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Ultrasound of the female internal genitalia

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Introduction

To investigate the female pelvis by transabdominal sonography (TAS) the bladder should be kept distended by a sufficient amount of urine. In this way, the uterus can be clearly detected as a pear-shaped organ located in the middle of the pelvis. Owing to its dimensions and central position, the uterus is the point of reference from where to start investigating the internal female organs. The principal planes are the longitudinal [Figure 1] and the transverse ones [Figure 2].

Figure 1 Transabdominal longitudinal section of a female pelvis with a full bladder. The uterus can be easily visualized as a peer-shaped organ behind the posterior bladder wall.

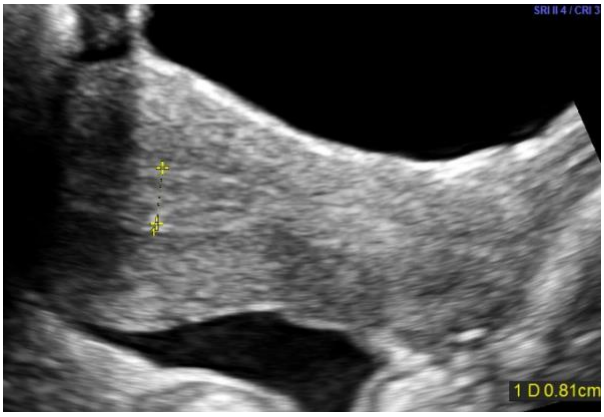
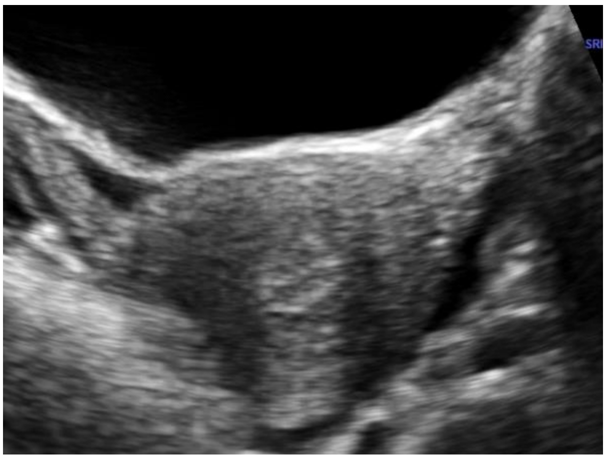


Figure 2 Transabdominal transverse section of the uterus.



In some cases it is possible to obtain a variety of intermediate planes, such as a semicoronal section. The version and flexion angles of the uterus are easy to recognize. Transvaginal ultrasound (TVS) can provide additional support for TAS because of the proximity of the probe to the pelvic organs and the use of high frequencies, which can produce better ultrasound images. The three main parts of the uterus clearly distinguished on TAS are the body, the isthmus and the cervix [Figure 3].

Figure 3 **Transabdominal section of an antiverted uterus in the case of an empty bladder. The uterus can be measured in two orthogonal diameters (longitudinal and anteroposterior), and the body, the isthmus and the cervix can be easily recognized.**

The volume of the uterus varies depending on age, parity and the hormonal status of the patient [(1-3)] (Table 1 and 2).

Table 1. Normal dimensions of the uterus before puberty (Modified from Orsini, 1984).

			Uterine diameter (cm)		**Uterine volume (cm^3)**
Age	No. Pts.	**Longitudinal**	Anteroposterior	Anteroposterior	

(years)		**diameter**	diameter of the body	diameter of the cervix	
2	7	33.1±4.4	7.0±3.4	8.3±2.0	1.98±1.58
3	8	32.4±4.3	6.4±1.3	7.6±2.2	1.63±0.81
4	15	32.9±3.3	7.6±1.8	8.6±1.8	2.10±0.57
5	7	33.1±5.5	8.0±2.8	8.4±1.8	2.36±1.39
6	9	33.2±4.1	6.7±2.9	7.5±1.8	1.80±1.57
7	9	32.3±3.9	8.0±2.2	7.7±2.5	2.32±1.07
8	11	35.8±7.3	9.0±2.8	8.4±1.7	3.12±1.52
9	11	37.1±4.4	9.7±3.0	8.8±2.0	3.70±1.62
10	13	40.3±6.4	12.8±5.3	10.7±2.6	6.54±3.78
11	13	42.2±5.1	12.8±3.1	10.7±2.6	6.66±2.87
12	6	54.3±8.4	17.3±5.3	14.3±5.2	16.18±9.15
13	5	53.8±11.4	15.8±4.5	15.0±2.4	13.18±5.64

Before menarche the uterine body is approximately half the length of the cervix, at menarche the uterine body and cervix are similar in dimensions, and in women of fertile age the body is approximately double the length of the cervix.

Table 2 Main uterine diameters during different stages of life (Modified from Platt, 1990.)

	Longitudinal diameter	**Anteroposterior diameter**	**Transversal diameter**	**Volume**
Prepubertal	**1–3 cm**	**0.5–1 cm**	**0.5–1 cm**	**10–20 ml**
Multiparous	**8 cm**	**4 cm**	**5 cm**	**60–80 ml**
Nulliparous	**6 cm**	**3–4 cm**	**3–4 cm**	**30–40 ml**
Post-menopausal	**4–6 cm**	**2–3 cm**	**2–3 cm**	**14–17 ml**

Normal endometrium

The endometrium is easily seen on TAS. The endometrium appears as a hyperechoic line within the anterior and posterior myometrial walls. To evaluate the endometrium accurately and measure its thickness, the optimal technique is TVS, which permits a better spatial and contrast resolution. On a longitudinal scan through the uterine corpus the entire length of the endometrium can be seen. In this scan, with the uterus magnified to occupy >75% of the screen and the focus towards the endometrial stripe, the correct measurement of the endometrial thickness can be obtained by positioning the callipers proximally and distally at the level of the myometrial-endometrial junction. The probe should be then tilted laterally in both directions to visualize the endometrium from one tubal ostium to the contralateral. If the uterine cavity is deformed by myomas or adenomyosis the endometrial stripe may not be recognisable.

Pre-pubertal age

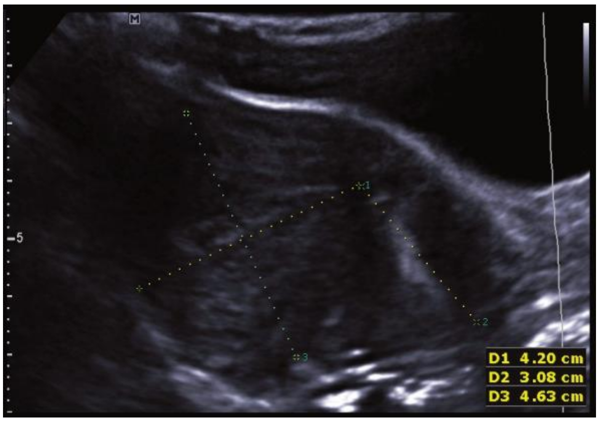
In patients of pre-pubertal age, the study of the endometrium is only possible transabdominally, and therefore is always difficult. The endometrium of the neonate is thick and hyperechogenic because of the effect of maternal placental hormones. After the first week of life the endometrium becomes atrophic and appears as a thin line (<1 mm) until ovarian hormonal activity begins, when it begins to proliferate and thicken [(4)]. The study of the endometrium and ovarian volume and morphology are important during this period for diagnosing delayed or precocious puberty [(5)]. In cases of delayed puberty the endometrium appears atrophic and thin, indicating a lack of ovarian hormonal activity; in comparison, in cases of early puberty the endometrium appears thickened and hyperechogenic.

Reproductive age

In women of reproductive age the cyclical production of ovarian hormones induces histological modifications to the endometrium, which are shown on TAS as variations in thickness and echostructure.

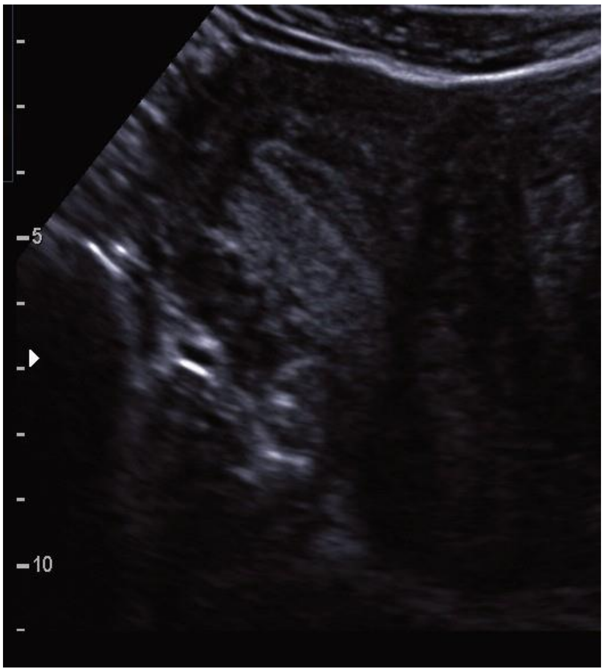
During the menstrual phase, inhomogeneous material can be seen inside the uterine cavity [Figure 4] due to the presence of blood mixed tissue from the shedding of the functional layer. Therefore, this phase of the cycle is not recommended for the study of endometrial pathologies.

Figure 4 Transabdominal section of a retrofexed uterus. The fundus is pointing toward the rectum. During menstruation the endometrium can be identified as an inhomogeneus stripe within the two myometrial layers.



In the early proliferative phase, the endometrial cells increase in number and size and the endometrium appears as a well-defined median line, which is more echogenic than the surrounding myometrium. In the late proliferative phase, and until ovulation, the endometrium is seen as a “trilaminar” structure [Figure 5] due to the presence of two adjacent hypoechogenic layers surrounded by hyperechogenic lines.

Figure 5 Anteverted uterus with a typical “trilaminar” endometrium.



The two hypoechogenic endometrial layers correspond to the mucosa that covers the anterior and posterior walls of the uterus, the external lines are determined by the acoustic interface of the endometrium and myometrium whereas the median line is determined by the juxtaposition of the two endometrial layers inside the uterine cavity.

In the secretive phase the endometrium becomes increasingly hyperechogenic and thickened [Figure 6] due to the effect of progesterone.

Figure 6 Transabdominal section of an antiverted uterus distorted by the presence of an intramural leiomyoma in the posterior uterine wall. During the secretory phase the endometrium is markedly hyperechoic.

Post-menopause

With the cessation of ovarian hormonal activity, the endometrium becomes thin and atrophic. It appears as a thin hyperechogenic median line, contrasting with the myometrium. The normal thickness of the physiological post-menopausal atrophic endometrium is generally less than 5–6 mm [(6-8)].

It is not unusual to see a moderate quantity of anechoic fluid inside the uterine cavity in such a way the atrophic endometrial mucosa of the anterior and posterior walls assumes the appearance of two well distinct lines delimiting a central anechogenic area. In these conditions, the two anterior and posterior endometrial layers are visible because of fluid acting as a contrast medium. The endometrial thickness can be calculated by adding the thicknesses of the two parts.

Pathology of the endometrium

Endometrial hyperplasia

Endometrial hyperplasia is characterised by a continuous spectrum of histological alterations in the number and histological structure of the glands, and the growth and morphology of the cells. On ultrasound, the endometrium usually appears as irregularly thickened and markedly hyperechoic in contrast to the surrounding myometrium. Sometimes small anechoic cystic spaces are visible in the endometrium due to the accumulation of mucus produced by the hyperplastic glands.

Endometrial polyps

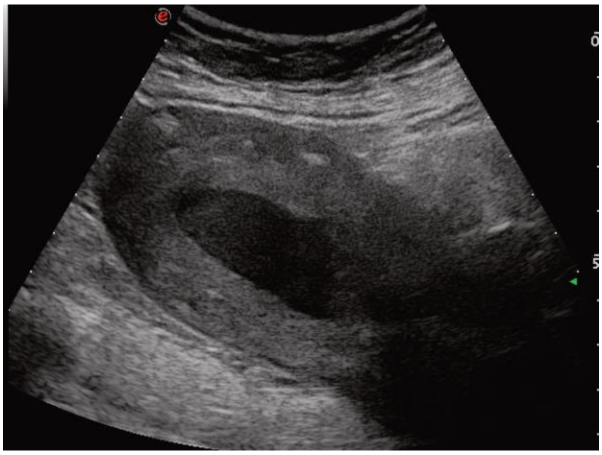
Endometrial polyps are ovoid sessile or pedunculated masses of varying size that extend out into the uterine cavity. They can be single or multiple, their consistency is gelatinous and they are compressed by the walls of the uterus to fill a part of the uterine cavity. They can be microscopic or very large, sometimes filling the entire endometrial cavity, which makes a differential diagnosis with hyperplasia and endometrial cancer difficult. In the majority of cases it is possible to see the polyp as a hyperechogenic focal lesion surrounded by endometrium of normal appearance. It is essential to use the maximum magnification of the ultrasound system to look for the oval profile of the polyp inside the, apparently uniformly thickened, endometrium. Visualising endometrial polyps is easier during the proliferative phase of the cycle because the endometrial mucosa is thinner and the surrounding endometrium is hypoechoic, which acts as a contrast agent. In the luteal phase the endometrium assumes the same echogenicity as the polyps, making their visualisation more difficult. The polyps are fed by vessels that can be easily detected on colour Doppler ultrasound as a colour line crossing the endometrial-myometrial interface.

Submucous myomas should always be taken into consideration in the differential diagnosis of endometrial polyps. They are less echogenic than the surrounding myometrium and are round in shape, possibly with internal calcifications and a cone of shadow.

Endometritis

Endometritis can have variable ultrasound signs depending on the cause and severity of the condition. The endometrium can appear normal or, more commonly, inhomogeneous and thickened; sometimes a small amount of hypoechoic fluid is found in the uterine cavity, which is a sign of the presence of blood or pus. When the endometrial cavity is completely filled with pus this is known as pyometra [Figure 7].

Figure 7 Pyometra: hypoechoic material distending the uterine cavity.



Endometrial carcinoma

Endometrial carcinoma can be seen as a polypoid endometrial mass with irregular borders, localised or diffused throughout the entire endometrial cavity. Sometimes the only ultrasound feature is a thickening of the endometrium, which is difficult to distinguish from endometrial hyperplasia or polyps. The first structure to be invaded by an endometrial carcinoma is the myometrium of the uterine walls, and later the cervical canal, which should be evaluated accurately. The echo-texture of the neoplastic tissue is variable: it is hyperechoic in well-differentiated carcinomas (G1 and G2) and is usually iso- or hypoechoic in moderately differentiated or anaplastic carcinomas (G3). Sometimes the mucus collects inside the uterus and acts as a hypo- or anechogenic contrast agent that permits the better study of the endocavitarial surface of the neoplasm.

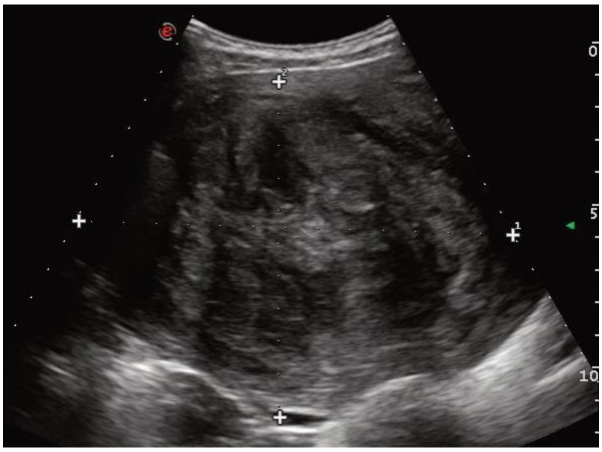
Myometrium

The myometrium has a variable echogenicity during different stages of life due to the presence of a variable proportion of collagen fibre, this is in contrast to muscle cells, and is dependent on endocrinal conditions and parity. Furthermore, a wide range of pathologies can affect the ultrasound appearance.

Leiomyomas

Leiomyomas are benign tumours that consist of connective tissue and smooth muscular cells. They can originate in any part of the uterus, they can be single or multiple and can vary from a few millimetres to several centimetres. Leiomyomas can have a wide range of echo-structures, depending on the quantity of muscle fibres and connective tissue present. Generally, the higher the proportion of collagen and calcium deposits, the greater the echogenicity of the mass. Typical ultrasound characteristics are the presence of a round or ovoid hypoechogenic mass inside the uterus, which is distinct from the surrounding myometrium [Figure 8].

Figure 8 Leiomyoma of the uterus, transabdominal scan. A round solid mass with distinct borders is seen surrounded by normal myometrium (callipers).



Sometimes it is possible to visualise the interface between the pseudocapsule and the adjacent normal myometrium. Other characteristics of uterine myomas include deformity of the profile of the uterus, distortion of the endometrium, poor acoustic transmission and alterations in myometrial echogenicity. The myometrial echo-structure is often inhomogeneous, with hyper- and hypoechoic areas, and there is no possibility of clearly distinguishing individual nodules of the myoma. Generally, the uterus is increased in volume and assumes a globular morphology. Leiomyomas can be defined as sub-serous, intramural and sub-mucous in relation to their position in the uterine wall.

For the submucous ones, the classification used worldwide and developed by Wamsteker et al. (1993), considers the degree of cavitary distortion of the myoma. According to this classification, a G0 myoma is completely embedded within the uterine cavity; a G1 myoma has its larger part (>50%) in the uterine cavity, circumscribed by the endometrium, while a G2 myoma has its larger part (>50%) in the myometrium.

Table 3 Differential diagnosis of intramural myomas.

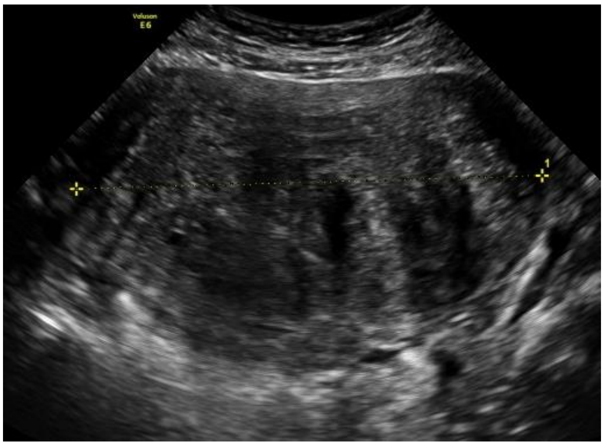
	Adenomyosis	**Intramural myoma**
Echo-structure	Inhomogeneous	Mixed, partly hyper- and partly hypoechogenic
Posterior cone of shadow	Multiple stripy shadows	Strong, single
Morphology	Indistinct outer borders	Ovoid, round
Hypoechogenic lacunas	Present	Rare
Pseudocapsule	Absent	Present
Doppler	Few scattered vessels in the myometrium	Peripheral flow in the pseudocapsule, rarely inside the myoma

The differential diagnosis between intramural myomas and adenomyomas (the nodular form of adenomyosis) may be difficult using TAS (Table 3). The presence of a pseudocapsule and regular edges, the absence of hypoechogenic lacunae [(9)], the presence of calcified areas, and occasionally association with posterior cones of shadow [(10)] favour the diagnosis of a uterine fibroid. Although the blood vessels in myomas run mostly in the periphery and parallel to the pseudocapsule, in the case of adenomyosis the flow is sparse in the myometrium [(11)]. Myomas can have unusual features due to degenerative phenomena, and have a wide range of sonographic aspects. Necrosis of part of or the entire myoma can manifest itself in unusual ways and can simulate malignant masses of adnexal origin. The most common degenerative form is calcification due to calcium deposits inside the mass.

Adenomyosis

Adenomyosis is a common condition characterised by growth of glands and endometrial stroma inside the myometrium. Frequency varies considerably depending on the studies, 5% to 70% have been reported [(12)]. Generally, the uterus has an increased volume on ultrasound, and has a globular appearance [Figure 9] [(13)] with hypoechoic areas of a few millimetres distributed throughout the myometrium.

Figure 9 Transabdominal transverse scan of a uterus with diffuse adenomyosis: the uterus has an enlarged volume and a globular appearance.



It is believed that these areas are a result of ectopic endometrial glands that are visible as internal focal haemorrhages or hidden modifications of the glands. Power Doppler ultrasound shows absence of blood flow inside these adenomyotic nuclei; this criterion can help in the differential diagnosis with varicosity of the uterine vessels and adenomyosis. Another ultrasound sign of adenomyosis is a poorly-defined endometrial stripe and very small multiple cones of shadow (hypoechoic stripes).

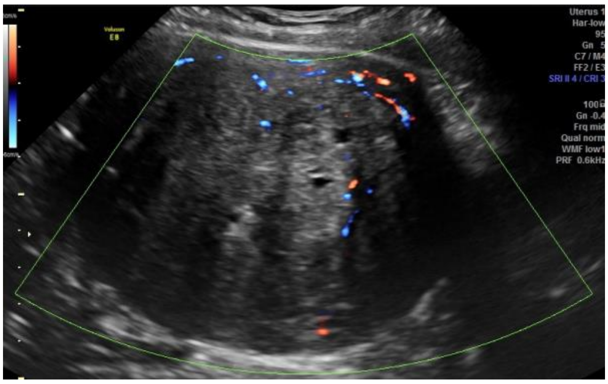
Ultrasound signs of adenomyosis

- Globular uterine morphology: the fundus of the uterus appears enlarged.
- Small irregular cystic spaces scattered in the myometrium.
- Inhomogeneous, irregular myometrial echotexture.
- Indistinct endometrial-myometrial borders, shaggy endometrial stripe.
- Multiple tiny hypoechoic posterior cones of shadow

Sarcomas

Sarcomas are rare neoplasms that can develop from a leiomyoma or, more often, originate de novo from the normal myometrium or endometrial stroma [(14)]. The diagnosis of a uterine sarcoma is essentially histological, and made on the basis of the mitotic index (more than 10 mitoses per high power field), nuclear atypia and the presence of mass necroses. Pre-operative ultrasound diagnosis is difficult, and at present there are no typical ultrasound characteristics for these sarcomas. In particular, the differential diagnosis with benign leiomyomas can be difficult. The rapid volumetric increase of a known leiomyoma should raise diagnostic suspicion, especially in post-menopausal women, together with abundant vascularisation with colour Doppler [(15)]. More often, sarcomas are seen as highly vascularised large single solid masses with irregular outer borders and an inhomogeneous echotexture [Figure 10].

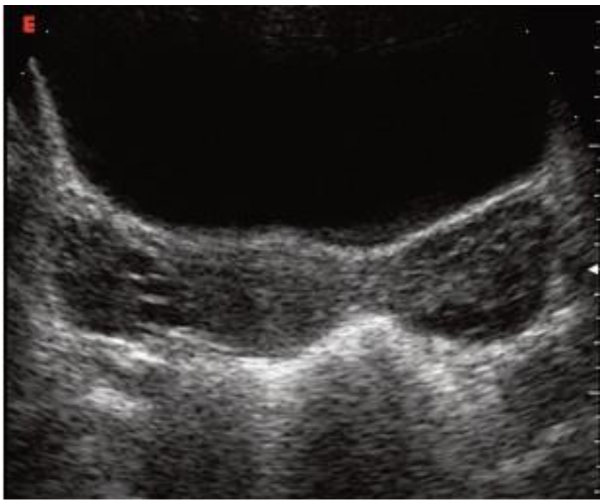
Figure 10 Uterine leiomyosarcoma: transabdominal longitudinal scan showing the uterus transformed in a bulky mass of inhomogeneous echotexture, with irregular cystic areas. Colour Doppler shows several blood vessels inside the mass.



Ovaries

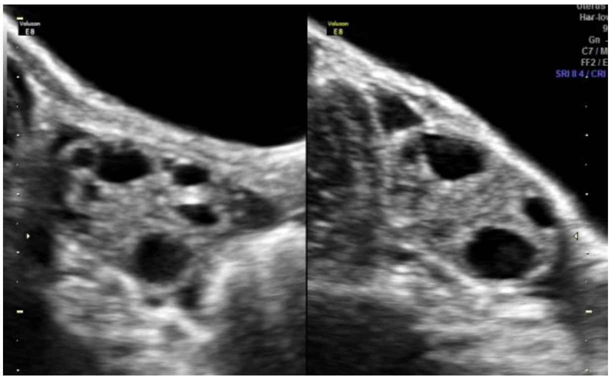
The ovaries lie between the uterus and the lateral pelvic wall, they are anteromedial to the external iliac vessels, or, rarely, located low in the pouch of Douglas. In the presence of a full bladder, the ovaries lie close to the bladder wall, and are therefore easily visible on TAS [Figure 11].

Figure 11 In the presence of a full bladder, the ovaries are easily visible on TAS lateral to the uterus, medial to the pelvic side walls



The morphology of the ovaries is roughly ovoidal, which means their volume can be calculated using the formula for an ellipsoid: $(d1) \times (d2) \times (d3) \times (\pi/6)$.
Both ovaries should be visualized on a transverse and a longitudinal plane [Figure 12].

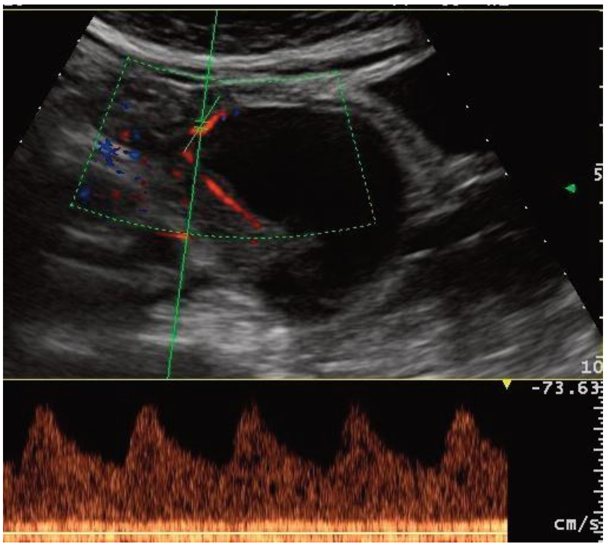
Figure 12 The right ovary is visualized by means of the split screen image on both a transverse and a longitudinal plane of section



The volume of the ovaries varies over the course of life, and cyclically in women of reproductive age. Ultrasound studies have documented an increase in the average ovarian volume during the first two decades of life; from the fourth decade the average volume tends to diminish. The maximum ovarian volume is considered to be approximately 20 ml in the fertile period and 10 ml after menopause [(18-19)].
During the fertile period the ovaries have a variable amount of small antral follicles. These appear as anechoic round areas with smooth regular walls of up to 30 mm in mean diameter, which are scattered in the ovarian parenchyma. During ovulation, the dominant follicle collapses and assumes the appearance of a hypoechogenic area in an eccentric position, which is not always distinct from the rest of the parenchyma. The corpus luteum normally measures 2–3 cm in diameter. Sometimes, owing to the internal accumulation of blood, it assumes a cystic appearance and can be larger. The ultrasound appearance of the contents of luteal cysts can vary from transonic to a greatly enlarged fine trabecular (or jelly-like) echo-structure that mimics the appearance of neoplastic ovarian tumours. With colour

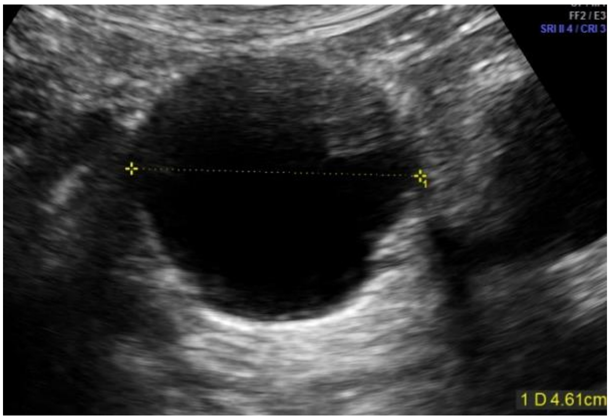
or power Doppler ultrasound it is possible to observe their typical high-velocity, low-impedance peripheral vascularisation (known as the ring of fire) [Figure 13].

Figure 13 A large corpus luteum cyst showing a typical high-velocity, low-impedance peripheral vascularisation (ring of fire) at Doppler evaluation



A second, more frequent, functional swelling in the fertile period is caused by follicular cysts. These are unilocular transonic cysts of 3–8 cm in diameter [Figure 14]. After menopause, the ovaries become atrophic with the cessation of activity and are therefore small and are hardly visible on TAS.

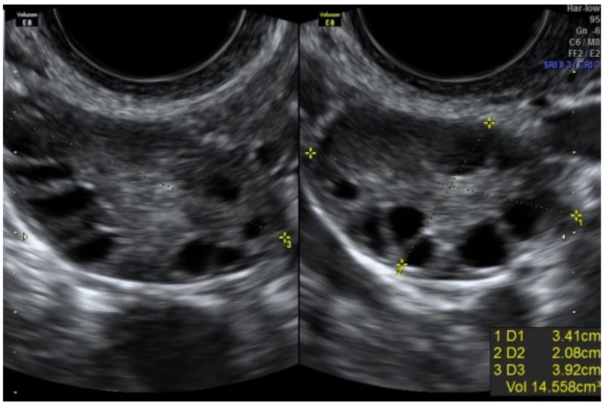
Figure 14 A follicular cyst appearing as a unilocular anechoic cyst with smooth internal surface



Polycistic ovarian syndrome (PCOS)

Ovaries may be normal in PCOS, and women without the syndrome can present with polycystic ovarian morphology (PCOM). It is well recognised that women with PCOS usually have larger ovaries with an increased number of follicles, measuring 2 to 9 mm in mean diameter. The updated diagnostic criteria using transabdominal ultrasound in patients more than eight years post menarche, have as mandatory an enlarged ovarian volume and a threshold of ≥10 mL for either ovary as one of the cut-offs for diagnosis, so long as no corpora lutea, cysts or dominant follicles are present [Figure 15].

Figure 15 Transvaginal scan of a patient with polycystic ovaries. The right ovary appears enlarged and shows multiple follicles of 2-9 mm in mean diameter, dispersed at the periphery of the ovarian parenchyma



In adolescent females (within eight years of menarche, or age <20 years), the diagnostic criteria does not include ultrasound, as the incidence of multi-follicular ovaries in this life stage is high. As opposed to the initial Rotterdam criteria of ≥12 follicles and a volume of more than 10 ml, subsequent recommendations consider an ovarian volume of at least 16 ml to make the diagnosis of a polycystic ovary [(20-21)].

There are other morphological features typical for polycystic ovaries, which seem to correlate with symptomatology, but are not included in formal Rotterdam diagnostic criteria:

- hyperechoic central stroma
- peripheral location of follicles (string of pearls sign)

Benign ovarian cysts

Every ovarian cyst must be studied, whenever possible, by means of TVS because the proximity of the transducer to the adnexal site allows the use of probes of a higher frequency (up to 12MHz) and, therefore, a better evaluation of the tumour with higher contrast and spatial resolution. TAS is always useful combined with TVS especially in the case of masses of large dimensions that extend beyond the confines of the true pelvis.

Furthermore, TAS is indicated every time there is a suspected malignant adnexal pathology to better evaluate an eventual spread to the upper abdomen of metastatic lesions.

A complete sonographic examination of the adnexa should be performed according to a standardised logical sequence that provides information about:

- the position, morphology, dimensions and internal echostructure of the cysts;
- the origin of the adnexal masses, their nature and their relationship with the adjacent organs;
- the presence of anomalies associated with the pelvic organs;
- the presence of ascites and fluids of inflammatory or neoplastic origin in the abdomen.

Both in pre- and post-menopausal women, adnexal masses have a varied morphological appearance that reflects the different histological types of ovarian lesions and pelvic organs that can produce swellings in the ovaries.

Firstly, the sonologist should be able to classify the adnexal mass into one of five different morphologic classes (unilocular, unilocular-solid, multilocular, multilocular-solid, solid) on the basis of their US appearance [(16)]. Then, the content should be described (anechoic, low-level, ground-glass, haemorrhagic, mixed).

In particular, the presence of papillary projections and solid portions should be investigated and recorded, together with their measurement (height and base).

Finally, the eventual presence of vascularisation of the mass (in particular evaluating the solid portions or papillae, and septations) should be investigated by means of Colour or Power Doppler, and a subjective semi-quantitative score should be evaluated, giving a rate of 1 (no blood traces), 2 (few blood vessels), 3 (moderate vascularisation), or 4 (abundant).

The risk of malignancy of a given adnexal mass relies heavily on its morphology and colour score, as demonstrated by a vast literature on the subject [(17, 18)].

All lesions are classified qualitatively into one of six categories, as follow:

1. Unilocular cyst»: a unilocular cyst without septa and without solid part or papillary projections
2. Unilocular-solid cyst»: a unilocular cyst with a measurable solid component or at least one papillary structure of at least 3 mm height

3. Multilocular cyst»: a cyst with at least one septum but not measurable solid component or papillary projections
4. Multilocular-solid cyst»: a multilocular cyst with a measurable solid component or at least one papillary projection
5. «Solid tumour»: a tumour where the solid components comprise 80% or more of the tumour where assessed in a two-dimensional section:
6. «not classifiable»: e.g.: because of poor visualization.

In the large database of IOTA (International Ovarian Tumour Analysis) studies the prevalence of malignancy according to morphologic appearance was 65% for solid tumors, 45% for multilocular-solid tumors, 33% for unilocular-solid tumors, 10% for multilocular tumors and 0.6% for unilocular masses [(16)]. On the basis of morphological appearances, a histological classification of ovarian lesions can be done, but TVS remains the best approach to hypothesize a histological subtype.

Additional sonographic criteria for the differential diagnosis of adnexal masses [(19)] are:

- Mono/bilaterality
- Margins (internal and external), defined as smooth or irregular
- Presence of septa, their thickness and distribution
- Site of the anatomical mass and its relationship with the pelvic organs
- Morphology (spherical, ovoidal, tubular-shape, stellate, irregular)
- Posterior echoes of the mass (i.e. cone of shadow, acoustic reinforcement)
- Mobility of the mass
- Presence of ascites

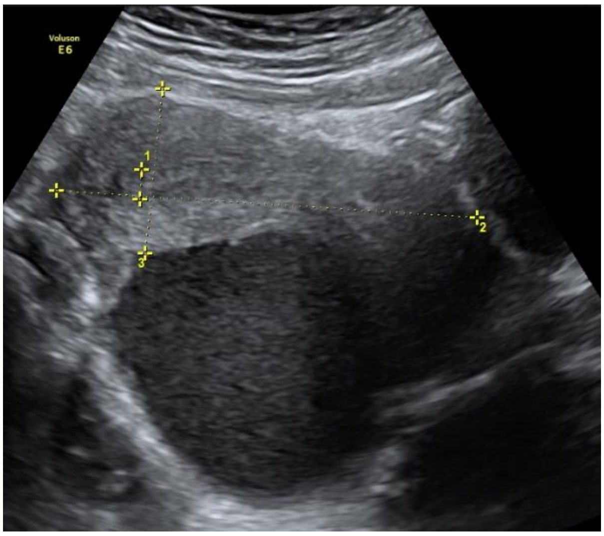
Serous ovarian cysts

Serous ovarian cysts can be single or, rarely, multiple and are characterised by their anechoic content and smooth well-defined internal walls. Generally they are unilocular cysts with a smooth internal surface, devoid of internal solid projections/papillae. Their dimensions can vary in women of fertile age in whom anechoic cysts of diameter <3 cm cannot be distinguished from ovarian follicles. Unlike pre-ovulatory follicles, the persistence of cysts over time represents the most important parameter to be considered in the differential diagnosis.

Endometriotic cysts

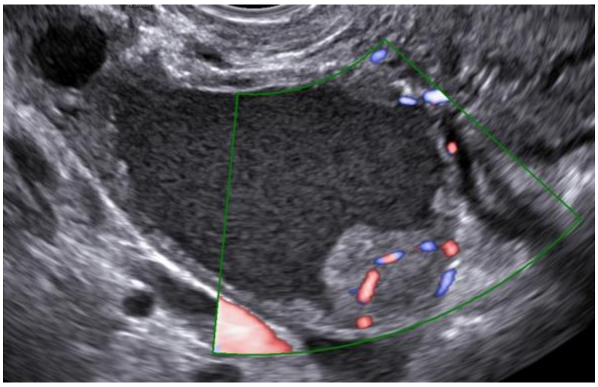
The majority of endometriomas are unilocular or multilocular (with up to three locules) cysts with a smooth wall and a homogeneous low-level echoes (known as the ground-glass appearance) due to the collection of old blood. An ultrasound sign found in 45% of endometriomas, which can help in their differential diagnosis from other masses with similar echotexture, is the presence of small hyperechogenic wall foci [Figure 16].

Figure 16 Unilocular endometriotic cyst with a ground glass content located behind the uterus



Less frequently endometriotic cysts are multilocular, with regular septations that divide different locules and can demonstrate echoic internal projections that mimic true solid parts or papillary projections. Generally the internal projections consist of clots or debris that has adhered to the walls of the cyst. Moreover, the ectopic endometrial mucosa that covers the cyst can undergo acute or chronic inflammatory phenomena, oedema and decidualisation, which occurs during pregnancy [Figure 17].

Figure 17 Transvaginal scan of a decidualised endometrioma showing rounded papillary projections



In such cases, the walls of the cyst become irregular and thickened and thus the differential diagnosis with neoplastic ovarian tumours can be very difficult. Moreover, endometriomas can show an inhomogeneous internal echotexture, because of the presence of hyper- and hypoechoic areas mixed together owing to the presence of a different density of the liquid content. Ovarian dermoid cysts, cystadenomas and cystic corpora lutea should be taken into consideration in the differential diagnosis of endometriotic cysts because these swellings can have a similar ultrasound characteristic [Table 4]. In fact, mucinous cystadenomas often have a slightly hypoechoic content when the mucus produced is particularly dense; the cystic corpora lutea have very small internal echoes due to the presence of blood and clots, whereas some dermoid cysts can be internally hypoechoic owing to the accumulation of sebum without hair and hair fragments.

Table 4. Differential diagnosis of endometriotic cysts.

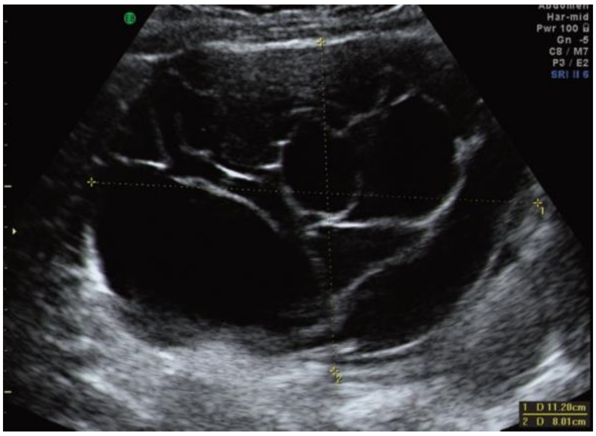
	Endometrioma	Cystic corpus luteum	Cystadenoma	Dermoid
Septations	Rare	No	Frequent	Rare
Echogenic areas	Rare	Yes	Rare	Frequent
Shadow cone	No	No	No	Frequent
Hyperechogenic	Frequent	No	No	No

spots

Ovarian cystadenomas

Serous cystadenomas are bilateral in a fifth of cases; they are completely transonic or hypoechoic with a smooth, regular external surface. Papillary projections are generally absent or very small. Mucinous cystadenomas are frequently multilocular due to the internal presence of numerous thin septations that are usually parallel and sometimes constitute a very dense network. These tumours can reach large dimensions, up to 30 cm. The internal surface is smooth, and only rarely is it possible to observe hypoechoic papillae. The internal echostructure is hypo- or anechoic [(20)] [Figure 18].

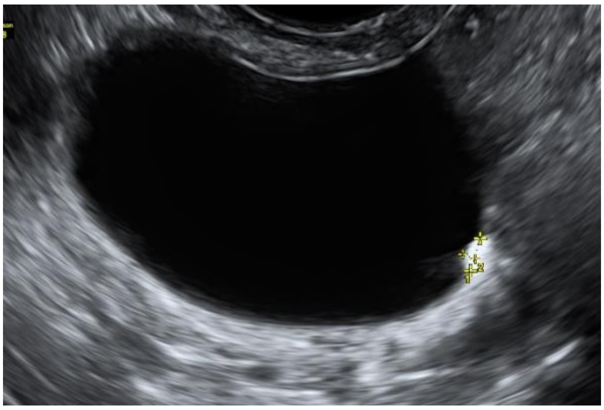
Figure 18 A large mucinous multilocular cystadenoma showing several thin internal septations



Cystadenofibromas

Cystadenofibromas constitute a rare type of benign epithelial ovarian tumour, mainly serous although mucinous subtypes exist. The sonographic aspect of cystadenofibromas is heterogeneous but few specific features are described in the literature. They may appear as unilocular-solid due to the presence of small hyperechoic papillary projections, more often avascular. A tiny cone of shadow can often be seen behind the papillae [Figure 19]. The diagnosis may be guided by the persistence of the papillae which rarely grow over time and represent a reactive connective tissue along the wall of the cyst. The differential diagnosis should be made with borderline or malignant ovarian masses which usually show a higher number of taller papillae, or frank solid portions along the cyst wall, rapidly growing over time [(21)].

Figure 19 Transvaginal scan of a cystadenofibroma appearing as a unilocular-solid cyst containing a small hyperechoic papilla (callipers).



Ovarian fibromas and fibrothecomas

Fibromas and fibrothecomas are benign tumours of stromal origin. Fibromas originate from fibroblasts and do not produce hormones while fibrothecomas originate from both fibroblasts and theca cells and may be hormonally active.

Typically, they appear as a hypoechoic round or oval solid tumour, with posterior acoustic shadow, but in a small percentage of cases these benign lesions can show cystic areas, due to necrosis, oedema or haemorrhage within the tissue. Doppler findings vary, but more frequently the lesions show absent or minimal vascularisation.

Para-ovarian and paratubal cysts

Para-ovarian and paratubal cysts represent approximately 10% of all adnexal masses and for this reason are included in this chapter. They are normally transonic single unilocular anechoic cysts with thin outer walls. They rarely contain septations or papillae. Useful diagnostic criteria include the visualisation of a close but distinct ipsilateral ovary, the absence of a pericystic ovarian parenchyma, the movement of the cyst from the contiguous ovary when exercising a light pressure with the probe [(22)].

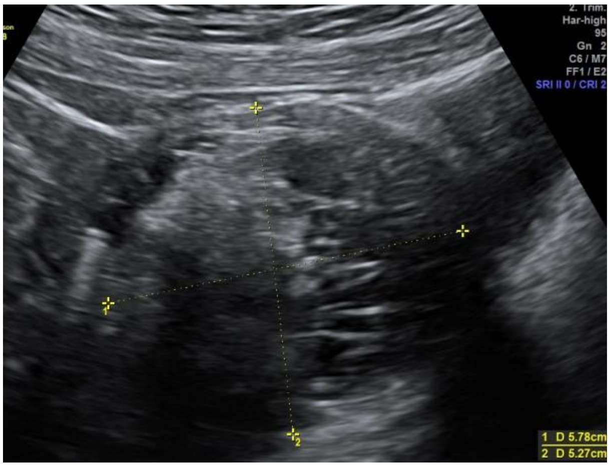
Dermoid cysts

The ultrasound appearance of dermoid cysts varies widely according to the histological differentiation of the tissues they contain (epidermidis, hair, fat, bones, teeth…). They are round or oval masses with a mixed internal structure due to the presence of mixed hypoechoic, anechoic and hyperechoic areas. Usually a posterior cone of shadow is visible [Figure 20]. The use of colour or power Doppler ultrasound is crucial to reveal absence of blood vessels within the echoic portions of the dermoid.

The three most common ultrasound characteristics of dermoid cysts are [(23)]:

- Hypo- or anechoic cysts containing one or more hyperechoic nodules (“dermoid plug”) with a posterior cone of shadow;
- Cysts containing hyperechoic thin stripes and spots on a hypo- or anechoic background (“starry sky” appearance);
- Cysts with uniformly hypoechoic content.

Figure 20 Transabdominal scan of a dermoid cyst (callipers) showing a mixed content

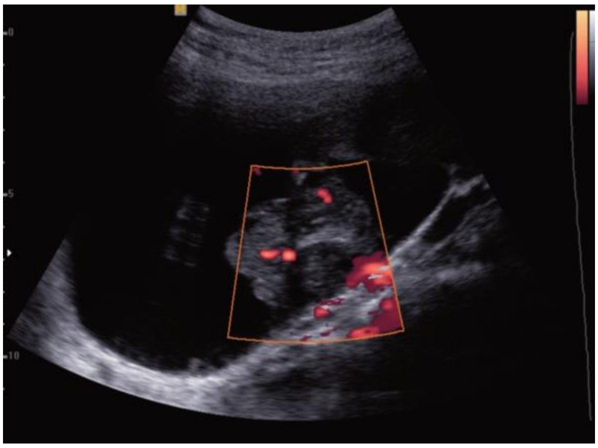


It should be remembered that the presence of closely packed hairs inside a dermoid cyst can give it an ultrasound appearance similar to an intestine full of faeces or gas. However, a meticulous scan permits the visualisation of peristaltic movements in the bowel loops, and not inside the dermoid. Occasionally, an interface develops between the serous fluid and fat inside the cyst due to the difference in density (“fat-fluid level”).

Malignant ovarian tumours

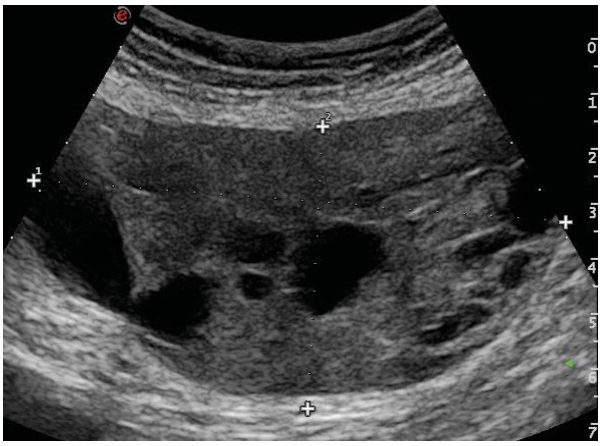
Malignant tumours can present a variety of ultrasound features. Furthermore, their morphology is influenced by histology and stage of growth. Whereas ultrasound characteristics of neoplasms at an advanced stage are fairly easy to recognise (large masses with solid portions, extensions into surrounding organs, presence of ascites, neoplastic bridges between bowel loops, omental thickening known as “omental cake”), considerable experience is needed to distinguish benign cysts from malignant ones at a very early stage in development. Malignant neoplasms are frequently bilateral, contain one or more papillae and solid parts that make the internal wall irregular [Figure 21].

Figure 21 Ovarian serous papillary carcinoma with a large internal solid projection. Power Doppler shows vascularization of the solid part.



The solid portions of the mass can become the major part of the cyst and in many cases ovarian carcinomas appear as mostly solid masses, containing scarce, small cystic spaces ("Swiss cheese" appearance) due to the accumulation of fluid secreted by the neoplastic cells or produced by intratumoural haemorrhage and necrosis [(20, 24)] [Figure 22].

Figure 22 Ovarian adult granulosa cell tumor with a so-called Swiss cheese appearance. The tumor is predominantly solid with small internal cystic areas.

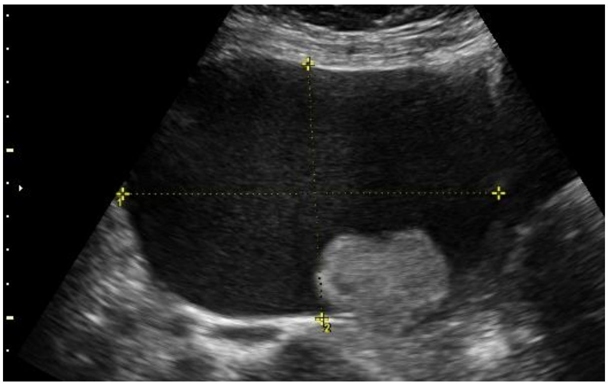


Septations are usually thick and the internal and external walls of the tumour are irregular. On Doppler ultrasound, malignant ovarian neoplasms generally have a rich internal vascular network, with frequent arteriovenous anastomoses, vascular lakes and an irregular flow distribution.

Borderline tumors

The differential diagnosis between borderline tumours (9), cystadenomas, cystadenofibromas and invasive malignant tumours is quite tricky. Serous and mucinous endocervical type BOTs typically appear as unilocular solid tumours with a high number of vascular papillary projections within the cyst [Figure 23].

Figure 23 Transabdominal scan of a serous papillary borderline ovarian tumour

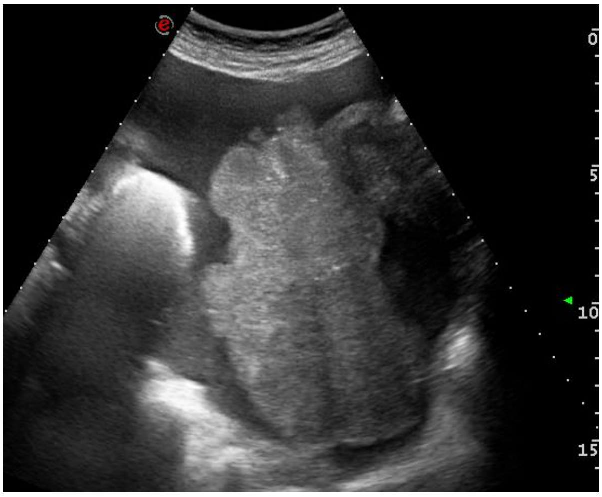


Mucinous intestinal type BOT on the other side usually are seen as large, multilocular tumours with a high number of locules encased by thick, hyperechoic tissue with no evidence of solid components, typically with the 'honeycomb' sign formed by septae within the cyst. Doppler evaluation is not useful in distinguishing between borderline and invasive tumors.

Primary invasive ovarian epithelial cancer

Ultrasound images of primary invasive ovarian epithelial cancers at stage I can mimic borderline tumours, but the in later stage disease the appearance differs. In the early phases, it is quite common to see papillary projections within a cyst and less commonly they are purely solid. While later stage primary ovarian tumours usually appear entirely solid or multilocular with a high proportion of solid tissue and frequently ascites as well as metastatic disease to the peritoneum, omentum and elsewhere in the abdomen and pelvis are pointed out [Figure 24]. They are also highly vascularized with colour scores 3–4.

Figure 24 Transabdominal scan of a serous papillary invasive ovarian tumour appearing as a solid irregular mass. A massive ascites is present in the abdomen.



Ovarian metastasis

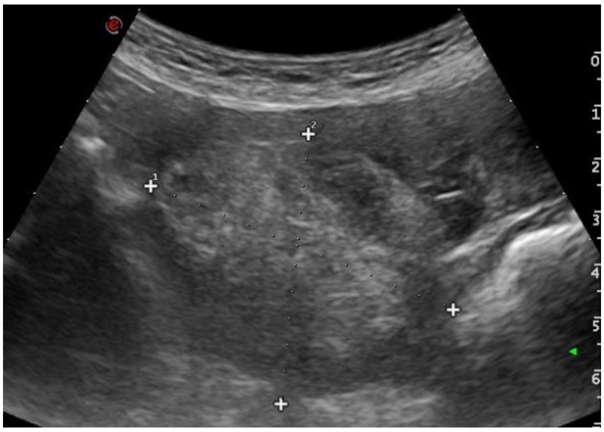
On ultrasound scanning, ovarian metastasis from gastric, breast, lymphomas and uterine cancers appear as solid tumours. Colon, rectum and biliary tract cancers usually produce multilocular-solid or ipoechogenic masses when metastatised in the ovaries and they are typically larger and with irregular margins. A common feature of metastatic tumours is their high vascularity (color score 3–4) and usually a "lead vessel" can be identified, penetrating from the periphery to the central part of the lesion.

Adnexal torsion

Typical symptoms of patients with an adnexal torsion are acute pelvic pain and tenderness. Torsion of the ovary and tube usually produce an obstruction in lymphatic and venous drainage that leads to an enlarged, oedematous adnexal mass [Figure 25]. US features suggestive for ovarian or adnexal torsion are:

1. The presence of a adnexal mass enlarging the ovary
2. Unusual position of the ovary (e.g.: located above the uterine fundus or in the vescico-uterine space)
3. An oedematous appearance of the ovarian stroma, with dispersion of the follicles toward the ovarian cortex
4. Variable amount of fluid in the Douglas pouch
5. Twisted ovarian vessels at Doppler

Figure 25 Transabdominal scan of an adnexal torsion. The ovary appears enlarged, hypoechoic and roundish due to the massive oedema.



Colour Doppler can help diagnosis showing the typical "whirpool sign", due to the twisted infundibolopelvic ligament which can be seen adjacent to the torted ovary. This feature is best seen using transvaginal ultrasound. Free fluid in the pelvis is the result of accumulation of exudation from the ovary after lymphatic and venous obstruction [(25)].

Hydrosalpinx

A normal Fallopian tube cannot be visualized on TAS. However, when a variable amount of fluid accumulates in the lumen, a sausage-shape mass, with thin walls, incomplete septations, and a cogwheel appearance on cross section can be seen. Unlike bowel loops, it does not show any peristalsis. Hydrosalpinges are typically asymptomatic, reflecting the presence of a previous inflammation of the fallopian tube, resulting in a chronic damage.

Tubo-ovarian abscess

An ascending infection can involve the tube and ovary producing a tubo-ovarian abscess. Typical ultrasound findings are the presence of a heterogenous mass of mixed content, blurred margins, painful on pressure with the probe, with thick walls. Hyperechoic retroperitoneal fat usually accompanies the presence of a pelvic abscess. Sometimes portions of a fluid-filled fallopian tube or the ovary can be seen inside the abscess.

Peritoneal inclusions cysts

Also called peritoneal pseudocysts, they are cystic structures that contain hypo or anechoic peritoneal fluid. These masses can be produced after surgery or pelvic infections and are formed by adhesions that entrap a variable amount of fluid. A typical finding at sonography is the movement of septations inside the pseudocyst (so called “flapping sail sign”). Normal ovaries can be seen inside the pseudocyst or lateral to it. Usually these cysts are asymptomatic, and the past medical/surgical history should guide the diagnosis.

Elastography

Uterine stiffness as measured by elastosonography has been evaluated in order to differentiate uterine leiomyomas from adenomyotic lesions. Data are scanty and most research has been conducted by means of TVS [(26)]. Elastosonography seems to be a useful tool in the diagnosis of adenomyosis because it is non-invasive, easy to understand, easy to perform, and has a short learning curve to become skilled at the procedure [(27, 28)].

Contrast enhanced ultrasound

Differentiation of benign from malignant adnexal masses was attempted by visual assessment of (Ultrasound Contrast Agents) UCA distribution and by quantification of enhanced Doppler signals but, despite some difference in average values for some variables, no feature with sufficient clinical potential was obtained. By using contrast-enhanced ultrasound (CEUS), it was demonstrated that adnexal masses without internal enhancement are invariably benign [(29)], but the presence of enhancement is not a specific sign of malignancy. CEUS does not greatly improve the accuracy of colour Doppler US for the diagnosis of malignancy in adnexal masses [(30-32)]. A multicentre study on the diagnosis of malignancy in adnexal masses, including quantitative CEUS features, confirmed that CEUS was not superior to conventional colour Doppler US [(33)]. Although findings on CEUS differed between benign and malignant ovarian masses, there was substantial overlap between benign and borderline tumours, although CEUS was able to differentiate invasive malignancies from other tumours [(33)].

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