Effect of Different Techniques of Cervical Immobilization on Intracranial Pressure in Healthy Volunteers: Observational Study

Mohamed Bosily Saad[a]*, Mohamed Gamal Elbahnasawy[a], Wafaa Abdelsalam[b], Hatem Fawzy[c], Tarek Mohamed Saad[c], Mohamed Ezzat Nasreddin[a]

[a]Emergency Medicine and Traumatology, Faculty of Medicine, Tanta University, Tanta, Egypt.

[b]Anesthesia and Surgical ICU Department, Faculty of Medicine, Kafrelsheih University, Kafrelsheih, Egypt.

[c]Ophthalmology Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt.

Abstract

Background: Cervical immobilization is crucial for preventing further injury in spinal trauma. However, cervical immobilization may increase intracranial pressure (ICP), which results in a reduction in cerebral blood flow and a subsequent decline in neurological function. Optic nerve sheath diameter (ONSD) measurement evolved as a non-invasive, reliable surrogate of intracranial pressure.

Objectives: This research aimed to assess the impact of neck collars and headblocks strapped on the backboard as methods of cervical immobilization on ONSD, a surrogate of intracranial pressure, in healthy individuals.

Materials and methods: The prospective comparative study involved 100 healthy volunteers of both sexes who were over eighteen years of age and divided into two groups. Cervical immobilization was done by neck collar in Group A and head blocks strapped on the backboard in Group B. ONSD was measured in both groups at baseline and subsequently at 20, 40, and 60-minute intervals and statistically analyzed.

Results: Baseline ONSD measurement of both eyes was insignificantly different; however, it became significantly higher after 20 min, 40 min, and 60 min compared to baseline in both groups ($P<0.05$). Notably, ONSD measurements were more elevated at 20, 40, and 60 min in group A compared to group B ($P <0.05$).

Conclusion: Headblocks strapped on the backboard were superior to the neck collar as evidenced by a lower elevation rate of ONSD, which may reflect a lower increase in ICP.

Keywords: Cervical immobilization; Neck collar; Head blocks; Optic nerve sheath diameter; Intracranial pressure.

DOI: 10.21608/SVUIJM.2024.334064.2015

***Correspondence:** mohamed.bosily@med.tanta.edu.eg

Received: 6 Novenmber,2024.

Revised: 18 December, 2024.

Accepted: 21 decmber, 2024.

Published: 29 January, 2025

Cite this article as Mohamed Bosily Saad, Mohamed Gamal Elbahnasawy, Wafaa Abdelsalam, Hatem Fawzy, Tarek Mohamed Saad, Mohamed Ezzat Nasreddin.(2025). Effect of Different Techniques of Cervical Immobilization on Intracranial Pressure in Healthy Volunteers: Observational Study. *SVU-International Journal of Medical Sciences*. Vol.8, Issue 1, pp: 194-200.

Introduction

Immobilization of all trauma patients with cervical spinal column injuries is recommended until a spinal injury is ruled out. Cervical immobilization is crucial for preventing further injury in spinal trauma. Following the advanced trauma life support guidelines, the patient must be immobilized by securing a rigid cervical collar and headblocks to the backboard **(Holla, 2012)**.

For a long period, cervical collars have been the accepted standard of treatment for trauma patients in emergency medical services **(Kissmer and Morris, 2023)**. In numerous case series and studies, the utilization of cervical collars for spinal immobilization has been shown to elevate intracranial pressure (ICP), which results in a reduction in cerebral blood flow and a subsequent decline in neurological function **(Hunt et al., 2001, Hoogervorst et al., 2013, Yard et al., 2019)**.

Headblocks strapped on the backboard primarily aim to restrict lateral head movement. However, their strap use can exert pressure, possibly affecting venous return and ICP **(Feldman et al., 1992)**.

In various studies, the optic nerve sheath diameter (ONSD) is a useful marker for indirectly measuring the ICP **(Kim et al., 2017, Yazici and Yavaşi, 2024)**. Measuring ONSD has been investigated as a noninvasive method to estimate ICP and monitor patients for signs of elevated intracranial pressure. Understanding its effects on ONSD is important for clinicians monitoring ICP, especially in head-injured patients **(Yard et al., 2019)**. Increased ICP can lead to the enlargement of the optic nerve sheath because of the transmission of pressure along the subarachnoid space surrounding the optic nerve **(Munawar et al., 2019)**. As a result, the ONSD may become enlarged, which can be observed through imaging studies such as magnetic resonance imaging (MRI), computed tomography (CT), and ultrasonography **(Wang et al., 2022)**.

ONSD measured by ultrasound, is a highly effective diagnostic technique for detecting elevated ICP in clinicians **(Koshy and Gadkari, 2024)**.

In the literature, there are many studies in which ONSD measurements of trauma patients with cervical collars were obtained using the US **(Woster et al., 2018, Şık et al., 2022, Yard et al., 2019)**. However, the studies using headblocks are lacking. Therefore, our objective in this research is to assess the impact of neck collars, and headblocks strapped on the backboard as methods of cervical immobilization on intracranial pressure, represented as ONSD, in healthy individuals.

Materials and methods

This prospective comparative study was carried out on one hundred healthy volunteers, more than 18 years old, both sexes, at Tanta University Hospital, Egypt, following approval from the institutional ethical committee and registration at clinicaltrials.gov (ID: NCT04507620) from 8th July 2020 to 7th September 2022. The included individuals provided informed written consent.

The criteria for exclusion were stroke history, inability to give consent, inability to remain in a supine position for 60 minutes on a bed or table, glaucoma history, injury to the globe, implantation of the lens, a recent refractive procedure, intracranial pathology, carotid artery disease, and uncontrolled hypertension.

The healthy volunteers were divided into two equal groups. Cervical immobilization was done by neck collar in Group A and headlocks strapped on the backboard in Group B.

Optic nerve sheath diameter measurement

The individual was supine, while the cranium was increased at a 30° angle and centrally situated during the ONSD measurements. A layer of lubricant was applied to the contracted pupils, and a clear film protective dressing was applied to both eyes. To prevent the globe from being subjected to pressure, with meticulous positioning, A linear array ultrasonographic probe with a frequency of 10 MHz was employed to examine the contracted pupils. The optic nerve health was optimally visualized by positioning the instrument on the temporal region of the upper eyelid. The probe was oriented horizontally, from left to right, and the eye examination was conducted in the horizontal and vertical plane. The imaging was conducted on both eyes. At an angle perpendicular to the optic nerve, the mean binocular ONSD was measured in both eyes at a depth of 3 mm behind the sclera's lamina cribrosa **(Kim et al., 2017)**.

The measurement was recorded by a well-trained emergency physician on ONSD evaluation by point-of-care ultrasonography using (Phillips Affinity 50) device. Both eyes & Averaged ONSD measurements were recorded before applying cervical immobilization devices and at 20, 40, and 60-minute intervals in each group.

Sample Size: The sample size was determined by utilizing G*Power 3.1.9.2 (Universitat Kiel, Germany). A pilot study was conducted with five individuals in each group. The mean (± SD) ONSD of both eyes at 60 min was 4.32 ± 0.78 mm in group A and 3.97 ± 0.32 mm in group B. The following parameters were used to determine the sample size: a group ratio of 1:1, an effect size of 0.583, 80% power, 95% confidence level, and each group was supplemented with two individuals to mitigate drop-out. Consequently, we recruited 50 individuals for each category.

Statistical analysis

SPSS v27 (IBM©, Armonk, NY, USA) was used for statistical analysis. The Shapiro-Wilks test and histograms were employed to evaluate the normality of the data distribution. The unpaired student t-test was employed to analyze the quantitative parametric data presented as mean and standard deviation. The Mann-Whitney test was employed to analyze the quantitative non-parametric data, which were reported as median and interquartile range (IQR). A repeated measure ANOVA test was employed to compare the measurements in the same groups. The Chi-square test was employed to analyze the qualitative variables presented as frequency and %. A statistically significant two-tailed P value was defined as less than or equal to 0.05.

Results

The demographic data did not exhibit any statistical difference between the two categories. (**Table.1).** At baseline, the ONSD of both eyes did not exhibit any discernible difference between the two groups. Following 20, 40, and 60 minutes of applying either the cervical immobilization method, the ONSD of both eyes was markedly more elevated than baseline (P<0.05). However, this rise was markedly more elevated in group A, the collar group, than in group B, the headblocks group. (P <0.05), (**Table. 2).**

Table 1.Demographic data of the studied groups

Variables		Group A (n=50)	Group B (n=50)	P #
Age (years)		40.2 ± 9.94	42.72 ± 12.81	0.274
Sex	**Male**	34 (68%)	32 (64%)	0.673
	Female	16 (32%)	18 (36%)	
Weight (kg)		77.74 ± 9.81	79.78 ± 10.86	0.327
Height (m)		1.67 ± 0.08	1.66 ± 0.07	0.419
BMI (kg/m^2)		27.96 ± 3.73	29 ± 3.38	0.145

Data are presented as mean ± SD or frequency (%).

Table 2: ONSD of the right and left eye of the studied groups

Variables	Group A (n=50)	Group B (n=50)	P #
Right eye			
Baseline	3.68±0.85	3.42±0.87	0.134
20min	4.05±0.85	3.63±0.87	0.016*
P ##	<0.001*	<0.001*	
40min	4.23±0.87	3.84±0.9	0.029*
P ##	<0.001*	<0.001*	
60min	4.43±0.84	3.97±0.85	0.008*
P ##	<0.001*	<0.001*	
Left eye			
Baseline	3.52±0.89	3.33±0.87	0.298
20min	3.99±0.88	3.62±0.85	0.035*
P ##	<0.001*	<0.001*	
40min	4.27±0.88	3.79±1.15	0.021*
P ##	<0.001*	0.02*	
60min	4.36±0.89	3.91±1.15	0.031*
P ##	<0.001*	0.004*	

Data are presented as mean ± SD. *: Significant as P value≤0.05. ONSD: Optic nerve sheath diameter. P #: P value between group A and group B. P ##: P value compared to baseline.

Average ONSD was insignificantly different at baseline between the two groups but was significantly higher at 20 min, 40 min, and 60 min in all patients, regardless of the immobilization technique used (P<0.05), (**Table.3).**

Table 3. Average of ONSD of the studied groups

Variables	Group A (n=50)	Group B (n=50)	P #
Baseline	3.6±0.6	3.38±0.61	0.069
20min	4.02±0.6	3.62±0.6	0.001*
P ##	<0.001*	<0.001*	
40min	4.25±0.61	3.82±0.77	0.002*
P ##	<0.001*	<0.001*	
60min	4.4±0.59	3.94±0.73	0.001*
P ##	<0.001*	<0.001*	

Data are presented as mean ± SD. *: Significant as P value≤0.05. ONSD: Optic nerve sheath diameter. P #: P value between group A and group B. P ##: P value compared to baseline.

Delta change of ONSD between 60 minutes and baseline was markedly more elevated in group A, with a collar applied (P=0.003), (**Table.4).**

Table 4.Delta change of ONSD between baseline and 60min of the studied groups

Variables	Group A (n=50)	Group B (n=50)	P #
Delta change between 60min and baseline	0.75(0.7 - 0.89)	0.5(0.16 - 1.04)	0.003*

Data is presented as median (IQR). *: Significant as P value≤0.05. ONSD: Optic nerve sheath diameter. P #: P value between group A and group B.

Discussion

Ultrasonography is a simple method for assessing ONSD, and it is significantly correlated with ICP **(Amini et al., 2013, Sahoo and Agrawal, 2013)**.

Cervical collars have been reported to elevate ICP, which may adversely affect clinical outcomes and induce tissue injury by disrupting cerebral perfusion **(Davies et al., 1996)**. A neck collar has several complications, such as restricting the neck and chest movement, leading to difficulty breathing and decreased lung capacity. The collar can also limit the movement of the throat, making it difficult for the patient to swallow. Prolonged mobilization can lead to stiffness, decreased range of motion in the neck, and muscle atrophy, so using cervical collars for spinal immobilization is now widely debated. This encourages us to use another method, such as head blocks, to avoid or reduce neck collar complications and reduce elevation of ICP.

Head blocks provide support and cushioning for the patient's head, reducing pressure points and enhancing comfort. Few studies addressed the effect of various cervical spine immobilization techniques on intracranial pressure.

In our result, the ONSD of both eyes was almost similar at baseline, being significantly higher at 20, 40, and 60 minutes in both groups and markedly more elevated in group A than in group B.

The mechanism for the rise in ICP is that the cervical collar directly compresses jugular veins, and less blood is drained from the cranial cavity. This can cause fluid accumulation in the intracranial area, which subsequently leads to an increase in ICP **(Stone et al., 2010, Karason et al., 2014, Davies et al., 1996, Mobbs et al., 2002, Núñez-Patiño et al., 2020)**. Also, a neck collar can cause hypotension (low blood pressure) by applying pressure to the carotid arteries located in the neck. These arteries are responsible for supplying blood to the brain. When pressure is applied to these arteries, it can restrict blood flow to the brain, decreasing blood pressure **(Nardone et al., 2020)**.

Head blocks, on the other hand, produce less pressure over the jugular veins and reduce change in ICP **(Mobbs et al., 2002)**. They also do not cause significant muscle tension **(Holla, 2012)**. Therefore, headblocks have less of an effect on ONSD than neck collars.

Consistent with our findings, Colak et al. **(Colak and Celik, 2020)** demonstrated that the ONSD recorded after 20 minutes from the application of cervical collar in trauma patients who were referred to the emergency department was significantly larger than the diameter that was detected at the time of admission. In the same line, Yard et al. **(Yard et al., 2019)** revealed that cervical collars elevated the ONSD more than the control group. Similarly, Maissan et al. **(Maissan et al., 2018)** demonstrated that the ONSD in healthy volunteers is substantially increased by using a rigid cervical collar compared to the control group. Furthermore, Ladny et al. **(Ladny et al., 2020)** and Woster et al. **(Woster et al., 2018)** revealed that the ONSD among healthy volunteers increased significantly from the baseline and subsequently the implantation of a cervical collar. Also, Karacabey et al. **(Karacabey and Sanri, 2022)** found that ONSD increased after neck collar placement when compared to the baseline measurements in minor head trauma patients.

Our study has a few limitations, including research conducted at a solitary location with a relatively small sample size. Additionally, as conducted on healthy volunteers, future studies are needed to compare both techniques in trauma patients.

Conclusion

Despite the significant elevation of ONSD in either method of cervical immobilization, this effect is more prominent with a hard neck collar.

Acknowledgments: Nil

Financial support and sponsorship: Nil

Conflict of Interest: Nil

References

- **Amini A, Kariman H, Dolatabadi AA, Hatamabadi HR, Derakhshanfar H, Mansouri B, et al. (2013)**. Use of the sonographic diameter of optic nerve sheath to estimate intracranial pressure. Am J Emerg Med, 31(1): 236-239.

- **Colak T, Celik K. (2020)**. The association between cervical collar and intracranial pressure measured by the optic nerve sheath diameter in trauma patients refered to the emergency department. Signa Vitae, 25(2): 16-34.
- **Davies G, Deakin C, Wilson A. (1996)**. The effect of a rigid collar on intracranial pressure. Injury, 27(9): 647-649.
- **Feldman Z, Kanter MJ, Robertson CS, Contant CF, Hayes C, Sheinberg MA, et al. (1992)**. Effect of head elevation on intracranial pressure, cerebral perfusion pressure, and cerebral blood flow in head-injured patients. J Neurosurg, 76(2): 207-211.
- **Holla M. (2012)**. Value of a rigid collar in addition to head blocks: a proof of principle study. Emerg Med J 29(2): 104-107.
- **Hoogervorst EM, van Beeck EF, Goslings JC, Bezemer PD, Bierens JJLM. (2013)**. Developing process guidelines for trauma care in the Netherlands for severely injured patients: results from a Delphi study. BMC Health Serv Res, 13(2): 1-10.
- **Hunt K, Hallworth S, Smith M. (2001)**. The effects of rigid collar placement on intracranial and cerebral perfusion pressures. Anaesthesia, 56(6): 511-513.
- **Karacabey S, Sanri E. (2022)**. Optic nerve sheath diameter affected by cervical collar placement in minor head trauma patients. IRCMJ, 12(1): 10-16.
- **Karason S, Reynisson K, Sigvaldason K, Sigurdsson GH. (2014)**. Evaluation of clinical efficacy and safety of cervical trauma collars: differences in immobilization, effect on jugular venous pressure and patient comfort. Scand J Trauma Resusc Emerg Med, 22(2): 1-7.
- **Kim DH, Jun JS, Kim R. (2017)**. Ultrasonographic measurement of the optic nerve sheath diameter and its association with eyeball transverse diameter in 585 healthy volunteers. Sci Rep, 7(1): 159-206.
- **Kissmer N, Morris D. (2023)**. Knowledge, attitude, and practices regarding cervical collars in adult trauma patients amongst practitioners at three hospitals in kwazulu-natal, south africa. Afr J Emerg Med, 13(4): 241-244.
- **Koshy P, Gadkari C. (2024)**. Measurement of optic nerve sheath diameter by bedside ultrasound in patients with traumatic brain injury presenting to emergency department: A review. Cureus, 16(6): 617-768.
- **Ladny M, Smereka J, Ahuja S, Szarpak L, Ruetzler K, Ladny JR. (2020)**. Effect of 5 different cervical collars on optic nerve sheath diameter: A randomized crossover trial. Medicine (Baltimore), 99(16): 197-240.
- **Maissan IM, Ketelaars R, Vlottes B, Hoeks SE, den Hartog D, Stolker RJ. (2018)**. Increase in intracranial pressure by application of a rigid cervical collar: a pilot study in healthy volunteers. Eur J Emerg Med, 25(6): 24-28.
- **Mobbs RJ, Stoodley MA, Fuller J. (2002)**. Effect of cervical hard collar on intracranial pressure after head injury. ANZ journal of surgery, 72(6): 389-391.
- **Munawar K, Khan MT, Hussain SW, Qadeer A, Shad ZS, Bano S, et al. (2019)**. Optic nerve sheath diameter correlation with elevated intracranial pressure determined via ultrasound. Cureus, 11(2): 41-45.
- **Nardone M, Guzman J, Harvey PJ, Floras JS, Edgell H. (2020)**. Effect of a neck compression collar on cardiorespiratory and cerebrovascular function in postural orthostatic tachycardia syndrome (POTS). J Appl Physiol (1985), 128(4): 907-913.

- **Núñez-Patiño RA, Rubiano AM, Godoy DA. (2020)**. Impact of cervical collars on intracranial pressure values in traumatic brain injury: A systematic review and meta-analysis of prospective studies. Neurocrit Care, 32(2): 469-477.
- **Sahoo SS, Agrawal D. (2013)**. Correlation of optic nerve sheath diameter with intracranial pressure monitoring in patients with severe traumatic brain injury. Indian J Neurotrauma, 10(1): 9-12.
- **Şık N, Ulusoy E, Çitlenbik H, Öztürk A, Er A, Yılmaz D, et al. (2022)**. The role of sonographic optic nerve sheath diameter measurements in pediatric head trauma. J Ultrasound, 25(4): 957-963.
- **Stone MB, Tubridy CM, Curran R. (2010)**. The effect of rigid cervical collars on internal jugular vein dimensions. Acad Emerg Med, 17(1): 100-102.
- **Wang LJ, Zhang Y, Li C, Liu Y, Dong YN, Cui L, et al. (2022)**. Ultrasonographic optic nerve sheath diameter as a noninvasive marker for intracranial hypotension. Ther Adv Neurol Disord, 15(3): 31-62.
- **Woster CM, Zwank MD, Pasquarella JR, Wewerka SS, Anderson JP, Greupner JT, et al. (2018)**. Placement of a cervical collar increases the optic nerve sheath diameter in healthy adults. Am J Emerg Med, 36(3): 430-434.
- **Yard J, Richman PB, Leeson B, Leeson K, Youngblood G, Guardiola J, et al. (2019)**. The Influence of Cervical Collar Immobilization on Optic Nerve Sheath Diameter. J Emerg Trauma Shock, 12(2): 141-144.
- **Yazici MM, Yavaşi Ö. (2024)**. Effect of a cervical collar on optic nerve sheath diameter in trauma patients. World J Emerg Med, 15(2): 126-130.