

FIGO CONSENSUS GUIDELINES ON INTRAPARTUM FETAL MONITORING

Safe Motherhood and Newborn Health Committee
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CARDIOTOCOGRAPHY

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The views expressed in this document reflect the opinion of the individuals and not necessarily of the institutions that they represent.

1. INTRODUCTION

The purpose of this chapter is to assist in the use and interpretation of intrapartum cardiotocography (CTG), as well as in the clinical management of specific CTG patterns. In the preparation of these guidelines, it has been assumed that all necessary resources, both human and material, required for intrapartum monitoring and clinical management are readily available. Unexpected complications may occur during labour, even in patients without prior evidence of risk, so maternity hospitals need to ensure the presence of trained staff, as well as appropriate facilities and equipment for an expedite delivery (in particular emergency caesarean section). CTG monitoring should never be regarded as a substitute for good clinical observation and judgement, or as an excuse for leaving the mother unattended during labour.

2. INDICATIONS

The evidence for the benefits of continuous CTG monitoring, as compared to intermittent auscultation, in both low and high-risk labours is scientifically inconclusive¹⁻². When compared to intermittent auscultation, continuous CTG has been shown to decrease the occurrence of neonatal seizures, but no effect has been demonstrated on the incidence of overall perinatal mortality or cerebral palsy. However, these studies were carried out in the 1970s, 1980s, and early 1990s where equipment, clinical experience and interpretation criteria were very different from current practice, and they were clearly underpowered to evaluate differences in major outcomes³. These issues are discussed in more detail below (see section 8 of this chapter). In spite of these limitations, most experts believe that continuous CTG monitoring should be considered in all situations where there is a high risk of fetal hypoxia/acidosis, whether due to maternal health conditions (such as vaginal haemorrhage and maternal pyrexia), abnormal fetal growth during pregnancy, epidural analgesia, meconium stained liquor, or the possibility of excessive uterine activity, as occurs with induced or augmented labour. Continuous CTG is also recommended when abnormalities are detected during intermittent fetal auscultation. The use of continuous intrapartum CTG in low-risk women is more controversial, although it has become standard of care in many countries. An alternative approach is to provide intermittent CTG monitoring alternating with fetal heart rate (FHR) auscultation. There is some evidence to support that this is associated with similar neonatal outcomes in low-risk

pregnancies ⁴. Intermittent monitoring should be carried out long enough to allow adequate evaluation of the basic CTG features (see below). The routine use of admission CTG for low-risk women on entrance to the labour ward has been associated with an increase in caesarean section rates and no improvement in perinatal outcomes ⁵, but studies were also underpowered to show such differences. In spite of the lack of evidence regarding benefit, this procedure has also become standard of care in many countries.

3. TRACING ACQUISITION

Maternal position for CTG acquisition

Maternal supine recumbent position can result in aorto-caval compression by the pregnant uterus, affecting placental perfusion and fetal oxygenation. Prolonged monitoring in this position should therefore be avoided. The lateral recumbent, half-sitting, and upright positions are preferable alternatives ⁶.

CTG acquisition can be performed by portable sensors that transmit signals wirelessly to a remote fetal monitor (telemetry). This solution has the advantage of allowing the mother to move freely during signal acquisition, rather than be restrained to bed or a sofa, and should therefore be the preferred option when available. Telemetry systems differ in the maximum distance allowed between patient and monitor for adequate signal transmission ⁷.

Paper scales for CTG registration and viewing

The horizontal scale for CTG registration and viewing is commonly called “paper speed” and available options are usually 1, 2 or 3 cm/min. In many countries throughout the world 1 cm/min is selected, while in the Netherlands it is usually 2 cm/min, and in North America and Japan it is almost exclusively 3 cm/min. Some experts feel that 1 cm/min provides records of sufficient detail for clinical analysis, and this has the advantage of reducing tracing length. Other experts feel that the small details of CTG tracings are better evaluated using higher papers speeds. The vertical scale used for registration and viewing may also be different, and available alternatives are 20 or 30 bpm/cm.

The paper scales used in each centre should be the one with which healthcare professionals are most familiar, because tracing interpretation depends on pattern recognition and these patterns may appear very different. Inadvertent use of paper scales to which the staff is unaccustomed may lead to erroneous interpretations of CTG features. For example, at 3 cm/min variability appears reduced to a clinician familiar with the 1 cm/min scale, while it may appear exaggerated in the opposite situation (see examples below).

External versus internal FHR monitoring

External FHR monitoring uses a Doppler ultrasound transducer to detect the movement of cardiac structures. The resulting signal requires signal modulation and autocorrelation to provide adequate quality recordings ⁸. This process results in an approximation of the true heart rate intervals, but this is considered to be sufficiently accurate for analysis. External FHR monitoring is more prone to signal loss, to inadvertent monitoring of the maternal heart rate ⁹ (Fig. 1), and to signal artefacts such as double-counting (Fig. 2) and half-counting ⁸, particularly during the second stage of labour. It may also not record fetal cardiac arrhythmias accurately.



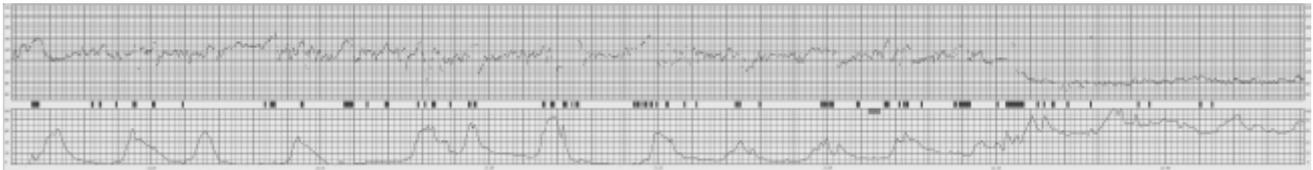


Fig 1. Maternal heart rate monitoring in the last 9 min of the tracing. External FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).



Fig 2. Double-counting of the FHR during decelerations (arrows). External FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).

Internal FHR monitoring using a fetal electrode (usually known as scalp electrode, but it can also be applied to the breech) evaluates the time intervals between successive heart beats by identifying R waves on the fetal electrocardiogram QRS complex, and therefore measures ventricular depolarisation cycles. This method provides a more accurate evaluation of intervals between cardiac cycles, but it is more expensive because it requires a disposable electrode. It is very important that the fetal electrode is only applied after a clear identification of the presenting part and that delicate fetal structures such as the sutures and fontanels are avoided. Internal FHR monitoring requires ruptured membranes and has established contra-indications, mainly related to the increased risk of vertical transmission of infections. It should not be used in patients with active genital herpes infection, those who are seropositive to hepatitis B, C, D, E, or to human immunodeficiency virus^{10,11}, in suspected fetal blood disorders, when there is uncertainty about the presenting part, or when artificial rupture of membranes is inappropriate (i.e. an unengaged presentation). Fetal electrode placement should also preferably be avoided in very preterm fetuses (under 32 weeks gestation).

External FHR monitoring is the recommended initial method for routine intrapartum monitoring, provided that a recording of acceptable quality is obtained, i.e. that the basic CTG features can be identified. Minimum requirements for using this method are that careful repositioning of the probe is carried out during the second stage of labour, that in all atypical FHR tracings maternal heart rate monitoring is ruled out (see below), and if any doubt remains fetal

auscultation, ultrasound evaluation or internal FHR monitoring are performed. If an acceptable record cannot be obtained with external monitoring or if a cardiac arrhythmia is suspected, then internal monitoring should be used, in the absence of the previously mentioned contra-indications.

External versus internal monitoring of uterine contractions

External monitoring of uterine contractions using a tocodynamometer (toco) evaluates increased myometrial tension measured through the abdominal wall. Incorrect placement, reduced tension applied to the supporting elastic band, or abdominal adiposity may result in failed or inadequate registration of contractions. In addition, this technology only provides accurate information on the frequency of contractions. It is not possible to extract reliable information regarding the intensity and duration of contractions, nor on basal uterine tone.

Internal monitoring of uterine contractions using an intrauterine catheter provides quantitative information on the intensity and duration of contractions, as well as on basal uterine tone, but it is more expensive as the catheter is disposable, and requires ruptured membranes. Contra-indications include uterine haemorrhage of unknown cause and placenta praevia. It may also be associated with a small risk of fetal injury, placental haemorrhage, uterine perforation, and infection ¹². The routine use of intrauterine pressure catheters has not been shown to be associated with improved outcomes in induced and augmented labour ¹³, and so it is not recommended for routine clinical use.

Simultaneous monitoring of the maternal heart rate

Simultaneous monitoring of the maternal heart rate (MHR) can be useful in specific maternal health conditions and in cases where it is difficult to distinguish between maternal and fetal heart rates ⁹ (for example complete fetal heart block). Some CTG monitors provide the possibility of continuous MHR monitoring, either by electrocardiography or pulse oximetry. In some recent models, the latter technology has been incorporated in the tocodynamometer, allowing continuous MHR monitoring without the use of additional equipment. Providing that the technology is available and does not cause discomfort to the mother, simultaneous MHR monitoring should be considered when performing continuous CTG, especially during the second stage of labour, when tracings show accelerations coinciding with contractions and expulsive efforts ⁹, or when the MHR is elevated.

Monitoring of twins

Continuous external FHR monitoring of twin gestations during labour should preferably be performed with dual channel monitors that allow simultaneous monitoring of both FHRs, as duplicate monitoring of the same twin may occur and this can be picked up by observing almost identical tracings. Some monitors have embedded algorithms to alarm when this situation is suspected. During the second stage of labour, external FHR monitoring of twins is particularly affected by signal loss, and for this reason some experts believe that the presenting twin should preferably be monitored internally for better signal quality ¹⁴, if no contraindications to fetal electrode placement are present. Other experts believe that external monitoring of both twins is acceptable, provided that distinct and good quality FHR signals can be obtained.

Storage of tracings

All CTG tracings need to be identified with the patient name, place of recording, "paper speed", date and time when acquisition started and ended. In hospitals where paper CTG recordings are used, the latter should be considered as part of the patient record and preserved as such. In hospitals using digital CTG archives ¹⁵, a secure file backup system needs to be in place, and all tracings should be readily available for review by the clinical staff.

4. ANALYSIS OF TRACINGS

CTG analysis starts with the evaluation of basic CTG features (baseline, variability, accelerations, decelerations and contractions) followed by overall CTG classification.

EVALUATION OF BASIC CTG FEATURES

BASELINE – this is the mean level of the most horizontal and less oscillatory FHR segments. It is estimated in time periods of 10 minutes and expressed in beats per minute (bpm). The baseline value may vary between subsequent 10-minute sections.

In tracings with unstable FHR signals, review of previous segments and/or evaluation of longer time periods may be necessary to estimate the baseline¹⁶, in particular during the 2nd stage of labour and to identify the fetal behavioural state of active wakefulness (see below – Fig. 3) that can lead to an erroneously high baseline estimation.



Fig 3. Fetal behavioural state of active wakefulness. This pattern may lead to an erroneously high baseline estimation if it is identified at the top of accelerations. External FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).

Normal baseline – a value between 110 and 160 bpm.

Preterm fetuses tend to have values towards the upper end of this range and post term fetuses towards the lower end. Some experts consider the normal baseline values at term to be between 110-150 bpm.

Tachycardia – a baseline value above 160 bpm lasting more than 10 minutes.

Maternal pyrexia is the most frequent cause of fetal tachycardia, and it may be of extra-uterine origin or associated with intrauterine infection. Epidural analgesia may also cause a rise in maternal temperature resulting in fetal tachycardia¹⁷. In the initial stages of a non-acute fetal hypoxemia, catecholamine secretion may also result in tachycardia. Other less frequent causes are the administration of beta-agonist drugs¹⁸ (salbutamol, terbutaline, ritodrine, fenoterol), parasympathetic blockers (atropine, escopolamine), and fetal arrhythmias such as supraventricular tachycardia and atrial flutter.

Bradycardia – a baseline value below 110 bpm lasting more than 10 minutes

Values between 100 and 110 bpm may occur in normal fetuses, especially in postdate pregnancies. Maternal hypothermia¹⁹, administration of beta-blockers²⁰, and fetal arrhythmias such as atrial-ventricular block are other possible causes.

VARIABILITY – refers to the oscillations in the FHR signal, evaluated as the average bandwidth amplitude of the signal in one-minute segments.

Normal variability – a bandwidth amplitude of 5-25 bpm.

Reduced variability – a bandwidth amplitude below 5 bpm for more than 50 minutes in baseline segments²¹ (Figs. 4-5), or for more than 3 minutes during decelerations²² (Figs. 8-9).

Reduced variability can occur due to central nervous system hypoxia/acidosis and resulting decreased sympathetic and parasympathetic activity, but it can also be due to previous cerebral injury²³, infection, administration of central nervous system depressants or parasympathetic blockers. During deep sleep, variability is usually in the lower range of normality, but the bandwidth amplitude is seldom under 5 bpm. There is a high degree of subjectivity in the visual evaluation of this parameter, and therefore careful re-evaluation is recommended in borderline situations. Following an initially normal CTG, reduced variability due to hypoxia is very unlikely to occur during labour without preceding or concomitant decelerations and a rise in the baseline.

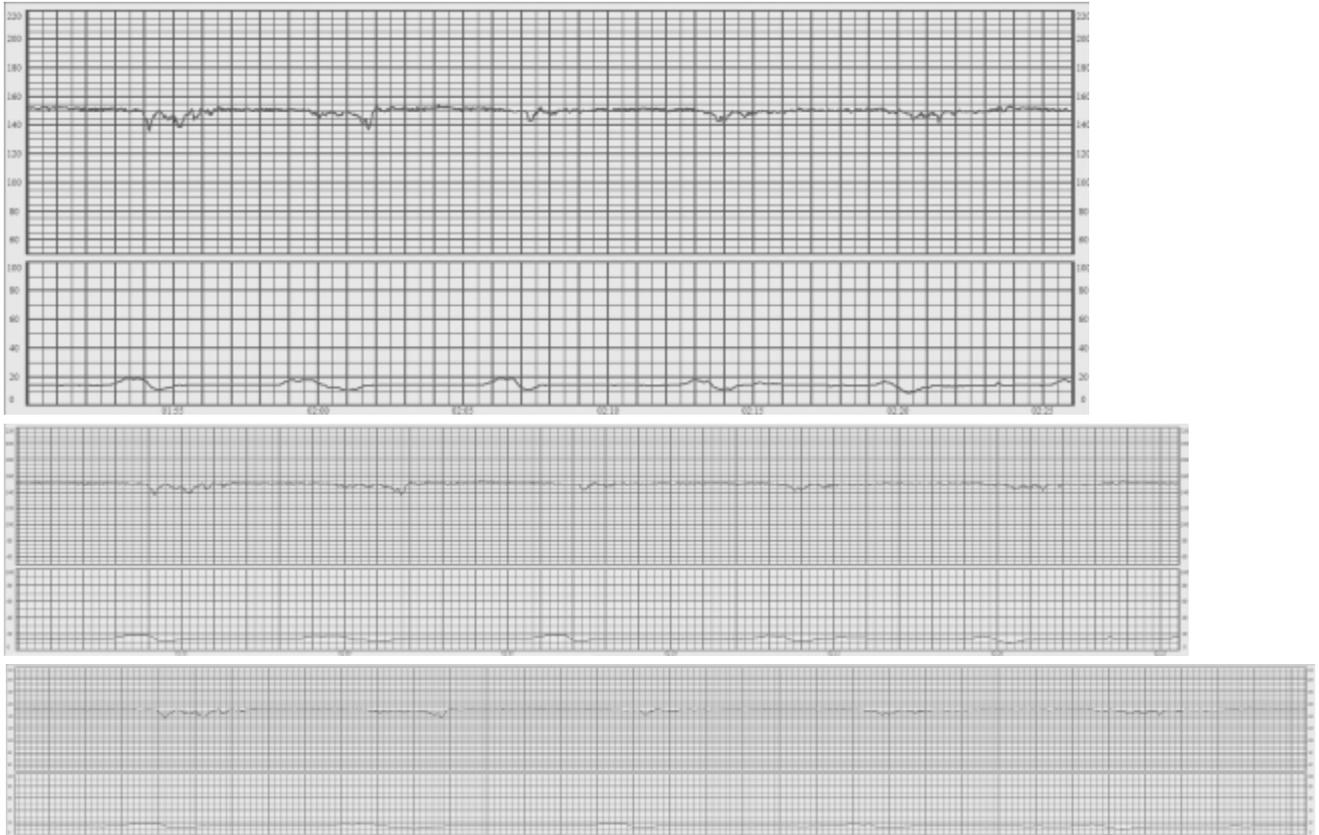


Fig 4. Reduced variability. External FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).



Fig 5. Reduced variability – the baseline is affected by contractions causing decreases in FHR that are close to fulfilling the criteria for decelerations, but the bandwidth remains reduced. Internal FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).

Increased variability (saltatory pattern) – a bandwidth value exceeding 25 bpm lasting more than 30 minutes (Fig. 6).

The pathophysiology of this pattern is incompletely understood, but it may be seen linked with recurrent decelerations, when hypoxia/acidosis evolves very rapidly. It is presumed to be caused by fetal autonomic instability/hyperactive autonomic system²⁴.

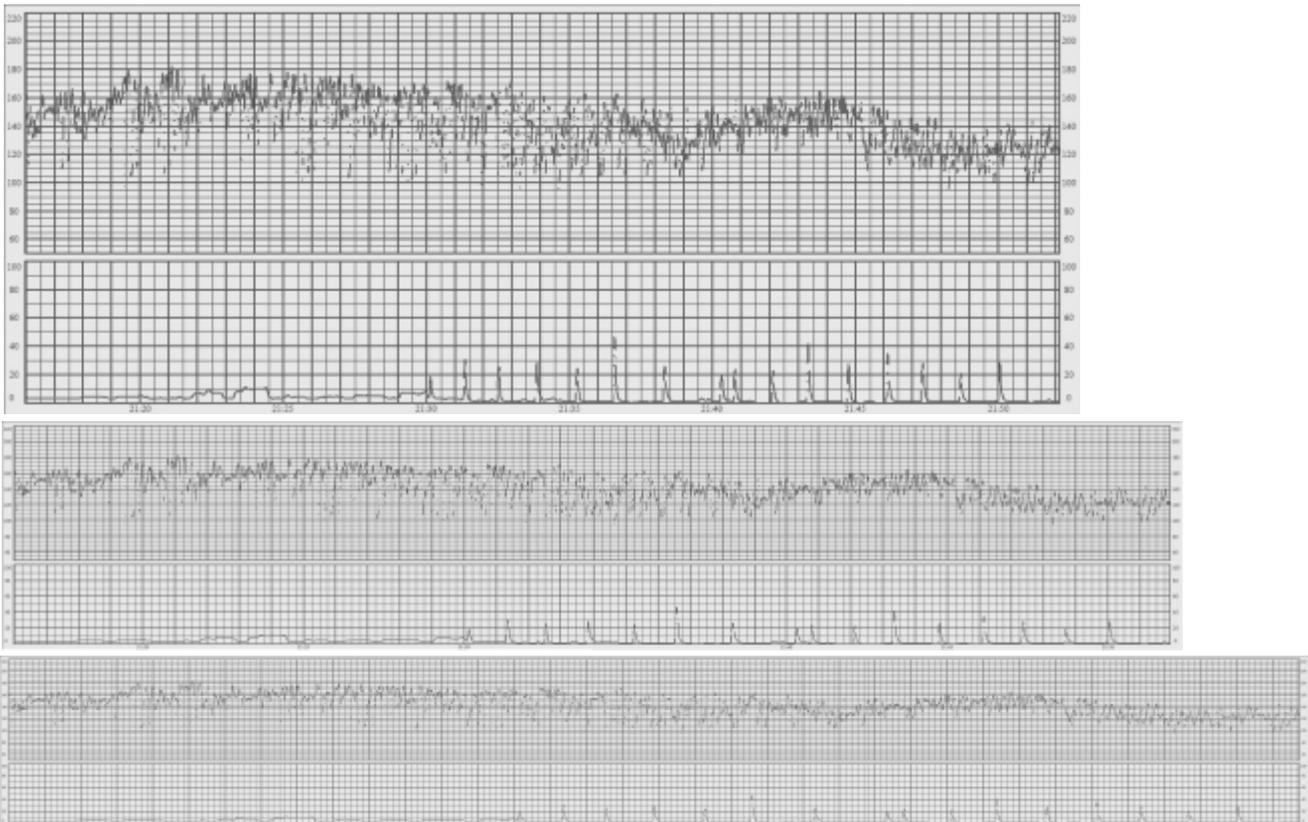


Fig 6. Increased variability - saltatory pattern. Internal FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).

ACCELERATIONS – abrupt (onset to peak in less than 30 seconds) increases in FHR above the baseline, of more than 15 bpm in amplitude, and lasting more than 15 seconds but less than 10 minutes.

Most accelerations coincide with fetal movements and are a sign of a neurologically responsive fetus that does not have hypoxia/acidosis. Before 32 weeks' gestation, their amplitude and frequency may be lower (10 seconds and 10 bpm of amplitude). After 32-34 weeks, with the establishment of fetal behavioural states, accelerations rarely occur during periods of deep sleep, which can last up to 50 minutes²¹. The absence of accelerations in an otherwise normal intrapartum CTG is of uncertain significance, but it is unlikely to indicate hypoxia/acidosis. Accelerations coinciding with uterine contractions, especially in the second stage of labour, suggest possible erroneous recording of the maternal heart rate, since the FHR more frequently decelerates with a contraction, while the maternal heart rate typically increases⁹.

DECELERATIONS – decreases in the FHR below the baseline, of more than 15 bpm in amplitude, and lasting more than 15 seconds.

Early decelerations – decelerations that are shallow, short-lasting, with normal variability within the deceleration and are coincident with contractions. They are believed to be caused by fetal head compression²⁵ and do not indicate fetal hypoxia/acidosis.

Variable decelerations (V-shaped) – decelerations that exhibit a rapid drop (onset to nadir in less than 30 seconds), good variability within the deceleration, rapid recovery to the baseline, varying size, shape and relationship to uterine contractions (Fig. 7).

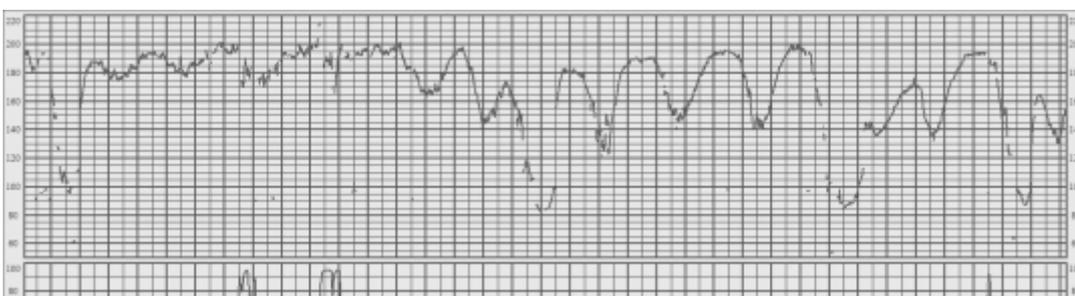
Variable decelerations constitute the majority of decelerations during labour, and they translate a baroreceptor-mediated response to increased arterial pressure, as occurs with umbilical cord compression²⁶. They are seldom associated with an important degree of fetal hypoxia/acidosis, unless they evolve to exhibit a U-shaped component, reduced variability within the deceleration (see late decelerations below), and/or their individual duration exceeds 3 minutes^{22,27} (see prolonged decelerations below).



Fig 7. Variable decelerations. Internal FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).

Late decelerations (U-shaped and/or with reduced variability) – decelerations with a gradual onset and/or a gradual return to the baseline and/or reduced variability within the deceleration (Fig. 8). Gradual onset and return occurs when more than 30 seconds elapses between the beginning/end of a deceleration and its nadir. When contractions are adequately monitored, late decelerations start more than 20 seconds after the onset of a contraction, a nadir after the acme, and a return to the baseline after the end of the contraction.

These decelerations are indicative of a chemoreceptor-mediated response to fetal hypoxemia^{25,27}. In the presence of a tracing with no accelerations and reduced variability, the definition of late decelerations also includes those with an amplitude of 10-15 bpm.



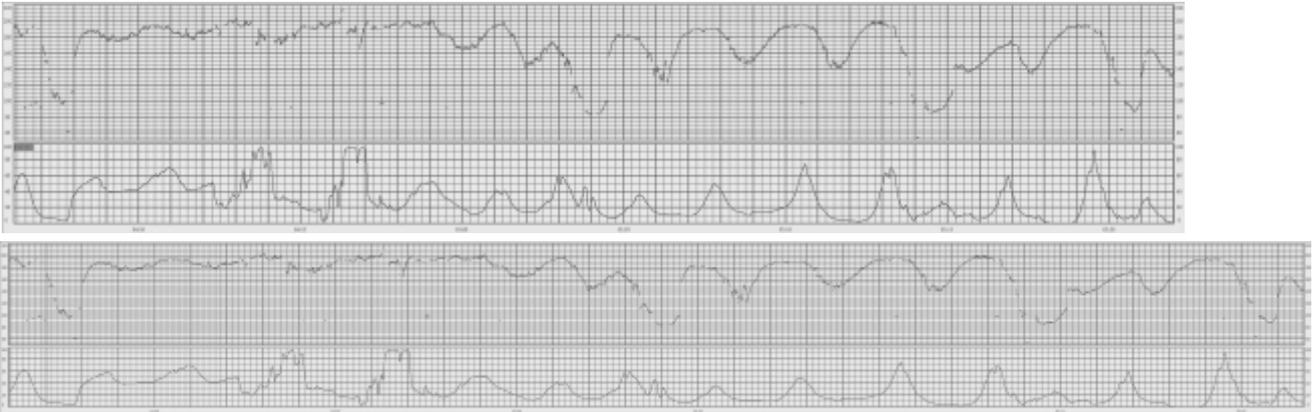


Fig 8. Late decelerations in the second half of the tracing. External FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).

Prolonged decelerations – lasting more than 3 minutes.

These are likely to include a chemoreceptor-mediated component and thus to indicate hypoxemia. Decelerations exceeding 5 minutes, with FHR maintained <80 bpm and reduced variability within the deceleration (Fig. 9), are frequently associated with acute fetal hypoxia/acidosis^{22,28-30} and require emergent intervention.



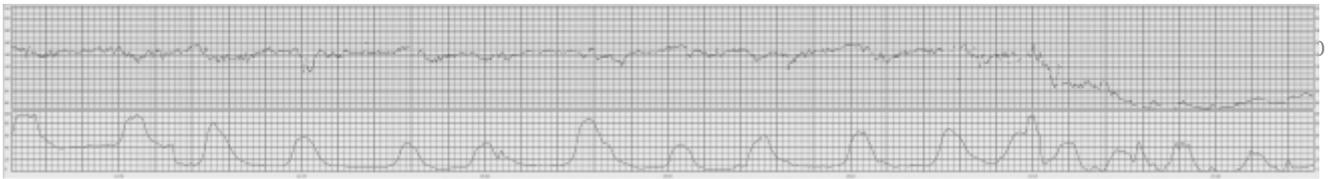


Fig 9. Prolonged deceleration. External FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).

SINUSOIDAL PATTERN – a regular, smooth, undulating signal, resembling a sine wave, with an amplitude of 5-15 bpm, and a frequency of 3-5 cycles per minute. This pattern lasts more than 30 minutes, and coincides with absent accelerations (Fig. 10).

The pathophysiological basis of the sinusoidal pattern is incompletely understood, but it occurs in association with severe fetal anemia, as is found in anti-D allo-immunisation, fetal-maternal hemorrhage, twin-to-twin transfusion syndrome and ruptured vasa praevia. It has also been described in cases of acute fetal hypoxia, infection, cardiac malformations, hydrocephalus and gastroschisis³¹.



Fig 10. Sinusoidal pattern. External FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).

PSEUDO-SINUSOIDAL PATTERN – a pattern resembling the sinusoidal pattern, but with a more jagged “saw-tooth” appearance, rather than the smooth sine-wave form (Fig. 11). Its duration seldom exceeds 30 minutes and it is characterised by normal patterns before and after.

This pattern has been described after analgesic administration to the mother, and during periods of fetal sucking and other mouth movements³². It is sometimes difficult to distinguish the pseudo-sinusoidal pattern from the true sinusoidal pattern, leaving the short duration of the former as the most important variable to discriminate between the two.

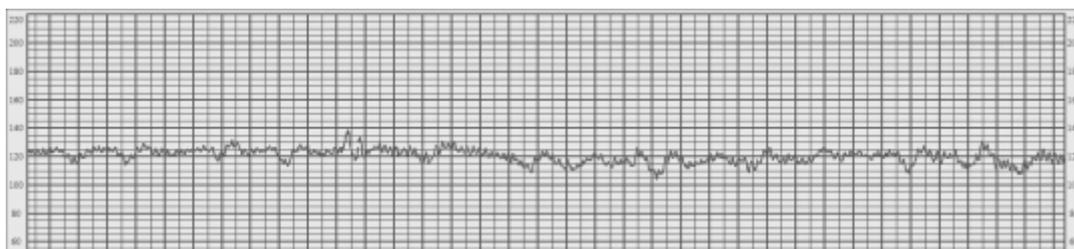




Fig 11. Pseudo-sinusoidal pattern. External FHR monitoring at 1 cm/min (top graph), 2 cm/min (middle graph) and 3 cm/min (bottom graph).

FETAL BEHAVIOURAL STATES – refers to periods of fetal quiescence reflecting deep sleep (no eye movements), alternating with periods of active sleep (rapid eye movements) and wakefulness^{33,34}. The occurrence of different behavioural states is a hallmark of fetal neurological responsiveness and absence of hypoxia/acidosis. Deep sleep can last up to 50 minutes²¹ and is associated with a stable baseline, very rare accelerations, and borderline variability. Active sleep is the most frequent behavioural state, and is represented by a moderate number of accelerations and normal variability. Active wakefulness is rarer and represented by a large number of accelerations and normal variability (Fig. 1). In the latter pattern, accelerations may be so frequent as to cause difficulties in baseline estimation (see Fig 1 above). Transitions between the different patterns become clearer after 32-34 weeks of gestation, consequent to fetal nervous system maturation.

CONTRACTIONS – these are bell-shaped gradual increases in the uterine activity signal followed by roughly symmetric decreases, with 45-120 seconds in total duration.

Contractions are essential for the progression of labour, but they compress the vessels running inside the myometrium and may transiently decrease placental perfusion and/or cause umbilical cord compression (see Chapter 1). With the tocodynamometer, only the frequency of contractions can be reliably evaluated, but increased intensity and duration can also contribute to FHR changes.

Tachysystole – represents an excessive frequency of contractions and is defined as the occurrence of more than 5 contractions in 10 minutes, in two successive 10-minute periods, or averaged over a 30-minute period.

5. TRACING CLASSIFICATION

Tracing classification requires a previous evaluation of basic CTG features (see above). Tracings should be classified into one of three classes: normal, suspicious or pathological, according to the criteria presented in Table 1. Other classification systems including a larger number of tiers are recommended by some experts^{35,36}. Due to the changing nature of CTG signals during labour, re-evaluation of the tracing should be carried out at least every 30 minutes.

Normal	Suspicious	Pathological
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Baseline	110-160 bpm	Lacking at least one characteristic of normality, but with no pathological features	< 100 bpm
Variability	5-25 bpm		Reduced variability for > 50 min, increased variability for >30 min, or sinusoidal pattern for > 30 min
Decelerations	No repetitive* decelerations		Repetitive* late or prolonged decelerations during > 30 min or 20 min if reduced variability, or one prolonged deceleration with > 5 min
Interpretation	Fetus with no hypoxia/acidosis	Fetus with a low probability of having hypoxia/acidosis	Fetus with a high probability of having hypoxia/acidosis
Clinical Management	No intervention necessary to improve fetal oxygenation state	Action to correct reversible causes if identified, close monitoring or additional methods to evaluate fetal oxygenation (chapter 4).	Immediate action to correct reversible causes, additional methods to evaluate fetal oxygenation (chapter 4), or if this is not possible expedite delivery. In acute situations (cord prolapse, uterine rupture or placental abruption) immediate delivery should be accomplished.

Table 1. CTG classification criteria, interpretation and recommended management. The presence of accelerations denotes a fetus that does not have hypoxia/acidosis, but their absence during labour is of uncertain significance. *Decelerations are repetitive in nature when they are associated with more than 50% of uterine contractions ²⁹.

6. CLINICAL DECISION

Several factors, including gestational age and medication administered to the mother, can affect FHR features (see above), so CTG analysis needs to be integrated with other clinical information for a comprehensive interpretation and adequate management. As a general rule, if the fetus continues to maintain a stable baseline and a reassuring variability, the risk of hypoxia to the central organs is very unlikely. However, the general principles that should guide clinical management are outlined in Table 1.

7. ACTION IN SITUATIONS OF SUSPECTED FETAL HYPOXIA/ACIDOSIS

When fetal hypoxia/acidosis is anticipated or suspected (suspicious and pathological tracings), and action is required to avoid adverse neonatal outcome, this does not necessarily mean an immediate cesarean section or instrumental vaginal delivery. The underlying cause for the appearance of the pattern can frequently be identified and the situation reversed, with subsequent recovery of adequate fetal oxygenation and the return to a normal tracing.

Excessive uterine activity is the most frequent cause of fetal hypoxia/acidosis (see Chapter 1) and it can be detected by documenting tachysystole in the CTG tracing and/or palpating the uterine fundus. It can usually be reversed by reducing or stopping oxytocin infusion, removing administered prostaglandins if possible, and/or starting acute tocolysis with beta-adrenergic agonists (salbutamol, terbutaline, ritodrine) ³⁷⁻³⁹, atosiban ⁴⁰, or nitroglycerine ⁴¹. During the second stage of labour, maternal pushing efforts can also contribute to fetal hypoxia/acidosis and the mother can be asked to stop pushing until the situation is reversed.

Aorto-caval compression can occur in the supine position and lead to reduced placental perfusion. Excessive uterine activity may also be associated with the supine position ^{42,43}, possibly due to the stimulation of the sacral plexus by the uterine weight. In these cases, turning the mother to her side is frequently followed by normalization of the CTG pattern. Transient cord compression is another common cause of CTG changes (variable decelerations), and these can sometimes be reverted by changing the maternal position or by performing amnioinfusion ⁴⁴.

Sudden maternal hypotension can also occur during labour, usually after epidural or spinal analgesia ⁴⁵, and it is usually reversible by rapid fluid administration and/or an intravenous ephedrine bolus. Other less frequent complications affecting the maternal respiration, maternal

circulation, placenta, umbilical cord or the fetal circulation can also result in fetal hypoxia/acidosis (see Chapter 1), and their management is beyond the scope of this document.

Oxygen administration to the mother is widely used with the objective of improving fetal oxygenation and consequently normalising CTG patterns, but there is no evidence from randomised clinical trials that this intervention, when performed in isolation, is effective when maternal oxygenation is adequate⁴⁶. Intravenous fluids are also commonly used for the purpose of improving CTG patterns, but again there is no evidence from randomised clinical trials to suggest that this intervention is effective in normotensive women⁴⁷.

Good clinical judgement is required to diagnose the underlying cause for a suspicious or pathological CTG, to judge the reversibility of the conditions with which it is associated, and to determine the timing of delivery, with the objective of avoiding prolonged fetal hypoxia/acidosis, as well as unnecessary obstetric intervention. Additional methods may be used to evaluate fetal oxygenation, and these are considered in detail in chapter 4. When a suspicious or worsening CTG pattern is identified, the underlying cause should be addressed before a pathological tracing develops. If the situation does not revert and the pattern continues to deteriorate, consideration needs to be given for further evaluation or rapid delivery if a pathological pattern ensues.

During the second stage of labour, due to the additional effect of maternal pushing, hypoxia/acidosis may develop more rapidly. Therefore, urgent action should be undertaken to relieve the situation, including discontinuation of maternal pushing, and if there is no improvement, delivery should be expedited.

8. LIMITATIONS OF CARDIOTOCOGRAPHY

Cardiotocography has well documented limitations, and it is necessary to be aware of these for a safe use of the technology.

It has been well demonstrated that CTG analysis is subject to considerable intra- and inter-observer disagreement, even when experienced clinicians use widely accepted guidelines⁴⁸⁻⁵⁰. The main aspects that are prone to observer disagreement are the identification and classification of decelerations, the evaluation of variability⁴⁹, and the classification of tracings as suspicious and pathological^{49,50}. The subjectivity of observer analysis has also been demonstrated in retrospective audit of tracings, where CTG features are frequently assessed to be more abnormal in cases with known adverse neonatal outcome⁵¹.

Many studies have evaluated the ability of suspicious and pathological CTGs to predict the occurrence of hypoxia/acidosis. Different CTG interpretation criteria, different intervals between tracing abnormality and birth, and different criteria to define adverse outcome have been used, resulting in mixed findings⁵². However, it is recognised that hypoxia/acidosis has not been documented shortly after a normal CTG tracing. On the other hand, suspicious and pathological tracings have a limited capacity to predict metabolic acidosis and low Apgar scores, i.e. a large percentage of cases with suspicious and pathological tracings do not have these outcomes⁵². While there is a strong association between certain FHR patterns and hypoxia/acidosis, their capacity to discriminate between newborns with or without metabolic acidosis is limited. Thus, they are sensitive indicators, but have a low specificity and low positive predictive value. However, it should not be forgotten that the aim of intrapartum fetal monitoring is to identify situations that precede hypoxia/acidemia so as to avoid fetal injury. The subjectivity of CTG interpretation, and the fact that hypoxia is a continuum that may not reach the threshold of metabolic acidosis or injury are probably important contributing factors to these limitations.

A large number of randomised controlled trials have been conducted comparing continuous CTG monitoring with intermittent auscultation as screening methods for fetal hypoxia/acidosis during labour, in both low- and high-risk women^{1,2}. However, these trials took place in the 1970s, 1980s, and early 1990s, and used different CTG interpretation criteria, so it is difficult to establish how their results relate to current clinical practice. With these limitations in mind, they indicate a limited benefit of continuous CTG for fetal monitoring in all women during labour, as the only significant improvement was a 50% reduction in neonatal seizures (hypoxic-ischemic encephalopathy was not evaluated in most trials), and no differences were found in the incidences of overall perinatal mortality and cerebral palsy. However, it is widely recognised that the trials were underpowered to detect differences in these outcomes³. Only a small proportion of perinatal deaths and cerebral palsies are caused by intrapartum hypoxia/acidosis, so a large number of cases is needed to show any benefit. On the other hand, continuous CTG was associated with a 63% increase in cesarean delivery and a 15% increase in instrumental vaginal deliveries¹.

Unnecessary obstetric intervention confers additional risks for the mother and newborn^{53,54}, and the former may result from poor CTG interpretation, limited knowledge of the

pathophysiology of fetal oxygenation, and inadequate clinical management. It is recognised that, for consistent implementation, clinical guidelines need to be as simple and objective as possible, to allow rapid decision-making even in complex and stressful situations. In addition, regular and structured training of the labour ward staff is essential to ensure proper use of this technology.

References

- Alfirevic Z, Devane D, Gyte GM. Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour. *Cochrane Database of Systematic Reviews* 2013 May 31;5:CD006066.
- Vintzileos AM, Nochimson DJ, Guzman ER, Knuppel RA, Lake M, Schiffrin BS. Intermittent electronic fetal heart rate monitoring versus intermittent auscultation: a meta-analysis. *Obstet Gynecol* 1995;85:149-55.
- Royal College of Obstetricians and Gynaecologists. The use of electronic fetal monitoring. Evidence-based clinical guideline, number 8. London: RCOG Press; 2001.
- Herbst A, Ingemarsson I. Intermittent versus continuous electronic fetal monitoring in labour: a randomized study. *Br J Obstet Gynaecol* 1994;101:663-8.
- Devane D, Lalor JG, Daly S, McGuire W, Smith V. Cardiotocography versus intermittent auscultation of fetal heart on admission to labour ward for assessment of fetal wellbeing. *Cochrane Database Syst Rev* 2012 Feb 15;2:CD005122.
- Carbonne B, Benachi A, Leveque ML, Cabrol D, Papiernik E. Maternal position during labor: effect on fetal oxygen saturation measured by fetal pulse oximetry. *Obstet Gynecol* 1996; 88:797-800.
- Di Renzo GC, Luzzi G, Caserta G, Clerici G, Cosmi EV. The role of telemetry in perinatal monitoring. *J Perinat Med* 1994;22(6):517-22.
- Carter MC. Signal processing and display - cardiotocographs. *Br J Obstet Gynaecol* 1993;100 Suppl 9:21-3.
- Nurani R, Chandraharan E, Lowe V, Ugwumadu A, Arulkumaran S. Misidentification of maternal heart rate as fetal on cardiotocography during the second stage of labour: the role of the fetal electrocardiograph. *Acta Obstet Gynecol Scand* 2012;91(12):1428-32.
- Maiques V, Garcia-Tejedor A, Perales A, Navarro C. Intrapartum fetal invasive procedures and perinatal transmission of HIV. *Eur J Obstet Gynecol Reprod Biol* 1999;87:63-7.
- Kaye EM, Dooling EC. Neonatal herpes simplex meningoencephalitis associated with fetal monitor scalp electrodes. *Neurology* 1981;31:1045-7.
- Handwerker SM, Selcik AM. Placental abruption after insertion of catheter tip intrauterine pressure transducers: a report of four cases. *J Reprod Med* 1995;40:845-9.
- Bakker JJ, Janssen PF, van Halem K, van der Goes BY, Papatsonis DN, van des Post JA, Mol BW. Internal versus external tocodynamometry during induced or augmented labour. *Cochrane Database Syst Rev* 2013 Aug 3;8:CD006947.
- Bakker PC, Colenbrander GJ, Verstraeten AA, Van Geijn HP. Quality of intrapartum cardiotocography in twin deliveries. *Am J Obstet Gynecol* 2014;191:2114-9.
- Nunes I, Ayres-de-Campos D, Figueiredo C, Bernardes J. An overview of central fetal monitoring systems in labour. *J Perinat Med* 2013;41:93-99.
- Ayres-de-Campos D, Bernardes J, Marsal K, Nickelsen C, Makarainen L, Banfield P, Xavier P, Campos I. Can the reproducibility of fetal heart rate baseline estimation be improved? *Eur J Obstet Gynecol Reprod Biol* 2004;112:49-54.
- Segal S. Labor epidural analgesia and maternal fever. *Anesth Analg* 2010;111:1467-75.
- Neilson JP, West HM, Dowswell T. Betamimetics for inhibiting preterm labour. *Cochrane Database Syst Rev* 2014 Feb 5;2:CD004352.
- Jadhon ME, Main EK. Fetal bradycardia associated with maternal hypothermia. *Obstet Gynecol* 1988;72(3 Pt 2):496-7.
- Boutrov MJ. Fetal and neonatal effects of the beta-adrenoreceptor blocking agents. *Dev Pharmacol Ther* 1987;10:224-31.
- Suwanrath C, Suntharasaj T. Sleep-wake cycles in normal foetuses. *Arch Gynecol Obstet* 2010;281:449-54.
- Hamilton E, Warrick P, O'Keeffe D. Variable decelerations: do size and shape matter? *J Matern Fetal Neonatal Med* 2012;25:648-53.
- Nelson KB, Dambrosia JM, Ting TY, Grether JK. Uncertain value of electronic fetal monitoring in predicting cerebral palsy. *N Engl J Med* 1996;334(10):613-8.
- Nunes I, Ayres-de-Campos D, Kwee A, Rosen KG. Prolonged saltatory fetal heart rate pattern leading to newborn metabolic acidosis. *Clin Exp Obstet Gynecol* 2014;41(5):507-11.
- Court DJ, Parer JT. Experimental studies of fetal asphyxia and fetal heart rate interpretation. In: *Research in Perinatal Medicine (I)*. Nathanielsz PW, Parer JT (eds). Perinatology Press, New York 1984:113-69.
- Ball RH, Parer JT. The physiologic mechanisms of variable decelerations. *Am J Obstet Gynecol* 1992;166:1683-9.
- Holzmann M, Wretler S, Cnattingius S, Nordstrom L. Cardiotocography patterns and risk of intrapartum fetal acidemia. *J Perinat Med* 2014 Jun 10 (Epub ahead of print).
- Westgate JA, Wibbens B, Bennet L, Wassink G, Parer JT, Gunn AJ. The intrapartum deceleration in center stage: a physiologic approach to the interpretation of fetal heart rate changes in labor. *Am J Obstet Gynecol* 2007;197:236.e1-11.
- Cahill AG, Roehl KA, Odibo AO, Macones GA. Association and prediction of neonatal acidemia. *Am J Obstet Gynecol* 2012;207:206.e1-8.
- Takano Y, Furukawa S, Ohashi M, Michikata K, Sameshima H, Ikenoue T. Fetal heart rate patterns related to neonatal brain damage and neonatal death in placental abruption. *J Obstet Gynecol Res* 2013;39:61-6.
- Modanlou HD, Murata Y. Sinusoidal fetal heart rate pattern: reappraisal of its definition and clinical significance. *J Obstet Gynaecol Res* 2004;30:169-80.

32. Graça LM, Cardoso CG, Clode N, Calhaz-Jorge C. An approach to interpretation and classification of sinusoidal fetal heart rate patterns. *Eur J Obstet Gynecol Reprod Biol* 1988;27:203-12.
33. Nijhuis JG, Prechtl HF, Martin CB, Bots RS. Are there behavioural states in the human fetus? *Early Hum Dev* 1982;6:177-95.
34. de Vries JJP, Visser GHA, Prechtl HFR. The emergence of fetal behaviour. II. Quantitative aspects. *Early Hum Dev* 1985;12:99-120.
35. Parer JT, Ikeda T. A framework for standardized management of intrapartum fetal heart rate patterns. *Am J Obstet Gynecol* 2007;197:26.e1-6.
36. Coletta J, Murphy E, Rubeo Z, Gyamfi-Bannerman C. The 5-tier system of assessing fetal heart rate tracings is superior to the 3-tier system in identifying fetal acidemia. *Am J Obstet Gynecol* 2012;206:226.e1-5.
37. Heuser CC, Knight S, Esplin S, Eller AG, Holmgren CM, Richards D, Henry E, Jackson GM. Tachysystole in term labor: incidence, risk factors, outcomes, and effect on fetal heart tracings. *Am J Obstet Gynecol* 2013;209:32e 1-6.
38. Briozzo L, Martinez A, Nozar M, Fiol V, Pons J, Alonso J. Tocolysis and delayed delivery versus emergency delivery in cases of non-reassuring fetal status during labor. *J Obstet Gynaecol Res* 2007;33(3):266-73.
39. Heus R, Mulder EJH, Derks JB, Visser GHA. Acute tocolysis for uterine activity reduction in term labor: a review. *Obstet Gynecol Surv* 2008;63(6):383-8.
40. Heus R, Mulder EJH, Derks JB, Kurver PHJ, van Wolfswinkel L, Visser GHA. A prospective randomized trial of acute tocolysis in term labour with atosiban or ritodrine. *Eur J Obstet Gynecol Reprod Biol* 2008;139:139-45.
41. Pullen KM, Riley ET, Waller SA, Taylor L, Caughey AB, Druzin ML, El-Sayed YY. Randomized comparison of intravenous terbutaline vs nitroglycerin for acute intrapartum fetal resuscitation. *Am J Obstet Gynecol* 2007;197(4):414.e1-6.
42. Williams EA. Abnormal uterine action during labour. *J Obstet Gynaecol Br Emp* 1952;59:635-41.
43. Caldeyro-Barcia R, Noriega-Guerra L, Cibils LA, Alvarez H, Poseiro JJ, Pose ST. Effect of position changes on the intensity and frequency of uterine contractions during labor. *Am J Obstet Gynecol* 1960;80:284-90.
44. Hofmeyr GJ, Lawrie TA. Amnioinfusion for potential or suspected umbilical cord compression in labour. *Cochrane Database Syst Rev* 2012 Jan 18:1:CD000013.
45. Simmons SW, Taghizadeh N, Dennis AT, Hughes D, Cyna AM. Combined spinal-epidural versus epidural analgesia in labour. *Cochrane Database Syst Rev* 2012 Oct 17;10:CD003401.
46. Fawole G, Hofmeyr GJ. Maternal oxygen administration for fetal distress. *Cochrane Database Syst Rev* 2012 Dec 12;12:CD000136.
47. Simpson KR, James DC. Efficacy of intrauterine resuscitation techniques in improving fetal oxygen status during labor. *Obstet Gynecol* 2005;105:1362-8.
48. Paneth N, Bommarito M, Stricker J. Electronic fetal monitoring and later outcome. *Clin Invest Med* 1993;16:159-65.
49. Ayres-de-Campos D, Bernardes J, Costa-Pereira A, Pereira-Leite L. Inconsistencies in classification by experts of cardiotocograms and subsequent clinical decision. *BJOG* 1999;106:1307-10.
50. Blackwell SC, Grobman WA, Antoniewicz L, Hutchinson M, Gyamfi-Bannerman C. Interobserver and intraobserver reliability of the NICH 3-tier fetal heart rate interpretation system. *Am J Obstet Gynecol* 2011;205:378.e1-5.
51. Ayres-de-Campos D, Arteiro D, Costa-Santos C, Bernardes J. Knowledge of adverse neonatal outcome alters clinicians' interpretation of the intrapartum cardiotocograph. *BJOG* 2011;118:978-84.
52. Spencer JA. Clinical overview of cardiotocography. *Br J Obstet Gynaecol* 1993;100 Suppl 9:4-7.
53. National Institute for Health and Clinical Excellence. Clinical guideline number 13: Caesarean section. April 2004. <http://www.nice.org.uk/guidance/cg13/resources/guidance-caesarean-section-pdf> (accessed 1st August 2014)
54. O'Mahony F, Hofmeyr GJ, Menon V. Choice of instruments for assisted vaginal delivery. *Cochrane Database Syst Rev* 2010 Nov 10;11:CD005455.