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Full Length Research Paper

Usefulness fetal heart rate of intrapartum fetal pulse oximetry in clinical decision-making based on cardiotocographic criteria of nonreassuring

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The objective of this study was to quantify the influence of intrapartum fetal pulse oximetry on rates of cesarean delivery motivated by nonreasssuring fetal heart rate. This is an Interventional quasi-experimental single-cohort study of women who fulfilled cardiotocographic criteria for ending labor. The decision whether to allow labor to proceed or to end labor was based on the $FSpO_2$ value. Of the 156 pregnant women who met the cardiotocographic criteria for ending labor, cesarean delivery was used for only 47 based on a protocol for intrapartum fetal monitoring with pulse oximetry. Mean umbilical artery blood pH was 7.20. Intrapartum pulse oximetry for fetuses with nonreassuring fetal heart rate provided information on actual fetal oxygenation status, and led to a lower rate of false positive findings than with cardiotocographic monitoring and hence a reduction in the number of cesarean deliveries due to nonreassuring fetal heart rate.

Key words: Cesarean delivery, fetus, fetal pulse oximetry, electronic fetal monitoring.

INTRODUCTION

During labor, some mechanisms can alter maternofetal homeostasis. When oxygen and nutrient exchange is impeded, fetal asphyxia can occur, that is, gas exchange that can be harmful to the fetus to decreased blood due oxygen, increased CO_2, increased base deficit and decreased pH. If this situation persists, it can lead to irreversible harm to the fetus (Low et al., 1999; Parer et al., 2000). Since most fetuses tolerate brief intervals of asphyxia, thanks to compensatory metabolic mechanisms, healthy term fetuses are compromised only by severe acidosis (Wiberg et al., 2006). The challenge, therefore, is to identify fetuses in which the risk of irreversible lesions necessitates prompt termination of labor.

Fetal pulse oximetry is a noninvasive method for measuring arterial oxygen saturation (SaO_2) in the hemoglobin with optic-based technology. This method, which reflects the amount of oxygen available for fetal metabolism, should make it possible to identify which

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Abbreviations: CTG: Cardiotocographic; **FHR:** fetal heart rate; **$FSpO_2$:** fetal arterial oxygen saturation monitored with pulse oximetry sensor; **IUGR:** intrauterine grown restriction; **NRFS:** nonreassuring fetal status; **NRFHR:** nonreassuring fetal heart rate; **PRM:** premature rupture of membranes; **SaO_2:** arterial oxygen saturation; **ICU:** intensive care unit.

fetuses require intervention, and thus improve the quality of intrapartum fetal monitoring.

The present research was based on the hypothesis that the use of pulse oximetry during labor for fetuses with nonreassuring cardiotocographic (CTG) tracings can identify well-oxygenated fetuses for which labor can be allowed to proceed safely. The aim of the study was to determine whether the use of pulse oximetry can decrease the rate of cesarean deliveries motivated by nonreassuring fetal heart rate (NRFHR) without affecting neonatal outcomes.

MATERIALS AND METHODS

This quasi-experimental intervention study was designed to compare pre- and post-intervention groups, without a control group. The eligible population comprised pregnant women in the Dilation Area of the Obstetrics and Gynecology Department of Virgen de las Nieves University Hospital in Granada (Spain). The exclusion criteria were multiple gestation, presentation other than cephalic, fetal anomalies incompatible with life, imminent delivery, ominous CTG signs, umbilical cord prolapse, placenta previa, premature detachment of the placenta, any vaginal bleeding of unknown cause, and vertically transmissible maternal viral infection.

Initially, we selected women at term gestation in whom labor had begun spontaneously or after induction, with sufficient cervical dilation to insert a fetal pulse oximetry probe, and with CTG patterns compatible with NRFHR, defined as the presence of one or more of the CTG inclusion criteria shown in Table 1.

All women selected were given written and verbal information about the use of pulse oximetry and provided their informed consent. The study was approved by the Clinical Research Ethics Committee of Virgen de las Nieves University Hospital, which authorized the study at this center.

After the appearance of the CTG inclusion criteria was verified, we placed an FS-14B pulse oximetry sensor (Nellcor Puritan Bennett) and began to monitor fetal arterial blood oxygen saturation ($FSpO_2$).

Of the women initially selected, we analyzed the results only for cases in which the CTG criteria for ending labor were met. The CTG criteria for ending labor were CTG patterns which appeared alone or in combination, which persisted for more than 15 min, and which, in the absence of pulse oximetric monitoring or other procedures that are able to provide assurance of fetal wellbeing, would constitute an indication to end labor by the most appropriate method available (Table 2).

After the appearance of the CTG criteria for ending labor, the decision whether to allow labor to proceed or to end labor was made not on the basis of the CTG criteria, but on the basis of the $FSpO_2$ value in accordance with our protocol for intrapartum monitoring with fetal pulse oximetry (Figure 1). According to this protocol, fetuses with an SpO_2 value >30% were considered well oxygenated, and labor was allowed to proceed. An SpO_2 value of <10% was considered an indication for immediate delivery. When SpO_2 was between 10 and 30% for more than 10 min, we evaluated fetal status based on fetal heart rate after scalp stimulation. If this procedure indicated a reassuring fetal status, labor was allowed to proceed; otherwise immediate delivery was indicated.

Sample size was determined in a pilot study with the same design as the main study. The pilot study included 100 pregnant women who fulfilled the inclusion criteria, and the result was a decrease in the rate of cesarean deliveries motivated by nonreassuring fetal status from 12% based only on fetal heart rate to 4% when pulse oximetry criteria were considered together with fetal heart rate. In the light of these results, we determined sample size based on two premises. i) Fetal pulse oximetry would lead to 8% decrease in the rate of cesarean deliveries motivated by risk of NRFHR. ii) Based on an alpha error of 0.05 and a beta error of 0.10 for two-sided tests, the number of cases needed was calculated for paired samples with the Ene 2.0 program (Applied Statistics Service, Autonomous University of Barcelona and GlaxoSmithKline GSK). Based on this calculation, 124 participants were needed to obtain statistically significant results. All statistical analyses were done with the Statistical Package for Social Sciences (SPSS) at the Statistics Department of Virgen de las Nieves University Hospital. A p value of <0.05 was considered significant.

RESULTS

A total of 156 pregnant women who fulfilled the CTG criteria for ending labor were included. Demographic information and data on their obstetric characteristics are shown in Table 3. The fetal pulse oximetry sensor could be successfully placed in all women, and good signal quality was obtained for 69% of the time the sensor was in place.

After the CTG criteria for ending labor had appeared, the decision to finalize labor or allow it to proceed was made based on the SpO_2 value. We found that in 94.9% of the cases, $FSpO_2$ was above 30%, and labor was allowed to proceed. In 2 cases, the pulse oximetry value was below 10%, and labor was ended. In 6 cases, arterial blood oxygen saturation was between 10 and 30%; in 2 cases fetal heart rate increased transitorily in response to scalp stimulation, and labor was allowed to proceed. In 4 cases in which scalp stimulation led to no response, labor was ended.

The use of pulse oximetry for fetal monitoring allowed us to prolong the duration of labor. The mean time elapsed from the appearance of CTG patterns indicative of the need to end labor and the moment of delivery was 156 ± 121 min (range 20-800 min), hence the likelihood

Table 1. Cardiotocographic inclusion criteria.

Inclusion criteria
Baseline FHR value between 100 and 120 beats/min without accelerations >15 beats/min for >15 s
Baseline FHR value <100 beats /min with accelerations
Increased variability >25 beats/min for more than 30 min
Slight to moderate variable decelerations for more than 30 min
Late decelerations (≥1 every 30 min)
Persistent late decelerations for more than 15 min in more than 50% of the contractions
Decreased variability (<5 beats/min for more than 30 min)
Tachycardia >160 beats/min with variability <5 beats/min
Sinusoidal pattern
Variable decelerations with any of the following:
Decreased fetal heart rate to <70 beats/min or decrease to 70 beats/min for more than 60 s
Slow recovery of baseline
Variability <5 beats/min
Tachycardia >160 beats/min
Recurrent prolonged decelerations (≥2 decelerations <70 beats/min for more than 90 s in 15 min)

FHR: Fetal heart rate.

Table 2. Cardiotocographic criteria for ending labor.

Cardiotocographic criteria for ending labor
Persistent delayed decelerations in more than 50% of the contractions
Sinusoidal pattern
Variable decelerations with any of the following:
Decrease in fetal heart rate to <70 beats/min or decrease to 70 beats/min for more than 60 s
Slow recovery of baseline
Variability <5 beats/min
Tachycardia >160 beats/min
Prolonged recurrent decelerations (≥2 decelerations <70 beats/min for more than 90 s)
Decreased variability (<5 beats/min) for more then 60 min
Tachycardia >160 beats/min with variability <5 beats/min for more than 60 min

of vaginal delivery increased.

Of the 156 women whose labor would have ended with cesarean delivery due to NRFHR, only 20.5% of them underwent cesarean delivery because of nonreassuring fetal status. This number reflected a significant decrease ($p < 0.001$) in the rate of cesarean delivery with pulse oximetry compared to the number of cesarean deliveries that would have been required based on CTG criteria alone.

The route of delivery and indications for ending labor are shown in Table 4. There were no complications related to the use of pulse oximetry.

Regarding neonatal outcomes, mean Apgar score at 1 and 5 min was 9/9. Mean umbilical artery blood pH was 7.20, and mean base deficit was −6.3 mEq/L. Other data for neonatal outcomes are summarized in Table 5.

DISCUSSION

The introduction of intrapartum fetal monitoring has led to an increase in the rate of cesarean and operative deliveries indicated for NRFHR. These deliveries could be avoided if a method of intrapartum fetal monitoring were available to identify those fetuses actually at risk

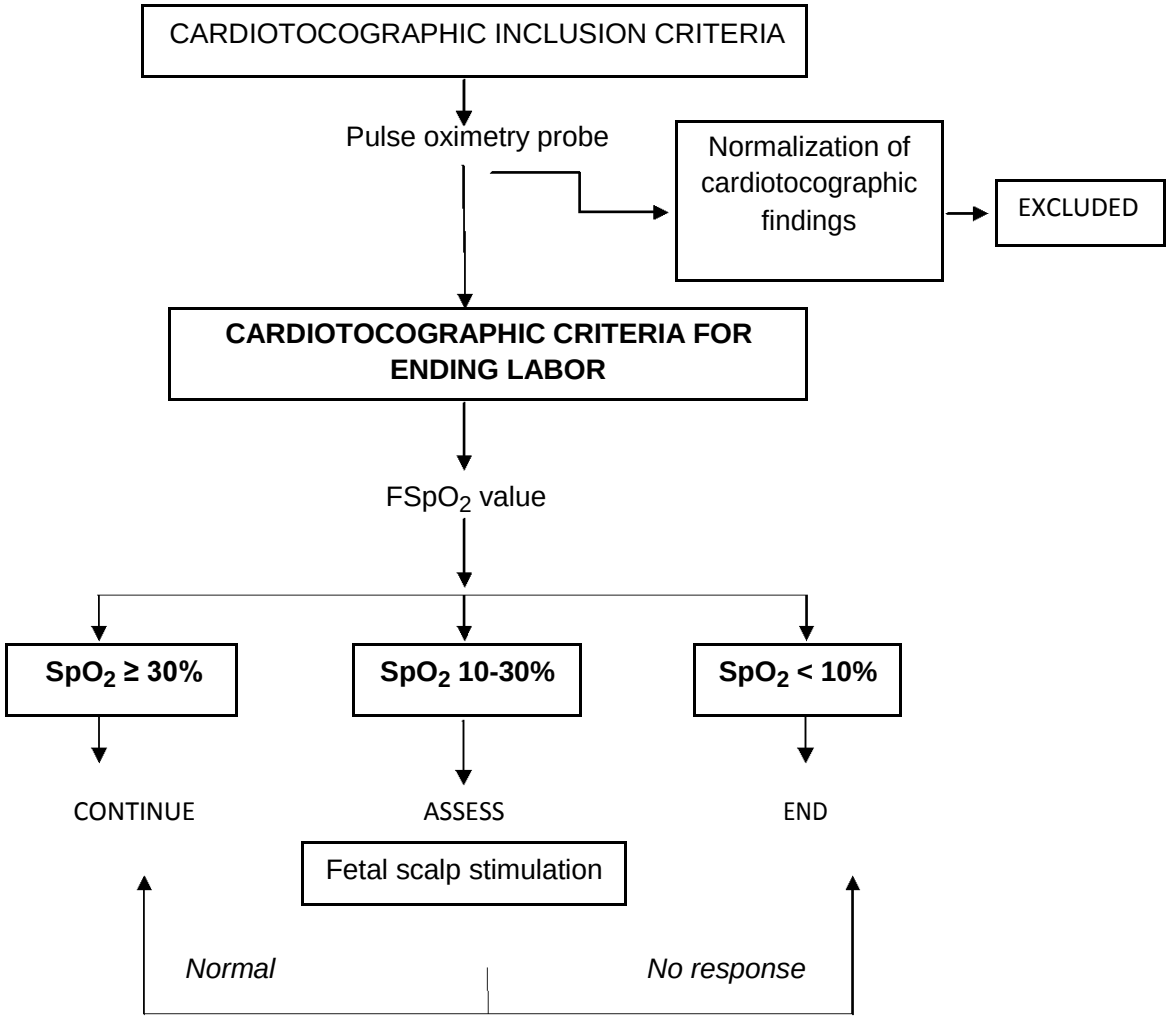

Figure 1. Protocol for intrapartum fetal monitoring with pulse oximetry.

(Puertas, 2004).

Fetal pulse oximetry made it possible for us to allow labor to proceed in many women in our study group. Without this method, we would have been unable to reach this decision unless we had used serial pH determinations. The use of this technique is often associated with issues related to the characteristics of labor, technical difficulties, or lack of the necessary equipment. Some research has found that the positive and negative predictive values are similar for both monitoring methods (Carbonne et al., 1997); as a result, a normal SpO_2 value would obviate the need for many diagnostic and operative interventions (Saling 1996; Nonnenmacher et al., 2010).

The increased duration of labor that pulse oximetry can afford allowed us to reach a decision regarding the finalization of labor and mode of delivery, and in many cases undoubtedly influenced the choice of route of delivery, with the result that vaginal delivery was possible in 109 cases (69.9%).

The mean pH at birth of 7.20 in a population selected on the basis of high risk of NRFHR is an acceptable result, and resorting to cesarean delivery for all women included in our study as soon as they fulfilled the CTG criteria for ending labor was unlikely to have led to better neonatal outcomes. Of the 156 cases that would have resulted in cesarean delivery because of NRFHR, pulse oximetry reduced the need for this mode of delivery to only 47 women, and only 32 of such deliveries were motivated by nonreassuring fetal status. This represents an 80% reduction in the rate of cesarean deliveries that would have been done for NRFHR; moreover, 35% were normal vaginal deliveries. These data support the findings of randomized clinical trials published to date (Garite et al., 2000; Kuhnert et al., 2004; East et al., 2007), which reported that pulse oximetry achieved a

Table 3. Demographic and obstetric characteristics of the women included in this study.

Mother's age (years)	32 ± 5*
Parity	
Primipara	71.2%
Multipara	28.8%
Gestational age (days)	280 ± 9.7
Onset:	
Spontaneous	57 cases (36.5%)
Induced	99 cases (63.5%)
Indication for induction:	
PRM	38 (38.4%)
Oligoamnios	13 (13.1%)
Maternal pathology	10 (10.1%)
Postterm gestation	14 (14.1%)
IUGR	3 (3%)
Other	21 (21.2%)
Epidural analgesia	92.3%
Amniotic fluid :	
Clear	99 (30.1%)
Meconium +	27 (17.3%)
Meconium ++/+++	20 (12.8%)
Amnioinfusion	40 (32%)
Dilation	4 ± 1.7 cm
SpO_2 values:	
Maximum	57.4 ± 11.06
Mean	39 ± 7.8
Minimum	21.05 ± 9.9

*Values are the mean ± standard deviation or number and percentage (in parentheses);
IUGR: intrauterine growth restriction. PRM: Premature rupture of the membranes.

Table 4. Mode of delivery and indications for ending labor.

Mode of delivery	**n (%)**
Spontaneous	54 (34.6%)
Assisted vaginal birth	
NRFS	31 (19.9%)
Shorten phase 2	21 (13.5%)
Nonprogression of labor	3 (1.9%)
Total	55 (35.2%)
Cesarean delivery	
NRFS	32 (20.5%)
Failure of induction	1 (0.6%)
Nonprogression of labor	14 (8.9%)
Total	47 (30.1%)

NRFS: Nonreassuring fetal status.

Table 5. Neonatal outcomes.

Fetal sex:	
Male	85 (54.5%)*
Female	71 (45.5%)
Fetal weight	3230 ± 511 g
Mean Apgar score:	
1 min	9
5 min	9
Apgar <4 at 1 min (n)	1 (0.6%)
Apgar <7 at 5 min (n)	5 (3.2%)
Arterial pH	7.20 ± 0.1
Arterial pH<7.20	61 (39.1%)
Arterial base deficit	−6.3 ± 5.1
Venous pH	7.25 ± 0.09
Venous base deficit	−4.7 ± 5.0
Type V resuscitation (n)†	1
ICU admission (n)	1 (0.6%)

*Values are the mean ± standard deviation or number and percentage (in parentheses);
†Type V resuscitation: medication required to resuscitate the fetus;
ICU: Intensive care unit.

reduction in the rate of cesarean deliveries done because of nonreassuring fetal status. However, these studies did not report an overall reduction in the rate of cesarean deliveries, since the number of such deliveries motivated by nonprogression of labor increased in the group monitored with this method.

When pulse oximetry is not used, considerable numbers of cesarean deliveries are done because of NRFHR, and these cases may disguise the occurrence of cephalopelvic disproportion. Pulse oximetry can help distinguish between the two indications without affecting neonatal outcomes, since in cases with cephalopelvic disproportion, SpO_2 values remain within normal limits and neonatal outcomes are favorable. In addition, avoiding an urgent cesarean delivery done because of the suspicion of nonreassuring fetal status has implications for clinical practice since it can reduce maternal stress levels, and also has implications for health care providers (East et al., 2006). However, these results were not supported by the largest trial done to

date (Bloom at al., 2006), which found low SpO_2 values in 25% of the fetuses with both normal CTG patterns and 35% of those with noreassuring CTG patterns.

Our quasi-experimental study design has limitations that need to be considered. The choice of this design was based on our aim to document the usefulness of pulse oximetry in ordinary clinical practice, with an approach somewhat different from those used to date. We analyzed the effect of an intervention (pulse oximetry) used in a group of nonrandomly selected women for whom a cesarean or other instrumental delivery would have been done according the "classical" decision-making process based on CTG criteria. Despite the potential methodological limitations of this approach, our results suggest that the use of pulse oximetry in clinical practice is an effective procedure in reducing the rate of cesarean deliveries motivated by NRFHR without increasing the occurrence of metabolic compromise due to fetal acidosis.

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