Maternal and fetal heart rate confusion during labour

Abstract

Continuous electronic fetal heart rate monitoring is commonly used by clinicians during labour and delivery to assess fetal wellbeing.
The Doppler ultrasound cardiotocograph (CTG) detects the fetal heart rate (FHR) and the uterine activity (toco) simultaneously and displays it in the form of graph. There have been reports of the FHR being substituted by the maternal heart rate (MHR) with this method of monitoring. FHR/MHR confusion left undetected can lead to adverse outcomes.

This article gives an overview of the pattern of the MHR during labour in continuous maternal and fetal heart rate monitoring using an abdominal maternal and fetal electrocardiograph monitor (abfECG) in contrast with more traditional Doppler methods.

The exploration of the pattern of the MHR during labour and delivery demonstrates how an incorrect assessment of fetal wellbeing could be made if the monitor was used in isolation and the MHR was being reported rather than the FHR.
This article also explores how midwives can minimize the risk of such incidents occurring.

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In external electronic FHR monitoring reports of the fetal signal being replaced by an alternative source have occurred, this could include the MHR.

> ***'This masks the condition of the fetus without the attending staff being alerted to the loss of fetal signal. In approximately 10,000 deliveries we have encountered 5 examples of unexpected adverse fetal outcome attributed to this signal ambiguity. We have also seen several cases without adverse outcome.' (Neilson et al, 2008: 717)***

There has been little development in fetal electronic heart rate monitors since the introduction of digital processing in the early 1980s. The transducers and processing algorithms used to detect the FHR have undergone little evolution although there has been an increase in sensitivity. One possible outcome of the increased sensitivity of the Doppler transducer and the complex algorithms for extracting the FHR is the confusion of the heart rate between the mother, fetus and other artefacts when the fetal signal is poor.

Ultrasound itself is high frequency sound that is beamed into the maternal abdomen using a transducer and held in place using a belt. The high frequency sound waves are then scattered by the red cells or reflected off the fetal heart valves and other structures (e.g. the heart walls and blood vessels). Some of this scattered/reflected energy is detected by the transducer. If the ultrasound is scattered/reflected from a moving structure it will undergo a change in frequency, called the Doppler shift. It is this change in frequency between the transmitted and reflected signal that can be heard from the loudspeaker of the monitor.

> ***'CTGs use a low power ultrasound Doppler signal to detect movement within the mother's abdomen. The fetal heartbeat is a weak signal in a noisy environment. Signal processing techniques are used to extract a periodic/repetitive signal. In the majority of cases the FHR is correctly displayed and accelerations and decelerations are faithfully reproduced. However, it would appear that when there is no fetal heartbeat the CTG may respond to a weak signal derived from a combination of the maternal aorta, iliac and uterine arteries. The resulting trace shows reactivity and variability due to maternal heart rate changes and muscle contractions. This condition only occurs in a small number of stillbirths but causes distress for all those involved' (MHRA, Safety Warnings, 2002).***

Jezewski et al (2006) clearly illustrates how the ultrasound signal detects the mechanical activity of the heart, and how widely the activity is dispersed. Therefore various durations of the cardiac cycle can be obtained depending on which event is selected as representing a given cycle (*Figure 1*).

Maternal and fetal heart rate comparison

Abdominally detected fetal ECG heart rate monitoring was first described by Cremer in 1906. Advances in this area have lead to new technol-

ogies that are capable of obtaining a clinically useful non invasive abdominal fetal ECG along with the maternal ECG. In order to compare the maternal and fetal heart rates simultaneously the abdominal fetal and maternal electrocardiograph (abfECG) was used. *Figure 2* shows the electrodes attached to the mother's abdomen and the monitor.

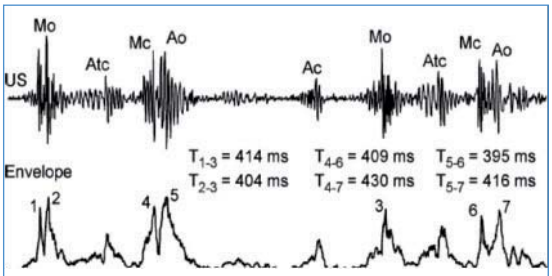
The abfECG monitor calculates the MHR as well as the FHR simultaneously. It uses the height and the width of the QRS complex (electrical activation of the ventricles of the heart), both of which are linked to the size of the heart, to differentiate between the fetal and maternal heart signals, The fetal width is always below 60 milliseconds and the maternal QRS is greater than 60 milliseconds in adults who have no unusual underlying cardiac pathology. *Figure 3* demonstrates the raw electrophysiological data recorded by the monitor from the maternal abdomen before MHR and FHR hearts are calculated. Once the maternal ECG is identified a template of the QRS complex is built up and then subtracted from the electrophysiological signal to leave the fetal QRS complex as shown in *Figure 3*.

The upper part of diagram shows the raw fetal and maternal signal—the red markers indicate a fetal heart signal. The lower part of the diagram shows the fetal ECG once the maternal ECG is subtracted. The R–R interval is used to calculate the MHR and FHR from their respective signals.

The maternal heart rate

The maternal heart rate normally responds to the uterine contractions in labour by an increase in heart rate, owing to the increase in maternal cardiac output and catecholamine secretion. Catecholamines, epinephrine and norepinephrine, cause characteristic 'fight or flight' responses including increased heart rate and blood pressure, vasoconstriction, and other autonomic responses. *Figure 4* demonstrates the increase in the maternal heart rate with the contraction of the uterus using the abfECG monitor to obtain this data.

Decelerations of the MHR can also be associated with uterine contractions although they can occur rarely and often remain unexplained. Sherer et al (2005) describes a case of a 39-week pregnant woman with systemic lupus erythematosus (postrenal transplant for lupus nephropathy-related renal failure) who during intrapartum continuous FHR/MHR monitoring in labour demonstrated repetitive decelerations of the MHR of 60 beats per minute.



ms=milliseconds (1000 milliseconds in one second)
Atc=atrial wall contraction; Mo and Mc= mitral valve opening and closing
Ao and Ac= aortic valve opening and closure

Figure 1. Cardiac cycle (Jezewski et al, 2006)

> ***'Simultaneously depicted fetal heart rate was reassuring. In addition, this case illustrates the potentially dangerous similarity of an intrapartum maternal heart rate to an abnormal fetal heart rate pattern, and emphasizes the importance of correct identification of the maternal and fetal heart rates, respectively'. (Sherer et al, 2005: 165)***

Decreases in the MHR during contractions using the abfECG monitor is illustrated in *Figure 5*. If signal source switching had occurred between the MHR/FHR in this assessment of the fetal well-being it would have been completely different with unnecessary intervention as a possible consequence.

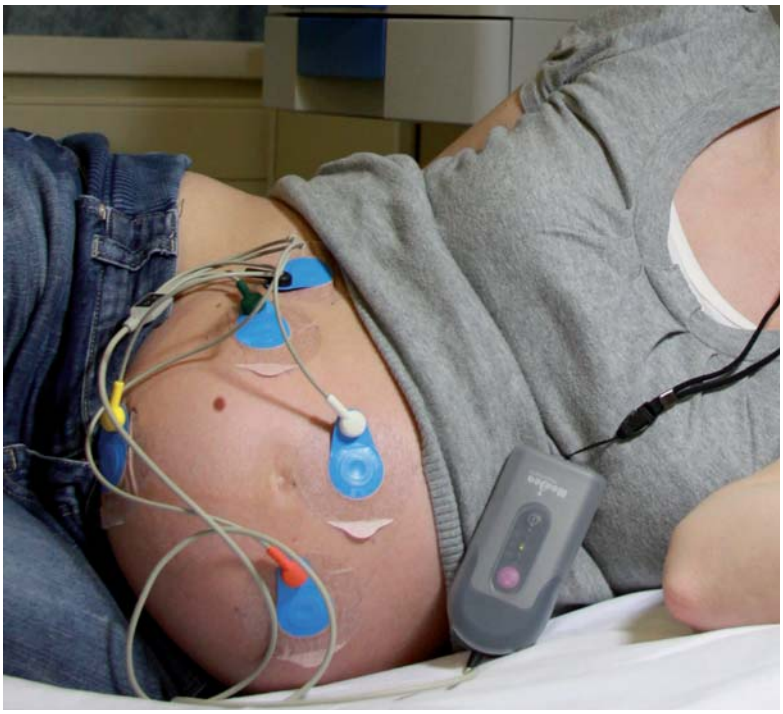


Figure 2. Abdominal maternal and fetal ECG monitor

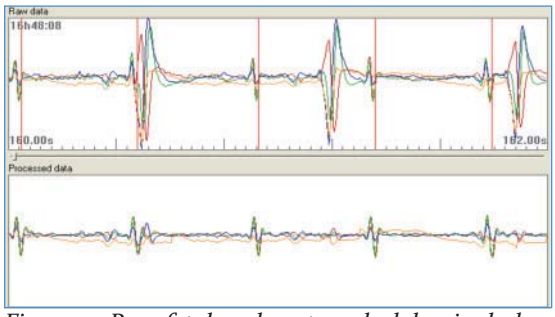


Figure 3. Raw fetal and maternal abdominal electrophysiological data

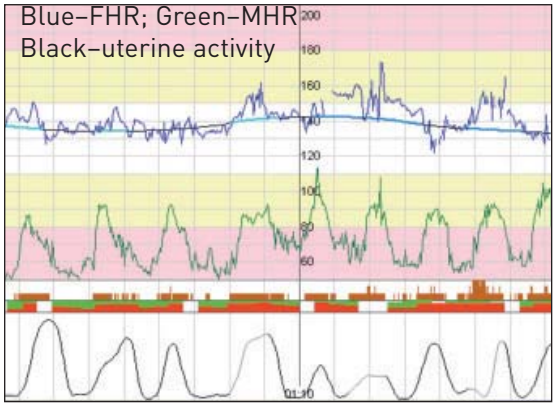


Figure 4. CTG, maternal and fetal heart rate, and uterine activity data

Clinicians clearly describe the consequences of MHR/FHR confusion, Neison et al (2008) describes a particular case of FHR/MHR confusion, which resulted in a stillbirth. The CTG had shown persistent heart rate accelerations during the second stage of labour. This incident would clearly be distressing for the mother, family and staff involved and could have been avoided if the FHR auscultation with MHR palpation had been taken on a regular basis.

An alternative to intermittent MHR palpation is to record the MHR continuously with the FHR. Doppler FHR, abdominal ECG MHR and abdominal ECG FHR are shown simultaneously in *Figure 6*. *Figure 6a* shows the Doppler FHR with periods of decreases in FHR as well as artefact and loss of contact. *Figure 6b* adds the abdominal fetal ECG FHR obtained simultaneously which shows no decrease in the FHR. *Figure 6c* adds the abdominal maternal ECG MHR to the FHR traces. It can now be hypothesized that the Doppler FHR is shifting to a maternal signal source leading to possible misinterpretation of the FHR.

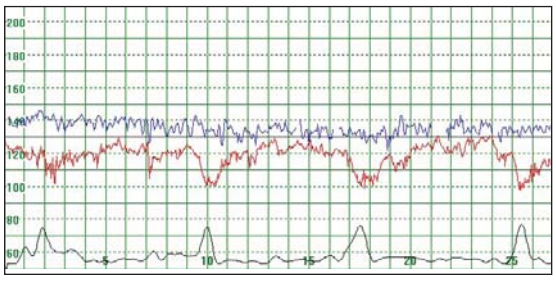


Figure 5. abfECG CTG showing MHR decelerations during contractions

Neilson et al (2008) describes that signal source shifting between FHR/MHR can occur repeatedly and occur with minimal or no data interruption. In his paper he reviewed a number of cases with MHR insertion.

> ***'Experienced obstetricians reviewing these cases have been unable to determine the transition points. Therefore, the staff is not alerted to the possibility of misleading data, and the potential for unrecognized fetal distress occurs.' (Neilson et al, 2008: 724)***

Recommendations

There appears to be an increasing focus on FHR/MHR confusion. The latest recommendations from Philips Healthcare (sent to health providers in September 2009) to reduce the risk of errors occurring during continuous FHR monitoring were to:

> ***'Confirm fetal life before using the monitor:***
> ***• Obstetric stethoscope***
> ***• Doppler***
> ***• Ultrasound Imaging.***
> ***Continue to confirm that the fetus is the signal for the fetal heart rate particularly if abrupt changes in the fetal heart rate are noted***
> ***• Consider monitoring the maternal heart rate.***
> ***• Consider using fetal scalp electrode if a discrepancy is suspected.'***
> ***(Philips Healthcare, 2009)***

The National Institute of Health and Clinical Excellence Guidelines (NICE) (2007) recommend that as part of the initial observations of a woman presenting in labour the FHR should be auscultated for a minimum of 1 minute immediately after a contraction. The maternal pulse should be palpated to differentiate between MHR and FHR.

During established first stage of labour the NICE guidelines (2007) recommend the maternal pulse should be checked hourly, intermittent auscultation of the fetal heart should occur for at least 1 minute after a contraction every 15 minutes, and recorded as an average rate. The maternal pulse should be palpated if a FHR

abnormality is detected to differentiate the two heart rates. During the second stage of labour observations should include hourly maternal pulse and intermittent auscultation of the fetal heart after a contraction for at least 1 minute every 5 minutes. It is recommended that if there is suspected bradycardia or other FHR anomaly the maternal pulse should be palpated to differentiate the two heart rates.

Case example of the MHR during labour

One of the key objectives in a hospital in the Middle East was to reduce the number of fetal scalp electrodes (FSE) applied during labour but to also review their current protocol on FHR monitoring during labour. The protocol was that all women in labour had continuous FHR monitoring. An FSE was used with any woman in labour who had a FHR deceleration on the trace or the trace was of poor quality. Good quality FHR data was the main reason for using a FSE so that the hospital would have good records in case of any litigation cases. The hospital wanted to explore the feasibility of using a abfECG monitor.

A 23-year-old pregnant woman is admitted to this hospital in the Middle East for the induction of labour for post maturity, her pregnancy gestation is 40 weeks and 1 day (indication of induction as per hospital protocol in this hospital). She is gravid 3 para 2, and her two previous deliveries were normal. She has no history of any medical problems and no problems identified in this pregnancy.

At 8.50 am she is admitted to the labour ward with no signs of labour on admission and the findings from the vaginal examination were that the cervix was 2 cm dilated. The decision was made to do an artificial rupture of membranes and to begin a syntocinon infusion. The FHR was monitored continuously using a Doppler ultrasound with the toco placed at the fundus of the uterus. The woman used entonox for pain relief in labour. An FSE would usually have been applied but a decision was made to use the data from the abfECG monitor. The maternal position throughout labour was in bed in a supine/semi-recumbent position.

The woman progressed well in labour and had a normal delivery of a female infant at 1.19 pm, Apgar scores were 8 at 1 minute and 9 at 5 minutes. *Figure 7* is a copy of the trace produced by the abfECG monitor, the pattern of the MHR remaining consistent in relation to the contractions.

Figure 8 shows part of the CTG recorded by Doppler ultrasound. It demonstrates positional

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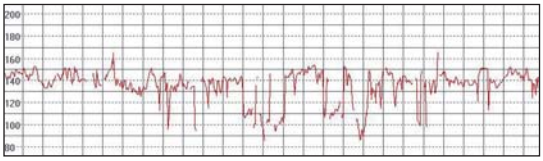
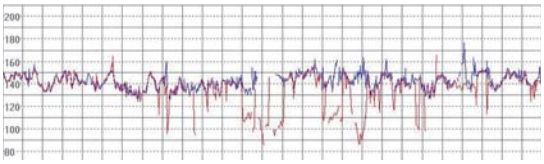
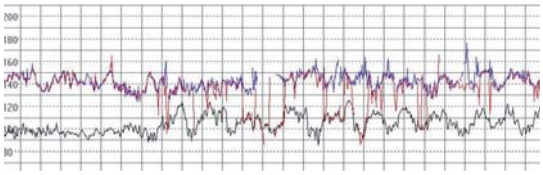
mechanical changes and therefore potential for MHR/FHR confusion. The added information of the MHR was of interest to the obstetric nurse, the pattern follows that similar to the uterine activity pattern and this is something she had not observed before.



6a. Red= FHR using Doppler ultrasound



6b. Red= FHR using Doppler ultrasound; Blue= FHR using abfECG



6c. Black= MHR; Red= Doppler ultrasound; Blue= abfECG

Figure 6. FHR and MHR comparison

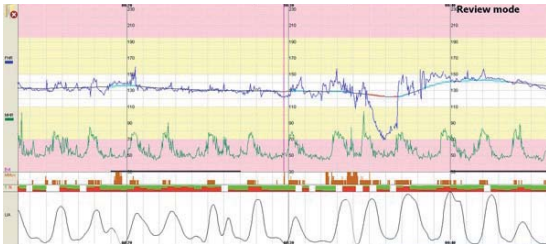


Figure 7. CTG from the abfECG monitor

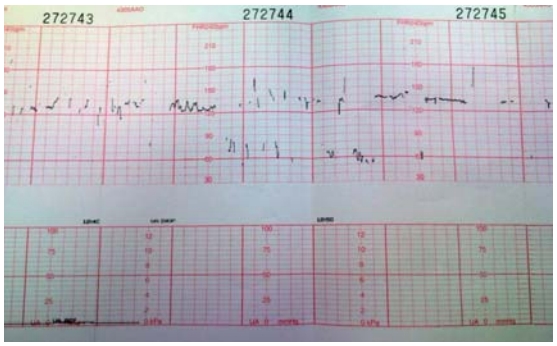


Figure 8. Small segment of the CTG trace using Doppler Ultrasound

Discussion

The authors were inspired to write this article because of the verbal feedback from some midwives and nurses using the abfECG monitor. They previously did not have the opportunity to reflect on CTG traces displaying both MHR and FHR simultaneously. They were surprised to see the uniformity of the MHR accelerations with that of the contractions of the uterus. They therefore could relate to how MHR and FHR confusion could be left undetected in electronic fetal heart rate monitoring if appropriate steps are not taken to differentiate between the MHR and FHR. Many had not observed this previously as the maternal pulse was normally taken for a maximum of 1 minute by using the mother's radial pulse. In the case example the obstetric nurse thought the maternal pulse displayed on the screen was the maternal uterine activity. By encouraging the nurse to make a clinical assessment using her hands to take the maternal pulse she could relate her assessment with what was being displayed on the monitor. Before any electronic form of monitoring or doubting the information obtained by the monitor, midwives and nurses should make a physical clinical assessment. It is also imperative to record this in the documentation. The Pinard is also an invaluable method of determining the FHR and it is recommended by manufacturers that the Pinard stethoscope should be used before the Doppler CTG monitor is used (Philips Healthcare, 2009). Though in some institutes it appears to be a skill that is becoming less and less used in fetal assessment.

To minimize the risk of MHR confusion when using the Doppler CTG, always determine the fetal position so the transducer can be placed over the fetal back and use the signal quality indicator to ensure it is good. It is important to periodically compare the mother's pulse with that of the signal coming from the monitor's loudspeaker to establish that it is the FHR that is being recorded. This is highlighted in user guides.

Conclusion

Despite the increased focus on incidents of MHR confusion, many staff have not had the opportunity to view the pattern of MHR and FHR simultaneously and thus remain unconvinced of the necessity of confirming the signal source as that of the fetus and not of any other source including MHR. If continual FHR monitoring is indicated consideration should be given to monitoring the MHR simultaneously to avoid FHR/MHR confusion. **BJM**

Key points

- Maternal heart rate (MHR) and fetal heart rate (FHR) confusion that can occur in electronic FHR monitoring has lead to unexpected fetal outcome when gone undetected.
- Using the Pinard stethoscope to listen to the FHR before undertaking a Cardiotocograph (CTG) as well as periodically confirming that the fetus is the signal source for the FHR is recommended by manufacturers.
- Traces in this article demonstrate how variable the MHR can be especially in response to contractions. This can easily lead to false interpretation of FHR and fetal wellbeing if MHR/FHR confusion occurs.
- Advances in abdominal fetal electrocardiography (abfECG) now make it possible to record the MHR and FHR simultaneously from the same electrodes, reducing the incidence of MHR/FHR confusion occurring, without added intervention.
- Whenever electronic FHR monitoring is recommended, MHR should always be monitored.

Acknowledgments

The authors would like to thank Monica Healthcare Ltd and participants for allowing the use of the images to illustrate the issue of MHR/FHR confusion in electronic FHR monitoring.

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Sherer D, Dalloul M, Pierre N (2005) Intrapartum Repetitive Maternal Heart Rate Deceleration Pattern Stimulating Nonreasuring Fetal Status. *Am J Perinatol* **22**(3): 165–7