Clinical Neuroscience Research, 2023, Volume 1, Issue 1
http://ojs.bbwpublisher.com/index.php/CNR

Evaluation of Optic Nerve Sheath Diameter Measurement in the Management of Patients Admitted to the Emergency Department with Head Trauma

Özge Can*, Murat Ersel, Sercan Yalcinli, Funda Karbek Akarca

Department of Emergency Medicine, Faculty of Medicine, Ege University, Izmir 35040, Turkey

***Corresponding author:** Özge Can, ozge.can@ege.edu.tr

Abstract: *Objective:* Ultrasonographic measurements of optic nerve sheath diameter is associated with increased intracranial pressure. Intracranial pressure measurements are usually performed on critical areas or intensive care unit patients. The effect of ultrasonographic measurement of optic nerve sheath diameter in predicting pathology or the need for surgery in mild or moderate head trauma has not been evaluated. In our study, we compared ultrasonographic optic nerve sheath diameter measurements with cranial computed tomography (CT) findings and clinical outcomes of patients with head trauma. *Materials and methods:* Patients with head trauma admitted to the emergency department who were diagnosed with mild, moderate, and severe brain injury were selected for this retrospective study. The optic nerve sheath diameters were measured by ultrasonography. The findings were compared with the outcome and cranial tomography characteristics of the patients. *Results:* Of the 58 patients admitted to the emergency department with head trauma, mild traumatic brain injury was most common. Hospitalization or operation was required in 51.7% of the patients (30 patients). The mean optic nerve sheath diameter was 4.96 ± 1.02 mm (3.1–7.3 mm) on the right and 4.92 ± 1.02 mm (3.3–7.8) on the left. Optic nerve sheath diameter of 5 mm or more were statistically significant in predicting hospitalization, the presence of pathology, and increased intracranial pressure on cranial CT ($P < 0.05$). *Conclusion:* Optic nerve sheath diameters of patients with moderate and mild head trauma may provide information about the need for hospitalization or surgery and can be used as a triage criterion in determining the need for monitoring and follow-up and imaging priorities.

Keywords: Head trauma; Optic nerve sheath diameter measurement; Ultrasonography; Emergency department

Online publication: May 24, 2023

1. Introduction

Traumatic brain injury is a common cause of early death [1,2]. Patients usually have time to reach the hospital. Although altered consciousness is one of the most common findings, the Glasgow Coma Score (GCS) cannot be a direct indicator of traumatic brain injury because it may also occur due to metabolic reasons [3,4]. In patients with suspected traumatic brain injury, cranial computed tomography (CT) is used to form a diagnosis and to detect increased intracranial pressure (ICP) with a mortal course [2,4,5]. Since intracerebral hemorrhage (ICH) is a major cause of mortality, many diagnostic studies have been done [5]. Measurements can be performed with ventriculostomy or intraparenchymal transducer in patients with GCS ≤ 8 [2,6]. However, the fact that invasive interventions cannot be performed in the emergency department, not all

patients have GCS ≤ 8 and cranial CT shows indirect findings, and this has led to the search for a new diagnostic method. Accordingly, diagnostic classifications in cranial CT have been developed and associated with mortality [1,2]. Optic nerve sheath diameter (ONSD) measurement has been evaluated as one of these methods [3]. Especially in intensive care unit patients, ONSD was found to be effective in diagnosing increased intracranial pressure non-invasively compared to intracranial pressure measurement [6-8].

Most cases of traumatic brain injury presenting to the emergency department are mild or moderate [9]. In the literature, no study was found in which ONSD measurements were compared with cranial CT results or that ONSD was used as an outcome indicator in patients with mild head trauma.

In our study, we compared the ONSD measurements of patients with traumatic brain injury with their cranial CT results.

2. Materials and methods

The prospective cross-sectional study was conducted in the emergency department of a university hospital with a level 3 trauma center. During a nine-month period, 58 patients who met the inclusion criteria were recruited from patients admitted with trauma. After obtaining the approval of the local ethics committee (Decision number: 12-10.1/41), the study was conducted in accordance with the 1975 Declaration of Helsinki.

2.1. Selection of patients

Patients over 18 years of age who presented to the emergency department with head trauma were included in the study. Patients under 18 years of age and patients with head trauma but no symptoms of intracranial pathology were excluded. Headache, nausea, vomiting, and anisocoria, motor deficits, altered consciousness, and loss of light reflexes were considered as indicators of intracranial pathology. Therefore, head trauma patients with these symptoms were included in the study. Hemodynamically unstable patients, patients requiring emergency operation, and patients with eye trauma that would interfere with the measurements were excluded.

2.2. Study method

Bedside measurement of ONSD was performed by an emergency physician with basic ultrasonography training and two or more years of experience in the emergency department. The presence of pathology or indirect signs of increased intracranial pressure in cranial CT taken after ONSD measurement was evaluated. The predictive effect on the need of hospitalization and surgery was investigated. If the patients met the inclusion criteria after presentation to the emergency department, the patient was asked to undergo an ultrasound examination without knowledge of tomography or additional injuries. The decision for hospitalization or operation was made by the neurosurgeon.

2.3. Evaluation of pathologic findings in cranial CT

Cranial CT images were evaluated by a radiologist and concluded according to the presence of increased intracranial pressure and intracranial lesions. Tomography results were obtained from official reports. Midline shifting, fading of sulcus and cisternae, ventricular compression and diffuse edema were interpreted in favor of increased intracranial pressure. Intracranial pathologies (subdural, epidural, subarachnoid hemorrhage, contusion, etc.) were evaluated separately.

2.4. Optic nerve sheath diameter (ONSD)

ONSD were performed by emergency medicine residents who had received basic and advanced ultrasound

training, had performed at least 25 ONSD measurements under the supervision of an expert, and had more than two years of experience working in the emergency department. The eyes of the patient lying in supine position were protected with transparent gloves and transverse measurement was made from the upper eyelid with a linear probe, and the measurements were taken 3 mm posterior to the junction of the optic nerve with the eyeball (**Figure 1**). Both eyes were measured with a Sonosite Micromaxx ultrasound machine and a 7.5 Mhz linear probe, and values of 5 mm and above were considered pathologic [6-8].

2.5. Statistical method

Patients were divided into three groups according to traumatic brain injury classification: severe (< 9), moderate (9–13), and mild (14–15). Their age, gender, presence of increased ICP, presence of pathology findings on tomography, mean OSND, and clinical outcome were evaluated. The demographic of the patients with one of the primary outcome measures were analyzed according to the need for operation and hospitalization. Numerical data were given as mean and standard deviation. Chi-square test was used in the presence of independent variables that fit the normal distribution. Continuous and normally distributed independent variables were tested with *t*-test. ROC analysis was performed to evaluate the effect of OSND measurement in determining the need for hospitalization for more than 24 hours for follow-up and surgery.

2.6. Findings

Among the head trauma patients admitted to the emergency department, 16 (27.6%) were female and 42 (72.4%) were male. The mean age was 45.10 ± 17.93 (18–80) years. The causes of head trauma were falls (*n* = 28 48.5%), traffic accidents (*n* = 21 36.2%), and direct blows to the head (*n* = 9 15.5%). When classified according to GCS, there were 42 patients with severe (72.4%), moderate (13.8%), and mild (13.8%) traumatic brain injury. The mean OSND was 4.96 ± 1.02 mm (3.1–7.3 mm) for the right eye and 4.92 ± 1.02 mm (3.3–7.8 mm) for the left eye. The OSND of 31 (53.4%) patients were < 5mm, whereas 27 patients (46.6%) had an OSND > 5 mm. Among these patients, 7 (13.8%) underwent surgery and 23 (37.9%) patients were hospitalized for more than 24 hours. The characteristics of the patients according to their outcomes are shown in **Tables 1 and 2**.

Table 1. Characteristics of head trauma patients admitted to the emergency department according to their clinical outcome

	Patients who underwent surgery (*n* = 7)	**Inpatients (*n* = 23)**	**Patients who were discharged (*n* = 28)**	***P***
Gender				0.113
Female	2 (28.6)	3 (13.1)	11 (39.3)	
Male	5 (71.4)	20 (86.9)	17 (60.7)	
Average age	38.42 ± 17.39	50.04 ± 18.13	42.71 ± 17.46	0.203
(Min.–Max.)	(21.00–63.00)	(18.00–80.00)	(21.00–73.00)	
Traffic accident	3 (42.9)	11 (47.8)	7 (25)	
Blow to the head	-	4 (17.4)	5 (17.9)	
Falling	4 (57.1)	8 (34.8)	16 (57.1)	
GCS				N/A
< 9	4 (57.1)	4 (17.4)	–	
9–13	1 (14.3)	7 (30.4)	–	
14–15	2 (37.5)	12 (52.2)	28 (100.0)	

Table 2. Distribution of head trauma patients admitted to the emergency department according to diagnostic test findings and outcomes

Diagnostic tests	Patients who underwent surgery (*n* = 7)	Inpatients (*n* = 23)	Patients who were discharged (*n* = 28)	*P*
OSND (mm)				< 0.05
< 5	1 (14.3)	4 (17.4)	26 (92.9)	
> 5	6 (85.7)	19 (82.6)	2 (7.1)	
Right OSND	5.50 ± 0.92 (3.60–6.90)	5.47 ± 0.97 (3.70–6.80)	4.39 ± 0.79 (3.10–5.70)	< 0.05
Left OSND	5.62 ± 1.16 (3.60–7.00)	5.38 ± 1.05 (3.50–7.80)	4.36± 0.59 (3.30–5.70)	< 0.05
Cranial CT				
Pathology				N/A
Yes	7 (100.0)	23 (100.0)	–	
No	–	–	28 (100.0)	
ICP				N/A
Positive	3 (42.9)	6 (26.1)	–	
Negative	4 (57.1)	17 (73.9)	28 (100.0)	

Table 3. OSND measurements of patients according to hospitalization-discharge decision

Outcome	OSND > 5 mm *n* (%)	OSND < 5 mm *n* (%)	*P*
Hospitalized/underwent surgery	25 (83.3)	5 (16.7)	**< 0.05**
Discharged	2 (7.1)	26 (92.9)	

Table 4. Evaluation of OSND on tomography finding and positive ICP

OSND		> 5 mm	< 5 mm	*P*
Presence of pathology on CT scan	Yes	25	5	**< 0.05**
	No	2	26	
ICP	Positive	9	0	< 0.05
	Negative	18	31	

At the time of presentation to the emergency department, 50 (86.2%) patients had moderate to mild head trauma. Hospitalization or operation was required in 51.7% (30) of the patients.

In 9 patients with positive ICP elevation, the mean OSND was 5.74 ± 0.51 mm on the right and 5.75 ± 0 .95 mm on the left. When the OSND cut-off value above 5 mm was considered significant, the sensitivity of OSND measurement in predicting the need for hospitalization and operation was 83.33% (65.28–95.36%), with a specificity of 92.86% (76.51–99.12%), positive predictive value of 92.59% (76.51–97.96%), and negative predictive value of 83.87% (69.89-92.1). The positive likelihood ratio was 11.67 (3.04–44.79%), while the negative likelihood ratio was 0.18 (0.08–0.4), with an accuracy of 87.93% (76.7–95.01%), as shown in **Table 3**.

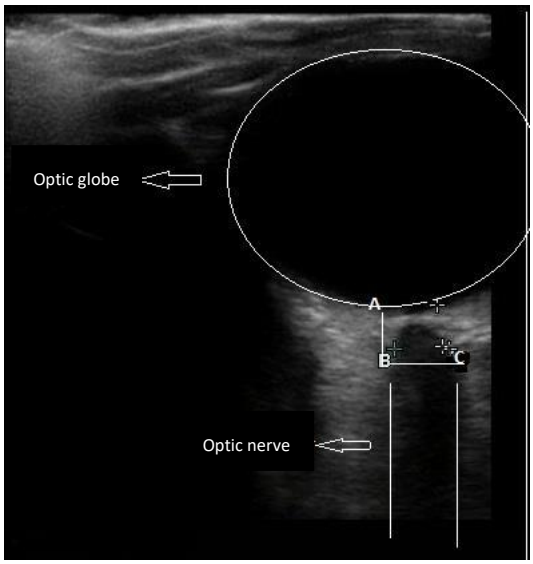

Figure 1. Ultrasonographic image of optic nerve sheath diameter measurement. (A) Optic nerve exit from the eyeball. (B) 3 mm posterior to the exit from the eyeball for OSND measurement. (C) Transverse measurement of OSND.

The area under the curve (AUC) was 0.805 for the right side and 0.802 for the left side as a result of the evaluation of the OSND measurement with ROC analysis in determining the need for hospitalization and operation (**Figure 2**).

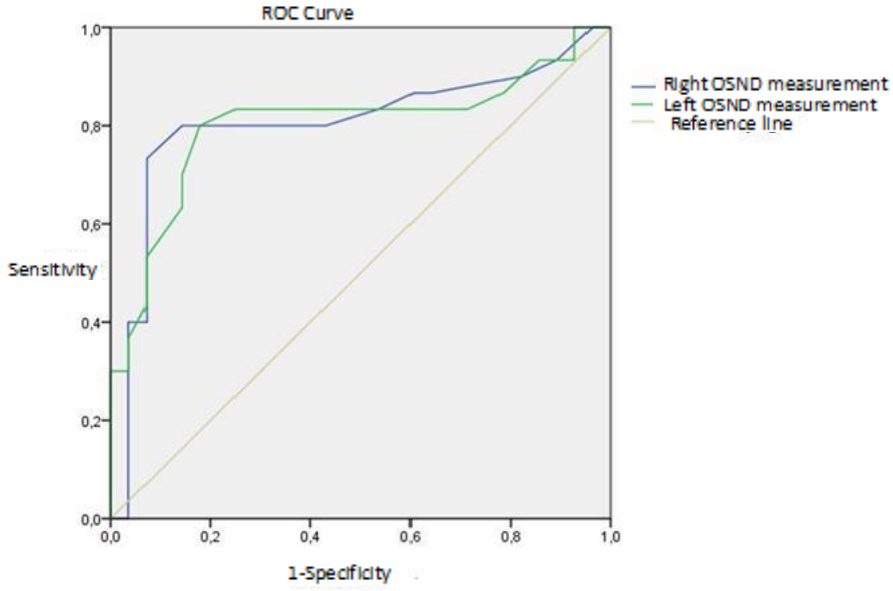

Figure 2. OSND measurement evaluation of patients in need of hospitalization and operation.

OSND over 5 mm was found to be statistically significant with the presence of pathologic findings and increased ICP on tomography ($P < 0.05$). The sensitivity, specificity, PPD, and NPD of OSCT measurement over 5 mm in predicting the presence of ICP on tomography were 33.33% (16.52–53.96%), 100%, 100%, and 63.27% (56.88–69.22%), respectively. The negative likelihood ratio was 0.67 (0.51–0.87), and the accuracy was 68.97% (55.46–80.46%), as shown in **Table 4**.

3. Discussion

In our study in which patients with head trauma admitted to the emergency department were examined,

most patients suffered mild to moderate head trauma according to the GCS score at the time of admission. However, half of these patients required hospitalization or surgery. Among the hospitalized and operated patients, OSND values above 5 mm were found to be statistically significant for pathology. An OSND measurement of 5 mm or more was also found to be statistically significant In the detection of increased intracranial pressure or cranial pathology. We found that OSND measurement is a good test to indicate the need for hospitalization or operation in patients with head trauma.

OSND measurement is considered as a noninvasive measurement method of increased intracranial pressure [7,8,10–12], and most of the studies involve intensive care unit patients [6,11]. Studies on patients with head trauma in emergency department usually involve severe head trauma [5,7]. The most important difference of our study was that OSND was measured in patients with moderate and mild head trauma. Most patients presenting to the emergency department with head trauma suffer from mild head trauma [9]. Half of the patients with moderate and mild head trauma in our study required operation and hospitalization. The diagnosis of these patients is made by cranial CT [13,14]. Considering the density of the emergency department, it is important for emergency physicians to be able to use a bedside imaging method in addition to the examination in the critical area follow-up of patients with mild or moderate head trauma or in determining imaging priority. Our study suggests that OSND measurement is a useful test for predicting hospitalization or operation of patients with mild or moderate head trauma, which makes a unique contribution to medical literature since no such comparison has been made before.

We found that OSND more than 5 mm was statistically significant in predicting the pathology through cranial CT. There were also patients with OSND above 5 mm who did not have signs of increased ICP when evaluated with tomography. In a study, the sensitivity for increased ICP was 86% and specificity was 100%, while the sensitivity for detecting intracranial pathology was 60% and specificity was 100% [14]. In our study, although OSND measurement was statistically significant in detecting intracranial pathology, sensitivity, and specificity were low. In our study, no pathology was detected through cranial CT in two patients with OSND of more than 5 mm. One of these patients had hypertension and this supports the increase in OSND in hypertensive patients reported in literature [15]. Although the sensitivity of OSND in predicting ICP was low, its specificity was 100%, supporting its use as a triage test in critical patient follow-up. The fact that the accuracy of OSND in predicting ICP was found to be 68.97% may be associated with the low number of patients with ICP.

In a review by Restrepro et al., it was emphasized that the determination of ICP increase is useful for emergency services and intensive care units, but more studies are needed for daily use [3]. The data obtained in our study suggest that OSND measurement can be used in addition to the clinical findings of the patient without ICP. In the study by Das et al. evaluating OSND measurements from cranial tomography sections, it was stated that it could be used as a triage tool in determining the decision or time of tomography in patients with mild head trauma [16], which is also consistent with our study.

When we evaluated the measurement of ICP and OSND and the relationship of OSND of more than 5 mm with increased ICP. Raffız et al. found head trauma patients of OSND 5.22 mm and Jean et al. 5.6 mm experienced increased ICP [17,18]. In our study, the mean OSND was found to be 5.7 mm in patients with ICP.

4. Limitations

Due to the limited sample size of our study, stronger evidence cannot be obtained from our results alone, and the inability to perform invasive measurement of ICP in the emergency department and the use of CT may have led to limitations in the definitive diagnosis of ICP. One of the important limitations of the study is that there was no agreement obtained between ultrasound practitioners.

5. Conclusion

ONSD is not only useful for patients with severe head trauma but also for patients with mild and moderate head trauma. In addition to clinical findings, its measurement can be used as a predictor in determining the need for operation or hospitalization by determining the need for tomography and its duration. It can be used as a useful diagnostic tool other than ICP, especially in critically ill patients.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Moppett IK, 2007, Traumatic Brain Injury: Assessment, Resuscitation and Early Management. Br J Anaesth Br J Anaesth. 99(1): 18–31. https://www.doi.org/10.1093/bja/aem128

[2] Helmy A, Vizcaychipi M, Gupta AK, 2007, Traumatic Brain Injury: Intensive Care Management. Br J Anaesth, 99(1): 32–42. https://www.doi.org/10.1093/bja/aem139

[3] Jimenez Restrepo JN, León OJ, Quevedo Florez LA, 2019, Ocular Ultrasonography: A Useful Instrument in Patients with Trauma Brain Injury in Emergency Service. Emerg Med Int., 2019: 9215853. https://www.doi.org/10.1155/2019/9215853

[4] Rosenfeld JV, Maas AI, Bragge P, et al., 2012, Early Management of Severe Traumatic Brain Injury. Lancet, 380(9847):1088–1098. https://www.doi.org/10.1016/S0140-6736(12)60864-2

[5] Martin M, Lobo D, Bitot V, et al., 2019, Prediction of Early Intracranial Hypertension After Severe Traumatic Brain Injury: A Prospective Study. World Neurosurg, 127: e1242–e1248. https://www.doi.org/10.1016/j.wneu.2019.04.121

[6] Geeraerts T, Launey Y, Martin L, et al., 2007, Ultrasonography of the Optic Nerve Sheath May be Useful for Detecting Raised Intracranial Pressure After Severe Brain Injury. Intensive Care Med., 33(10): 1704–1711. https://www.doi.org/10.1007/ s00134-007-0797-6

[7] Blaivas M, Theodoro D, Sierzenski PR, 2003, Elevated Intracranial Pressure Detected by Bedside Emergency Ultrasonography of the Optic Nerve Sheath. Acad Emerg Med. 10(4): 376–381. https://www.doi.org/10.1197/aemj.10.4.376

[8] Tayal VS, Neulander M, Norton HJ, et al., 2007, Emergency Department Sonographic Measurement of Optic Nerve Sheath Diameter to Detect Findings of Increased Intracranial Pressure in Adult Head Injury Patients. Ann Emerg Med, 49(4): 508–514. https://www.doi.org/10.1016/j.annemergmed.2006.06.040

[9] Seabury SA, Gaudette É, Goldman DP, et al., 2018, Assessment of Follow-up Care After Emergency Department Presentation for Mild Traumatic Brain Injury and Concussion: Results From the TRACK-TBI Study. JAMA Netw Open, 1(1): e180210. https://www.doi.org/10.1001/jamanetworkopen.2018.0210

[10] Altayar AS, Abouelela AZ, Abdelshafey EE, et al., 2021, Optic Nerve Sheath Diameter by Ultrasound is a Good Screening Tool for High Intracranial Pressure in Traumatic Brain Injury. Ir J Med Sci., 190(1): 387–393. https://www.doi.org/10.1007/s11845-020-02242-2

[11] Robba C, Santori G, Czosnyka M, et al., 2018, Optic Nerve Sheath Diameter Measured Sonographically as Noninvasive Estimator of Intracranial Pressure: A Systematic Review and Meta-Analysis. Intensive Care Med., 44(8): 1284–1294. https://www.doi.org/10.1007/s00134-018-5305-7

[12] Soldatos T, Chatzimichail K, Papathanasiou M, et al., 2009, Optic Nerve Sonography: A New Window

for the Non-Invasive Evaluation of Intracranial Pressure in Brain Injury. Emerg Med J., 26(9): 630–634. https://www.doi.org/10.1136/emj.2008.058453

[13] Amini A, Kariman H, Arhami Dolatabadi A, et al., 2013, Use of the Sonographic Diameter of Optic Nerve Sheath to Estimate Intracranial Pressure. Am J Emerg Med., 31(1): 236–239. https://www.doi.org/10.1016/j.ajem.2012.06.025

[14] Major R, Girling S, Boyle A, 2011, Ultrasound Measurement of Optic Nerve Sheath Diameter in Patients with a Clinical Suspicion of Raised Intracranial Pressure. Emerg Med J., 28(8): 679–681. https://www.doi.org/10.1136/emj.2009.087353

[15] Roque PJ, Wu TS, Barth L, et al., 2012, Optic Nerve Ultrasound for the Detection of Elevated Intracranial Pressure in the Hypertensive Patient. Am J Emerg Med., 30(8): 1357–1363. https://www.doi.org/10.1016/j.ajem.2011.09.025

[16] Das SK, Shetty SP, Sen KK, 2017, A novel triage tool: Optic Nerve Sheath Diameter in Traumatic Brain Injury and its Correlation to Rotterdam Computed Tomography (CT) scoring. Polish J Radiol., 82: 240–243. https://www.doi.org/10.12659/PJR.900196

[17] Raffiz M, Abdullah JM, 2017, Optic Nerve Sheath Diameter Measurement: A Means of Detecting Raised ICP in Adult Traumatic and Non-Traumatic Neurosurgical Patients. Am J Emerg Med, 35(1): 150–153. https://www.doi.org/10.1016/j.ajem.2016.09.044

[18] Jeon JP, Lee SU, Kim SE, et al., 2017, Correlation of Optic Nerve Sheath Diameter with Directly Measured Intracranial Pressure in Korean Adults using Bedside Ultrasonography. PLoS One., 12(9): 1–11. https://www.doi.org/10.1371/journal.pone.0183170