Electronic Fetal Monitoring Case Review Series

Electronic fetal monitoring is a popular technology used to establish fetal well-being. Despite its widespread use, terminology used to describe patterns seen on the monitor has not been consistent until recently. In 1997, the National Institute of Child Health and Human Development (NICHD) Research Planning Workshop published guidelines for interpretation of fetal tracings. This publication was the culmination of 2 years of work by a panel of experts in the field of fetal monitoring and was endorsed in 2005 by both the American College of Obstetricians and Gynecologists (ACOG) and the Association of Women’s Health, Obstetric and Neonatal Nurses. In 2008, ACOG, NICHD, and the Society for Maternal-Fetal Medicine reviewed and updated the definitions for fetal heart rate (FHR) patterns, interpretation, and research recommendations. The following is a summary of the terminology definitions and assumptions found in the 2008 NICHD workshop report. Normal values for arterial umbilical cord gas values and indications of acidosis are defined in Table 1.

Assumptions From the NICHD Workshop

- Definitions are developed for visual interpretation, assuming that both the FHR and uterine activity recordings are of adequate quality
- Definitions apply to tracings generated by internal or external monitoring devices
- Periodic patterns are differentiated based on waveform, abrupt or gradual (eg, late decelerations have a gradual onset and variable decelerations have an abrupt onset)
- Long- and short-term variability are evaluated visually as a unit
- Gestational age of the fetus is considered when evaluating patterns
- Components of FHR do not occur alone and generally evolve over time

Definitions

Baseline FHR

- Approximate mean FHR rounded to increments of 5 beats per minute in a 10-minute segment of tracing, excluding accelerations and decelerations, periods of marked variability, and segments of baseline that differ by >25 beats per minute
- In the 10-minute segment, the minimum baseline duration must be at least 2 minutes (not necessarily contiguous) or the baseline for that segment is indeterminate
- Bradycardia is a baseline of <110 beats per minute; tachycardia is a baseline of >160 beats per minute
- Sinusoidal baseline has a smooth sine wavelike undulating pattern, with waves having regular frequency and amplitude

Baseline Variability

- Fluctuations in the baseline FHR of 2 cycles per minute or greater, fluctuations are irregular in amplitude and frequency, and fluctuations are visually quantitated as the amplitude of the peak to trough in beats per minute
- Classification of variability:
  - Absent: Amplitude range is undetectable
  - Minimal: Amplitude range is greater than undetectable to 5 beats per minute
  - Moderate: Amplitude range is 6 to 25 beats per minute
  - Marked: Amplitude range is >25 beats per minute

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Accelerations
- Abrupt increase in FHR above the most recently determined baseline
- Onset to peak of acceleration is <30 seconds, acme is ≥15 beats per minute above the most recently determined baseline and lasts ≥15 seconds but <2 minutes
- Before 32 weeks’ gestation, accelerations are defined by an acme ≥10 beats per minute above the most recently determined baseline for ≥10 seconds
- Prolonged acceleration lasts ≥2 minutes but <10 minutes

Late Decelerations
- Gradual decrease in FHR (onset to nadir ≥30 seconds) below the most recently determined baseline, with nadir occurring after the peak of uterine contractions
- Considered a periodic pattern because it occurs with uterine contractions

Early Decelerations
- Gradual decrease in FHR (onset to nadir ≥30 seconds) below the most recently determined baseline, with nadir occurring coincident with uterine contraction
- Also considered a periodic pattern

Variable Decelerations
- Abrupt decrease in FHR (onset to nadir <30 seconds)
- Decrease is ≥15 beats per minute below the most recently determined baseline lasting ≥15 seconds but <2 minutes
- May be episodic (occurs without a contraction) or periodic

Prolonged Decelerations
- Decrease in the FHR ≥15 beats per minute below the most recently determined baseline lasting ≥2 minutes but <10 minutes from onset to return to baseline
- Decelerations are tentatively called recurrent if they occur with ≥50% of uterine contractions in a 20-minute period.
- Decelerations occurring with <50% of uterine contractions in a 20-minute segment are intermittent.

Sinusoidal FHR Pattern
- Visually apparent, smooth sine wavelike undulating pattern in the baseline with a cycle frequency of 3 to 5 per minute that persists for ≥20 minutes.

Uterine Contractions
- Quantified as the number of contractions in a 10-minute window, and averaged over 30 minutes.
- Normal: ≤5 contractions in 10 minutes
- Tachysystole: >5 contractions in 10 minutes

Interpretation
A 3-tier FHR interpretation system has been recommended as follows:

<table>
<thead>
<tr>
<th>Table 1. Arterial Umbilical Cord Gas Values</th>
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<tr>
<td>pH</td>
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<tr>
<td>Normal*</td>
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<td>Respiratory acidosis</td>
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<td>Metabolic acidosis</td>
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<td>Mixed acidosis</td>
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<table>
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<th>Table 2. Arterial Umbilical Cord Gas Results</th>
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<tr>
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• Category I FHR tracings: Normal, strongly predictive of normal fetal acid-base status and require routine care. These tracings include all of the following:
  – Baseline rate: 110 to 160 beats per minute
  – Baseline FHR variability: Moderate
  – Late or variable decelerations: Absent
  – Early decelerations: Present or absent
  – Accelerations: Present or absent
• Category II FHR tracings: Indeterminate, require evaluation and continued surveillance and reevaluation. Examples of these tracings include any of the following:
  – Bradycardia not accompanied by absent variability
  – Tachycardia
  – Minimal or marked baseline variability
  – Absent variability without recurrent decelerations
  – Absence of induced accelerations after fetal stimulation
  – Recurrent variable decelerations with minimal or moderate variability
  – Prolonged decelerations
  – Recurrent late decelerations with moderate variability
  – Variable decelerations with other characteristics, such as slow return to baseline
• Category III FHR tracings: Abnormal, predictive of abnormal fetal acid-base status and require prompt intervention. These tracings include:
  – Absent variability with any of the following:
    ■ Recurrent late decelerations
    ■ Recurrent variable decelerations
    ■ Bradycardia
    ■ Sinusoidal pattern


We encourage readers to examine each strip in the case presentation and make a personal interpretation of the findings before advancing to the expert interpretation provided.

Case Presentation

History

This case involves a 26-year-old G2 P1 with limited prenatal care that presented at 39 2/7 weeks’ gestation in labor with decreased fetal movement in the last 24 hours. Her contractions had been present for the past 24 hours, but became more intense and frequent over the last few hours. She denied any leaking of fluid or vaginal bleeding. Her past medical history was significant for a primary cesarean delivery for breech presentation 4 years ago. Her prenatal laboratory results were all normal, and she was group B Streptococcus negative. Cervical examination result was 2 to 3 cm, with a bulging bag of waters. The patient did not want a trial of labor and requested a repeat cesarean delivery. An external fetal monitor was placed and was shown in Fig 1.

Figure 1. EFM Strip #1.
Findings on Fig 1

- Variability: Minimal to absent
- Baseline rate: 150
- Episodic patterns: None
- Periodic patterns: Recurrent late decelerations
- Uterine contractions: Every 2 to 4 minutes lasting 60 to 70 seconds, palpate for intensity and tone
- Interpretation: Category II to III
- Differential Diagnoses: The indeterminate FHR tracing is not predictive of normal fetal acid-base status, but minimal to absent variability without accelerations is concerning for hypoxia and metabolic acidosis. Possible causes would be placental insufficiency of unknown etiology or acute fetomaternal hemorrhage.
- Action: The history of decreased fetal movement for the past 24 hours and minimal to absent variability, with recurrent late decelerations, should raise the question of a pre-admission hypoxic event causing metabolic acidemia. Therefore, a prompt and complete evaluation to rule out decreased placental perfusion and fetal acidemia/acidosis should take place.

Testing should include a biophysical profile and umbilical artery Doppler study, which provide a noninvasive measure of fetoplacental hemodynamic state. In addition, a Kleihauer-Betke test that determines the amount of fetal blood in the maternal circulation should also be performed to rule out a fetomaternal hemorrhage.

The goal of action at this point is to optimize blood flow to the uterus and improve oxygenation to the fetus. Interventions should include placing the mother in a lateral position, intravenous fluid bolus of 500 mL, and application of O2 per nonrebreather mask. The provider should be notified of indeterminate FHR pattern that is category II but clearly evolving to category III status. The patient’s request for a repeat cesarean delivery should prompt an immediate evaluation by the physician. In this case, the physician was notified and orders were received to monitor the FHR closely and prepare for an expedited cesarean delivery.

One hour later, the following tracing is shown in Fig 2.

Figure 1. EFM Strip #1.

Figure 2. EFM Strip #2.
Interpretation of Fig 2

- Variability: Minimal to absent variability
- Baseline rate: 150
- Episodic patterns: None
- Periodic patterns: Recurrent late decelerations
- Uterine contractions: Every 2 to 4 minutes, lasting 80 to 90 seconds, requires palpation to determine intensity.
- Interpretation: Category II to III
- Differential Diagnosis: Same
- Action: Despite implementation of all of the interventions discussed above, there was no improvement in the FHR status over the past hour. Most experts would recommend proceeding to immediate delivery, especially in a patient with a history of a previous cesarean delivery refusing a trial of labor. However, in this case since the health-care team continued to interpret FHR as a Category II tracing, they chose to continue to observe the FHR.

Since 2008, when the NICHD, ACOG, and the Society for Maternal-Fetal Medicine reviewed and updated the definitions for FHR patterns, interpretation, and research recommendations, it has been recognized that there is no clear consensus on the management of category II FHR patterns. (1)(2) The unintended consequence of the initial guidelines has been that many providers were not intervening with expedited delivery until the FHR reached a category III status. In a recent publication, Clark et al (1) suggested that with category II tracings that do not exhibit moderate variability or accelerations, but continue to exhibit patterns of persistent late decelerations, significant metabolic acidosis cannot be excluded. In fact, these deceleration patterns are often present when a fetus is physiologically stressed, and therefore the risk of acidemia is significantly increased. Their conclusion was that expedited delivery be recommended in this situation. (3)

Twenty minutes later, the following tracing is shown in Fig 3.

Figure 2. EFM Strip #2.

Figure 3. EFM Strip #3.
Interpretation of Fig 3

- Variability: Minimal
- Baseline Rate: 155
- Episodic patterns: None
- Periodic patterns: Recurrent late decelerations
- Uterine Contractions: Every 2 to 5 minutes, lasting 90 to 100 seconds, palpate for intensity
- Interpretation: Category II
- Differential Diagnosis: Same
- Action: The continued pattern of minimal to absent variability without evidence of fetal well-being such as accelerations or periods of moderate variability is worrisome. This case illustrates the ongoing concern of the category II classification, in that the health-care providers decisions were totally dependent on the supposed presence of variability, even though it was “minimal.” The current 3-tier classification requires variability to be “absent” to reclassify as a category III tracing. Even though the plan was to perform a cesarean delivery, there was no effort made to expedite the delivery at this point.

One hour later, there is no change in fetal status. The final tracing is shown in Fig 4.

Figure 3. EFM Strip #3.

Figure 4. EFM Strip #4.
Interpretation of Fig 4

- Variability: Minimal
- Baseline Rate: 150
- Episodic patterns: None
- Periodic patterns: Recurrent late decelerations
- Uterine Contractions: Every 2 to 3 minutes
- Interpretation: Category II
- Differential Diagnosis: Same
- Action: The patient was prepared for surgery and transported to the operating room 10 minutes later for a repeat cesarean delivery.

Outcome

A viable female infant weighing 3.14 kg was delivered with Apgar scores of 1, 1, 6, and 8 at 1, 5, 10, and 15 minutes, respectively. A possible velamentous insertion of the cord was noted at the time of delivery. The infant was pale, and covered with meconium, with normal tone and respiratory effort. Approximately 1 mL of meconium was suctioned from the cords. At this point, the infant became apneic and bag mask ventilation was given for 3 minutes, heart rate was 58, and pulse oximetry revealed a saturation of 59%. At 5 minutes, an umbilical venous catheter (UVC) line was placed, normal saline was given, and the infant was intubated. The infant immediately showed improvement in color and heart rate and was transported to the neonatal intensive care unit (NICU) and placed on mechanical ventilation.

Initially the infant had a hemoglobin level of 3 and hematocrit value of 11%. A Kleihauer-Betke test was positive, indicating a large fetomaternal hemorrhage, with a fetal blood loss of approximately 400 mL.

On day 2, the infant was extubated and experienced a seizure that was treated with phenobarbital and Keppra with no further seizures noted. Magnetic resonance imaging on day after birth no. 8 revealed extensive ischemic injury including corpus callosum, left parietal region, and periventricular area along occipital of the lateral ventricles.

The management of category II FHR patterns, which is observed in a large number of labors, continues to challenge providers. The category II classification has unfortunately included a large number of FHR patterns that range from near normal “no evidence of acidosis” to near abnormal “high likelihood of metabolic acidosis.” The NICHD guidelines emphasize the importance of the clinical circumstances in each individual case when utilizing the FHR monitoring data for clinical decision-making. In this case, when there was a history of decreased fetal movement, and the patient presented with recurrent late decelerations, minimal to absent variability and no accelerations, there was evidence of ongoing hypoxia. There was no evidence of fetal well-being. The consideration of an acute hypoxic event such as a fetomaternal hemorrhage hours before presentation needed to be considered. The fetomaternal hemorrhage most likely occurred in the 24 hours before admission, around the time of the patient’s report of decreased fetal movement. This fetomaternal hemorrhage likely led to an acute and sustained hypoxic event leading to significant metabolic acidosis. The algorithm for management of category II FHR tracings by Clark et al (1) recommends that if there are significant decelerations including late decelerations of any depth with ≥50% of contractions for 30 minutes, and the absence of moderate variability and/or accelerations, expedited delivery is indicated. The important difference between this recommendation and the NICHD classification is that moderate variability and/or accelerations are required to diagnosis a nonacidotic fetus. The distinction between minimal and absent variability therefore becomes irrelevant.

In this case, given that the acute hypoxic event most likely occurred hours before the patient presenting to the
hospital, immediate delivery may not have significantly changed the neonatal outcome. In the absence of significant decelerations, the clinician may be reassured that while the fetus may already be damaged, there is no ongoing damage. However, with persistent decelerations, such as in this case, there is a high probability of continuing hypoxia and acidosis. (Table 2) Given the uncertainty of the degree of central nervous system damage at presentation, expedited delivery would have been the most appropriate intervention.

References

American Board of Pediatrics Neonatal-Perinatal Content Specification
- Know the significance, interpretation, and management of abnormalities or changes in FHR patterns during labor (eg, variable decelerations, late decelerations, sinusoidal patterns, bradycardia, and tachycardia).
Strip of the Month: June 2014
Maurice L. Druzin and Nancy Peterson
NeoReviews 2014;15:e249
DOI: 10.1542/neo.15-6-e249

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