The 2008 National Institute of Child Health and Human Development Workshop Report on Electronic Fetal Monitoring

Update on Definitions, Interpretation, and Research Guidelines

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In April 2008, the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development, the American College of Obstetricians and Gynecologists, and the Society for Maternal-Fetal Medicine partnered to sponsor a 2-day workshop to revisit nomenclature, interpretation, and research recommendations for intrapartum electronic fetal heart rate monitoring. Participants included obstetric experts and representatives from relevant stakeholder groups and organizations. This article provides a summary of the discussions at the workshop. This includes a discussion of terminology and nomenclature for the description of fetal heart tracings and uterine contractions for use in clinical practice and research. A three-tier system for fetal heart rate tracing interpretation is also described. Lastly, prioritized topics for future research are provided.
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See related editorial on page 506.

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For a list of workshop participants, see the Appendix online at www.greenjournal.org/cgi/content/full/112/3/661/DC1.

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The *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) convened a series of workshops in the mid- 1990s to develop standardized and unambiguous definitions for fetal heart rate (FHR) tracings, culminating in a publication of recommendations for defining fetal heart rate characteristics.[1] The goal of these definitions was to allow the predictive value of monitoring to be assessed more meaningfully and to allow evidence-based clinical management of intrapartum fetal compromise.

The definitions agreed upon in that workshop were endorsed for clinical use in the most recent American College of Obstetricians and Gynecologists (ACOG) Practice Bulletin in 2005 and also endorsed by the Association of Women's Health, Obstetric and Neonatal Nurses.[2] Subsequently, the Royal College of Obstetricians and Gynaecologists (RCOG, 2001) and the Society of Obstetricians and Gynaecologists of Canada (SOGC, 2007) convened expert groups to assess the evidence-based use of electronic fetal monitoring (EFM). These groups produced consensus documents with more specific recommendations for FHR pattern classification and intrapartum management actions.[3,4] In addition, new interpretations and definitions have been proposed, including terminology such as "tachysystole" and "hyperstimulation" and new interpretative systems using three and five tiers.[3–5] The SOGC Consensus Guidelines for Fetal Health Surveillance presents a three-tier system (normal, atypical, abnormal), as does RCOG.[3,4] Parer and Ikeda[5] recently suggested a five-tier management grading system. Recently, the NICHD, ACOG, and the Society for Maternal-Fetal

Medicine jointly sponsored a workshop focused on EFM. The goals of this workshop were 1) to review and update the definitions for FHR pattern categorization from the prior workshop; 2) to assess existing classification systems for interpreting specific FHR patterns and to make recommendations about a system for use in the United States; and 3) to make recommendations for research priorities for EFM. Thus, while goals 1 and 3 are similar to the prior workshop, a new emphasis on interpretative systems (goal 2) was part of the recent workshop.

As was true in the prior publication,[1] before presenting actual definitions and interpretation, it is necessary to state a number of assumptions and factors common to FHR interpretation in the United States. These were defined in the initial publication[1] and were affirmed and/or updated by the panel:

A. The definitions are primarily developed for visual interpretation of FHR patterns. However, it is recognized that computerized interpretation is being developed and the definitions must also be adaptable to such applications.
B. The definitions apply to the interpretations of patterns produced from either a direct fetal electrode detecting the fetal electrocardiogram or an external Doppler device detecting the fetal heart rate events with use of the autocorrelation technique.
C. The record of both the FHR and uterine activity should be of adequate quality for visual interpretation.
D. The prime emphasis in this report is on intrapartum patterns. The definitions may also be applicable to antepartum observations.
E. The characteristics to be defined are those commonly used in clinical practice and research communications.
F. The features of FHR patterns are categorized as either baseline, periodic, or episodic. Periodic patterns are those associated with uterine contractions, and episodic patterns are those not associated with uterine contractions.
G. The periodic patterns are distinguished on the basis of waveform, currently accepted as either "abrupt" or "gradual" onset.
H. Accelerations and decelerations are generally determined in reference to the adjacent baseline FHR.
I. No distinction is made between short-term variability (or beat-to-beat variability or R–R wave period differences in the electrocardiogram) and long-term variability, because in actual practice they are visually determined as a unit. Hence, the definition of variability is based visually on the amplitude of the complexes, with exclusion of the sinusoidal pattern.
J. There is good evidence that a number of characteristics of FHR patterns are dependent upon fetal gestational age and physiologic status as well as maternal physiologic status. Thus, FHR tracings should be evaluated in the context of many clinical conditions including gestational age, prior results of fetal assessment, medications, maternal medical conditions, and fetal conditions (eg, growth restriction, known congenital anomalies, fetal anemia, arrhythmia, etc).
K. The individual components of defined FHR patterns do not occur independently and generally evolve over time.
L. A full description of an EFM tracing requires a qualitative and quantitative description of:
   1. Uterine contractions.
   2. Baseline fetal heart rate.
   3. Baseline FHR variability.
   4. Presence of accelerations.
   5. Periodic or episodic decelerations.
   6. Changes or trends of FHR patterns over time.

Uterine contractions are quantified as the number of contractions present in a 10-minute window, averaged over 30 minutes. Contraction frequency alone is a partial assessment of uterine activity. Other factors such as duration, intensity, and relaxation time between contractions are equally important in clinical practice.

The following represents terminology to describe uterine activity:

A. *Normal*: ≤5 contractions in 10 minutes, averaged over a 30-minute window.
B. *Tachysystole*: >5 contractions in 10 minutes, averaged over a 30-minute window.
C. *Characteristics of uterine contractions:*
   - Tachysystole should always be qualified as to the presence or absence of associated FHR decelerations.
   - The term tachysystole applies to both spontaneous or stimulated labor. The clinical response to tachysystole may differ depending on whether contractions are spontaneous or stimulated.
   - The terms hyperstimulation and hypercontractility are not defined and should be abandoned.

Fetal heart rate patterns are defined by the characteristics of baseline, variability, accelerations, and decelerations.

The *baseline* FHR is determined by approximating the mean FHR

rounded to increments of 5 beats per minute (bpm) during a 10-minute window, excluding accelerations and decelerations and periods of marked FHR variability (>25 bpm). There must be at least 2 minutes of identifiable baseline segments (not necessarily contiguous) in any 10-minute window, or the baseline for that period is indeterminate. In such cases, it may be necessary to refer to the previous 10-minute window for determination of the baseline. Abnormal baseline is termed *bradycardia* when the baseline FHR is <110 bpm; it is termed *tachycardia* when the baseline FHR is >160 bpm.

Baseline FHR variability is determined in a 10-minute window, excluding accelerations and decelerations. Baseline FHR variability is defined as fluctuations in the baseline FHR that are irregular in amplitude and frequency. The fluctuations are visually quantitated as the amplitude of the peak-to-trough in bpm.

Variability is classified as follows: *Absent* FHR variability: amplitude range undetectable. *Minimal* FHR variability: amplitude range>undetectable and ≤5 bpm. *Moderate* FHR variability: amplitude range 6 bpm to 25 bpm. *Marked* FHR variability: amplitude range >25 bpm.

An acceleration is a visually apparent *abrupt* increase in FHR. An *abrupt* increase is defined as an increase from the onset of acceleration to the peak in <30 seconds. To be called an acceleration, the peak must be ≥15 bpm, and the acceleration must last ≥15 seconds from the onset to return. A *prolonged* acceleration is ≥2 minutes but <10 minutes in duration. Finally, an acceleration lasting ≥10 minutes is defined as a *baseline change*. Before 32 weeks of gestation, accelerations are defined as having a peak ≥10 bpm and a duration of ≥10 seconds.

Decelerations are classified as late, early, or variable based on specific characteristics (see the Box, "Characteristics of Decelerations"). Variable decelerations may be accompanied by other characteristics, the clinical significance of which requires further research investigation. Some examples include a slow return of the FHR after the end of the contraction, biphasic decelerations, tachycardia after variable deceleration(s), accelerations preceding and/or following, sometimes called "shoulders" or "overshoots," and fluctuations in the FHR in the trough of the deceleration.

A *prolonged* deceleration is present when there is a visually apparent decrease in FHR from the baseline that is ≥15 bpm, lasting ≥2 minutes, but <10 minutes. A deceleration that lasts ≥10 minutes is a *baseline change*.

A *sinusoidal fetal heart rate pattern* is a specific fetal heart rate pattern that is defined as having a visually apparent, smooth, sine wave–like undulating pattern in FHR baseline with a cycle frequency of 3–5/min that persists for ≥20 minutes.

Quantitation of Decelerations

The magnitude of a deceleration is quantitated by the depth of the nadir in beats per minute (excluding transient spikes or electronic artifact). The duration is quantitated in minutes and seconds from the beginning to the end of the deceleration. Accelerations are quantitated similarly.

Some authors have suggested grading of decelerations based on the depth of the deceleration or absolute nadir in beats per minute and duration.[4–7] These grading systems require further investigation as to their predictive value.

Decelerations are defined as *recurrent* if they occur with ≥50% of uterine contractions in any 20-minute window. Decelerations occurring with <50% of uterine contractions in any 20-minute segment are defined as *intermittent*.

General Considerations for the Interpretation of Fetal Heart Rate Patterns

A variety of systems for EFM interpretation have been developed and propagated in the United States and worldwide.[3–5] Any interpretation system must be based, to the greatest extent possible, on existing evidence (recognizing that in some areas evidence is lacking). In addition, any system should be simple and applicable to clinical practice.

Given that the fetal heart rate response is a dynamic process, and one that evolves over time, the categories of FHR patterns are dynamic and transient, requiring frequent reassessment. It is common for FHR tracings to move from one category to another over time.

The FHR tracing should be interpreted in the context of the overall clinical circumstances, and categorization of a FHR tracing is limited to the time period being assessed. The presence of FHR accelerations (either spontaneous or stimulated) reliably predicts the absence of fetal metabolic acidemia. The absence of accelerations does not, however, reliably predict fetal acidemia. Fetal heart rate accelerations can be stimulated with a variety of methods (vibroacoustic, transabdominal halogen light, and direct fetal scalp stimulation).

Moderate FHR variability reliably predicts the absence of fetal metabolic acidemia at the time it is observed. Minimal or absent FHR variability alone does not reliably predict the presence of fetal hypoxemia or metabolic acidemia. The significance of marked FHR (previously described as saltatory) variability is unclear.

Characteristics of Decelerations

Late Deceleration

- Visually apparent usually symmetrical *gradual* decrease and return of the fetal heart rate (FHR) associated with a uterine contraction.
- A *gradual* FHR decrease is defined as from the onset to the FHR nadir of ≥30 seconds.
- The decrease in FHR is calculated from the onset to the nadir of the deceleration.
- The deceleration is delayed in timing, with the nadir of the deceleration occurring after the peak of the contraction.
- In most cases, the onset, nadir, and recovery of the deceleration occur after the beginning, peak, and ending of the contraction, respectively.

Early Deceleration

- Visually apparent, usually symmetrical, *gradual* decrease and return of the FHR associated with a uterine contraction.
- A *gradual* FHR decrease is defined as one from the onset to the FHR nadir of ≥30 seconds.
- The decrease in FHR is calculated from the onset to the nadir of the deceleration.
- The nadir of the deceleration occurs at the same time as the peak of the contraction.
- In most cases the onset, nadir, and recovery of the deceleration are coincident with the beginning, peak, and ending of the contraction, respectively.

Variable Deceleration

- Visually apparent *abrupt* decrease in FHR.
- An *abrupt* FHR decrease is defined as from the onset of the deceleration to the beginning of the FHR nadir of <30 seconds. The decrease in FHR is calculated from the onset to the nadir of the deceleration.
- The decrease in FHR is ≥15 beats per minute, lasting ≥15 seconds, and <2 minutes in duration.
- When variable decelerations are associated with uterine contractions, their onset, depth, and duration commonly vary with successive uterine contractions.

Interpretation of Fetal Heart Rate Patterns

Based on careful review of the available options, a three-tier system for the categorization of FHR patterns is recommended (see the Box, "Three-Tier Fetal Heart Rate Interpretation System"). Although the development of management algorithms is a function of professional specialty entities, some general management principles were agreed upon for these categories. Fetal heart rate tracing patterns provide information on the current acid–base status of the fetus and cannot predict the development of cerebral palsy. Categorization of the FHR tracing evaluates the fetus at that point in time; tracing patterns can and will change. A FHR tracing may move back and forth between categories depending on the clinical situation and management strategies employed.

Category I FHR tracings are *normal*. Category I FHR tracings are strongly predictive of *normal* fetal acid–base status at the time of observation. Category I FHR tracings may be followed in a routine manner, and no specific action is required.

Category II FHR tracings are *indeterminate*. Category II FHR tracings are not predictive of *abnormal* fetal acid–base status, yet we do not have adequate evidence at present to classify these as Category I or Category III. Category II FHR tracings require evaluation and continued surveillance and reevaluation, taking into account the entire associated clinical circumstances.

Category III FHR tracings are *abnormal*. Category III tracings are predictive of *abnormal* fetal acid–base status at the time of observation. Category III FHR tracings require prompt evaluation. Depending on the clinical situation, efforts to expeditiously resolve the *abnormal* FHR pattern may include, but are not limited to, provision of maternal oxygen, change in maternal position, discontinuation of labor stimulation, and treatment of maternal hypotension.

Research Recommendations

Since the last workshop, there has not been a wealth of research on EFM. With the high penetrance of

Three-Tier Fetal Heart Rate Interpretation System

Category I

Category I fetal heart rate (FHR) tracings include all of the following:

- Baseline rate: 110–160 beats per minute (bpm)
- Baseline FHR variability: moderate
- Late or variable decelerations: absent
- Early decelerations: present or absent
- Accelerations: present or absent

Category II

Category II FHR tracings include all FHR tracings not categorized as Category I or Category III. Category II tracings may represent an appreciable fraction of those encountered in clinical care. Examples of Category II FHR tracings include any of the following:

Baseline rate

- Bradycardia not accompanied by absent baseline variability
- Tachycardia

Baseline FHR variability

- Minimal baseline variability
- Absent baseline variability not accompanied by recurrent decelerations
- Marked baseline variability

Accelerations

- Absence of induced accelerations after fetal stimulation

Periodic or episodic decelerations

- Recurrent variable decelerations accompanied by minimal or moderate baseline variability
- Prolonged deceleration ≥2 minutes but <10 minutes
- Recurrent late decelerations with moderate baseline variability
- Variable decelerations with other characteristics, such as slow return to baseline, "overshoots," or "shoulders"

Category III

Category III FHR tracings include either:

- Absent baseline FHR variability and any of the following:
  - Recurrent late decelerations
  - Recurrent variable decelerations
  - Bradycardia
- Sinusoidal pattern

this technology into obstetric practice, well-designed studies are needed to fill gaps in knowledge. Areas of highest priority for research include observational studies focused on indeterminate FHR patterns, including descriptive epidemiology, frequency of specific patterns, change over time, the relationship to clinically relevant outcomes, and the effect of duration of patterns (eg, recurrent late decelerations with minimal variability) on clinical outcomes. Other needed studies include work that evaluates contraction frequency, strength, and duration on FHR and clinical outcomes. Research also needs to be focused on the effectiveness of educational programs on EFM that include all relevant stakeholders. Although computerized interpretation systems have not developed as rapidly as anticipated, studies are needed on the effectiveness of computerized compared with provider interpretation, including the analy-

sis of existing data sets. Other areas for work include the development of new comprehensive data sets integrating outcomes with EFM in digitally addressable format and research on effectiveness of techniques supplementary to EFM, such as ST segment analysis.

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