Electronic Fetal Monitoring During Labor

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The use of continuous electronic fetal monitoring (EFM) during the labors of both low- and high-risk obstetric patients has increased dramatically in the past decade. EFM is a screening tool used for the early detection of fetal hypoxia and prevention of its consequences. Fetal heart rate patterns generated should be thought of as either reassuring or not reassuring of fetal oxygenation. Combinations of nonreassuring patterns are very frequently associated with significant fetal hypoxia.

Initially EFM was accepted without serious question of its benefits and risks. Recently more skeptical attitudes about EFM have developed, and studies evaluating the efficacy of EFM have increased. The use of EFM improves fetal outcome in high-risk pregnancies. There is no clear indication that EFM has an advantage over careful auscultation in low-risk pregnancies. The risks of continuous ultrasound and fetal and maternal infection following EFM appear minimal. The cesarean section rate has risen in recent years, but the contribution of EFM to this increase is not known. The psychologic and emotional risks of EFM have not been well defined.

Continuous electronic fetal monitoring (EFM) during labor was first reported by Hon at Yale University in 1958.[1] In the following years much research was done to define the various fetal heart rate (FHR) patterns and their significance. In 1968, the first electronic fetal monitor became available for practical clinical use. Also in 1968, Benson et al[2] published the results of a review by a collaborative project under the auspices of the National Institute of Neurologic Diseases and Blindness. It was concluded that "no reliable single auscultatory indicator of fetal distress exists in terms of fetal heart rate, save in the extreme degree." This challenge to the validity of auscultation during labor helped set the stage for the widespread use of EFM. In many centers, EFM is now used routinely during the labors of both low-risk and high-risk patients.

Most early studies indicate that continuous EFM during the labors of high-risk patients clearly results in improved perinatal outcome.[3] However, there remain only five prospective, controlled studies which examine the risks and benefits of EFM.[4-8]

In recent years, a more skeptical attitude has developed regarding electronic fetal monitoring. Many have argued that the technique was accepted without proof of value or question of risk. The debate about EFM was intensified in 1978 when Banta and Thacker[9] published a literature review of the use of EFM and raised serious questions about the costs and benefits of its use. Also, there have been many changes in obstetric practice and attitudes toward childbirth in the past decade, including increasing interest in minimal intervention obstetrics, family-centered childbirth, and concerns about rising health care costs. Each

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of these has been a challenge to the routine use of EFM.

Proponents of continuous EFM during all labors point out that there has been a significant decrease in perinatal morbidity and mortality during the period in which EFM has grown in popularity.[3] Intrapartum events, which still account for about 30 percent of stillbirths and early neonatal deaths, 20 to 40 percent of cerebral palsy, and 10 percent of severe mental retardation, continue to be an important source of potentially preventable death and damage.[3] All of these factors have led to increasing debate over the proper role of EFM.

Much has been written in recent years about the various fetal heart rate patterns and their use in assessing intrapartum fetal distress. These patterns and their significance will be discussed together with the risks and benefits of EFM during labor.

Fetal Monitor Patterns

General Considerations

The goal of electronic fetal monitoring is to detect fetal hypoxia at its earliest stage and to prevent the consequences of prolonged or severe hypoxia. When analyzing a fetal monitor tracing, it is therefore important to always think of FHR patterns in terms of whether they are reassuring of adequate fetal oxygenation or are not reassuring of adequate oxygenation. FHR patterns that have been shown to be reassuring are accelerations, most early decelerations, mild variable decelerations, good beat-to-beat variability, and no periodic changes.[10] Nonreassuring patterns include severe variable decelerations, late decelerations, loss of variability of fetal heart rate, some prolonged decelerations, tachycardia, and sinusoidal pattern.

It is important to consider FHR patterns in the context of the clinical circumstance. Many nonreassuring patterns can be explained by means other than fetal hypoxia. Nonreassuring patterns are often associated with good perinatal outcome and high Apgar scores, but low Apgar scores are more common in these infants than in infants with reassuring patterns.[11] Combinations of nonreassuring patterns generally herald significant fetal distress.[12,13] A normal FHR pattern is almost completely accurate in predicting high Apgar scores.[11]

Early Deceleration

In most instances early deceleration is caused by pressure on the fetal head, which results in vagal stimulation and a slowing of the heart rate. It is abolished by atropine and is not associated with sustained fetal tachycardia or loss of variability. In such instances, the early deceleration is a reassuring pattern and is not associated with hypoxia, acidosis, or low Apgar scores.[14]

Mendez-Bauer et al[15] have found that early decelerations occurring when head compression is unlikely (ie, before labor or early in labor) often reflect cord compression. Early deceleration in this special circumstance may serve as a warning of impending fetal difficulty.

Variable Deceleration

The variable deceleration is the most frequently encountered fetal monitor pattern. It is a pattern of great significance because it may be either a reassuring or nonreassuring pattern. It is thought to be the pattern most frequently responsible for unnecessary intervention.

Variable decelerations are due to umbilical cord compression. Occlusion of the uterine arteries leads to an increase in fetal blood pressure, with a resultant reflex decrease in the fetal heart rate. Accelerations occurring before variable decelerations are observed in nonstressed infants and are a sign of the response of an intact nervous system to compression of the umbilical vein only.[16]

Because variable decelerations can have different prognostic implications, it is important to further categorize them. They can be classified as mild, moderate, or severe variable decelerations on the basis of their amplitude and duration[17]:

1. *Mild.* Nadir no fewer than 80 beats per minute regardless of duration
2. *Moderate.* Duration 30 to 60 seconds with a nadir of fewer than 70 beats per minute, or duration greater than 60 seconds with a nadir of greater than 70 beats per minute
3. *Severe.* Duration of greater than 60 seconds with a nadir of fewer than 70 beats per minute

It is important to inspect variable decelerations for reassuring and ominous characteristics. Ominous patterns associated with variable decelerations include any severe deceleration, fetal tachycardia, decreasing baseline fetal heart rate, loss of variability of the fetal heart rate, and slow return of the deceleration to the baseline heart rate.[10,11] Reassuring patterns associated with variable decelerations include decelerations lasting no more than 45 seconds on a repetitive basis, abrupt return of the deceleration to the baseline heart rate, steady baseline heart rate, and accelerations before and after the variable deceleration.[10]

Cibils[18] studied variable decelerations during the labors of high-risk patients and found that the duration of the variable deceleration is a more important predictor of fetal distress than is the magnitude of drop of FHR. He also found that when variable decelerations are combined with other nonreassuring patterns (eg, late deceleration), there is a markedly increased incidence of fetal distress. Significant variable decelerations were found to be present much more frequently in patients who experienced premature rupture of membranes. Ingemarrson[12] reports that significant variable decelerations are encountered much more frequently when the infant is in the occiput posterior position. However, she found that fetal outcome was similar for infants in both the occiput posterior position and occiput anterior position, despite the increase in significant variable decelerations in the occiput posterior group.

When moderate or severe variable decelerations are noted, the following measures should be taken:

1. Perform a vaginal examination to check for cord prolapse, position, or imminent delivery
2. Change maternal position to a position in which the FHR is most improved
3. Administer oxygen by face mask and discontinue oxytocin (if running)
4. Inspect the tracing carefully for any other signs of fetal distress

Late Deceleration

The late deceleration is associated with uteroplacental insufficiency and implies some degree of fetal hypoxia. It is in general the earliest marker of hypoxia.[19] Late decelerations are caused by inadequate oxygen exchange within the placenta and are provoked by uterine contractions. Any decrease in uterine blood flow or placental dysfunction can cause late decelerations (Table 1).

Any late deceleration is ominous and requires careful observation of the clinical setting and the fetal monitor tracing. The presence of tachycardia or loss of variability in addition to late decelerations correlates very highly with fetal distress.[20] There is generally a correlation between magnitude of late decelerations and the degree of hypoxia, but occasionally very depressed infants will have only shallow late decelerations.

The management of late decelerations should include placement of the patient in the left lateral position, hydration, oxygen by face mask, and discontinuation of oxytocin. If the late decelerations are not associated with other nonreassuring patterns and are corrected by these measures, labor may proceed. If the late decelerations are associated with unexplained tachycardia or poor variability, or if they are not corrected by the above measures, fetal scalp pH sampling or immediate delivery should be performed.

Table 1. Causes of Late Decelerations

Uteroplacental Insufficiency
Chronic hypertension
Post maturity
Any cause of intrauterine growth retardation
Diabetes mellitus
Pre-eclampsia
Various maternal medical illnesses
Decreased Uterine Blood Flow
Uterine hypertonus (oxytocin, spontaneous abruption)
Hypotension due to vena caval or aortoiliac occlusion (supine position)
Hypotension due to anesthetics (eg, epidural)

Variability of the Fetal Heart Rate

Variability of the fetal heart rate reflects intact neurologic modulation of fetal heart rate and normal cardiac responsiveness. It reflects the interplay of the parasympathetic and sympathetic nervous systems, resulting in the normal variance in intervals of the cardiac cycle. The causes of decreased variability are many and are listed in Table 2. Prematurity is a cause of decreased variability because the sympathetic nervous system is dominant early in gestation, with the parasympathetic nervous system gaining influence later in gestation. There is little variability before 28

Table 2. Causes of Decreased Variability

Drugs that depress the central nervous system (eg, general anesthetics, narcotics, phenothiazines, barbiturates)
Drugs that interfere with autonomic function (atropine, hydroxyzine)
Prematurity
Fetal hypoxia
Fetal sleep cycle
Congenital anomalies (particularly congenital heart disease)
Fetal tachycardia
Magnesium sulfate
Beta blockers

Table 3. Causes of Fetal Tachycardia

Fetal hypoxia
Maternal fever
Maternal tachycardia
Anemia
Hyperthyroidism
Fetal anemia
Parasympatholytic drugs (atropine, hydroxyzine)
Sympathomimetic drugs (ritodrine, terbutaline)
Amnionitis
Fetal cardiac tachyarrythmias
Prematurity

weeks, and variability should be normal after 32 weeks. Decreased variability is usually associated with severe or prolonged hypoxia. With mild hypoxia, variability may actually be increased—the so-called saltatory pattern.[21]

When there is significant fetal hypoxia, decreased variability is usually associated with other patterns of concern. Decreased variability is usually an ominous sign because other nonreassuring patterns usually precede it. In the presence of other nonreassuring patterns, loss of variability is associated with a high incidence of fetal acidosis and low Apgar scores.[22]

One of the most common errors in interpretation of fetal monitor tracings occurs when an attempt is made to assess variability of fetal heart rate while using external monitoring techniques. The recorded variability is increased by the ultrasound systems used in external monitors, and poor variability of the fetal heart rate is often masked.

Management of loss of variability should include a careful review of the differential causes and a search for other signs of distress.

Tachycardia

Fetal tachycardia is defined as a baseline FHR greater than 160 beats per minute. It is due to an increase in sympathetic tone or a decrease in parasympathetic tone and is therefore often associated with decreased variability. Causes of fetal tachycardia are listed in Table 3.

Kubli et al[23] have shown that fetuses with baseline tachycardia without other nonreassuring patterns have a generally good outcome, except when tachycardia is due to amnionitis. They have also shown that tachycardia associated with nonreassuring patterns has a much greater incidence of fetal compromise. Therefore, management of fetal tachycardia should include a search for correctable etiologic factors and for other nonreassuring patterns.

Bradycardia and Prolonged Decelerations

Fetal bradycardia is defined as a baseline FHR less than 120 beats per minute. Bradycardia, with variability maintained and no other nonreassuring patterns, is nearly always benign.[13] FHR below 70 beats per minute is not infrequently due to complete heart block and is associated with a high incidence of congenital heart disease.[24]

Prolonged decelerations, also called fetal reacting bradycardias,[25] are isolated decelerations lasting longer than 60 to 90 seconds. They may be merely prolongations of moderate or severe variable decelerations but may also occur with umbilical cord prolapse, fetal vagal stimulation, tetanic uterine contractions, and paracervical anesthesia. Because of the possibility of cord prolapse or rapid fetal descent, a vaginal examination should always be performed immediately when prolonged decelerations are detected. Tetanic uterine contractions occur with oxytocin hyperstimulation and placental abruption, but they may also occur spontaneously. Paracervical anesthesia may cause profound prolonged decelerations. The fetal heart rate will usually return to baseline in 4 to 12 minutes after a

Table 4. Causes of Prolonged Decelerations
Prolonged cord compression or prolapse
Caine drug effect (paracervical, epidural, spinal anesthesia)
Uterine hypertonus (oxytocin, spontaneous, abruption)
Narcotics overdose
Maternal seizure
Fetal vagal stimulation (eg, rapid descent, vigorous vaginal examination, application of scalp electrode)

paracervical block depending on the anesthetic agent used. A more complete list of causes of prolonged decelerations is found in Table 4.

The fetoplacental unit is very effective in resuscitation during prolonged decelerations. The usual response to a deceleration of more than three minutes' duration is an outpouring of epinephrine from the fetal adrenal glands with resultant tachycardia and decreased variability. Subsequently there is a return to baseline. If the cause of the deceleration cannot be identified and it persists for more than five minutes, preparations should be made for rapid intervention.

Sinusoidal Pattern

A sinusoidal pattern has a sine wave pattern above and below the baseline with a periodicity of four to eight cycles per minute. It is apparently a response to loss of central nervous system control of heart rate, with an increase in long-term variability and a decrease in short-term variability. It occurs in infants with severe anemia, high-output heart failure, and hypoxia and in nondepressed infants.[26] It is a nonreassuring pattern, but recommendations for proper management have not been outlined.

Abnormal FHR Patterns During the Second Stage of Labor

In a recent review and study of patterns of bradycardia during the second stage of labor, Krebs et al[27] found that abnormal FHR patterns occurred in the second stage in 91 percent of labors. They were particularly interested in the effect of changes in the baseline fetal heart rate during the second stage and defined five basic patterns:

1. *Normocardia:* baseline rate of 120 to 160 beats per minute
2. *Transitory bradycardia:* heart rate falling below 120 beats per minute and remaining there for more than 10 minutes before returning to a rate of greater than 120 beats per minute
3. *Persistent bradycardia:* heart rate falling below 120 beats per minute and remaining there
4. *Progressive bradycardia:* heart rate falling progressively further below 120 beats per minute
5. *Tachycardia:* baseline heart rate remaining above 160 beats per minute

A significantly increased incidence of fetal distress was found for each of the last four patterns.

Among tracings with a normal baseline rate, the presence of variable deceleration was associated with a slightly increased incidence of fetal distress when compared with tracings with no decelerations, but variable deceleration was not associated with increased fetal distress when compared with the outcomes of all labors. Decreased variability associated with any of the bradycardia patterns described above was an indicator of severe hypoxia.

Benefits and Risks of EFM During Labor

Perinatal and Neonatal Mortality

Obviously, the goal of EFM is the early detection of the hypoxic fetus and the lowering of perinatal and neonatal mortality and morbidity rates through appropriate intervention. The most recent extensive review of data published on this subject is the 1979 National Institute of Health publication entitled *Antenatal Diagnosis*,[3] comparing the effect of EFM and auscultation on perinatal and neonatal mortality. A compilation of seven large retrospective studies involving more than 72,000 births was made.[3] Collectively the studies showed a 2.6-fold decrease in the intrapartum fetal death rate and a 1.9-fold decrease in the neonatal death rate in EFM groups. These studies can be seriously criticized because they did not directly compare monitored and unmonitored groups and because they compared combinations of high-risk and low-risk pregnancies. They did show that the introduction of EFM was accompanied by a reduction of perinatal and neonatal death rates and suggested, but did not prove, a beneficial effect of EFM on death rates. It must be remembered that during this period vast improvements were made in prenatal care and neonatal intensive care.

There have been only five randomized, controlled trials evaluating the use of EFM and auscultation during labor.[4-8] In these trials, no difference was seen in intrapartum and neonatal death rates between EFM and auscultated groups. However, a total of only 3,000 patients were involved in these trials. The number is far too small to draw any definite conclusion about the differential effects of EFM and auscultation. Neutra et al[28] retrospectively studied nearly 16,000 deliveries resulting in live births. The crude neonatal death rate was 1.7 times higher for unmonitored infants than for those monitored. Patients were divided into five risk categories, and it was found that in the lowest risk group (babies at term with no risk factors) the use of EFM produced no decrease in neonatal morbidity or mortality. This lowest risk group made up 76 percent of all births in the study. The study also shows a definite advantage for EFM in high-risk pregnancies. In most of the above studies, auscultated groups received frequent and careful auscultation. The usual techniques employed were auscultation of FHR every 15 to 30 minutes during the first stage of labor and every 5 to 15 minutes during the second stage of labor, in both instances for a period of 30 seconds immediately after a contraction.

Neurologic Sequelae

Little is known concerning the neurologic sequelae of infants from EFM and auscultated labors. Langendoerfer et al[29] reported the results of a controlled prospective study that assessed the neurologic function of infants of high-risk patients. No significant difference was found among auscultated and EFM groups with respect to neonatal morbidity and mortality, Apgar scores, Brazelton examinations at 48 hours, growth and development at 9 months, or Bayley scales of infant development at 9 months. In the prospective studies by Haverkamp et al[4,7] and Kelso et al,[6] there was no immediate increase in neonatal neurologic complications in auscultated deliveries. Renou et al[5] report a higher incidence of brain-damaged infants in the auscultated group. All cases that resulted in brain damage in this study involved large term infants born after difficult second stages and traumatic deliveries.

A recent study[30] showed an increased incidence of neurologic abnormalities at one year of age in infants who had severe variable decelerations or late decelerations during labor.

High-risk situations in which EFM is clearly of benefit have not been defined rigorously. Many scoring schemes for estimate of risk have been developed, including very popular ones by Hobel et al[31] and Goodwin et al.[32] The NIH publication[3] mentioned earlier recommends EFM in all pregnancies with (1) low estimated fetal weight, (2) prematurity, postmaturity, or suspected intrauterine growth retardation, (3) medical complications of pregnancy, (4) meconium staining, (5) intrapartum obstetric complication, (6) use of oxytocin in labor, and (7) presence of abnormal auscultatory findings.

Fetal Infection

Fetal scalp infections following internal monitoring are usually minor infections requiring only local treatment. In a prospective study, Okada et al[33] report a scalp infection rate of 4.5 percent following the use of fetal scalp electrodes. They also report that factors associated with significant rates of scalp infection include duration of monitoring and high-risk indications for monitoring. Baumgarten[34] has reported that of over 11,000 infants on whom fetal scalp electrodes were used, none developed "severe" complications. There are isolated reports of osteomyelitis, eyelid lesions, scalp hematomas, and cerebrospinal fluid leaks.[3]

Maternal Infection

There are conflicting data regarding the risk of maternal infection following intrauterine monitoring. Hagen[35] reported that the infection rate was most pronounced if patients have had intrauterine catheters and then have undergone cesarean section. Gibbs et al[36] performed a multivariate analysis on over 400 patients and found that long labors, prolonged rupture of membranes, and many vaginal examinations each had much greater importance in determining infection than did internal monitoring. Haverkamp et al[7] reported no increase in postpartum infections in EFM groups. Intrauterine monitoring does not appear to significantly increase the maternal infection rate.

Effect on Cesarean Section Rate

Many attribute the rise in cesarean section rate in the past ten years to the increasing use of EFM. The exact contribution of EFM is difficult to determine because many obstetric practices have changed dramatically. Difficult forceps deliveries are done less frequently, primigravidas with breech presentation are being delivered by cesarean section, the salvage rate of premature infants is increasing with a corresponding increase in the number of cesarean sections used to deliver premature infants, and patients who have undergone previous cesarean sections are given fewer trials of labor.

Haverkamp et al[7] demonstrated a dramatic rise in cesarean section rate in patients receiving continuous EFM. The cesarean rate with EFM alone was 18 percent, with EFM and the option for fetal scalp pH sampling was 11 percent, and with auscultation alone was 9 percent. It is suggested that the availability of fetal scalp blood sampling provided information that may reduce the number of monitor-associated cesarean sections. In other controlled, prospective studies, Renou et al[5] report no statistically significant difference in cesarean section rate, and Kelso et al[6] state that "the C-section rate was significantly increased in monitored patients, although these were not performed for fetal distress."

Bottoms et al[37] reviewed the literature and found an increase in cesarean section rate in the United States of 8 percent from 1960 to 1976. They found that only 13 percent of this increase was attributable to cesarean sections performed for fetal distress. It was therefore concluded that EFM caused only a 1 percent rise in the overall cesarean section rate. Freeman and Garite[10] suggest that overreaction and inappropriate intervention for benign patterns occur most frequently in hospitals where the staff is not well trained in EFM and is insecure about reading monitor tracings.

Risk of Ultrasound

Ultrasound is commonly used for external fetal monitoring. Doppler ultrasound units emit about 1,000 times more energy than do diagnostic ultrasound units.[38] Hobbins et al[38] reviewed the current literature on the use of ultrasound in obstetric practice and concluded that a definitive assessment of the potential risks is not possible at this time. They did quote the most recent report of the American Institute of Ultrasound in Medicine Committee on Bioeffects, which stated: "In the low megahertz frequency range there have been as of 1978 no independently confirmed significant biologic effects of ultrasound on mammalian tissues exposed to intensities less than 100 milliwatts per cm^2." The average intensity of Doppler systems is 20 mW/cm^2 with a maximum of 50 mW/cm^2.

Psychologic Effects of EFM

Few studies have been done to explore the psychologic and emotional effects of EFM. It seems probable that for some patients, EFM would cause considerable anxiety, which could have deleterious effects on the progress and outcome of labor. Concerns have arisen over the possibility of EFM leading to neglect of other aspects of maternal service. Also, the continuous use of EFM may decrease both emotional and physical contact between mother and father or other supporting individuals during labor. Several small informal studies concerning the psychologic aspects of EFM have appeared in the nursing literature. One such study[39] reports widely varying attitudes about EFM among mothers. It was emphasized that all patients desired close nursing supervision throughout labor regardless of whether or not EFM was used. It also was suggested that pregnant women who have discussed the uses, benefits, and risks of EFM prior to labor and early in labor are less likely to have negative reactions.

Conclusions

EFM is a screening tool, not a diagnostic tool. Patterns generated can be interpreted only as suggestive of fetal distress.

All EFM findings should be interpreted in light of the clinical situation. When a nonreassuring pattern is detected, the differential causes should be considered and minimized. Infants whose tracings have two or more nonreassuring patterns have a significantly increased incidence of perinatal morbidity and mortality.

A normal FHR pattern indicates fetal well-being in almost every case.

Intrapartum fetal distress is far more common in high-risk pregnancies. EFM is a useful tool in detecting fetal hypoxia and reducing perinatal and neonatal morbidity and mortality in high-risk pregnancy. Continuous EFM should be employed during the labors of high-risk obstetric patients.

Most of the present evidence suggests that in low-risk pregnancies EFM and auscultation result in similar fetal outcome.

Intermittent, frequent auscultation during labor provides an adequate method of monitoring low-risk pregnancies. Individualized care by well-trained nurses is a necessity.

The cesarean section rate has risen significantly in the past decade. EFM appears to have contributed to the rise, but the degree of contribution is not known.

The use of fetal scalp pH can provide additional useful information when fetal hypoxia is suspected.

The use of internal fetal monitoring equipment does not appear to appreciably increase the risk of maternal or fetal infection. The risk of external fetal monitoring appears minimal.

No conclusive data are available on the psychologic and emotional risks of EFM. Women should have the opportunity to discuss the use, risks, and benefits of EFM before and during labor.

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