OBSTETRICS

A framework for standardized management of intrapartum fetal heart rate patterns

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OBJECTIVE: The purpose of this study was to classify fetal heart rate (FHR) monitor patterns according to risk of fetal acidemia and risk of evolution to a more serious pattern and to use this information to construct a standardized process for FHR pattern management, with the ultimate aim of minimizing newborn infant acidemia without excessive obstetric intervention.

STUDY DESIGN: We have identified 134 FHR patterns that have been classified by baseline rate, baseline variability, and type of deceleration. Based on the best available evidence, we have assigned a risk of newborn infant acidemia or low 5-minute Apgar score to these patterns. We have also evaluated each pattern for the risk that the pattern would evolve further into a pattern with a higher risk of acidemia.

RESULTS: Each FHR pattern has been color-coded, from no threat of fetal acidemia (green, no intervention required) to severe threat of acidemia (red, rapid delivery recommended). Three intermediate categories (blue, yellow, and orange) require escalated informing of appropriate individuals for intervention and resuscitation (obstetrician, anesthesiologist, and neonatal resuscitator) and preparation for urgent delivery (eg, staff and surgical suite availability and conservative techniques to ameliorate the FHR patterns).

CONCLUSION: This framework is applicable potentially to the institutions where it was developed and will need to be modified for other situations, depending on the logistics, facilities, and personnel available. This may provide a framework for developing algorithms for the standardized management of FHR patterns during labor, which can be tested for validity.

Key words: fetal acidemia, fetal heart rate management, intrapartum

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Despite numerous attempts in the past 30 years, the obstetric community has been unable to reach a broad consensus on a standardized approach to the management of most fetal heart rate (FHR) monitoring patterns. Such disagreement can be seen in the National Institute for Child Health and Human Development (NICHD) publication regarding FHR nomenclature, which contained a small clinical statement.[1] There was consensus that the normal pattern (defined as normal baseline rate, normal [moderate] FHR variability [FHRV], presence of accelerations, and absence of decelerations) confers an extremely high predictability of a normally oxygenated fetus when it is obtained. Thus, no intervention is required for this pattern. At the other end of the spectrum from normality, there was consensus that the pattern of recurrent late or variable decelerations or substantial bradycardia, with absent FHRV, is predictive of current or impending fetal asphyxia so severe that the fetus is at risk of neurologic or other fetal damage or death. The implication is that the fetus should be delivered as soon as possible, unless acidemia can be ruled out rapidly.

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Despite the consensus regarding these 2 patterns, the members of the NICHD committee were unable to make overall recommendations for the FHR tracings between these 2 extremes, which represent at least 50% of all intrapartum fetuses, because of the uncertainty in our current state of knowledge about the presumed condition of the fetus in such cases.

The Royal College of Obstetricians and Gynecologists (RCOG) Clinical Effectiveness Support Unit[2] issued a substantial document in 2001 on the use of electronic fetal monitoring, which apparently expanded the guidelines that were proposed by the International Federation of Gynecology and Obstetrics (FIGO) in the 1980s[3] and comprehensively examined the world's literature on the subject. In that document, they classified patterns as normal, suspicious, or pathologic, depending on the incidence of 4 "nonreassuring" or "abnormal" characteristics of the FHR pattern, which they have defined. The guidelines recommended conservative or ameliorating techniques for the suspicious (1 FHR abnormality) categories. For the pathologic categories (≥2 FHR abnormalities) conservative means plus fetal blood sampling are recommended; if fetal blood sampling is not possible, then delivery should be expedited.

The American College of Obstetricians and Gynecologists (ACOG) re-

cently reissued a Practice Bulletin on Intrapartum Fetal Heart Rate Monitoring.[4] Although the preamble purports to describe the management of nonreassuring FHR patterns, the body of the text is concerned mainly with tracing assessment, ancillary testing to rule out acidemia or hypoxia, and "intrauterine resuscitation." The latter techniques are used to ameliorate FHR patterns that are presumed to represent fetal jeopardy.

Although these and other guidelines may be of some use, we have found them to be of limited use in our own labor and delivery room setting. For example, the 4 "abnormalities" of FHR in the RCOG[2] document are neither universally accepted nor equally weighted for degree of risk of fetal jeopardy. Again, fetal blood sampling, which is an important aspect of the RCOG guidelines, is used rarely in the United States today. Fetal stimulation testing is not part of the guidelines. Many of the previously recommended approaches have omitted reference to the likelihood of patterns that evolve to more severe types and have lacked recommendations regarding the speed of clinical reactions to certain more serious patterns to minimize fetal acidemia.

Despite these official positions, we believe that, because of the ubiquity of FHR monitoring, there is an urgent need to standardize management more specifically at this time, with the use of the best available evidence.

In an attempt to develop practical guidelines for the intermediate patterns mentioned in the NICHD document,[1] a multidisciplinary committee at the University of California, San Francisco, produced a 90-page document for the management of all conceivable FHR patterns for internal use. Our intramural committee attempted to determine the severity of FHR patterns that were based on the risk of fetal acidemia by reference to evidence in the literature.[5] This formed the basis for the management recommendations. However after a period of having it available to staff on the labor and delivery unit, we found that is it was infrequently used because of its complexity.

From this vantage point, we now have developed a set of algorithms and recommendations that are much simpler in presentation and therefore may be of more usefulness in practice. As before, the algorithms and recommendations are based on the best available evidence regarding the risk of acidemia of the various patterns, and we have incorporated probability of evolution to more serious patterns as an indicator of urgency of preparation for delivery.

We must stress that this approach was developed in institutions with specific logistics, facilities, and staffing and is highly unlikely to be applicable to other institutions without modification. In addition, although it has been used in our units to demonstrate feasibility, it has not been subjected to appropriate prospective testing, which must be done to determine its validity.

Material and Methods

We constructed a grid of all possible heart rate patterns based on baseline rate (normal, tachycardia, and bradycardia), type of decelerations (early, late, variable, and prolonged), and quantity of variability (undetectable, minimal, moderate, and marked). All definitions were according to the NICHD statement on the nomenclature of FHR patterns.[1] In defining the degree of severity of decelerations, we used the classifications of Kubli et al,[6] in some cases with slight modifications.

Variable decelerations were defined by the National Institutes of Health (NIH) guidelines, and we used the diagram proposed by Chao[7] to quantify them. Severe variable decelerations are ≥60 seconds in duration and <70 beats/min or ≥2 minutes in duration and <80 beats/min. Moderate variable decelerations have a duration of 30 to 60 seconds and are <70 beats/min or ≥60 seconds in duration and <80 beats/min. All other variable decelerations are mild. An unresolved feature of this quantitation is whether the FHR must be below the minimum specified FHR for the whole of the specified time. We have decided arbitrarily that the FHR deceleration must be below this minimum for at least 10 seconds.

Late decelerations, as defined by NIH guidelines, are severe if the decrement of the deceleration is ≥45 beats/min below the baseline, moderate if the decrement is >15 beats/min but <45 beats/min below the baseline, and mild if the decrement is no more than 15 beats/min below the baseline.

Early decelerations were not quantitated because of their rarity and disagreement about the definition in the past.

Prolonged decelerations, as defined by NIH guidelines, require the FHR to be depressed for ’2 minutes. *Severe* was defined as <70 beats/min, moderate as between 70 and 80 beats/min, and mild as not <80 beats/min. These are criteria that are similar to those used for quantitating bradycardias.

We initially evaluated each of the patterns on the basis of the risk of fetal acidemia. These associations were made on the basis of a survey of the literature that related FHR patterns to the likelihood of acidemia.[5] The following conclusions were drawn from these associations: (1) The presence of moderate FHRV, even in the presence of decelerations, is associated strongly (98%) with the absence of pH ≤7.15 or Apgar score of <7 at 5 minutes. (2) Minimal or less FHRV with decelerations has a 23% association with pH <7.15 or Apgar score of <7 at 5 min-

TABLE 1
Five gradations of fetal acidemia

Category	Definition
Green	No acidemia
Blue	No central fetal acidemia (oxygenation)
Yellow	No central fetal acidemia, but FHR pattern suggests intermittent reductions in O_2 which may result in fetal O_2 debt
Orange	Fetus potentially on verge of decompensation
Red	Evidence of actual or impending damaging fetal asphyxia

TABLE 2
Risk of acidemia, evolution of FHR patterns to more serious risk, and recommended action

Variable	Risk of acidemia	Risk of evolution	Action
Green	0	Very low	None
Blue	0	Low	Conservative techniques* & begin preparation
Yellow	0	Moderate	Conservative techniques* & increased surveillance
Orange	Borderline/acceptably low	High	Conservative techniques* & prepare for urgent delivery
Red	Unacceptably high	Not a consideration	Deliver

* See Table 3.

utes. (3) The likelihood of acidemia increases with the depth of decelerations, especially with late decelerations, and particularly in patterns with reduced FHRV and more so with absent variability. The risk categories depend on decelerations being recurrent (that is, occurring with ≥50% of contractions in any 20-minute segment).[1]

We then evaluated the risk that the patterns would evolve into a more serious pattern with a higher risk of acidemia. This was based on a conclusion from the previously mentioned report,[5] that, in a fetus with a pattern evolving from normal to decelerative with reduced FHRV, potentially hazardous acidemia develops relatively slowly, over a period of ≥1 hour. It was also based on preliminary work that showed the evolution of patterns in a consecutive series of >1000 fetuses in the last hour before delivery.[8]

Each pattern was classified into 1 of 5 categories for risk of acidemia and evolution to more serious patterns. Other proposed FHR management systems have used 5 categories of risk of either fetal acidemia or hypoxia.[9,10] We made use of the color coding of the Homeland Security Advisory System[11] for the risk of a terrorist attack by categorizing the risk from green (low risk) to red (severe risk). We have substituted the risk of fetal acidemia in these color-coded groups (Table 1).

In place of the protective measures that were proposed by the Homeland Security Advisory System, we have substituted protective measures to avoid acidemia in the fetus. These include a gradation of increasing surveillance and techniques for the amelioration of variant FHR patterns through the various risk groups, with the ultimate protective measure being emergency delivery.

We have not included fetal blood sampling in the management of patterns, because it is rarely used in the United States now; it has been replaced, in general, by observation of the retention of FHRV and accelerations and the use of fetal stimulation testing.

Results

A comparison of the 5 grades of the threat of fetal acidemia and evolution of the pattern is depicted in Table 2; the proposed general actions for each category are shown. The protective measures range from simple observation without intervention for the lowest risk category to emergency operative delivery for the highest risk category. The 3 intermediate categories include such actions as attempts to ameliorate the patterns with conservative techniques (Table 3).

More detailed proposed management and preparations to ensure the ability to mount a rapid response if needed and the availability of appropriate personnel are shown in Table 4.

A grid of each of the possible 134 patterns is shown in Table 5. Each pattern has been color-coded to correspond to 1 of the 5 risk categories; the categories are stratified by quantity of FHRV. In addition, 2 separate categories that are marked variability and sinusoidal patterns are appended.

The need to rule out acidemia by stimulation testing is restricted to relatively few patterns, virtually only those in which there is reduced (or sometimes absent) FHRV and the hope for a vaginal delivery in the near future. Thus, we would accept fetal stimulation testing (either tactile or vibroacoustic stimulation) as appropriate in certain cases of the fourth category (orange) or for uncertain or puzzling patterns.

Comment

As noted earlier, few publications on the management of FHR patterns specify what interventions should be applied to specific FHR patterns and particularly what interventions are required to deliver a fetus in a timely fashion to avoid continuing intrauterine hypoxia. This framework has been developed to be a first step in guidelines for optimal FHR pattern management.

The proposed framework has several potential advantages over previous systems. For example the FIGO[3] and RCOG[2] approaches advise action for certain patterns that contain FHR characteristics for which there is not universal agreement regarding immediate fetal

TABLE 3
Conservative ameliorating techniques for the modification of variant FHR patterns

Position change
Hyperoxia
Correct hypotension
Adequate intravascular volume
Correct excessive contractions (eg, decrease oxytocin)
Avoid constant pushing
Tocolysis
Amnioinfusion to correct amniotic fluid deficit

TABLE 4
Proposed management of the color-coded categories

Category	Conservative techniques	Operating room	Obstetrician	Anesthetist	Newborn infant resuscitator	Location of patient
Green	No	—	—	—	—	—
Blue	Yes	Available	Informed	—	—	—
Yellow	Yes	Available	At bedside	Informed	Informed	—
Orange	Yes	Immediately available	At bedside	Present	Immediately available	Operating room
Red	Yes	Open	At bedside	Present	Present	Operating room

jeopardy. The current proposal allows more selective approaches to each individual FHR pattern and still gives guidelines to the risk of fetal acidemia and rapidity with which preparations for delivery should be made based on the likelihood of evolution of the pattern to a pattern with a higher risk of acidemia.

The proposals in the system of Keith et al[9] have the benefit of having been subjected to validation is a nonrandomized trial and appear to minimize fetal acidemia, while also minimizing unnecessary obstetric intervention. However, the program requires special equipment that is not yet available to the practitioner.

Further ancillary testing has been proposed recently for patterns in which it is believed that the risk of acidemia is uncertain (eg, fetal pulse oximetry[12] and ST-segment analysis[13]). Pulse oximetry has not achieved acceptance as an ancillary technique to FHR monitoring in the United States because of unclear results of efficacy in trials.[14] ST-segment analysis in association with FHR monitoring has been tested widely in Europe, and trials have shown a reduction in newborn infant acidemia and no adverse effect on obstetric interventions.[13] It has been ap-

TABLE 5
Risk categories for fetal acidemia related to FHRV, baseline rate, and presence of recurrent decelerations

Variable	No	Early	Mild VD	Moderate VD	Severe VD	Mild LD	Moderate LD	Severe LD	Mild PD	Moderate PD	Severe PD
Moderate (normal) variability											
Tachycardia	B	B	B	Y	O	Y	Y	O	Y	Y	O
Normal	G	G	G	B	Y	B	Y	Y	Y	Y	O
Mild bradycardia	Y	Y	Y	Y	O	Y	Y	O	Y	Y	O
Moderate bradycardia	Y	Y			O		O	O			O
Severe bradycardia	O	O			O			O			O
Minimal variability											
Tachycardia	B	Y	Y	O	O	O	O	R	O	O	O
Normal	B	B	Y	O	O	O	O	R	O	O	R
Mild bradycardia	O	O	R	R	R	R	R	R	R	R	R
Moderate bradycardia	O	O			R		R	R			R
Severe bradycardia	R	R			R			R			R
Absent variability											
Tachycardia	R	R	R	R	R	R	R	R	R	R	R
Normal	O	R	R	R	R	R	R	R	R	R	R
Mild bradycardia	R	R	R	R	R	R	R	R	R	R	R
Moderate bradycardia	R	R			R		R	R			R
Severe bradycardia	R	R			R			R			R
Sinusoidal							R				
Marked variability							Y				

B, blue; *G*, green; *LD*, late decelerations; *O*, orange; *PD*, prolonged decelerations; *R*, red; *VD*, variable decelerations; *Y*, yellow.

TABLE 6
Fetal pH in late decelerations with decreased FHRV

Late decelerations	Mean pH	1 SD	2 SD
Mild	7.23	7.18	7.13
Moderate	7.16	7.12	7.07
Severe	7.09	7.04	6.99

Adapted from Paul RH, Suidan AK, Yeh S, Schifrin BS, Hon EH. Clinical fetal monitoring: VII, the evaluation and significance of intrapartum baseline FHR variability. Am J Obstet Gynecol 1975;123:206-10 (with permission).

proved recently by the Food and Drug Administration for marketing in the United States.

We believe this proposed standardization of management is required even while awaiting agreement on the acceptability of these ancillary techniques, because of the relatively long delay in the widespread introduction of these techniques. If the ancillary techniques are finally accepted, they will fit readily into these management approaches.

The ACOG[4] proposal rightly points out the relative paucity of objectively collected data for many aspects of FHR monitoring and interpretation and does not really give specific recommendations for actual management but rather gives the range of options that are currently acceptable. The ACOG guideline is quite general in many ways and of limited use to practitioners who seek specific guidance.

A number of aspects of FHR pattern management have been omitted from this framework, primarily to maintain simplicity. Our assumption is that reduced variability in the absence of decelerations is not due to hypoxia. Periods of reduced variability (eg, because of fetal sleep cycles) may last over an hour. A further point is that, in the setting of reduced variability, the presence of accelerations of the FHR (either provoked or spontaneous) gives assurance of absence of significant fetal acidemia.

A further omission from the proposal is any distinction between FHR patterns in the first and second stages of labor. Decelerations are more common in the second stage, and management in this stage is often modified by the fact that delivery may be achieved by an operative vaginal delivery, instead of a cesarean section.

In the construction of the color-coded grid, certain decisions had to be made with regard to the risk of fetal jeopardy. As noted earlier, there is good evidence that the normal trace confers a high chance of the absence of fetal acidemia and that other patterns (eg, the absence of FHRV and deep decelerations) are associated with an unacceptably high risk of acidemia. However, the many patterns between these 2 extremes have varying risks, for which there are limited data in the literature. Even where we do have data, there is still the need to make a decision regarding what level of risk is acceptable. We have used lower limit thresholds of pH 7.1 and base excess of −12 mEq/L in umbilical arterial blood as acceptable. These are 2.5% or 2 SD below the mean for normal newborn infants[15] and are well above the values in cases in which fetal hypoxic damage is seen.[16]

An example of the decision-making process in the application of risk to various patterns can be seen by reference to the categories of severity of late decelerations with reduced or absent FHRV. Data from the paper by Paul et al[17] have been abstracted from their figure that relates to fetal scalp blood pH to severity of late decelerations and are shown in Table 6. Mean values are given together with estimated SDs below the mean.

Severe late decelerations with reduced FHRV have mean pH below our threshold of 7.1 and warrant expeditious delivery. Moderate late decelerations with reduced FHRV have an acceptable mean pH, but in this category 2.5% of fetuses will have a pH <7.07, which is below our acceptable range. The 7.1 threshold lies between 1 and 2 SDs and represents perhaps 10% of fetuses in this category. Therefore, a decision must be made whether to expedite delivery in all 100% of these cases to prevent unacceptable acidemia in the 10%.

Mild decelerations with reduced FHRV present a more difficult quandary. Fetuses are 97% likely to have a pH >7.13. However, there will be approximately 1% of fetuses below our pH threshold of 7.1. Should we expeditiously deliver all 100% of these babies for the 1% who actually need it?

There is obstetric precedent for acceptable risk. For example, we offer amniocentesis for karyotyping in mothers where the risk of aneuploidy is <1%. The morbidity for well-managed vaginal breech delivery is <1%, yet patients most now have cesarean delivery. The risk of uterine rupture in vaginal birth after cesarean candidates is approximately 0.5%, but vaginal birth after cesarean birth is fast disappearing. With this in mind, we tentatively propose that a threshold risk of pH 7.1 be set to capture all but 1% of babies; we believe most of these in tracings with reduced FHRV with pH <7.1 will be relatively close to this value and >7.0.

It should be clear that the guidelines must be modified for use in institutions other than our own and may need to be modified at different times of the day, as logistics change. It should also be obvious that this is a preliminary approach, which, although it may appear to work in principle, will need to be subjected ultimately to appropriate testing. ■

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