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What we have learned about intrapartum fetal monitoring trials in the MFMU Network

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ABSTRACT

The vast majority of pregnant women are subjected to electronic fetal heart monitoring during labor. There is limited evidence to support its benefit compared with intermittent auscultation. In addition, there is significant variability in interpretation and its false-positive rate is high. The latter may have contributed to the rise in operative deliveries. In order to address the critical need for better approaches to intrapartum monitoring, the MFMU Network has completed two large multisite randomized trials, one to evaluate fetal pulse oximetry and the other to evaluate fetal ECG ST segment analysis (STAN). Both of these technologies had been approved for clinical use in the United States based on prior smaller trials. These technologies were evaluated in laboring women near term and their primary outcomes were overall cesarean delivery for the oximetry trial and a composite adverse neonatal outcome for STAN. Both the trials failed to show a benefit of the technology, neither in the rates of operative deliveries nor in the rates of adverse neonatal outcomes. The experience with these trials, summarized in this report, highlights the need for rigorous evidence before introduction of new technology into clinical practice and provides a blueprint for future trials to address the need for better intrapartum monitoring approaches.

Introduction

When first introduced, electronic fetal heart rate monitoring was used primarily in complicated pregnancies, but gradually it came to be used during most labors. In 1978, it was estimated that nearly two-thirds of American women were being monitored electronically during labor.[1] By 1998, nearly 3.3 million American women, comprising 84% of all live births, underwent electronic fetal heart rate monitoring.[2]

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By the end of the 1970s, however, questions about the efficacy, safety, and costs of electronic monitoring were being voiced by the Office of Technology Assessment, the United States Congress, and the Centers for Disease Control and Prevention. Banta and Thacker[1] analyzed 158 reports and concluded that "the technical advances required in the demonstration that reliable recording could be done seems to have blinded most observers to the fact that this additional information will not necessarily produce better outcomes." They attributed the apparent lack of benefit to the imprecision of electronic monitoring to identify fetal distress. Moreover, increased usage was linked to more frequent cesarean delivery. They estimated that additional costs of childbirth in the United States, if half of labors had electronic monitoring, were approximately $400 million per year in 1979.

The *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) appointed a task force to study these concerns, and a consensus report was published in 1979.[3] After an exhaustive review of the electronic fetal heart rate monitoring literature, the group concluded that the evidence only suggested a trend toward improved infant outcome in complicated pregnancies. They emphasized that few scientifically rigorous investigations had been done to address perinatal benefits. A subsequent NICHD consensus panel,[4] convened to address the dramatic increase in cesarean births in the United States, concluded that use of electronic fetal heart rate monitoring was a contributing factor.

Almost 20 years later, the NICHD Fetal Monitoring Workshop[5] formulated research recommendations intended to assess the reliability and validity of fetal heart rate patterns in the prevention of asphyxial brain damage. The workshop participants concluded that the effectiveness of fetal heart rate monitoring still remains to be established despite widespread use in the United States. Another reason for the failure of fetal heart rate monitoring technology to be proven beneficial is the now well-accepted non-specificity of fetal heart rate patterns to predict fetal compromise. This poor specificity of fetal heart rate pattern interpretation has resulted in a continuing search for adjunctive tests that could be used to distinguish false-positive fetal heart rate patterns.

A number of adjunctive measures have been proposed, including fetal scalp sampling for pH, fetal scalp stimulation, fetal lactate measurement, determination of fetal oxygen saturation, and monitoring of fetal ECG. The *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Maternal-Fetal Medicine Units (MFMU) Network identified intrapartum monitoring as one of the areas in need for more research, especially given that one of the major aims of the Network is to "evaluate maternal and fetal interventions for efficacy, safety, and cost-effectiveness."[6] In this review, we attempt to present the rationale, the findings, and our experience with two large randomized trials conducted by the Network designed to measure the efficacy and safety of two promising adjuvants to electronic fetal monitoring—fetal pulse oximetry and fetal ECG. Although neither of these trials showed benefit, we believe that these ambitious efforts helped ensure that interventions were not introduced prior to their efficacy and safety being validated and hope that this information will be valuable for future research designed to improve intrapartum fetal assessment.

Fetal pulse oximetry

In May 2000, the United States Food and Drug Administration (FDA) granted conditional approval of the Nellcor OxiFirst Fetal Pulse Oximetry System for use as an adjunct to electronic fetal monitoring.[7] This technology was designed to improve knowledge of the intrapartum condition of the fetus in the presence of a non-reassuring fetal heart rate pattern by continuously measuring fetal oxygen saturation. With this technology, a specialized sensor is inserted through the dilated cervix after ruptured membranes and positioned against the fetal face. Once in contact with the fetal skin, the device permits measurement of fetal oxygen saturation during labor.[8]

The fetal pulse oximetry system was designed based upon principles of spectrophotometry and plethysmography.[9] The sensor contains two low-voltage, light-emitting diodes as light sources and one photodetector. One light-emitting diode emits red light (735 nm), and the other emits infrared light (890 nm). When light from each light-emitting diode passes through fetal tissue at the sensor application site, a fraction is absorbed. The photodetector measures the light that was not absorbed—that is, the light that is reflected. Because oxyhemoglobin and deoxyhemoglobin have different light-absorption characteristics—relatively less red light is absorbed by oxyhemoglobin compared with deoxyhemoglobin and relatively more infrared light is absorbed by oxyhemoglobin compared with deoxyhemoglobin—pulse oximetry employs the ratio of these differences to calculate fetal oxygen saturation during each arterial pulse.[9]

A number of published observational studies in both animals and humans demonstrated a correlation between fetal metabolic acidosis and increasing duration of fetal pulse oximetry saturations below 30% in the setting of a non-reassuring fetal heart rate pattern.[10–12] These studies were followed by the first randomized controlled trial of fetal pulse oximetry, which was published by Garite et al.[13] In this trial, a total of 1010 women with term pregnancies in active labor with an abnormal fetal heart rate pattern were randomly assigned to electronic fetal monitoring alone (the control group) or to electronic fetal monitoring plus continuous fetal pulse oximetry (the study group). The primary outcome was a reduction in cesarean deliveries for the indication of non-reassuring fetal status.

As shown in Table 1, the frequency of the primary outcome was significantly lower in the study group compared with the control group (5% vs. 10%, $P < 0.001$).

However, as also shown in Table 1, there were no significant differences in the overall cesarean rate, the overall operative vaginal delivery rate, or the rate of operative vaginal delivery for non-reassuring fetal status. Looking at the results from a different angle, although the rate of cesarean delivery for non-reassuring fetal status was halved in the fetal pulse oximetry arm, the rate of cesarean delivery for dystocia more than doubled in this same group (9% vs. 19%, $P < 0.001$). This increase in the rate of cesareans for dystocia was unexpected, and the results of the study raised several key questions. For example, were the discrepancies in the effect of the oximeter according to the indication for cesarean delivery reproducible?