Ultrasound in obstetrics and gynaecology

Nirmala Murugandoss
Nuala Coyle
Shreelata Datta

Abstract

Ultrasound is a key first line imaging modality in obstetrics and gynaecology. It is cheap, painless, inexpensive and has a long safety record in pregnancy. Its use as a screening and diagnostic tool is dependent upon the technical skill of the operator and their ability to interpret the scan findings. This review summarizes the theoretical and practical elements of the clinical application of ultrasound in obstetrics and gynaecology.

Keywords cancer; ectopic; fetal anomaly; miscarriage; ultrasound

Introduction

Ultrasound is a key investigation used both in diagnosis and in treatment of patients in obstetrics and gynaecology. However, it is important to understand the mechanics of ultrasound and the machines used in clinical practice to maximize its effectiveness. Patient factors such as body mass index also play a role in the ability of the operator to obtain a high quality image.

How does ultrasound work?

Ultrasound uses sound frequencies above the top of the audible range, 20 kHz. For medical applications, frequencies of 1–15 MHz are used. Piezoelectric crystals in the transducer act as the source of ultrasound. When an electrical current is applied to these crystals they change shape rapidly and the vibrations as a result of this produce sound waves. As well as emitting sound waves, these crystals produce an electric current, when sound waves or echoes return to them.

Pulses of sound leave the transducer, travels through the patient, and encounters different tissues along the way. Different tissues have different effects on the sound waves passing through them. This is described as acoustic impedance. The junction between different tissues is known as the acoustic interface. At each interface a proportion of the sound beam is reflected back to the transducer as an echo. This is the pulse–echo principle underlying ultrasound.

Nirmala Murugandoss ***MBBS MD DGO MRCOG*** *is a ST7 in Obstetrics and Gynaecology at King's College Hospital, London, UK. Conflicts of interest: none declared.*

Nuala Coyle ***MBBS*** *is a ST5 in Obstetrics and Gynaecology at King's College Hospital, London, UK. Conflicts of interest: none declared.*

Shreelata Datta ***MD MRCOG LLM MBBS BSc (Hons)*** *is a Consultant Obstetrician and Gynaecologist at King's College Hospital, London, UK. Conflicts of interest: none declared.*

The electrical voltage produced in the piezoelectric crystal by this echo is stored by the ultrasound machine as a single line of information. The voltage is assigned a brightness level. As multiple pulses leave the transducer and multiple echoes are received, a cross sectional image is produced, known as brightness mode or B-mode.

Optimising ultrasound images and safety

In order to obtain the highest quality image, whilst simultaneously maintaining safety, the following principles need to be considered:

Power: ultrasound is absorbed as it passes through tissues, therefore lower power is needed for women with a lower BMI. Excessive power causes image distortion through noise and affects the thermal index (TI) and mechanical index (MI). The TI estimates tissue heating and the MI estimates mechanically induced tissue damage. Both MI and TI must be maintained within certain safety limits and this is particularly pertinent for early pregnancy ultrasound. The 'as low as reasonably achievable' (ALARA) principle should guide the operator and so it is recommended that the higher the TI, the shorter the ultrasound exposure should be.

Frequency: frequency measures the number of wavelengths per unit of time and is usually measured in Hertz (Hz). The ultrasonographer has control over this; a higher frequency will give better image resolution, but lower penetration. Deeper structures will not be seen as clearly at higher frequencies.

Gain: gain alters the brightness of the image. Increased gain results in brighter echoes but also increases image noise and artefact, leading to a loss of contrast.

Focus: the focus denotes the narrowest part of the beam and should be directed to the area of interest to achieve the highest quality image at this point.

Harmonics: harmonics reduce background noise and can improve contrast. It is particularly useful when examining cystic structures where the artefacts are reduced.

Angle/Sector width: resolution is improved by scanning a smaller area: reducing the sector width increases the frame rate and resolution thus resulting in a better quality image. Increasing the sector width does not improve the image quality but allows appreciation of the scope of large structures.

Depth/Zoom: increasing the depth allows visualisation of structures further away from the probe but compromises image quality. When scanning structures near the probe reducing the depth improves the image quality.

Using zoom over a small area restricts ultrasound processing to that area; this allows the maximum amount of detail to be acquired for that area.

Colour and Pulsed wave Doppler: doppler is associated with an increase in temperature and care must be taken to maintain the TI within safety limits. Colour Doppler is useful in assessing tissue vascularity. Pulsed Doppler should not be used before 11

weeks' gestation due to the high-energy output associated with this. Instead, M-mode can be used to measure the fetal heart rate. Routine use of Doppler at 11–14 weeks' gestation is not recommended. If necessary for clinical indication, the TI should be <1.0, keeping the duration of exposure as short as possible.

Assessment prior to ultrasound

The pathology likely to be identified on ultrasound can often be delineated from the patient's clinical history and a thorough history should be taken prior to ultrasound scan. In addition, ultrasound does not replace the need for examination and in some cases this can help with interpretation of scan findings.

Transvaginal ultrasound (TVUS) is recommended by NICE for diagnosis in early pregnancy. It is also preferred over transabdominal scan (TAUS) for the imaging of pelvic masses due to its increased sensitivity and specificity. TAUS is a useful adjunct to TVUS in the assessment of large pelvic masses, and it may also be an alternative modality in women who have never been sexually active or for those women who decline TVUS. Transrectal ultrasound (TRUS) can also be considered in these cases if transabdominal views are suboptimal. TVUS and TRUS ultrasound should be performed with an empty bladder and for TAUS the bladder should be full.

An explanation should be given prior to the scan and verbal consent should be obtained. The patient's identity should be confirmed and a chaperone should be available during the scan. For TVUS and TRUS latex allergy status should also be checked.

Performing the ultrasound

The orientation of the probe should be checked prior to scan. The operator should be familiar with the settings and how to adjust these during the scan to optimize the views of the organs being examined.

The pelvic ultrasound scan should be performed in a systematic manner to examine the following structures:

Uterine position

- Identification of the bladder and cervix should take place first and then the position of the uterus can be assessed.

Presence of uterine anomalies

- This is assessed by sweeping through the uterus in the longitudinal and transverse plane from cervix to fundus.

Endometrial thickness

- The entire length of the cervical canal and uterine cavity should be examined in the sagittal plane and the endometrial thickness measured at its thickest point.

Ovarian morphology and volume

- Ovaries are usually seen lateral to the uterus and medial to the internal iliac vessels. The position of the ovaries can vary depending on the length of the infundibulopelvic ligament and the presence of adhesions.

Pouch of Douglas

- The presence of and appearance of free fluid (anechoic), blood or pus (echogenic) should be recorded.
- Look for any nodules or adhesions

Mobility of the pelvic organs

- Use the non-scanning hand to move the pelvic organs closer to the probe and assess the movement of organs on the ultrasound monitor to establish mobility or the presence of adhesions.
- Also, clinically assess for probe tenderness or discomfort while scanning.

Any abnormalities

- If pathology, such as an ovarian cyst, is identified early in the scan it is often better to look at this at the end of the scan to avoid missing any co-existing pathology.

Gynaecological ultrasound

Uterine pathology

Leiomyoma: fibroids are the most common uterine tumours, arising in up to 40% of pre-menopausal women. They appear as symmetrical, well-defined, hypoechoic, and heterogeneous masses. They are often multiple and usually cause acoustic shadowing. Calcification may be present, particularly in post-menopausal women. Degenerating fibroids may contain cystic areas, and haemorrhage with in a fibroid may appear hyperechoic.

Ultrasound can help define the location of fibroids, classifying them as subserosal, intramural or submucosal. Pedunculated and subserosal fibroids (Figure 1) may mimic the appearance of a solid ovarian tumour. In these cases it is important to identify the fibroid pedicle and the ovary separately from the fibroid. The degree of intracavity projection of submucosal fibroids can be aided by instilling saline into the uterine cavity. This is clinically important as Grade 0 (pedunculated intracavitary) and Grade 1 (<50% intramural) may be suitable for transcervical resection in a symptomatic woman.

Adenomyosis: adenomyosis is defined as the presence of endometrial glands and stroma within the myometrium leading to hypertrophy and hyperplasia of surrounding adjacent myometrium. A TVUS in women with heavy menstrual bleeding, and who have a bulky tender uterus on examination, suggestive of adenomyosis (Figure 2), may show the following features, although adenomyosis is a histological diagnosis and cannot be confidently made on ultrasound scan alone;

- o Globular enlarged uterus
- o Echogenic linear striations
- o Myometrial cysts
- o Heterogeneous myometrium
- o Myometrial anteroposterior asymmetry
- o Poor definition of the endometrial–myometrial junction
- o Parallel shadowing
- o Hyperechoic islands
- o Adenomyomas

Congenital uterine anomalies: congenital uterine anomalies have been reported in 5.5% of asymptomatic women. Uterine anomalies are identified by sweeping through the entire uterine cavity in the transverse plane. Uterine anomalies are suspected

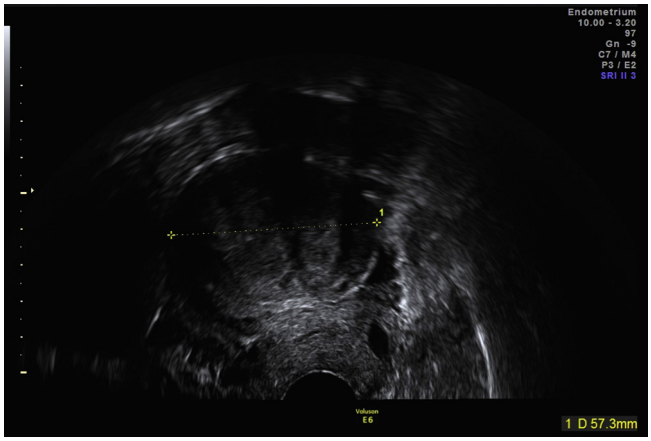

Figure 1 Subserosal fibroid.

Figure 2 Adenomyosis showing abnormal endomyometrial junction of the uterus.

when there is a duplication of the uterine cavity or when the interstitial portions of both fallopian tubes cannot be seen. 3-D ultrasound can be useful in diagnosing the abnormality (see Figure 5 below).

Endometrial pathology

In pre-menopausal women the appearance of the endometrium varies throughout the menstrual cycle. In the proliferative phase the endometrium has a trilaminar appearance (Figure 3a). In the secretory phase it is at its thickest and is uniformly echogenic (Figure 3b).

Endometrial polyps: in pre-menopausal women ultrasound to assess for endometrial abnormalities is best performed in the early proliferative phase (days 4–6 of the cycle) when the endometrium is thin.

Polyps appear as hyperechoic areas within the uterine cavity, and instilling saline into the endometrial cavity can outline the polyp (Figure 4). The Presence of a feeder arterial vessel, demonstrated by colour flow Doppler, is even more diagnostic of a polyp.

Hyperplasia: TVUS is useful in assessing the endometrium in women with risk factors for hyperplasia. The endometrium may appear irregular in profile and thickened with cystic spaces. In pre-menopausal women with PCOS, hyperplasia is unlikely if the endometrial thickness is less than 7 mm.

Malignancy: in symptomatic post-menopausal women with an endometrial thickness less than 4 mm the risk of endometrial cancer is low, approximately 1%. An endometrial thickness of 4 mm or more should prompt further investigation to exclude endometrial malignancy.

Adnexal pathology

Ultrasound assessment of ovarian lesions involves the understanding of the terminology used to describe such lesions. The International Ovarian Tumor Analysis (IOTA) Group have attempted to standardize the descriptive terms used in ultrasound analysis of adnexal lesions (Table 1).

Distinguishing between benign and malignant adnexal lesions: the Risk of Malignancy Index (RMI) is the most widely used system for triaging women with suspected ovarian malignancy in a post-menopausal woman. An RMI threshold of 200 has a sensitivity of 78% and a specificity of 87% for the detection of malignancy. The IOTA group developed simple rules based on ultrasound features to classify adnexal masses as malignant (M-Rules) or benign (B-Rules) (Table 2) and has comparable results to the RMI. If one or more M features are present in the absence of a B feature, the mass is classified as malignant. If one or more B features are present in the absence of an M feature, it is classified as benign. If both M features and B features are present, or if none of the features are present, the simple rules are inconclusive. Using these rules the reported sensitivity is as high as 95%, with a specificity of 91%.

Common adnexal pathologies

Polycystic ovaries *(*Figure 6*)* – a polycystic ovary is defined as an ovary with 20 or more follicles measuring between 2 and 9 mm, and/or an ovarian volume above 10 cm^3. Ovaries will be defined as polycystic in as many as 20% of women with normal menses.

Functional cysts – physiological cysts are common and vary according to the stage of the menstrual cycle. Follicular cysts are seen in the first half of the cycle and corpus luteum cysts in the second. Corpus luteum cysts can appear solid, cystic or haemorrhagic. They are surrounded by healthy ovarian tissue and demonstrate peripheral vascularity known as the 'ring of fire'.

Simple ovarian cyst *(*Figure 7*)* – small simple ovarian cysts (less than 50 mm diameter) are likely physiological and resolve spontaneously. These have a low risk of malignancy, particularly if asymptomatic. The ovarian crescent sign, a rim of healthy ovarian tissue, is often seen in association with benign ovarian cysts.

TVUS features of a simple cyst

1. Round or oval shape
2. Thin or imperceptible wall
3. Posterior acoustic enhancement
4. Anechoic fluid
5. Absence of septations or nodules

Cystadenoma – serous cystadenomas are the second most common benign ovarian tumours. They are unilocular, thin

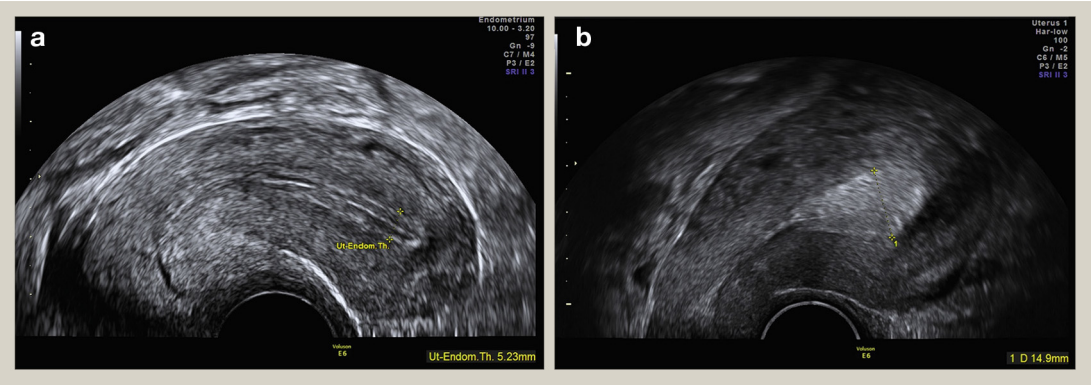

Figure 3 Proliferative endometrium (**a**) and secretory endometrium (**b**).

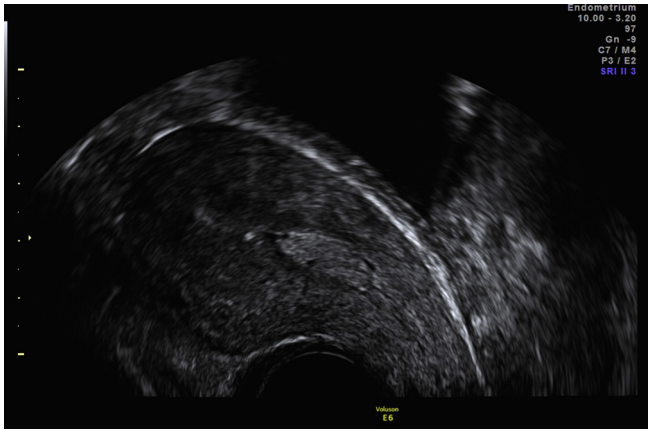

Figure 4 —Endometrial polyp.

walled and persistent, unlike functional cysts, and can be large. Mucinous cystadenomas are often large, multilocular cysts containing multiple thin septations with mucinous fluid of low-level echogenicity.

Endometrioma — endometriomas may be unilateral or bilateral, have ground glass echogenicity, and are poorly vascularized (Figure 8). There may be other features of endometriosis including pelvic adhesions or nodules.

Dermoid cyst: dermoid cysts are characterized by the presence of fine echogenic bands representing hair within the cyst (Figure 9). A Rokitansky protuberance may be seen, i.e. a highly echogenic focus with posterior shadowing. A fat fluid level may also be visualised.

Hydrosalpinx — a hydrosalpinx appears as a thin or thick walled tubular structure separate from the uterus and ovaries (see Figure 10). Thickened folds within the dilated fallopian tube produce a 'cog-wheel' appearance. Incomplete septations may give rise to a 'beads on a string' appearance.

Adnexal torsion — torsion should be suspected in women with a history of an ovarian cyst and pain. Ultrasound findings may reveal an enlarged ovary with a complex cyst. The ovarian stroma surrounding the cyst appears oedematous with loss of visualisation of the follicles and there may be free fluid in the pelvis. The ovary may also be positioned abnormally. There might be 'whirlpool sign' due to a twisted ovarian pedicle. Positive Doppler blood flow does not exclude torsion as torsion may be intermittent and the ovary has dual blood supply from the ovarian and uterine arteries.

Early pregnancy ultrasound

Ultrasound is the principle diagnostic tool used to assess the location and status of an early pregnancy. Prior to 12 weeks, TVUS is recommended but TAUS can be offered to women who decline TVUS. They should be informed that abdominal ultrasound is less reliable.

A pregnancy is not identified on ultrasound scan in up to 31% of women attending early pregnancy units. The rate of pregnancy

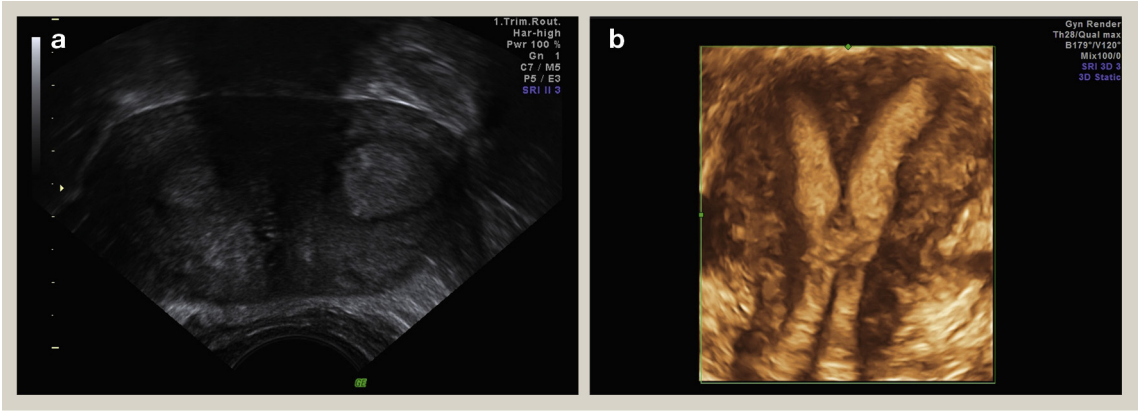

Figure 5 Transverse view of a uterine cavity (**a**) with a 3D image demonstrating a uterine septum (**b**).

Summary of IOTA descriptive terms for adnexal tumours

Terminology	Definition
Lesion	Part of the ovary or adnexa judged to be inconsistent with normal physiological findings
Septum	A thin stand of tissue running across the entire length of the cyst cavity
Incomplete septum	A thin stand of tissue running across the entirely length of the cyst cavity but not complete in some scanning plans
Solid cyst content	High echogenicity suggesting the presence of tissue
Cystic cyst content	Anechoic – black cyst contents Low level echogenic – similar to amniotic fluid Ground-glass –as seen in endometriomas Haemorrhagic – Echogenicity is star-shaped, 'cob-web' or jelly like Mixed echogenicity – as seen in dermoid cysts
Solid papillary projection	Solid projection into the cyst cavity from the cyst wall with a height >3 mm
Smooth	Smooth internal wall
Irregular	Irregular internal wall, presence of papillary projection denotes an irregular cyst wall
Acoustic shadowing	Loss of acoustic echo behind a structure
Ascites	Presence of fluid outside the Pouch of Douglas
Unilocular cyst	No septa, no solid component, no papillary projections
Unilocular-solid cyst	Unilocular cyst with a solid component or papillary structure
Multilocular cyst	At least 1 septum but no solid component or papillary projection
Multilocular solid cyst	Multilocular cyst with a solid component or papillary projection
Solid cyst	The solid component makes up ≥80% of the cyst contents
Not classifiable	Due to poor visualization or overlying shadowing

Table 1

of unknown location is dependent upon the quality of the ultrasound scan performed and presumed gestation, and can therefore differ between units. A normal intrauterine pregnancy should be visible on TVUS when serum β-hCG is over 1000 mIU/ml (Discriminatory zone).

An early pregnancy scan should follow the steps outlined for TVUS in gynecology with assessment of the uterus, adnexae and pouch of Douglas, in addition to the pregnancy, to ensure a complete assessment of the patient.

The ultrasound assessment of an intrauterine pregnancy should include:

Number of gestation sacs

- *Dichorionic twins will have two chorions (gestation sacs), monochorionic twins will have one*

IOTA 'rules' to classify masses as benign (B-rules) or malignant (M-rules)

B-Rules	M-rules
Unilocular cysts	Irregular solid tumour
Presence of solid components where the largest solid component is <7 mm	Ascites
Presence of acoustic shadowing	At least 4 papillary structures
Smooth multilocular tumour with a largest diameter <100 mm	Irregular multilocular solid tumour with largest diameter ≥100 mm
No blood flow	Very strong blood flow

Table 2

- *Amnionicity is best evaluated at 7–12 weeks when the amniotic sac appears*

Mean gestation sac diameter

- Measurements are taken in three planes from the inner edge of the trophoblast

Presence of a yolk sac

- Measurements are taken in three planes from the centre of the wall of the yolk sac

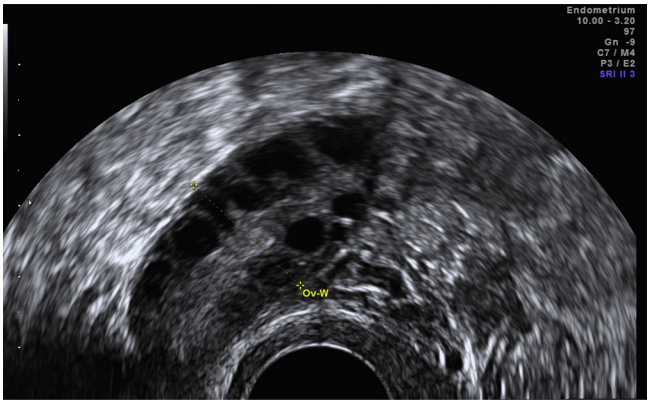

Figure 6 Polycystic ovary.

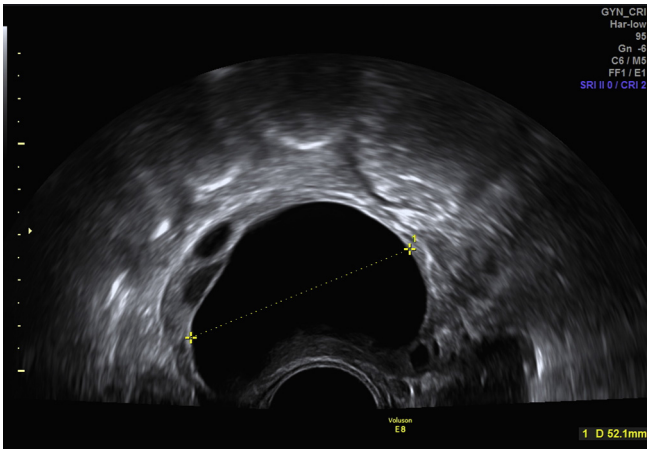

Figure 7 –Simple ovarian cyst, as outlined by calipers; outer rim of normal ovarian tissue highlighted by arrow.

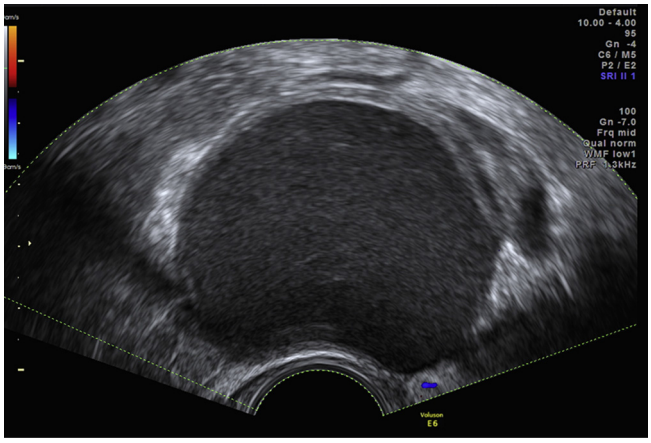

Figure 8 Ovarian endometrioma; arrow highlights ground glass echogenicity.

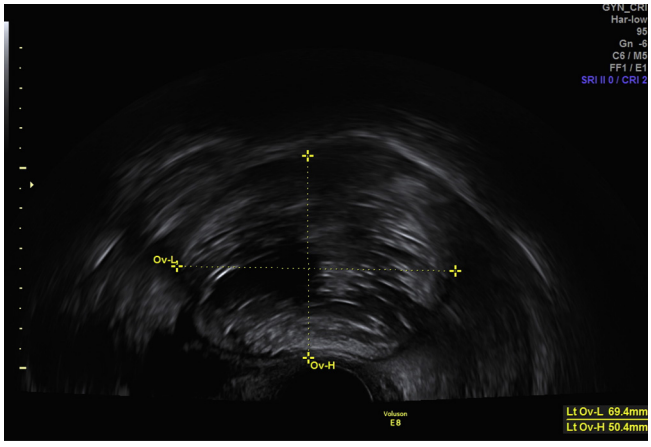

Figure 9 Dermoid cyst as highlighted by caliper measurements.

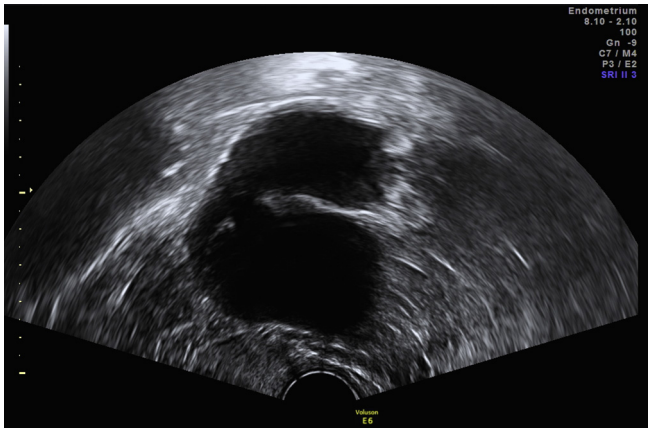

Figure 10 Hydrosalpinx.

Presence of an amniotic sac

o Measurements are taken in three planes from the centre of the amniotic membrane

Crown rump length

o The greatest length of the embryo (head to bottom) without including other intra-gestational sac structures

Fetal heart beat

o Measured using M-mode only

The earliest an intrauterine pregnancy can be seen on TVUS is 4 + 3 weeks (31 days' gestation); a small gestation sac is seen implanted below the endometrium, surrounded by a rim of trophoblast. The yolk sac is first seen at 5 + 1 (36 days), with the embryo visible at 5 + 6 (41 days). The amniotic membrane is seen at 7 + 0 (49 days).[12] Fetal heart action can usually be visualized once an embryo is visible, and fetal heart action should definitely be identified in a normal embryo measuring more than 7 mm.

Miscarriage

The diagnosis of miscarriage should be considered if an embryo is seen without fetal heart pulsations and measures over 7 mm in diameter, or when an empty gestation sac measuring 25 mm or more is found. In these cases, a second option should be sought to confirm the diagnosis of miscarriage, or the scan should be repeated in one week. If the scan is performed transabdominally it should be repeated after 14 days.

A diagnosis of pregnancy of uncertain viability is made if an empty gestation sac of <25 mm is seen, or a embryo <7 mm in diameter is measured but fetal heart pulsations are not observed. In such cases further scans are needed to assess viability.

Ultrasound findings associated with an increased risk of miscarriage include small crown rump length, enlarged yolk sac, small gestation sac diameter relative to crown rump length and bradycardic embryo.

Ectopic pregnancy

Ectopic pregnancy is defined as a pregnancy that implants outside the uterine cavity. While the fallopian tube is the most common site for ectopic pregnancy, 5% of ectopic pregnancies implant within the wall of the uterus but outside the cavity. These include interstitial, intramural, cervical and caesarean scar pregnancies.

The uterine cavity will be empty on ultrasound examination when the pregnancy is ectopic, however the diagnosis can only be made once products of conception, or a gestation sac, are seen outside the uterine cavity.

78% of ectopics are on the same side as the corpus luteum. A tubal ectopic pregnancy may appear as an homogeneous mass adjacent to but separate from the ovary (blob sign), a mass with a hyperechoic ring around a gestation sac (bagel sign) or a gestation sac with a yolk sac and/or fetal pole (Figure 11). Care must be taken to ensure the mass is separate from the ovary by applying pressure with the probe to see if the mass slides off the ovary, this is known as the sliding sign. False positives diagnoses may occur when the corpus luteum, a hydrosalpinx, or another pelvic mass are misinterpreted as being pregnancy tissue.

Another ultrasound feature associated with an ectopic pregnancy is a fluid collection within the endometrial cavity known as a pseudosac. A pseudosac can be distinguished from a gestation sac because it is avascular and will be found to lie in the midline of the uterus, between the endometrial layers. A true gestational sac is eccentrically placed within the endometrial cavity and has a hyperechoic rim. Echogenic fluid may be seen in the pouch of Douglas suggesting a ruptured ectopic pregnancy or

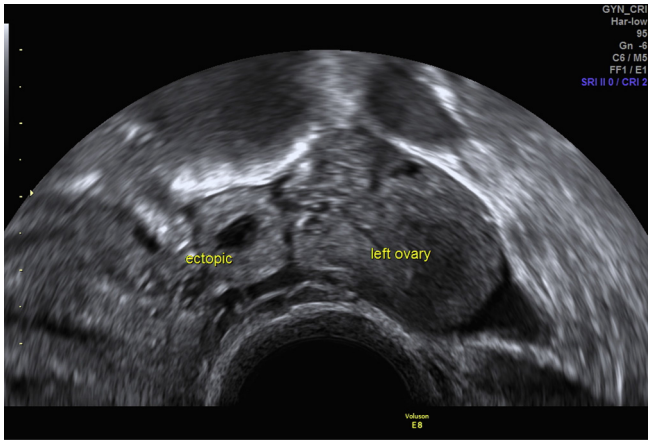

Figure 11 Left tubal ectopic pregnancy.

tubal miscarriage. If the echogenic fluid level is above the fundus of uterus, then the bleeding is considered significant.

Gestational trophoblastic disease

Molar pregnancies usually present as an early embryonic demise on ultrasound scan (Figure 12). Certain ultrasound features suggest molar pregnancy and the ability of ultrasound to identify these increases with advancing gestational age. One study demonstrated an overall ultrasound detection rate of 35–40% before 14 weeks' gestation compared to around 60% after this gestation. The ultrasound detection rate was significantly better for complete rather than partial hydatidiform moles.

The characteristic ultrasound appearance of a complete molar pregnancy is that of a uterine cavity filled with a heterogeneous mass (snow-storm appearance). Theca lutein cysts secondary to elevated βhCG may also be visible. These give the ovaries a 'soap bubble' or 'spoke wheel' appearance however they are usually only seen at more advanced gestations.

The ultrasound diagnosis of partial molar pregnancy is more challenging; a non-viable fetus with cystic spaces in the placenta is suggestive of partial molar pregnancy (Figure 13). Ratios of transverse to anteroposterior diameters of the gestation sac of over 1.5 are also more commonly seen in partial molar pregnancies.

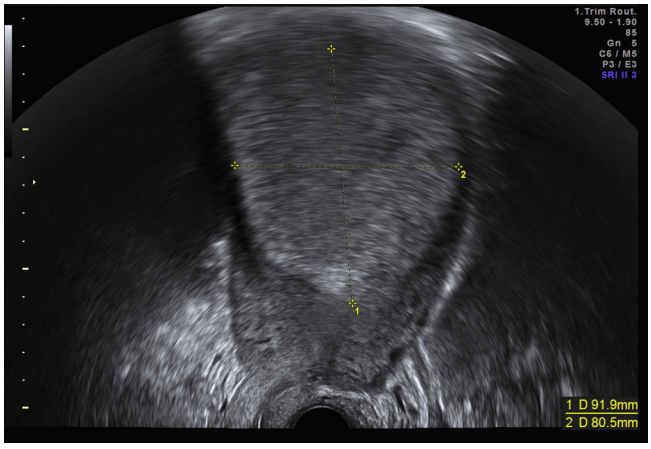

Figure 12 –Complete molar pregnancy; arrow highlights snowstorm appearance.

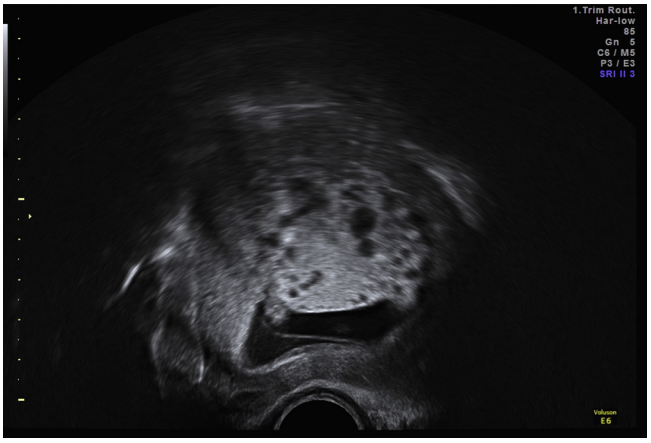

Figure 13 Partial molar pregnancy; arrow highlights cystic spaces in placenta.

Obstetric ultrasound

Fetal anatomy

Ultrasound screening for fetal anomalies was introduced in the UK in the late 1970s and has now become part of routine antenatal care. Up to 5% of babies are born with a congenital abnormality. Ultrasound for fetal anomalies at the 11–14 and 18–23 week scans improves the accuracy of screening and diagnosis. The main anomalies detected at the second trimester scan are those of the central nervous system, the heart, the renal, abdominal wall and gastrointestinal system.

A detailed anomaly scan includes a systematic examination of: the head, spine, chest, abdominal wall and its contents, limbs and the soft markers.

The head: Ultrasound assessment of the head includes the skull bones, brain, orbits, lips, facial profile and the ears. When examining the cranium the outline and the oval shape should be assessed. The brain is visualized in three planes:

- Transthalamic: to measure the BPD (bi-parietal diameter) and head circumference (HC), assess thalamic nuclei, third ventricle and cavum septum pellucidum
- Transcerebellar: to estimate the transcerebellar diameter (TCD) and visualize cerebellar hemispheres and cisterna magna (should measure no more than 10 mm).
- Transventricular: assessing the lateral cerebral ventricles and choroid plexus. The posterior horn of the lateral ventricles should measure no more than 10 mm.

At 20 weeks' gestation the inter-orbital distance is equal to the ocular diameter. This is a useful tool to diagnose hyper- and hypotelorism. Assessment of lips in coronal plane with nasal tip is important to diagnose facial clefting.

Examination of the spine requires identification of the three primary ossification centres of the vertebra, from cervical spine caudally to the sacrum. The spine should be viewed in all three planes, where possible. Assessing the integrity of the skin overlying the spinal column in a sagittal view is key in diagnosing spina bifida.

The thorax: Examination focuses on cardiac situs, the four chamber heart and the outflow tracts, the lung fields and the diaphragm.

Cardiac assessment necessitates confirming the following;

- Left atrium nearest to the fetal spine
- Right atrium nearest to the chest wall
- Atria appear equal in size, as do the ventricles
- The atrioventricular septum and the valves appears as an offset cross, with no defects in the ventricular septum
- The outflow tracts are of normal origin, size and orientation
- A normal three vessel and trachea view
- Normal aortic and pulmonary arches

The lung fields are expected to appear homogeneous. Cystic spaces are suggestive of diaphragmatic hernia or cystic adenomatous malformation. A rim of fluid surrounding the lungs represents a pleural effusion.

The abdomen: Systematic assessment and visualization of the integrity of the abdominal wall, particularly at the cord insertion, is necessary to diagnose exomphalos (a central defect into the base of the umbilical cord, with an intact peritoneal sac) and gastroschisis (where the defect usually lies to the right of the umbilical cord insertion and the externalized loops of bowel are not contained within a membrane).

The size, location and echogenicity of the kidneys and the anteroposterior diameter of the renal pelvis should be determined. A renal AP pelvic diameter of up to 7 mm is considered normal, but serious pathology is unlikely below 10 mm.

Failure to repeatedly see fluid in the stomach is suggestive of oesophageal atresia and the 'double-bubble' sign points to duodenal atresia. Echogenic bowel can indicate cystic fibrosis or viral infection, and dilated bowel loops may be a sign of volvulus, bowel atresias or duplication cysts.

Failure to visualize the bladder raises the possibility of bladder exstrophy, and a very large thick walled bladder may be a sign of LUTO (lower urinary tract obstruction), particularly if associated with oligohydramnios.

All four limbs should be identified, and seen to be symmetrical, including feet and hands. Abnormal hand and feet (talipes) positioning is a key feature of a variety of genetic syndromes and associations. The femur is the only long bone which is routinely measured, but the humerus, radius, ulna, tibia and fibula should be identified on each side. If the femurs look straight and measure in the normal range, skeletal dysplasia is mostly excluded. If the femur length is below the 5th centile, then all long bones should be measured. Short long bones are a key feature of skeletal dysplasias, particularly if bowed, but can also be a marker for fetal growth restriction and aneuploidy (Down syndrome).

Cervical assesment

TVUS can be used to assess cervical length, dilatation and funneling. A cervical length of less than 25 mm is associated with an elevated risk of preterm labour and ultrasound can be used in the second trimester in symptomatic and asymptomatic women to assess the risk of premature delivery.

The placenta

Obstetric ultrasound should routinely comment on the appearance and location of the placenta and its proximity to the internal os. The term placenta praevia should not really be used until the late second or third trimester is reached, with 'low-lying placenta' being a better term to use until the lower segment is really establishing itself (usually said to be from approximately 28 weeks' gestation). A placenta completely covering or overlapping the internal os after that time is described as a major placenta praevia. When the lower placental edge is within 2 cm of the internal os, but not reaching the os, a minor placenta praevia is diagnosed. Transvaginal scan improves the accuracy of placental localization and is safe, so the finding of a probably low lying placenta after 16 weeks' gestation by abdominal scan should be confirmed by a transvaginal scan at some point, ideally 32 weeks if there has been no bleeding prior to that time. Ultrasound may diagnose vasa praevia and abnormal placental invasion, although these conditions usually need to be specifically sought-out in pregnancies at risk. The umbilical cord and the number of vessels should also be documented.

Amniotic fluid

Assessment should identify the deepest pool of liquor. This is measured in the area without limbs and umbilical cord and is called the maximum vertical pool (MVP). An alternative assessment is the Amniotic Fluid Index (AFI) which is calculated by adding together the deepest vertical pockets found in each quadrant of the uterus (Table 3).

Fetal growth

Commonly utilized biometric measurements of the fetus include the head circumference (HC), abdominal circumference (AC) and femur length (FL). A variety of formulae are available which translate these measurements into an estimated fetal weight for that gestation. Centile charts are available for these measurements, and these may be customized to ethnicity and maternal characteristics. Much controversy exists surrounding the use of fetal biometry in diagnosing fetal growth restriction and identifying the unborn baby at risk. Biometric measurements may also reveal a large for gestational age fetus, although uncertainty prevails regarding the optimum management in the absence of diabetes.

Doppler

Doppler assessment can demonstrate relative or absolute blood flow velocities in the fetoplacental and uteroplacental circulations. Resistance to flow through these vessels, or the absolute speed of flow, can be determined and this information can be used to risk assess pregnancies, and monitor pregnancies where

Amniotic fluid

Diagnosis	MVP	AFI
Oligohydramnios	<2 cm	<5 cm
Reduced	2–3 cm	5–10 cm
Normal	3–8 cm	10–20 cm
Polyhydramnios	>8 cm	>25 cm

Table 3

the fetus is small for gestational age. Absolute velocities in the middle cerebral artery can be used to screen for fetal anaemia.

Conclusion

Ultrasound is an invaluable tool in the assessment of patients in gynaecology and during pregnancy. Ultrasound should not replace, but rather complement, clinical assessment. The validity of the information obtained depends on the experience of the operator as well as their understanding of the principles of ultrasound. ◆

FURTHER READING

AIUM practice guidelines for the performance of Obstetric Ultrasound Examination. available online at: http://www.aium.org/resources/guidelines/obstetric.pdf.

Condous G, Timmerman D, Goldstein S, Valentin L, Jurkovic D, Bourne T. Pregnancies of unknown location: consensus statement. *Ultrasound ObstetGynecol* 2006; **28:** 121–2.

Ectopic pregnancy and miscarriage: diagnosis and initial management in early pregnancy of ectopic pregnancy and miscarriage. NICE guidance CG154.

Endometrial Hyperplasia, RCOG Green-top guideline No. 67 – 26/2/2016.

Fetal anomaly screening programme (FASP): NHS fetal anomaly screening programme handbook valid from August 2018.

Jurkovic D, Gruboeck K, Campbell S. Ultrasound features of normal early pregnancy development. *Current Opinion in Obstetrics and Gynaecology* 1995; **7:** 493.

Levi S, Hyjaz Y, Schaaps JP, Defoort P, Coulon R, Bueckens P. Sensitivity and specificity of routine antenatal screening for congenital anomalies by ultrasound: the Belgian Multicentric Study. *Ultrasound ObstetGynecol* 1991; **1:** 102–10.

RCOG/BSGE joint Guideline. Management of suspected ovarian masses in premenopausal women, RCOG Green-top guideline No. 62, November 2011.

Obstetric and Gynaecological Ultrasound Made Easy, 2e by Norman C. Smith MD FRCOG. 2 edition. Churchill Livingstone, 2005.

Ovarian cysts in postmenopausal women, RCOG Green-top guideline No. 34 – 19/7/2016.

Pathak S, Lees C. Ultrasound structural fetal anomaly screening: an update. *Arch Dis Child Fetal Neonatal Ed* 2009; **94:** F384–90. Published Online First: 22 March 2009.

Placenta praevia and placenta accreta: diagnosis and management, RCOG Green-top Guideline No. 27a, 27/9/2018

P. Schwärzler, M.-V. Senat, D. Holden, J. P. Bernard, T. Masroor and Y. Ville, Feasibility of the second-trimester fetal ultrasound examination in an unselected population at 18, 20 or 22 weeks of pregnancy: a randomized trial, Fetal Medicine Unit, St. George's Hospital Medical School, London, UK

Timmerman D, Valentin L, Bourne TH, et al. Terms, definitions and measurements to describe the sonographic features of adnexal tumors: a consensus opinion from the International Ovarian Tumor Analysis (IOTA) Group. *Ultrasound Obstet Gynecol* 2000; **5:** 500–5.

Ultrasound from conception to 10+0 weeks gestation. *Scientific impact paper* 13/15/2015; **49**.

Practice points

- Understanding the principles of ultrasound and adjusting the machine to allow for patient factors such as BMI will enable operators to optimize image quality and the information obtained.
- Adopting a systematic approach when performing ultrasound will ensure that important or unexpected findings are not missed. If an abnormality is identified early in the scan it is often useful to assess this at the end of the scan to avoid missing co-existing pathology.
- Ultrasonographers should be aware of the ultrasound safety settings including mechanical and thermal indices particularly during ultrasound in pregnancy.
- Standardising terminology and adopting simple ultrasound rules can aid ultrasonographers in distinguishing benign and malignant adnexal lesions.
- Ultrasound should be viewed as an adjunct to clinical examination, not an alternative.