Technology Update

Fetal Pulse Oximetry

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Pulse oximetry has become a standard of care in anesthetic, pediatric and neonatal practice (l,2). It measures the per cent saturation of hemoglobin based upon the Beer Lambart's spectrophotometric principle of differential absorption of red and infrared light waves (660 nm and 940 nm, respectively) by the oxyhemoglobin and reduced hemoglobin(3). Pulse oximetry has been recently adopted for continuous intrapartum surveillance and fetal pulse oximetry has been projected as an accurate predictor of fetuses at risk for asphyxia with the significant additional advantage of being a non-invasive technique (4). This communication is intended to highlight the need, advantages and limitations of fetal, pulse oximetry.

Why Fetal Pulse Oximetry?

The search for a reliable technique for intrapartum fetal surveillance still continues(4,5). Electronic fetal heart rate morning (EHRM), the standard technique used to diagnose fetal distress for the last two decades though very sensitive, lacks specificity and positive predictive value(6). Because of the poor specificity, an increased incidence of instrumental deliveries has been noted with no measurable improvement in fetal outcome(4-7). Scalp blood sampling has the disadvantages of being invasive and inconvenient and continuous monitoring is not practicable(4,5). Nevertheless, severe acidemia correlates with an increased incidence of neonatal seizures and hypotonia and appropriate obstetric intervention with the identification of a developing acidosis may reduce the incidence of these complications(8). Continuous fetal transcutaneous oxygen tension ($tcpO_2$) measurements are often inaccurate and only weak correlations noted between $tcpO_2$ and umbilical arterial pO_2(9). Therefore, there exists a need for an exacting modality to identity the at risk fetuses.

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Design of the Fetal Pulse Oximeter

The major changes involved in the design of a pulse oximeter adopted for fetal monitoring are that it is a reflectance pulse oximeter (sensors and light emitting diodes lie in the same plane) and that a specialized probe is needed. Much attention has been paid to the design of an appropriate probe to ensure good apposition to the fetal presenting part. Apart from the difficulty in ensuring good apposition, the other factors which interfere with getting adequate readings of fetal SaO_2, are curly hair and palpable caput (10-12). Johnson *et al* used a 2 cm round silicone cap type probe which attaches to the presenting part by suction (l0). While Gordosi *et al.* (11) used a double clip probe. More recently the Nellcor N-400 fetal oxygen saturation, monitor and FS-10 oxisensor have been developed (13). This oxisensor measures the electrical impedance to determine good apposition in order to ensure that the readings are truly reflective of fetal SaO_2(13,14).

The Nellcor fetal pulse oximeter has been calibrated in the range of 10-100% using data available from fetal sheep. Direct comparison of the measured SaO_2 by pulse oximetry against the actual SaO_2 measured by hemoximeter has shown the limits of agreement (±2 SD) to be ±3.5% - 7.06% (15,16).

Clinical Applications of Fetal Pulse Oximetry

In their initial study, Johnson *et al.* could obtain adequate recording of fetal SaO_2 in only 60% of occasions (86 out of 145 mothers) with uncomplicated labor (l0). They found the mean SaO_2 in early labor ($\leq$5 cm cervix dilation) to be 68% and in late labor ($\geq$9 cm dilation) to be 58%. Gordosi *et al*. (ll) using a double clip probe obtained adequate SaO_2 tracings in 58% of occasions (61 out of 105 labors). They found the mean SaO_2 values in vertex presentation to be 82%. In 3 cases of breech presentation, mean values of SaO_2 were lower at 50-60%. This is in accordance with the physiology of the fetal circulation. Dips in SaO_2 to below 60% preceded the detection of fetal acidemia (pH <7.2, base deficit >10 mEq) in 4 babies. Further mere cardiotocographic abnormalities without acidosis were not associated with SaO_2 alterations which testify to the promise this new modality holds for picking up the fetus at risk. The mean SaO_2 values reported by *Gordosi et al*.(ll) are higher than those reported by Johnson *et al*.(10) which they attributed to the better apposition they obtained with their double clip probe.

Using the refined Nellcor fetal pulse oximeter and oxisensor, Dildy *et al.* could obtain reliable signal in all the study subjects (n=73) during 50% of the time monitored; the mean SaO_2 during labor was 57.9±10.3%(13). In their subsequent study(17), they found the mean SaO_2 in subjects with normal delivery outcome (n=160) to be 50±10% whereas in subjects with abnormal delivery outcome (acidosis or low Apgar score or cesarean section) the mean SaO_2 was 52±11% ($p < 0.01$) and in the subgroup (n=7) with only acidosis or low Apgar score, the mean SaO_2 was 48±15%. It should be noted the metabolic acidosis in instrumented fetal sheep started below an SaO_2 value of 30%(18).

In the setting of fetal cardiac arrhythmias, EFHRT monitoring becomes invalid and uninterpretable. Fetal pulse oximeter has been successfully used in such situations to monitor the fetuses during labor and helped to avoid unnecessary obstetric interventions(18,19). Dildy *et al.* report a fetus with atrial flutter and heart block with a baseline FHR of 70-80 beats/ min monitored by fetal pulse oximeter (SaO_2 range 50%-85%, scalp blood pH=7.31, umbilical artery pH=7.34) leading to a spontaneous vaginal delivery and subsequently electro-cardioverted(19). Audibert *et al.* have reported the successful intrapartum monitoring using Nellcor fetal pulse oximeter in 2 pregnancies complicated by fetal supraventricular tachyarrhythmia (20).

Maternal oxygen therapy has been proposed as a mode of *'in-utero'* resuscitation (5): Fetal pulse oximeter has been used in two studies to evaluate the utility of this therapy. In the study by McNamara *et al.* the fetal SaO_2 jumped from a mean baseline value of 50.1% to 57.3% and 61.17% with 28% and 100% oxygen, respectively administered to mothers with uncomplicated labor for 10 minutes (21). Dildy *et al.* found that 100% oxygen administration to the mother for 20 minutes increased fetal SaO_2 to 64% from 50% whereas 40% oxygen was not effective in increasing fetal SaO_2(22). Thus fetal pulse oximeter could be used as a dynamic non invasive fetal monitoring technique.

The chief advantages of fetal pulse oximeter are its non invasiveness and capability for continuous monitoring. It allows direct assessment of fetal

oxygen status and tissue perfusion thus eliminating false diagnoses of fetal hypoxia. Given the steep fetal oxyhemoglobin dissociation curve, even small changes in pO2 result in wide swings in SaO_2 and hence theoretically fetal pulse oximetry is more sensitive to changes in fetal physiologic status. Hope exists that a stress fetal pulse oximetric test could be evolved to detect fetuses with poor placental reserve(l0).

The wide range of baseline fetal SaO_2 values reported by the different authors may imply that normal fetuses have a wide range of SaO_2 during labor and it is essential to have the baseline trace in each fetus before interpreting a low SaO_2 as abnormal. The problem of improving the design of the probe to facilitate recording of good quality signals at all the time merits urgent consideration. Further, the correlation of low fetal oxygen saturation to the long term newborn outcome and whether intervention based upon fetal SaO_2 improves the long term outcome remain to be established. Direct measurement of fetal cerebral oxygenation using near infrared spectroscopy (MRS) has now been developed(23). Though MRS is very expensive and may not be available for clinical use in the near future, studies could be done correlating the fetal SaO_2 to the cerebral oxygen status to determine the utility of fetal pulse oximetry as an exacting modality for intrapartum monitoring.

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NOTES AND NEWS

PEDIATRIC CONFERENCE OF NORTH INDIA-1996

This event along with one day CME Programme is being hosted by the Indian Academy of Pediatrics-Jammu and Kashmir State Branch on November 15-17, 1996 at the Government Medical College, Jammu. The Registration Fee inclusive of CME on November 15 is Rs. 450/- before September 15, Rs. 550/- till October 31 and Rs. 650/- thereafter. The accompanying members are entitled to a discount of Rs. 100/- and PG students, on production of a certificate from the Head of the Department, to a discount of Rs. 150/- (before September 15) or Rs. 200/-. For further details please contact: Dr. D.F3. Sharma, 34-Danis Gate, (Opp. L. Hans Raj Municipal Park), Jammu Tawi 180 001. Tel: Res: 542372; Office: 547635.

AN UPDATE IN PEDIATRIC EMERGENCIES

This event is being organized by the Department of Pediatrics, PGIMER, Chandigarh with help from visiting pediatricians from U.S. on November 25,1996. The Registration fee is Rs. 200/-. For further information please contact Dr. Sunit C. Singhi, Additional Professor, Department of Pediatrics, PGIMER, Chandigarh 160 012. Tel.: (0172) 542161-68, Extn. 508; Fax: (0172) 540 401.