Assessing antepartum fetal health

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Abstract
Most pregnancies lead to the delivery of a healthy baby, irrespective of risk factors. Some pregnancies, however, are complicated by differing pathologies that can lead to increased risk of perinatal morbidity and mortality. Fetal surveillance should be instituted, attempting to identify at-risk fetuses and reduce their chances of complications. Traditionally obstetricians have classified pregnancies into ‘low-risk’ or ‘high-risk’ and applied surveillance tools to the latter group. However, the majority of stillbirths occur in low-risk women. In this article we will evaluate the evidence behind the current tools used to assess antepartum fetal health in both high- and low-risk groups, and their ability to detect an at-risk fetus or improve outcome. This article does not address fetal surveillance during labour.

Keywords amniotic fluid index; biophysical profile; cardiotocography; Doppler; symphysis-fundal height; biometry

Classification of pregnancies into ‘low-risk’ or ‘high-risk’ takes place on the basis of the likelihood of an adverse outcome being less or greater than that of the general population. Currently the majority of stillbirths in this country occur in the low-risk group. Most pregnancies lead to the delivery of a healthy baby, irrespective of risk factors. Some pregnancies, however, are complicated by differing pathologies that can lead to increased risk of perinatal morbidity and mortality. Identification of these pregnancies will allow the initiation of appropriate assessment tools with the aim to improve the outcomes.

This article will focus on the tools available for assessment of antepartum fetal health and will exclude assessment in labour. The ability of each individual test to identify and improve outcome in an at-risk fetus will be investigated. Whilst each test alone may not be diagnostic of an at-risk fetus a combination of tests is necessary to identify the risk factors. Some pregnancies, however, are complicated by differing pathologies that can lead to increased risk of perinatal morbidity and mortality. Identification of these pregnancies will allow the initiation of appropriate assessment tools with the aim to improve the outcomes.

Aims of assessing antepartum fetal health:

- To prevent the death of the fetus
- To optimize the timing of delivery, minimizing fetal and neonatal morbidity
- To avoid unnecessary intervention (e.g. pre-term delivery) if fetal health is confirmed

Fetal movement monitoring
Maternal recognition of reduced fetal movements is associated with an increased likelihood of fetal death; however, meta-analysis of formal fetal movement monitoring has failed to show an improvement in the perinatal outcome. This may be related to the low positive predictive value for this assessment tool (2–7%) in a low-risk population; to prevent one fetal death, the policy of formal fetal movement monitoring would need to be performed in 1250 pregnancies. Furthermore, false reassurance or inappropriate interpretation of a CTG may be confounding factors in the failure of this formal monitoring method to reduce the number of stillbirths. However, current evidence does not support the recommendation for routine use of formal fetal monitoring; rather, women with reduced movements should be advised to contact their midwife or hospital for further assessment.

Symphysis-fundal height (SFH)
SFH measurement should be performed, at 2–3 weekly intervals, from 24 weeks onwards with the mother lying in a semi-recumbent position, legs extended and bladder empty. The uterine fundus is palpated and a non-elastic tape measure (scale markings on the underside) placed over this position. The distance from here to the upper edge of the symphysis pubis is recorded, in centimetres, on a growth chart. It is a NICE Guideline for Antenatal Care recommendation that all women should have SFH measured and plotted at each antenatal clinic visit. The advantage of this test is that it is readily available and simple, low in cost, and requires minimal equipment, training and time.

Palpation of the abdomen alone has a sensitivity of 21% and specificity of 96% for the detection of small for gestational age (SGA) fetuses. SFH measurement leads to very little improvement in prediction, with a sensitivity and specificity of 27% and 88% respectively, although there is a wide variation in the predictive accuracy depending upon the study quoted. Serial measurements, especially by the same person, however, may allow changes in the rate of growth to be observed and improve the sensitivity and specificity of this test.

One of the drawbacks of this test is that if the SFH measurement is less than expected it does not distinguish fetal growth restriction (FGR) from a constitutionally small fetus, which accounts for 50–70% of cases with a birth weight below the 10th centile. These fetuses are appropriate in size for parity, ethnicity and parental size, and do not have an increased risk of morbidity or mortality. FGR, by comparison, defined as a failure of the fetus to obtain its genetic growth potential due to a reduction in fetal growth, has increased risks of perinatal morbidity and mortality. It is illogical to expect SFH measurement to detect a fetus that is growth restricted but above the 10th centile.
Customized charts for SFH have been developed that are individualized according to maternal height, weight, parity and ethnic group and are recommended by the Royal College of Obstetricians and Gynaecologists, although the NICE Guidelines on Antenatal Care suggest that further prospective research is required into their diagnostic value and cost-effectiveness. Studies have shown an improvement in detection of both SGA, from 29% to 48%, and large for gestational age fetuses, from 24% to 46%. Although such charts have not been shown to improve perinatal outcome they do decrease the number of ultrasound scans requested for assessment of growth.

**Indication for referral for ultrasound on the basis of customized growth charts:**

- The first symphysis-fundal height measurement is below the 10th centile on the customized chart.
- Growth is static or slow compared to the slope of the curves on the chart on consecutive measurements.
- Growth is excessively steep compared to the slope of the curves on the chart on consecutive measurements.

(The first measurement above the 90th centile is not an indication for referral for large for dates unless there are other clinical concerns).

**Assessment of fetal heart sounds and rate**

There is no predictive value for future health in auscultation of the fetal heart; it merely confirms that the baby is alive. Routine fetal heart auscultation is therefore not a NICE recommendation although NICE guidelines state that it may be performed for reassurance of the mother, on her request. Similarly, no studies on hand-held Doppler assessment of the fetal heart have shown an improvement in outcome. Routine auscultation or Doppler assessment could, in theory, detect a fetal arrhythmia and initiate further investigation. Arrhythmias are rare, however, and require documentation of the actual fetal heart rate, which is not routinely done.

**Cardiotocography (CTG) and computerised CTG**

Intrinsic cardiac activity and autonomic reflex changes are determinants of the fetal heart rate, which can be recorded using cardiotocography (CTG). The normal baseline fetal heart rate is between 110 and 160 beats per min (bpm) with fluctuation around this baseline, or variability, of 5–25 bpm. Two accelerations in a 20 min trace are considered reactive in a term pregnancy; accelerations can be more difficult to identify in pre-term fetuses, especially less than 28 weeks. CTG changes occur very late in the disease process of FGR, much later than Doppler abnormalities, making their use in the antepartum assessment of fetal health of limited value. Interpretation of antepartum CTGs within and between observers can also display poor reliability and scoring systems have failed to help.

There are no trials looking at the role of antepartum CTG in low-risk women and very few in the high-risk group. The Cochrane collaboration review of Randomized Controlled Trials (RCT) found that antepartum CTG in a high-risk group had no significant effect on perinatal morbidity or mortality (RR [relative risk] 2.05; 95% confidence interval 0.95–4.42) although the meta-analysis was underpowered to assess this outcome (n = 1627). Therefore current evidence does not support the routine use of antepartum CTG.

Computerized CTG has been developed to aid interpretation of CTGs. They have a better accuracy than clinicians, particularly in the determination of short-term variability (<3.5 ms) in fetal heart rate and in predicting fetal acidaemia, hypercarbia and low Apgars. Comparison with traditional CTG in a small group of women (n = 469) has shown a significant reduction in perinatal mortality (RR 0.20; 95% confidence interval 0.04–0.88) but further studies focusing on the use of computerized CTGs in high-risk women is warranted.

**Ultrasound biometry and estimated fetal weight**

Placental dysfunction results in a reduction in the nutrient supply to the fetus. Whilst the blood supply to the vital organs of the heart and brain are maintained, adaptation occurs with mobilization of glycogen stores from the liver and a reduction in blood flow to, and growth of, non-vital organs like the gut, liver and kidneys. The most sensitive biometric measurements in predicting FGR is a reduced abdominal circumference or estimated fetal weight (EFW) on USS. As growth is a dynamic process, serial measurements further improve prediction; growth is reduced in FGR but maintained in SGA. The presence of abnormal umbilical Doppler and reduced amniotic fluid index increases the detection of FGR to 66.7%, from a positive predictive value of 38.1% with reduced abdominal circumference alone.

Formulae have been devised, which measure parameters including biparietal diameter, femur length, head and abdominal circumference, to calculate an EFW. Sheppard and Aoki’s formulae were found to have the best correlation with birth weight. Validation of these formulae has been achieved at birth weights of 2080–4430 g; accuracy outside these ranges is unknown. Customized ultrasound EFW charts are also available with better sensitivities for detecting FGR and lower false positive rates; they are also predictive of poor perinatal outcomes. In a low-risk population, systematic review does not support the use of routine ultrasound after 24 weeks, as this fails to achieve an improvement in perinatal mortality.

**Amniotic fluid volume**

Amniotic fluid production is a reflection of fetal renal perfusion secondary to its relation to urine production. Decreased blood flow to the fetal kidney in FGR leads to a reduction in amniotic fluid production. Oligohydramnios occurs when the largest vertical pocket of amniotic fluid is less than 2 cm or the amniotic fluid index (AFI- defined as the sum from each quadrant of the vertical amniotic pool depth) is less than 5 cm. There is a poor correlation between both these measurements and true amniotic fluid volume. Furthermore, oligohydramnios may be caused by factors other than growth restriction (e.g. ruptured membranes). There is no evidence that one method (deepest vertical pocket or AFI) is superior to the other in the prevention of perinatal morbidity or mortality. The use of AFI, however, is associated with significantly more cases being diagnosed and subsequently
Biophysical profile (BPP)

The BPP is an ultrasound and CTG assessment of fetal behaviour that includes five elements: fetal breathing movement, body or limb movement, fetal tone, amniotic fluid volume and heart rate (CTG) analysis (Table 1). Each one of these five elements is awarded a score of two if present, to a maximum score of ten. It is a time consuming test with a minimum ultrasound time of 30 min followed by 30 min on a CTG. According to the Cochrane database, there is insufficient RCT evidence to support the use of the BPP as a test of fetal wellbeing. 10 000 women would need to be studied before conclusions could be drawn on its true impact on perinatal mortality but only 2974 patients are included in the systematic review.

The abnormalities in a BPP are caused by fetal neuro-behavioural adaptations in the face of deterioration in fetal acid–base status. Changes in fetal behaviour occur late in the disease process, preceded by abnormalities in the umbilical artery Doppler. At this point the BPP often deteriorates rapidly. It must, therefore, be performed daily to impact upon perinatal mortality. The first changes usually to occur are a reduction in global fetal movements and breathing movements, at a mean pH of 7.10–7.20; abnormalities in fetal tone occur later. The BPP may have a greater role in monitoring and timing delivery in cases of growth restriction with abnormal umbilical artery Doppler due to its high negative predictive value - fetal death is extremely unlikely if the BPP is normal.

**Fetal arterial Doppler**

Many vessels have been investigated in the prediction of fetal wellbeing including the aorta, carotid, iliac, mesenteric, renal, coronary, middle cerebral and umbilical arteries. The two arterial Doppler parameters commonly used clinically for antepartum assessment of fetal health are the umbilical and middle cerebral arteries.

**Umbilical artery Doppler**

The umbilical artery Doppler is primarily a test of placental function. Approximately 30% of a placenta has to be damaged for a reduction in umbilical artery end-diastolic velocity to occur and 60–70% for absent or reversed end-diastolic flow. The normal patho-physiological sequence is for a raised Doppler to progressively lead to absent followed by a reversed diastolic component of flow. Although this test is not related to increased antepartum, obstetric or neonatal intervention, several umbilical artery Doppler studies have failed to show a reduction perinatal mortality or morbidity in low-risk pregnancies and the test, in isolation, has poor diagnostic value in the prediction of SGA fetuses. Thus, in this group, umbilical artery Doppler cannot be recommended as a screening tool. In contrast, performing umbilical artery Doppler studies in high-risk (FGR) pregnancies will lead to a reduction in perinatal mortality of one case per 203 women scanned. Meta-analysis has shown that in high-risk (FGR) pregnancies umbilical artery Doppler does reduce perinatal mortality (RR 0.71) and morbidity, antenatal admission (RR 0.72), induction of labour (RR 0.89) and Caesarean sections (RR 0.90). It can be used as a surveillance tool in this group. The perinatal mortality rises with deterioration in the Doppler indices, such that with absent or reversed end-diastolic flow it is 4 and 10.6 folds higher, respectively, than with positive end-diastolic flow.

There are several Doppler indices but the most commonly used in clinical practice are the pulsatility index (Systolic–Diastolic/mean [S–D/M]), resistance index [S–D/S] or systolic/diastolic ratio [S/D]. One difference is that the pulsatility index has a theoretical benefit of ongoing numerical analysis in the presence of absent end-diastolic flow.

### Biophysical profile table

<table>
<thead>
<tr>
<th>BPP variable</th>
<th>Normal (score = 2)</th>
<th>Abnormal (score = 0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetal breathing</td>
<td>At least one episode of ≥30 s duration in 30 min</td>
<td>No episodes of FBM ≥30 s duration in 30 min</td>
</tr>
<tr>
<td>movements</td>
<td>≥3 body/limb movements in 30 min</td>
<td>≤2 or less body/limb movements in 30 min</td>
</tr>
<tr>
<td>Body movements</td>
<td>At least one episode of active extension and return to flexion of limbs or trunk</td>
<td>Either slow extension with return to partial flexion OR movement of limb in full extension OR no movements with hand extended (partial or complete)</td>
</tr>
<tr>
<td>Fetal tone</td>
<td></td>
<td>No pool depth of ≥2 cm in two perpendicular planes</td>
</tr>
<tr>
<td>Amniotic fluid</td>
<td>Pool depth of ≥2 cm in two perpendicular planes</td>
<td>Less than 2 accelerations (≥15 bpm for ≥15 s) in a 30 min CTG</td>
</tr>
<tr>
<td>CTG</td>
<td>At least 2 accelerations (≥15 bpm for ≥15 s) in a 30 min CTG</td>
<td></td>
</tr>
</tbody>
</table>

Table 1
**Middle cerebral artery (MCA) Doppler**

The fetus adapts to placental dysfunction by preferential redistribution of well-oxygenated blood to the brain and the heart at the expense of organs like the kidney and gut. Thus, in a growth restricted fetus, further Doppler studies may be useful to assess antepartum fetal health and plan the timing of delivery. Early changes include a reduction in the impedance of blood flow to the MCA characterized by a low MCA pulsatility index and decreased cerebroplacental ratio (the ‘brain sparing effect’). With further fetal compromise and reduced cardiac function, this brain protective effect is lost as cerebral auto-regulation becomes abnormal with normalization of MCA Doppler index.

The second useful role of middle cerebral artery Doppler is in cases of fetal anaemia. As the fetal haemoglobin and haematocrit fall, cardiac output increases and blood viscosity falls resulting in blood flow at a higher velocity. Studies have shown that MCA peak systolic velocities correlate with fetal haemoglobin in cases of isoimmunization with greater precision than maternal antibody titre. The peak systolic velocity can be serially monitored and plotted on reference ranges. Intervention zones are available to direct clinicians as to when the invasive procedure of fetal blood sampling and transfusion is recommended and have led to a reduction in invasive testing without adverse fetal outcome.

**Fetal venous Doppler (ductus venosus, IVC, umbilical vein)**

Characteristically triphasic venous Dopplers reflect cardiac compliance, contractility and cardiac afterload. In a normal fetus, atrial systole (a-wave) should always demonstrate forward flow in the ductus venosus; however, physiological reversal may be evident in other veins such as the inferior vena cava and hepatic veins. The final stage of placental insufficiency is cardiac decompensation, due to hypoxia of the myocardial tissue and subsequent dysfunction. This results in increased venous pressure (due to increased cardiac afterload) and is visualized on ultrasound as increased pressures in the IVC, venous pulsations in the umbilical vein and reversal of the a-wave in the ductus venosus. Abnormal venous Doppler studies are correlated with a significant risk of fetal acidemia and intellectual impairment and are the most compelling Doppler predictor of stillbirth.

Both behavioural and cardiovascular changes in pre-term FGR usually follow a predictable pattern as depicted in Figure 1. As a result, the longitudinal assessments of CTG, ultrasound and Doppler changes in each growth restricted fetus can be used to optimize the timing of delivery, thereby achieving the maximal gestational age without adverse perinatal morbidity and mortality. The pace of progression of Doppler changes varies and is, in part, dependent upon gestational age, degree of placental dysfunction and coexisting maternal disease. Monitoring should be individualized with more frequent assessment with increasingly abnormal Doppler parameters. For a comprehensive evaluation of placental vascular function and fetal cardiovascular status, examination of the Doppler waveforms in the umbilical artery, middle cerebral artery, ductus venosus and umbilical vein should be performed. Consideration of a single vessel, in

![Schematic representation of the timing of fetal cardiovascular and behavioural changes in the presence of placental insufficiency](image-url)

**Figure 1**
isolation, results in an incomplete picture. A change in maternal condition (e.g. development of pre-eclampsia or antepartum haemorrhage) should coincide with consideration of reassessment of the fetus.

**Uterine artery Doppler**

Uterine artery Doppler is used for the prediction of the pregnancy complications of fetal growth restriction and pre-eclampsia. It is more accurate when performed in the second, compared to the first, trimester. Abnormal uterine artery Doppler indices at 24 weeks are found in 5% of low-risk pregnancies; it is more common in high-risk pregnancies and at earlier gestations. An increased pulsatility index with notching has been shown to be the best predictor of growth restriction in low-risk pregnancy (positive likelihood ratio 9.1). However, it must be remembered that this is a screening test for risk and not an assessment of antepartum fetal health, so has no role in the management of fetuses with established growth restriction.

**Clinical practice and conclusions**

Pregnancies are usually assigned to a low- or high-risk group. To impact upon perinatal mortality it is vital to allocate women to the correct group by careful enquiry and identification of risk factors. Incorrect assignment to a group due to human error or a yet unknown risk factor can occur which may explain why the majority of stillbirths remain in the low-risk group. During the course of a pregnancy, with the development of complications, movement from a low to high-risk group is also possible. For low-risk pregnancies, the usual assessment tools are maternal monitoring of fetal movements, SFH measurement and auscultation of the fetal heart. Only the first of these investigations has proven value; fetuses with reduced fetal movements are at increased risk of fetal death. The pregnancy should then be considered high-risk and monitored accordingly. There is no evidence to support the use of routine ultrasound (other than a dating and anomaly scan) and Doppler velocimetry in a low-risk pregnancy.

In all high-risk pregnancies, appropriate surveillance should be planned and implemented following an assessment of the risk to the fetus. Each pregnancy requires an individualized plan, with modification if there is alteration of the clinical circumstances. If the risk factor is hypoxia, due to placental insufficiency from whatever cause, ongoing assessment methods should be used throughout the pregnancy with umbilical artery Doppler, amniotic fluid volume, fetal size and growth velocity an appropriate assessment of the health of the fetus over such a time course. Umbilical artery Doppler is the most important surveillance tool as its use has been shown to reduce perinatal mortality. CTG and BPP tests that assess current fetal health with limited ability to predict wellbeing in the longer-term. There are currently no effective tests that predict acute event, like feto-maternal haemorrhage, cord accident or placental abruption-reducing mortality and morbidity from such conditions is not possible at present.

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**FURTHER READING**


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**Practice points**

- Accurate assessment of fetal growth and wellbeing requires certainty of gestational age- the probability is increased by current NICE recommendation of routine first trimester ultrasound for dating.
- Maternal perception of reduced fetal movements is associated with increased risk of fetal death and must be investigated.
- Customized growth charts may improve the sensitivity of symphysis-fundal height measurement in detecting SGA.
- Umbilical artery Doppler has no role in assessment of low-risk pregnancies.
- In high-risk fetuses the use of umbilical artery Doppler reduces perinatal mortality, morbidity, antenatal admissions, induction of labour and Caesarean section.
- Fetal cardiovascular and behavioural deterioration follows a predictable pattern.
- Umbilical venous pulsations and reversal of the a-wave in the ductus venosus are the strongest predictors of stillbirth.