Journal of Pediatric Surgery xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Cerebral, renal and mesenteric regional oxygen saturation of term infants during transition

Paolo Montaldo [a,*], Chiara De Leonibus [b], Lucia Giordano [b], Massimiliano De Vivo [b], Paolo Giliberti [b]

[a] Department of Pediatrics, Second University of Naples
[b] Department of Neonatal Intensive care, Monaldi Hospital, Naples, Italy

ARTICLE INFO

Article history:
Received 13 September 2014
Received in revised form 6 April 2015
Accepted 7 April 2015
Available online xxxx

Key words:
Near-infrared spectroscopy
Newborn infant
Oxygen/metabolism
Oxygen/blood
Brain/metabolism
Splanchnic circulation
Kidney/metabolism

ABSTRACT

Objective: To measure cerebral regional oxygen saturation ($CrSO_2$), renal regional oxygenation saturation ($RrSO_2$) and mesenteric tissue regional oxygen saturation ($MrSO_2$) during immediate transition and continuously for the first 9 hours of age. Fractional tissue oxygen extraction of the brain (CtFOE), kidneys (RtFOE), splanchnic tissue (MtFOE) were also assessed.

Study design: Prospective, observational study of 61 term infants, delivered by elective caesarean section. Using near-infrared spectroscopy, changes in $CrSO_2$, $RrSO_2$, $MrSO_2$ and changes in CtFOE, RtFOE and MtFOE were measured all through the first 9 hours of life. All the episodes of feeding during this period were recorded.

Results: Mean $CrSO_2$ increased quickly to 7 minutes, with no further changes. On the other hand, mean $RrSO_2$ and mean $MrSO_2$ increased for 10 minutes and thereafter they remained on their newly reached level. $RrSO_2$ and $MrSO_2$ were significantly lower at 3-4-5-6-7 minutes of life compared to the $CrSO_2$ ($p < 0.05$). RtFOE and MtFOE were significantly higher at 3-4-5-6-7 minutes of life compared to the CtFOE ($p < 0.05$). During feeding, $CrSO_2$, $RrSO_2$ and $MrSO_2$ did not significantly change.

Conclusions: During early adaptive period, oxygen delivery is preserved to 'vital' organs, like brain, at the expense of kidneys and splanchnic tissue. Term infants can provide for the increasing metabolic activity of the intestinal tract during feeding periods without compromising oxygenation.

The transition to life after birth is characterized by major physiological changes in the respiratory and hemodynamic function. These changes are predominantly initiated by breathing at birth and clamping of the umbilical cord. Many studies have shown that, during post-natal transition, there is a slow rise in peripheral oxygen saturation (SpO_2) in healthy term and pre-term infants [1–3]. Newborns, in fact, need more than 5 minutes to reach a SpO_2 value >80% and nearly 10 minutes for a value of 90% [1–3].

Meeting oxygen demand of the tissues with oxygen delivery represents one of the key functions of the cardiovascular system. Near-infrared spectroscopy (NIRS) measures the regional oxygen saturation (rSO_2) of various organs (brain, kidney, liver, muscle, and others) and provides a reflection of the balance between tissue oxygen supply and demand [4].

There is currently a keen interest in hemodynamic transition at birth.

Fetal to neonatal transition is generally defined as the first 15 minutes after birth, starting when newborns take their first breaths, thus initiating major physiological respiratory and hemodynamic changes [5], even though the whole neonatal transition is considered as spanning over the first 24–48 post-natal hours [6].

So far, many studies have assessed cerebral regional tissue oxygenation during post-natal transition [7–10] but there remains the question about what happens in the low-priority vascular beds of both kidneys and mesenteric tissue.

The aim of this study was to measure cerebral regional oxygen saturation ($CrSO_2$), renal regional oxygen saturation ($RrSO_2$), mesenteric tissue regional oxygen saturation ($MrSO_2$) during neonatal transition. Fractional tissue oxygen extraction of the brain (CtFOE), kidneys (RtFOE), splanchnic tissue (MtFOE) were also assessed. Furthermore, the study assessed whether there was any difference in these values during the periods of rest and feeding.

For the purpose of the study, the first 9 hours from birth were studied in order to assess both the immediate post-natal adaption and the following phase of the neonatal transition.

1. Patients and methods

This is a prospective, observational study. The sample under investigation included all the newborns with ≥37 weeks of gestational age, delivered by elective caesarean section between February 2013 and February 2014 at the perinatal centers of the Monaldi Hospital Network, Italy. Newborns with intrauterine growth restriction, supplemental inspired oxygen or resuscitation during transition, and the ones presenting malformations were excluded. Only infants with uncomplicated transitional periods were included.

* Corresponding author at: Via L. De Crecchio 4, Naples, 80131, Italy. Tel.: +39 0815665418; fax: +39 0815790594.
E-mail address: montaldop@hotmail.it (P. Montaldo).

http://dx.doi.org/10.1016/j.jpedsurg.2015.04.004
0022-3468/

Table 1
Demographic data of the sample.

No. of patients	61
Male gender, n (%)	21 (34)
Gestational age, (±SD) weeks	39.2 (1.2)
Body weight, (±SD) g	3397 (548)
Head circumference, (±SD) cm	34.8 (1.4)
APGAR: 1 minute (±SD)	9 (0.2)
APGAR: 5 minutes (±SD)	10 (0.3)

2. Near-infrared spectroscopy

The newborns were studied continuously by multi-probe NIRS (Nonin EQUANOX 7600 Regional Oximetry System, Amsterdam, the Netherlands).

The device enables non-invasive, real-time measurement of rSO_2 by emitting near-infrared light (730 and 810 nm) from a sensor containing a LED, placed on the skin. After penetrating the subjacent tissue, these particular wavelengths are absorbed by oxygenated and deoxygenated hemoglobin. Two detectors are placed on the sensor at different distance from the LED, thus allowing the measurement of two penetration depths. It is a mixed measurement of arterial, venous and capillary blood supply [11].

The umbilical cord was clamped immediately after birth and an NIRS transducer was applied to the forehead for $CrSO_2$, to the posterior flank at T12-L2 for $RrSO_2$ and to infra-umbilical abdomen for $MrSO_2$. The sensor on the forehead was secured with a bandage. A pulsoximetry sensor to concurrently measure SpO_2 and heart rate was also attached. SpO_2 and heart rate were measured with the Rad-87 Monitor (Masimo Set, CA, USA) at a preductal level on the right hand. The newborn was then given to the mother and positioned in the prone position on the mother's chest. A neonatologist observed the transition of the newborn infant and recorded Apgar scores at 1, 5, and 10 minutes.

After the adaptive period, the babies were either with their mothers or in the healthy newborn nursery. The period of monitoring continued up to 9 hours of age in order to assess both the immediate post-natal adaption and the following part of the neonatal transition.

Within 2 minutes after birth, saturation signals could be measured for all infants. For this reason, the data analysis started from the second minute of life. For subsequent analysis, all data were stored electronically at a sample rate of 2 seconds. All the NIRS studies were performed by the same investigators, who were not involved in the delivery room care of the neonates. Written informed consent was obtained before the birth of all infants and the study design was approved by the hospital's Ethics Committee.

All continuously measured NIRS data were evaluated individually.

Fractional oxygen tissue extraction was calculated as $(SpO_2 - rSO2)/SpO_2$.

Episodes of feeding were assessed by nurses and verified with mothers before termination of data collection. The episodes of breastfeeding were assessed by LATCH "(Breastfeeding Charting System)" [12] and only the episodes with a total LATCH score of 10 were included in the analysis. As far as bottle-feeding is concerned, only episodes of more than 30 ml/kg/day were considered adequate [13] and included in the analysis.

3. Data acquisition and statistical analysis

The infants' characteristics are presented as numbers and proportions for categorical variables, means and SDs for continuous variables. Near-infrared spectroscopy data were reduced to 1-minute averages. A linear mixed-effects model with a fixed effect for the NIRS monitoring site and the interaction between time (postnatal age) and NIRS monitoring site, was used for calculating the differences over time between the continuous variables. The slope (change in concentration per minute) was calculated for all variables for the part of adaptation with the largest concentration changes. The means were pairwise compared using Bonferroni adjustment for inflated type I error. In order to compare the different variables between feeding and resting periods, 15 minute mean values before feeding were considered as resting period and compared with those during the whole feeding. Significance was set at p value 0.05. Statistical analyses were carried out with the Software Package for the Social Sciences (SPSS for Windows, version 15.0, SPSS Inc, Chicago, Ill).

4. Results

As many as 67 infants fulfilled the criteria for study entry. The parents of 6 infants refused to participate in the study. The total sample included 61 infants [Table 1].

In all the newborns under investigation, SpO_2 values were always above the 10th percentile, according to the percentiles published by Dawson et al. [3], and heart rate was always above 100 beats/minute.

$RrSO_2$ and $MrSO_2$ were significantly lower at 3-4-5-6-7 minutes from birth compared to the $CrSO_2$ ($p < 0.05$). RtFOE and MtFOE were significantly higher at 3-4-5-6-7 minutes compared to the CtFOE ($p < 0.05$) [Fig. 1].

Mean $CrSO_2$ increased quickly to 7 minutes, with no further statistically significant changes during the 9 hours of assessment whereas mean $RrSO_2$ and $MrSO_2$ increased for 10 minutes and thereafter they remained on their newly reached level, with no statistically significant changes afterwards [Fig. 2]. $RrSO_2$, $MrSO_2$ increased more slowly compared to $CrSO_2$ within the first 7 minutes of life (5.6 %/min compared to 3.2 %/min and 3.1%/min; $p < 0.05$).

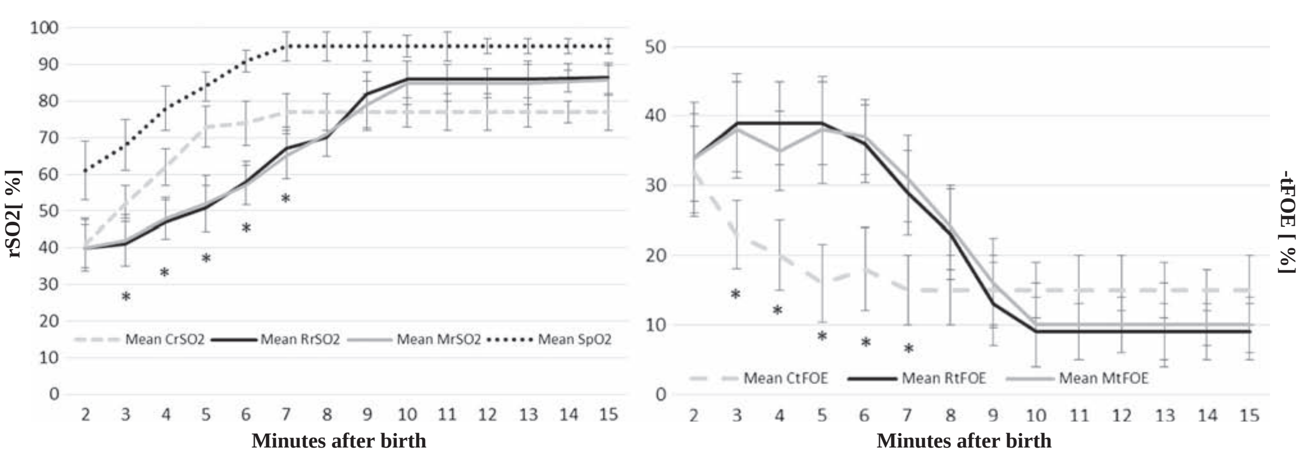

Fig. 1. The mean (95% CI error bars, *$p < 0.05$) of $CrSO_2$, $RrSO_2$, $MrSO_2$, CtFOE, RtFOE, MtFOE and SpO_2 of the whole sample during the first 15 minutes of life. The mixed model analysis showed a statistical significant interaction between $RrSO_2$, $MrSO_2$ and $CrSO_2$ and between RtFOE, MtFOE and CtFOE at 3, 4, 5, 6, 7 minutes of age $p = 0.001$.

Please cite this article as: Montaldo P, et al, Cerebral, renal and mesenteric regional oxygen saturation of term infants during transition, J Pediatr Surg (2015), http://dx.doi.org/10.1016/j.jpedsurg.2015.04.004