ELECTRONIC FETAL MONITORING CASE REVIEW SERIES

Electronic fetal monitoring (EFM) is a popular technology used to establish fetal well-being. Despite its widespread use, the 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 (AWHONN). 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. 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 the Table.

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/min in a 10-minute segment of tracing, excluding accelerations and decelerations, periods of marked variability, and segments of baseline that differ by >25 beats/min
- 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/min; tachycardia is a baseline of >160 beats/min
- Sinusoidal baseline has a smooth sine wave-like undulating pattern, with waves having regular frequency and amplitude
Baseline Variability
- Fluctuations in the baseline FHR of ≥2 cycles per minute, fluctuations are irregular in amplitude and frequency, 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/min
  - Moderate: Amplitude range is 6–25 beats/min
  - Marked: Amplitude range is >25 beats/min

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

### TABLE. Arterial Umbilical Cord Gas Values

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>PCO₂ (mm Hg)</th>
<th>PO₂ (mm Hg)</th>
<th>BASE EXCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal*</td>
<td>≥7.20</td>
<td>&lt;60 (35 to 70)</td>
<td>≥20</td>
<td>≤–10 (–2.0 to –9.0)</td>
</tr>
<tr>
<td>Respiratory acidosis</td>
<td>&lt;7.20</td>
<td>&gt;60</td>
<td>Variable</td>
<td>≤–10</td>
</tr>
<tr>
<td>Metabolic acidosis</td>
<td>&lt;7.20</td>
<td>&lt;60</td>
<td>Variable</td>
<td>≥–10</td>
</tr>
<tr>
<td>Mixed acidosis</td>
<td>&lt;7.20</td>
<td>&gt;60</td>
<td>Variable</td>
<td>≥–10</td>
</tr>
</tbody>
</table>

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

A 32-year-old gravida 2 para 1-o-0-1 woman presented to the maternal fetal medicine unit at gestational age 41 weeks and 2 days for late-term testing. She underwent ultrasonography, which confirmed a cephalic fetus estimated to weigh 3,918 g (79%). The amniotic fluid index was 2.9 cm, with a maximum vertical pocket of only 1.5 cm, consistent with oligohydramnios. Results of her antenatal testing were otherwise reassuring, with appropriate fetal movements, normal fetal tone, and regular fetal breathing by ultrasonography, resulting in 6/8 biophysical testing (minus 2 points for oligohydramnios). Because the patient was at late-term gestation with a new diagnosis of oligohydramnios, delivery was recommended. Her obstetric history was notable for a previous low transverse cesarean delivery in the setting of FHR tracing abnormalities during the second stage of labor. Otherwise, she had a benign medical history and a negative screen for group B Streptococcus colonization. She was counseled on her options for delivery: a repeated cesarean delivery or induction of labor. She was motivated to attempt a vaginal delivery.

#### Case Progression

On arrival at the labor and delivery unit, her cervical examination showed 2-cm dilation, 60% effacement, -2 station, soft consistency, and mid-positioning. Although her cervix was dilated, the patient was comfortable and not in labor. Given her previous hysterotomy, use of misoprostol for induction of labor was contraindicated because of the increased risk of uterine rupture. Therefore, her induction was initiated with an intracervical Foley balloon, which was inflated with saline. Risks and benefits of these induction agents were reviewed with the patient before use. Figure 1 exemplifies the FHR tracing on admission. This tracing represents a reactive tracing, which completes the fetal testing of 8/10, when combined with the biophysical profile, thus overall reassuring.

![Figure 1. Electronic fetal monitoring strip 1.](image-url)
Findings from EFM strip 1 are as follows:

- Variability: Moderate
- Baseline rate: 130 beats/min
- Episodic patterns: None
- Periodic patterns: None
- Uterine contractions: None
- Interpretation: Category I
- Differential diagnosis: Reactive and reassuring FHR tracing
- Action: Induction of labor was initiated

Risks and benefits were reviewed with the patient, and an intravenous oxytocin infusion was added to induce labor. Almost immediately after this induction agent was started, the patient began to have mild, irregular contractions that were not all traced on tocotometry. Figure 2 represents the FHR tracing after oxytocin initiation.

Figure 1. Electronic fetal monitoring strip 1.

Figure 2. Electronic fetal monitoring strip 2.
Findings from EFM strip 2 are as follows:

- **Variability:** Moderate
- **Baseline rate:** 140 beats/min
- **Episodic patterns:** Prolonged deceleration
- **Periodic patterns:** None
- **Uterine contractions:** Rare
- **Interpretation:** Category II

**Differential diagnosis:** A prolonged deceleration signifies a disruption in fetal oxygenation for longer than 2 minutes; this can be due to placental abruption, umbilical cord compression, tachysystole, tetanic uterine contractions, uterine rupture, or rapid change in fetal station.

**Action:** Oxytocin was continued; the physician was notified; no additional interventions were necessary because the FHR spontaneously returned to baseline.

The goal of obstetrical management in a category II FHR tracing is to optimize blood flow to the uterus to improve oxygenation to the fetus. Ongoing fetal evaluation by external continuous monitoring is recommended. Prolonged decelerations should prompt urgent assessment because the cause of fetal hypoxia needs to be corrected as soon as possible. Maternal hypotension, vaginal bleeding, or worsening abdominal pain may raise suspicion for placental abruption or uterine rupture, especially in the setting of a previous hysterotomy. Intravenous fluids or vasopressors can be used to treat maternal hypotension, if present. A cervical examination should be performed to ensure that there is no loss of fetal station (a sign of uterine rupture), to evaluate for rapid labor progression, and to exclude umbilical cord prolapse. Maternal repositioning to either the lateral recumbent or hands-and-knees position can be attempted to increase placental perfusion and relieve potential umbilical cord compression if the FHR deceleration does not resolve. Maternal oxygen administration may be used as well. If tachysystole or a tetanic contraction is suspected, discontinuation of intravenous oxytocin may be necessary. Alternatively, administration of a tocolytic agent such as terbutaline facilitates rapid cessation of contractions and allows for FHR recovery. Immediate cesarean delivery is indicated if the FHR deceleration persists despite these maneuvers and labor has not progressed sufficiently.

After this event, the patient continued to have intense and frequent contractions. The Foley balloon spontaneously expelled. The woman then underwent artificial rupture of membranes, and repeated cervical examination demonstrated 5-cm dilation, 80% effacement, and −1 station. She requested epidural placement. The FHR tracing at this time is represented in Fig 3.
Findings from EFM strip 3 are as follows:

- Variability: Moderate
- Baseline rate: 150 beats/min
- Episodic patterns: None
- Periodic patterns: Recurrent variable decelerations
- Uterine contractions: Every 2 to 3 minutes
- Interpretation: Category II
- Differential diagnosis: Our patient’s variable decelerations are likely due to low amniotic fluid volume given her diagnosis of oligohydramnios, compounded by her recent artificial rupture of membranes; a nuchal cord, umbilical knot, and umbilical cord prolapse can also result in variable decelerations
- Action: The patient’s cervix was examined and she was repositioned

Variable decelerations result from transient umbilical cord compression and can be either intermittent (associated with <50% of contractions) or recurrent (associated with >50% of contractions). Whereas intermittent variable decelerations are benign and can be expectantly managed, recurrent variable decelerations require intervention. A cervical examination should be performed to rule out an umbilical cord prolapse, followed by maternal repositioning in an attempt to alleviate cord compression. If the patient continues to have recurrent variable decelerations, an amnioinfusion can be considered. In this specific scenario, uterine rupture should also be considered, and a cervical examination would be helpful to determine whether there is a loss in fetal station. The patient’s cervical examination demonstrated 6-cm dilation, 90% effacement, and −1 station. The variable decelerations resolved with repositioning, and the induction was continued with intravenous oxytocin. Her cervix made further changes to 9-cm dilation, 90% effacement, and −1 station.

Over the next 4 hours, our patient’s cervical examination findings remained unchanged, and there was increasing concern for arrest of dilation. In addition, the patient developed a fever. An intrauterine pressure catheter was placed to assess the adequacy of her uterine contractions (Fig 4).
Findings from EFM strip 4 are as follows:

- **Variability:** Moderate
- **Baseline rate:** 170 beats/min
- **Episodic patterns:** None
- **Periodic patterns:** Recurrent variable decelerations
- **Uterine contractions:** Contractions every 3 to 4 minutes; 120 Montevideo units (MVU)
- **Interpretation:** Category II
- **Differential diagnosis:** In the setting of a maternal fever, fetal tachycardia is most likely due to chorioamnionitis; less likely, but also possible, are medication adverse effects, fetal hypoxia, fetal anemia, and fetal arrhythmia
- **Action:** The patient was treated for chorioamnionitis with antibiotics and antipyretics.

Chorioamnionitis, or intra-amniotic infection, affects 1% to 4% of pregnancies (1) and can present with fever, maternal tachycardia, fetal tachycardia, foul-smelling amniotic fluid, and uterine fundal tenderness. It results from a polymicrobial infection caused by ascending vaginal and enteric flora, and it is typically treated with intravenous ampicillin and gentamicin, as was the case in this patient.

A new diagnosis of chorioamnionitis should prompt evaluation of the patient’s labor curve to ensure that progress is being made toward delivery. Diagnosis of arrest of dilation requires the patient to have greater than or equal to 6-cm dilation with membrane rupture and 1 of the following: 1) greater than or equal to 4 hours of adequate contractions without cervical change or 2) greater than or equal to 6 hours of inadequate contractions without cervical change. (2) Contractions are adequate if greater than 200 MVU. Although our patient had inadequate contractions (120 MVU), her cervix had not changed in 4 hours and, therefore, had not yet met the criteria for arrest of dilation. The patient was motivated for a vaginal delivery, and given her overall reassuring status, labor was allowed to continue. The recurrent variable decelerations resolved with repositioning, and the decision was made to continue her induction with up-titration of intravenous oxytocin. Figure 5 shows the FHR tracing pattern that ensued.
Findings from EFM strip 5 are as follows:

- **Variability:** Moderate
- **Baseline rate:** 170 beats per min
- **Episodic patterns:** None
- **Periodic patterns:** Late decelerations
- **Uterine contractions:** Contractions every 1 to 4 minutes; 100 MVU
- **Interpretation:** Category II
- **Differential diagnosis:** Includes maternal hypotension or hypoxia and uteroplacental insufficiency
- **Action:** Isolated late decelerations that spontaneously return to baseline, as was the case here, may not require any additional interventions; if late decelerations become recurrent, maneuvers to reduce fetal hypoxia by improving uteroplacental perfusion should be considered; as described previously herein, this can be achieved by maternal repositioning, administration of supplemental oxygen or intravenous fluid bolus, and temporarily discontinuing intravenous oxytocin.

An additional 2 hours passed without any cervical change, and the patient failed to reach 10 cm of cervical dilation. She was diagnosed as having an arrest of the first stage of labor. Additional diagnosis included chorioamnionitis with fetal tachycardia. Due to the arrest disorder and the return of the recurrent variable decelerations with intermittent late decelerations, a cesarean delivery was advised, and the patient agreed.

**Outcome**

The patient underwent an uncomplicated repeated low transverse cesarean delivery of a liveborn male infant from the occiput posterior position. The infant weighed 3,800 g and had Apgar scores of 8 and 9 at 5 and 10 minutes, respectively. Intraoperative findings were notable for an anterior placenta as well as a 3- to 4-cm uterine window in the lower uterine segment. Placental pathology confirmed the diagnosis of acute chorioamnionitis.

**DISCUSSION**

In recent years, attention has focused on reducing the cesarean delivery rate in the United States as a public health measure. As a result, women are increasingly electing for trial of labor after cesarean delivery (TOLAC). Much of the benefit of a vaginal birth after cesarean delivery (VBAC) is related to avoidance of major intraabdominal surgery, which carries the risks of hemorrhage, blood transfusion, infection, and venous thrombosis, among others. In addition, a successful VBAC has implications for future pregnancies because it reduces maternal morbidity associated with multiple cesarean sections, including abnormal placentation, bowel injury, cystotomy, and hysterectomy.

Counseling regarding mode of delivery for a patient with a previous cesarean delivery involves discussion surrounding previous indication for surgery, specifically whether recurrent need for cesarean delivery is likely. Providers should also take into consideration the type of hysterotomy performed, as well as the likelihood of success based on maternal characteristics, including previous vaginal birth, age, body mass index, race and ethnicity, and short-interval delivery. Predicting the likelihood of successful vaginal delivery can be estimated with the Maternal-Fetal Medicine Units online calculator, which is based on a nomogram and takes into account all the aforementioned factors. In addition, the risk of uterine rupture in labor must be discussed. All patients undergoing a TOLAC should be counseled on the risk of uterine rupture and uterine dehiscence; these complications account for most neonatal and maternal morbidity due to TOLAC. Our patient had a previous low transverse cesarean delivery, which portends a 0.5% to 0.9% risk of uterine rupture. It must also be reviewed with the patient that a failed TOLAC is associated with more complications than an elective repeated cesarean delivery. Not all women are ideal candidates for TOLAC, and
all patients should undergo assessment for the likelihood of VBAC. Our patient had a predicted success rate for VBAC of 60% to 70% using this calculator.

As described previously herein, in the setting of non-early decelerations in patients undergoing TOLAC, there should always be high suspicion for uterine rupture. Intraoperatively, our patient was found to have a uterine window (uterine dehiscence), which could have contributed to the FHR abnormalities discussed herein. Uterine scar dehiscence can ultimately progress to uterine rupture, but it is difficult to predict before delivery due to imaging limitations. In women undergoing TOLAC, nonreassuring fetal heart status may prompt a repeated cesarean delivery, as it is a predictor of uterine rupture or dehiscence. (5)(6) Although FHR patterns associated with uterine rupture have been characterized, there is limited information on how uterine dehiscence affects the FHR during labor. Some studies indicate that in the time preceding uterine rupture it is more common to note recurrent late decelerations and terminal bradycardia. (7)(8) Other studies have cited variable decelerations, uterine tachysystole, and reduced baseline variability as potential warning signs of uterine rupture. (8)(9)(10)(11)

Although the maternal and neonatal consequences of uterine rupture have been described in the literature, the implications of uterine dehiscence remain unclear. In a retrospective study, women with a history of pregnancy complicated by uterine scar dehiscence were at increased risk for iatrogenic preterm delivery, low birthweight, and peripartum hysterectomy. Interestingly, in this particular study the rates of uterine rupture were similar in women with and without a history of uterine dehiscence. (12) All of the above was taken into account when counseling our patient on her future pregnancies.

American Board of Pediatrics
Neonatal-Perinatal Content
Specifications

- Know the complications and effects of chorioamnionitis in the mother and the fetus.
- Know the indications for and perinatal complications of operative vaginal delivery (forceps, vacuum extraction, etc) and of vaginal delivery after cesarean delivery.

References

Attempt at Trial of Labor After Cesarean Delivery in Late-Term Gestation with Oligohydramnios
Ashley Aluko and Melissa Spiel
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DOI: 10.1542/neo.19-6-e361
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