Assessment of the fetus before and during labour

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Abstract

Perinatal death or cerebral palsy are devastating events for families. In an attempt to prevent these pregnancy outcomes, fetal wellbeing is assessed during labour by a variety of means. In this review, the most common means to confirm fetal wellbeing, the rationale for their use and evidence of their efficacy are discussed. With respect to labour, the indications for continuous electronic fetal monitoring are presented, together with a guide to interpretation of cardiotocograph (CTG) or fetal scalp blood samples (FBS).

Keywords Antenatal care; asphyxia; cardiotocography; fetal blood sampling; fetal monitoring; fetal movements; hypoxic-ischaemic encephalopathy; intrapartum care; intrapartum stillbirth

Royal College of Anaesthetists CPD Matrix: 2B05, 2B07, 3B00

Learning objectives

After reading this article, you should:

- understand the reasons for monitoring fetal wellbeing in and around the time of labour
- understand the indications for fetal monitoring during labour
- be able to describe strategies for monitoring fetal wellbeing in early and established labour
- understand the limitations of each method of assessment of fetal wellbeing

Background

Perinatal asphyxia affects approximately 2–5 per 1000 live births.[1] The aim of fetal assessment in the peripartum and intrapartum period is to prevent asphyxia and the resulting morbidity and mortality. The outcomes of perinatal asphyxia are poor; in high-income countries up to 40% of infants will die and 30% will have significant long-term neurodisability.[1] These outcomes are tragic for the families involved and also place a significant burden on the NHS. A recent analysis of claims made in maternity to the NHS Litigation Authority over a period of 10 years, found the most frequent causes of litigation were management of labour (14%), caesarean section (13%) and cerebral palsy (11%).[2] Claims for management of labour and cerebral palsy along with interpretation of intrapartum monitoring were the most expensive.[2] Thus, improving fetal assessment to prevent complications is highly desirable. Failure to identify infants at risk of complications was recently highlighted in the Kirkup report into maternal deaths, stillbirths and neonatal deaths occurring in a single secondary obstetric unit in the UK. This report emphasized that the death of an otherwise healthy infant at term is a preventable tragedy; fetal monitoring in combination with appropriate action may prevent such events occurring.[3] Fetal assessment may be divided into measures instituted during pregnancy (antenatal), around the onset of established labour (peripartum) and those used in established labour (intrapartum).

Antenatal care and fetal assessment

Care during the antenatal period involves assessment and identification of fetuses at risk of developing fetal growth restriction (FGR) and subsequent asphyxia, so that they can be monitored appropriately during pregnancy.[4] Risk factors include pre-existing maternal disease (e.g. diabetes, hypertension) and suspected placental insufficiency in previous pregnancies (previous FGR and stillbirth).[5] Women deemed to be high risk are then monitored more closely in the antenatal period with ultrasound measurement of fetal growth and liquor volume, and Doppler studies of the umbilical artery. Where the risk is thought to be low, screening continues with serial measurements of symphysis-fundal height. If concerns arise (e.g. rate of growth decreases or measurement estimates fetal weight <10th centile), assessment is made with ultrasound. The sensitivity and specificity of this method of screening is low (27% and 88%, respectively),[6] and there is insufficient evidence to recommend scanning women at low-risk of FGR.[7] If FGR is identified, the fetus is monitored primarily with the use of Doppler ultrasound of umbilical artery blood flow and of the ductus venosus and these measurements inform the timing of delivery. If abnormalities are present such as absent or reversed end-diastolic flow, delivery should be planned after 32 weeks' gestation and sooner in the presence of abnormal waveform in the ductus venosus.[5]

Presently, women are advised to be aware of fetal movements after 28 weeks of pregnancy and to seek medical advice if they perceive a reduction in fetal movements. If mothers perceive that fetal movements are reduced after 28 weeks' gestation, guidelines suggest that cardiotocography (CTG) should be performed (see below) and patients with an increased risk of FGR should then be offered ultrasound assessment of fetal size and liquor volume.[8] A study in Norway investigated this approach; combining maternal education about fetal movements, CTG and ultrasound measurements and demonstrated a reduced perinatal mortality in cases of reduced fetal movement from 4.2 to 2.4%.[9] However, a large stepped-wedge cluster randomized controlled trial of standardized information and management of reduced fetal movements did not lead to a statistically significant reduction in stillbirth (4.4 per 1000 births during the control period

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and 4.06 per 1000 births in the intervention period (adjusted odds ratio adjusted odds ratio [aOR] 0.90, 95% CI 0.75–1.07).[10]

CTG is used antenatally for fetuses deemed to be at risk of asphyxia although meta-analysis has shown that this does not reduce mortality in low-risk populations.[11] This may be related to false reassurance provided by a normal trace, that actually only provides an assessment of fetal wellbeing for the duration of the recording.[11] In comparison, use of computerized CTG in the antenatal period is associated with a reduction in perinatal mortality (relative risk 0.20, 95% CI 0.04–0.88).[11] Importantly, computerized CTG assessment in the antenatal period may overcome difficulties with manual interpretation of CTG traces which have been highlighted as a critical issue in Confidential Enquiries into Stillbirth.[12,13]

Intrapartum monitoring of the fetus

Fetal monitoring in labour aims to recognize and prevent fetal asyphxia, reducing resulting acidaemia and ultimately the consequent complications such as hypoxic ischaemic encephalopathy (HIE), neurodevelopmental disorders and neonatal death.[14] The main method of fetal monitoring in labour is continuous electronic fetal monitoring using CTG, which may be supplemented with fetal scalp blood sampling (FSBS) or analysis of the fetal electrocardiogram (fECG).

The technique of CTG was first introduced in the 1970s in the absence of strong evidence and subsequent meta-analyses have failed to establish a significant relationship between its use and a reduction in perinatal death or cerebral palsy, although a reduction in neonatal seizures has been observed.[15] An increase in caesarean section and instrumental vaginal births with the use of CTG monitoring in labour has however been demonstrated. This may be related to the poor specificity of CTG monitoring, leading to intervention in the absence of acidaemia.[15] The risk assessment made antenatally should be reviewed during early labour, and revised during labour. Women who are deemed to be high-risk of intrapartum fetal asphyxia should be continuously monitored using CTG (Table 1).[16] Risk assessment should continue throughout labour as risk factors such as bleeding per vagina, the presence of meconium stained liquor or development of intrauterine infection may arise as labour progresses. The technique(s) of fetal monitoring employed depends upon the mothers' risk status for intrapartum fetal asphyxia and the results from other monitoring techniques.

Intermittent auscultation

Women identified as 'low risk' for fetal asphyxia should have intermittent auscultation of the fetal heart rate during labour. This should be undertaken for 60 seconds every 15 minutes immediately after a contraction in the first stage of labour and every 5 minutes immediately after a contraction in the second stage of labour.[16] Intermittent auscultation of the fetal heart is usually achieved with a handheld Doppler device, but a Pinard stethoscope may also be used. If an abnormality is suspected on auscultation, maternal pulse should be palpated simultaneously to identify a difference between the two heart rates.[16]

Continuous electronic fetal monitoring by CTG

The fetal heart rate is usually recorded by trans-abdominal Doppler ultrasound combined with a pressure transducer to measure contractions. If fetal heart rate trace cannot be obtained in this way, a fetal scalp electrode may be applied. The pressure transducer measures the frequency of contractions (but no indication of the intensity of contractions can be obtained). The number of contractions is usually expressed as x in 10 minutes.[4]

Several aspects of the fetal heart rate are used to interpret the trace according to international or national guidelines (those described here are derived from the UK National Institute of Health and Care Excellence). Each individual feature is classified as reassuring, non-reassuring or abnormal and an overall judgement made whether the CTG is normal, suspicious or pathological, or that the CTG warrants urgent action. The following features of a CTG are evaluated: (i) baseline rate – the average fetal heart rate; (ii) baseline variability – the

Risk factors for intrapartum fetal asphyxia

Antenatal period

Maternal	*Fetal*
Antepartum Haemorrhage	Breech presentation
Cardiac disease	Intrauterine growth restriction
Connective tissue disorder	Multiple pregnancy
Diabetes mellitus	Postmature pregnancy (>42 weeks)
Hypertensive disorder (including pre-eclampsia)	Preterm birth (<37 weeks)
Renal disease	
Previous caesarean section/uterine surgery.	

In labour

Maternal	*Fetal*	*Labour*
Vaginal bleeding in labour	Abnormalities detected on intermittent auscultation	Augmentation with oxytocin
Epidural anaesthesia	Meconium-stained liquor	Induction of labour
Signs of infection (pyrexia, tachycardia, offensive liquor).		Prolonged rupture of membranes

Table 1

fluctuations of fetal heart rate (similar to the amplitude of the trace); (iii) the presence of decelerations – downward deflections of fetal rate more than 15 beats per minute beneath the baseline for more than 15 seconds. The presence of accelerations – upward deflections of fetal heart rate for more than 15 beats per minute above the baseline for more than 15 seconds, is thought to be reassuring. However, in an otherwise normal trace in labour, their absence does not indicate acidosis.[16]

Decelerations are classified according to their timing with contractions, and must also be assessed for 'concerning characteristics'. 'Variable decelerations' have variable morphology and timing relative to contractions. 'Late decelerations' commence after the contraction starts, have their nadir after the peak of the contraction and end after the contraction. A deceleration is classified as containing 'concerning characteristics' if: the deceleration lasts for more than 60 seconds, there is reduced baseline variability within the deceleration, the fetal heartbeat fails to return to baseline, a biphasic (W) shape is demonstrated or if 'shouldering' (the reassuring sign of fetal heart acceleration immediately prior to and after a deceleration) is absent.

Decelerations that occur early in the contraction are due to head compression so are not viewed as pathological. Variable decelerations with no concerning characteristics indicate a normal fetal response to cord compression during contraction. Late decelerations or variable decelerations with concerning characteristics indicate cord compression with placental insufficiency, these are viewed as pathological and associated with fetal acidaemia. The classification system proposed in the NICE guideline is shown in Table 2.[16]

Figure 1 shows a normal fetal heart trace. Here, uterine activity is 4–5:10, baseline rate is 135 with variability >5 and no decelerations. Accelerations are present. The CTG in Figure 2

An example of a classification system used to determine whether the CTG is normal, suspicious or pathological

Feature	Baseline (beats/min)	Baseline Variability (beats/min)	Decelerations
Normal	110–160	5–25	None or early Variable decelerations with no concerning characteristics for less than 90 minutes
Non-reassuring	100–109 161–180	<5 for 30–50 mins OR >25 for 15–25 mins	Variable decelerations with no concerning characteristics for 90 minutes or more OR Variable decelerations with any concerning characteristics in up to 50% of contractions for 30 minutes or more OR Variable decelerations with any concerning characteristics in over 50% of contractions for less than 30 minutes OR Late decelerations in over 50% of contractions for less than 30 minutes, with no maternal or fetal clinical risk factors such as vaginal bleeding or significant meconium
Abnormal	>180 or <100	<5 for >50 mins OR >25 for >25 mins OR Sinusoidal pattern	Variable decelerations with any concerning characteristics in over 50% of contractions for 30 minutes (or less if any maternal or fetal clinical risk factors [see above]) OR Late decelerations for 30 minutes (or less if any maternal or fetal clinical risk factors) OR Acute bradycardia, or a single prolonged deceleration lasting 3 minutes or more

Category	
Normal	All 3 features reassuring.
Suspicious	1 non-reassuring with 2 reassuring features
Pathological	1 Abnormal feature Or 2 Non-reassuring features
Need for urgent intervention	Acute bradycardia, or a single prolonged deceleration for 3 minutes or more

Table 2

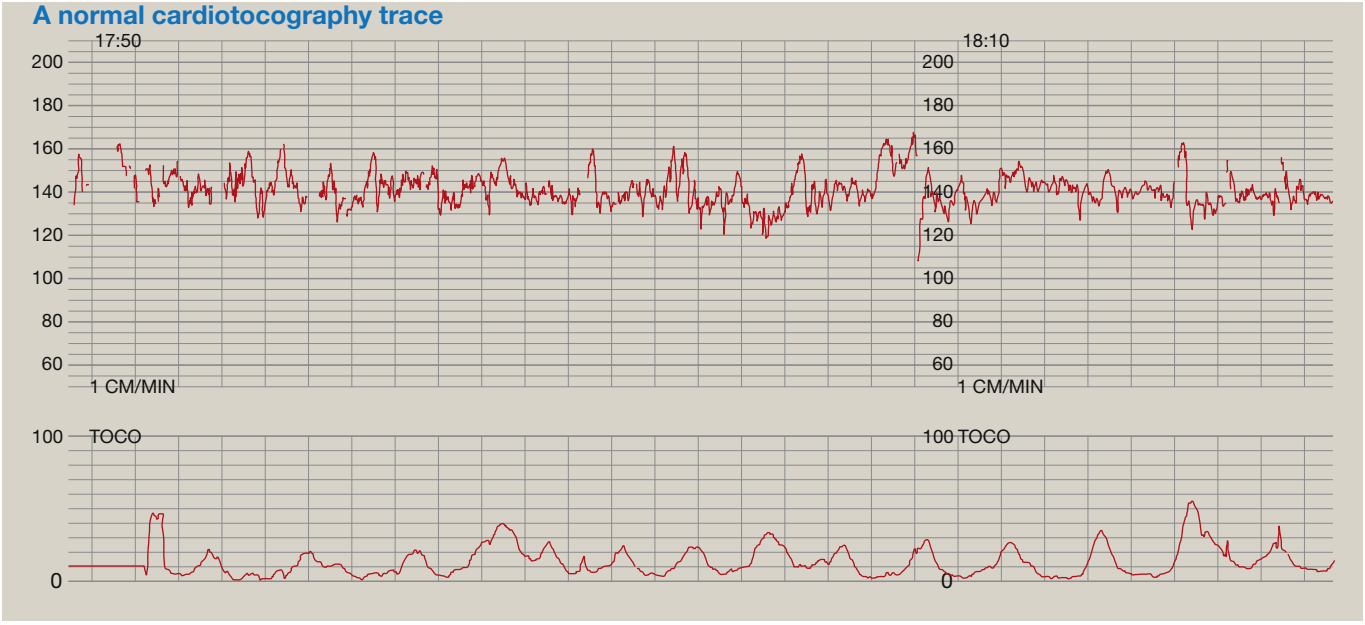

Figure 1 The baseline is 140 beats/minute, variability >5 beats/minute, accelerations are present and there are no decelerations.

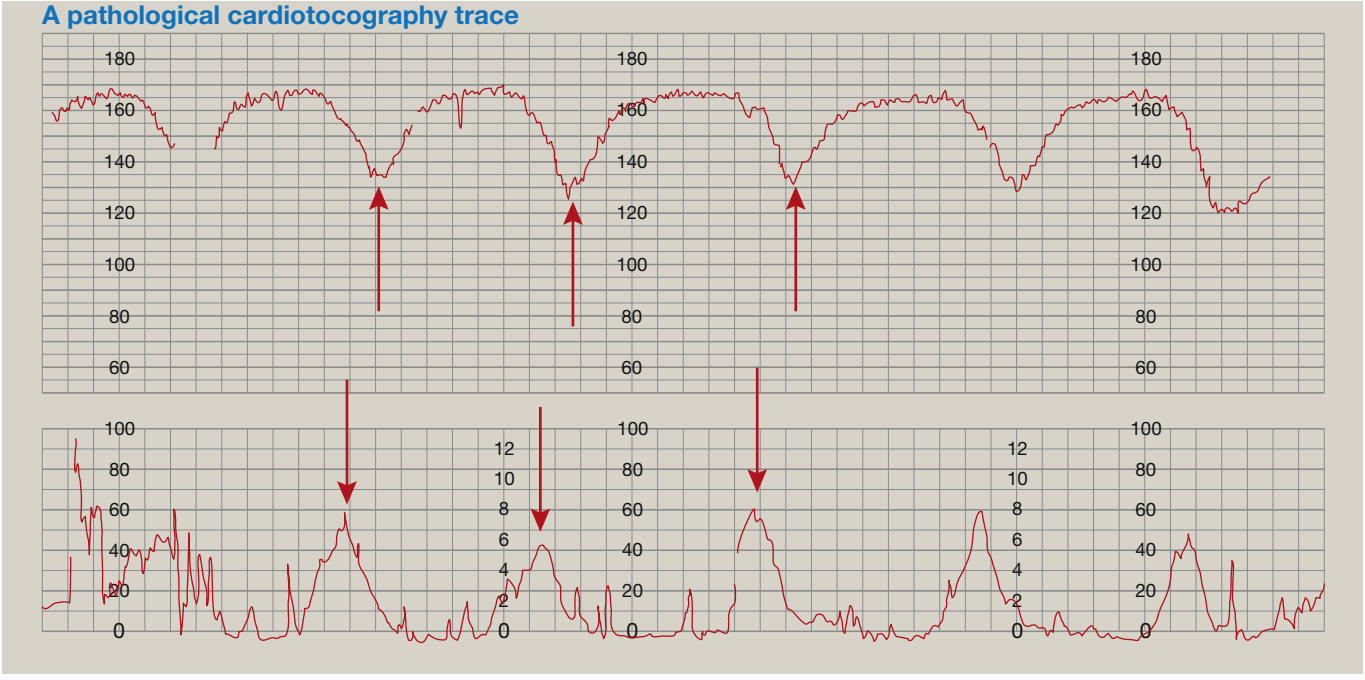

Figure 2 The baseline is 160 beats/minute, variability <5 beats/minute, there are no accelerations and late decelerations. The nadir of the deceleration and peak of the contraction are marked by arrows. Reproduced from J Gardosi, T Vanner, L Chadwick and M Terret e CTG Tutor, PRAM, 1996. Perinatal Institute www.pi.nhs.uk/ctg.

displays a baseline rate of 160 bpm, variability <5 and late decelerations (lasting >60 seconds with no shouldering). This trace is abnormal. CTG monitoring can be used in the low-risk setting if concerns arise on intermittent auscultation. If the trace is normal after 20 minutes of monitoring, it can be discontinued and intermittent auscultation resumed.

Conservative measures are advised if the CTG is suspicious or pathological. These include encouraging the woman to move into the left-lateral position rather than supine to optimize venous return; offering oral or intravenous fluids; and administering paracetamol if the woman is pyrexial. If an oxytocin infusion is in use, this can be stopped to reduce frequency of contractions. In the absence of oxytocin, terbutaline 0.25 mg can be administered subcutaneously. If the trace is pathological, digital fetal scalp stimulation (during vaginal examination) can be undertaken. The presence of acceleration elicited in this

way can be regarded as a reassuring sign and should be taken into consideration. However, if the CTG remains pathological, FSBS should be performed in conjunction with conservative measures.[13]

If FSBS is not possible or is contraindicated, then delivery should be expedited by the quickest means (caesarean section or instrumental vaginal delivery).[16] In the instance of fetal bradycardia or a single prolonged deceleration that persists below 100 beats/minute for 3 minutes or more, plans should be made for urgent intervention without fetal blood sampling as this indicates a high probability of fetal acidosis. If this persists for 9 minutes, delivery should be expedited.[16]

When interpreting CTG traces, it is important to note that the trace should always be used in the context of the clinical picture and decisions should not be made on isolated interpretation of the trace.

Fetal scalp blood sampling

FSBS is used to improve the specificity of CTG (i.e. to identify which fetuses with a pathological fetal heart rate trace are genuinely compromised). Two recent systematic reviews found that FSBS reduces the incidence of cord blood acidosis, need for neonatal resuscitation, neonatal seizures and low Apgar scores, but the procedure may increase the rate of operative delivery.[15,16] Conversely, other studies suggest that FSBS decreases the rate of caesarean section.[17] FSBS can usually be performed with cervical dilatation of 3 cm or greater, although the procedure takes shorter time at greater cervical dilatations,[18] with those performed at a dilatation of 5 cm or greater taking approximately 30% less time. FSBS is contraindicated when there is a possibility of fetal bleeding disorder (e.g. male infant of a haemophilia carrier) or maternal blood-borne infection (e.g. human immunodeficiency virus). An amnioscope is inserted into the vagina to enable visualization of the fetal scalp, ethyl chloride spray is used to give local vasodilatation and a small scratch made on the fetal scalp and a capillary sample taken. The pH and base excess are then measured. A pH of 7.20 or lower is an indication for delivery by the quickest means. If the pH is 7.21–7.24 then the FSBS procedure should be repeated within 30 minutes if the CTG remains pathological. If the pH is 7.25 or higher then FSBS should be repeated within 60 minutes if the CTG remains pathological. FSBS is a safe procedure, but guidelines recommend that a senior obstetrician is involved in the case if three or more FSBS procedures are required.[9] FSBS is being developed to measure lactate rather than pH which reduces the failure rate from 10.4% for pH to 1.2% for lactate.[19]

Developing areas

Low specificity of identification of intrapartum asphyxia as a result of mis-interpretation of abnormal CTG traces has led to development of new techniques in fetal monitoring. Trials have been conducted into the monitoring and analysis of fetal echocardiogram (ST segment and PR interval) in addition to CTG. Rates of instrumental delivery and fetal blood sampling were seen to be reduced. However, caesarean section rates and perinatal outcomes overall were not affected.[20] A multicentre randomized controlled trial (INFANT ISRCTN98680152) analysed data from 46,042 women recruited to the trial of computerized decision support in CTG interpretation in labour; the trial found no difference in the incidence of poor neonatal outcome between the groups, 172 (0.7%) babies in the decision-support group compared with 171 (0.7%) babies in the no-decision-support group (adjusted risk ratio 1.01, 95% CI 0.82–1.25).[21] At 2 years, no significant differences were noted in terms of developmental assessment. Thus, efforts are still required to improve the sensitivity and specificity of intrapartum fetal assessment to ensure that fetuses with perinatal asphyxia are accurately identified in a timely manner, while those with no evidence of compromise do not have unnecessary intervention. ◆

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