Assessment of time-course changes in cerebral blood volume in preterm infants during the first 3 days of life using a portable near-infrared time-resolved spectroscopy system

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Abstract

**Objective**: The aim of this study was to evaluate, using a portable 3-wavelength near-infrared time-resolved spectroscopy (NIR-TRS) system, chronological changes in cerebral blood volume (CBV) and to clarify their association with cerebral oxygen metabolism, PCO₂, mean arterial blood pressure (MABP) and hematocrit (Ht) levels during the first 3 postnatal days of preterm infants.

**Study Design**: CBV, cerebral oxygen saturation (cSO₂) and cerebral fractional tissue oxygen extraction (FTOE) among 31 preterm infants of 28–35 weeks gestation were monitored using NIR-TRS at 3–6, 12, 24, 48 and 72 hours after birth with the optode placed on the front head. MABP, PCO₂ and Ht levels were measured simultaneously with the NIR-TRS measurement.

**Results**: CBV and cSO₂ transiently decreased 12 hours after birth and subsequently significantly increased (P<0.01) 72 hours after birth. Conversely, FTOE increased steadily until 12 hours after birth and then significantly decreased (P<0.01). CBV correlated with cSO₂ 3–6 hours (P<0.05, r=0.38), 12 hours (P<0.01, r=0.62) and 24 hours (P<0.05, r=0.36) after birth, with FTOE 12 hours (P<0.01, r=−0.58) after birth, and with Ht 3–6 hours (P<0.01, r=−0.49), 48 hours (P<0.01, r=−0.51) and 72 hours (P<0.05, r=−0.38) after birth. There were no correlations among CBV, PCO₂ or MABP.

**Conclusion**: This study indicates that changes in CBV may be related to those in the cerebral oxygen utilization and Ht level during the first 3 days of life in preterm infants.

Introduction

Drastic hemodynamic changes in adaptation during the transition from fetal to extrauterine life lead to cardiac insufficiency and cerebral complications, including intraventricular hemorrhage (IVH) and hypoxic ischemic encephalopathy (HIE) in newborn infants during the postnatal period. Furthermore, preterm infants are at greater risk of these cerebral injuries due to their immaturity. Cerebral complications are major problems that can cause long-term neurological sequelae, and therefore it is essential to evaluate cerebral perfusion during the immediate postnatal period. To date, changes in cerebral perfusion have not yet been fully elucidated.

Near-infrared spectroscopy (NIRS) can noninvasively investigate cerebral oxygenation and metabolism. Sev-
eral kinds of NIRS instruments have been developed and widely applied to evaluate cerebral perfusion in different neonatal fields. Although there have been several reports on the quantification of cerebral blood flow (CBF) or cerebral blood volume (CBV) using NIRS in conjunction with the intravenous $^{133}$Xenon clearance technique, rapid changes in arterial oxygen saturation and injection of indocyanine green (ICG), these procedures may be harmful in immature neonates, and it is difficult to obtain measurements in sick infants.

By using a recently developed near-infrared time-resolved spectroscopy (NIR-TRS) system, the distribution of the optical path length is directly measured using a time-correlated single photon counting (TCSPC) method. Furthermore, by using a photon diffusion equation, we can measure absolute the light absorption coefficient ($\mu_a$), light-reduced scattering coefficient $\mu'_a$, oxyHb and deoxyHb using a photon diffusion theory at the bedside, and also calculate CBV without performing any invasive procedures.

In this study, we evaluated the time-course changes in the CBV of preterm infants using a portable NIR-TRS system and clarified their association with cerebral oxygen metabolism, PCO$_2$, mean arterial blood pressure (MABP) and hematocrit (Ht) levels during the first 3 postnatal days.

Materials and Methods

Study participants

We studied 31 preterm infants admitted to the neonatal intensive care unit of Tokyo medical university hospital from November 1, 2009 to February 28, 2011. The inclusion criteria of the study were as follows: 1) subjects without anomalies and who were not small for their gestational age; 2) subjects who had not undergone a cranial ultrasound scan during the study; 3) subjects who were maintained in a stable respiratory condition with or without mechanical ventilation (SpO$_2$ ≥ 90% and PCO$_2$ range=30–60 mm Hg during the study period); 4) subjects who did not show severe electrolyte abnormalities or metabolic acidosis during the study; 4) subjects who were maintained in a stable respiratory condition with or without mechanical ventilation (SpO$_2$ ≥ 90% and PCO$_2$ range=30–60 mm Hg during the study period); 5) subjects with an Apgar score of greater than 7 at 5 minutes. This study was approved by the Research Ethics Committee of Tokyo Medical University, and written informed consent was obtained from the parents of all infants.

NIR-TRS system and analysis

Measurements were obtained using a portable NIR-TRS system (TRS-20, Hamamatsu Photonics K.K., Shizuoka, Japan) employing the TCSPC method to obtain a temporal profile of the detected photons. This system features improved optical sensitivity compared with the TRS-10 system employing a GaAs photocathode photomultiplier tube (H7422P-50MOD, Hamamatsu Photonics K.K.), with a quantum efficiency above 12% at approximately 800 nm. The TRS-20 is computer-controlled through a digital input/output (I/O) interface, consisting of a 3-wavelength (761, 801 and 834 nm) pico-second light pulser (PLP, Hamamatsu Photonics K.K.) as the light source, a photon-counting head (composed of a fast-response, highly sensitive photomultiplier tube and high speed amplifier) with a 9-step optical attenuator for single photon detection, and signal processing circuits (which consisted of a constant fraction discriminator, time-to-amplitude converter, analog/digital (A/D) converter and histogram memory) for time-resolved measurement. The PLP generates a light pulse with a pulse width of 100 ps, a pulse rate of 5 MHz and an average power of approximately 80 µW. Three PLPs emit light pulses sequentially, and the 3-wavelength light pulses are guided into 1 illuminating optical fiber by a fiber coupler (NTT Advanced Technology Corporation, Tokyo, Japan). A grated index (GI)-type single optical fiber with a numerical aperture (NA) of 0.25 and a core diameter of 200 µm was used for tissue irradiation. An optical bundle fiber (Moritex Corporation, Tokyo, Japan) with an NA of 0.26 and a bundle diameter of 3 mm was used to collect diffuse light from the tissue for light detection.

To calculate the values of $\mu_a$ and $\mu'_a$ for the 3 wavelengths, the re-emission profiles observed at each measurement point were fitted into the photon diffusion equation proposed by Patterson et al using the non-linear least squares fitting method. Then, oxyHb and deoxyHb levels were calculated from the $\mu_a$ of the 3 wavelengths (761, 801 and 834 nm) using the following equations:

\[ \mu_a 761 \text{nm} = \epsilon_{\text{oxyHb}} 761 \text{nm} C_{\text{oxyHb}} + \epsilon_{\text{deoxyHb}} 761 \text{nm} C_{\text{deoxyHb}} + \epsilon_{\text{H}_2\text{O}} 761 \text{nm} C_{\text{H}_2\text{O}} \]
\[ \mu_a 801 \text{nm} = \epsilon_{\text{oxyHb}} 801 \text{nm} C_{\text{oxyHb}} + \epsilon_{\text{deoxyHb}} 801 \text{nm} C_{\text{deoxyHb}} + \epsilon_{\text{H}_2\text{O}} 801 \text{nm} C_{\text{H}_2\text{O}} \]
\[ \mu_a 834 \text{nm} = \epsilon_{\text{oxyHb}} 834 \text{nm} C_{\text{oxyHb}} + \epsilon_{\text{deoxyHb}} 834 \text{nm} C_{\text{deoxyHb}} + \epsilon_{\text{H}_2\text{O}} 834 \text{nm} C_{\text{H}_2\text{O}} \]

where $\epsilon_m$ is the molar extinction coefficient of the substance $m$ at wavelength $\lambda$, and $C_m$ is the concentration of the substance $m$. On the assumption that in the living body, light absorption in this wavelength occurs in oxyHb, deoxyHb and water, and that there is no other background absorption in the living body, we determined the TRS values for TRS HbO$_2$ and TRS deoxyHb with a tissue water concentration of 85%.

Cerebral total Hb (Hb) level, cerebral oxygen saturation (cSO$_2$), CBV and cerebral fractional tissue oxygen extraction (FTOE) were obtained using the following equations:

\[ [\text{Hb}] (\mu\text{M}) = [\text{oxyHb}] + [\text{deoxyHb}] \]
\[ \text{cSO}_2(\%) = [\text{oxyHb}]/[\text{Hb}] \times 100 \]
\[ \text{CBV} (\text{mL/100 g}) = [\text{Hb}] \times \text{MW}_{\text{Hb}} \times 10^{-6}/(t\text{Hb} \times 10^{-2} \times \text{Dt}) \]
\( \text{FTOE} = \frac{(\text{SpO}_2 - \text{cSO}_2)}{\text{SpO}_2} \)

where \([\text{ ]}\) indicates the Hb level (\(\mu\text{M}\)), \(\text{MW}_{\text{Hb}}\) is the molecular weight of Hb (64,500), \(\text{Hb}\) is the blood Hb level (g/dL), and \(\text{Dt}\) is the brain tissue density (1.05 g/mL).

The TRS-20 was switched on for more than 20 minutes before measurements were taken to stabilize the system. The optode with a distance of 30 mm between the irradiation fiber and the detection fiber was placed on the front head, and was covered with an opaque cloth to prevent stray light from reaching the detector. Measurements were taken in the reflectance mode 3, 6, 12, 24, 48, and 72 hours after birth. The conditions of infants were stable, and each measurement session lasted for more than 1 minute. If the measurement was affected by movement artifact or stray light, we took repeated measurements until we obtained reproducible data.

**Measurements of other variables**

Heart rate (HR), MABP and SpO\(_2\) were monitored and recorded simultaneously with the NIRS measurement by a neonatal monitoring system (BSM-2300; Nihon Kohden Corporation, Tokyo, Japan). MABP was measured either directly with arterial lines or indirectly (oscillometric technique with an inflatable cuff: BSN-2303; Nihon Kohden Corporation). HR and SpO\(_2\) were continuously measured using a pulse oximeter (Nellcor Pulse Oximeter N-200; Tyco Healthcare Japan, Tokyo, Japan). Blood gas (PCO\(_2\), blood Hb and Ht) levels were collected by a heel lance immediately after TRS-20 measurements (ABL835; Radiometer K.K., Tokyo, Japan). The data were stored in a personal computer, and we calculated the median values over the measurement period.

**Statistical analysis**

Statistical analyses were performed using the computer package SPSS II for Windows (SPSS Japan, Tokyo, Japan). The gestational age (GA) and birth weight were expressed as means±standard deviation (SD). Serial data obtained using NIR-TRS and physical examination at different time points were compared using repeated-measures one-way ANOVA, followed by Bonferroni multiple comparison tests. The Pearson correlation coefficient and simple linear regression analysis were used to determine the relationships among CBV, cSO\(_2\), MABP, PCO\(_2\) and Ht level at each measurement point. A \(P\) value of less than 0.05 was considered to indicate a statistically significant difference.

**Results**

Cerebral complications were not diagnosed by cranial ultrasound examinations during the study period. Periventricular leukomalacia diagnosed by magnetic resonance imaging developed in 1 infant before discharge. The clinical variables of the infants are shown in Table 1.

The mean CBV was 1.67±0.28 (standard deviation (SD)) mL/100 g during the study period. The mean cSO\(_2\) was 71.1%±4.2% (SD) during the study period.

**Table 1 Clinical data of 31 infant subjects**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational age (w)</td>
<td>32±2 (28-35)</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>1695±427 (914-2406)</td>
</tr>
<tr>
<td>Blood pH at birth</td>
<td>7.32±0.1</td>
</tr>
<tr>
<td>Male/female</td>
<td>13/18</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>17</td>
</tr>
<tr>
<td>Indomethacin</td>
<td>4</td>
</tr>
<tr>
<td>Mode of delivery (TV/CS)</td>
<td>10/21</td>
</tr>
</tbody>
</table>

Values are presented as means (standard deviation [SD]) of number of cases

VD, vaginal delivery; CD, cesarean delivery
3 to 6 hours and 48, and 72 hours, and between 12 hours and 48, and 72 hours after birth. There were significant decreases in Ht level between 3 to 6 hours and 48, and 72 hours, between 12 hours and 48, and 72 hours after birth. There was no significant change in PCO₂.

The correlations between CBV and other variables are shown in Table 3. There were significant correlations between CBV and cSO₂ 3–6 hours (P<0.05, r=0.38), 12 hours (P<0.01, r=0.62) and 24 hours (P<0.05, r=0.36) after birth. There was a significant inverse correlation between CBV and cSO₂ 3–6 hours (P<0.01, r=−0.49), 48 hours (P<0.01, r=−0.51) and 72 hours (P<0.05, r=−0.38) after birth. Analysis of correlations among CBV and [tHb] and blood Hb levels was not appropriate as CBV was derived from [tHb] and blood Hb levels. There were no correlations between CBV and PCO₂, or between CBV and MABP.

**Discussion**

We set out to evaluate the time course changes in CBV of preterm infants by NIR–TRS and clarified their association with cerebral oxygen metabolism, PCO₂, MABP and Ht levels during the first 3 postnatal days. There have been several studies of CBV in neonates by NIRS using oxyHb⁵ or ICG⁶ as a tracer. The estimated CBVs were 2.22±0.4 and 3.7 mL/100 g using the modified Beer–Lambert law, with changes in arterial saturation³ and PCO₂, respectively. Leung et al⁹ reported an absolute CBV of 1.72±0.76 mL/100 g as determined by NIR–SRS with ICG. Ijichi et al¹¹ reported an absolute CBV of 2.31±0.56 mL/100 g as determined by NIR–TRS in neonates (mean GA: 36.8±3.1 (SD) wks, mean BW: 2,365±791 g (SD)). These results were higher than those of the present study (1.67±0.28 (SD) mL/100 g).

It has been reported that CBV increases with postconceptional age, and that the relationship between these variables was based on the results of anatomic studies of the development of cerebral blood vessels. Furthermore, it has been reported that the CBV in human adults was 4.81±0.37 mL/100 g using single–photon emission computed tomography¹⁰, and 4.7±1.1 mL/100 g using positron emission tomography⁹, which were higher than those in neonates. Wyatt et al¹³ speculated that regional

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**Table 2** Measurement results

<table>
<thead>
<tr>
<th>Variable</th>
<th>3–6 h</th>
<th>12 h</th>
<th>24 h</th>
<th>48 h</th>
<th>72 h</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBV (ml/100 g)</td>
<td>1.61±0.30</td>
<td>1.54±0.27</td>
<td>1.62±0.25</td>
<td>1.78±0.22</td>
<td>1.80±0.26</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>cSO₂ (%)</td>
<td>70.1±4.1</td>
<td>70.0±5.3</td>
<td>69.9±3.4</td>
<td>73.4±2.9</td>
<td>73.0±2.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>FTOE</td>
<td>0.28±0.05</td>
<td>0.30±0.06</td>
<td>0.28±0.04</td>
<td>0.24±0.03</td>
<td>0.25±0.03</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>MABP (mmHg)</td>
<td>38.4±6.3</td>
<td>40.1±5.1</td>
<td>39.8±7.8</td>
<td>43.0±6</td>
<td>43.3±6.3</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>HR (min)</td>
<td>142±16</td>
<td>136±12</td>
<td>132±11</td>
<td>132±10</td>
<td>133±12</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>SpO₂ (%)</td>
<td>98 (98–99)</td>
<td>98 (97–100)</td>
<td>98 (96–99)</td>
<td>97 (95–99)</td>
<td>98 (97–98)</td>
<td>0.03</td>
</tr>
<tr>
<td>PCO₂ (mm Hg)</td>
<td>41.3±10.2</td>
<td>39.7±8.3</td>
<td>36.8±6.9</td>
<td>40.1±5.3</td>
<td>41.6±5.2</td>
<td>0.09</td>
</tr>
<tr>
<td>Hb (g/dl)</td>
<td>18.2±1.7</td>
<td>18.4±2.0</td>
<td>17.5±2.0</td>
<td>16.6±1.9</td>
<td>16.6±1.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Ht (%)</td>
<td>55.4±5.1</td>
<td>56.1±6.0</td>
<td>53.4±6.1</td>
<td>50.7±5.8</td>
<td>50.8±5.3</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Values are presented as means±standard deviation [SD]. Data for SpO₂ are presented as medians (interquartile range [IQR]). CBV: cerebral blood volume; cSO₂: cerebral oxygen saturation; FTOE: fractional regional cerebral oxygen extraction; MABP: mean arterial blood pressure; HR: heart rate; Hb: blood hemoglobin; Ht: hematocrit

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**Table 3** Correlations between CBV and other variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>3–6 h</th>
<th>12 h</th>
<th>24 h</th>
<th>48 h</th>
<th>72 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>MABP</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>PCO₂</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>Ht</td>
<td>P &lt; 0.01</td>
<td>r = −0.49</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
<td>r = −0.51</td>
</tr>
<tr>
<td>FTOE</td>
<td>P &gt; 0.05</td>
<td>P &lt; 0.01</td>
<td>r = −0.58</td>
<td>P &gt; 0.05</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>cSO₂</td>
<td>P &lt; 0.05</td>
<td>r = 0.38</td>
<td>P &lt; 0.01</td>
<td>r = 0.62</td>
<td>P &lt; 0.05</td>
</tr>
</tbody>
</table>

r = Pearson correlation coefficient
CBV was lower in the white matter than in the gray cerebral matter, and the relatively low mean CBVs in infants may reflect a relative preponderance of the white matter compared with the adult brain. These hypotheses support the current results, as the mean GA in this study (32 wks) was shorter than that of a study using NIR-TRS (36.8 wks). The different time window of measurements may also have influenced these results, because CBV measurements by NIRS using oxyHb and ICG as a tracer were higher than the current results, despite the immaturities noted (mean GA: 29 wks and 28 wks).

Changes in CBV mainly represent alterations in cerebral Hb levels, which may be influenced by CBF. In this study, CBV gradually decreased until 12 hours from birth. We previously reported a relationship between systemic circulation and cerebral circulation by echocardiography and NIRS-SRS in extremely low birth weight (ELBW) infants during the first 3 days after birth which demonstrated that the tissue oxygenation index (TOI) values that represented CBF with stable Hb and SpO2 levels decreased until 12 hours and then increased gradually. The changing pattern of the CBV in the present study was similar to that of the TOI in our previous study. We also demonstrated in our previous report that the changing pattern of TOI was similar to that of systemic perfusion in terms of left ventricle cardiac output and superior vena cava flow. We proposed that the changes in cerebral oxygenation and blood flow immediately after birth were likely to reflect low cardiac output because of the limited capacity of the immature myocardium to adapt to perinatal circulatory change.

It has been said that PCO2 is important factors that affect CBF. Cerebrovascular resistance decreases with an increase in PCO2. CF measurements using the Xenon clearance technique have indicated that an increase in postnatal age correlates with changes in PCO2. However, several other reports have failed to demonstrate a relation between CBF and PCO2. In the present study, there was no correlation between CBV and PCO2. While a report by Pryds and Greisen showed a correlation between CBV and PCO2, the mean PCO2 levels were (4.0 (30), 4.6 (34.5) and 4.4 (33) kPa (mm Hg) on days 1, 2 and 3, respectively), which were lower than the present results (mean: 39.9 ± 7.5 (SD) mm Hg). This may explain why PCO2 did not affect cerebrovascular resistance at approximately 40 mm Hg in the present study.

The Ht level increased until 12 hours after birth, and then gradually decreased. This changing pattern of Ht was inversely correlated to that of CBV, and we found significant inverse correlations between these variables. The current results are supported by a study which demonstrated a significant inverse correlation between CBF and arterial blood Hb concentration, or Ht level using the Xenon clearance technique. Although both arterial oxygen content and blood viscosity have been reportedly related to CBF, it has been suggested that CBF increased mainly as a compensatory mechanism for the lower oxygen-carrying capacity to maintain constant oxygen delivery.

In the present study, we showed an inversely changing pattern in CBV and FTOE, and found a significant negative correlation between these variables 12 hours after birth.

Cerebral fractional oxygen extraction (FOE) is a useful measurement variable which represents the ratio of cerebral oxygen consumption to cerebral oxygen delivery. Naulaes et al showed a close correlation between the FTOE measured by NIRS and the actual FOE in piglets and concluded that FTOE is likely to provide important information on the oxygenation status of the brain. An increase in FTOE reflects an increase in oxygen extraction by brain tissue, suggesting a higher consumption of oxygen than delivery and a decrease in FTOE indicates less utilization of oxygen by brain tissue compared with oxygen supply. There have been several reports of a relationship between blood Hb level and FTOE. Van Hoften et al found that blood transfusion led to a decrease in FTOE, which indicated that if the blood Hb level decreased, FTOE would increase as a compensatory mechanism to maintain cerebral tissue oxygenation. However, in the present report, although the blood Hb level decreased, FTOE continued to decrease concurrently with an increase in CBV after birth. These results suggest that any increase in CBV which occurs as a result of an increase in CBF depends not only on a change in Ht level as described above, but also on other variable changes as adaptations from fetal to extrauterine life. Meek et al and Kissack et al showed an increase in CBF during the first 3 days of life of ELBW infants, and proposed that this change may be a normal adaptive response of the cerebral circulation to postnatal life. We speculate that an increase in oxygen delivery via increased CBF as an adaptive response exceeds a decrease in oxygen delivery via decreased blood Hb level. As a result of increased CBF, sufficient oxygen is delivered to the brain, possibly causing FTOE to decrease.

The relationship between cerebral perfusion and arterial blood pressure is controversial. Tsuji et al reported that in preterm neonates, blood pressure and cerebral oxygenation index (oxyHb level-deoxyHb level), which possibly reflects CBF, have a significant association, which indicates an absence of cerebral autoregulation in some preterm infants. In this study, we found no correlation between CBV and MABP. This result suggests that the autoregulation of cerebral circula-
tion was intact in the subjects in our cohort. However, as the number of patients was small, the results should be interpreted cautiously, and further studies are required.

The change in cSO₂ is determined mainly by changes in blood Hb level, SpO₂, CBF, the cerebral metabolic rate of oxygen utilization and the arterial and venous anatomical ratio. For this reason, it has been considered that a change in cSO₂ may reflect a change in CBF among infants with stable blood Hb and SpO₂ levels. However, in the present study, although we demonstrated similar changing patterns in CBV and cSO₂, a significant correlation between these variables was not shown 48 hours after birth. This may be because the drastic changes in FTOE and blood Hb levels, which influence cerebral hemodynamics during the immediate postnatal period, affected these relationships.

There were some limitations in this study. The number of patients of this cohort was small, and there were patients with various circulatory conditions. It has been considered that respiratory distress syndrome, surfactant therapy and mechanical ventilation influence cerebral hemodynamics. However, these conditions were not investigated in the present study. Furthermore, although the sensitivity and the reliability of this NIR-TRS system have previously been assessed using a piglet hypoxia model, there have been few reports regarding the cerebral perfusion of human neonates, and further studies are required.

In conclusion, we evaluated changes in cerebral perfusion in preterm infants during the immediate postnatal period using a newly developed portable NIR-TRS system without any invasive procedures. CBV showed a significant increase, and CBV changes may be related to changes in CBF, the cerebral metabolic rate of oxygen utilization, and Ht level. Serial measurements of these parameters at bedside using a portable NIR-TRS system may be useful for evaluating postnatal changes in CBV and the cerebral metabolism of preterm infants in an intensive care unit.

Acknowledgments

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Conflict of interest

All authors declare no conflicts of interest associated with this study. There was no external financial support received for this study.

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近赤外時間分解分光装置を用いた早産児における生後3日間の脳血液量の経時的評価

藤岡泰生 高見剛 石井宏樹
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【目的】移動式3波長近赤外時間分解分光法システム（NIR-TRS；near-infrared time-resolved spectroscopy）を用いた、早産児における生後3日間の脳血液量（CBV；cerebral blood volume）の経時的変化の評価及び、CBVと脳組織酸素代謝、血中二酸化炭素分圧（PCO₂）、平均血圧との関連性の検討を目的とした。【対象および方法】対象は在胎週数28-35週の早産児31例。NIR-TRSのオプトードを頭部に設置し、生後3-6、12、24、48、72時間においてCBV、脳組織ヘモグロビン酸素飽和度（cSO₂）、脳組織fractional tissue oxygen extraction（FTOE）を計測した。NIR-TRS計測と同時に、平均血圧、PCO₂、ヘマトクリット（Ht）を測定した。【結果】CBVとcSO₂は生後12時間に一過性に低下し、その後、72時間にかけ有意な上昇を示した（P<0.01）のに対し、FTOEは生後12時間に一過性に上昇し、その後、有意な低下（P<0.01）を示した。CBVとcSO₂の間に生後3-6時間（P<0.05、r=0.38）、12時間（P<0.01、r=0.62）、24時間（P<0.05、r=0.36）において有意な正の相関を認めた。CBVとFTOEの間に生後12時間（P<0.01、r=−0.58）において有意な負の相関を認めた。CBVとHtの間に生後3-6時間（P<0.01、r=−0.49）、48時間（P<0.01、r=−0.51）、72時間（P<0.01、r=−0.38）において有意な負の相関を認めた。CBVとPCO₂、平均血圧の間に有意な相関は認めなかった。【結語】本研究により早産児における生後3日間のCBVの変化は脳における酸素摂取率や血中Htに影響を受ける可能性が示唆された。

（キーワード）脳血液量（CBV）、脳組織ヘモグロビン酸素飽和度（cSO₂）、FTOE、近赤外時間分解分光法（NIR-TRS）、早産児