Gynaecological ultrasound

Introduction

Ultrasound is the first-line imaging investigation in gynaecological disorders. It has the advantages of being readily available and inexpensive as well as avoiding the use of ionizing radiation. Common indications for performing pelvic ultrasound include menstrual disorders, pelvic pain, symptoms suggestive of a pelvic mass and postmenopausal bleeding. This article summarizes the technical aspects and anatomy relevant to gynaecological ultrasound before describing the conditions commonly encountered during sonographic assessment of the female pelvis.

Technical aspects

Transabdominal and transvaginal scanning

Transabdominal and transvaginal approaches are used in pelvic ultrasound. The two techniques complement each other, enabling complete visualization of the pelvic organs. Transabdominal ultrasound (TAUS) requires a distended bladder to displace bowel loops out of the pelvis and to act as an acoustic window, allowing visualization of the uterus and adnexae posteriorly. A 3.5–5 MHz curvilinear probe is used to perform grey-scale (B-mode) imaging in the sagittal and transverse planes.

For transvaginal ultrasonography (TVUS) the bladder is emptied and a high frequency 5–10 MHz probe is inserted into the vagina. Owing to the higher frequency of the probe and its proximity to the pelvic organs, TVUS provides better resolution of the endometrium and adnexal masses and improved visualization of the retroverted uterus in comparison to TAUS. It is also helpful in the examination of obese patients or those unable to achieve adequate bladder distension for TAUS (*Table 1*). TAUS provides a wider field of view and allows assessment of the entire pelvis, helpful in the evaluation of larger pelvic masses and in examining ovaries situated outside the range of the transvaginal probe.

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Anatomy and normal ultrasonographic appearances

The uterus has a variable orientation within the pelvis. It is normally anteverted but the entire uterus may be tilted backwards relative to the vagina (retroversion), or the body may be tilted backwards relative to the cervix (retroflexion). In these positions adequate visualization may only be possible with TVUS.

At ultrasound the uterine myometrium returns homogeneous low-level echoes. The normal endometrium is a highly echogenic linear structure in the centre of the uterus, measured as a double layer thickness in the sagittal plane (*Figure 1*). The appearance of the endometrium varies depending on hormonal status. During menstruation the endometrium is thin and hyperechoic. In the proliferative phase it thickens to between 4 and 8 mm and develops a multi-layered appearance as ovulation approaches. Following ovulation in the secretory phase, the endometrium becomes increasingly echogenic and thickens further to between 7 and 14 mm. The endometrium atrophies after the menopause and should measure less than 5 mm in thickness.

The ovaries typically lie laterally or posterolaterally to the anteverted uterus, closely related to the iliac vessels, although they may also be identified in the recto-uterine pouch or high up on the pelvic sidewall. The normal ovary measures up to 8 cc in volume and contains multiple peripheral anechoic follicles (*Figure 2*). During the proliferative phase of the menstrual cycle several follicles increase in size with one follicle subsequently becoming dominant, reaching a size of 2–2.5 cm at the time of ovulation. Following ovulation the follicle collapses and forms a corpus luteum. This may show haemorrhagic changes internally. Following menopause, the ovaries involute and may be difficult to identify on ultrasound.

The recto-uterine recess or pouch of Douglas should be examined at ultrasound. Following ovulation, a small amount of fluid within the recto-uterine recess is physiological but larger amounts of fluid suggest underlying pathology.

Table 1. Advantages of transvaginal sonography

Improved resolution because high frequency probe is used
Evaluation of the retroverted uterus
Better detail of adnexal masses including characterization of internal architecture
Better detail of the endometrium
Requires empty bladder: frequently more comfortable and useful in incontinent patients
Examination of obese patients

Uterine pathology

Congenital abnormalities

Failure of development or fusion of the paired Mullerian ducts may result in a variety of congenital uterine abnormalities, often detectable on ultrasound. The com-

Figure 1. Transvaginal scan of a normal uterus on day 10 of the menstrual cycle (proliferative phase) showing a normal endometrial thickness (between calipers) of 4.7 mm.

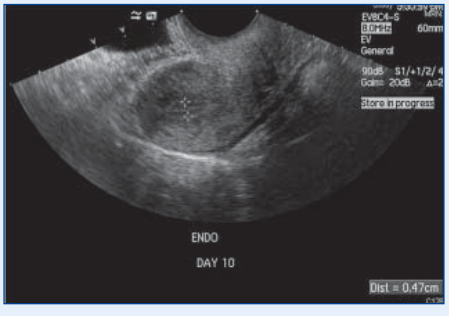
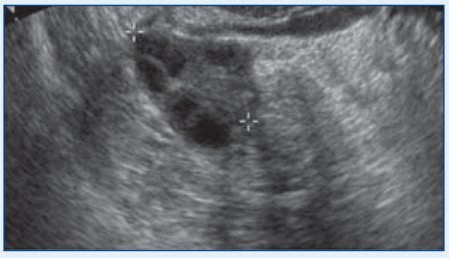


Figure 2. Transvaginal scan of a normal ovary demonstrating several anechoic follicles.



monest abnormality is the septate uterus in which a thin fibrous septum divides the endometrial cavity but the normal fundal contour is preserved. Bicornuate uterus results from partial failure of fusion of the Mullerian ducts. As with septate uterus two separate endometrial cavities are identified on ultrasound but they are more widely separated with intervening myometrium and there is indentation of the external contour of the fundus. There is an association with renal tract anomalies. Other congenital abnormalities include unicornuate uterus and the rare didelphis uterus with duplication of the uterus, cervix and occasionally the vagina.

Fibroids

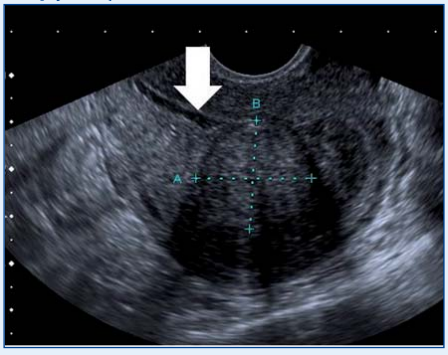
Fibroids, or uterine leiomyomas, are common benign soft tissue tumours of the myometrium with a prevalence of 20–50%. They are categorized according to their location within the myometrium and may be intramural (confined to the myometrium), submucosal (projecting into and distorting the endometrial cavity) (*Figure 3*), or subserosal (projecting from the peritoneal surface of the uterus).

On ultrasound the typical appearance of a localized leiomyoma is a hypoechoic or heterogeneous lesion that may cause diffuse acoustic shadowing. Multiple small leiomyomata may not be visualized as discrete masses but instead give rise to an enlarged uterus with a heterogeneous echotexture. A pedunculated subserosal fibroid may present as an adnexal mass.

Adenomyosis

Adenomyosis is characterized pathologically by the presence of endometrial glands and stroma within the myometrium. At ultrasound, the uterus is typically enlarged with diffuse heterogeneity and thickening of the myometrium and subendometrial cysts.

Figure 3. Transvaginal scan of a submucosal fibroid (between calipers) bulging into the endometrial cavity (arrow) which has a small amount of fluid in it.



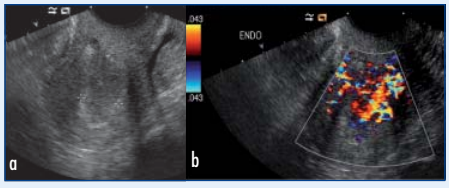
Endometrial pathology

TVUS allows excellent visualization of the endometrium and is a useful tool in the assessment of postmenopausal bleeding. Although endometrial atrophy is the commonest cause of postmenopausal bleeding, the incidences of endometrial carcinoma, hyperplasia and polyps all increase with age. In the postmenopausal patient a uniformly thin endometrium measuring less than 5 mm has a high negative predictive value for endometrial carcinoma. Endometrial thickness of over 5 mm in women with postmenopausal bleeding who are not receiving hormone replacement therapy is abnormal and requires further assessment, including hysteroscopy and biopsy (*Figure 4*).

Endometrial hyperplasia and carcinoma can both give rise to diffuse echogenic endometrial thickening or more focal, irregular thickening. The ultrasound appearances are non-specific and biopsy is required to establish the diagnosis. Invasive endometrial carcinoma may result in loss of clarity of the endometrial-myometrial border on ultrasound but in biopsy-proven cases, magnetic resonance imaging (MRI) is used for local staging to assess extent of myometrial invasion. Significant endometrial fluid collections in the postmenopausal patient raise the possibility of endometrial or cervical malignancy. At ultrasound endometrial polyp (*Figure 5*) may appear as a discrete echogenic mass or an area of focal endometrial thickening.

In premenopausal patients polyps, hyperplasia and cancer are relatively uncommon and endometrial thickening is usually a normal variant seen in the secretory phase. Correlation with pregnancy test result is essential as endometrial thickening is seen in normal early intrauterine pregnancy, ectopic pregnancy, missed abortion and gestational trophoblastic neoplasia (*Figure 6*). The latter comprises a range of conditions from partial and complete hydatidiform mole to invasive mole, choriocarcinoma and placental site trophoblastic tumour. Ultrasound is important in initial diagnosis and typically reveals an enlarged uterus containing a centrally placed echogenic mass which demonstrates marked vascularity on colour Doppler imaging. *Table 2* lists the common causes of endometrial thickening.

Figure 4. Carcinoma of the uterus. a. Transvaginal scan showing echopoor endometrial thickening of 1.6 cm (between calipers) in a postmenopausal woman which (b) is very vascular on colour Doppler.



Adnexal masses

TVUS provides excellent visualization of the internal architecture of adnexal masses which may be cystic, complex (containing both cystic and solid elements) or solid.

Figure 5. Transvaginal scan of an endometrial polyp (arrow) with a feeding vessel.

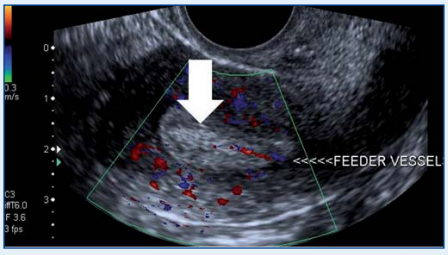


Figure 6. Transvaginal scan of a markedly vascular hydatidiform mole (arrow) in a 24-year-old woman.

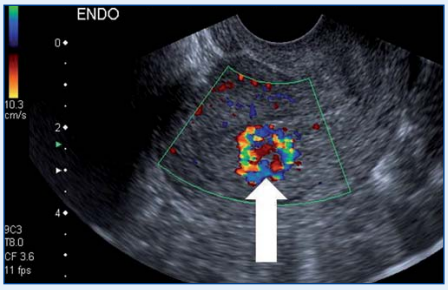


Table 2. Causes of endometrial thickening

Endometrial polyp
Endometrial hyperplasia
Endometrial carcinoma
Submucosal fibroid
Normal secretory phase endometrium
Pregnancy: normal early intrauterine pregnancy, ectopic pregnancy, missed abortion, gestational trophoblastic neoplasia
Endometritis

This characterization helps determine the likelihood of the mass being benign or malignant, although correlation with clinical data including age, family history and CA-125 level is important. The majority of adnexal masses are benign and expectant management with follow-up ultrasound is often appropriate (Conway et al, 1998; Alcazar et al, 2005). If surgical management of a 'probably benign' mass is necessary, a laparoscopic approach is commonly used. If an adnexal mass is thought likely to be malignant, full exploratory laparotomy is performed both to provide definitive diagnosis and staging and to resect the tumour. *Table 3* lists the common causes of adnexal masses.

Numerous studies have looked at the role of both grey-scale and Doppler ultrasound in differentiating benign and malignant ovarian masses. Scoring systems, for example one developed by Sassone et al (1991), may improve the reproducibility of classifying masses as benign and malignant and combining morphologic and Doppler ultrasound parameters can also improve this differentiation (Kinkel et al, 2000). The characteristic features of benign and malignant masses are shown in *Table 4*.

Although ultrasound is used in the initial assessment of an adnexal mass, MRI is superior in some cases because of its excellent contrast resolution. It is used as a problem-solving tool in cases where TVUS is equivocal. In addition, MRI and computed tomography are superior to ultrasound in staging advanced ovarian carcinoma (Tempany et al, 2000).

Table 3. Causes of adnexal masses

Functional ovarian cysts +/- haemorrhage
Endometrioma
Ovarian tumours: serous and mucinous cystadenomas and cystadenocarcinoma, endometrioid carcinoma, mature cystic teratoma
Ovarian torsion
Parovarian cyst
Tubo-ovarian abscess
Hydro- and pyosalpinx
Pedunculated sub-serosal uterine fibroid
Ectopic pregnancy
Non-gynaecological masses (e.g. appendix abscess, diverticular abscess, bowel malignancy, bladder diverticulum)

Benign ovarian pathologies

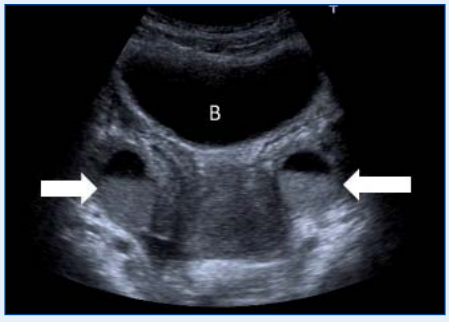
Failure of a follicle to rupture or regress can result in formation of a follicular cyst. The sonographic appearance is of a unilocular simple cyst with a thin wall, absence of internal echoes and the presence of posterior acoustic enhancement. They may be large measuring up to 10 cm in diameter. A corpus luteal cyst results from failure of involution of the corpus luteum and typically has a thicker wall than a follicular cyst. Haemorrhage may occur into both these types of functional cysts and commonly presents with acute pelvic pain. Haemorrhagic cysts may display internal echoes, septations, a fluid–debris level (*Figure 7*) or a focal echogenic area that represents clot. Most functional cysts spontaneously regress but in the case of large simple cysts or atypical haemorrhagic cysts a repeat study 6 weeks later will help confirm resolution and the benign aetiology of the cyst. Small simple cysts, measuring up to 3 cm in diameter, are also seen in postmenopausal women and do not require follow up.

The ovary is the commonest site for localized deposits in endometriosis. Termed endometriomas or 'chocolate cysts', these deposits typically appear on ultrasound as well-defined unilocular or multilocular cystic masses with diffuse low-level internal echoes (*Figure 8*). A more solid appearance and fluid–fluid levels may also occur, making differentiation from a haemorrhagic cyst difficult.

Table 4. Features suggestive of malignancy in an ovarian mass

Thick irregular septations
Solid papillary projections
Iso- or hypoechoic solid elements
Central vascularity
Ascites
Peritoneal deposits

Figure 7. Bilateral haemorrhagic ovarian cysts seen as echogenic blood/fluid levels (arrows). Bladder (B).



Ovarian torsion typically presents with acute pelvic pain, vomiting and fever. The presence of an ovarian mass or cyst predisposes to this condition. Ultrasound may reveal an enlarged ovary in the midline or superior to the uterus. Doppler assessment may be useful, particularly if decreased flow relative to the normal asymptomatic side is demonstrated, although presence of blood flow does not exclude torsion.

Polycystic ovarian syndrome is a common cause of infertility and may display characteristic sonographic features: 12 or more follicles (3–12 mm in diameter) peripherally or diffusely arranged and an ovarian volume over 10 mm^3 (*Figure 9*). Bright ovarian stroma may also be seen. Only a single ovary need be affected to make the diagnosis. The imaging appearances are found in less than 50% of women with polycystic ovarian syndrome and correlation with clinical findings and biochemistry is essential in establishing the diagnosis.

Ovarian tumours

Primary ovarian tumours are classified according to their cell-line of origin as epithelial, sex-cord stromal or germ cell

Figure 8. Endometrioma seen as a well-defined avascular unilocular cystic lesion with diffuse low-level internal echoes.

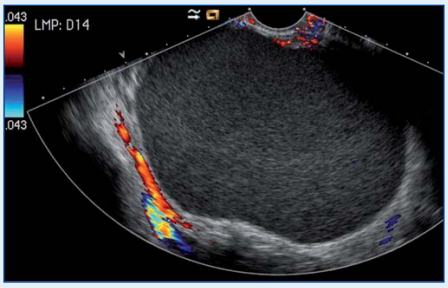
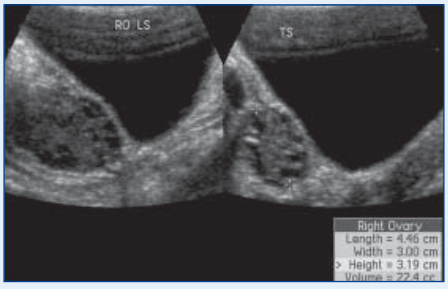


Figure 9. Two views of an enlarged (22 cc) right ovary showing multiple peripheral follicles consistent with polycystic ovarian syndrome.



tumours. Epithelial tumours are the commonest ovarian tumours accounting for 65–75% of all ovarian tumours and 90% of ovarian malignancies. They are classified as benign, borderline (of low malignant potential) and malignant. The most common subtypes, serous and mucinous tumours, both produce predominantly cystic masses that cannot be reliably differentiated at ultrasound. Benign cystadenoma appears as a large unilocular cyst, possibly with thin internal septations. Cystadenocarcinomas (*Figure 10*) may be large multiloculated cysts with thickened septations and papillary projections.

Mature cystic teratoma or dermoid (*Figure 11*) is the commonest ovarian tumour of germ-cell origin and accounts for 10–15% of all ovarian tumours. The sonographic appearances are variable depending on the relative contributions of the three germ cell layers but these are predominantly cystic tumours. Characteristic features include the presence of a highly echogenic focus, representing either fat or calcification, the latter producing acoustic shadowing. Fluid–fat or hair–fluid levels may be also seen. Ovarian metastases occur most commonly with primary tumours of the stomach, breast and colon and lymphoma. A solid hypoechoic ovarian lesion is typical and bilateral metastases are often seen.

Figure 10. Complex mixed cystic solid ovarian mass (between calipers) which was histologically a cystadenocarcinoma.

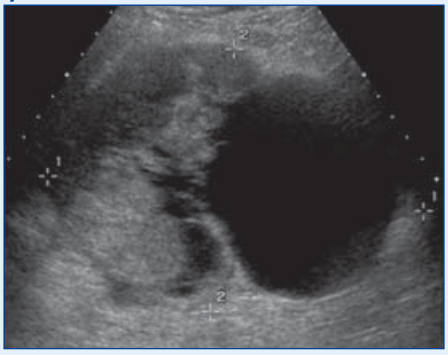
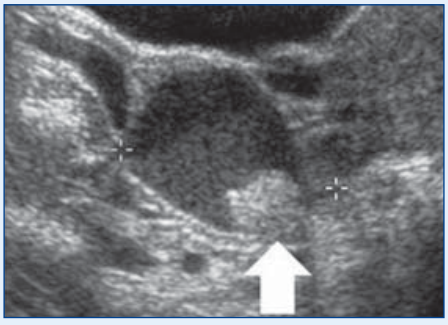


Figure 11. Dermoid (between calipers) showing a characteristic echogenic plug (arrow) and a fat/fluid level.

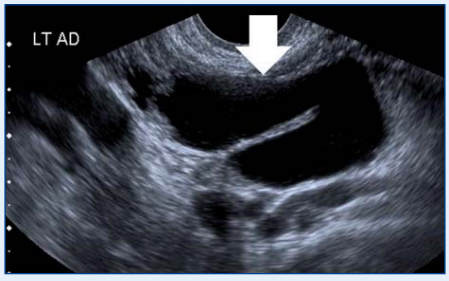


Other adnexal masses

Pelvic inflammatory disease may result in tubal occlusion and formation of a hydro- or pyosalpinx. At ultrasound these may be difficult to distinguish from other causes of an adnexal mass but a tubular configuration to a thin-walled anechoic cystic mass is suggestive of hydrosalpinx (*Figure 12*). The presence of internal echoes suggests pus or debris within a pyosalpinx.

In the appropriate clinical setting ectopic pregnancy is an important differential diagnosis of an adnexal mass as prompt diagnosis is vital. At ultrasound the most specific finding of a live embryo outside the uterus is seen in only 25% of cases. In the context of a positive pregnancy test ultrasound findings of an absent intrauterine pregnancy and a complex adnexal mass are highly suggestive of the diagnosis. As 95% of ectopic pregnancies occur in the fallopian tube and ovarian ectopics are very rare, separate identification of the ovary from the adnexal mass is important. An endometrial fluid collection (the pseudogestational sac) and free fluid in the pouch of Douglas may also be seen.

Figure 12. Hydrosalpinx (arrow) seen as a fluid-filled tubular adnexal structure.



Conclusions

Ultrasound is a vital tool in the assessment of the female pelvis. With a transvaginal approach, accurate assessment of the endometrium and adnexal masses is often possible. Additional techniques including sonohysterography and administration of intravenous ultrasound contrast agents may provide additional information in some conditions. Like all ultrasound examinations, pelvic ultrasound is highly operator dependent and in some contexts, particularly in the assessment of equivocal adnexal masses and staging of endometrial and ovarian carcinoma, MRI has an important role to play alongside ultrasound. **BJHM**

Conflict of interest: none.

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KEY POINTS

- Pelvic ultrasound is the first-line imaging investigation in gynaecological disorders. It is widely available and avoids ionizing radiation. Transvaginal and transabdominal approaches together often allow complete visualization of the pelvic organs.
- In women with postmenopausal bleeding, endometrial thickness of 5 mm or greater at transvaginal ultrasound is abnormal and requires further investigation including hysteroscopy and biopsy.
- Transvaginal ultrasound enables excellent visualization of adnexal masses and can help determine the likelihood of a benign or malignant aetiology. Additional ultrasound techniques, including intravenous ultrasound contrast agent administration, may help improve characterization of adnexal masses.
- Simple ovarian cysts that lack features suspicious of malignancy can often be followed up with serial sonographic examination.
- Additional imaging techniques, predominantly magnetic resonance imaging, may be required for assessment of problematic cases and full staging of gynaecological malignancy.