

Comparison of ultrasonographic measurement of optic nerve sheath diameter (ONSD) versus direct measurement of intracranial pressure (ICP) in traumatic brain injury patients

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ABSTRACT

Aim. To compare ultrasonographic measurement of optic nerve sheath diameter (ONSD) with direct measurement of intracranial pressure (ICP) and evaluate the correlation between them in traumatic brain injury patients.

Patients and methods. Twenty traumatic brain injury patients were enrolled in the study. Patients had a median Glasgow Coma Scale (GCS) score of 5. All patients underwent noninvasive measurement of ICP by ultrasonographic measurement of ONSD and invasive ICP measurement using an intraventricular catheter. We used MedCalc to analyze data.

Results. We compared the ONSD measurement in patients with ICP less than 20 cm H₂O with patients with ICP greater than 20 cm H₂O. The mean ONSD for 8 patients with ICP > 20 cm H₂O was 7.6 +/- 0.8 mm, and for 18 patients with ICP < 20 cm H₂O was 5.6 +/- 0.6 mm. Student t-test comparison between these two groups showed a statistically significant mean difference of 1.99 (95 % CI = 1.4-2.6). The ROC curve showed that the optimal cutoff value of ONSD for predicting ICP > 20 cm H₂O was 6.1, with sensitivity of 100 % and specificity of 83 %. (the area under the curve was 0.98, 95 % CI = 0.825-0.990). In this study, the usually used cutoff of ONSD > 5 mm gives a sensitivity of 100 %, but a specificity of only 22 %.

Conclusion. Ultrasonographic measurement of ONSD correlates with direct measurement of ICP. This method has potential as a screening test for elevated ICP in traumatic brain injury.

Key words: ultrasound, ONSD, ICP

Introduction

Elevated intracranial pressure (ICP) is a frequent manifestation of traumatic brain injury and can lead to secondary brain injury, so it requires rapid diagnosis. There is a need for a diagnostic method for distinguishing traumatic brain injury patients with elevated intracranial pressure from traumatic brain injury

patients without elevated intracranial pressure. The use of an intracranial catheter is the "old standard" for diagnosing elevated ICP, but this method has contraindications for insertion like coagulopathy or thrombocytopenia and demands neurosurgical expertise and time for insertion. For these reasons, noninvasive techniques for the detection of elevated ICP have been developed and include computed tom-

ography (CT) of the head, ophthalmoscopy, transcranial Doppler sonography (TCD) and optic nerve sheath diameter (ONSD) sonography. We studied the last method. The optic nerve is part of the central nervous system and elevated ICP is transmitted to the perioptic nerve space, causing an increase in optic nerve diameter. Measurement of the ONSD is possible by optic nerve sonography. In the present study we

researched whether alteration in ONSD correlates with invasive measurement of ICP in traumatic brain injury patients. Noninvasive evaluation of ICP was performed using ONSD ultrasonography and invasive measurement of ICP was performed by surgical placement of an intracranial catheter.

Patients and methods

This study was performed in the Central Intensive Care Unit of the University Hospital „Sestre Milosrdnice“, Zagreb, Croatia. We enrolled 20 patients with elevated intracranial pressure as a result of traumatic brain injury. Twenty six ultrasonography measurements were performed on 20 patients. Of the 20 patients, 17 patients had one scan, 1 patient had two scans, 1 patient had three scans and 1 patient had four scans. All patients underwent bilateral optic nerve measurements. All patients had invasive ICP monitoring. No patients were known to have glaucoma, some other disease of the optic nerve or injury to the eye. Exclusion criteria were history of glaucoma or some disease of the optic nerve, patients with acute head trauma, but also with injury of the eye and patients with acute head trauma, but without ICP monitoring (those for whom ICP was not possible for any reason). This study was approved by the institutional review board.

All patients underwent optic nerve sonography and ICP monitoring. Ultrasonographic measurements were done using a 7.5-MHz linear ultrasound probe (Sonosite Micromaxx gray-scale ultrasonographic machine). All patients were examined in the supine position. The structure of the eye was visualised to adjust the optic nerve directly opposite the probe. A single optic nerve sheath diameter was measured 3 mm behind the globe for each eye and the mean ONSD of the two ONSD (left and right eye) was calculated. Mean ONSD measurement for each eye was averaged to create a binocular ONSD measurement. The ICP was recorded manually after ultrasonographic measurement. An intraventricular catheter

was inserted in all patients with traumatic brain injury. Elevated ICP was defined as an ICP of 20 cm H₂O or greater. Data regarding age, gender, ICP, and ONSD ultrasonographic measurements were recorded. Summary data are expressed as a mean \pm standard deviation. Student t-test was used to compare the mean ONSD values and mean ICP values between groups. The nonparametric Spearman rank correlation coefficient was used to assess the relationship between ONSD and ICP variables. A receiver operating characteristic ROC curve was created to determine the cutoff value of ONSD for the prediction of ICP of 20 cm H₂O or greater. All data were analysed using MedCalc.

Results

Twenty patients were enrolled in the study, 18 male and 2 female, with a median age of 31 (18-58). The patients had a median Glasgow Coma Scale (GCS) score of 5 (3-9). We evaluated the relationship between ONSD (mean value between both eyes) and ICP using the nonparametric Spearman rank correlation coefficient and it was found to be 0,89 ($P < 0,01$). Next, we compared the ONSD measurement in patients with ICP less than 20 cm H₂O with patients with ICP greater than 20 cm H₂O. The median ONSD for 8 patients with ICP > 20 cm H₂O was 7.7 mm (6.3-8.8), and for 18 patients with ICP < 20 cm H₂O was 5.8 mm (4.9-6.9). Kruskal-Wallis test comparison showed a statistically significant difference between these two groups ($p < 0,01$). The ROC curve showed that the optimal cutoff value of ONSD for predicting ICP > 20 cm H₂O was 6.1, with sensitivity of 100 % and specificity of 83 %. (the area under the curve was 0.98, 95 % CI = 0.825-0.990) (figure 1). In this study, the usually used cutoff of ONSD > 5 mm gives a sensitivity of 100 %, but a specificity of only 22 %.

Discussion

In traumatic brain injury patients there is a need for fast diagnosis of elevated intracranial pressure because of the

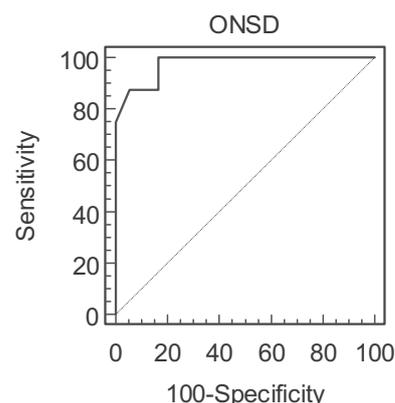


Figure 1. ROC curve for ONSD for patients with ICP > 20 cm H₂O (threshold of ONSD = 6,1) ICP, intracranial pressure; ONSD, optic nerve sheath diameter; ROC, receiver operator curve.

requirement for early treatment and prevention of secondary injury of the brain. (1) Most present methods for detecting elevated intracranial pressure, such as CT of the head or measurement of ICP by intraventricular catheter, have some disadvantages. CT does not allow direct measurement of ICP, so with CT findings we only assume elevated ICP. (2,3) Also, performing a CT of the head requires time, and in such emergency situations there is lack of time. (4) Direct measurement of ICP by intraventricular catheter is the gold standard and most confident method for detecting elevated ICP, but demands neurosurgical expertise. (2,5,6) For this reason, we need a method for diagnosing elevated ICP which is fast, confident and does not require the presence of a neurosurgeon. Such a method is ultrasonographic measurement of ONSD. Ultrasonographic measurement of ONSD is a method which is very quick, safe and readily available. (1) It is noninvasive, so there is no risk of further brain damage. Also, it is possible to learn this method very quickly.

In this study we compared ultrasonographic measurement of ONSD with direct measurement of ICP and evaluated the correlation between ONSD and elevated ICP in traumatic brain injury patients. Most recent studies compa-

red ultrasonographic measurement of ONSD with head CT findings and, as I said, with CT findings we only assume elevated ICP. (1,3-5) So, it is more accurate to compare ultrasonographic measurement of ONSD with direct measurement of ICP and evaluate the correlation between them. (2,6-8) In our study we used direct measurement of ICP by intraventricular catheter as a reference standard. This study points to a strong correlation between values of ICP measured by ICP catheter and ultrasonographic measurement of ONSD. In this study, the ROC curve showed that the optimal cutoff value of ONSD for predicting ICP > 20 cm H₂O was 6.1 with sensitivity of 100 % and specificity of 83 %. Other studies, which have compared ultrasonographic measurement

of ONSD with direct measurement of ICP, revealed similar results. Kimberly revealed that the optimal cutoff value of ONSD for predicting ICP > 20 cm H₂O was 5 mm. (7) Geeraerts concluded that the optimal cutoff value of ONSD for predicting ICP > 20 cm H₂O was 5.68 mm. (6) Soldatos determined that the optimal cutoff value of ONSD for predicting ICP > 20 cm H₂O was 5.7 mm. (2) As we can see, the margin for the optimal cut-off value of ONSD for predicting ICP > 20 cm H₂O is moving up. An explanation for the high optimal cut-off value in our study is probably the low to median GCS score of 5. This study is limited by its small size and the results should be validated with larger trials in prospective clinical design.

Ultrasonographic measurement of ONSD is a method which could be used for quick evaluation of elevated intracranial pressure in traumatic brain injury patients, while waiting for head CT or transport to a larger hospital. (9) Using ONSD measurement as an indicator of elevated ICP, we could start with early treatment and hence gain more time to do complete diagnostics such as head CT, which is necessary for finalising neurosurgical care. (10)

Conclusion

Ultrasonographic measurement of optic nerve sheath diameter correlates with direct measurement of intracranial pressure. This method has potential as a screening test for elevated ICP in traumatic brain injury.

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