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Avoiding CTG misinterpretation: A review of the latest Dawes-Redman CTG analysis

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Abstract

The antepartum cardiotocogram (CTG) diagnoses current fetal health robustly and economically. The interpretation of CTG patterns is unreliable when done, subjectively, by eye. Computerised analysis ensures consistency and relates the many patterns to outcome in an evidence-based way. This underpins the oldest system (Dawes-Redman), in use for nearly 25 years. Since its inception, the Dawes-Redman system has been constantly upgraded, now being based on about 100,000 traces. Hence it brings the memory of this vast number of records to bedside interpretation – something that no clinician can do. It takes account of all aspects of the trace, avoiding inappropriate overemphasis on single features, such as short-term variation. This article looks afresh at the latest and most powerful release of the Dawes-Redman system.

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Antepartum cardiotocogram (CTG) was introduced in the 1970s at a time when it was impossible to assess fetal health in any way other than by the mothers' perception of movements, listening to the fetal heart with a Pinard stethoscope or by an x-ray of the uterus. It was immediately apparent that the new technique yielded previously unattainable information about fetal distress or imminent intrauterine death. The technique was introduced without stringent trials and has since become embedded in clinical practice. It clearly works in specific circumstances, particularly with the so-called 'terminal' trace, when the heart rate is flat with repetitive shallow decelerations (Visser and Huisjes, 1977).

The grey zone

The problem with assessing antepartum heart-rate traces is how to interpret the many different patterns in the grey zone between what is clearly normal and what is grossly abnormal.

The most common form of fetal stress is secondary to shortage of oxygen which leads to accumulation of lactic acid and lowers the fetal blood pH (acidaemia). In most circumstances this develops over a period of time, during which the fetus has a chance to compensate for the stress. For example, an early deceleration during a contraction is an example of compensation to a brief period of reduced oxygen supply.; its occurrence is evidence of a normal healthy fetus that is coping with the situation—fetal stress, not distress. When a fetus becomes so compromised that it cannot cope with its situation, it is then distressed and its heart rate shows patterns that demand immediate intervention.

The grey zone is of huge importance to clinicians. This group includes a small number of key patients whose risks can potentially be identified and where timely intervention will ensure fetal safety. However, it also includes many more normal fetuses, which are not destined for acute distress and for whom urgent intervention is unnecessary. The heart-rate patterns that are involved are many, complex and, although clearly not normal, are not abnormal. How can we distinguish the normal from the abnormal in the grey zone?

Accurate measurement

To this day, the standard way of assessing the antepartum CTG is by eye (subjective visual interpretation), but this can create problems. The obvious and unresolved issue is of standardisation—a feature that may be recognised by clinician A may not be recognised by clinician B or vice versa. A large number of studies (Bernardes et al, 1997; Devoe et al, 2000; Chauhan et al, 2008) have repeatedly shown this to be a major problem. Clinicians do not agree with one another and even one clinician may not agree with him or herself when assessing the same trace at different times.

A visual assessment is in fact a 'guesstimate', which is not always good enough. Any test that may lead to interventions that are not trivial and involved with life and death should be based on reliable, reproducible and accurate measurement. To get round this problem, various systems of clinical scoring have been introduced (Bracero et al, 2000). These work to a degree but are not true measurements, more an attempt to standardise opinions. To measure clinically relevant aspects of the CTG, continuous heart-rate signals need to be analysed by computerised

techniques. Important features of normality or abnormality can then be numerically graded such that the importance of a particular pattern is recognised identically whenever it occurs anywhere in the world.

The second problem of subjective visual interpretation is that not all observers are equally experienced. It is neither sensible nor possible to expect all health professionals who see antepartum CTGs to be exceptionally experienced in their interpretation. In fact, even the most experienced observer cannot hold in his memory the huge range of patterns that may occur and what they signify. Once again this is a problem that computerised analysis solves—in effect it brings to the bedside the experience of the entire archive that has contributed to the analysis.

The need for computerised measurement of the fetal heart rate led to the Dawes-Redman system.

The Dawes-Redman system for assessing the antepartum CTG

Development began in 1978 and the first commercial system was marketed by Oxford Instruments at the end of the 1980s. It was designed to connect to any monitor, and the principles of the system were to determine when enough information was available to conclude that the recording was normal and further monitoring was not necessary. Normality was determined by a number of criteria, now called the Dawes-Redman criteria, with the minimum duration of trace set at 10 minutes. If, however, criteria had not been met by the end of one hour the trace would end with the conclusion that normality had not been demonstrated ('criteria not met').

All assessment of the CTG begins by determining the baseline, which can be surprisingly difficult. By eye it is an intuitive and approximate judgement. It would be highly unlikely that two individuals could ever 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. There are many subtleties in this process which cannot be discussed here. Some CTGs are so unstable that there is no baseline even when judged by eye; others have so much missing signal that interpretation is unreliable or impossible.

Important evidence of normality is the episodic variation in the heart rate caused by the fetus' different phases of sleep. In deep sleep, the fetal heart rate is relatively flat with lower short-term variation. When the baby becomes active, as is well known, 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 which is categorised as 'an episode of high' (meaning a period of high fetal heart-rate variation). After one of these events has been detected, unless there are other worrying features, criteria have been met and the trace can be stopped. The strength of this system is that it minimises the time needed to monitor normal babies. However, an episode of deep sleep may last as long as 40 or 50 minutes, so in some cases a longer trace is needed to prove normality.

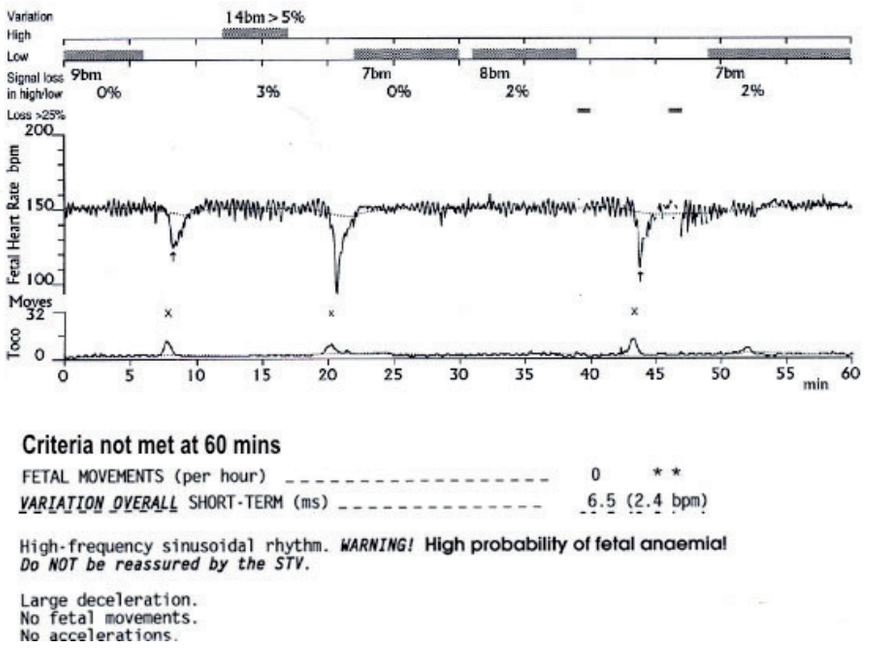

Figure 1. Fast sinusoidal rhythm indicative of severe fetal anaemia. Note the short term variation is normal but the problem has been detected by the computerised analysis

The trace with a rapid sinusoidal rhythm

This is a rare but extremely important pattern that indicates fetal anaemia. There may be multiple causes. When the anaemia is severe enough to cause this pattern, fetal safety is seriously compromised. It is an easy pattern for experts to detect by eye, but many traces are performed by non-experts, who cannot be expected to immediately recognise the pattern and what it signifies. Here the Dawes-Redman system also performs well. It reliably detects the problem and alerts the clinical attendant that it is serious *(Figure 1)*.

Validation of the Dawes-Redman system

Since its inception, the system has been continuously developed and improved. It incorporates many new features, many of which are not apparent to users, and some are to avoid

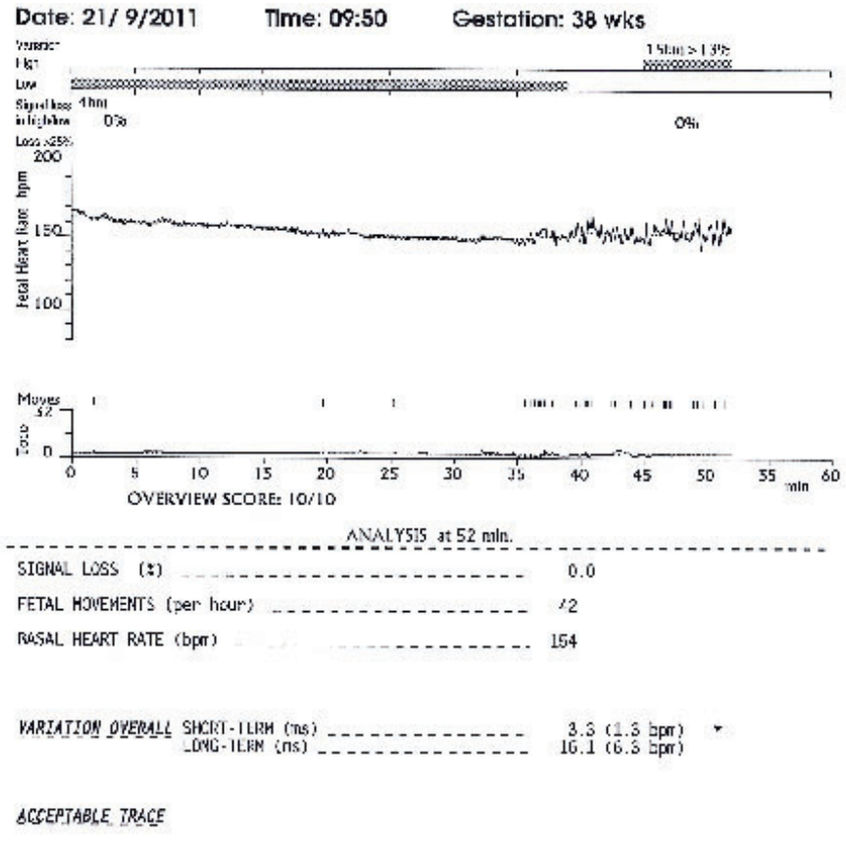

Figure 2. An unusually long phase of quiet sleep at term. Note that normality is not established until the last 6 minutes of the trace when the fetus becomes active and an episode of high heart-rate variation is detected. The trace is normal but the short term variation is low not because of a problem but because the trace happened to start at the beginning of a long period of quiet sleep. If the trace had been stopped early the short term variation could have been misinterpreted as fetal distress

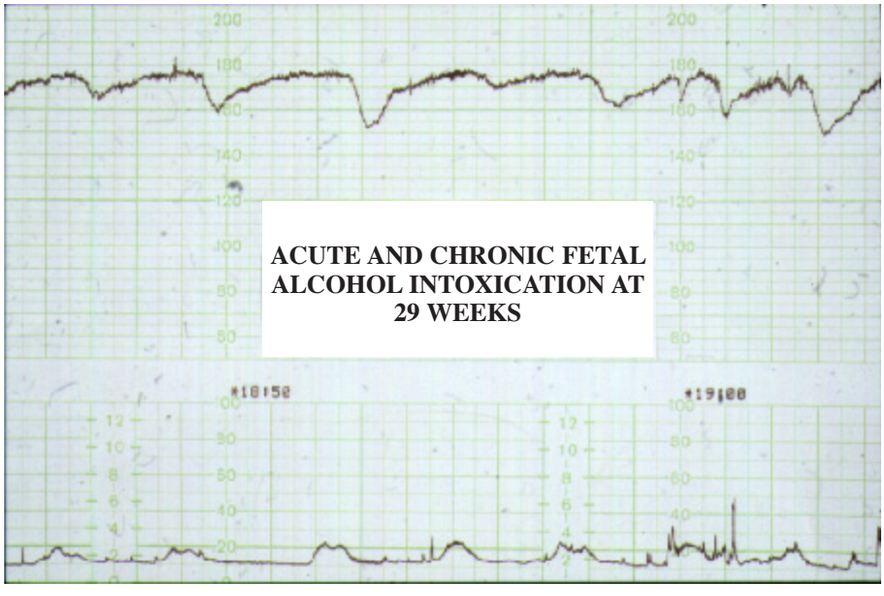

Figure 3. The fetal brain controls fetal heart rate patterns. Here the mother was intoxicated with alcohol as therefore was the fetus. The trace is abnormal but returned to complete normality when alcohol intake ceased

misreading difficult but unusual or rare patterns.

The procedure that recognises the rare but dangerous fast sinusoidal rhythm is unique in its design and testing (Reddy et al, 2009) and is only available in the authentic Dawes-Redman system. The way in which the baseline is assigned has been updated several times to accommodate unusual but clinically important situations. The system considers borderline features in combination, not in isolation, generating important warning messages where necessary. The system has been developed from a database of about 100,000 records. Every new development is now validated on this database, which is the largest in the world. Archived records have been linked to detailed clinical outcome data for more than 20 years. No change is made in the system unless it performs reliably in the whole dataset—all of which make the system dependable and unique.

The current version is marketed exclusively by Huntleigh, following its acquisition of Sonicaid in 2006, and is the only analysis to include these enhancements and more powerful algorithm. There are a number of imitations of its analysis on the market today but these are based on the original published work and do not include the many enhancements added in the last 20 or so years.

Short term variability, the fetal brain and fetal health

Short term variability (STV) is an important index of fetal wellbeing, but by no means the only one. It is not the same as beat-to-beat variation which cannot be determined by monitoring with external Doppler ultrasound techniques. STV is, however, measurable by the external Doppler detection systems that are universally used around the world. A low STV is most commonly encountered with growth retarded, chronically stressed fetuses. A value of <4msecs is low, <3msecs is abnormal and <2msecs highly abnormal. These thresholds are only valid when measured over the full period of 60 minutes. It may happen that an operator gets concerned about a low STV and stops the record prematurely. This is a mistake—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 *(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 of which is intoxication by alcohol as seen in the figure of a fetus of an alcoholic mother

(Figure 3). Another is congenital central nervous system abnormality—anencephalic fetuses have very flat traces, for example.

It is a mistake to assume that STV is the only parameter of interest. The strength of the Dawes-Redman system is that the criteria encompass several different aspects of fetal health. A recent analysis of maternity litigation within the NHS (the most costly part of the global claims against the NHS) emphasises the importance of CTG interpretation (NHS Litigation Authority, 2012). Whereas the primary issue is interpretation of the intrapartum CTG, the same issues are involved with analysis of the antepartum system where the Dawes-Redman system provides the gold standard for interpretation.

A fetus is more than its short term variation

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. Hence it is important to use all the information that is available in assessing the patient's wellbeing.

An antepartum CTG is a diagnostic not predictive or screening test

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 stillbirths where there is no gross pathology that could cause respiratory deprivation. Shaxted and Jenkins' (1981) remarkable report shows 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, and 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 such catastrophes as a sudden abruption—the trace can be reassuring for the moment, but if the problem persists it will have to be repeated from time to time. If there is background concern about a particular case—for example, a woman with long-term diabetes, but no reason to suspect fetal compromise at this moment—there is no reason to do 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 done rapidly. BJM

Key points

- The antepartum CTG detects severe fetal distress accurately
- In the grey zone between normality and fetal distress, interpretation is difficult and diagnostic accuracy is lower
- Subjective visual interpretation of the CTG is inconsistent and inaccurate
- Computerised analysis is the only way to get around these drawbacks
- The latest version of the Dawes-Redman system has been refined over many years, and is the most robust and powerful of systems currently available
- It minimises recording time
- Short term variation is a useful measure of fetal condition. However, it is only valid if measured after 60 minutes of recording and is only one aspect of fetal condition
- The current Dawes-Redman system has features and updates which are not included in commercially available imitators of the system

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