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the third trimester ultrasound

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Introduction

The monitoring of fetal growth is a vital part of antenatal care. The accurate determination of whether a fetus is small for gestational age (SGA), large for gestational age (LGA), suffering from intrauterine growth restriction (IUGR), or appropriately grown is of prime importance as it can affect antenatal and postnatal management. The consequences of IUGR include stillbirth (40%-70% of stillbirths are SGA), pre-term delivery, and neonatal morbidity such as asphyxia, hypoglycaemia or neonatal death [1]. Later adverse outcomes include cerebral palsy, hypertension and neurodevelopmental or postnatal growth problems. As an adult there is an increased risk of hypertension, insulin resistance and type two diabetes, coronary heart disease and stroke [1].

Large for gestational age fetuses are usually found in diabetic mothers. Glucose, but not insulin, crosses the placenta. In the second trimester maternal hyperglycaemia causes fetal hyperglycaemia, the result of which is excessive fetal insulin production. As insulin is the major growth hormone in the fetus, a macrosomic fetus which is one weighing greater than 4000g and demonstrating disproportionately large chest and shoulders may result [2]. Therefore large fetuses of diabetic mothers are at increased risk of an obstructed delivery, intrauterine fetal death in the last four to six weeks of pregnancy and respiratory distress syndrome. Newborns can suffer from metabolic disturbances such as hypoglycaemia. Long-term problems include obesity and carbohydrate intolerance [2].

A third trimester ultrasound to assess growth is often considered the easiest obstetric ultrasound to learn. However, careful ultrasound measurements and technique with pedantic attention to detail is of prime importance. Screening for SGA fetuses has resulted in only approximately 25% of cases being detected [3] and the ultrasound diagnosis of macrosomia is often not reliable [4].

Factors affecting fetal growth

The control of fetal growth is only partly determined by genetics. Birth weight has been found to correlate better with intrauterine environment; that is, maternal height and weight. Customised growth charts that take these maternal variables into account are better predictors of fetal weight gain in normal and compromised pregnancies [3]. A program for calculating customised percentiles can be obtained free from the Internet on www.gestation.net. Other factors that affect fetal growth include paternal height, parity, ethnicity, maternal smoking and fetal gender [3].

Definitions of fetal size and growth

Small for gestational age and LGA definitions usually refer to the 10th and 90th birth weight percentiles respectively. Other criteria used are 5th and 95th percentile, 3rd and 97th percentile or plus or minus (±) two standard deviations (2SD), which are more predictive of abnormal growth. A fetus that is SGA may not necessarily be IUGR; just as some IUGR fetuses are not SGA. Multiple gestations have similar growth curves to singletons until the third trimester. After 32 weeks the abdominal circumference (AC) gradually falls in twins; however, the femur length (FL) remains similar to singletons [4].

Improving the prediction of fetal growth

To improve the assessment of fetal growth, gestational age (GA) must be established using either a reliable last normal menstrual period (LNMP) or by ultrasound, preferably in the first trimester. A crown rump length (CRL) performed at 6-14 weeks gestation is the best determinant of GA giving an error of ± 4 days. However, when a CRL is greater than 60mm, it should be used in conjunction with other parameters. A biparietal diameter (BPD) and head circumference (HC) are reliable parameters from 13 weeks gestation when parietal bone ossification has occurred. A femur length (FL) is reliable from 13 weeks gestation [4].

Routine biometry performed during the second trimester includes BPD, HC, AC and FL. Of these, the HC is the most predictive parameter of GA from 14-22 weeks. Combining biometric parameters improves GA prediction slightly more than using HC alone. In general the accuracy is ± 1 week from 14-22 weeks

gestation and ± 2 weeks from 22-28 weeks. The BPD can be affected by head shape and should be excluded from GA determination if the head is dolichocephalic or brachycephalic. Dolichocephaly, an elongated flattened head, can occur when a fetus is in breech presentation, when oligohydramnios is present or in cases of multiple pregnancy. Brachycephaly, a rounded head, may be seen in fetuses with brain anomalies, abnormal chromosomes or may be a normal variant. The AC may be a difficult measurement to obtain in the second trimester and should not be used to calculate GA. However, the AC should be measured so that early onset IUGR is not missed.

During the third trimester fetal size, not GA, is calculated, as the error for dating is ± 4 weeks from 28 weeks until term. Occasionally GA is requested if there has been no antenatal care and the error in calculating GA should be reported.

Fetal biometric parameters

Fetal growth is assessed by measuring different fetal biometric parameters and comparing them with expected values for the GA. Four measurements are routinely performed and include BPD, HC, AC and FL.

Biparietal diameter

This measurement is obtained from a transverse or axial plane image of the fetal cranium at the level of the falx, thalami and cavum septum pellucidum (CSP). The falx should be perpendicular to the ultrasound beam. The head should be 'egg shaped' and the cerebral hemispheres equal in size. The BPD is measured from the outer to inner edge of the cranium, leading edge to leading edge, at 90 degrees to the falx (fig 1). The limitation of the BPD measurement is that it is affected by head shape.

Head circumference

This measurement is obtained at the same level as the BPD (fig 1). The calipers are placed on the skull margin and the skin is not included. If the image is poor quality, for example, because of fetal position, this should be stated and the measurement not used. The BPD and HC reflect head size and therefore brain growth [4].

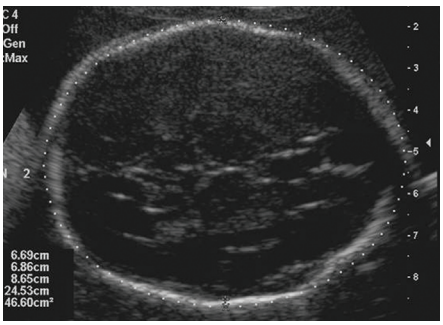

Fig 1. Transverse image of fetal head showing BPD and HC measurement.

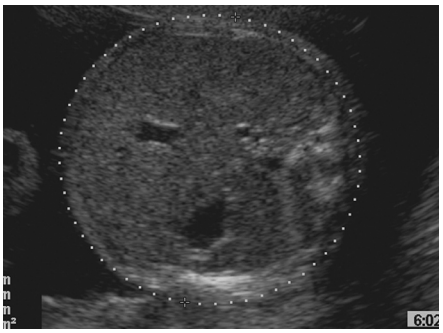

Fig 2. Transverse image of fetal abdomen showing AC measurement.

Abdominal circumference

An AC measurement is obtained from a transverse section of the fetal abdomen. It is carried out at the level of the stomach and intrahepatic portion of the umbilical vein (UV) where the left portal vein appears as a 'J' shape. Adrenals can be included in the AC image but not the kidneys. The AC should be round with the fetal spine preferably to the maternal left or right, with all the relevant anatomy visible (fig 2). Care should be taken to ensure that the AC is not deformed by transducer pressure. The image should not demonstrate the UV at the level of the umbilicus as this occurs when an oblique view of the abdomen is obtained and will result in an erroneously large AC measurement. The skin and soft tissue should be included. The AC reflects internal organ size, especially the liver. This parameter is most predictive of fetal weight but not GA and should demonstrate linear growth.

Femur length

This measurement is performed by placing calipers at each end of the femoral diaphysis, blunt end to blunt end, with the femur perpendicular to the ultrasound beam. An acoustic shadow should be cast posterior to the femoral shaft (fig 3). Oblique views

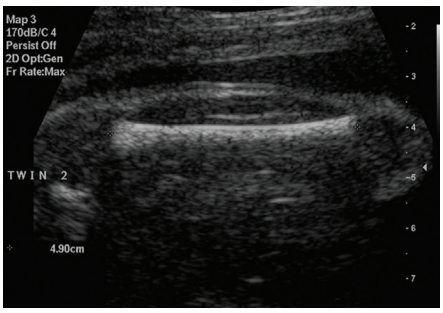

Fig 3. Femur length measurement.

of the femur will result in a foreshortened measurement. The FL is a reliable measurement with accuracy of ± one week in the second trimester and ± three to four weeks at term. Femoral measurements correlate with maternal height after 18-19 weeks and vary with ethnicity [4].

Another useful measurement is the transcerebellar diameter (TCD). Whilst this parameter is not used to estimate fetal weight it can be used to estimate GA in the late second and third trimester fetus and in growth restricted fetuses, especially if GA is unknown or in doubt. The TCD will measure appropriately in a LGA or IUGR fetus, the latter due to the brain sparing effect. A disadvantage of the TCD is it is increasingly difficult to measure with increasing gestation because of the bony occiput. The TCD is measured at the level of the falx, CSP, cerebral peduncles and cerebellum, at the BPD level with a caudal posterior tilt of the transducer. There are published normal range charts available [5].

Estimating fetal weight

The accuracy of estimated fetal weight (EFW) is directly proportional to the number of biometric parameters used. These include BPD, HC, AC and FL. These parameters are entered into a multiple regression equation to give EFW of which there are a number published [4]. The error in estimating fetal weight is ± 10-20% in experienced hands but can be greater with inexperience. The biometry should always be plotted on a normal range chart and EFW should be compared with expected weight for GA. Assessing interval growth over a period of time provides more information than a single set of measurements. Due to the error of ultrasound measurements, the greater the interval between scans the more reliable is the estimate of interval weight gain. This interval should be not less than 14 days.

Abnormal growth

Ultrasound is the first line of investigation for identifying fetal growth disturbances. An ultrasound may be ordered based on the clinical findings of decreased fundal height, poor maternal weight gain or maternal risk factors such as diabetes, hypertension or renal disease. Deviations in growth can be seen by 20 weeks gestation [4]. There are two types of growth abnormalities, growth restriction and accelerated growth.

Growth restriction

Growth restriction results from a combination of possible maternal and fetal disorders. Ascertaining the cause directs counselling, management and outcome. Approximately 20% of IUGR fetuses will have congenital malformations and/or abnormal chromosomes. The most common abnormal karyotypes are trisomy 13, 18 and 21 although trisomy 13 fetuses can demonstrate normal growth patterns. Triploidy, deletions and ring chromosome structures may also alter growth. The risk of chromosomal abnormalities increases if IUGR occurs before 26 weeks or if growth restriction is seen in association with polyhydramnios [6]. Other risk factors for IUGR include multiple pregnancy, maternal vascular disease (25-30%), early onset pre-eclampsia and hypertension, severe maternal nutritional disorders such as starvation or inflammatory bowel disease and thrombophylic disorders. Infections such as cytomegalovirus (CMV), rubella, parvovirus or toxoplasmosis, or drug use (smoking, alcohol, cocaine, heroin and anticonvulsants) are also risk factors. A placenta which is abnormal in function or size, for example a chorioangioma or circumvallate placenta, or which has abnormal chromosomes can also result in an IUGR fetus [6].

An IUGR fetus is usually diagnosed by a combination of ultrasound findings such as biometry below the 10th, 5th or 3rd percentile, poor interval growth, reduced liquor and abnormal Doppler studies. Utero-placental dysfunction produces fetal hypoxaemia, subnormal growth, decreased liquor and changes in blood flow. Symmetric IUGR is denoted by a reduction of all fetal biometric measurements as compared to asymmetric IUGR where the HC is greater than the AC, that is, an increased HC/AC ratio. Originally symmetric IUGR was thought to reflect fetal abnormalities such as aneuploidy and asymmetric IUGR utero-placental dysfunction. These assumptions have been proven incorrect. However, it is important to note the HC/AC ratio, as a fetus may be asymmetrically grown but lie within the normal range. Asymmetric IUGR fetuses are at increased risk of a poor neonatal outcome such as respiratory distress syndrome, cerebral interventricular hemorrhage and infection. A small HC, less than three standard deviations (3SD) below the mean, may indicate that the fetus has microcephaly [4].

Large for gestational age

The definition of a LGA fetus is EFW greater than the 90th percentile for GA. Neonatal macrosomia was defined as a birth weight greater than 4000g, but in some circles a weight of greater than 4500g is used. Diagnosing a LGA fetus is important because of the increased risk of fetal morbidity and mortality. The main risk factors are maternal diabetes, obesity, post dates and excessive maternal weight gain. Some genetic anomalies can result in a LGA fetus, for example Beckwith-Wiedemann syndrome. It is noted however, that the ultrasound diagnosis of LGA is not reliable. The ultrasound error when estimating fetal weight is greater with a macrosomic fetus compared with a normally grown fetus. However, the predictive value of LGA increases when polyhydramnios is present [4].

Assessing fetal well-being

It is important to try to differentiate between the healthy and compromised fetus. The size of the fetus should be correlated with a cardiotocograph (CTG), the biophysical profile (BPP), amniotic fluid index (AFI) and Doppler studies. A CTG measures fetal heart variability and is usually performed and interpreted by midwives and obstetricians.

The biophysical profile

The modified BPP, which is not performed in conjunction with a CTG, evaluates fetal movement, tone, breathing and liquor. Each variable scores either a two or a zero indicating the presence or absence of each parameter respectively, with a maximum score of eight out of a possible eight (8/8). The basis of the BPP is that a set pattern occurs with a loss of breathing first, although this is the most sensitive it is the least specific, then movement and finally tone. These reflect acute changes. A decrease in the AFI reflects chronic hypoxia. Oligohydramnios is defined as an AFI below five cm. A pool of liquor greater than or equal to two cm will score two on the BPP. When reporting the results of the BPP, a variable that scores zero should be identified, for example the BPP = 6/8, zero for liquor.

Amniotic fluid index

The AFI is measured by dividing the uterus into four quadrants and measuring the deepest vertical pool in each quadrant. Colour Doppler should be used to ensure that umbilical cord is not included in the measurement. The normal range for an AFI is 5 to 25cm with a deepest pool measurement greater than or equal to 2cm and less than 10cm. Polyhydramnios is defined when the AFI is greater than 25cm with a deepest pool measurement equal or in excess of 10cm.

Doppler studies

Doppler studies have been useful for predicting adverse outcomes, especially in the SGA fetus. The umbilical artery is the most common vessel assessed in the pregnant woman (fig 4). It reflects downstream placental vascular resistance. Abnormal patterns such as increased resistance, absent and reversed end diastolic flow, can be seen with IUGR and placental dysfunction (figs 5 and 6). With increasing placental insufficiency, the diastolic flow decreases with time. The umbilical artery should be sampled with a Doppler angle of zero degrees so that maximum Doppler shift is obtained. This can be achieved by moving the transducer so the artery is parallel with the Doppler sample cursor and the sample gate is in the middle of the vessel. A low wall filter should be selected and a fast sweep speed. Ensuring good technique means when an abnormal reading is obtained the results are more likely to reflect a true reading and are not a result of poor technique.

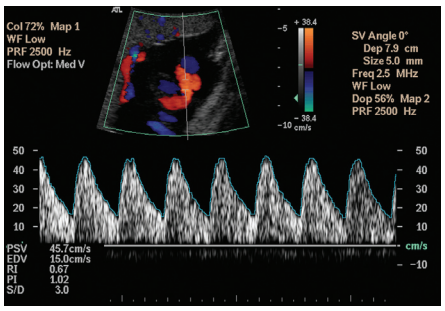

Fig 4. Normal umbilical artery Doppler.

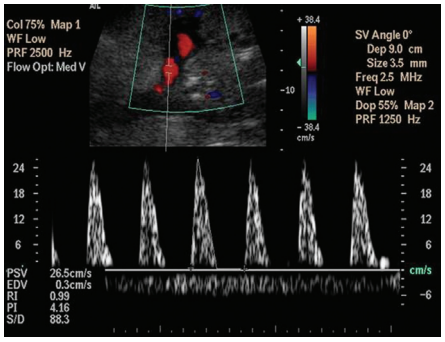

Fig 5. Umbilical artery Doppler demonstrating absent diastolic flow.

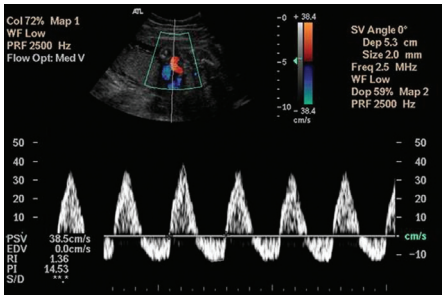

Fig 6. Umbilical artery Doppler demonstrating reversed diastolic flow.

Other vessels can be sampled and may include the descending aorta, splenic artery, middle cerebral artery (MCA), uterine arteries, inferior vena cava (IVC), ductus venosus (DV) and umbilical vein (UV). Of these the most commonly sampled are the uterine artery, MCA, DV and UV because they are reproducible and technically easier to sample. The uterine artery Doppler waveform reflects maternal uterine-placental circulation and is used as a screening test to predict pre-eclampsia and IUGR. This vessel is sampled where it appears to cross the iliac artery and vein lateral to the uterus in the left and right adnexa. An abnormal uterine artery waveform demonstrates a diastolic notch at and after 22-24 weeks gestation.

The MCA is generally sampled for two reasons, firstly to determine if fetal anaemia is present and secondly in the IUGR fetus to assess if blood flow is being shunted from the body to the cerebral circulation, known as the brain sparing effect. Fetal anaemia will demonstrate increased peak systolic velocities with a chart published by Mari et al. (1995) commonly used to assess such changes [7]. Growth restriction or placental dysfunction demonstrates decreased vascular resistance to the fetal brain and this is reflected in the MCA waveform as reductions in the systolic diastolic (SD) ratio, and pulsatility (PI) and resistive (RI) indices. The MCA can be sampled by obtaining an image of the fetal head at the BPD measurement level, moving the transducer caudally to the level of the circle of Willis, and activating power or pulsed Doppler. A zero degrees Doppler angle yields the maximum Doppler shift and reproducible values (fig 7).

Arterial Doppler abnormalities are usually the first Doppler changes to be seen followed by changes in fetal venous Doppler studies. Abnormal venous Doppler studies reflect fetal cardiac dysfunction. The DV (fig 8) and UV show late signs of fetal adaptation associated with fetal acidaemia. Abnormal CTG and BPP seem to follow venous Doppler changes. The UV should be sampled in an area of free floating umbilical cord and is abnormal when the waveform demonstrates pulsations. The DV is abnormal when the A-wave is absent or reversed (fig 9). The DV is sampled at the isthmus where it leaves the UV. The easiest plane to identify the DV is in transverse at the level where the AC is measured. By activating colour Doppler the DV can be identified as a small area of aliasing. Normal third trimester colour Doppler settings for the UA can be used to detect aliasing in the DV. Make sure that the DV is sampled between zero and sixty degrees as a greater angle will make the aliasing almost impossible to detect.

Fetal presentation and placenta position

Fetal presentation is usually reported as either cephalic, breech or transverse. In a multiple pregnancy the fetus closest to the cervix is reported as the 'presenting' fetus.

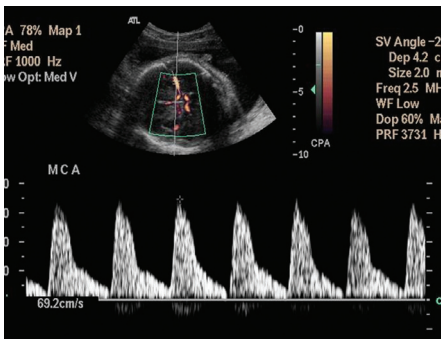

Fig 7: Middle cerebral artery Doppler.

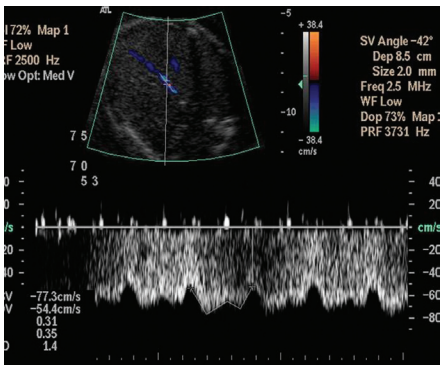

Fig 8. Normal ductus venosus flow (note waveform is inverted).

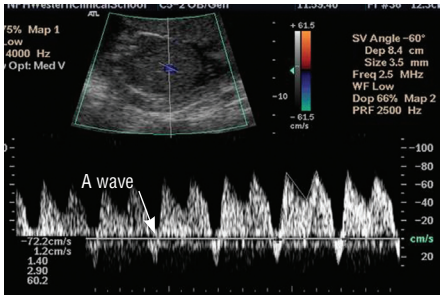

Fig 9. Abnormal ductus venosus flow demonstrating reversed 'A' wave.

A placenta is considered to be low lying if its inferior margin is two cm or less from the internal os. Placenta praevia is not diagnosed until the third trimester and until this time the placenta is referred to as low lying. If a low lying placenta is suspected in the third trimester, a transvaginal (TV) ultrasound should be performed to assess the distance of the inferior placental margin from the internal os. A TV ultrasound is contraindicated if the woman is bleeding and in such instances a translabial ultrasound may be warranted. Colour Doppler imaging should be used to exclude the presence of vasa praevia.

Conclusion

Ultrasound has an established role in estimating gestational age, size and assessing fetal growth and well-being. A third trimester ultrasound should not be used in isolation, and as the results can affect antenatal care, attention to detail when scanning is important. The sonographer should ensure high quality reproducible measurements and images are provided to the reporting physician. The sonographer should also provide the referring physician with an assessment of whether the fetus is appropriately grown and biophysically well.

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