

Cerebral tissue oxygenation during cranial osteopathic CV4 procedure in newborns

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Abstract

Background. The cranial osteopathic manipulative medicine has been shown to alter regional cerebral tissue oxygenation (cStO₂) in adult patients; however, there are no reports regarding the neonatal population.

Objectives. To assess the influence of compression of the 4th ventricle (CV4) osteopathic procedure on cStO₂ in neonates.

Material and methods. Thirty-one patients born between 25 and 39 weeks of gestation were screened for inclusion in the neonatal unit. Twenty-two infants presenting with hyperstimulation of autonomous nervous system (ANS) according to the Neonatal Behavioral Assessment Scale were enrolled in the study. Near-infrared spectroscopy was used for continuous cStO₂ monitoring; pulse oximeter oxygen saturation (SpO₂) and heart rate (HR) measured with pulse oximetry were simultaneously monitored 10 min before CV4, during the therapy and 10 min after it was stopped.

Results. Patients' condition remained stable throughout the study. There were no significant differences in the mean cStO₂ values recorded before (69 ± 8%), during (69 ± 8%) and after CV4 (70 ± 8%; $p > 0.05$). Mean SpO₂ was almost constant during the study (96 ± 4% before, 95 ± 3% during and 95 ± 4% after the intervention). Heart rate was also stable pre-, during and post-therapy (153 ± 21 min, 151 ± 18 min and 151 ± 20/min, respectively).

Conclusions. Compression of the 4th ventricle osteopathic procedure does not influence the cStO₂ in newborns. This method seems to be well-tolerated but its clinical efficacy needs to be further investigated in this group of patients.

Key words: neonates, cerebral oxygenation, osteopathic procedure

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Introduction

Immaturity of the nervous system is an important issue related to the pathophysiology and clinical care of preterm infants, as the autonomic nervous system (ANS) development is the most dynamic in the 3rd trimester of pregnancy.¹ Every year about 15 million infants are born preterm worldwide, including an estimated 25,000 neonates in Poland.^{2,3} Preterm infants may require early developmental stimulation to alleviate the neurodevelopmental delay resulting from incomplete intrauterine development.⁴ Methods such as Neurodevelopmental Treatment (NDT) Bobath therapy has become a standard of care, and it seems that the application of selected osteopathic procedures could also be considered.⁴ Compression of the 4th ventricle (CV4) is an osteopathic technique used to influence the ANS.⁵ An altered sympathetic–vagal balance reflecting the heart rate (HR) has been reported after application of this procedure.⁶ In particular, increased parasympathetic and decreased sympathetic activity were observed.⁷ Although CV4 has been practiced for over 80 years in adults (e.g., decreasing anxiety and relieving pain), it is still perceived as innovative in various aspects, and the knowledge regarding its effects in neonates is limited.^{8,9} The procedure is easy to apply, short and seems well-tolerated by pediatric patients.¹⁰ It is advised for the specialists who are aiming to apply the procedure to complete a five-year course rather than 3 weekend-long chiropractic training. In contrast to methods such as chiropractic techniques performed on the neck or spinal manipulative therapy, there were no safety concerns reported for osteopathic techniques.^{11,12} According to previous observations, application of these methods may reduce the length of hospitalization of preterm newborns and lower the occurrence of gastrointestinal symptoms.^{11,13–16} While osteopathic procedures will not replace established physiotherapeutic interventions in the newborn, they might be considered as supplementary or alternative methods. For example, CV4 has an advantage over NDT Bobath technique, because it requires less maneuvers and holding. Compression of the 4th ventricle procedure may be performed by experienced physical therapists and osteopaths according to the standards described in the literature and definitions established by the osteopathic medical profession of Educational Council on Osteopathic Principles (ECOP).^{8,17–19} The therapist places one hand in the palm of the other, so that the thenar eminences are laid parallel, medial to the lateral angles of the occipital squama, next to occipitomas-toid suture (Fig. 1). The weight of the patient's head rests on the thenar eminences of the therapist who applies gentle compression that leads to the approximation of lateral angles of occipital squama. The procedure is continued until a reduction in “cranial rhythm”, defined as specific bone motion, is detected.^{8,9,20} It is followed by the patients' cranial bone motion, which resembles the initial cycle.^{8,9,20}

Compression of the 4th ventricle procedure was reported to reduce pain in infantile colic and otitis media.^{20,21} It was

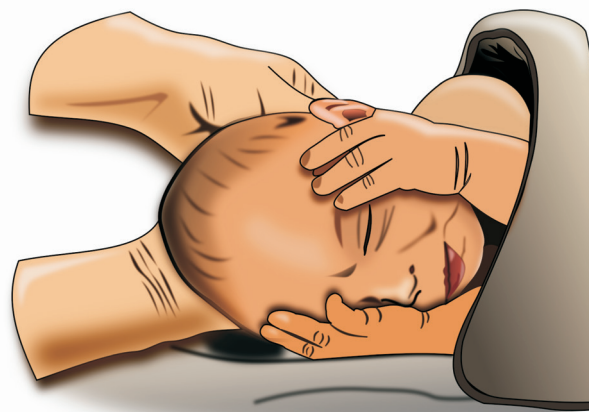


Fig. 1. Compression of the 4th ventricle procedure

also observed that CV4 decreases HR and systolic blood pressure (SBP) in patients with stage 1 hypertension, most likely due to altered sympathetic–vagal balance.²² The technique was shown to alter regional cerebral tissue oxygen saturation (cStO₂) measured using near-infrared spectroscopy (NIRS) in the adult patients; however, there are no reports regarding the neonatal population.²³ The change in the cStO₂ is not always desirable, because it may be associated with reduced cerebral blood flow due to vasoconstriction, which was suggested in the previous studies.²³ This was proposed as a plausible explanation by Shi et al., assuming that the observed decrease in cStO₂ during CV4 technique in adults was most likely due to reduced oxygen delivery resulting from depression of cerebral blood flow.²³

The aim of this pilot study was to assess the influence of CV4 on cStO₂ in neonates undergoing the procedure. We focused on the following research questions:

1. Is cStO₂ altered by the CV4 procedure?
2. Are cStO₂ values within the reference range during and after CV4?
3. Are HR and SpO₂ changing during and after intervention?

Material and methods

During the study period, 41 infants were hospitalized in the neonatal unit. Thirty-one inborn infants (15 boys and 18 girls) born between 25 and 39 weeks of gestation (mean 31 ± 4 weeks standard deviation (SD)) were screened for inclusion at 32–39 weeks postmenstrual age and 22 patients (8 boys and 14 girls) were enrolled. Mean birth weight of infants was 2300 ± 920 g. Mean postconceptional age in the time of described intervention was 36 ± 2 weeks. Patients' characteristics were summarized in Table 1. Patients' autonomic nervous system items were assessed using Neonatal Behavioral Assessment Scale (NBAS) on enrollment.^{24,25} The NBAS was used for enrollment because it is a noninvasive, painless method, which enables

Table 1. Patients' characteristics

Parameter	Value
Week of gestation (mean; SD)	31; 4
Postmenstrual age at enrollment [weeks] (mean, SD)	36; 2
Birth weight [g] (median; IQR)	1529; 1140–2010
Body weight at enrollment [g] (median; IQR)	2190; 1860–2540
NBAS ANS (mean, SD)	4.4; 1.7

NBAS – Neonatal Behavioral Assessment Scale; ANS – autonomous nervous system; SD – standard deviation; IQR – interquartile range.

the assessment of ANS, habituation, reflexes, and even neurobehavior in infants until 8 weeks of life. We included stable infants with signs of hyperstimulation of ANS cluster in NBAS with more than 2 points in “tremulousness and startles” and score different (lower or higher) than 5 in “lability of skin color”, which meant that they presented with tremors, startles and changes in skin color.^{24–26} Infections, encephalopathy and congenital defects were exclusion criteria. Main causes for not including screened patients were unstable general condition (e.g., frequent desaturations) or insufficient NBAS scoring.

Written consent was obtained before the procedure from parents or legal guardians. Institutional Ethical Review Board at Poznan University of Medical Sciences (Poland) approved the study (decision No. 1009/18).

During the CV4 procedure, physiotherapist stood behind the infant, held the occipital bone and carefully approximated the lateral squama of the occipital bone towards the posterior occipital convexity and took the cranium into extension. The physiotherapist held this position for about 3–5 min until the cranial base was motionless and released cranium when its movement was noted again.^{8,18,23} Compression of the 4th ventricle procedure was administrated only once by an experienced and certified physiotherapist according to established standards.⁵ The neonatologist supervised each procedure, carried out monitoring and was observing for complications possible (e.g., apnea), although not expected based on previous reports.^{13–15,27} All preterm infants were in stable condition throughout the study. No episodes of apnea, bradycardia or desaturation were observed while CV4 was performed.

Heart rate, peripheral oxygen saturation (SpO₂) and cStO₂ were continuously monitored 10 min before CV4, during the procedure and 10 min afterwards; this approach was similar to previous studies assessing short-term physiological effects of CV4.^{8,9,23} The device used to measure both the HR and SpO₂ was Nellcor OxiMax N-600x (Covidien, Minneapolis, USA) placed on the neonate's foot. Cerebral tissue oxygenation was monitored with INVOS 5100C oximeter (Medtronic, Minneapolis, USA). The sensors were placed on the forehead.

Analyzed parameters were compared at the following time points: 1) 10 min, 5 min, 1 min, and 30 s intervals before CV4; 2) during the procedure; 3) 30 s, 1 min, 5 min, and

10 min.^{8,18,23} Artifacts were removed manually and mean values of parameters at each time point were calculated based on 1 min of stable, continuous signal. Statistical analysis was performed using STATISTICA v. 13 software (StatSoft, Inc., Tulsa, USA). To describe experimental results, variables were represented as mean ± standard deviation (SD). Single-factor repeated-measures one-way analysis of variance (ANOVA; univariate tests results) for dependent variables was used, with Tukey's honestly significant difference (HSD) post hoc test.

Results

No significant differences were found between mean values and SD of cStO₂ before, during and after CV4 (Fig. 2). No cStO₂ desaturations below hypoxic threshold for InVos neonatal sensor (63%) were observed and mean values of cStO₂ were within a range considered as normal for the age group.^{28,29} No statistically significant differences in mean SpO₂ value were observed before, during and after CV4 (Fig. 3). Mean HR values were also similar before, during and after CV4 (Fig. 4).

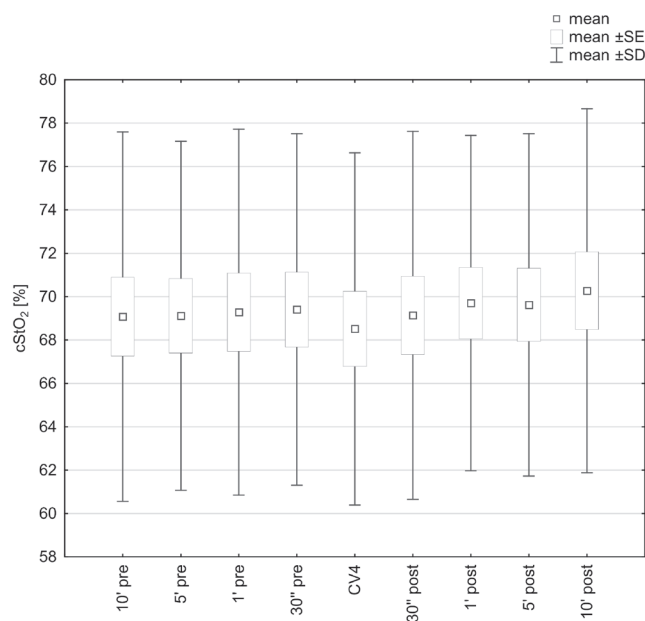


Fig. 2. Cerebral tissue oxygen saturation (%) before (“pre”), during and after (“post”) CV4 procedure

Discussion

Patients in neonatal units are exposed to stressful diagnostic and therapeutic procedures, which may be of particular significance in preterm infants. Among efforts to alleviate these effects, CV4 may be considered to decrease stress and ANS hyperstimulation. In our study, NBAS ANS cluster assessment was performed at enrollment to investigate CV4 with a similar profile of hyperstimulation at baseline. The NBAS was firstly designed for full term;

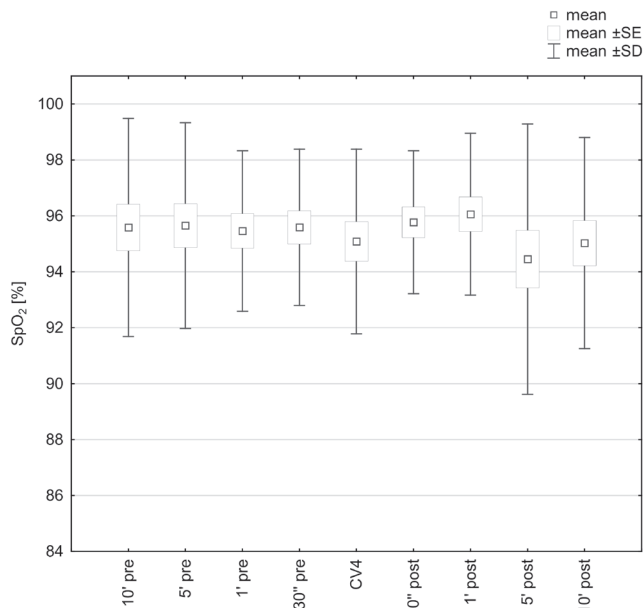


Fig. 3. Peripheral oxygen saturation (%) before ("pre"), during and after ("post") CV4 procedure

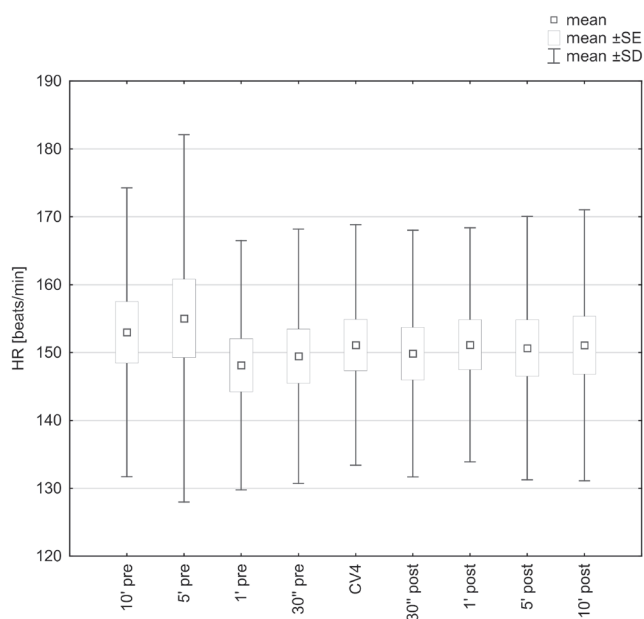


Fig. 4. Heart rate [beats/min] before ("pre"), during and after ("post") CV4 procedure

however, according to the available literature, this scale has also been used for very preterm infants.²⁶ In previous reports, CV4 was associated with reduced norepinephrine levels, improvement of sleep quality and latency, and pain relief in adult patients. Significant reduction in crying and sleep improvement has been shown in infants suffering from colic. Treated infants required less parental attention than the untreated group.^{16,21}

An altered sympathetic–vagal balance, as seen in the HR, has been reported after use of the CV4 technique.⁶ Increased parasympathetic and decreased sympathetic activity was observed.²² The CV4 was found to decrease HR and

decrease systolic blood pressure.²² In the present study, we did not find any significant changes in HR. No significant effects on SpO₂ were observed either, which is similar to findings in adults reported by of Shi et al.²³

According to the previous reports, CV4 may influence the nervous system. Application of this procedure was associated with the reduction of sleep latency or even altered electroencephalography tracing.⁵ To our knowledge, this is the first study assessing the potential influence of CV4 on cStO₂ in the preterm infants. The procedure was shown to decrease cStO₂ in adults. It was suggested that these findings might have been caused by a reduction of the cerebral blood flow. According to a proposed theory, enhancing cranial extension and discouraging cranial flexion could create intracranial force to facilitate venous outflow from the dural sinuses into the internal jugular vein and to decrease internal carotid arterial blood flow.²³ However, in the presented study, no statistically significant differences in cStO₂ before, during and after single CV4 were found. Perhaps more pronounced effects of CV4 might be observed in neonates in worse clinical condition or with repeated procedures, as some authors suggest the impact to be greater in patients with excessive intracranial pressure or volume with repeated therapy bouts or multiple therapy sessions.²³ Recorded cStO₂ values were not only above the hypoxic threshold for the sensor, but they were also comparable throughout the study. No complications were observed during CV4, which is in accordance with previous studies regarding osteopathic treatment in infants.^{13–16,21} Together with stable HR, SpO₂ and no apneic events, this seems to suggest that CV4 is a safe procedure in preterm infants.

Limitations of the study include a relatively small group of patients and a limited number of physiological variables studied. Among the strengths of this study, it should be highlighted that, in contrast to the previous studies, the patient's ANS status was assessed at baseline and only infants with clearly defined ANS hyperstimulation were enrolled.

Compression of the 4th ventricle seems to be a well-tolerated osteopathic procedure in neonates with no significant impact on cStO₂. Further investigations are needed to assess the potential clinical benefits of this procedure.

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