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Near-infrared spectroscopy in newborns and infants under general anesthesia

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The aim of this study was to find out absolute values of cerebral oxygenation during uncomplicated anesthesia in otherwise healthy newborns and infants undergoing general surgery and to correlate them with demographic and clinical variables. We examined 10 term newborns and infants ASA class I or II without any documented neurological and cardiovascular disorders. All patients underwent general anesthesia with sevoflurane, fentanyl and muscle relaxants. After induction of anesthesia, near-infrared spectroscopy (NIRS) was started and used throughout the surgery. Overall mean (standard deviation (sd)) rSO_2 value was 84 ± 8% and weakly correlated with weight (r = 0.5), postnatal age (r = 0.2), SpO_2 (r = 0.3) and arterial blood pressure (r = 0.2), $p < 0.05$ for all variables. We conclude that NIRS is a noninvasive, continuous method for monitoring cerebral oxygenation, simple and easy to perform. Earlier studies and our data suggest that normative values in otherwise healthy term newborns and infants could be weight or age dependant. Further studies are required to assess the clinical value of the routine use of cerebral NIRS in general neonatal and pediatric patient population.

Key words: near-infrared spectroscopy, newborns, general surgery, anesthesia

INTRODUCTION

Brain of the newborns and young infants is vulnerable due to circulation and oxygenation changes, which can affect long-term outcome (1). However, the human brain remains the most poorly monitored organ, thus, negative events may occur unnoticed and treatment delayed. The main purpose of near-infrared spectroscopy (NIRS) is to evaluate regional tissue perfusion and oxygenation continuously and noninvasively (2). In 1985, Brazy and Lewis reported the first pediatric application of NIRS for monitoring cerebral oxygenation in sick preterm infants (3). Since then application of NIRS increased. Currently it is widely used as a standard of care during cardiac surgery (2, 4), and research is ongoing on the application of NIRS in neonatal population (5, 6, 7, 8).

We do not know any studies describing application of cerebral NIRS in newborns and infants undergoing general surgery. Therefore the aim of

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this study was to find out absolute values of cerebral oxygenation during uncomplicated anesthesia in otherwise healthy newborns and infants undergoing general surgery and to correlate them with demographic and clinical variables.

MATERIALS AND METHODS

We recruited 10 term newborns and infants at our university hospital from April to July 2012. All patients were ASA class I or II and without any documented neurological disorders. Approval of the local ethical committee was not searched as NIRS monitoring is within the frames of contemporary monitoring during anesthesia (9).

All patients underwent general anesthesia with tracheal intubation. Sevoflurane (N = 8) or propofol 1–3 mg/kg (N = 2) were used for induction. Sevoflurane, fentanyl and muscle relaxants were used for maintenance in all patients. After intubation of the trachea, two self-adhesive sensors containing the infrared light source and light detectors ((INVOS®, SOMANETICS) were fixed on the both sides of the forehead (Fig. 1) and rSO_2 was assessed continuously and fixed down every 5 min throughout the operation. Standard anesthesia monitoring was used in all patients. During surgery all patients were hemodynamically stable and anesthesia and surgery were uneventful.

STATISTICAL ANALYSIS

Continuous variables such as patients' weight, postnatal age, duration of surgery and Hb values were checked for normality of distribution and described as mean (sd). Correlations between rSO_2 and SpO_2, arterial blood pressure, weight, and age were calculated using the Pearson linear correlation coefficient. $P < 0.05$ was considered statistically significant.

RESULTS

The demographic data of the patients are shown in the Table. The mean rSO_2, arterial blood pressure and SpO_2 throughout anesthesia are shown in Fig. 2. The overall mean (sd) rSO_2 value was 84 ± 8%. There was a weak correlation between rSO_2 and SpO_2 and the mean arterial blood pressure ($r = 0.3$, $r = 0.2$; $p < 0.05$, respectively). A moderate correlation between the mean rSO_2 value and the weight ($r = 0.5$; $p < 0.05$) and a weak correlation with the postnatal age ($r = 0.3$; $p < 0.05$) were found. There was not any correlation of rSO_2 with the preoperative Hb value.

Fig.1. Cerebral oxymetry in the newborn

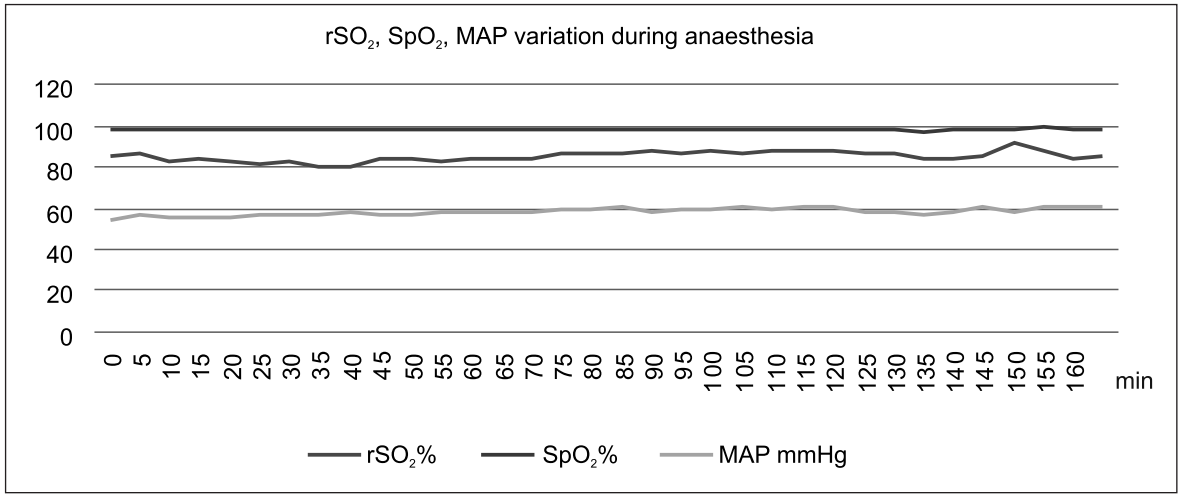

Fig. 2. Mean rSO_2, mean arterial pressure and SpO_2 in 10 patients throughout the surgery

Table. Demographic data of the patients

No.	Gender	Weight, g	Postnatal age, days	Preoperative Hb, mg/l	Duration of surgery, min	Diagnosis
1.	f	3 200	10	200	160	Teratoma sacri
2.	m	4 300	55	130	120	Hernia inguinalis
3.	m	4 680	2	199	160	Atresia ani
4.	f	3 300	2	186	160	Pancreas annulare
5.	f	4 490	23	149	60	Naevi pigmentosus antebrachii
6.	m	4 800	58	114	120	Hirschsprung disease
7.	F	3 570	10	183	150	Cysta cavi peritonei
8.	F	3 300	11	158	90	Membrana et stenosis duodeni
9.	F	2 600	1	172	120	Atresia intstini tenui
10.	F	3 800	58	144	45	Pylorostenosis

DISCUSSION

The present study showed that the overall mean (sd) rSO_2 in full term neonates and infants under general anesthesia was 84 ± 8%. Tina et al. reported median values of 72–76% in term healthy newborns 6 hours after their birth (6, 7). We do not know any published results describing cerebral rSO_2 values in older newborns. Large interindividual variability exists, and a correlation with patients' gestational age was noted previously (6, 7). As all our newborns were term, we did not consider the gestational age as a significant variable, however, a weak correlation with the postnatal age was found. We also found a moderate correlation with patient's weight, but this must be interpreted with caution as our sample size was low.

We found a weak correlation with the arterial oxygen saturation in our patients. As all our patients breathed 50% oxygen in air during surgery, there were no Hb desaturation episodes, therefore a weak correlation with rSO_2 was not unexpected. A significant correlation with arterial oxygen saturation was found in spontaneously breathing term and preterm neonates (6). However, normal arterial oxygen saturation may not always preclude normal cerebral saturation, especially when additional oxygen is administered (5).

We also did not find a strong correlation with the mean arterial pressure. All our patients were hemodynamicaly stable, presumably cerebral circulation remained constant throughout anesthesia and had no significant impact on rSO_2 values. It has been reported that propofol-induced hypotension

may decrease cerebral oxygenation in preterm infants, in which cerebral autoregulation is impaired during the first days of life (10).

Hemoglobin is an important determinant of tissue oxygenation, as a result, rSO_2 values may be affected by the hemoglobin level. We did not find any correlation with preoperative Hb in our patients. However, all Hb values were within the normal range, thus any significant effect on rSO_2 was unlikely. In clinically relevant anemia rSO_2 may potentially be used as one of transfusion triggers (9).

The limitations of our study are a small number of patients and a short monitoring interval. More patients and a prolonged monitoring window would have provided with a deeper insight into normal cerebral rSO_2 values in healthy newborns and infants of different postnatal ages.

Clinical benefits of cerebral NIRS in cardiac surgery have been documented (9, 11, 12). It is difficult to assess NIRS in other pediatric surgical settings and so far there has been no evidence to support that this exists. However, due to the simplicity and continuous, non-invasive monitoring, NIRS has the potential to become a valuable tool to optimize patient care in daily anesthesia practice.

CONCLUSIONS

Near-infrared spectroscopy is a noninvasive, continuous method for monitoring cerebral oxygenation, simple and easy to perform. Earlier studies and our data suggest that normative values in otherwise healthy term newborns and infants could be weight or age dependant. Further studies are required to assess the clinical value of the routine use of cerebral NIRS during general surgery in neonatal and pediatric population.

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INFRARAUDONŲJŲ SPINDULIŲ ATSPINDŽIO SPEKTROSKOPIJA TAIKANT NAUJAGIMIAMS IR KŪDIKIAMS BENDRĄJĄ ANESTEZIJĄ

Santrauka

Atlikto tyrimo tikslas buvo nustatyti naujagimių ir kūdikių, patyrusių pilvo ar bendrosios chirurgijos operaciją, smegenų oksimetrijos reikšmes ir jų koreliaciją su demografiniais ir klinikiniais rodikliais nekomplikuotos anestezijos metu. Mes ištyrėme 10 išnešiotų naujagimių ir kūdikių I ir II ASA klasės be jokios neurologinės ir širdies bei kraujagyslių patologijos. Visiems pacientams taikyta bendroji anestezija sevofluranu, fentaniliu ir raumenų relaksantais. Po anestezijos indukcijos smegenų oksimetrija (rSO_2) pradėta stebėti NIRS (*near-infrared spectroscopy*, infraraudonųjų spindulių atspindžio spektroskopija) metodu ir buvo tęsiama visos operacijos metu. Apskaičiuotas smegenų oksimetrijos reikšmių vidurkis (standartinis nuokrypis) 84 ± 8 % silpnai koreliavo su svoriu (r = 0,5), pogimdyminiu amžiumi (r = 0,2), SpO_2 (r = 0,3) ir arteriniu kraujospūdžiu (r = 0,2) ir siekė $p < 0,05$. Tyrimo išvada – šis neinvazinis tęstinis smegenų oksimetrijos stebėjimo metodas yra lengvai atliekamas. Remdamiesi atliktų studijų bei mūsų tyrimo duomenimis, galime teigti, kad išnešiotų naujagimių ir kūdikių be neurologinės ir širdies bei kraujagyslių patologijos normalias rSO_2 reikšmes gali nulemti svoris ir amžius. Tolesni tyrimai leistų įvertinti klinikinę smegenų oksimetrijos naudą naujagimių ir kūdikių populiacijai.

Raktažodžiai: infraraudonųjų spindulių atspindžio spektroskopija, naujagimiai, bendroji chirurgija, anestezija