Improving assessment of fetal health

PROFESSOR CHRIS REDMAN, Emeritus professor of obstetric medicine, Nuffield Department of Obstetrics and Gynaecology, John Radcliffe Hospital, Oxford, speaks to *The Clinical Services Journal* about the key challenges of detecting fetal distress, using antepartum cardiotocography, in order to improve outcomes. **LOUISE FRAMPTON** reports.

Electronic monitoring of the baby's heart beat is a well established way to diagnose fetal distress, either during or before labour. The method called cardiotocography (CTG) gives a print out of the baby's heartbeat and associated uterine contractions. During labour, the stress of contractions and descent through the birth canal can reduce a baby's oxygen supply. Most babies are able to cope with this stress, but around 2% suffer birth asphyxia.[1] Some 250 babies in the UK die each year[2] as a result of oxygen deprivation, while those who survive may suffer permanent brain damage.

This article is about antepartum cardiotocography, which is used to measure a baby's health before powerful labour contractions have begun. Before its introduction in the 1970s, the only way to assess fetal health before labour was through the mother's perceptions of movements, listening to the fetal heartbeat with a stethoscope, or through an X-ray of the uterus. Today, the use of the antepartum CTG to monitor fetal heart beat and uterine contractions is standard practice across the world – providing a low cost method of detecting fetal distress before labour. It is effective in detecting the 'terminal trace' (when the heartbeat is flat with repetitive shallow decelerations).[3] This is a rare and extreme situation. More commonly, with less severely affected babies, the abnormalities of the trace may be more subtle, which makes visual interpretation difficult.

This raises the issue of how to interpret the many different heart rate patterns in the 'grey area' between what is clearly defined as 'normal' and what is grossly 'abnormal'. Here, opinion on the meaning of a trace can vary significantly between clinical staff. Visual interpretation is always subjective to the extent that many studies confirm that even experienced observers frequently disagree with each other. Moreover, not all observers are experienced, which is an even greater problem and may lead to unnecessary intervention or, worse still, no intervention when it is urgently required. In fact, a large number of studies have identified the drawbacks of visual interpretation of the CTG .[4-6]

To overcome this problem, a system of computerised interpretation of the CTG is needed. One of the pioneers behind the Dawes Redman CTG computerised analysis system, Professor Chris Redman points out that visual assessment of the trace is still commonplace, despite the unresolved issue of unreliability and poor standardisation. "A visual assessment is a 'guesstimate' – this is simply not good enough," he commented. "Any test that may lead to interventions that are not trivial and are involved with life and death should be based on reliable, reproducible and accurate measurement," he argued.

Clinical scoring systems have been introduced to attempt to standardise visual assessment .[7] However, Prof. Redman argues that while these scoring systems may have helped to standardise opinions, they are unable to offer the levels of consistency and accuracy provided by computerised analysis.

"If you take a single trace and show it to a variety of individuals they will differ widely in opinion on its clinical significance. If you show it to a group of experts, this variation may be less apparent, but it is unlikely that the person at the bedside will be a top expert. If you show a trace to the same person on two occasions, six months apart, they will often contradict themselves and express a different interpretation from their original opinion. With a computerised system, you will arrive at the same conclusion every time."

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Dawes Redman system

The Dawes Redman computerised system was developed to overcome some of the drawbacks of antepartum CTG monitoring. The technology (now well established since its introduction in the late 1980s) is designed to measure patterns of fetal heart rate, highlight which patterns are important, assess how important they are, and enable informed clinical decisions to be made. The system was developed from an archive of over 70,000 heart rate traces and associated outcomes, and has been regularly updated to incorporate new clinical data.

"Even the most experienced observer cannot hold in his or her memory the huge range of heart rate patterns that may occur and what they signify. Computerised analysis solves this problem – in effect, it brings to the bedside the experience of the entire archive that has contributed to the analysis. There is no expert in the world that is capable of memorising this number of patterns and the associated outcomes. The computerised system can access all of this information very quickly," Prof. Redman commented.

The principle behind the system is to determine when sufficient information is available to conclude that the recording is 'normal' and further monitoring is unnecessary. Normality is determined by a number of criteria, now called the 'Dawes Redman criteria'. The minimum duration of trace is 10 minutes. If, however, criteria have not been met by the end of one hour the trace will end with the conclusion that normality has not been demonstrated (i.e. 'criteria not met').

All assessment of the CTG begins by determining the baseline. This can be surprisingly difficult. By eye it is an intuitive and approximate judgement and it is unlikely that any two individuals will place a baseline in exactly the same location. Once assigned, the features related to the baseline, such as accelerations or decelerations, can be identified and measured.

Accelerations are defined, according to the Dawes Redman algorithm, to be an increase in heart rate at least 10 bpm above the baseline for more than 15 seconds. A deceleration is a decrease in heart rate below the baseline, either 10 bpm for at least 60 or 20 bpm for at least 30 seconds.

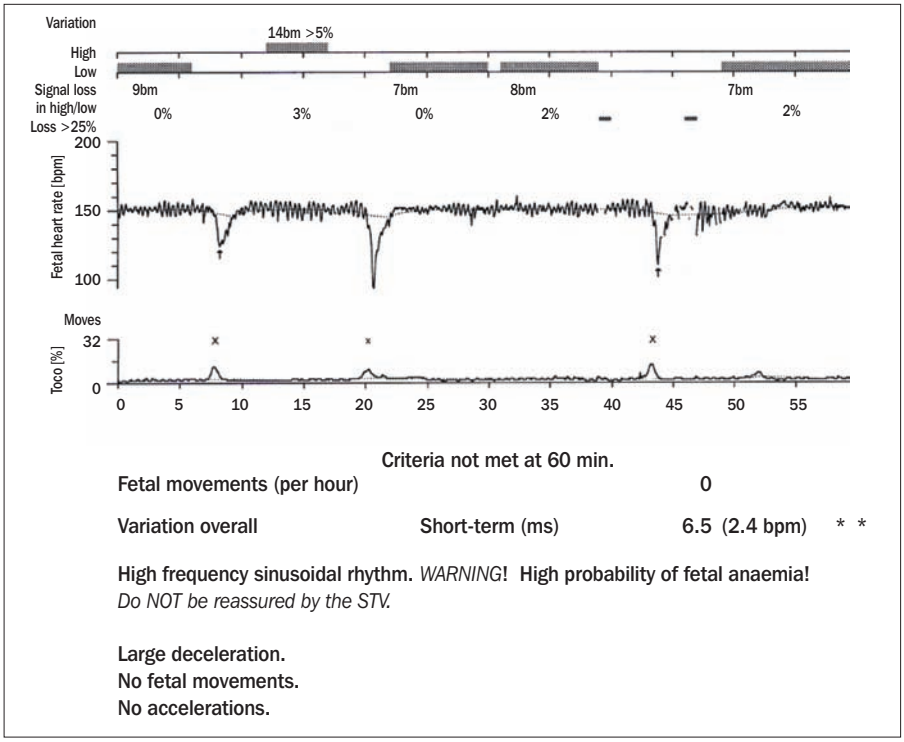

Figure 1.

> 'The system substitutes measurements for opinions – allowing the operator to switch off the trace based on objective data and not subjective interpretation.'

Important evidence of normality is the variation in the heart rate. In deep sleep, the fetal heart rate is relatively flat with lower short-term variation. When the baby becomes active, the heart rate shows many accelerations and is said to be 'reactive'. One of the primary aims of the Dawes Redman system is to detect reactivity i.e. a period of 'high fetal heart rate (FHR) variation'.

"Ultimately, the state of the brain determines the state of the heart rate pattern and, during deep sleep, the fetal brain is quiet and this is reflected in the reduced variation. This cannot be distinguished from the quietness that results from fetal stress or distress. Only when the baby wakes up do you see clear episodes of normality," Prof. Redman explained."To establish whether the baby is well, it is necessary to analyse the heart rate when it is awake, which is unpredictable – the clinician may start to monitor the baby during a quiet period of sleep and gain a false impression of the baby's condition."

To address this problem, the Dawes Redman system is able to identify a period of wakeful 'normal' activity. For 'normal criteria' to be achieved, there must be five or six minutes of high fetal heartbeat variation consistent with a wakeful baby, then the trace can be stopped. However, an episode of deep sleep may last as long as 40 or 50 minutes – so, in some cases, a longer trace may be required to prove normality.

"The system substitutes measurements for opinions – allowing the operator to switch off the trace based on objective data and not subjective interpretation. Once the criteria have been met and deemed to be normal, there is no need to extend the monitoring period further. Hence the system is very time efficient and this means that the mother does not need to be attached to the trace for longer than is necessary," Prof. Redman commented.

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He added that there must not be too many decelerations and, in particular, no large deceleration for normality to be achieved: "A deceleration of the heartbeat is usually caused by a period of a lowering of the baby's oxygen. If this occurs once and is not repeated, it is probably caused by the baby resting temporarily on the umbilical cord," Prof. Redman explained."If it keeps happening, it may signify a response to contractions. If the baby is becoming short of oxygen and is not coping well with the situation, it may exhibit heart beat patterns that may demand immediate intervention."

In addition, the heart beat must not be too low or too high. There are also other clinically important patterns such as a trace with a rapid sinusoidal rhythm (Fig. 1). This rhythm is a rare but critical pattern which indicates fetal anaemia and is a significant cause for concern.

"When the anaemia is severe enough to cause this pattern, fetal safety is seriously compromised. It is an easy pattern to identify using visual interpretation, but many traces are performed by non-experts who may not immediately recognise its significance. The Dawes Redman system reliably detects the problem, and alerts the clinician that the situation is serious," Prof. Redman commented.

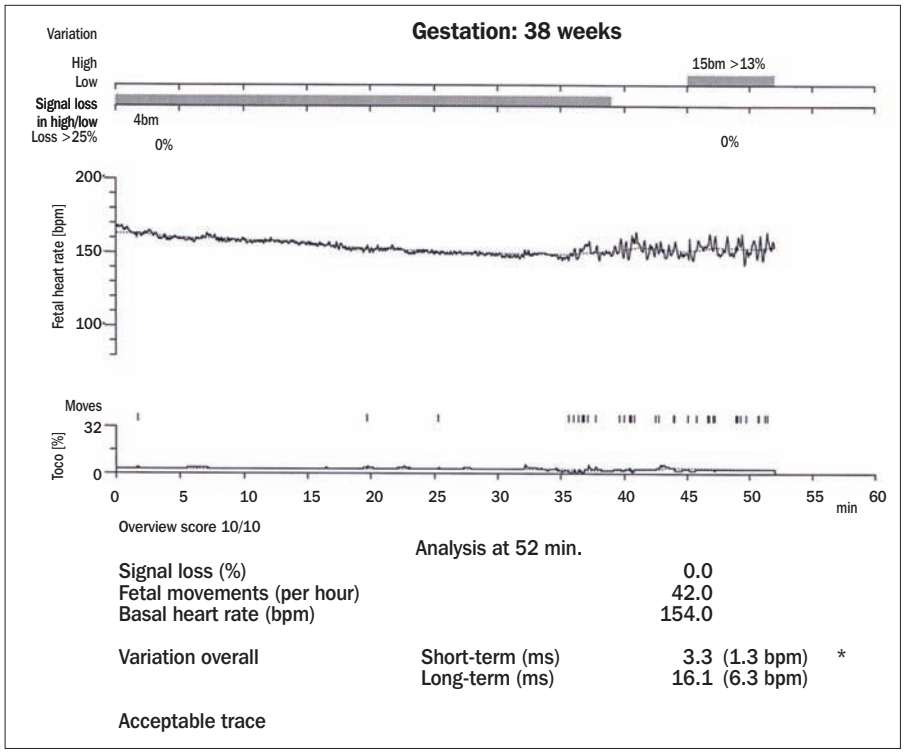

Figure 2.

> 'A visual assessment is a 'guesstimate' – this is simply not good enough. Any test that may lead to interventions that are not trivial and are involved with life and death should be based on reliable, reproducible and accurate measurement.'

Measuring short-term variability

He went on to explain that short-term variability (STV) is a powerful indication of potential fetal problems. A low STV is most commonly encountered with growth retarded, chronically stressed fetuses. A value of <4 msecs is low, <3 msecs is abnormal and <2 msecs highly abnormal. These thresholds are only valid when measured over the full period of an hour. In certain circumstances, an operator may become concerned about a low STV and stop the record prematurely. However, this is a mistake – Prof. Redman points outs that such a trace may be that of a baby having a long quiet period who may wake up and show normal reactivity before the full hour, when criteria can be said to be not met. An example is shown in Figure 2.

However, not all flat traces are caused by chronic stress secondary to placental dysfunction. The pattern of a normal trace is determined by normal fetal brain activity. When the fetus becomes totally asphyxiated it is comatose, with severely depressed brain function. But there are other causes of fetal coma. One such cause is intoxication by alcohol, as seen in Figure 3. Another is congenital central nervous system abnormality. For example, anencephalic fetuses have very flat traces.

Prof. Redman stresses that it is a mistake to assume that the STV is the only parameter of interest, however. The strength of the Dawes Redman system is that the criteria encompass a variety of different aspects of fetal health. He points out that when a fetus fails to meet criteria, even though the STV is normal, the risk of a poor outcome (perinatal death or birth asphyxia) is still increased – especially at early gestational ages. For example, before 30 weeks, the risk may be increased as much as 15 times (Redman and Moulden, unpublished data) even though the STV is normal. Therefore, it is important to use all the information that is available in assessing fetal wellbeing.

In total, there are 11 clinical criteria that need to be met before reassurance can be given by the Dawes Redman system. During recording, the mother is asked to press a button each time she feels a movement. There must be at least five per hour – if there are insufficient movements the criteria for 'normality' are not met.

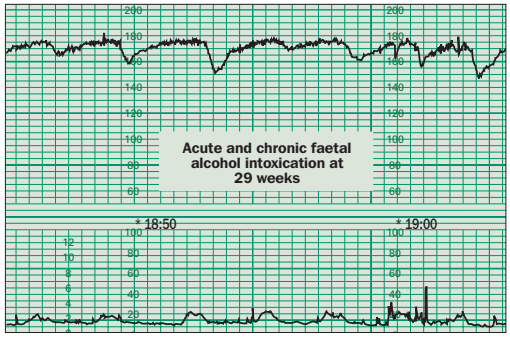

Figure 3: The fetal brain controls fetal heart rate patterns. Here the mother was intoxicated with alcohol as therefore was the fetus. The trace is abnormal but returned to complete normality when alcohol intake ceased.

Capabilities and limitations

Some of the key factors that can be highlighted by the system include:

- The fetus is acidaemic or hypoxic.
- The fetus is anaemic.
- The fetal central nervous system is impaired.
- The fetus may have an infection.
- The fetus has an arrhythmia.
- Further investigation is required.

However, Prof. Redman is at pains to point out that even a normal trace does not provide an absolute guarantee that a

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fetus is safe. He emphasises that antepartum CTG should be viewed as a clinical diagnostic tool – and not as a predictive or screening test.

He emphasises that antepartum CTG analysis has one important limitation – it only indicates the *current* fetal state. There are rare instances of fetal death occurring within a short time of a normal fetal CTG. These deaths are probably in the category of unexplained still births where there is no gross pathology that could cause respiratory deprivation. A previous report by Shaxted and Jenkins (1981) showed one case of a fetus at 36 weeks which suddenly died during the course of an antepartum CTG.

At the start of the CTG the record was entirely normal. At delivery there was no overt pathology. This is a typical unexplained stillbirth which is now a major cause of perinatal loss in this country. Nor can antepartum CTGs predict other catastrophes such as a sudden abruption. In other words, the trace can be reassuring for the moment but, if there are persisting clinical concerns, repeated testing continues to be necessary – once a day or more often.

If there is background concern about a particular case, for example, a woman with long-term diabetes, but no reason to suspect fetal compromise, there is no reason to perform a CTG as a non-specific screening test. It adds nothing to the assessment of the case. However, if the mother reports reduced fetal movements, vaginal bleeding or uterine pain then a CTG is the first and most helpful investigation that can be performed rapidly.

In conclusion, Prof. Redman pointed out that subjective visual interpretation of the CTG is inconsistent and inaccurate; and, within the 'grey area' between normality and fetal distress, interpretation is particularly difficult. Computerised analysis is the only way of overcoming these drawbacks and can help inform clinical decisions on managing care, to ensure better outcomes, when considered within the context of a full clinical assessment.

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Further reading

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About the Dawes Redman system

In 1977, professors Dawes and Redman at Oxford University, UK, started to investigate how to computerise the fetal heart rate to assess fetal health. This work led to the development of the computerised Dawes Redman now marketed by Huntleigh Healthcare under the brand name Sonicaid Fetalcare. There has been ongoing work with Mary Moulden and colleagues on the update of the system and, today, the CTG analysis is based on a database of more than 100,000 traces. The system incorporates many new features – some of which are designed to avoid misreading of difficult but unusual or rare patterns. The procedure that recognises the rare but dangerous fast sinusoidal rhythm is unique in its design and testing, and is only available in the authentic Huntleigh system. A new version is planned for release in 2013-14.

Professor Chris Redman

Professor Chris Redman; MB BChir MA Camb, MA Oxf, FCRP, FRCOG, graduated from Cambridge University and after short appointments in Baltimore (US), Oxford and Sheffield he embarked upon work which has led to his present research interests in pre-eclampsia and fetal heart rate monitoring.

He has worked at Oxford University since 1970; first as a lecturer in the Regius Department of Medicine, then in the Nuffield Department of Obstetrics and Gynaecology. He is one of a very small number of physicians with a specialist interest in medical problems of pregnancy. He started the Silver Star Unit in the 1970s in Oxford which was the first Obstetric Medicine Unit in the UK with dedicated obstetric and midwifery staff. He retired in 2009 and is now Emeritus Professor of Obstetric Medicine.

He is a Fellow adeundum of the Royal College of Obstetricians and Gynaecologists and recipient of the Chesley Award of the International Society for the Study of Hypertension in Pregnancy (2000), the Barnes Award, of the International Society of Obstetric Medicine (2002), ex-president of the International Society for the Study of Hypertension in Pregnancy (2006-2008) and Founder and Trustee of the charity Action on Pre-eclampsia.