Intrapartum fetal monitoring: overview, controversies and pitfalls

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Introduction

Interpretation of fetal heart rate (FHR) patterns during labour remains the most controversial and problematic issue in Obstetrics despite cardiotocography (CTG) being the commonest medical procedure in the western world, and also the most extensively studied.[1,2] The CTG is well entrenched in clinical practice, based on perceived and commonly observed prevention of perinatal morbidity/mortality, although randomised controlled trials[3] have failed to demonstrate its benefits.

Severe perinatal hypoxia remains rare but can lead to distressing catastrophic outcomes like perinatal death or permanent neurological damage. The NHS in England paid out £3.1 billion (49% of the value of all claims) for negligence linked to maternity care in the past decade, mainly for cerebral palsy and errors in the interpretation of CTGs.[4] This financial imperative, rightly or wrongly, pushes the issue of 'intrapartum fetal monitoring' to the top of the patient safety agenda. The above clearly underscores the opportunity, need and potential to improve intrapartum fetal monitoring and patient safety. National bodies such as NICE (National Institute for Health and Care Excellence) face a difficult and unenviable task of making evidence based recommendations.[5,6]

This brief article is mainly directed at Obstetricians and midwives, and does not repeat the definitions and classifications of FHR patterns which have been dealt extensively by many national guidelines. It describes the current perspectives on fetal monitoring, possible deficiencies and remedies, and comments on likely future developments. Currently, the two most widely accepted techniques of fetal monitoring are 'intermittent auscultation (IA) of FHR' and 'cardiotocography' (CTG). Newer techniques under investigation are fetal ECG (STAN or ST analysis), fetal oximetry and computerised CTG interpretation.

Intermittent auscultation (IA)

NICE[5] suggests that about 45% of all labours are at low risk for fetal hypoxia and strongly recommends IA for these labours with fairly specific criteria to switch over to CTG. Randomised controlled trials of IA vs CTG have shown equivalent perinatal outcome with reduced operative intervention in IA group.[3,5] NICE recommends counting FHR with doppler or Pinard stethoscope for 60 seconds after a contraction every 15 minutes in first stage and every 5 minutes in second stage of labour. The intention is to detect/suspect late FHR decelerations.[5] With increasing use of IA, it is hoped that there may be future refinements.[7] In developing countries, the vast majority of labours (low and high risk) are monitored by IA. (personal communication)

Cardiotocography (CTG)

This involves continuous recording of FHR as well as uterine contractions. CTG interpretation in the UK is governed by NICE guidelines[5,6] but these seem to be in a state of flux. It has been shown that the categorisation of the vast majority of FHR decelerations as 'variable' and then as 'atypical' (pathological) seems flawed.[8,9] Following this, NICE has discarded the subclassification of 'variable' decelerations as typical or atypical.[5] This will make a major difference to CTG interpretation because large numbers of CTGs were unhelpfully classified as pathological because of 'atypical' decelerations, as a consequence of frequent lack of 'shoulders'

or small accelerations. In addition, there is an urgent need for well-designed studies to augment the evidence base given the quality of currently available evidence. NICE[5] conclude most evidence as being 'of moderate and low quality and showing a moderate to low degree of association between different FHR parameters and neonatal acidosis." FHR decelerations are centre-stage in CTG interpretation.[10] The proposed[5] discrimination of FHR decelerations based on a 60 seconds cut off for duration or depth seems better than the previous one[6] based on atypical features; but the degree of correlation to fetal acidaemia is unknown. We are still in the realm of a 'trial and error' approach.

None of the national 3-tier classifications were published with the estimate of their sensitivity or false positivity.[11] A recent high quality study found no correlation between the American 3 tier system and neonatal acidaemia.[12] Whilst the adoption of an evidence based approach since the 1980s remains the best hope of consensus and progress, this approach has not diminished the controversies for the following reasons:

1. Significant variations in definitions and grading of FHR parameters in different studies over the years make it extremely difficult to draw valid conclusions.

2. Outcomes of importance (e.g. hypoxaemic ischemic encephalopathy) are very rare so that large numbers of cases would be needed to show a difference.

3. It is almost impossible to separate 'treatment effect' because intervention in the presence of an abnormal CTG modifies the neonatal outcome. It is unethical and impractical to conduct truly blinded RCTs.

4. The fetal heart rate is only a surrogate for fetal hypoxia and not a very good one.[5]

5. Complex tasks of 'pattern recognition' together with clinical evaluation may not be captured in simple algorithms and not reflected in the research trials and reviews.[5]

6. Framing and Confirmation bias: These unrecognised biases seem to be very important correctible factors. "Anchoring/framing bias" is the tendency to create a coherent initial picture without examining all the available information.[13,14] These biases can become ingrained with "confirmation bias", when we selectively focus upon evidence that supports our beliefs while ignoring more comprehensive evidence that disproves these ideas.[13,14] There is much less controversy about FHR baseline, variability and accelerations. FHR decelerations are the commonest aberrant features on the CTG and are complex to interpret but most are benign. When authorities/guidelines propose that the benign FHR decelerations due to the invariable phenomenon of head compression in labour (i.e. early decelerations) are extremely rare, it seems important to explore if there has been framing and confirmation bias leading to unscientific distorted categorisation of FHR decelerations.[8,9] FHR decelerations were the 'low hanging fruit' (generally with major effect) which were immediately picked up by pioneers like Hon[15] and Caldeyro-Bracia[16] based on clearly discernible observational evidence. They categorised FHR decelerations based primarily on their time-relationship to contractions only.[15,16] It would be a shame to drop this 'low hanging fruit' by introducing framing / confirmation

biases in the definitions of decelerations and consequently proceed in the wrong direction. Specific, unambiguous and standardised definitions of FHR decelerations are important. If these are missing [5,6] then categorisation can become dysfunctional through the adoption of several different definitions, each with a varying scientific evidence base.[8]

Fetal Electrocardiography (ECG)

Fetal ECG can be recorded with a fetal scalp electrode. ST segment analysis (STAN) has been practiced for over a decade, mainly in Nordic countries but also in a few centres in the UK and USA. Five RCTs and five systematic reviews with meta-analyses show very divergent results.[17] This may suggest that we are looking for marginal gains here. An absence of a clear background, lack of transparency and a sense of 'Magic Black Box' have been suggested.[17] Most importantly an ST event loses its significance if the CTG is "normal". Hence, STAN is completely dependent on prior visual CTG interpretation. Thus major changes in classifying a CTG as "abnormal"[5,6] would further complicate interpretation of the trials of CTG+STAN vs CTG alone by changing the 'start line' as well as the 'finish line'.

Fetal pulse oximetry

This technology involves attachment of a light emitting sensor to the fetal scalp or temple to measure the proportion of haemoglobin that is carrying oxygen. A recent Cochrane review found that fetal pulse oximetry as an adjunct to CTG (again dependent on correct interpretation of CTG) did not improve neonatal outcome or reduce the overall incidence of caesarean section.[18]

Computerised CTG interpretation

A lot of hope rests on the premise that computer aided analysis of CTG will be more objective and reliable, with the potential to overcome human factors, and may eventually replace visual CTG interpretation completely. However, it has been surprisingly slow in development and adoption, despite the exponential increase in the analytical and functional power of digital technology. The difficulties are providing good quality evidence of its reliability or superiority over visual CTG interpretation and medicolegal considerations. Many singular instruments/parameters like 'total deceleration area', 'short-term variability (STV)', 'approximate entropy' and 'phase-rectified signal averaging (PRSA)' have been shown to correlate to fetal status.[19] But a "strong" correlation with useful positive and negative predictive values would be required for clinical application. It remains to be seen if any isolated parameter would fulfil this promise given the complexity of FHR patterns. It is worth noting that the FHR patterns during the expulsive second stage are quite different from first stage (more frequent and deeper decelerations and higher variability). A mental adjustment is made for this difference during visual CTG interpretation which may not occur in computerised analysis. Hence, computerised analysis criteria (e.g. deceleration area) differentiated for the first and second stage of labour would be highly desirable and indeed may improve correlation with fetal status.[19] One could argue that the computerised analysis should emulate the principles of visual CTG interpretation. The results of the 'INFANT study'[20] evaluating a computer based 'Intelligent Fetal Assessment' system (K2MS, Plymouth)[21] vs continuous CTG are eagerly awaited. The 'Infant' (Intelligent Fetal Assessment) software emulates the criteria of visual interpretation and

provides four colour-coded categories.[21] Will such software need to be recalibrated and re-evaluated when visual CTG interpretation changes significantly?[5,6] These are major challenges. Similarly another piece of software PeriCALM Patterns™ (PeriGen, Princton, NJ, USA) attempts to recognise EFM patterns in accordance with baseline variability, FHR decelerations and contractions.[11] Both 'Infant' and PeriCALM™ do not claim to replace visual CTG interpretation but propose to provide additional support at present. However, the time has come to start recording and archiving all CTGs digitally and testing cord blood gases routinely in every delivery. This would facilitate well designed retrospective studies which could be both informative and pragmatic, given prospective RCTs are often impractical and resource-intensive.

Adjunctive tests of fetal wellbeing

CTG has a good negative predictive value but high false positive rate for prediction of fetal acidaemia. In many clinical situations abnormal CTG may be enough to expedite delivery. But at times an adjunctive test may be necessary. In the UK fetal scalp blood sampling (FSBS) is the only widely accepted and practiced test. Even FSBS is no stranger to controversy[22] but remains a practically useful if not a perfect test. There is need to systematically study other possible tests like 'fetal scalp stimulation test' and 'vibroacoustic stimulation' which would be less invasive.[23]

Pitfalls in intrapartum fetal monitoring

Errors in CTG interpretation are possible at any of the three stages involved, namely signal acquisition, interpretation of signal and clinical intervention.[11]

1. **Signal acquisition:** The technology of obtaining FHR record with an external doppler and fetal scalp electrode has improved remarkably. Erroneous recording of the maternal heart rate signal as FHR should be thing of the past. An attempt should always be made to obtain a good record of timing and duration of contractions in order to correlate them to any FHR decelerations.

2. **Interpretation of FHR patterns:** Variation in interpretation of CTG remains a problem although a lot of standardisation of terminology and analysis has been achieved over last 15 years by most national guidelines.[2] The current 3-tier systems are a graded classification of increasing abnormality of the combinations of many FHR parameters like baseline, baseline variability and types of decelerations. Experts admit that CTG interpretation still has a small element of 'art' (expertise and intuition) in addition to 'science based rules'.[5] Furthermore, if standardisation is of the wrong sort then it is likely to be misleading and counterproductive. Framing/ confirmation biases are necessarily unscientific and should not be dismissed as only of 'academic interest'.[24] A significant framing bias would corrupt all succeeding interpretation systems or structures embodying it. Thus the guidelines for CTG interpretation are still evolving, and could undergo further significant change. Secondly, similar CTG abnormalities have a more serious implication (higher positive

predictive value) in the presence of 'high risk' factors like growth retardation, thick meconium staining, infection and diabetes. Lastly, several human factors can affect interpretation such as tiredness, tunnel vision, and failure of situational awareness. These are being addressed by safer working hours regulations, appropriate staffing levels, 'fresh eyes' approach and regular training, updates and 'skills –drills' sessions.

3. **Clinical intervention:** This final step is directly responsible for improving fetal outcome and safety.[11] The type and speed of the clinical intervention has to be fine-tuned to the degree and evolution/ progression of the CTG abnormality in any given clinical scenario. It is a complex balance to decide upon appropriate action without unduly increasing operative intervention. Automated warning systems when based on more reliable computerised CTG interpretation criteria would be a very useful adjunct to improve patient safety

Conclusion

Interpretation of the CTG involves complex pattern recognition of multiple FHR parameters in the context of the clinical setting. National guidelines, standardisation of terminology and structured systems are key factors for meaningful interpretation. Birth attendants should apply critical thinking and reflect upon available techniques and clinical cases to ensure their decision making achieves the best outcomes for their patients, as well as allowing them to provide an informed opinion on future recommendations for fetal monitoring.

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Declaration of interest

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