PHILIPS

Avalon

Smart Pulse

Maternal insertion

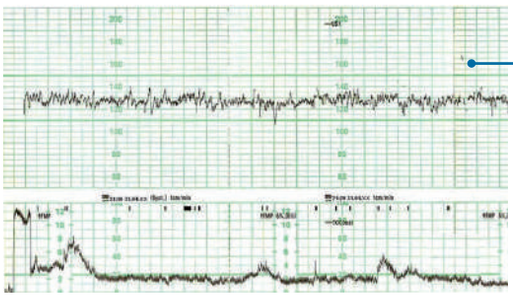
Clinical challenges

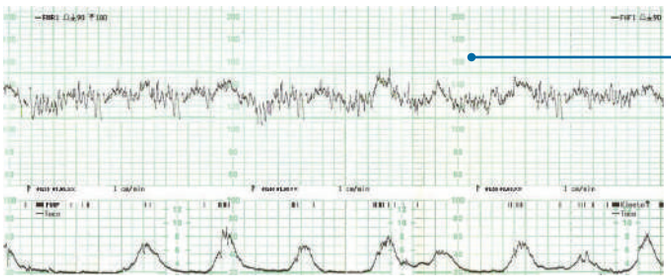
The detection and display of the maternal pulse during fetal heart rate monitoring with an electronic fetal monitor (EFM)

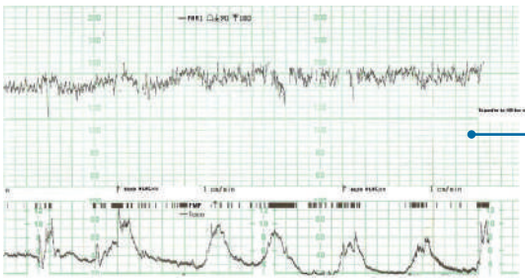
Case report

A 21-year-old G1P0 arrives in active labor

Past medical history: none
Antenatal period: no antenatal checks performed during pregnancy







Labor

21:00
- Admitted in spontaneous labor at 21:00
- Contracting 3:10
- Dilatation 5 cm
- BP 140/80
- Mother with low-grade fever (37.5°C)
- WCC 17000
- Bolus dose cephalosporin given

01:35
- Dilatation 5 cm
- Epidural inserted, with minimal pain relief

06:10
- Spontaneous rupture of membranes
- Thick green fluid
- Dilatation 7 cm
- Temp 37.5°C
- WCC 26000
- Decision to perform C-section

Outcome

- Baby boy
- Weight 3840 g
- Length 50 cm
- Head circumference 34 cm
- Apgar 0 / 0 / 0
- Grade 3 maceration
- Placenta and umbilical cord; no abnormalities
- Fetal death related to maternal infection

Discussion

A normal fetal physiological response to a uterine contraction is a deceleration that can be triggered by head compression, umbilical cord compression, or reduced placental perfusion.

The maternal heart rate (MHR) typically will accelerate due to a transient increase in maternal venous return, maternal anxiety, and pain. In the first stage of labor, it is also not uncommon to see “early” decelerations with the MHR, the etiology of which needs further investigation.[1]

In the absence of a fetal heart rate in the above case report, the ultrasound transducer of the EFM detected and displayed the maternal pulse.

A combination of maternal fever and dehydration created an increase in the maternal heart rate baseline which was within the normal range for the fetus, leading the clinicians to believe that the heart rate being displayed was of fetal origin.

In this case report, the fetal movement profile (FMP) is recording movements. These are maternal movements that have been detected and displayed. The FMP should never be used as a primary means to detect fetal life.

While earlier detection of the issue would not have changed the outcome for the mother and fetus, it would have prevented the stress and feelings of guilt experienced by the caregivers.

Clinical background

The electric fetal monitor (EFM) uses the Doppler ultrasound method to externally monitor the fetal heart rate. The ultrasound transducer (in transmitter mode) sends sound waves into the body which are then reflected by different tissues. These reflections (Doppler echoes) are picked up by the transducer (in listening mode). Doppler echoes are then processed through an autocorrelation algorithm to determine the fetal heart rate (FHR).

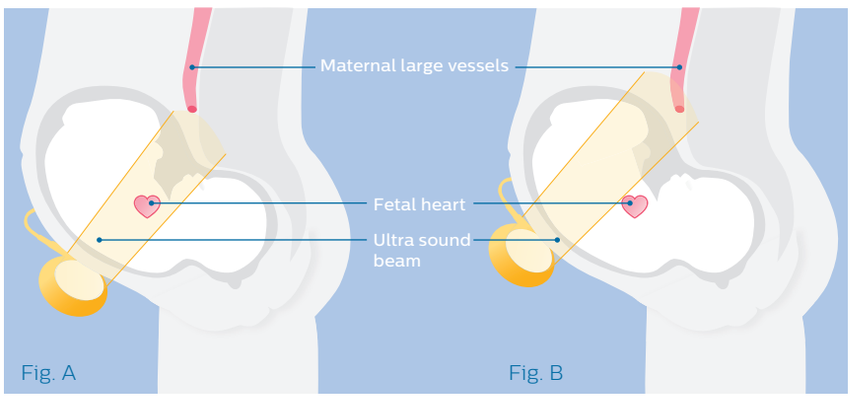
All tissues moving toward or away from the ultrasound transducer will generate Doppler echoes. In contrast to the timely well-defined R-peak of an ECG signal obtained with a fetal scalp electrode, the ultrasound Doppler signal from a fetal heart consists of multiple components from atria (diastole), ventricles (systole), valves, and pulsating arteries.

To assist in identifying the true fetal heart, the Philips EFM uses an autocorrelation algorithm, which continuously compares incoming waveform data to accurately determine the periodic heart signal.

If the signal is erratic, such as from a fetal arrhythmia or strong fetal movements, the autocorrelation algorithm may have trouble tracking the abrupt changes and create artifacts.

During the second stage of labor, when the fetal head is deep in the pelvis, it is not uncommon to encounter challenges with recording an accurate fetal heart rate via the ultrasound transducer. This is because it can be positioned closer to the pelvis inadvertently over the maternal aorta or great iliac vessels (Fig B), or over maternal vessels of the placenta (if within the ultrasound beam, for example with an anterior placenta). The transducer can also move during position changes or strong contractions where the fetus may be pushed out of the ultrasound beam (Fig. B versus Fig. A).

If intrauterine fetal death has occurred, the Doppler echoes that are generated and processed are coming from maternal vessels as described above. It should be noted that using a fetal scalp electrode in this instance will also produce maternal insertion, as the maternal ECG signal is picked up through the fetal scalp electrode and displayed as the FHR.



As maternal pulse can show similar characteristics to the FHR, maternal insertion can be overlooked. If this occurs during the second stage of labor, the fetus is not being monitored during a period of hypoxic stress and adverse outcomes could result.

Features of the FHR trace that may indicate that a maternal pulse is being recorded:[2]

- Absence of decelerations in second stage of labor
- Accelerations coincide with uterine contractions or pushing efforts
- Presence of baseline fetal bradycardia (maternal hemodynamic changes during labor; increased baseline heart rate that resembles fetal bradycardia rate)

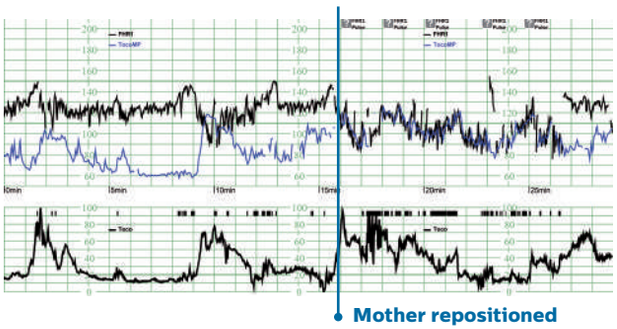
A recent study by Van Veen et al,[1] that looks at maternal heart rate patterns in the first and second stages of labor recommends that fetal traces with repetitive accelerations during contractions (particularly if a delta of 20 bpm from baseline) should be viewed as being maternal until proven otherwise.

Accelerations coinciding with uterine contractions occurred in 11.7% of cases being monitored with an ultrasound transducer and 4% of cases being monitored with scalp electrode in a study by Nurani et al.[3] This is an important finding as it is the first time that insight into the frequency of maternal insertion has been documented.

These accelerations were deemed “non-physiologic” from a fetal view in the Nurani study and a recommendation to investigate and rule out maternal origin was made.

In an attempt to avert maternal insertion, it is strongly recommended prior to commencing EFM to confirm fetal life by independent means, for example, by palpation of fetal movement or auscultation of fetal heart sounds using a fetoscope, stethoscope, or Pinard stethoscope. If fetal heart sounds cannot be detected and fetal movements are not palpated, then obstetric ultrasound imaging should be used to confirm fetal life.

At regular intervals during EFM, the signal source should be confirmed to be of fetal origin, especially when a sudden change in the features of a fetal trace occurs. In the below example, the mother has been repositioned at 03:25 and the ultrasound transducer has been recording the MHR for approximately 10 minutes. In this case, the observer may interpret the drop in fetal heart rate as a prolonged deceleration and instigate an emergency intervention which is unnecessary.



One method of detecting maternal insertion is by measuring either maternal ECG or SpO_2 continuously and then using the cross-channel verification (CCV) feature in the Philips EFM. The CCV compares the maternal and fetal heart rates continuously and alerts the clinician when maternal insertion occurs, making it a reliable tool for detecting maternal insertion.

The limitation of this method is that it requires additional equipment, which may not be readily available, and the mother is tethered to the EFM, which may restrict her ability to move and impact her experience of a natural birth.

Spotlight on

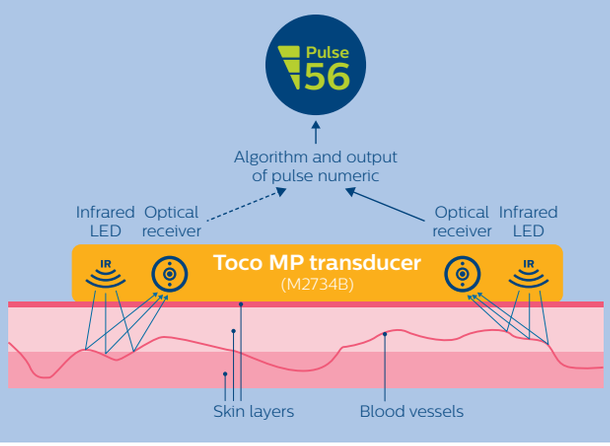
Avalon Smart Pulse

The Philips Toco MP Transducer has two built-in sensors to measure maternal pulse. The technology used is similar to SpO_2, but measures the maternal pulse only.

Avalon Smart Pulse provides a basis for confident decision making. Its integrated sensors emit infrared light that is invisible to the human eye, but reflected by tissue and blood vessels. The pulsating diameter of the small arteries causes changes in the reflected light. These changes are then measured and evaluated in an algorithm which then displays a maternal pulse value.

The reason for having two sensors is to make sure that the value being displayed is highly accurate. The signal from the sensor with the better quality will be used by the algorithm to display the maternal pulse.

Smart Pulse measurement principle



Avalon Smart Pulse offers two key benefits: it does not require any additional handling by the caregiver, and it is continuous. As soon as the Toco MP transducer is applied, the maternal pulse is detected, displayed, and recorded. The cross-channel verification (CCV) feature automatically compares the maternal pulse and fetal heart rate for incidences of maternal insertion and issues an audible and visible alarm if detected.

Should the CCV issue a notification, the caregiver should attempt to reposition the ultrasound transducer. If the issue cannot be corrected, an alternative method for measuring the fetal heart rate should be used, such as a fetal scalp electrode.

Together, the Avalon Smart Pulse and automated maternal-fetal heart rate coincidence detection warn of potential sources of error and provide a basis for confident decision making.

Smart Pulse is standard on all Philips Avalon fetal monitors.

References

[1] Van Veen TR et al. "Maternal heart rate patterns in the first and second stages of labor". Act Obstetric Gynecology Scand 2012; 91: 598-604.

[2] Sherman DJ et al. "Characteristics of Maternal Heart Rate Patterns during Labor and Delivery". ACOG Vol. 99, No. 4, April 2002

[3] Nurani R et al. "Misidentification of maternal heart rate as fetal on cardiotocography during the second stage of labor: the role of the fetal electrocardiograph". Acta Obstet Gynecol Scand 2012 Dec; 91(12): 1428-32. doi: 10.1111/j.1600-0412.2012.01511.x.

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