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CLINICAL STUDY

Correlation between fetal blood oxygen saturation and umbilical blood pH values

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Abstract: *Aim:* The aim of the study was to find out whether there is correlation between the fetal blood oxygen saturation values detected by intrapartum fetal pulse oximetry and the umbilical blood pH values taken postpartum, and what is the effect of intrapartum fetal pulse oximetry on the mode of delivery.
Background: Seventy six women were examined in the study.
Methods: Intrauterine fetal well-being was monitored with cardiotocography equipment (FC 700), intrapartum fetal pulse oximetry (Nellcor OxiFirst, TYCO Inc, Pleasanton, CA), and the neonatal umbilical blood pH values were taken postpartum using an acid-base analyzer (AVL Compact 3).
Descriptive statistics, Shapiro-Wilk normality test, Spearman rank correlation test and Mann-Whitney test were used for statistical data processing.
Results: The study results showed a highly significant correlation between the fetal blood oxygen saturation values and the neonatal umbilical blood pH values (rS=0.54; p<0.0001), and between the fetal blood oxygen saturation values and Caesarean section rate (rS= -0.68; p<0.0001).
Conclusion: In the light of the results of the study the authors recommend monitoring the fetal status using intrapartum fetal pulse oximetry in cases of non-reassuring or pathological cardiotocography, which allows a significant reduction in the Caesarean section rate for an imminent fetal hypoxia *(Tab. 5, Fig. 1, Ref. 17)*. Full Text (Free, PDF) *www.bmj.sk.*
Key words: intrapartum fetal pulse oximetry, Caesarean section, saturation.

Monitoring of the intrauterine fetal status is an essential diagnostic and reassurance method indispensable in modern obstetrics. Intensive obstetrical care is based on the knowledge that the main element of perinatological pathology is hypoxia or fetal and neonatal asphyxia, and it is the most frequent indication for an operative delivery. An early detection of intrauterine fetal distress during labor gives sufficient reserve to take efficient measures and lowers the rates of overall perinatal mortality as well as of intrapartum and postpartum neonatal morbidity. There are several examination methods permitting detection of fetal hypoxia in labor. It is the fetal intrapartum pulse oximetry, in combination with cardiotocography (the most conventional methods of intrapartum monitoring), which permits a more accurate diagnosis of an imminent fetal hypoxia (1).

That method was developed on the basis of oximetry, which means measuring oxygen saturation of hemoglobin. It is a non-invasive, continuous method based on Lambert-Beer relationship between light transmittance and optic density where light transmittance is a logarithmic function of density or absorbent concentration. Pulse oximetry measures the frequency of light transmitted through tissues with two different light wave lengths. Oxygenated hemoglobin absorbs relatively more infrared light and deoxyhemoglobin absorbs more red light. Light emitting diodes transmit light through tissues with vascular bed, and a photo detector on the other side measures light which is transmitted through tissue and not absorbed by oxyhemoglobin or by deoxyhemoglobin. These measurements enable determination of hemoglobin oxygen saturation. For the photo detector to be able to discern between the two wavelengths, the diodes emit light at intervals, thus generating independent measurements about 1000x per second. The equipment ignores effects from non-pulsatile tissues, yet monitors light absorption in arterioles. The measured values are then converted to values of hemoglobin oxygen saturation. The principle, however, is based on transmittance which is hard to use for monitoring of intrapartum fetal oxygen saturation. For that reason reflection sensors working on the principle of measurements of light reflected from tissues were developed. The amount and wave length of the reflected light are used to determine hemoglobin oxygen saturation. Reflection oxysensors are about 6 cm long, 1 cm wide and 2 mm thick. Their surface is smooth and non-traumatizing. The sensor contains a photo detector, electrodes, and red and infrared light emitting diodes (2).

Women in the first stage of labor were monitored using cardiotocography in our study. Fetal blood oxygen saturation

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Tab. 1. Entire group (n=76).

	Age (Yrs)	Gestational week	CTG prior to SpO_2	SpO_2 (%)	pH
Median	29	40	7.00	40.00	7.23
95 % CI of Median	(28; 30)	(40; 41)	(6.00; 7.00)	(40; 50)	(7.19; 7.25)

Note: SpO_2 — fetal oxygen saturation, CTG — cardiotocography

Tab. 2. Group A (n=45).

	Age (Yrs)	Gestational week	CTG prior to SpO_2	SpO_2 (%)	pH
Median	29	40	7.00	50.00	7.26
95 % CI of Median	(27; 30)	(40; 41)	(6.00; 7.00)	(40; 50)	(7.24;7.27)

using fetal pulse oximetry during labor was measured in patients who had a presumed history or an actual history of a pathological cardiotocography resulting in a Caesarean section. The values were correlated with pH of neonatal umbilical blood sampled immediately after birth. We also wanted to find out whether a combination of the concerned methods has an effect on Caesarean section delivery rate.

Material and methods

The study includes seventy-six women who gave birth at the 2nd Clinic of Gynecology and Obstetrics of the University Hospital with Polyclinic of the Medical Faculty of the Comenius University, Ružinov Hospital, from January 2006 to December 2008. Only single gestation women were eligible for inclusion in the study. Intrauterine fetal status was monitored with the cardiotocography equipment (FC 700) and intrapartum fetal pulse oximeter (Nellcor OxiFirst, TYCO Inc, Pleasanton, CA), the umbilical blood pH values were determined using the acid-base analyzer (AVL Compact 3). The age of women, gestational age, pregnancy, parity, neonatal umbilical blood pH and the mode of delivery were recorded. Cardiotocographic recordings made prior to intrapartum fetal pulse oximetry were assessed by FIGO classification. Descriptive statistics, Shapiro-Wilk normality test, Spearman rank correlation test and Mann-Whitney test were used for statistical data processing. All data are expressed as medians and their 95 % confidence intervals (CI).

Results

The age of women in the entire group (n=76) was 29 (28; 30) years, the fetal oxygen saturation [%] was 40.00 (28; 41); umbilical blood pH was 7.23 (7.19; 7.25) (Tab. 1). A significant correlation between the fetal oxygen saturation values and the umbilical blood pH values [rS=0.54 (0.35; 0.68); p<0.0001] (Fig. 1) and between the fetal oxygen saturation values and Caesarean section rate [rS=-0.68(-0.78; -0.53); p<0.0001] was found. A highly significant correlation between the CTG values and fetal blood oxygen saturation values [rS=0.46 (0.26; 0.62); p<0.0001] was observed.

Women were then divided into the two groups depending on fetal oxygen saturation values. Group A consisted of women whose fetal oxygen saturation was 30 % and higher (n=45). The age of women in the group A was 29 (27; 30) years with a gestational age of 40 (40; 41) weeks. Primiparas represented 62.222 % (nAP=28). The fetal oxygen saturation value was 50.00 (40; 50) %. The neonatal blood pH value was 7.26 (7.24;7.27), CTG was 7.00 (6.00; 7.00) points (Tab. 2). A statistically significant correlation was found in this group between the fetal oxygen saturation values and the umbilical blood pH values [rS=0.33 (0.04; 0.57); p<0.0253], nA=37, i.e. 82.222 %. However, the relationship between the CTG and fetal blood oxygen saturation [rS=0.03 (-0.27; 0.32); p<0.859], and the relationship between fetal blood oxygen saturation and Caesarean section [rS=-0.2 (-0.47; 0.10); p=0.191], was statistically insignificant. Group B involved women whose fetal blood oxygen saturation values were less than 30 % for 10 minutes and longer (n=31). The age of women in this group was 29 (27; 30) years with a gestational age of 40 (40; 41) weeks. Primiparas represented 58.064 % (nBP=18) of the group. The fetal blood oxygen saturation was 25 (18; 26) %, the blood pH was 7.17 (7.13; 7.20), the CTG value was 6.00 (5.00; 7.00) points (Tab. 3). A non significant correlation was found

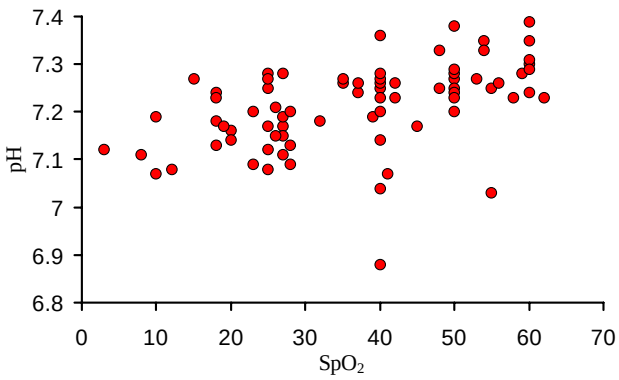

Fig. 1. Correlation between fetal blood oxygen saturation and umbilical blood pH.

Tab. 3. Group B (n=31).

	Age (Yrs)	Gestational week	CTG prior to SpO_2	SpO_2 (%)	pH
Median	29	40	6.00	25	7.17
95% CI of Median	(27; 30)	(40; 41)	(5.00; 7.00)	(18; 26)	(7.13; 7.20)

Tab. 4. Group C (n=37).

	SpO_2 (%)	pH
Median	25.00	7.19
95% CI of Median	(23; 27)	(7.15; 7.24)

Tab. 5. Group D (n=39).

	SpO_2 (%)	pH
Median	50.00	7.25
95% CI of Median	(41; 50)	(7.23; 7.27)

between the fetal blood oxygen saturation values and umbilical blood pH values [(rS=0.22 (-0.31; 0.39); p<0.240], nB=21 i.e. 67.743 %, or between the fetal blood oxygen saturation values and Caesarean section [rS=-0.05 (-0.31; 0.39); p<0.8067]. Yet, there was a highly significant correlation between the CTG values and fetal blood oxygen saturation values [rS=0.60 (0.31; 0.79); p<0.0004].

Comparisons of the fetal blood oxygen saturation values (SpO_2), pH values or CTG values showed a highly significant difference between the two groups (SpO_2A vs SpO2B: p<0.0001; pHA vs pHB: p<0.0001; CTGA vs CTGB: p<0.0005, respectively). In the Caesarean section rates, there was a statistically significant difference between the two groups (A vs B, p<0.0001). That means Caesarean section rate was 17.777 %, nASC=8 in group A. Cesarean section was in all cases performed for failure to progress in the first or the second stage of labor. The Caesarean section rate in the group B was 93.548 %, nBSC=29. In the remaining two cases delivery was concluded per forcipem sec. Simpson.

The entire group of women was subsequently divided into the two groups depending on the Caesarean section. Group C (Tab. 4). involved women who had a Caesarean section, nC=37. A statistically significant correlation was found in that group between the fetal blood oxygen saturation values and the umbilical blood pH values [rS=0.40 (0.09; 0.64), p<0.0123]. In the group D (Tab. 5) were women with vaginal delivery, nD=39. Also in this group a highly significant correlation between the fetal blood oxygen saturation values and the umbilical blood pH values [rS=0.45 (0.15; 0.67), p<0.0044] was observed.

Discussion

The authors of the study proved that in the entire group (n=76) there was a highly significant correlation between the fetal blood oxygen saturation values and the umbilical blood pH values or between the fetal blood oxygen saturation values and Caesarean section rate. In the group with fetal blood oxygen saturation levels higher than 30 % the umbilical blood pH values were 7.2 in 82.222 %, nA=37. In the group where the fetal blood oxygen saturation values were below 30 %, the umbilical blood pH values were <7.2 in 67.743 %, nB=21. In the entire group of 76 women, 37 Caesarean sections were performed, i.e. 48.684 %. In 8 cases, Caesarean section was indicated for failure to progress in the first or second stage of labor. After the exclusion of these patients, the total Caesarean section rate decreased to 38.158 %.

Saling (3) stated in his study that if the fetal blood oxygen saturation is higher than 30 %, the fetal oxygen saturation can be considered adequate. Carbone et al (4) in contrast, claimed in their study that the umbilical blood pH values did not go below 7.2 as long as the fetal blood oxygen saturation is higher than 40 %. Studies in animals conducted by Alshimmiri et al (5) showed that metabolic acidosis did not develop as long as the fetal blood oxygen saturation was higher than 30 %. The pH decreases only when the fetal blood oxygen saturation falls below 30 % for a longer time – several hours. Seelbach-Gebel et al (6) stated a significant negative relationship between the duration of the fetal blood oxygen saturation below 30 % and postpartum pH in a. and v. umbilicalis. Authors of other studies proved a decrease in umbilical blood pH by 0.02 per 10 minutes in ongoing fetal blood oxygen saturation below 30 %. Acid-base equilibrium changes, which mean the pH below 7.2, go with gradually decreasing fetal blood oxygen saturation below 30 % (7, 8, 9, 10). A rapid decrease in fetal blood oxygen saturation below 20 % for more than 2 minutes is an alarming condition. Such decrease, when it occurs within a 2 minute interval, has no effects on acidic-basic equilibrium in the fetus (6, 11, 12). Certain authors recommend Caesarean section without introduction of intrapartum fetal pulse oximetry in the case of a severe deceleration (less than 70 beats per minute) for longer than 5 minutes (13). Certain authors, on the other hand, are inclined to recommend monitoring of the intrauterine fetal condition using intrapartum fetal pulse oximetry, thus strongly reducing the Caesarean section rate for imminent fetal hypoxia (14, 15, 16). Rijnders et al (17), however, did not confirm a significant correlation between the umbilical blood pH values and fetal blood oxygen saturation values in their study and for that reason did not recommend introducing intrapartum fetal pulse oximetry to clinical practice.

Conclusion

In the light of the results, in cases of non-reassuring or pathological cardiotocography, monitoring the fetal condition using

intrapartum fetal pulse oximetry is recommended, allowing thereby a reduction of Caesarean section rate for an imminent fetal hypoxia.

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