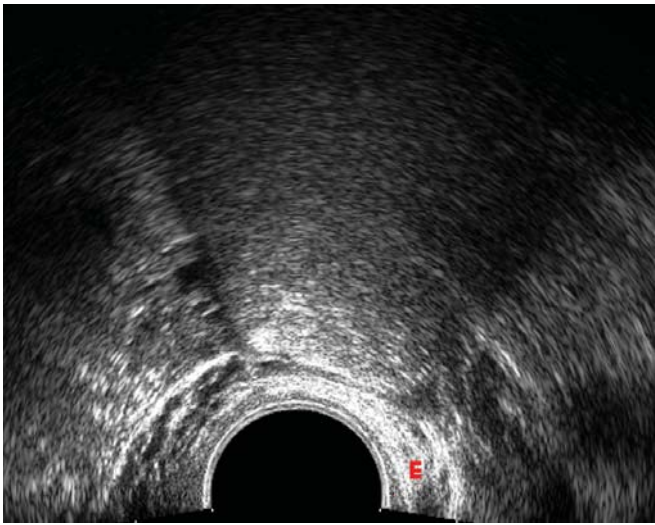


Fig. 5: Another B-mode findings of cystic teratoma: a dense echo pattern without a cystic component



Fig. 6: B-mode findings of a mucinous cystadenoma: a multilocular cyst containing fluid of different echogenicities, regular wall and septa, and no vegetations

suspected when one of the three following echo patterns was present: a densely echogenic tubercle associated with cystic echo pattern; echogenic thin band-like echoes; a dense echo pattern with or without a cystic component (Figs 4 and 5). Using this approach the sensitivity of transvaginal ultrasonography in differentiating cystic teratomas from other masses was 85% with a specificity of 98%.¹² This specificity is comparable with the previously reported one for two more expensive techniques, computed tomography (CT)² and magnetic resonance imaging (MRI).¹³

Ovarian Cystadenofibromas and Ovarian Fibroma

Alcazar et al¹⁴ describes ovarian cystadenofibromas as masses was predominantly cystic, although papillary projections or solid nodules appeared in 56.5% of the cases. For these reasons the risk of misdiagnosis with ovarian cancer is present if the operator uses the B-mode only. Few studies have investigated the transvaginal ultrasonographic appearance of ovarian fibroma. The pattern of a hypoechoic adnexal mass with acoustic shadowing should suggest a fibroma/thecoma, but in most cases the appearance is nonspecific.¹⁵ Usually the presence of a solid mass at ultrasonography should be suspected to be malignant.¹⁵

Mucinous Cystadenomas

The presence of a multilocular cyst containing fluid of different echogenicities, regular wall and septa, and no vegetations is usually considered characteristic of mucinous cystadenoma (Fig. 6).^{16,17} Using these criteria, Buy et al¹⁷ diagnosed mucinous cystadenomas with a sensitivity of 50% and a specificity of 96%. Recently, Caspi et al¹⁸ evaluated the reliability of the “variable echogenicity” sign in the preoperative

sonographic diagnosis of ovarian mucinous tumors. The risk of malignancy cannot be definitively excluded when a similar ultrasonographic appearance is present. In fact some cysts with an extremely large number of locules may be malignant even in the absence of irregularities or unequivocal solid components.¹⁶

PARAOVARIAN LOCALIZATION

Paraovarian cysts arise from the broad ligament between the Fallopian tube and the ovary¹⁹⁻²¹ and they are usually unilocular, anechoic thin-walled cysts visibly separate from a regular ovary.¹⁹⁻²¹ They can be delineated from the ovary by gently advancing the vaginal ultrasound probe and demonstrating a separation of the cyst from the omolateral ovary.¹⁹⁻²² In a study performed on 313 women, Guerriero et al²² suggest that transvaginal ultrasound showed good specificity (100%) with a good kappa value (0.63), but relatively low sensitivity (47%). Valentin¹⁶ in a small series of 167 cases with six paraovarian cysts, found a comparable specificity but a higher sensitivity (83%).

TUBAL LOCALIZATION

Hydrosalpinx

Using B-mode ultrasonography a hydrosalpinx was diagnosed when was visualized a tubular shape, the presence of incomplete septa or short linear projections, and the presence of small hyperechoic nodular wall nodules measuring about 2-3 mm (“beads-on-a-string” sign) (Fig. 7).²³⁻²⁴ In agreement with Timor-Tritsch *et al*,²³ the incomplete septa are hyperechoic septa that originate as a triangular protrusion from one of the walls, but do not reach the opposite wall. In addition Patel et al²⁵ introduces the concept of a “waist” in a cystic collection,



Fig. 7: B-mode findings of a hydrosalpinx: an elongated shaped mass with incomplete septa

referring to diametrically opposed indentations in the wall of the collection. Guerriero *et al.*²⁴ demonstrated that some hydrosalpinges can be missed by ultrasound because of the presence of faecal material and gas within the bowel in a pelvis distorted by other abnormalities such as pelvic adhesions and these authors reported a sensitivity of 84.6% of transvaginal ultrasonography in the screening of hydrosalpinx with a specificity of 99.7%.²⁴ A sensitivity of 93.3%, with a specificity of 99.6% and positive and negative predictive values of 93.3 and 99.6% respectively in the differential diagnosis of hydrosalpinx from other adnexal masses is reported in the same study.²⁴

Tubo-ovarian Abscess and Peritoneal Cysts

The ultrasound appearance of tubo-ovarian abscesses is considered variable.²⁶⁻²⁹ Timor-Tritsch *et al* in 1998²³ and recently Brown in 2007⁵ suggested the term of tubo-ovarian complex when there are inflammatory changes, but the ovary remains recognizable by ultrasound. Usually, these masses are characterized by a cystic component²⁶⁻²⁹ with septations, thick walls, internal echoes, and/or apparently solid areas (Fig. 8). In some cases a tubular component, suggestive of an associated pyosalpinx, is present.^{23,26-29} From the ultrasonographic point of view, the pyosalpinx looks like a hydrosalpinx but with an internal content with low-level echoes.^{5,23,26-29} The presence of pyosalpinx is the only certain ultrasonographic finding related to the presence of a tubo-ovarian abscess. In other all cases, the presence of clinical findings with signs and symptoms of pelvic inflammatory disease are necessary for a correct diagnosis of tubo-ovarian abscess. In addition, as stated by Valentin,¹⁶ given the complex and varied echogenicity of tubo-ovarian abscesses, “it is not surprising that they may be confused with a variety of other conditions, for example, endometriomas or malignancies”.



Fig. 8: A tubo-ovarian complex characterized by a relative few cystic component associated with an indeterminate appearance due to an apparently solid area. This findings must be submitted to color Doppler (see Fig. 20)

Most patients that have a history of pelvic inflammatory disease (PID) with or without a formation of a tubo-ovarian complex can develop pelvic adhesions. In particular some adhesions if filled by fluid can originate multilocular peritoneal inclusion cysts that are most commonly found in women of reproductive years and involve the abdomen and the pelvis.³⁰⁻³³ As a matter of fact, these adnexal cysts are created when fluid arising from the ovary is trapped by peritoneal adhesions due to an inflammatory reaction.³⁴ Among the findings observed in cases of peritoneal pseudocysts, the presence of a “bizarre lump-shaped” cyst with a thin wall and fine internal septations is considered the most suggestive (Fig. 9).³⁵⁻³⁶ The lump shape is due to the presence of adhesions filled by fluid and connecting the serosal surfaces of the surrounding organs.³⁶ Using these



Fig. 9: B-mode findings of a peritoneal cyst: the presence of a “bizarre lump-shaped” cyst with a thin wall and fine internal septations

patterns, Guerriero et al³⁷ reported a specificity and sensitivity of B-mode sonography for differentiating peritoneal cysts from other adnexal masses of 96% and 62%. In some cases, to aid the diagnosis, we can use an additional parameter recently proposed by Ying et al³⁸ as the “cyst distortion”. If the cyst change its shape while performing pressure on the abdominal wall using the left hand, the probability of a peritoneal pseudocyst is very high.

BORDERLINE CYSTS AND OVARIAN CANCER

An adnexal mass not showing the previously described typical benign patterns at B-mode transvaginal ultrasonographic evaluation should be always defined as indeterminate or suspicious. As a matter of fact a mass should be suspected to be malignant when an irregular, thickened wall and/or septa (≥ 3 mm); solid, echogenic, irregular portion or papillary projections (≥ 3 mm) inside is present (Figs 10 and 11).³⁹⁻⁴² A particular attention should be due to borderline tumors. Borderline mucinous tumors were multilocular in half the patients and contained papillations in 40% of the patients. On the contrary serous tumors were multilocular in only 30% of the patients but presented with solid or papillary patterns in 78% of the patients.⁴³ Furthermore the most frequent diagnostic feature on imaging of borderline tumors is the presence of papillae within the cyst (Fig. 12).⁴³

One of the possible approaches to the diagnosis of ovarian cancer is the use of scoring system. Many authors proposed scoring systems and mathematical models helping to calculate the risk of malignancy and in differential diagnosis between benign and malignant extrauterine pelvic masses. In 1991, Sassone et al⁴⁴ described the first morphologic scoring system for evaluating adnexal masses. In the following years several authors suggested the use of other score systems or logistic



Fig. 10: A invasive ovarian serous cystadenocarcinoma characterized by associated with an indeterminate appearance due to an apparently solid area. This findings must be submitted to color Doppler (see Fig.17)

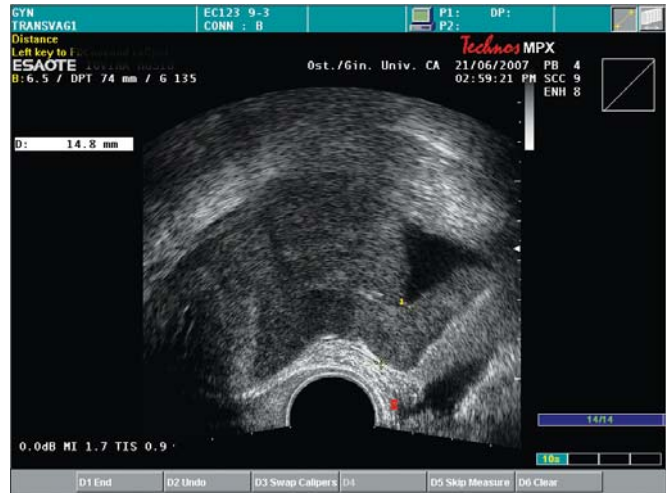


Fig. 11: Another invasive ovarian serous cystadenocarcinoma with a very suspicious appearance due to an apparently solid area. This findings must be submitted to color Doppler (see Fig. 18)



Fig. 12: A borderline ovarian tumor showing an irregular echogenic structure (> 3 mm) situated adjacent to the wall of the cyst

regression models to better distinguish between benign and malignant masses.⁴⁵⁻⁴⁷ According to Valentin,⁴⁸ the use of B-mode ultrasound morphology to characterize an adnexal mass, as suggested in the present review, is superior to all other ultrasound methods also in terms of reproducibility and simplicity. As a matter of fact new data are present today in the literature about the reproducibility of B-mode in the diagnosis of ovarian cancer. In a recent study Guerriero et⁴⁹ evaluate the intraobserver and interobserver agreement for identifying ovarian malignancy using typical grayscale ultrasonographic patterns. Intraobserver agreement was good or very good for all examiners with different degrees of experience (kappa = 0.72 to 1). Interobserver agreement was good for all expert operators (kappa = 0.69 to 0.75). Interobserver agreement between experts and highly experienced operators was moderate

or good ($\kappa = 0.51$ to 0.63). Interobserver agreement between the moderately experienced operator and experts was fair to moderate ($\kappa = 0.29$ to 0.46) while interobserver agreement between moderately and highly experienced operators was fair ($\kappa = 0.33$). The results of this study indicate that ultrasonographic malignant patterns previously described are reproducible, even in moderately experienced examiners, although more experience is associated with better interobserver agreement.

The main problem of B-mode morphologic ultrasonography remains the high false-positive rate in the differential diagnosis of adnexal malignancies. In fact, there are some benign tumors that are similar to malignant tumors, such as cystadenofibromas, low malignant potential tumors, fibromas, Brenner's tumors, granulosa cell tumors, and also some tubo-ovarian complex which are very difficult to discriminate.

With the aim of reducing the rate of false positive cases, some authors³⁹⁻⁴² propose the use of color Doppler in each ovarian lesion that is impossible to classify and that, according to Valentin *et al.*⁴⁸ is complex or suspicious. This approach will be discussed in detail:

COLOR DOPPLER IN ADNEXAL MASSES

The use of color Doppler to increase the accuracy of B-mode evaluation in the differential diagnosis of different kinds of adnexal masses has been proposed by several authors. In some cases the results obtained are completely useless as in the case of simple cysts.³ On the contrary, in other kinds of masses this additional tool can be useful.

While Pascual *et al.*⁵⁰ obtained an improved accuracy in transvaginal ultrasonography in the diagnosis of functional ovarian cysts, Alcazar *et al.*⁵¹ found no improvement in the diagnostic accuracy of B-mode transvaginal ultrasonography when transvaginal color Doppler was added. On the contrary, the results obtained by Guerriero *et al.*³ using a logistic regression showed that the presence of peripheral flow can help in diagnosing a luteal cyst.

At Doppler evaluation, endometriomas typically showed the absence of central vascular flow with vessels only in the periphery of the mass. After controversial data reported by some authors due to the use of flow indices only,⁵² Guerriero *et al.*⁵³ demonstrated that when the B-mode is doubtful for the presence of an echogenic portion in a round-shaped homogeneous hypoechoic ("ground-glass") cyst (Figs 13 and 14), the addition of power Doppler imaging, based on evaluation of vessel distribution, can reduce the number of false negative findings in the diagnosis of endometrioma.

In the diagnosis of hydrosalpinx, no increase in diagnostic accuracy was achieved by using color Doppler (Fig. 15).²⁴ Characteristically, ovarian cystadenofibroma presents vascularization in 47.8% of the cases, but only in the periphery.¹⁴ In particular, when a vegetation is present, the use of color Doppler can be truly useful.



Fig. 13: The atypical B-mode findings of endometrioma: due to an echogenic portion. This kind of mass must be evaluated by color Doppler to exclude the presence of flow in this intracystic portion

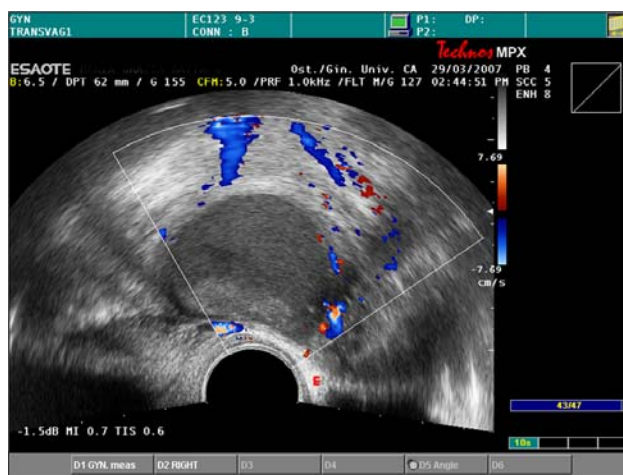


Fig. 14: The endometrioma previously described with an echogenic portion submitted to color Doppler to exclude the presence of central flow

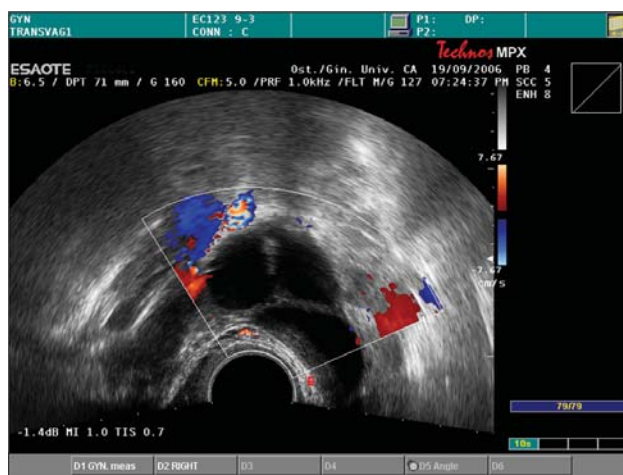


Fig. 15: Color Doppler findings of a hydrosalpinx: the vascular flow is peripheral but relatively useful for the final diagnosis (see Fig. 7)

The first studies on the use of color Doppler in the diagnosis of ovarian cancer have been performed using flow indices as resistance (RI) and pulsatility (PI) index. In the last years the majority of the published studies on ovarian vascularity, although agree that malignant ovarian tumors have a lower impedance in comparison with benign ovarian tumors, found a considerable overlap between the ranges of RI and PI values.⁵⁴⁻⁵⁸ For these reasons several authors have criticized the use of cutoff values of blood flow indices for the detection of ovarian cancer.^{39,54-58}

After the articles of Buy et al⁵⁷ and Guerriero et al,³⁹ that identify the presence of solid elements and central flow as the most important features of malignancy, several logistic regressions confirmed this assumption.^{40,41,59} A collaborative work including more than 800 complex adnexal masses validates this approach.⁴² This study confirmed that color Doppler evaluation was more accurate in the diagnosis of adnexal malignancies in comparison with gray scale sonography because of significantly higher specificity (94% and 84%, respectively) and by reducing the false positive rate without reduction of the sensitivity (95% and 99%, respectively).⁴² By color Doppler imaging, malignancy should be suspected when arterial flow is visualized in an echogenic portion of a mass defined as malignant by B-mode (Figs 16 to 20).^{39,42} On the contrary, a mass should be considered benign when no arterial flow is visualized in an echogenic portion or when the flow is only seen in the wall of the mass defined as malignant by B-mode.^{39,42}

This approach has been used also in the preoperative triage of adnexal masses.⁶⁰ Few studies about the presurgical triage of an adnexal mass are present in the literature.⁶⁰⁻⁶¹ Guerriero et al⁶⁰ performed a study to establish whether ultrasonography associated with color Doppler can provide the necessary

information to triage the patients with adnexal masses to the most appropriate surgical approach (laparotomy or laparoscopy), decreasing the number of false-positive cases in the differential diagnosis of adnexal malignancies from benign pelvic masses, and avoiding the problem of false-negative cases. In this study⁶⁰ a mass was considered at high-risk of malignancy if flow was demonstrated within the excrescences or solid areas and was submitted to laparotomy or laparoscopy with intraoperative surgical evaluation, the use of endobag, and the immediate frozen section. On the contrary a mass was considered at low-risk of malignancy if there was peripheral or absent flow and was scheduled for conventional operative laparoscopy.⁶⁰ Masses with evidence of gross metastatic disease and/or masses that extended above the umbilicus and/or ascites were considered at very high-risk of malignancy and underwent laparotomy.⁶⁰

Considering that the fundamental aim of a presurgical triage performed before elective surgical treatment for adnexal masses is to reduce the number of unnecessary laparotomic procedures in patients with benign adnexal masses, thus reducing the false-positive rate of B-mode evaluation used alone, this objective was fully achieved with the use of this presurgical algorithm, because the specificity of color Doppler evaluation was higher (91%) than that of B-mode evaluation used alone (82%).¹⁰ In terms of surgical treatment, the current method of preoperative assessment has allowed the approach by laparoscopy of 91% of the benign masses, whereas with B-mode used alone this rate seems to be significantly lower (79%).⁶⁰ This approach has been studied and confirmed also by Alcazar et al.⁶²

Finally, it should be mentioned that the use of ultrasonographic technique has been recently demonstrated to be related to the experience of the operator.⁶³

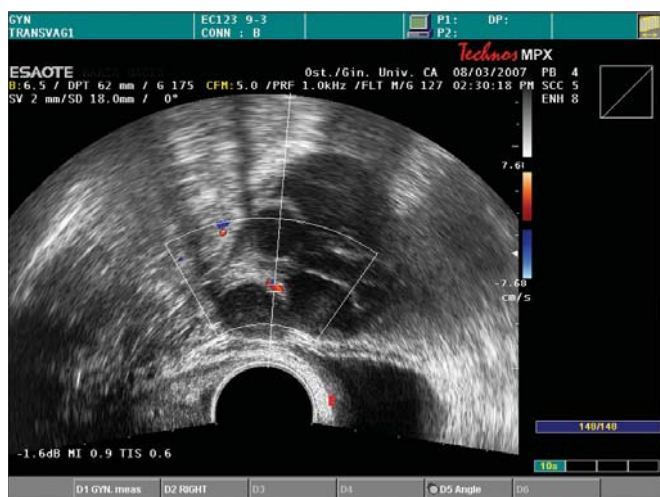


Fig. 16: Color findings of a mucinous cystadenoma: the vascular flow is peripheral but relatively useful for the final diagnosis (see Fig. 6)

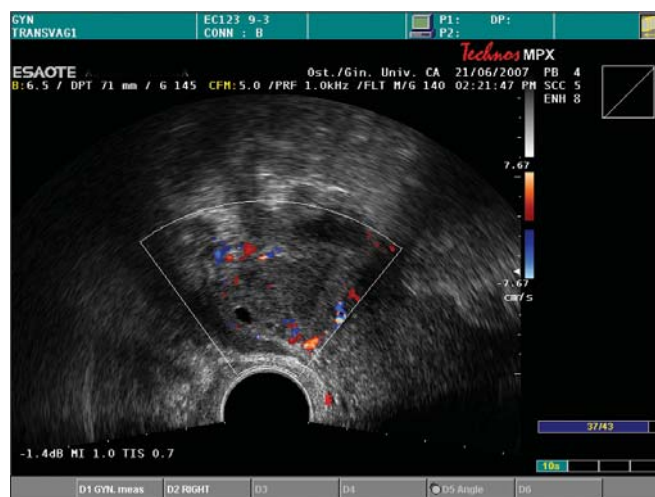


Fig. 17: A invasive ovarian serous cystadenocarcinoma characterized by central flow (see Fig. 10)

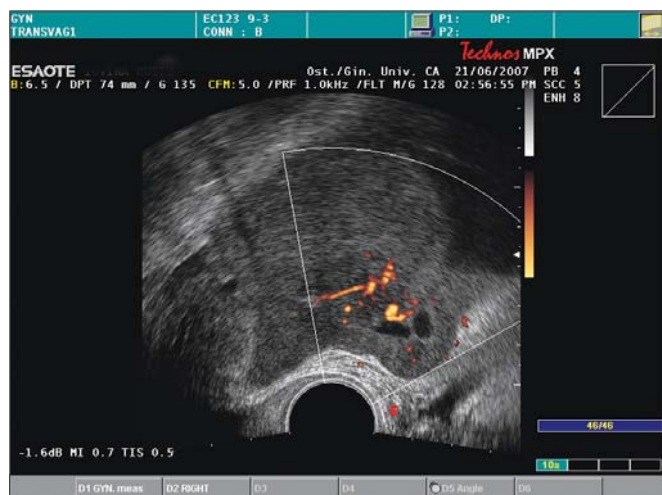


Fig. 18: Another invasive ovarian serous cystadenocarcinoma characterized by central flow (see Fig. 11)



Fig. 19: A endometrioid ovarian carcinoma characterized by a vascularized papilla

CONCLUSIONS

The transvaginal ultrasonography can be used as first imaging modality in case of presence of adnexal masses. Because of many adnexal masses have usually a typical ultrasound appearance related to their macroscopic pathology the results obtained showed a good and sufficient diagnostic accuracy. Unfortunately in some cases uncertain findings are present and in these cases the addition of color Doppler can be useful. Using the location of flow evaluated using color Doppler as main parameter a mass should be graded as malignant if flow is shown centrally within the excrescences or solid areas.

The same approach should be used to triage the patients with adnexal masses to the most appropriate surgical approach with an increase of less invasive surgery. For these reasons major

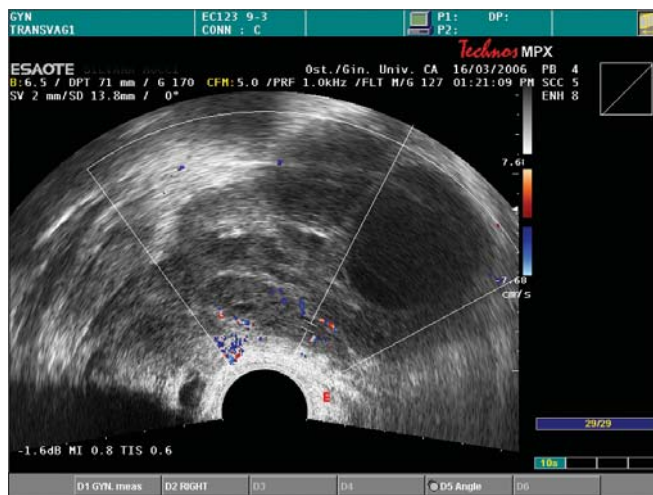


Fig. 20: A tubo-ovarian complex characterized by central vascularization. These masses are usually considered as false positive for the diagnosis of ovarian cancer but the associated symptoms can suggest the correct diagnosis (see Fig. 8)

efforts should be done to improve the quality of ultrasonography, resulting in a significant decrease in the number of major staging procedures and a shorter inpatient hospital stay.

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