Original papers

Cerebral tissue oxygenation during cranial osteopathic CV4 procedure in newborns

Roksana Malak[1,A–D], Zuzanna Kozłowska[2,B], Zuzanna Owsiańska[2,B], Dorota Sikorska[1,C], Mirosław Andrusiewicz[3,C], Marta Szymankiewicz-Bręborowicz[2,E], Włodzimierz Samborski[1,E,F], Tomasz Szczapa[2,A,C,E,F]

[1] Department and Clinic of Rheumatology, Rehabilitation and Internal Diseases, Poznan University of Medical Sciences, Poland
[2] Department of Neonatology, Neonatal Biophysical Monitoring and Cardiopulmonary Therapies Research Unit, Poznan University of Medical Sciences, Poland
[3] Department of Cell Biology, Poznan University of Medical Sciences, Poland

A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation;
D – writing the article; E – critical revision of the article; F – final approval of the article

Advances in Clinical and Experimental Medicine, ISSN 1899–5276 (print), ISSN 2451–2680 (online) *Adv Clin Exp Med*. 2020;29(10):1187–1191

Address for correspondence
Roksana Malak
E-mail: rmalak@ump.edu.pl

Funding sources
None declared

Conflict of interest
None declared

Received on June 12, 2020
Reviewed on July 2, 2020
Accepted on August 5, 2020

Published online on October 8, 2020

Abstract

Background. The cranial osteopathic manipulative medicine has been shown to alter regional cerebral tissue oxygenation ($cStO_2$) 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 $cStO_2$ 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 $cStO_2$ monitoring; pulse oximeter oxygen saturation (SpO_2) 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 $cStO_2$ values recorded before (69 ±8%), during (69 ±8%) and after CV4 (70 ±8%; $p > 0.05$). Mean SpO_2 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 $cStO_2$ 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

Cite as
Malak R, Kozłowska Z, Owsiańska Z, et al. Cerebral tissue oxygenation during cranial osteopathic CV4 procedure in newborns. *Adv Clin Exp Med*. 2020;29(10):1187–1191. doi:10.17219/acem/126048

DOI
10.17219/acem/126048

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 occipitomastoid 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 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 ($cStO_2$) measured using near-infrared spectroscopy (NIRS) in the adult patients; however, there are no reports regarding the neonatal population.[23] The change in the $cStO_2$ 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 $cStO_2$ during CV4 technique in adults was most likely due to reduced oxygen delivery resulting from depression of cerebral blood flow.[23]

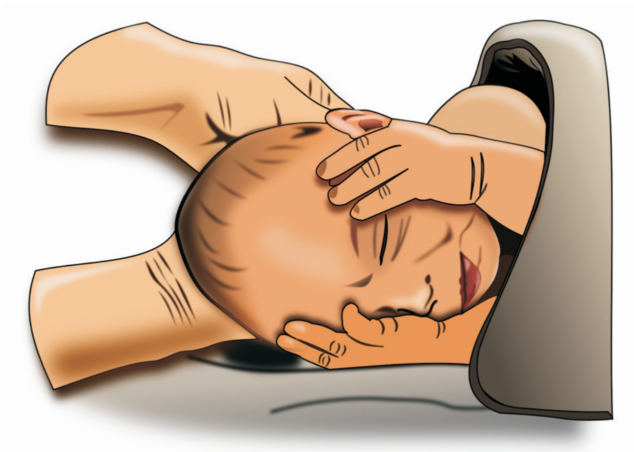

Fig. 1. Compression of the 4th ventricle procedure

The aim of this pilot study was to assess the influence of CV4 on $cStO_2$ in neonates undergoing the procedure. We focused on the following research questions:

1. Is $cStO_2$ altered by the CV4 procedure?
2. Are $cStO_2$ values within the reference range during and after CV4?
3. Are HR and SpO_2 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 (SpO_2) and $cStO_2$ 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 SpO_2 was Nellcor OxiMax N-600x (Coviden, 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 $cStO_2$ before, during and after CV4 (Fig. 2). No $cStO_2$ desaturations below hypoxic threshold for Invos neonatal sensor (63%) were observed and mean values of $cStO_2$ were within a range considered as normal for the age group.[28,29] No statistically significant differences in mean SpO_2 value were observed before, during and after CV4 (Fig. 3). Mean HR values were also similar before, during and after CV4 (Fig. 4).

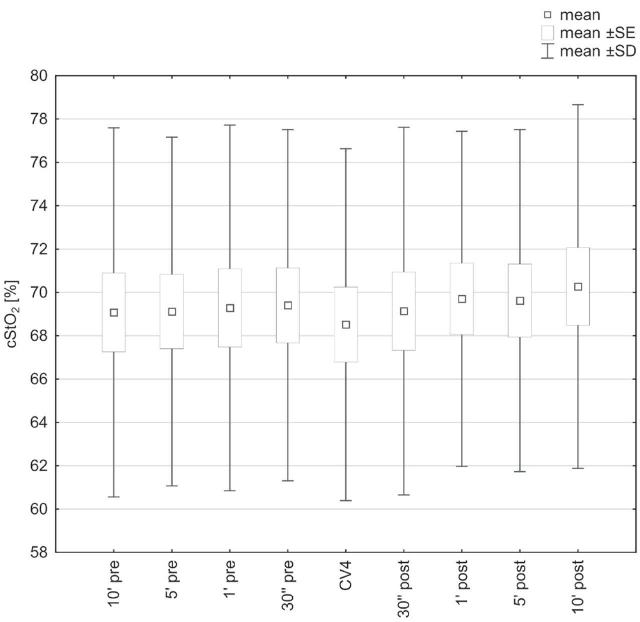

Fig. 2. Cerebral tissue oxygen saturation (%) before ("pre"), during and after ("post") CV4 procedure

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;

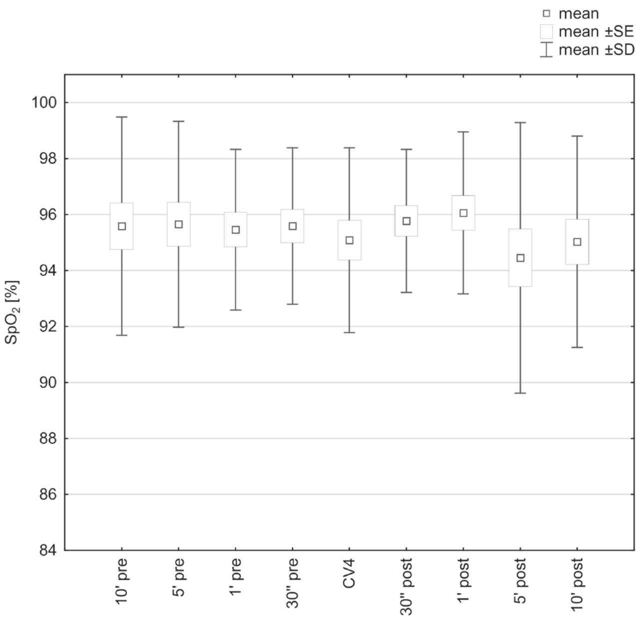

Fig. 3. Peripheral oxygen saturation (%) before ("pre"), during and after ("post") CV4 procedure

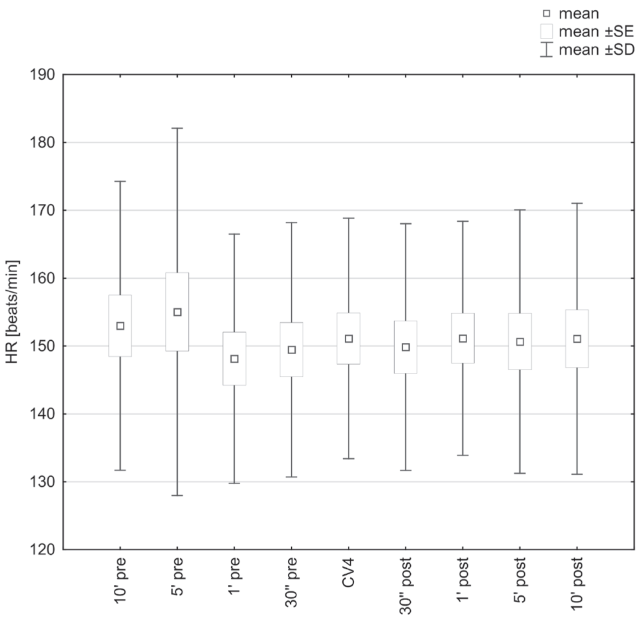

Fig. 4. Heart rate [beats/min] before ("pre"), during and after ("post") CV4 procedure

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 SpO_2 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 $cStO_2$ in the preterm infants. The procedure was shown to decrease $cStO_2$ 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 $cStO_2$ 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 $cStO_2$ 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, SpO_2 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 $cStO_2$. Further investigations are needed to assess the potential clinical benefits of this procedure.

ORCID iDs

Roksana Malak https://orcid.org/0000-0003-0521-5249
Zuzanna Kozłowska https://orcid.org/0000-0002-7750-048X
Zuzanna Owsiańska https://orcid.org/0000-0001-8348-3682
Dorota Sikorska https://orcid.org/0000-0001-7326-6916
Mirosław Andrusiewicz https://orcid.org/0000-0002-8781-3447
Marta Szymankiewicz-Bręborowicz https://orcid.org/0000-0002-7389-0708
Włodzimierz Samborski https://orcid.org/0000-0002-0338-894X
Tomasz Szczapa https://orcid.org/0000-0002-5214-2719

References

1. Schneider U, Bode F, Schmidt A, et al. Developmental milestones of the autonomic nervous system revealed via longitudinal monitoring of fetal heart rate variability. *PLoS One*. 2018;13(7):e0200799. doi:10.1371/journal.pone.0200799

2. World Health Organization. Preterm birth. https://www.who.int/news-room/fact-sheets/detail/preterm-birth. Accessed July 7, 2020.
3. Statistics Poland. Maria Klonowska-Matynia. Health aspects of human capital differentiation in Poland. *The Polish Statistician*. 2019; 1:32–51. https://stat.gov.pl/files/gfx/ portalinformacyjny/pl/default aktualnosci/5982/7/49/1/wiadomosci_statystyczne_01_2019.pdf. Accessed July 13, 2020.
4. Hadders-Algra M, Boxum AG, Hielkema T, Hamer EG. Effect of early intervention in infants at very high risk of cerebral palsy: A systematic review. *Dev Med Child Neurol*. 2017;59(3):246–258. doi:10.1111/dmcn.13331
5. Żurowska A, Malak R, Kołcz-Trzęsicka A, Samborski W, Paprocka-Borowicz M. Compression of the fourth ventricle using a craniosacral osteopathic technique: A systematic review of the clinical evidence. *Evid Based Complement Alternat Med*. 2017;2017:2974962. doi:10.1155/2017/2974962
6. Nelson KE, Sergueef N, Glonek T. The effect of an alternative medical procedure upon low-frequency oscillations in cutaneous blood flow velocity. *J Manipulative Physiol Ther*. 2006;29(8):626–636. doi:10.1016/j.jmpt.2006.08.007
7. Curi ACC, Maior Alves AS, Silva JG. Cardiac autonomic response after cranial technique of the fourth ventricle (cv4) compression in systemic hypertensive subjects. *J Bodyw Mov Ther*. 2018;22(3):666–672. doi:10.1016/j.jbmt.2017.11.013
8. Miana L, Hugo do Vale Bastos V, Machado S, et al. Changes in alpha band activity associated with application of the compression of fourth ventricular (CV-4) osteopathic procedure: A qEEG pilot study. *J Bodyw Mov Ther*. 2013;17(3):291–296. doi:10.1016/j.jbmt.2012.10.002
9. Cardoso-de-Mello-E-Mello-Ribeiro AP, Rodríguez-Blanco C, Riquelme-Agulló I, Heredia-Rizo AM, Ricard F, Oliva-Pascual-Vaca Á. Effects of the fourth ventricle compression in the regulation of the autonomic nervous system: A randomized control trial. *Evid Based Complement Alternat Med*. 2015;2015:148285. doi:10.1155/2015/148285
10. Wyatt K, Edwards V, Franck L, et al. Cranial osteopathy for children with cerebral palsy: A randomised controlled trial. *Arch Dis Child*. 2011;96(6):505–512. doi:10.1136/adc.2010.199877
11. Brand PLP, Engelbert RHH, Helders PJM, Offringa M. Systematic review of the effects of therapy in infants with the KISS-syndrome (kinetic imbalance due to suboccipital strain) [in Dutch]. *Ned Tijdschr Geneeskd*. 2005;149(13):703–707.
12. Dobson D, Lucassen PL, Miller JJ, Vlieger AM, Prescott P, Lewith G. Manipulative therapies for infantile colic. *Cochrane Database Syst Rev*. 2012;12:CD004796. doi:10.1002/14651858.cd004796.pub2
13. Raith W, Marschik PB, Sommer C, et al. General movements in preterm infants undergoing craniosacral therapy: A randomised controlled pilot-trial. *BMC Complement Altern Med*. 2016;16:12. doi:10.1186/s12906-016-0984-5
14. Cerritelli F, Pizzolorusso G, Ciardelli F, et al. Effect of osteopathic manipulative treatment on length of stay in a population of preterm infants: A randomized controlled trial. *BMC Pediatr*. 2013;13:65. doi:10.1186/1471-2431-13-65
15. Pizzolorusso G, Turi P, Barlafante G, et al. Effect of osteopathic manipulative treatment on gastrointestinal function and length of stay of preterm infants: An exploratory study. *Chiropr Man Therap*. 2011;19:15. doi:10.1186/2045-709X-19-15
16. Parnell Prevost C, Gleberzon B, Carleo B, Anderson K, Cark M, Pohlman KA. Manual therapy for the pediatric population: A systematic review. *BMC Complement Altern Med*. 2019;19(1):60. doi:10.1186/s12906-019-2447-2
17. Milnes K, Moran RW. Physiological effects of a CV4 cranial osteopathic technique on autonomic nervous system function: A preliminary investigation. *Int J Osteopath Med*. 2007;10(1):8–17. doi:10.1016/j.ijosm.2007.01.003
18. Cutler MJ, Holland BS, Stupski BA, Gamber RG, Smith ML. Cranial manipulation can alter sleep latency and sympathetic nerve activity in humans: A pilot study. *J Altern Complement Med*. 2005;11(1):103–108. https://doi.org/10.1089/act.2005.11.103
19. The Educational Council on Osteopathic Principles Meets at LUCOM. https://www.aacom.org/news-and-events/news-detail/2019/10/08/aacom-s-ecop-meets-at-lucom. Accessed July 13, 2020.
20. Mills MV, Henley CE, Barnes LLB, Carreiro JE, Degenhardt BF. The use of osteopathic manipulative treatment as adjuvant therapy in children with recurrent acute otitis media. *Arch Pediatr Adolesc Med*. 2003;157(9):861–866. doi:10.1001/archpedi.157.9.861
21. Hayden C, Mullinger B. A preliminary assessment of the impact of cranial osteopathy for the relief of infantile colic. *Complement Ther Clin Pract*. 2006;12(2):83–90. doi:10.1016/j.ctcp.2005.12.005
22. Curi ACC, Maior Alves AS, Silva JG. Cardiac autonomic response after cranial technique of the fourth ventricle (cv4) compression in systemic hypertensive subjects. *J Bodyw Mov Ther*. 2018;22(3):666–672. doi:10.1016/j.jbmt.2017.11.013
23. Shi X, Rehrer S, Prajapati P, Stoll ST, Gamber RG, Downey HF. Effect of cranial osteopathic manipulative medicine on cerebral tissue oxygenation. *J Am Osteopath Assoc*. 2011;111(12):660–666.
24. de Jesus VR, de Oliveira PMN, de Oliveira Azevedo VMG. Effects of hammock positioning in behavioral status, vital signs, and pain in preterms: A case series study. *Braz J Phys Ther*. 2018;22(4):304–309. doi:10.1016/j.bjpt.2018.03.002
25. Perez-Pereira M, Fernandez P, Gómez-Taibo M, et al. Neurobehavioral development of preterm and full term children: Biomedical and environmental influences. *Early Hum Dev*. 2013;89(6):401–409. doi:10.1016/j.earlhumdev.2012.12.008
26. Barlow J, Herath NI, Bartram Torrance C, Bennett C, Wei Y. The Neonatal Behavioral Assessment Scale (NBAS) and Newborn Behavioral Observations (NBO) system for supporting caregivers and improving outcomes in caregivers and their infants. *Cochrane Database Syst Rev*. 2018;3:CD011754. doi:10.1002/14651858.CD011754.pub2
27. Cerritelli F, Pizzolorusso G, Renzetti C, et al. A multicenter, randomized, controlled trial of osteopathic manipulative treatment on preterms. *PLoS One*. 2015;10(5):e0127370. doi:10.1371/journal.pone.0127370
28. Kleiser S, Ostojic D, Andresen B, et al. Comparison of tissue oximeters on a liquid phantom with adjustable optical properties: An extension. *Biomed Opt Express*. 2018;9(1):86. doi:10.1364/boe.9.000086
29. Pellicer A, Greisen G, Benders M, et al. The SafeBoosC phase II randomised clinical trial: A treatment guideline for targeted near-infrared-derived cerebral tissue oxygenation versus standard treatment in extremely preterm infants. *Neonatology*. 2013;104(3):171–178. doi:10.1159/000351346