J Surg Med. 2019;3(9):652-654.
DOI: 10.28982/josam.612145

Research article
Araştırma makalesi

Journal of Surgery and Medicine
e-ISSN: 2602-2079

Prognostic performance of optic nerve sheath diameters in CT images and serum procalcitonin levels in traumatic brain injury patients in the intensive care unit: A retrospective cohort study

Yoğun bakım ünitesinde travmatik beyin hasarlı hastalarda BT görüntülerinden elde edilen optik sinir kılıf çapı ve serum prokalsitonin değerlerinin prognostik performansları: Retrospektif kohort çalışma

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Ethics Committee Approval: Mugla Sitki Koçman University ethical Committee approved this study, 08.08.2019, 9/4.
Etik Kurul Onayı: Muğla Sıtkı Koçman Üniversitesi klinik araştırmalar Etik Kurulu bu çalışmayı onayladı 08.08.2019, 9/4.

Conflict of Interest: No conflict of interest was declared by the authors.
Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Financial Disclosure: The authors declared that this study has received no financial support.
Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

Published: 9/6/2019
Yayın Tarihi: 06.09.2019

Abstract

Aim: Traumatic brain injury (TBI) is one of the common emergencies with a high mortality rate. It is difficult to determine the mortality and prognosis of TBI in the intensive care unit (ICU). The aim of this study is to assess the prognostic relationship of optic nerve sheath diameters (ONSD) as seen on computerized tomography (CT) images as well as serum procalcitonin (PCT) levels to mortality and Glasgow Outcome Scale (GOS) scores of patients with traumatic brain injury in the ICU.

Methods: Data from 78 traumatic brain injury patients who were admitted to an ICU, underwent brain CT and had serum PCT levels measured, were investigated retrospectively. Patients' data were gathered from ICU medical records. The ONSD was measured at 3 mm behind the globe.

Results: The mean age of the patients was 57.11 (17.07) years. 57.7% of the patients were males, and 42.3% were females. The cut-off ONSD and serum PCT values were evaluated to determine mortality and prognosis (Cut-off values: right ONSD: 5.44, left ONSD: 5.37, PCT: 3.95 for mortality; right ONSD: 5.26, left ONSD: 5.28, PCT: 2.29 for GOS, respectively).

Conclusion: ONSD measurements and serum PCT levels are associated with mortality and prognosis in traumatic brain injury patients.

Keywords: Optic nerve sheath diameter, Procalcitonin, Traumatic brain injury

Öz

Amaç: Travmatik beyin hasarı (TBH) yüksek mortalite oranı ile sonuçlanan sık karşılaşılan acillerden biridir. Yoğun bakım ünitesinde (YBÜ) TBH için mortalite ve prognozu belirlemek zordur. Bu çalışmanın amacı, YBÜ'deki travmatik beyin hasarı olguların mortalite ve Glasgow outcome skalası ile bilgisayarlı tomografi (BT) görüntülerinden elde edilen optik sinir kılıf çapı ve serum prokalsitonin seviyeleri arasındaki ilişkiyi göstermek ve optik sinir kılıf çapıyla prokalsitonin seviyesinin prognostik değerini ölçmektir.

Yöntemler: Beyin BT görüntülemesi yapılmış ve serum prokalsitonin düzeyi çalışılmış 78 travmatik beyin hasarı hastasının verileri retrospektif olarak incelendi. Hasta verileri yoğun bakım tıbbi kayıtlarından elde edildi. Optik sinir kılıf çapı göz güresinin 3 mm arkasından ölçüldü.

Bulgular: Hastaların yaş ortalaması 57,11 (17,07) iken %57,7'si erkek, %42,3'ü kadındı. Optik sinir kılıf çapı ve serum prokalsitonin cut-off değerleri, mortalite ve prognozu belirlemek için hesaplandı. Mortalite için cut-off değerleri sırasıyla: Sağ ONSD: 5,44, sol ONSD: 5,37, PCT: 3,95, GOS için sağ ONSD: 5,26, sol ONSD: 5,28, PCT: 2,29'du.

Sonuç: Optik sinir kılıf çapı ölçümü ve prokalsitonin seviyeleri travmatik beyin hasarlı hastalarda mortalite ve prognoz ile ilişkilidir.

Anahtar kelimeler: Optik sinir kılıf çapı, Prokalsitonin, Travmatik beyin hasarı

How to cite / Atıf için: Gürsoy C, Gürsoy G, Demirbilek SG. Prognostic performance of optic nerve sheath diameters in CT images and serum procalcitonin levels in traumatic brain injury patients in the intensive care unit: A retrospective cohort study. J Surg Med. 2019;3(9):652-654.

Introduction

Traumatic brain injury (TBI) is one of the common emergencies with a high mortality rate [1]. Many factors, such as gender, age, the severity of the injury, comorbidities, anticoagulant use, initial Glasgow Coma Scale (GCS), the affected region of the brain, and the prevention of secondary brain injury determine the prognosis of TBI [2]. Intracranial pressure (ICP) monitoring is essential to decrease morbidity and to prevent patients from secondary brain injury in moderate and severe TBI in order to improve functional outcome and mortality [3].

The optic nerve is the most accessible part of the brain meninges. Previous studies have shown that examining the optic nerve sheath diameter (ONSD) calculated from the computed tomography (CT) images is one of the easiest ways to detect elevated ICP [4]. Serum procalcitonin (PCT) level is another indicator of the severity of TBI [5]. In theory, the combination of these two parameters should prove a better way to evaluate patient prognosis in TBI.

In this study, we aimed to assess the prognostic relationship of ONSD (calculated from CT images) as well as serum PCT levels to mortality and Glasgow Outcome Scale (GOS) in TBI patients.

Materials and methods

After obtaining approval from the ethical committee for clinical research of Mugla Sitki Koçman University on 08.08.2019 (approval number: 9/4), adults with TBI who were admitted to the Anesthesiology Intensive Care Unit of Mugla Sitki Koçman University Research and Training Hospital between January 2017 and June 2019 were enrolled in our study. We excluded patients who had facial trauma affecting the eyeballs, a pre-existing orbital disease affecting the orbital nerve, globe pathology, incomplete medical records, unavailable CT brain scans, and whose PCT levels were not obtained within the first 12 hours of admission.

Age, sex, initial GCS, Acute Physiology and Chronic Health Evaluation score, a mortality predictor, Revised Trauma Score, and GOS values were obtained from the medical records. Serum PCT and ONSD were recorded if they were tested within the first 12 hours. The ONSD was measured from brain CT images, at 3 mm posterior to the optic disc exit site in both eyes.

Statistical analysis

Data were analyzed using the IBM SPSS Statistics package version 23.0 (IBM Corp., Armonk, NY). Descriptive analysis was performed to calculate percentages and proportions. A t-test was used to compare the means of the two groups. A chi-square test was used to compare qualitative data for the level of significance. The values for PCT and ONSD were evaluated with a receiver operator characteristic (ROC) curve to determine the cut-off value. Regression analysis was used to examine the relationship between PCT, ONSD and mortality.

Results

A total of 109 patients with TBI were examined from the ICU registry. Among them, 31 patients were excluded based on the reasons listed above. A total of 78 patients with the following injuries were included in the study: subdural hematoma (4 patients), epidural hematoma (6 patients), subarachnoid hemorrhage (21 patients), brain edema (18 patients), intracerebral hematoma (6 patients), concussion (10 patients), and combined hemorrhage (13 patients). The mean age of the patients was 57.11 (17.07) years. Among them, 57.7% were males, and 42.3% were females (Table 1).

A statistically significant relationship was observed between ONSD (left and right) and mortality (t: -7.157, P<0.001; t: -6,853, P<0.001; respectively). A ROC curve was plotted to assess the prognostic value of the left and right ONSD measurement. The area under the curve (AUC) of the left and right ONSD were 0.883 and 0.879, with a 95% CI of 0.800 to 0.966 and 0.799 to 0.959, respectively. Results for the left ONSD at a cut-off point of 5.44 mm had a sensitivity of 92.77%, specificity of 86.21%, positive predictive value of 77.8%, and a negative predictive value of 78.4%. Results for the right ONSD at a cut-off point of 5.37 mm had a sensitivity of 96.56%, specificity of 84.43%, positive predictive value of 84.43%, and a negative predictive value of 81.5%.

According to the evaluation results of serum PCT with respect to mortality, the AUC was 0.841 with a 95% CI of 0.753 to 0.928. A cut-off value of 3.95 had a sensitivity of 92.19%, specificity of 83.25%, a positive predictive value of 58%, and a negative predictive value of 92%. A statistically significant negative correlation (-31.70) was found between PCT and mortality (t: -5.995, P<0.001).

The GOS was used to assemble two groups: poor recovery and good recovery. Those who scored two to five on the GOS were included in the poor recovery group while the good recovery group consisted only of those that scored one on the GOS. We compared ONSD and serum PCT with the poor and good recovery groups. The analyses of ROC and AUC are presented in Table 2. There was a statistically significant difference between the left-right ONSD and serum PCT, according to the GOS (P=0.002).

Table 1: Patient demographic characteristics and results

		Death (n=27)	TBI (n=51)	Total (n=78)	*P*-value
Gender %, (n)	Men	16.7% (13)	41% (32)	57.7% (45)	0.237
	Women	17.9% (14)	24.4% (19)	42.3% (33)	
Age		50.70 (17.7)	45.21 (16.59)	47.11 (17.07)	0.179
APACHE-II		30.22 (8.51)	20.49 (8.19)	23.85 (9.44)	<0.001
GCS		3.74 (1.65)	10.29 (3.48)	8.02 (4.31)	<0.001
RTS		4.59 (3.30)	6.62 (3.83)	5.92 (3.76)	0.022
PCT (ng/mL)		40.86 (29.41)	9.16 (17.33)	20.13 (26.78)	<0.001
ONSD (mm)	Left	5.57 (0.123)	5.06 (0.355)	5.24 (0.371)	<0.001
	Right	5.56 (0.147)	5.08 (0.314)	5.24 (0.382)	<0.001

Results are presented as number, mean (standard deviation) or percentage according to the normality of distribution. APACHE-II: Acute Physiology and Chronic Health Evaluation II, GCS: Glasgow Coma Score, ONSD: Optic nerve sheath diameter, PCT: Procalcitonin, RTS: Revised trauma score, TBI: Traumatic brain injury

Table 2: The results of the diagnostic scan and ROC curves for ONDS and PCT compared to mortality and GOS

		Diagnostic scan					ROC curve		*P*-value
		Cut-off	Sensitivity	Specifity	Positive Predictive Value	Negative Predictive Value	AUC	95% Confidence Interval	
Mortality	Left ONSD (mm)	5.44	92.77	86.21	77.8	78.4	0.883	0.800-0.966	<0.001
	Right ONSD (mm)	5.37	96.56	84.43	81.5	78.4	0.879	0.799-0.959	<0.001
	PCT (ng/mL)	3.95	92.19	83.25	85.2	86.9	0.841	0.753-0.928	<0.001
GOS	Left ONSD (mm)	5.26	72.69	81.75	98.9	97.6	0.711	0.578-0.842	0.002
	Right ONSD (mm)	5.28	70.28	81.67	98.9	97.6	0.710	0.579-0.842	0.002
	PCT (ng/mL)	2.29	74.56	70.61	88.9	91.2	0.715	0.600-0.830	0.002

AUC: Area under the curve, GOS: Glasgow Outcome Score, ONSD: Optic nerve sheath diameter, PCT: Procalcitonin

Discussion

Our study demonstrated that ONSD measurements and serum PCT values are useful parameters in predicting the mortality and prognosis of patients with TBI. Neurological examinations are important for determining TBI, but not enough to predict the prognosis. The present prognostic scores are complex, require numerous data and are not easily applied [6]. Thus, there is a need for a prognostic indicator that is non-invasive, simple and includes a small amount of data.

Many previous studies have demonstrated that ONSD measurement can be used for detecting increased ICP and that monitoring ICP is important for proper management of TBI [4]. Moreover, it has been shown that an enlarged ONSD on brain CT is an independent factor for mortality and poor prognosis [6]. A similar study by Lee et al. demonstrated that the cut-off value for ONSD on CT was 4.13 mm, and the AUC was 0.986 (95% CI: 0.939 to 0.989) [4]. The results of our study are similar with previous studies concerning ONSD values for the prediction of mortality and prognosis, but our cut-off value for ONSD on CT was higher. This difference could be explained by the fact that the brain CT scan was obtained within 12 hours after the trauma in our study.

Diverse techniques have been utilized for ONSD measurement. It was more frequently measured with ultrasound but this requires an experienced practitioner [2]. Magnetic resonance imaging (MRI) is another technique proposed for ONSD evaluation, however, limited accuracy and thicker brain slices may change the measured ONDS value. Most reported ONSD values are measured on CT and MRI [6]. In our study, we measured ONSD with CT scans.

PCT is an inflammatory marker present in the pathogenesis of severe complications such as sepsis or organ failure. Recent studies have demonstrated the role of PCT in neurotrauma that is caused by TBI or resuscitation [5,7]. When inflammatory process is triggered, messenger ribonucleic acid synthesized by calcitonin I gene is upregulated, giving rise to increasing PCT levels within a two to three-hour period. PCT reaches plateau levels within 6 to 12 hours and has a half-life of 20 to 24 hours. Via the same pathogenesis, TBI leads to increased PCT levels in blood circulation. However, PCT levels in patients with TBI are lower than those after extracranial injuries [5]. In our study, high PCT levels were detected in patients with multiple trauma.

Limitations

There are several limitations to this study. First, this is a single-center study with a retrospective design. Therefore, the results may have limited applicability. We could not standardize the data because of the small number of patients; and we could not group the data according to hours passed after trauma.

Conclusion

Traumatic brain injury is still one of the most mortal diseases amongst patients in intensive care units. The best and safest method used to determine mortality and prognosis in TBI is currently under investigation. In our study, there is a well-documented relationship between ONSD measurements, serum PCT levels, prognosis and mortality. In patients with TBI, ONSD measurements via CT and serum PCT can be safely used to determine prognosis and mortality.

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This paper has been checked for language accuracy by JOSAM editors.
The National Library of Medicine (NLM) citation style guide has been used in this paper.

Suggested citation: Patrias K. Citing medicine: the NLM style guide for authors, editors, and publishers [Internet]. 2nd ed. Wendling DL, technical editor. Bethesda (MD): National Library of Medicine (US); 2007-[updated 2015 Oct 2; cited Year Month Day]. Available from: http://www.nlm.nih.gov/citingmedicine