Intrapartum Fetal Monitoring

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In today's modern obstetrical care, continuous intrapartum electronic monitoring of the fetal heart rate (FHR) has reached a reliable and practical stage which makes it now feasible to monitor the FHR throughout labor and delivery. All the available data support the value of FHR monitoring because it provides predictable, dependable, and reproducible information about the condition of the fetus. New categories of FHR patterns are being defined and learned. We have come to the conclusion that, in a sense, labor makes all babies high risk, and we ought to aspire to universal FHR monitoring in order to provide a safer transition for the fetus to the outside world.

Obstetricians for years have been concerned with the problems of reducing maternal mortality and morbidity secondary to childbirth. Although great progress has been made in reducing maternal problems through the introduction of antibiotics, sophisticated blood banking, and improved surgical technique, the nation's perinatal mortality rate, unfortunately, has remained essentially unchanged. This fact has fostered a re-examination of the factors involved in perinatal survival and has led us to re-examine the gestation period in its entirety. This requires evaluation of the overall general medical condition of the patient, comprehensive antepartum surveillance, and intensive intrapartum and neonatal care. This report will concern itself with the possible indications, methods, utilization, and advantages of intrapartum fetal monitoring. In addition, it will review the principal fetal heart rate patterns and the role of fetal monitoring in modern obstetrical care.

Methods of Fetal Monitoring

For years fetal well-being during labor has been evaluated in two ways: by observation of the amniotic fluid for meconium staining and by auscultation of the fetal heart sounds using a stethoscope. Clinical fetal distress has been arbitrarily defined as a fetal heart rate (FHR) greater than 160 beats per minute (bpm), or less than 100 bpm. Meconium staining is sometimes associated with fetal distress, but most cases of meconium staining during labor do not result in perinatal compromise. Since auscultation is intermittent, only a small fraction of the available heart rate information is evaluated, and serious errors in estimating fetal condition are unavoidable. The limitations of intermittent auscultation have been underscored in a study by Benson et al,[1] who concluded that stethoscopic sampling of FHR is inadequate for the early detection of fetal distress.

Today we have available more precise techniques of intrapartum FHR and uterine contraction monitoring which provide continuous, reliable information about the condition of the fetus. Two main methods of continuous monitoring have been utilized: the direct and the indirect. The direct method is the most precise, reliable, and widely-used technique of continuous intrapartum FHR and uterine contraction monitoring. In this method, a spiral electrode is attached to the presenting part of the fetus in order to obtain a fetal electrocardiogram (FECG), from which the FHR is determined (see figure 1).

The uterine contractions are evaluated by a transcervical polyethylene fluid-filled catheter introduced into the uterine cavity. This provides quantitative information about the frequency, duration, and intensity of the uterine con-

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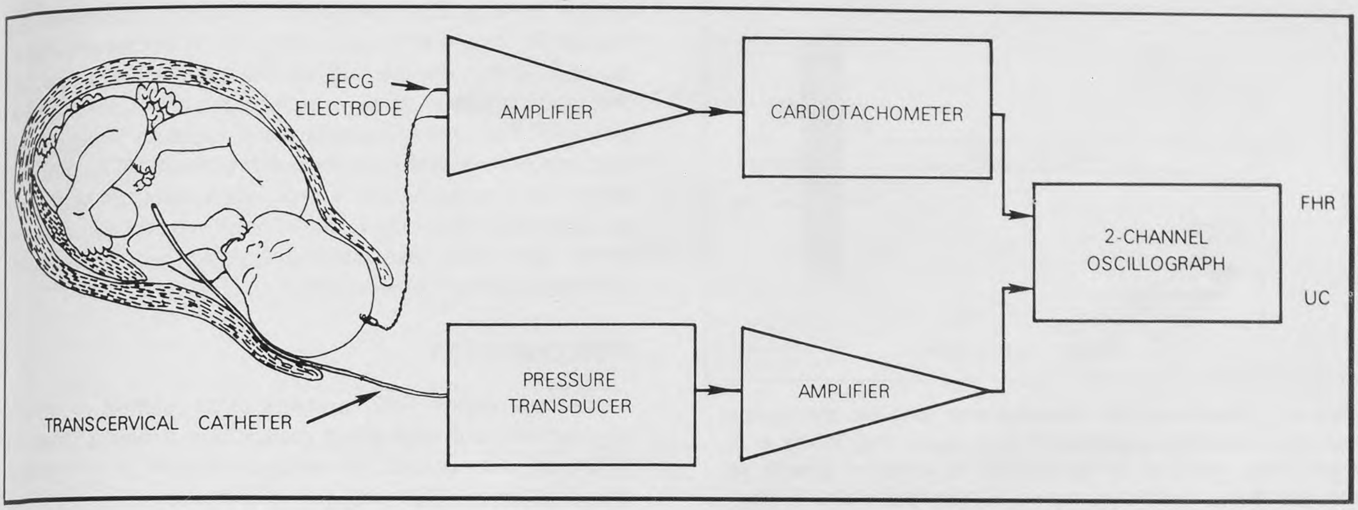

Figure 1. Schematic of a direct fetal monitoring system. Note the fetal ECG is obtained from a fetal scalp electrode and counted on a cardio-tachometer. The actual uterine pressure is recorded directly from a transcervical intrauterine catheter.*

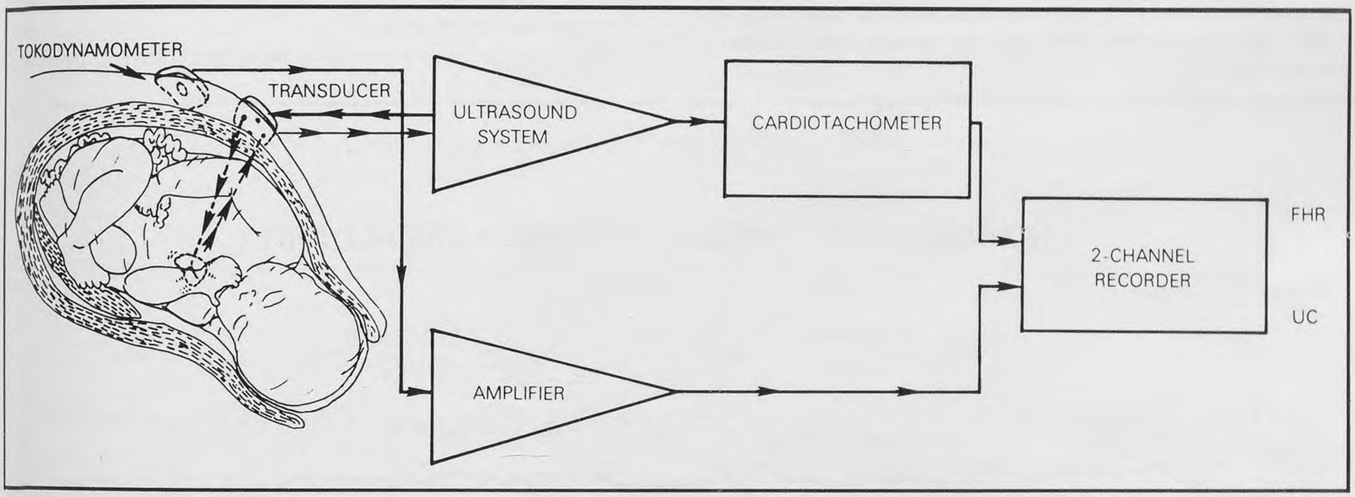

Figure 2. Schematic of an indirect fetal monitoring system. Note the fetal ultrasonogram is obtained from an abdominal wall transducer and then counted by a cardiotachometer. The external tocodynamometer measures uterine activity in a semi-quantitative fashion.

tractions. The FHR and the uterine contractions are recorded continuously on a strip chart recorder. Direct techniques require that amniotomy be done, that the cervix be at least one to two centimeters dilated for electrode application, and that the presenting part is at a sufficiently low station for electrode attachment.

The indirect method of monitoring uses external techniques to obtain FHR-uterine contraction data. FHR may be derived from fetal heart sounds, utilizing a microphone attached to the maternal abdominal wall or a sonocardiogram which employs the ultrasonic Doppler principle to determine FHR (shown in figure 2). A pressure-sensing transducer, called a tocodynamometer, is placed on the abdominal wall in order to ascertain the frequency and duration of uterine contractions. This technique does not, and cannot, provide precise information about the intensity of the contraction. The obvious advantages of this indirect method are that nursing personnel can easily apply the external monitoring equipment and that it may be used in early labor. Unfortunately, however, there are many limitations to the external systems. In a number of patients, a satisfactory fetal signal is unattainable; this may be related to such factors as maternal obesity, excessive maternal movement, fetal position, and active noise-producing movement of either the mother or the fetus. At present, indirect fetal monitoring systems using the ultrasonocardiogram provide the best indirect FHR labor recordings, and the reliability of this technique is progressively improving with new instrumentation and transducer designs.

Uterine contractions are also measured concurrently with FHR since it is known that uterine contractions represent a repetitive stress to the fetoplacental unit (see figure 3). The uterine contractions can apply pressure directly to the fetal vertex, causing molding, caput, and considerable increase in intracranial pressure. The uterine contractions may also compress the umbilical cord against the fetal body and thereby interfere with umbilical circulation. Lastly, the

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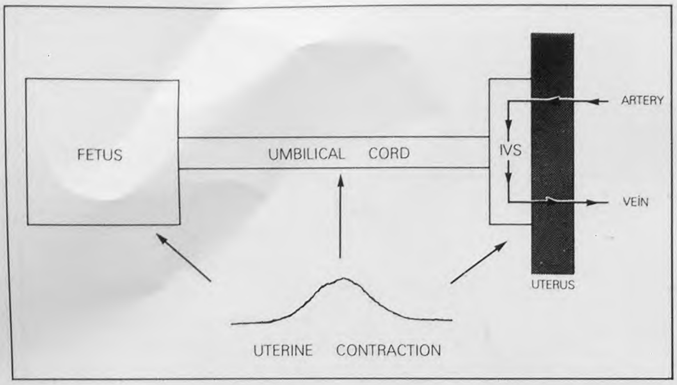


Figure 3. Block diagram demonstrates that the mechanical energy of a uterine contraction may cause fetal stress in at least three ways: a) by application of pressure directly to the fetal body, usually the vertex, b) by compression of the umbilical cord, c) by impeding venous outflow from, and arterial inflow to, the intervillous space.

Figure 4. A normal FHR with average baseline variability is shown. Note the normal FHR does not change with uterine contractions.

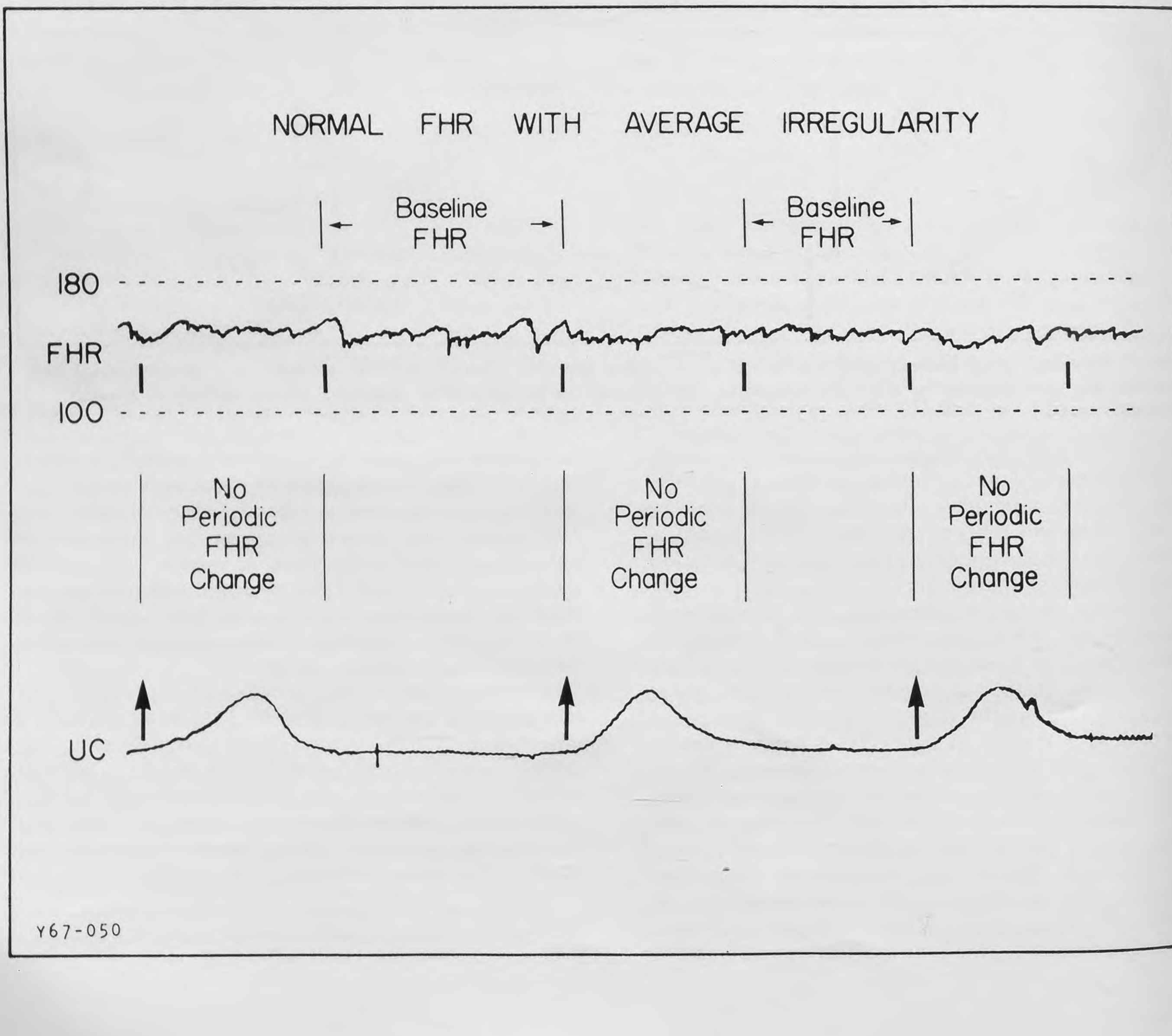
uterine contractions repeatedly impede intervillous exchange of oxygen and carbon dioxide by decreasing uterine blood flow into the intervillous space.[2] It is well recognized that labor is a fetal stress, which, in most instances, is well-tolerated; but when uteroplacental function is diminished (i.e., in toxemia, diabetes, Rh isoimmunization, etc.) or umbilical cord compression is prolonged, fetal tolerance may be exceeded. This may result in fetal hypoxia and acidosis, which have been associated with depressed neonates and sometimes even cause death.[3]

Interpretation

We now define FHR in terms of its relation to uterine contractions and distinguish contraction-related changes in FHR from non-contraction-related changes. A convenient classification of FHR patterns is as follows:[4]

1. Baseline FHR — FHR changes in the absence of, or between, uterine contractions.
2. Periodic FHR — Changes in FHR associated with uterine contractions.

The normal baseline FHR is between 120-160 bpm and



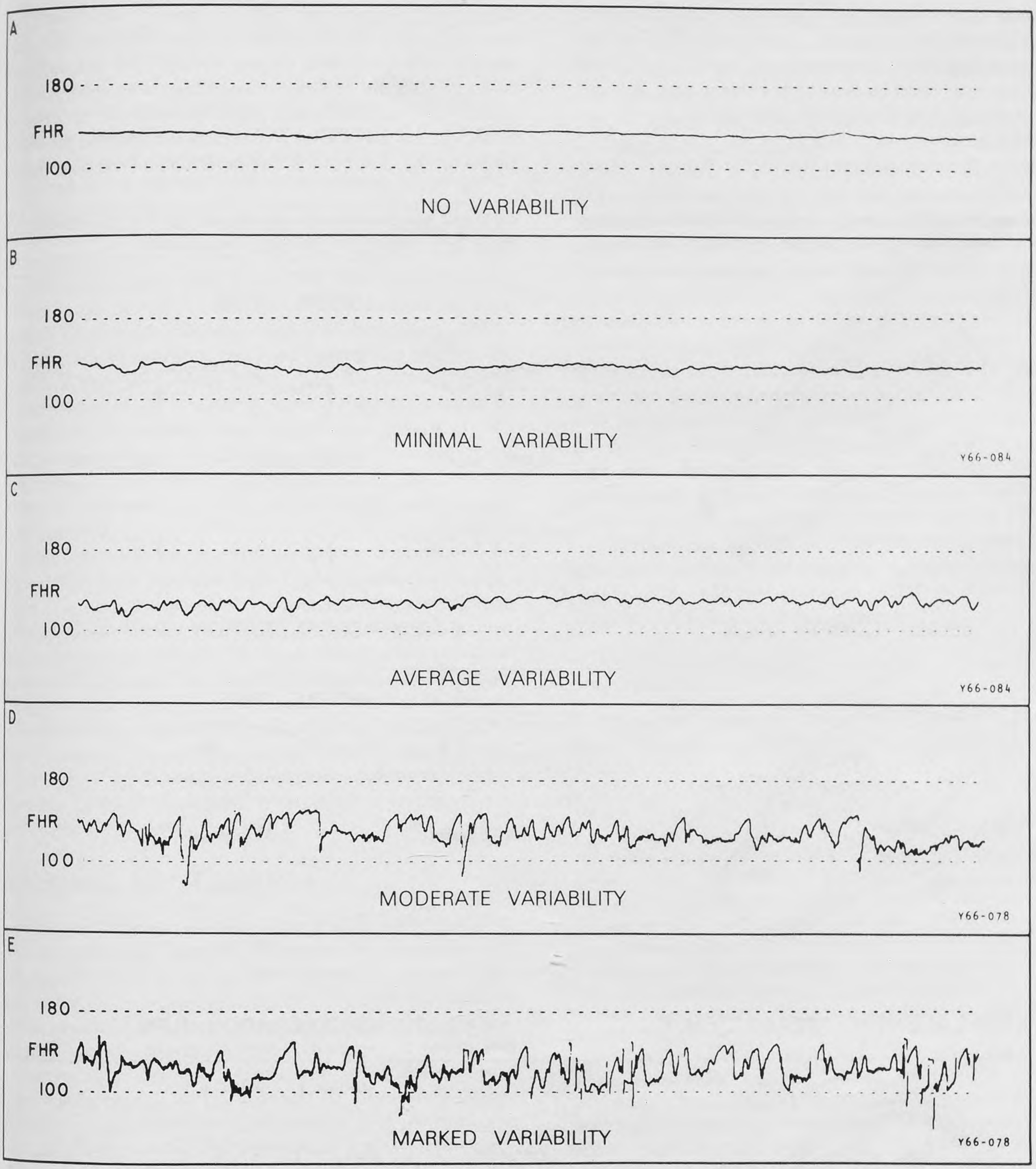


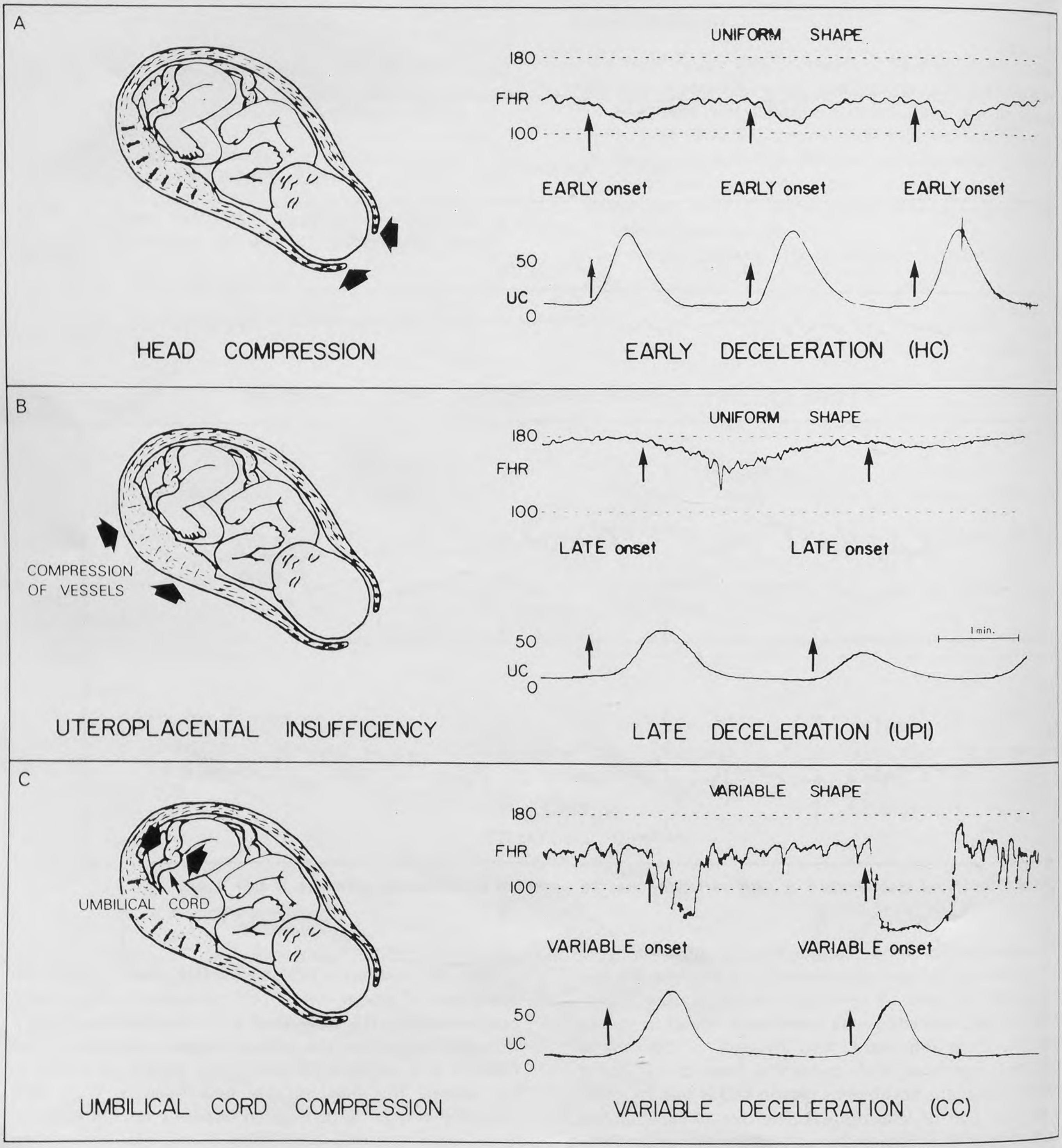
Figure 5. The visual identification of FHR variability may be assessed by using the examples in this figure.

does not vary with uterine contractions (as shown in figure 4). Rates below 100 bpm are referred to as bradycardia, and rates above 160 bpm are referred to as tachycardia. Tachycardia may be associated with maternal fever, atropine-like drugs, or, more important, fetal hypoxia. Bradycardia is sometimes associated with congenital heart block, but it may also occur for no obvious reason and is not, by itself, an absolute sign of fetal distress. The overall variability of the baseline FHR, as assessed visually, is also considered important.[5,6] (Figures 4 and 5).

These fluctuations in the baseline FHR seem to reflect the integrity of the fetal central nervous system, which exerts control on the FHR. In general, if the baseline variability is normal or increased, the fetus is in good condition. If the baseline FHR variability is diminished, absent, or judged to be smooth, this may indicate fetal hypoxia. Thus, FHR smoothness may be considered ominous since it is sometimes associated with depression of the fetal central nervous system. Unfortunately, unrelated factors may also lead to decreased baseline variability. These include drugs administered during labor, "narcotics and tranquilizers," and an immature fetal nervous system. For this reason, it is important to record any medication given to the mother on the monitor record.

Changes in the FHR patterns that occur during contractions are called periodic FHR changes and are divided into two categories: accelerations and decelerations. Accelerations in FHR occur with uterine contractions or fetal movement and are not apparently associated with acute fetal distress. Hon has described three patterns of deceleration based on the wave form of the deceleration and the timing between the onset of the deceleration and the beginning of

Figure 6. Demonstration of the three types of FHR deceleration patterns. Note in A and B the uniform wave form pattern of early and late deceleration are shown and in C the variable wave form pattern of variable deceleration.



the associated uterine contractions (shown in figure 6A-6C). There are two uniform types (early and late) and one variable type of deceleration.[7,4]

Early deceleration reflects the uniform shape of the associated uterine contraction. The deceleration begins early in the contracting phase of the uterus, and is thought to be due to head compression (figure 6A). Clinically, it is considered to be benign, and no treatment is indicated. Late deceleration has a uniform shape similar to early deceleration, but the onset of the deceleration begins late in the contracting phase and returns to the baseline rate only after the contraction is over (figure 6B). Late deceleration is thought to be caused by uteroplacental insufficiency, and clinically it has been associated with fetal depression, acidosis, and death.[3] Treatment includes turning the mother on her side to improve uterine blood flow, discontinuation of oxytocin infusion if it is running, starting maternal oxygen at 100 percent concentration with a tight face mask, and correcting maternal hypotension if present. If this ominous pattern cannot be corrected after these measures have been in effect for a reasonable period of time, delivery is recommended.

Variable deceleration is characterized by a non-uniform shape which often changes from contraction to contraction (figure 6C). Also, the onset of the deceleration may begin at varying times in relation to the uterine contraction. Variable decelerations are thought to result from umbilical cord compression and are the most common type of FHR patterns observed. These patterns, usually transient in nature, can frequently be alleviated by altering the mother's position. However, intervention is indicated if the variable deceleration is repetitive and severe, because the factors responsible for this type of pattern can result in fetal asphyxia and death.

Indications and Advantages

Ideally, all patients entering labor should be monitored, since a significant number of apparently uncomplicated pregnancies result in distressed infants. It has been observed that many fetuses encounter difficulties during labor which could not have been anticipated on the basis of maternal history or clinical findings.[8] Therefore, it seems not unreasonable to assume all fetuses are at risk during labor. The implementation of the concept of monitoring all patients has been hindered by limitations of cost, instrumentation, and personnel. In most institutions, only selected high-risk patients are currently being evaluated by electronic monitoring techniques. Some of the most frequent reasons for monitoring obstetrical patients at Los Angeles County-USC Medical Center are as follows:

1. To evaluate poor progress
2. To assess oxytocin stimulation
3. For premature rupture of the membranes
4. Meconium staining
5. Any irregularities of the fetal heart tones
6. Maternal factors increasing the fetal risk during labor
   a. Toxemia
   b. Diabetes
   c. Post-maturity syndrome
   d. Intrauterine growth retardation
   e. Abruptio placenta
7. Abnormal presentations (breech presentation)
8. Prematurity

Both animal and clinical studies support the value of intrapartum fetal monitoring. Myers[9] and co-workers,[10] and James[11] showed that late deceleration is associated with fetal hypoxia and hypotension, and that when these conditions are permitted to persist for a prolonged time, the fetal animal develops brain lesions similar to those found in the human with cerebral palsy. Paul[12] found a lower-than-anticipated intrapartum death rate in monitored high-risk patients, as compared to an unmonitored normal group. Schifrin[13], using a prediction system based only on FHR patterns within the last 30 minutes prior to delivery, attempted to predict five-minute Apgar scores. He found that a normal FHR pattern was almost completely accurate (99 percent) in predicting a baby born in good condition. Obviously, this high predictive accuracy does not hold when obstetrical trauma such as breech extraction, shoulder dystocia, prolonged anesthesia induction time, and difficult forceps occur during labor and delivery. This high correlation between predicted and observed neonatal outcome, as reflected by Apgar score, has demonstrated that FHR monitoring is of clinical value in obstetrical practice.

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