JOGNN PRINCIPLES & PRACTICE

Electronic Fetal Heart Rate Monitoring: Research Guidelines for Interpretation

The National Institute of Child Health and Human Development Research Planning Workshop

The purpose of the National Institutes of Health (NIH) research planning workshops are to assess the research status of clinically important areas. This article reports on a workshop, whose meetings were held between May 1995 and November 1996, in Bethesda, MD, and Chicago, IL. Its specific purpose was to develop standardized and unambiguous definitions for fetal heart rate (FHR) tracings. Their recommendations for interpreting FHR patterns are being published here, in *JOGNN*, and simultaneously by the *American Journal of Obstetrics and Gynecology*. *JOGNN, 26,* 635–640; 1997.

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Summary Report

I. Background of Fetal Heart Rate Monitoring

The original rationale for the introduction of fetal heart rate (FHR) monitoring was that it could serve as a screening test for asphyxia that is severe enough to cause neurologic damage or fetal death. That is, it could allow the recognition of asphyxia at a sufficiently early stage so that timely obstetric intervention would avoid asphyxia-induced brain damage or death.

The initial definitions of FHR patterns originated in research papers from various parts of the world in the 1960s. Since then, several groups have attempted to formalize the subject of FHR monitoring with definitions of the patterns, presumed physiologic etiology of the patterns, and recommendations for management in the face of "abnormal" patterns. In some cases, recommendations were made for future research on FHR monitoring. Examples of such publications include the American College of Obstetricians and Gynecologists (ACOG) Technical Bulletin No. 32 (June 1975); ACOG Technical Bulletin No. 44 (January 1977); The National Institute of Child Health and Human Development Consensus Development Task Force "Predictors of Intrapartum Fetal Distress: The Role of Electronic Fetal Monitoring" (October 1979); the Nurses Association of the American College of Obstetricians and Gynecologists (NAACOG) Technical Bulletin No. 7 (July 1980); the International Federation of Gynaecology & Obstetrics Workshop on Guidelines for the Use of Fetal Heart Rate Monitoring (*International Journal of Gynaecology & Obstetrics*, 1987, 25:159); ACOG Technical Bulletin No. 132 (September 1989). More recently, ACOG Technical Bulletin No. 209 (July 1995) has addressed "Fetal Heart Rate Patterns: Monitoring, Interpretation and Management," and the Society of Obstetricians and Gynaecologists of Canada has issued a policy statement on "Fetal Health Surveillance in Labour" (*Journal of the Society of Obstetricians and Gynecologists of Canada*, 1995, 17, 865).

II. Purpose of the Meeting

Within recent years it has become increasingly obvious to clinicians, epidemiologists, and physiologists that a major impediment to progress in the evaluation and investigation of FHR monitoring is lack of agreement in definitions and nomenclature of FHR patterns, despite the plethora of publications on the subject. By way of illustration, although there are at least 12 controlled trials of the efficacy of FHR monitoring, it is rarely possible to determine from most of the publications exactly what the authors used for definitions and quantification of the various patterns. In addition, the FHR patterns signifying jeopardy of the fetus

and the need for immediate delivery often are stated inexactly, and quantitation is rarely included.

The purpose of an NIH research planning workshop is to assess the research status of a clinically important area and to develop and publish research recommendations. This research workshop was organized to bring together a number of investigators with expertise in the field to propose a standardized and rigorously, unambiguously described set of definitions that can be quantitated. The workshop was to develop recommendations for the investigative interpretation of intrapartum FHR tracings so that the predictive value of monitoring could be assessed more meaningfully in appropriately designed observational studies and clinical trials. Ultimately, this research direction should lead to more evidence-based clinical management of intrapartum fetal compromise.

III. Preliminary Factors

Before presenting the actual definitions, it is necessary to state some assumptions and factors common to FHR interpretation in North America.

A. The definitions are developed primarily for visual interpretation of the FHR patterns. However, it is recognized that computerized interpretation is being developed, and the definitions also must be adaptable to such applications.

B. The definitions apply to the interpretation of patterns produced from either a direct fetal electrode detecting the fetal electrocardiogram or an external Doppler device detecting the fetal heart events using the autocorrelation technique. The most commonly used scaling is a paper speed (horizontal axis) of 3 $cm \cdot minute^{-1}$, and 30 bpm per cm of paper for the FHR (vertical axis). Other scaling is used on some machines (e.g., 20 bpm per cm for FHR). Although the appearance of FHR patterns differs according to the scale used, the definitions still apply. The record of FHR and uterine activity (if the latter is obtained) should be of adequate quality for visual interpretation.

C. The prime emphasis in this report is on intrapartum patterns. However, the definitions also are applicable to antepartum observations.

D. The characteristics to be defined are those commonly used in clinical practice and research communications, and no a priori assumptions were made of the putative etiology of the patterns or their relationship to hypoxemia or metabolic acidemia.

E. The patterns to be defined 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. To determine uterine activity, a tocodynamometer tracing of good quality is required.

F. The periodic patterns are distinguished based on wave form, currently accepted as "abrupt" versus "gradual" onset of the deceleration.

G. No distinction is made between short-term variability (or beat-to-beat variability or R-R wave period differences in the electrocardiogram [ECG]) and long-term variability, because in actual practice they are visually determined as a unit. Therefore, the definition of variability is based visually on the amplitude of the complexes, with exclusion of the regular, smooth sinusoidal pattern.

There is no consensus whether beat-to-beat variability alone is interpretable to the unaided eye, but quantitation is possible with a number of computer techniques. In addition, the amplitude range and frequency of the long-term complexes can be quantified by computer programs.

H. The biologic and clinical significance of the patterns is commonly considered to be related to the quantitative variation from the "normal" range. When quantification is not part of the actual definitions of the patterns, guidelines follow the definitions section.

I. There is good evidence that many characteristics of FHR patterns are gestational age dependent, so gestational age must be considered in the full description of the pattern. In addition, any FHR tracing must be evaluated in the context of maternal medical condition, prior results of fetal assessment, medications, and other factors.

J. The individual components of the FHR patterns that are defined do not occur alone and generally evolve over time. Therefore, a full description of a FHR tracing requires a qualitative and quantitative description of

1. baseline rate;
2. baseline FHR variability;
3. presence of accelerations;
4. periodic or episodic decelerations; and
5. changes or trends of FHR patterns over time.

IV. Definitions of FHR Patterns

A. Baseline FHR is the approximate mean FHR rounded to increments of 5 bpm during a 10-minute segment, excluding

1. periodic or episodic changes;
2. periods of marked FHR variability (see IV.B.4); and
3. segments of the baseline that differ by >25 bpm.

In any 10-minute window, the minimum baseline duration must be at least 2 minutes or the baseline for that period would be indeterminate. In this case, one may need to refer to the previous 10-minute segment(s) to determine the baseline.

If the baseline FHR is <110 bpm, it is termed bradycardia; if the baseline FHR is >160 bpm, it is termed tachycardia.

B. Baseline FHR variability is defined as fluctuations in the baseline FHR of 2 cycles per minute or greater. These fluctuations are irregular in amplitude and frequency and are visually quantitated as the amplitude of the peak-to-trough in bpm as follows:

1. amplitude range undetectable: absent FHR variability;
2. amplitude range > undetectable ≤ 5 bpm: minimal FHR variability;
3. amplitude range 6–25 bpm: moderate FHR variability; and
4. amplitude range >25 bpm: marked FHR variability.

These grades of fluctuations are illustrated in Figure 1, together with a sinusoidal pattern. The sinusoidal pattern differs from variability in that it has a smooth, sine wave-like pattern of regular frequency and amplitude and is excluded in the definition of FHR variability.

C. Acceleration is defined as a visually apparent *abrupt* increase (defined as onset of acceleration to peak in <30 seconds) in FHR above the baseline. The increase is calculated from the most recently determined portion of the baseline. The acme is ≥15 bpm above the baseline, and the acceleration lasts ≥15 seconds and <2 minutes from the onset to return to baseline. Before 32 weeks of gestation, accelerations are defined as having an acme ≥10 bpm above the baseline and a duration of ≥10 seconds.

Prolonged acceleration is ≥2 minutes and <10 minutes in duration.

Acceleration of ≥10 minutes is a baseline change (see IV.A).

D. Late deceleration of the FHR is a visually apparent *gradual* (defined as onset of deceleration to nadir ≥30 seconds) decrease and return to baseline FHR associated with a uterine contraction. The decrease is calculated from the most recently determined portion of the baseline. 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.

E. Early deceleration of the FHR is a visually apparent *gradual* decrease (defined as onset of deceleration to nadir ≥30 seconds) and return to baseline FHR associated with a uterine contraction. The decrease is calculated from the most recently determined portion of the baseline. It is coincident in timing, with the nadir of the deceleration occurring simultaneously to 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.

F. Variable deceleration of the FHR is defined as a visually apparent *abrupt* decrease (defined as onset of deceleration to the beginning of nadir <30 seconds) in FHR below the baseline. The decrease is calculated from the most recently determined portion of the baseline. The decrease in FHR below the baseline is ≥15 bpm, lasting ≥15 seconds, and <2 minutes from onset to return to baseline.

When variable decelerations are associated with uterine contractions, their onset, depth, and duration commonly vary with successive uterine contractions.

G. Prolonged deceleration of the FHR is a visually apparent decrease in FHR below the baseline. The decrease is calculated from the most recently determined portion of the baseline. The decrease from the baseline is ≥15 bpm, lasting ≥2 minutes, but <10 minutes from onset to return to baseline.

Prolonged deceleration of ≥10 minutes is a baseline change (see IV.A).

V. Quantification

A. Any deceleration is quantitated by the depth of the nadir in bpm below the baseline (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.

B. Decelerations are tentatively defined as recurrent if they occur with ≥50% of uterine contractions in any 20-minute segment.

C. Bradycardia and tachycardia are quantitated by the actual FHR in bpm, or the visually determined range if the FHR is not stable at one rate.

VI. Research Recommendations

The primary aim of this workshop was to standardize definitions. The participants recognized that in actual protocols and usage, some of these definitions may be found to be inadequate and that future changes in the definitions may be appropriate.

The research recommendations are concerned with use of these standardized definitions of FHR patterns in three aspects of monitoring that the research workshop group believes to be inadequately studied.

- Reliability of the technique of FHR pattern interpretation (i.e., is there adequate intra- and interobserver agreement in interpretation?).
- Validity of the technique (i.e., are some patterns closely associated with adverse neurologic outcome?).
- Causal relationship between FHR patterns and outcome (i.e., can obstetric intervention avoid an adverse neurologic outcome?).

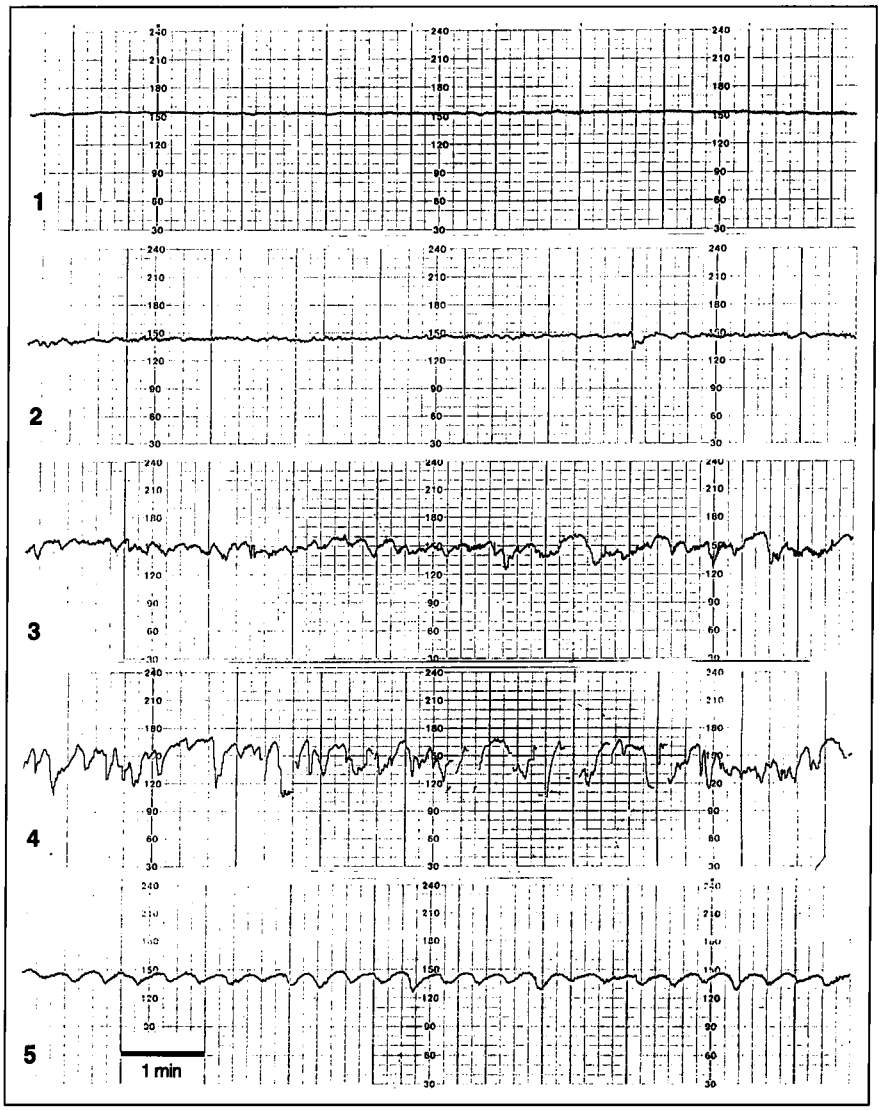

FIGURE 1
Varying degrees of FHR variability. 1, undetectable; 2, minimal; 3, moderate; 4, marked; and 5, the sinusoidal pattern. Original scaling, 30 bpm per cm vertical axis, and paper speed 3 cm·min^{-1} horizontal axis.

*A. **Reliability of FHR monitoring.*** We recommend a study of intra- and interobserver agreement as measured by kappa in FHR interpretation, using the above classification system. We recommend assessment before and after instruction in this classification system to determine whether there is improved reliability resulting from training. Results after instruction also could be compared with currently published reliability data on intra- and interobserver agreement.

*B. **Validity of FHR monitoring.*** Our recommendations include

1. A large, descriptive prospective or retrospective epidemiologic study of the frequency of the different FHR patterns using the above definitions. These patterns would be correlated with characteristics of the mother and infant (e.g., maternal age, gravidity, parity, ethnicity, maternal complications, gestational age, medications/drugs, etc).

2a. A specific study be conducted of a group of fetuses who are as healthy as can be determined from currently available tests at the beginning of labor, based on the following:
   i. term;
   ii. high- or low-risk mothers and fetuses (risk status to be defined);
   iii. normal FHR pattern on admission (normal FHR, normal FHR variability, accelerations present, periodic changes absent); and
   iv. if available, normal acoustic stimulation test results and normal biophysical profile and any other indices of fetal neurologic status.

2b. A definition and quantitation of changes in the FHR patterns over the duration of labor, as follows:
   i. development of decelerations or bradycardia;
   ii. definition of type of deceleration;

iii. quantitation of depth and duration of decelerations or bradycardia;
iv. quantitation of changes in accelerations;
v. quantitation of changes in FHR variability; and
vi. combinations of the above features.

3. As a measure of the validity of FHR patterns and their relationship to immediate and long-term outcome and several other obstetric features, the following studies are recommended:
   a. the correlation of FHR patterns as described above with immediate outcome measures of asphyxia:
      i. blood gases and acid-base state (in particular metabolic acidosis);
      ii. Apgar scores;
      iii. neurologic examination, presence of seizures, tone abnormalities, nursery course, etc.;
      iv. other organ abnormalities (e.g., heart, circulation, respiration, kidneys, coagulation system, liver, etc.); and
      v. death.
   b. correlation of FHR patterns as described above with long-term outcome measures in terms of neurodevelopment. Such studies would be required up to at least 2 years of age.
      i. cerebral palsy;
      ii. intelligence quotient; and
      iii. other organ dysfunction.
   c. correlation of FHR patterns as described above with potential risks.
      i. cesarean delivery rate;
      ii. operative vaginal delivery rate; and
      iii. trauma (e.g., from intervention).
   d. the role of ancillary techniques in improving the sensitivity and specificity of FHR interpretation alone.
      i. fetal blood sampling;
      ii. stimulation testing;
      iii. pulse oximetry;
      iv. ST segment analysis; and
      v. other possible modalities (e.g., cardiac function indices [ejection fraction], fetal blood flow and metabolism, magnetic resonance spectroscopy, positron emission tomography scan.

C. Determination of whether FHR monitoring can prevent neurologic damage. If the reliability and validity of FHR monitoring can be established, the final aspect of effectiveness of FHR monitoring must be established, that is, whether FHR monitoring can be used in a system of management to prevent intrapartum asphyxial brain damage.

It is our belief that it would be premature to recommend another randomized controlled trial at this stage because there is not yet a commonly agreed upon protocol for intervention. Such protocols are unlikely to become clear until after the above studies of reliability and validity are completed.

D. Recommendations in computer applications.

1. Development of a computerized system for FHR pattern analysis, which is expected to aid standardization of interpretation.
2. Examination of different modes of raw FHR data presentation (e.g., three-dimensional, four-dimensional plots) that may enable easier visual assessment of fetal condition.
3. Development of computer-assisted instruction systems based on consensual FHR information for presentation to trainees and for continuing education of practitioners.

VII. Clinical Statement

There was no consensus in the research workshop regarding strict guidelines for clinical management using FHR patterns, considering that evidence-based algorithms for management will need to await the results of research as outlined above.

However, there was relatively little variation in opinion within the group about the definition of the normal FHR tracing (i.e., normal baseline rate, normal [moderate] FHR variability, presence of accelerations, and absence of decelerations). Similarly, there was agreement that there is reasonably good evidence that such a tracing confers an extremely high predictability of a normally oxygenated fetus when it is obtained.

At the other end of the spectrum from normality, there are several patterns that most members believe are predictive of current or impending fetal asphyxia so severe that the fetus is at risk of neurologic and other fetal damage, or death. These patterns include recurrent late or variable decelerations or substantial bradycardia, with absent FHR variability.

Many fetuses have FHR tracings that are intermediate between these two extremes, and their presumed condition and clinical management are controversial. It is in this group that the members of the workshop believe that most progress can be made by the above research recommendations, potentially minimizing risky intervention and reducing significant metabolic acidemia. The members agreed that in the current state of our knowledge, giving strict recommendations for management of this group is premature.

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