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OVERVIEW

Ultrasound is the principal imaging modality used in obstetrics. Indeed, diagnostic ultrasound is used to screen all pregnancies in most developed countries. Ultrasound is used to date pregnancies and chart antenatal growth of the fetus and to identify congenital abnormalities. Colour and spectral Doppler can identify placental and fetal blood vessels and provide information on placental function and the fetal circulatory response to hypoxia.

Antenatal tests of fetal well-being are now principally based on ultrasound techniques and are designed to identify the fetuses that are in the early or late stages of fetal hypoxia. Continuous wave Doppler ultrasound is employed to provide continuous tracings of the fetal heart rate, the patterns of which alter when the fetus is hypoxic.

Three-dimensional ultrasound and increasingly magnetic resonance imaging (MRI) are used to provide further information when a fetal abnormality is suspected.

Diagnostic ultrasound in obstetric practice

In 1959, Professor Ian Donald, the Regius Chair of Midwifery at Glasgow University, noted that clear echoes could be obtained from the fetal head using ultrasound. Since the reporting of this initial discovery, the technique of ultrasound has developed into one which now plays an essential role in the care of nearly every pregnant woman in the developed world.

The ultrasound technique uses very high frequency sound waves of between 3.5 and 7.0 mega hertz emitted from a transducer. Transducers can be placed and moved across the maternal abdomen (transabdominal, Figure 6.1) or mounted on a probe which can be inserted into the vagina (transvaginal, Figure 6.2)

Transvaginal ultrasonography is useful in early pregnancy, for examining the cervix later in pregnancy and for identifying the lower edge of the placenta. It is also useful in early pregnancy in women with significant amounts of abdominal adipose tissue through which abdominal ultrasound waves would need to travel and



Figure 6.1 Ultrasound probe; abdominal

hence be attenuated prior to reaching the uterus and its contents, making visualization difficult. In general, however, after 12 weeks gestation, an abdominal transducer, which is a flat or curvilinear probe with a



Figure 6.2 Ultrasound probe; trans vaginal

much wider array, is used. Crystals within the transducer emit a focused ultrasound beam in a series of pulses and then receive the reflected signals from within the uterus between the pulses. The strength of the reflected sound wave depends on the difference in 'acoustic impedance' between adjacent structures. The acoustic impedance of a tissue is related to its density; the greater the difference in acoustic impedance between two adjacent tissues the more reflective will be their boundary. The returning signals are transformed into visual signals and generate a continuous picture of the moving fetus. Movements such as fetal heart beat and malformations in the fetus can be assessed and measurements can be made accurately on the images displayed on the screen. Such measurements enable the assessment of gestational age, size and growth in the fetus. Ultrasound images obtained can also be processed with computer software to produce three-dimensional (3D) images and even four-dimensional (moving 3D images) which provide more detail on fetal anatomical structure and the identification of anomalies.

The use of Doppler ultrasound allows the assessment of the velocity of blood within fetal and placental vessels and provides indirect assessment of fetal and placental condition. Doppler ultrasound makes use of the phenomenon of the Doppler frequency shift, where the reflected wave will be at a different frequency from the transmitted one if it interacts with moving structures, such as red blood cells flowing along a blood vessel with the change in

frequency being proportional to the velocity of the blood cells. If the red blood cells are moving towards the beam, the reflected signal will be at a higher frequency than the transmitted one and conversely the reflected beam will be at a lower signal if the flow is away from the beam. In this modality, signals from a particular vessel can be isolated and displayed in graphic form, with the velocity plotted against time. The significance of changes observed in waveform patterns obtained from placental and fetal vessels and how these observations can be used in clinical practice will be discussed later in the chapter.

Ultrasound scanning is currently considered to be a safe, non-invasive, accurate and cost-effective investigation in the fetus. This chapter will consider the diagnostic use of these techniques in more detail.

Clinical applications of ultrasound

The main uses of ultrasonography in pregnancy are in the areas discussed below.

Diagnosis and confirmation of viability in early pregnancy

The gestational sac can be visualized from as early as 4–5 weeks of gestation and the yolk sac at about 5 weeks (Figure 6.3). The embryo can be observed and measured at 5–6 weeks gestation. A visible heartbeat can be visualized by about 6 weeks.

Transvaginal ultrasound plays a key role in the diagnosis of disorders of early pregnancy, such as incomplete or missed miscarriage, blighted ovum where no fetus is present (Figure 6.4) and ectopic



Figure 6.3 Ultrasound sac showing yolk sac (ys) and embryo (e) with the vitelline duct (vd)

pregnancy. In a missed miscarriage, for example, the fetus can be identified, but with an absent fetal heart and in a blighted ovum, the absence of fetal development results in the presence of a gestational sac which is empty. An ectopic pregnancy is suspected if, in the presence of a positive pregnancy test, an ultrasound scan does not identify a gestation sac within the uterus, there is an adnexal mass with or without a fetal pole, or there is fluid in the pouch of Douglas.

Determination of gestational age and assessment of fetal size and growth

Up to approximately 20 weeks gestation the range of values around the mean for measurements of fetal length, head size and long bone length is narrow and hence assessment of gestation based on these measures is accurate. The crown-rump length (CRL) is used up to 13 weeks + 6 days, and the head circumference (HC) from 14 to 20 weeks gestation. The biparietal diameter (BPD) (Figure 6.5) and femur length (FL) (Figure 6.6) can also be used to determine gestational age. Essentially, the earlier the measurement is made, the more accurate the prediction, and measurements made from an early CRL (accuracy of prediction \pm 5 days) will be preferred to a biparietal diameter at 20 weeks (accuracy of prediction \pm 7 days).

In the latter part of pregnancy, measuring fetal abdominal circumference (AC) (Figure 6.7) and HC will allow assessment of the size and growth of the fetus and will assist in the diagnosis and management

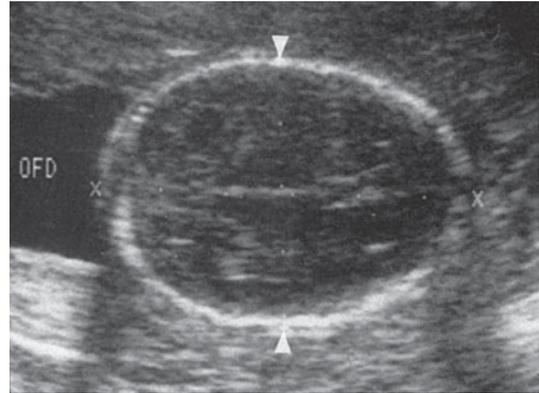


Figure 6.5 Biparietal diameter (BPD)

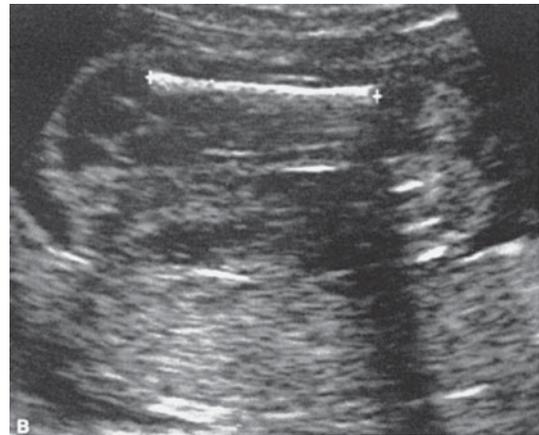


Figure 6.6 Femur length (FL)



Figure 6.4 Ultrasound image showing empty gestation sac in a case of blighted ovum

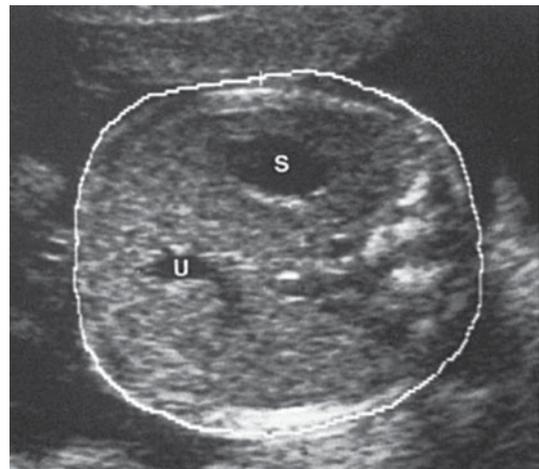


Figure 6.7 Abdominal circumference (AC) measurement demonstrating the correct section showing the stomach (S) and the umbilical vein (U)

of fetal growth restriction. In addition to AC and HC, BPD and FL, when combined in an equation, provide a more accurate estimate of fetal weight (EFW) than any of the parameters taken singly.

In pregnancies at high risk of fetal growth restriction (FGR), serial measurements are plotted on the normal reference range. Growth patterns are helpful in distinguishing between different types of growth restriction (symmetrical and asymmetrical). Asymmetry between head measures (BPD, HC) and AC can be identified in FGR, where a brain-sparing effect will result in a relatively large HC compared with the AC (Figure 6.8). The opposite would occur in a diabetic pregnancy, where the abdomen is disproportionately large due to the effects of insulin on the fetal liver and fat stores. Cessation of growth is an ominous sign of placental failure.

Gestational age cannot be accurately calculated by ultrasound after 20 weeks gestation because of the wider range of normal values of AC and HC around the mean.

Multiple pregnancy

Ultrasound is now the most common way in which multiple pregnancies are identified (Figure 6.9). In

addition to identifying the presence of more than one fetus, it can also be used to determine the chorionicity of the pregnancy.

Monochorionic twin pregnancies (i.e. those who 'share' a placenta) are associated with an increased risk of pregnancy complications and a higher perinatal mortality rate than dichorionic twin pregnancies. It is therefore clinically useful to be able to determine chorionicity early in pregnancy (see Chapter 9, Twins and higher multiple gestations).

The dividing membrane in monochorionic twins is formed by two layers of amnion and in dichorionic twins by two layers of chorion and two of amnion. Dichorionic twins therefore have thicker membranes than monochorionic twins and this can be perceived qualitatively on ultrasound. Ultrasonically, dichorionic twin pregnancies in the first trimester of pregnancy have a thick inter-twin separating membrane (septum), flanked on either side by a very thin amnion. This is in contrast to a monochorionic twin pregnancy, which on two-dimensional ultrasound has a very thin inter-twin septum.

Another method of determining chorionicity in the first trimester uses the appearance of the septum at its origin from the placenta. On ultrasound, a

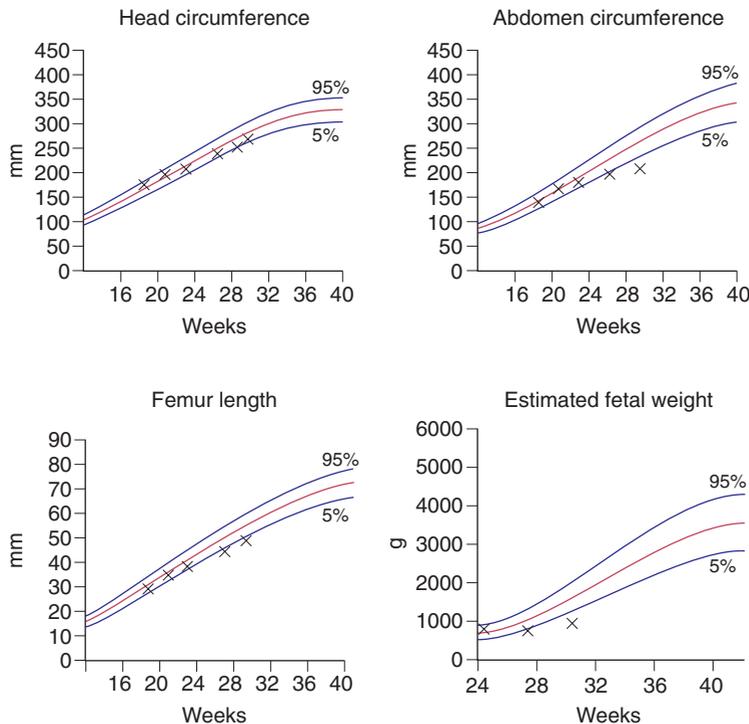


Figure 6.8 Ultrasound plots on reference range for head circumference (HC), abdominal circumference (AC) and estimated fetal weight (EFW) in a case of early onset fetal growth restriction (FGR). Note that HC remains above 5th centile while the AC falls below 5th centile. This is a case of asymmetric FGR with head sparing

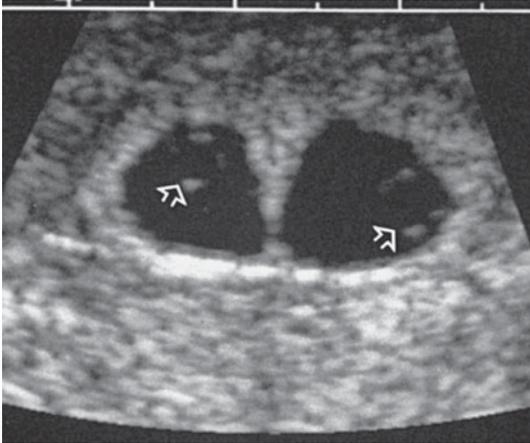


Figure 6.9 Early twin dichorionic pregnancy; note the 'peaked' inter twin membrane

tongue of placental tissue is seen within the base of dichorionic membranes and has been termed the 'twin peak' or 'lambda' sign. The optimal gestation at which to perform such ultrasonic chorionicity determination is 9–10 weeks. Dichorionicity will also be confirmed by the identification of two placental masses and later in pregnancy by the presence of different-sex fetuses.

Ultrasound is also invaluable in the management of twin pregnancy in terms of confirming fetal presentations, which may be difficult on abdominal palpation, evidence of growth restriction, fetal anomaly and the presence of placenta praevia, all of which are more common in this type of pregnancy, and any suggestion of twin-to-twin transfusion syndrome.

Diagnosis of fetal abnormality

Major structural abnormalities occur in 2–3 per cent of pregnancies and many can be diagnosed by an ultrasound scan at around or before 20 weeks gestation. Common examples include spina bifida and hydrocephalus, skeletal abnormalities such as achondroplasia, abdominal wall defects such as exomphalos and gastroschisis, cleft lip/palate and congenital cardiac abnormalities.

Detection rates of between 40 and 90 per cent have been reported. This means that a 'normal scan' is not a guarantee of a normal baby. A number of factors can influence the success of detecting an abnormality. Some are very difficult to visualize or to be absolutely certain about. Some conditions, for

example hydrocephalus, may not have been obvious at the time of early scans. The position of the baby in the uterus will influence visualization of organs such as the heart, face and spine. Repeat scans are sometimes required if visualization is a problem in anticipation that the fetus will be in a more accessible position.

First trimester ultrasonic 'soft' markers for chromosomal abnormalities such as the absence of fetal nasal bone, an increased fetal nuchal translucency (the area at the back of the neck) are now in common use to enable detection of fetuses at risk of chromosomal anomalies such as Down's syndrome.

Placental localization

Placenta praevia can cause life-threatening haemorrhage in pregnancy. Ultrasonography has become indispensable in the localization of the site of the placenta and thus ultrasonographic identification of the lower edge of the placenta to exclude or confirm placenta praevia as a cause for antepartum haemorrhage is now a part of routine clinical practice. The transvaginal approach, undertaken with caution, can be helpful in clearly identifying the lower placental edge if not seen clearly with an abdominal probe.

At the 20 weeks scan, it is customary to identify women who have a low-lying placenta. At this stage, the lower uterine segment has not yet formed and most low-lying placentas will appear to 'migrate' upwards as the lower segment stretches in the late second and third trimesters. About 5 per cent of women have a low-lying placenta at 20 weeks, and only 5 per cent of this group will eventually be shown to have a placenta praevia.

Amniotic fluid volume assessment

Ultrasound can be used to identify both increased and decreased amniotic fluid volumes. The fetus has a role in the control of the volume of amniotic fluid. It swallows amniotic fluid, absorbs it in the gut and later excretes urine into the amniotic sac. Congenital abnormalities that impair the fetus's ability to swallow, for example anencephaly or oesophageal atresia, will result in an increase in amniotic fluid. Congenital abnormalities that result in a failure of urine production or passage, for example renal agenesis and posterior urethral valves, will result in reduced or absent amniotic fluid. Fetal growth restriction can be associated with reduced amniotic

fluid because of reduced renal perfusion and hence urine output. Variation from the normal range of amniotic fluid volume calls for a further detailed ultrasound assessment of possible causes.

Assessment of fetal well-being

Ultrasound can be used to assess fetal well-being by evaluating fetal movements, tone and breathing in the Biophysical Profile. Doppler ultrasound can be used to assess placental function and identify evidence of blood flow redistribution in the fetus, which is a sign of hypoxia. These aspects of ultrasound use will be discussed later in the chapter.

Measurement of cervical length

Evidence suggests that approximately 50 per cent of women who deliver before 34 weeks gestation will have a short cervix. The length of the cervix can be assessed using transvaginal scanning.

Other uses

Ultrasonography is also of value in other obstetric conditions such as:

- confirmation of intrauterine death;
- confirmation of fetal presentation in uncertain cases;
- diagnosis of uterine and pelvic abnormalities during pregnancy, for example fibromyomata and ovarian cysts.

Scanning schedule in clinical practice

The National Institute for Health and Clinical Excellence (NICE) recommend that all pregnant women should be offered scans at between 10 and 14 weeks and 18 and 21 weeks gestation (Antenatal Care: Routine Care for the Healthy Pregnant Woman, 2008). The earlier scan is principally to determine gestational age, to detect multiple pregnancies and to determine nuchal translucency as part of screening for Down's syndrome. The 18–21 week scan primarily screens for structural anomalies. Scans performed after this stage in pregnancy are only performed if there is a clinical indication such as concern about fetal growth or well-being, discussed later in the chapter. Evidence suggests that routine ultrasound in early

pregnancy appears to enable better gestational age assessment, earlier detection of multiple pregnancies and earlier detection of clinically unsuspected fetal malformation at a time when termination of pregnancy is possible.

Ultrasound in the assessment of fetal well-being

Amniotic fluid volume

The amount of amniotic fluid in the uterus is a guide to fetal well-being in the third trimester. The influence of congenital abnormalities on amniotic fluid volume in early pregnancy has already been described.

A reduction in amniotic fluid volume is referred to as 'oligohydramnios' and an excess is referred to as 'polyhydramnios'. Definitions of oligohydramnios and polyhydramnios are based on sonographic criteria. Two ultrasound measurement approaches give an indication of amniotic fluid volume. These are maximum vertical pool and amniotic fluid index.

The maximum vertical pool is measured after a general survey of the uterine contents. Measurements of less than 2 cm suggest oligohydramnios, and measurements of greater than 8 cm suggest polyhydramnios.

The Amniotic Fluid Index (AFI) is measured by dividing the uterus into four 'ultrasound' quadrants. A vertical measurement is taken of the deepest cord free pool in each quadrant and the results summated. The AFI alters throughout gestation, but in the third trimester it should be between 10 and 25 cm; values below 10 cm indicate a reduced volume and those below 5 cm indicate oligohydramnios, while values above 25 cm indicate polyhydramnios.

Amniotic fluid volume is decreased in fetal growth restriction as a consequence of redistribution of fetal blood away from the kidneys to vital structures such as the brain and heart with a consequent reduction in renal perfusion and urine output.

The cardiotocograph

The cardiotocograph (CTG) is a continuous tracing of the fetal heart rate used to assess fetal well-being. The Doppler effect detects fetal heart motion and allows the interval between successive beats to be measured, thereby allowing a continuous

assessment of fetal heart rate. Fetal cardiac behaviour is regulated through the autonomic nervous system and by vasomotor, chemoceptor and baroreceptor mechanisms. Pathological events, such as fetal hypoxia, modify these signals and hence cardiac response including variation in heart rate patterns, which can be detected and recorded in the CTG. Features which are reported from a CTG to define normality and identify abnormality and potential concern for fetal well-being include the:

- baseline rate;
- baseline variability;
- accelerations;
- decelerations;

and each of these is discussed further below.

Interpretation of the CTG must be in the context of any risk factors, for example suspected FGR, and all features must be considered in order to make a judgement about the likelihood of fetal compromise.

The recording is obtained with the pregnant woman positioned comfortably in a left lateral or semi-recumbent position to avoid compression of the maternal vena cava. An external ultrasound transducer for monitoring the fetal heart and a tocodynamometer (stretch gauge) for recording uterine activity are secured overlying the uterus. Recordings are then made for at least 30 minutes with the output from the CTG machine producing two 'lines', one a tracing of fetal heart rate and a second a tracing of uterine activity.

Baseline fetal heart rate

The normal fetal heart rate at term is 110–150 bpm. Higher rates are defined as fetal tachycardia and lower rates fetal bradycardia. The baseline fetal heart rate falls with advancing gestational age as a result of maturing fetal parasympathetic tone and prior to term 160 bpm is taken as the upper limit of normal. The baseline rate is best determined over a period of 5–10 minutes. Fetal tachycardias can be associated with maternal or fetal infection, acute fetal hypoxia, fetal anaemia and drugs such as adrenoceptor agonists, for example ritodrine.

Baseline variability

Under normal physiological conditions, the interval between successive heart beats (beat-to-beat) varies. This is called 'short-term variability' and increases

with increasing gestational age. It is not visible on a standard CTG but can be measured with computer-assisted analysis. In addition to these beat-to-beat variations in heart rate, there are longer-term fluctuations in heart rate occurring between two and six times per minute. This is known as 'baseline variability'. Normal baseline variability reflects a normal fetal autonomic nervous system. Baseline variability is considered abnormal when it is less than 10 beats per minute (bpm) (Figure 6.10). As well as gestational age, baseline variability is modified by fetal sleep states and activity, and also by hypoxia, fetal infection and drugs suppressing the fetal central nervous system, such as opioids, and hypnotics (all of which reduce baseline variability). As fetuses display deep sleep cycles of 20–30 minutes at a time, baseline variability may be normally reduced for this length of time, but should be preceded and followed by a period of trace with normal baseline variability.

Fetal heart rate accelerations

These are increases in the baseline fetal heart rate of at least 15 bpm, lasting for at least 15 seconds. The presence of two or more accelerations on a 20–30-minute CTG defines a reactive trace and is indicative of a non-hypoxic fetus, i.e. they are a positive sign of fetal health.

Fetal heart rate decelerations

These are transient reductions in fetal heart rate of 15 bpm or more, lasting for more than 15 seconds. Decelerations can be indicative of fetal hypoxia or umbilical cord compression. There is a higher chance of hypoxia being present if there are additional abnormal features such as reduced variability or baseline tachycardia (Figure 6.11).

From the above descriptions, a normal antepartum fetal CTG can therefore be defined as a baseline of 110–150 bpm, with baseline variability exceeding 10 bpm, and with more than one acceleration being seen in a 20–30 minute tracing. Reduced baseline variability, absence of accelerations and the presence of decelerations are all suspicious features. A suspicious CTG must be interpreted within the clinical context. If many antenatal risk factors have already been identified, a suspicious CTG may warrant delivery of the baby, although where no risk factors exist, a repeated investigation later in the day may be more appropriate (Figure 6.12).

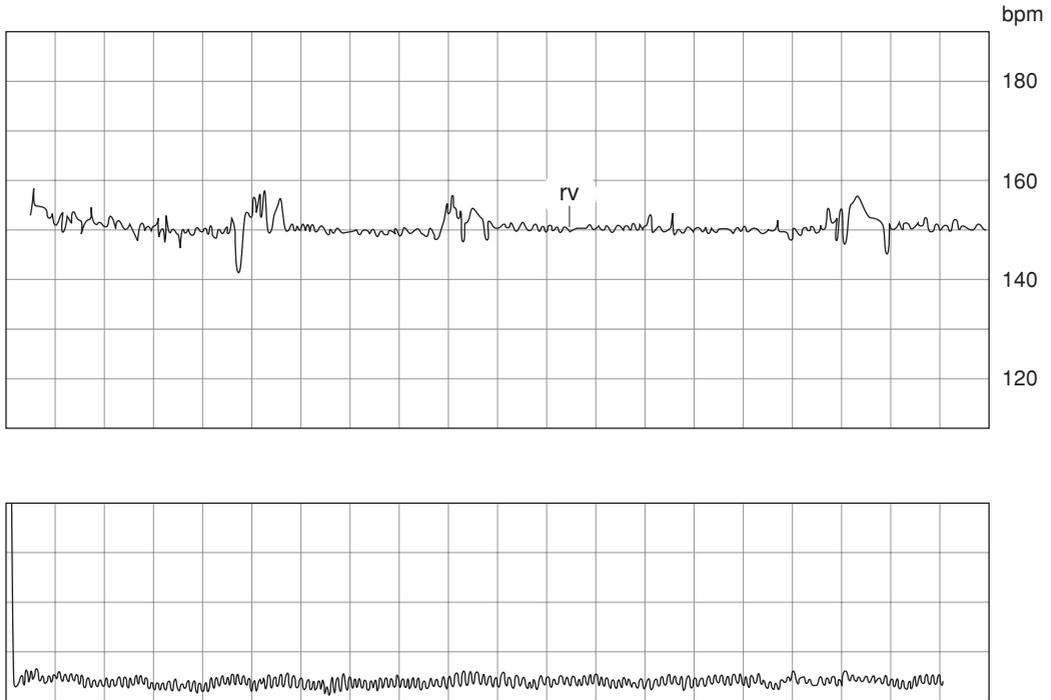


Figure 6.10 A fetal cardiogram showing a baseline of 150 beats per minute (bpm) but with reduced variability (rv)

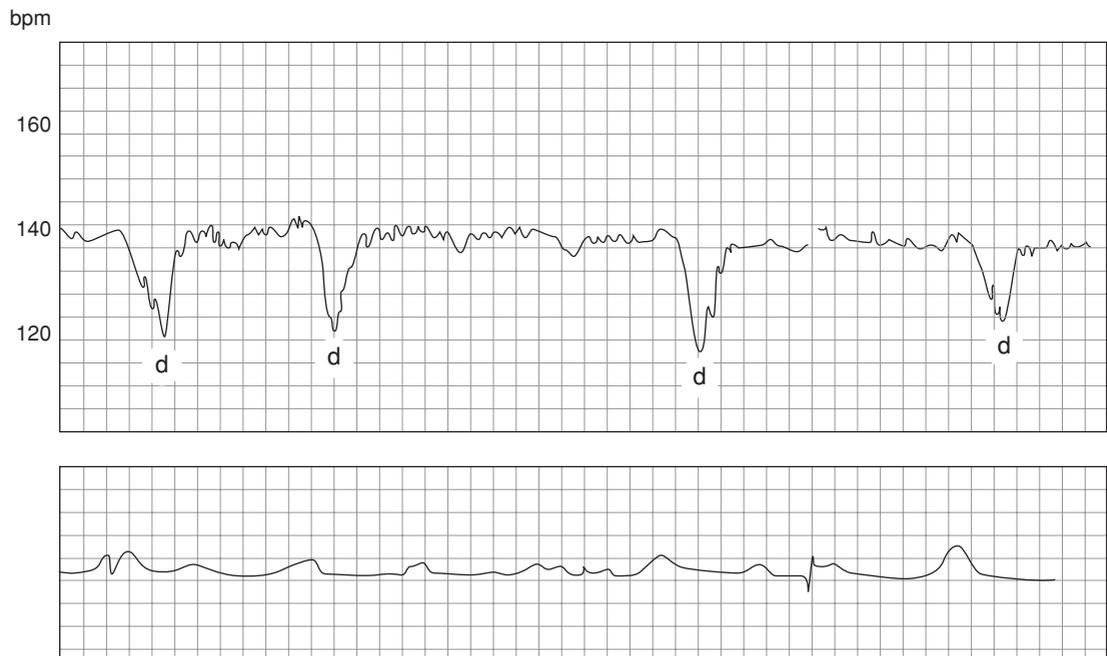


Figure 6.11 An admission cardiogram from a term pregnancy. Although the baseline fetal heart rate is normal, there is reduced variability, an absence of fetal heart rate accelerations, and multiple decelerations (d). The decelerations were occurring after uterine tightening and are therefore termed 'late'

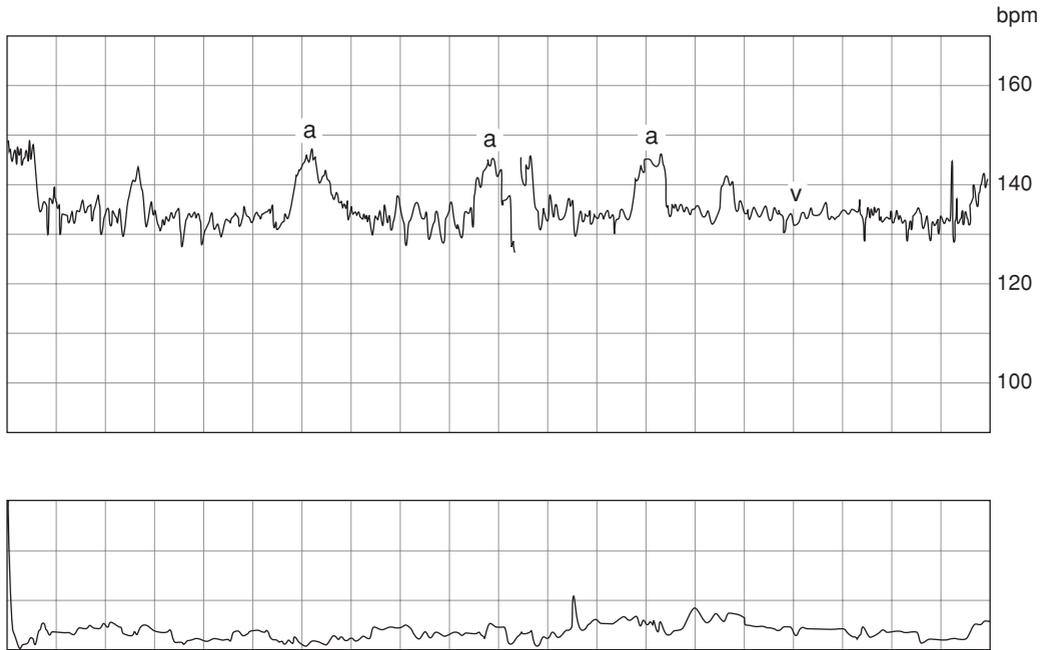


Figure 6.12 A normal fetal cardiocotograph showing a normal rate, normal variability (v), and the presence of several accelerations (a)

The computerized cardiocotograph

The basis of fetal CTG is pattern recognition, and this leads to differences in interpretation amongst different clinicians. Computerized CTG interpretation packages have been developed. These packages have been shown to be equal (or superior) to human interpretation in differentiating normal from abnormal outcome.

Biophysical profile

In an effort to refine the ability of fetal CTG to identify antenatal hypoxia, investigators have looked at additional fetal parameters such as fetal breathing movements, gross body movements, flexor tone and accelerations in fetal heart rate related to movements, all of which are abolished in the hypoxic state. A biophysical profile is a long (30 minute) ultrasound scan which observes fetal behaviour, measures amniotic fluid volume and includes a CTG. By assigning each of the active variables, and also amniotic fluid volume and the CTG scores of either 2 (normal) or 0 (suboptimal), it is possible to assign an individual fetus score of between 0 and 10. A score of 0, 2 or 4 is considered abnormal and a score of 8 or 10 normal. A score of 6 is equivocal and requires

repeat within a reasonable timescale (hours) to exclude a period of fetal sleep as a cause. This is the basis of fetal biophysical profiling (Figure 6.13).

Early observational studies suggested that delivery at a score of less than 6 was associated with a lower perinatal mortality than in similar high risk

| Parameter | Score 2 | Score 0 |
|---------------------------|---|---|
| Non-stress CTG | Reactive | Fewer than two accelerations in 40 minutes |
| Fetal breathing movements | ≥30 seconds in 30 minutes | Less than 30 seconds of fetal breathing in 30 minutes |
| Fetal body movements | ≥3 movements in 30 minutes | Two or fewer gross body movements in 30 minutes |
| Fetal tone | One episode of limb flexion | No evidence of fetal movement or flexion |
| Amniotic fluid volume* | Largest cord-free pocket of fluid over 1 cm | Less than 1 cm pocket of fluid |

Figure 6.13 Biophysical profile scoring system

pregnancies in which biophysical profiles (BPPs) were not performed. However, despite this early promise, widespread use did not occur. There appear to be several reasons for this lack of implementation. Biophysical profiles can be time consuming. Fetuses spend approximately 30 per cent of their time asleep, during which time they are not very active and do not exhibit breathing movements. It is therefore necessary to scan them for long enough to exclude this physiological cause of a poor score. Another problem with fetal BPPs is that by the time a fetus develops an abnormal score prompting delivery, it is likely to already be severely hypoxic. While delivery may reduce the perinatal death rate (death *in utero*, or within the first week of life), it may not increase long-term survival and, in particular, survival without significant mental and physical impairment.

More recent evidence in the form of a meta-analysis however, which included five trials involving 2974 women, found no significant differences between the groups in respect of perinatal deaths or poor fetal condition at birth as assessed by an Apgar score less than seven at 5 minutes. The authors concluded that there is currently insufficient evidence from randomized trials to support the use of BPP as a test of fetal well-being in high-risk pregnancies.

Doppler investigation

The principles of Doppler have already been discussed. Waveforms can be obtained from both the umbilical and fetal vessels. Data obtained from the umbilical artery provide indirect information about placenta function, whereas data from the fetal vessels provide information on the fetal response to hypoxia.

Umbilical artery

Waveforms obtained from the umbilical artery provide information on placental resistance to blood flow and hence indirectly placenta 'health' and function. An infarcted placenta secondary to maternal hypertension, for example, will have increased resistance to flow. A normal umbilical arterial waveform is shown in Figure 6.14. This is a plot obtained using Doppler ultrasound of velocity of blood flow against time and demonstrates forward flow of blood throughout the whole cardiac cycle, i.e. including diastole. A useful analogy to understand the concept of umbilical Doppler and placental resistance is to consider the umbilical artery as a hose carrying

water towards a placenta which in a healthy pregnancy will act like a sponge and in an infarcted placenta will act more like a brick wall. So, with a normal pregnancy blood will flow through the placenta without difficulty like water from a hose directed at the sponge and will pass straight through the sponge, whereas in a diseased placenta the blood will reflect back from the high resistance placenta like water from a hose being directed back from the wall at which it is directed. In the former, the normal constant forward flow in diastole will be seen and in the abnormal absent or reversed diastolic flow will be seen (Figure 6.15).

Most studies investigating the value of using this technique in clinical practice have looked at resistance to flow, which is reflected in the diastolic component. A small amount of diastolic flow implies high resistance downstream to the vessel being studied and implies low perfusion (Figure 6.16). A high diastolic component indicates low downstream resistance and

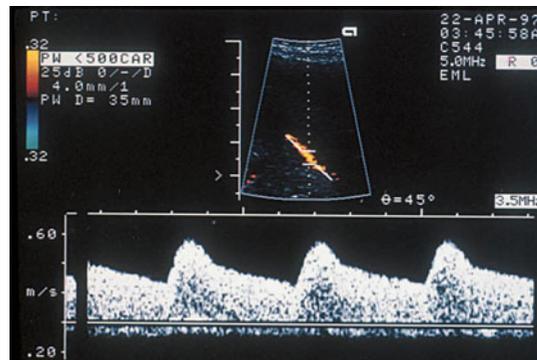


Figure 6.14 Normal umbilical arterial Doppler waveform

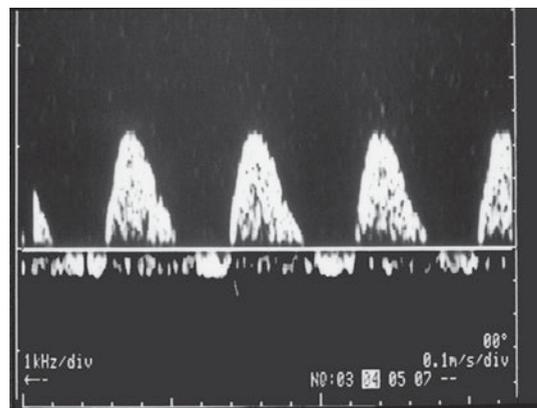


Figure 6.15 Reverse end diastolic flow in the umbilical artery

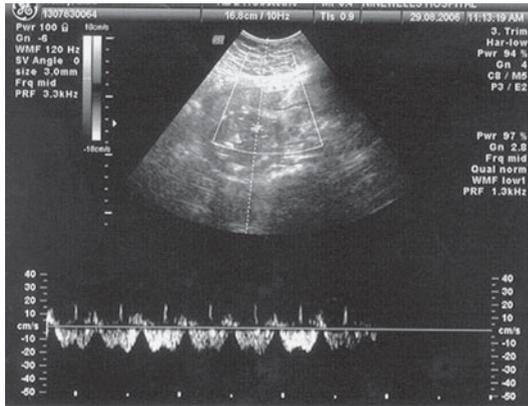


Figure 6.19 Reverse flow in ductus venosus

Doppler ultrasound and the prediction of adverse pregnancy outcome

Doppler studies of the uterine artery during the first and early second trimester have been used to predict pregnancies at risk of adverse outcome, particularly pre-eclampsia. The proposed pathogenic model of pre-eclampsia is one of incomplete physiological invasion of the spiral arteries by the trophoblast, with a resultant increase in uteroplacental vascular resistance (see Chapter 10, Pre-eclampsia and other disorders of placentation). This is reflected in the Doppler waveforms obtained from the maternal uterine circulation. Doppler ultrasound studies of the uterine arteries may demonstrate markers of increased resistance to flow including the diastolic 'notch' in the waveform (Figure 6.20) in early diastole, thought to result from increased vascular resistance in the uteroplacental bed. Studies have provided evidence of the association between high-resistance

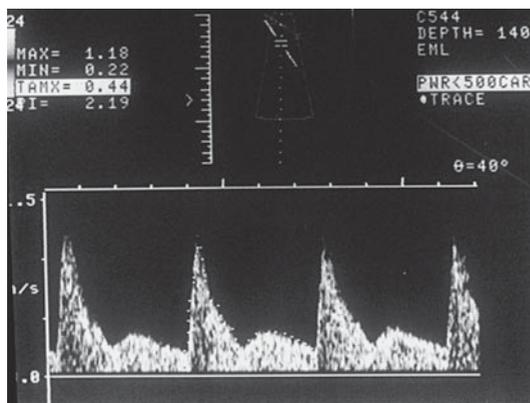


Figure 6.20 Uterine artery waveform with diastolic notch

waveform patterns and adverse outcomes, including pre-eclampsia, fetal growth restriction and placental abruption. Sixty to seventy per cent of women at 20–24 weeks gestation with bilateral uterine notches will subsequently develop one or more of these complications. Consequently, such pregnancies will require close monitoring of fetal growth rate increased surveillance for the possible development of maternal hypertension and proteinuria.

Ultrasound and invasive procedures

Ultrasound is used to guide invasive diagnostic procedures such as amniocentesis, chorion villus sampling and cordocentesis, and therapeutic procedures such as the insertion of fetal bladder shunts or chest drains. If fetoscopy is performed, the endoscope is inserted under ultrasound guidance. This use of ultrasound has greatly reduced the possibility of fetal trauma, as the needle or scope is visualized throughout the procedure and guided with precision to the appropriate place.

Summary of the aims of obstetric ultrasound

The early pregnancy scan (11–14 weeks)

The principal aims of this scan are:

- to confirm fetal viability;
- to provide an accurate estimation of gestational age;
- to diagnose multiple gestation, and in particular to determine chorionicity;
- to identify markers which would indicate an increased risk of fetal chromosome abnormality such as Down's syndrome;
- to identify fetuses with gross structural abnormalities.

The 20 week scan (18–22 weeks)

The principal aims of this scan are:

- to provide an accurate estimation of gestational age if an early scan has not been performed;
- to carry out a detailed fetal anatomical survey to detect any fetal structural abnormalities or markers for chromosome abnormality;

- to locate the placenta and identify the 5 per cent of women who have a low-lying placenta for a repeat scan at 34 weeks to exclude placenta praevia;
- to estimate the amniotic fluid volume.

Also, in some centres:

- to perform Doppler ultrasound examination of maternal uterine arteries to screen for adverse pregnancy outcome, for example pre-eclampsia;
- to measure cervical length to assess the risk of preterm delivery.

Ultrasound in the third trimester

The principal aims of ultrasound in the third trimester are:

- to assess fetal growth;
- to assess fetal well-being.

Magnetic resonance imaging

MRI utilizes the effect of powerful magnetic forces on spinning hydrogen protons, which when knocked off their axis by pulsed radio waves, produce radio frequency signals as they return to their basal state. The signals reflect the composition of tissue (i.e. the amount and distribution of hydrogen protons) and thus the images provide significant improvement over ultrasound in tissue characterization. Ultrafast MRI techniques enable images to be acquired in less than 1 second to eliminate fetal motion. Such technology has led to increased usage of fetal MRI which provides multiplanar views, better characterization of anatomic details of, for example, the fetal brain, and information for planning the mode of delivery and airway management at birth.

CASE HISTORY

An 18-year-old in her first pregnancy attends for review at the antenatal clinic at 34 weeks gestation. Her dates were confirmed by ultrasound at booking (12 weeks). She is a smoker. The midwife measures her fundal height at 30 cm. An ultrasound scan is performed because of the midwife's concern that the fetus is SGA, and the measurements are plotted in Figure 6.21.

Do the ultrasound findings support the clinical diagnosis of SGA?

Yes, because the fetal AC is below the 5th centile for gestation. This finding does not give an indication of the well-being of the fetus and is compatible with FGR secondary to placental insufficiency or a healthy, constitutionally small baby.

What additional features/measures on ultrasound assessment could give an indication of fetal well-being?

Liquor volume

Amniotic fluid volume is decreased in FGR associated with fetal hypoxia with redistribution of fetal blood flow away from the kidneys to vital structures such as the brain and heart, with a consequent reduction in renal perfusion and urine output.

Doppler ultrasound

Umbilical artery

Waveforms from the umbilical artery provide information on fetoplacental blood flow and placental resistance. Diastolic flow in the umbilical artery increases (i.e. placental resistance falls)

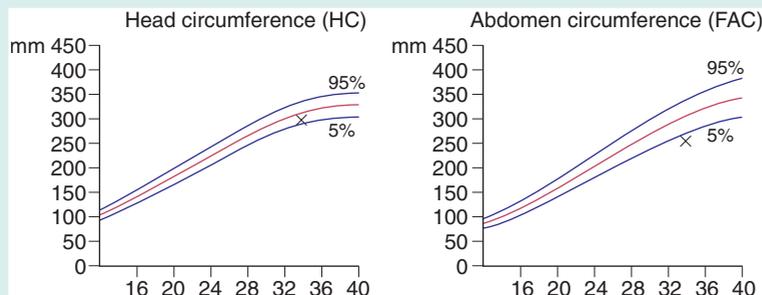


Figure 6.21 Plot of fetal head circumference and fetal abdominal circumference (FAC) for case history

continued >

CASE HISTORY *continued*

throughout gestation. If the resistance index (RI) in the umbilical artery rises above the 95th centile of the normal graph, this implies faulty perfusion of the placenta, which may eventually result in fetal hypoxia. Absent or reversed end-diastolic flow in the umbilical artery is a particularly serious development, with a strong correlation with fetal distress and intrauterine death.

Fetal vessels

Falling oxygen levels in the fetus result in a redistribution of blood flow to protect the brain, heart, adrenals and spleen, and vasoconstriction in all other vessels. The middle cerebral artery will show increasing diastolic flow as hypoxia increases, while a rising

resistance in the fetal aorta reflects compensatory vasoconstriction in the fetal body. When diastolic flow is absent in the fetal aorta, this implies fetal acidaemia. Increasing pulsatility in the central veins supplying the heart, such as the ductus venosus and inferior vena cava, is an indicator of fetal acidaemia and impending heart failure; when late diastolic flow is absent in the ductus venosus, fetal death is imminent.

Cardiotocography

Fetal tachycardia, reduced variability in heart rate, absence of accelerations and presence of decelerations identified on a CTG are associated with fetal hypoxia.

Additional reading

Alfirevic Z, Neilson JP. Doppler ultrasound for fetal assessment in high risk pregnancies. *Cochrane Database of Systematic Reviews*. 1996; (4): CD000073.

Lalor JG, Fawole B, Alfirevic Z, Devane D. Biophysical profile for fetal assessment in high risk pregnancies. *Cochrane Database of Systematic Reviews*. 2008; (1): CD000038.