CEREBRAL REGIONAL OXYGEN SATURATION OF THE NEONATE DURING THE TRANSITION TO EXTRAUTERINE LIFE

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Abstract

Currently, the use of pulse oximetry in the delivery room is accepted. The normal values of oxygen peripheral arterial saturation (SatO2) have been established in the first 10 minutes of life. Current methods of neonatal monitoring only objectively assess the cardiorespiratory status and peripheral oxygenation. Neonatal cerebral status is not yet evaluated objectively during the transition to extrauterine life. Near Infrared Spectroscopy (NIRS) allows the assessment of cerebral function by measuring oxygen at this level.

Objectives. In the presented study we propose to evaluate the reliability of this newborn monitoring in the delivery room and to establish the normal regional saturation (rcSO2) values in the first 10 minutes of life.

Material and method. Newborns with gestational age over 36 weeks were analyzed, normal pregnancy development, no complications at birth (a video extractor or forceps application) and uncomplicated adaptation to extrauterine life. Neonatal cerebral saturation was measured by NIRS by application of sensors in the frontal cerebral area and the cerebral oxygen extraction fraction (cFTOE) was calculated in the first 10 minutes of life following the formula: FTOE = (SatO2 - rcSO2) / SatO2.

Results. 74 newborns were analyzed, of which 28 were naturally born and 46 were by caesarean section. All newborns showed a gradual increase of regional brain saturation (rcSO2) parallel to SpO2 from an average of 35.8% (15.0%-62.0%) to 1 minute at 65.3%, 3% (46%-85%) at 5 minutes and reaching peak values of 76.8% (66.7% -87.4%) at 10 minutes of life.

Conclusions. Cerebral oxygen saturation is an ascending trend in the first 10 minutes. Real-time monitoring of this cerebral neonatal saturation can optimize oxygen therapy and management of neonatal reanimation in the delivery room, avoiding both hyperoxemia and hypoxemia.

Rezumat: Saturaţia de oxigen regională cerebrală a nou-născutului la termen în timpul tranziţiei la viaţa extrauterină

În prezent este acceptată utilizarea pulsoximetriei în sala de naşteri. Au fost stabilite valorile normale ale saturaţiei periferice arteriale de oxigen (SatO2) ale nou-născutului în primele 10 minute de viaţă. Metodele actuale de monitorizare neonatală evaluează obiectiv statusul cardiorespirator şi oxigenarea periferică. Statusul cerebral neonatal nu este încă evaluat obiectiv în perioada de tranziţie la viaţa extrauterină. Spectroscopia cu lumină infraroşu apropiată (NIRS – Near InfraRed Spectroscopy) permite evaluarea funcţiei cerebrale prin măsurarea oxigenării la acest nivel.

Obiective. În studiul prezentat ne propunem evaluarea fiabilităţii acestei monitorizări a nou-născutului în sala de naşteri şi stabilirea valorilor normale ale saturaţiei regionale cerebrale (rcSO2) în primele 10 minute de viaţă.

Material şi metodă. Au fost analizatii nou-născuţi cu vârsta de gestaţie peste 36 de săptămâni, dezvoltare normală în sarcină, fără complicări la naştere (aplicaţie de vidextractor sau forceps) şi adaptare normală la viaţa extrauterină. S-au măsurat prin tehnica NIRS saturaţia cerebrală neonatală prin aplicarea senzorilor în aria cerebrală frontală şi s-a calculat fracţia de extracţie a oxigenului la nivel cerebral (cFTOE) în primele 10 minute de viaţă după formula: FTOE = (SatO2 - rcSO2) / SatO2.

Rezultate. Au fost analizatii 74 de nou-născuţi, dintre care 28 născuţi pe cale naturală şi 46 prin cezariană. Toţi nou-născuţii au prezentat creşterea treptată a saturaţiei regionale cerebrale (rcSO2) paralelă cu SpO2 de la o medie de 35,8% (15,0%-62,0%) la 1 minut la 65,3% (46%-85%) la 5 minute şi ating pe valorile maxime de 76,8% (66,7%-87,4%) la 10 minute de viaţă.
**Introduction**

The use of pulse oximetry in the delivery room is accepted and the normal values of SatO2 have been established for the first 10 minutes of life. However, there are still controversies over the effects on short and long term after neonatal resuscitation using these ranges of SatO2. The brain is one of the most vulnerable organ to hypoxia and ischemia during neonatal transition. This is why the interest over the monitoring of the brain status after birth has recently grown. Cerebral status in the delivery room is now performed by 3 methods: transfontanelar ultrasound which evaluates the brain flows, NIRS assessment for cerebral oxygenation, and EEG with integrated amplitude that evaluates the brain electrical activity. Ultrasound in the delivery room is difficult to achieve due to newborn movements, and aEEG is still difficult to perform immediately after birth due to the complexity of applying the electrodes. Cerebral NIRS was immediately performed postnatally to determine the dynamics of neonatal rcSO2 in the first minutes of life. To establish an modern oxygen therapy guide for the neonatal resuscitation, based also on rcSO2 is useful and important in order to prevent the effects of hypoxia or hyperoxia.

**Objective.** In the present study, we aim to determine the normal values of crSO2 and cFTOE in the first 10 minutes of life, on neonates who did not require medical support at birth, and to identify the fetal or maternal factors that can occur during labor or expulsion and can influence these parameters.

**Material and method**

A prospective study was conducted at the Neonatology Clinic of INSMC Alessandrescu-Rusescu between March 2014 and August 2017. The study was approved by the Local Ethics Committee. A parental written consent was obtained before birth.

Inclusion criteria of patients were: gestational age (GA) over 37 weeks, and normal pregnancy development. The group has been splitted depending on the way of birth on two lots: vaginal or caesarean section.

Exclusion criteria were: the need for respiratory support or oxygen therapy in the first 10 minutes of life, suspected or known brain malformations, or birth complications (e.g. vacuum extraction or forceps application).

Measurements of crSO2 were made with INVOS 5100C (COVidiEN, Mansfield, MA, USA) by placing a neonatal brain sensor on the left frontal area. At the same time, SaO2 was measured by a Masimo SET pulse oximeter (Masimo Coorporation, Irvine, CA, USA) by applying a preductal pulse oximetry sensor in the right hand. The measurements were recorded in the first 10 minutes of life. Blood gas analysis and acid-base balance were performed from umbilical cord blood. All newborns were clinically observed and evaluated during this period by a neonatologist, and clinical status was assessed by Apgar score at 1, 5 and 10 minutes of life. The cFTOE was also calculated during the first 10 minutes of life following the formula: FTOE = (SatO2-rcSO2) / SatO2.

The statistical analysis was performed with the IBM SPSS Statistics 21 software.

**Results**

We analyzed 74 newborns, 28 of them were vaginally delivered and 46 of them were born by caesarean section. The group of those born vaginally
was characterized by an average GA of 38 weeks and 5/7 days (37-40 week), a mean birth weight (BW) of 3250 g (2700 g-3920 g), and an Apgar score (AS) of 9. The group of those extracted by caesarean section had an average GA of 38 weeks and 3/7 days (37-41), a BW of 3404 g (2740-4500 g), and the Apgar Score was 9.

Due to the delay in sensor capture time, both rcSO2 and SaO2 were measured starting from 1 minute of life. All newborns had heart rate over 100 beats / minute.

1. Postnatal cerebral oximetry determination (rcSO2 and cFTOE)

All newborns showed a gradual increase (see Figure 1) of rcSO2 simultaneously with the rise of SatO2, from an average of 35.8% at 1 minute, 65.3% at 5 minutes and reaching a peak value of 76.8% at 10 minutes of life (see Table no.1). Cerebral tissue extraction fraction of the oxygen had a downward evolution in the first ten minutes of life as it can be seen in Figure 2. The absolute values are shown in Table no. 1.

2. Mode of delivery and postnatal cerebral oxygenation

Assessing the cerebral oxygenation regarding the mode of delivery, newborns from the vaginal delivery group compared to those extracted by caesarean section had the rcSO2 significantly increased at 1 minute, 46% versus 27% (p <0.001) and at 5 minutes, 71% versus 64% (p = 0.075), as it can be seen in Table no.2. The elevated value of rcSO2 from the vaginal births, however, is not associated with a significant increase of SatO2. Therefore, it confirms that rcSO2 is not determined exclusively by the partial arterial pressure of O2. Cerebral oxygenation also depends on other factors such as oxygen intake, which in turn is influenced by cerebral blood flow (CBF). A significant decrease of the pulsatility index of the middle cerebral artery was observed in the first 4 minutes of life and this fact has evidenced an increase of CBF [1,2]. Immediate analysis of postnatal acidobase balance from the umbilical artery had revealed a decreased pH, 7.30 vs. 7.35 from vaginal birth versus caesarean birth (p = 0.075). In addition to this, the partial pressure of oxygen (pO2) is also lower, having values of 21.4 vs 23.9 mmHg (p = 0.089). Moreover, the partial pressure of carbon dioxide (pCO2) is statistically significant ranging between 52.6 vs. 42.9 mmHg (p = 0.007). Despite the fact that many biochemical factors of the neonate have cerebral vasodilatory effect, only the pCO2 is significantly involved in this process, as CO2 is the most effective cerebral vasodilator agent. Fetal CO2 increases in labor, respectively in case of vaginal delivery causing a fetal cerebral vasodilatation during expulsion and a
consequent increase in fetal cerebral blood flow and volume. This results in an increased hemoglobin level and, implicitly, higher values of rcSO2 in the first few minutes of life namely in vaginal delivery unlike the caesarean section.

Cerebral FTOE is significantly increased in neonates born by caesarean section at 1 minute of life 0.51 vs 0.2 (p < 0.001) and at 5 minutes of life 0.23 vs 0.19 (p = 0.008).

3. Other factors that affect brain status

Cerebral status is defined by four major cerebral parameters: a) cerebral intake, which depends on cerebral blood flow and intracranial pressure; b) cerebral oxygenation that is determined by oxygen arterial blood flow, circulating hemoglobin and cerebral blood flow; c) energetic and oxidative brain metabolism; and d) electrical cerebral activity. All of these factors are interdependent and are influenced by different biochemical, or mechanical / presional factors.

The role of pH in cerebral circulation was investigated comparing an analysis of a group without acidosis (defined by a pH in the umbilical artery above 7.20) and consisting of 55 term newborns, with a group of 11 newborns characterized by moderate perinatal acidosis (defined by a pH between 7.00 and 7.20 in the umbilical artery). Regional cerebral SO2 was increased in the first minute of life, but also insignificant in the case of moderate acidosis (35.5 vs. 39.8, p = 0.065). Simultaneously, SatO2 is significantly increased in the acidosis group (70.6 vs. 61, p = 0.005) although pO2 is significantly decreased in the same conditions (23.2 vs 17.5 mmHg). In the following minutes of life for both rcSO2 and SatO2 the differences were insignificant.
Table 2. rcSO2 of term newborns born via vaginal delivery (V) as compared to those delivered by caesarean section (C)

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<tr>
<th></th>
<th>rcSO2 1 min</th>
<th>rcSO2 5 min</th>
<th>rcSO2 10 min</th>
<th>FTOE 1 min</th>
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Fig 3. rcSO2 and acid-base balance

A partial blood pressure of CO2 over 60 mmHg is associated with a significant increase in rcSO2 in the first minute of life (32.2 vs 43.1, p = 0.020), as it is shown in Figure 3. Moderate acidosis, characterized by a base deficiency between -12 and -8 mmol/L, was not associated with a postnatal significant modification of rcSO2. The partial blood pressure of O2 does not influence fetal rcSO2. Brain status is significantly affected by pCO2 when its higher than 60 mmHg, whereas a pH between 7.0 and 7.2, a base deficit below 8 mmol/L or the pO2 does not have an impact on it. Measurements of fetal rcSO2 in the second stage of labor shows a slightly decrease in the last 30 minutes (in vaginal delivery), having a minimal value during expulsion and then, a gradual increase, postexpulsion, in the first 10 minutes [3,4]. Previous studies highlight a good fetal head protection during contractions and expulsions, for instance by direct measurements of intracranial and intraamniotic pressure on human fetuses with life-threatening hydrocephalus [5,6], and by indirect measurements, like cerebral flow, cerebral oxygenation, and fetal brain electrical activity. As a result, in the second stage of birth, during contraction or expulsion, the increased brain blood volume [6] and EEG background trace [7,8] are within normal limits. The physiologic decline of fetal rcSO2 in vaginal delivery is not caused neither by mechanical factors compressing the fetal cephalic area, nor by effects on cerebral flow of the metabolic biochemical factors. For this reason, the utero-placental oxygen intake must be studied unsing fetal pulse oximetry and cerebral metabolism.
Cerebral regional oxygen saturation of the neonate during the transition to extrauterine life

Taking into consideration the persistent controversy over the target values of peripheral oxygen saturation [9] and determining rcSO2 values at birth, we can guide oxygen therapy during the period of transition at extraterine life, therefore reducing the risk of hypo or hyperoxia [10].

Conclusions

Cerebral oxygen saturation of term newborns has an ascending trend in the first 10 minutes of life, ranging from 35.5% at 1 minute to 77.1% at 10 minutes. Reflecting the cerebral metabolic rate, the FTOE has a downward trend after birth from 0.42 at 1 minute of life to 0.19 at 10 minutes of life. The mode of delivery significantly influences rcSO2 and FTOE in the first 5 minutes of life. Regional cerebral SO2 is significantly higher, and respectively FTOE is significantly lower in the first 5 minutes of life, in newborns form vaginal delivery compared to those extracted by caesarian section. Increased blood pressure of CO2 is associated with increasing rcSO2 in the first few minutes of life.

References

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