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Optic Nerve Sheath Diameter Affected by Cervical Collar Placement in Minor Head Trauma Patients

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Abstract

Background: Head trauma may cause an increase in intracranial pressure (ICP). The use of ocular ultrasound to measure optic nerve sheath diameter (ONSD) is a method to determine the ICP. The use of the rigid cervical collar in head trauma patients contribute to elevating ICP, and therefore, potentially causing further deterioration in their condition.

Objectives: This study aimed to describe changes in ONSD after the placement of a c-collar and analyze these changes depending on the time in the c-collar.

Methods: This prospective study measured the ONSD of minor head trauma patients before and after the placement of a c-collar. Patients aged ≥18 with blunt head trauma and Glasgow Coma Score ≥13 were included in the study. Each eye was scanned twice. This was done before c-collar placement, at 5 and 20 min after placement. The mean values of both eyes were calculated and analyzed.

Results: This study investigated 50 patients. The mean baseline ONSD was obtained at 4.71mm±0.22 (4.54-4.77). Furthermore, T5 and T20 measurements were 5.19±0.41 (5.07-5.31) and 5.26±0.45 (5.14-5.39), respectively. The ONSD increased at T5 and T20. The changes from the baseline measurements were statistically significant (P=0.000, P=0.000). The difference between T5 and T20 groups was an increase in ONSD, and these differences were also statistically significant (0.07±0.19; P=0.008).

Conclusion: Our results revealed that minor head trauma patients using a c-collar may increase ONSD by timeline the clinical effects of which have to be determined with further studies. Enlargement in ONSD should be considered when interpreting ICP.

Keywords: Head trauma, Optic nerve sheath diameter, Ultrasound

1. Background

Head trauma is a major problem of mortality and morbidity that may cause an increase in intracranial pressure (ICP). For this reason, patients with elevated ICP need rapid and accurate diagnostic tools to prevent poor outcomes. The physical examination gives limited results and can not accurately detect elevated intracranial pressure caused by injury, sedation, or paralysis as part of their out-of-hospital care. External ventricular devices are classical methods for monitoring ICP. The use of these invasive and time-consuming devices is limited to trained physicians (1, 2).

Ultrasonography is widely used in emergency medicine as a diagnostic tool. One of the application methods is the use of ocular ultrasound to measure the optic nerve sheath diameter (ONSD) (3). Increased ICP effects on the optic nerve head cause optic nerve dilatation and optic disc edema (4). Thus, ultrasonographic measurement of ONSD has been used to detect elevated ICP (5, 6). The optic nerve is a part of the central nervous system and is covered by a leptomeningeal sheath. This sheath is the continuation of the dura and can expand through the anterior segment behind the globe. Papilledema can be used to detect increased ICP; however, the development of papilledema can take hours to days. A faster and more efficient diagnostic tool is proposed by researchers: ONSD measurement. Early human studies showed that increased ICP results in the distension of the optic nerve sheath (7). There is no consensus on the normal margins of ONSD measurements; however, 3.7 mm is accepted as a normal measurement. 5 mm is the borderline of the upper limit of ONSD, and >5mm is accepted as a high value (8).

Cervical spine injuries often coexist with head trauma and can not be excluded in prehospital settings. Therefore, immobilization with a cervical collar (c-collar) is a common method in head trauma patients. In previous studies, c-collar has been shown to increase ICP (8-12). The proposed mechanism of elevated ICP due to the c-collar is an obstruction in the venous outflow in the jugular region (12). Previous studies have described the effect of rigid c-collar in head trauma patients as a contributor to elevated ICP, and therefore, potentially causing further deterioration in their condition. As a result, immobilization with a c-collar may worsen the clinical outcomes by increasing the ICP in head trauma patients potentially with already increased ICPs (10, 11, 14, 15). Previous studies also revealed that the c-collar placement had affected ONSD measurements in healthy volunteers, and consequently, caused an increase in ICP (16-18). This study examined the measurement of ONSD before and after the placement of a c-collar.

2. Objectives

Moreover, it aimed to describe changes in ONSD after the placement of a c-collar and analyze these changes that were dependent on time in the c-collar.

3. Methods

3.1. Study Design

This prospective, single-center, before-after cohort study was conducted at a tertiary care hospital. The study protocol was approved by the university's Institutional Review Board (IRB No: 09.2018.298). It was also registered at ClinicalTrials.gov (ID: NCT03742427).

3.2. Participants

Patients appealed to the emergency department, aged ≥18 with blunt head trauma and Glasgow Coma Score ≥13, and those who signed the written informed consent were included in this study. On the other hand, the patients with known eye or intracranial disease, known or suspected findings of intoxication, respiratory acidosis, referred from another hospital or were brought to the emergency department with prior application of c-collar, those who can not be followed for any reason (treatment, refusal, unauthorized leave, and referral to the center), and cases who withdrawn their consent were excluded from the study.

3.3. Intervention

All the patients' trauma etiologies were recorded and assessed for NEXUS Head Computerized Tomography (CT) Rules for CT scans, and the sonographers were blinded for CT examination decisions and results.

NEXUS Head CT Rules:

- Age >65-year-old
- Evidence of significant skull fracture
- Scalp hematoma
- Neurological deficit
- Altered level of alertness
- Abnormal behavior
- Coagulopathy

Recurrent or forceful vomiting (19).

Patients were laid on a stretcher in a supine position and were told to close their eyes. Sterile ultrasound gel was applied to each eyelid of the patient. After the gel appliance, a 7.5-MHz linear probe with the ophthalmic setting (Mindray M5, Mindray, P.R.C.) was performed to measure the ONSD. The two experienced sonographers each performed at least 350 US per annum. They were certified for basic and advanced emergency sonography by the national emergency medicine society. The intraclass correlation coefficient of the two sonographers for sonographic measurement of ONSD was >0.9 according to local annual quality checks. Both sonographers measured 25 sonographic ONSD each before this study.

Both physicians were blinded to each other measurements. For each, individual ultrasound was performed in the supine position, eyes closed and looking directly ahead. ONSD measurement was made from the area between the hyperechoic dural sheaths located at the edge of the hypoechoic subarachnoid area surrounding the optic nerve. Ultrasound was performed individually from the sagittal plane, and from this level, measurements were made transversely. ONSD measurements were taken from the acknowledged standard location 3 mm posterior to the retina (Figure 1). Each eye measurement was recorded two times and then a mean binocular ONSD was calculated. In this way, baseline measurements were recorded. After this baseline measurement, a rigid c-collar (ENPLUS, EN2050, Adult Type Adjustable c-collar Istanbul, Turkey) was placed for all individual patients according to the appropriate size. The same technique was used to measure the ONSD after c-collar placement, and the mean ONSD was again calculated. This process was done at time points after placement of the c-collar (at 5 and 20 min). There was only one patient in the ultrasonography room and one researcher in the room at the same time. In this way, both researchers were blinded to each other's measurements.

It was estimated that a total sample size of 46 was needed for this study within the target significance level of 0.05, which achieves 80% power. To our knowledge, there is no similar research to our study. Accordingly, the sample size was calculated from the prior studies (14,16,17). Our final sample size was increased to 50 to compensate for inconclusive tests.

3.4. Statistical analysis

Continuous variables were reported as mean±SD with 95% confidence intervals (CI) since normality in distribution was observed by the Kolmogorov-Smirnov test. The significance of the difference between groups was assessed by the ANOVA test. Categorical variables were reported as proportions and counts, and the chi-squared test was used to compare proportions among groups. Student's t-test was also utilized as the post-hoc test for the ANOVA test, and the significance threshold was accepted as P<0.016 after Bonferroni correction. The inter-rater reliability of the sonographers for all time points was reported as intraclass correlation values and 95% CI. MedCalc Statistical Software (version 17.9.7) was employed for statistical analysis (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2017).

Figure 1. Image of optic nerve sheath diameter measurement

4. Results

In total, 50 minor head trauma patients with a mean age of 39.44±6.56 years were enrolled in this study. The majority of the patients were male (n=30; 60%). The mechanism of injury, presence of CT findings, and outcome of the patients were summarized in Table 1. Mean ONSD measurements at T0, T5, and T20 were given in Table 1. The distribution of 600 measurements of ONSD (two eyes, two raters) by three-time points is shown in Figure 2. ONSD increased at T5 and T20. When compared to the baseline measurements (T0), the increase in ONSD at T5 (0.48±0.38; P<0.001) and T20 (0.5±0.38; P<0.001) was statistically significant. The difference between T5 and T20 groups was an increase in ONSD, and these differences were also statistically significant (0.07±0.19; P=0.008).

The inter-rater reliability between the sonographers was strong overall (ICC>0.9). The concordance for mean (95% CI) ONSD values at T0, T5, and T20 were 0.94 (0.89-0.92), 0.93 (0.19-0.98), and 0.97 (0.76-0.99) respectively (Table 2).

Table 1. Characteristics and ONSD values of the patients

Variable **(mm) mean±SD (95% CI)**	
Age (years)	39.44±6.56 (37.57-41.31)
Male n (%)	30 (60)
Mechanism	
Standing Fall	24 (48)
Falls in bathroom	6 (12)
Other types of fall	4 (8)
Motor vehicle	2 (4)
Syncope	10 (20)
Assault	4 (8)
CT findings	
Intracranial ınjury	5 (10)
No finding of ıntracranial ınjury	45 (90)
Outcome	
Neurosurgical intervention	1 (2)
Discharged after observation	49 (98)
0th min. ONSD	4.71±0.22 (4.54-4.77)
5th min. ONSD	5.19±0.41 (5.07-5.31)
20th min. ONSD	5.26±0.45 (5.14-5.39)

CI: Confidence interval, CT: Computerized Tomography, ONSD: Optic nerve sheath diameter

Table 2. Inter-rater reliability at time points

Variable	ICC	95% CI	p
0th min. ONSD	0.94	0.89-0.92	<0.001
5th min. ONSD	0.93	0.19-0.98	<0.001
20th min. ONSD	0.97	0.76-0.99	<0.001

Min: minute
CI: Confidence interval, ICC: Intraclass correlation coefficient, ONSD: Optic nerve sheath diameter

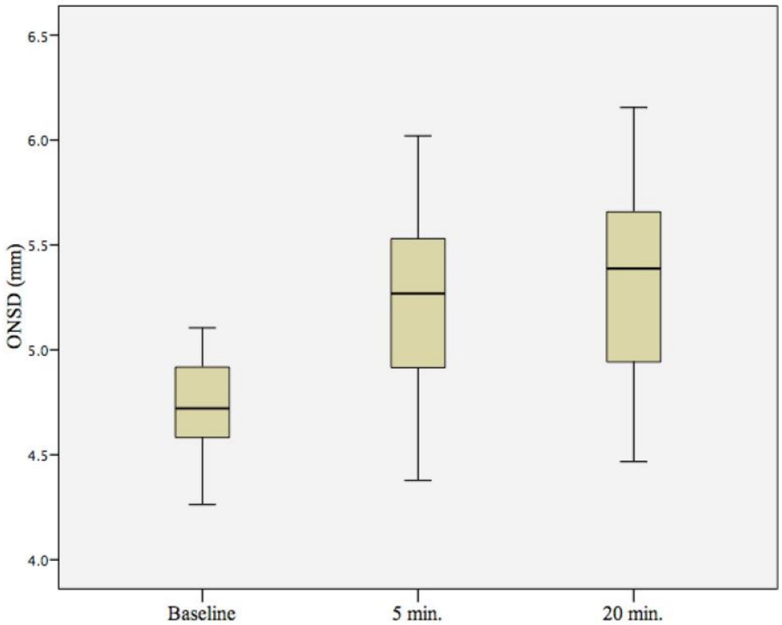

Figure 2. Distribution of ONSD measurements at baseline (T0) before collar application and at 5th and 20th minutes (T5, T20) after collar application

5. Discussion

It was found that the c-collar gradually increased ONSD values with longer immobilization times. The ONSD increased at 5 min after c-collar placement and continued increasing at T20 after the c-collar. It is likely that ONSD increases rapidly and slowed down but continues to increase over time. The supine position of the patients did not play a role in the increase of ONSD due to previous literature. It is the appropriate position in the care of head trauma patients. Classical ICP monitoring is an invasive and time-consuming procedure, and it may not always be available in the emergency department. Ocular ultrasonography, on the other hand, can be used to measure ONSD as a marker of ICP [3]. Moreover, ONSD measurements can be challenging and dependent on the sonographers' experience. Our inter-rater reliability results showed that ONSD measurements did not vary between experienced sonographers (8,9,13-15,20).

Previous studies discussed the impact of c-collars on intracranial pressure values in traumatic brain injury. All of these studies used invasive ICP monitoring methods and found that c-collars increased ICP (10,14,15,20). Woster et al. conducted a study on healthy volunteers. They reported that c-collar placement increased the ONSD at T5 and remained increased at T20; however, no significant increase was noted between T5 and T20 (8). Furthermore, Yard et al. conducted a study on healthy volunteers to validate the finding that ONSD measured by ultrasound increases after c-collar placement. Measurements were performed at supine for at least 5 min before the first set of measurements and remained so during the subsequent 10 min before the second set of measurements. They have found that c-collar placement was associated with increased ONSD for healthy volunteers (18). Similar to their results, this study found a rapid increase in T5 after c-collar placement. In addition, there was a significant increase between T5 and T20. This difference may be originated from the difference in patient groups between studies. In our study, the head trauma patients were evaluated. Head trauma may cause an increase in ICP, and with the additional impact of the c-collar, higher ICP values can be measured. Woster et al. also reported that c-collar application caused an increase in ONSD but remained below the accepted limit of 5mm (8). In our study, T5 and T20 were greater than 5 mm after the c-collar application of the measurement. It was also found that the ONSD measurements at T5 and T20 were greater than 5 mm.

Sanri et al. conducted a study on healthy volunteers. They have reported that head bed elevation of 30º and 45º for 20 min decreased the increased ONSD by c-collar significantly to its baseline values (17). Moreover, Ozdogan et al. performed a study on healthy volunteers to evaluate whether spinal immobilization at 20º instead of the traditional 0º affects ICP via the ultrasound measurement of ONSD (16). Their results were similar to the findings obtained by Sanrı et al. These studies found that c-collar may cause ICP increase and head bed elevation may reduce the ICP in healthy volunteers. Similar results were also observed in our study that c-collar placement increases the ONSD measurements. In another study, Maissan et al. found that c-collar placement causes an increase in ONSD among healthy volunteers that was similar to our results. However, the authors did not interpret the effect of time. The measurements were made 2 min after the c-collar placement (13).

5.1. Limitations

There are limitations to this study. First, the sonographers were not blinded to the presence of the c-collar, which may lead to bias in measurements. Second, the prior applied c-collar was excluded before appealing to the emergency department because the application time could not be standardized. Therefore, our results may not be generalized to all minor head trauma patients. Although the number of sample sizes seems sufficient, this study was conducted with a selected group of minor head trauma patients. It may be possible to generalize the results obtained by conducting more comprehensive studies with a larger number of patients.

6. Conclusion

Our results revealed that minor head trauma patients using the c-collar may increase ONSD after 5 min the clinical effects of which have to be determined with further studies. This suggests that enlargement in ONSD should be considered when interpreting ICP in head trauma patients after the application of the c-collar.

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None.

Footnotes

Conflicts of Interest: None declared.
Authors' Contributions: All authors contributed to the conception, study design, data collection, data analysis, and assembly. The manuscript was written and approved by all authors.
Ethical Approval: Ethical approval for this study was obtained from the Ethics Committee of the School of Medicine, Marmara University, Istanbul, Turkey (IRB No: 09.2018.298).
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