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Comparative study between ultrasound guided coronal versus axial optic nerve sheath diameter measurement in patients at risk of increased intracranial pressure

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Abstract

Background: This work intended to contrast the effectiveness as well as precision of ultrasound guided coronal versus axial optic nerve sheath diameter (ONSD) measurement in patients at danger of elevated intracranial pressure (ICP). The optic nerve is a tubular structure of approximately 5 cm in Length, in which its intraorbital segment is evaluable sonographically.

Methods: The 70 patients in this prospective, randomised, double-blinded trial spanned in age from 18 to 60 and had moderately to grave traumatic brain injury (TBI) when they were transferred to the intensive care unit (ICU) with a GCS of 3-12. There were two groups of patients: Patients in Group A do not exhibit elevated ICP readings on brain CT scans. Group B: Patients who had elevated ICP found on a brain CT scan.

Results: There were non-significant higher mean coronal ONSD in comparison to mean axial ONSD in both groups. significant higher mean ONSD and mean axial and coronal ONSD in patients of group B. The Glasgow Coma Scale (GCS) was considerably lower in group B patients. In addition, there was a substantial inverse correlation between the mean ONSD, mean coronal and axial ONSD (mm), and the GCS for patients in both categories.

Conclusions: In patients with trauma to the brain, monitoring the diameter of the optic nerve sheath with bedside ocular ultrasonography is a beneficial non-invasive way to detect excessive intracranial pressure earlier and correlation via the two methods (axial and coronal) gives us more accurate measurements.

Keywords: the diameter of the axial and coronal optic nerve sheaths, increased intracranial pressure

Introduction

Traumatic brain injury (TBI) is characterised as brain damage brought on by an outside mechanical force which triggers physical, cognitive, emotional, and behavioural symptoms. The expected outcome can range from full recovery to death or lifelong impairment. TBI, which mostly affects children and young people, is among the biggest causes of morbidity and mortality globally [1].

In patients with neurologic injury, increased intracranial pressure (ICP), which is defined as sustained pressure more than 20 mm Hg, is linked to poor clinical outcomes [2].

By lowering cerebral blood flow, which would lead to reduced cerebral oxygen supply, raised intracranial pressure (ICP) might result in secondary ischemia damage [3, 4].

A neurosurgeon must implant an intrusive monitor in order to measure ICP, which may not be possible in all institutions. Traditionally, basal cistern and sulcal effacement, as well as the presence of a midline shift of greater than 5 mm, have been utilised to indirectly identify elevated ICP. None of these techniques are thought to be accurate at foretelling elevated ICP [5, 6]. Optic nerve-sheath diameter (ONSD) measurements on ocular ultrasonography (US) are believed to be an indirect assessment of elevated ICP and reveal it to be a reliable and practical technique [7]. The optic nerve and optic nerve sheath are separated by a space filled with cerebrospinal fluid (CSF) because the optic nerve sheath attaches to the dura mater, which covers the brain and CSF. Elevated ONSD will be triggered by the sheath's tendency to expand as a result of elevated ICP [8].

The optic nerve may be viewed longitudinally behind the orbit at its largest width using the first of two ways to calculate ONSD utilising ultrasound: the axial method. In this approach, the ultrasound probe is horizontally oriented, forming an axial line across the patient's eyelid. Behind the retina, the diameter was measured at 3 mm. The ultrasonic probe is vertically positioned at the lateral canthus and pointed nasally and posteriorly until a circular optic nerve was visible at its highest point diameter in the second approach (coronal method) [9]. Up to date, no randomized controlled study compares the efficacy and accuracy of these techniques in measurement of ONSD in patient at risk of elevated ICP. The current study will compare the accuracy of both techniques to conclude which one will be more accurate in these patients [10].

The objective of this study was to assess the effectiveness and accuracy of coronal vs axial ultrasound guidance for measuring the diameter of the optic nerve sheath in individuals at risk for elevated intracranial pressure.

Patients and Methods

This prospective, randomised, controlled, double-blinded trial included 70 patients with moderate to severe TBI who were brought to the ICU with a GCS of 3-12. The patients ranged in age from 18 to 60.

After receiving clearance from Tanta University Hospitals' Ethical Committee, the study was carried out. The patients provided signed consent after being fully briefed.

Age younger than 18 years, facial harm to the orbits or eyes, pre-existing ocular illness affecting the optic nerve and/or orbital cavity, and hyperthyroidism with exophthalmia were all exclusionary factors.

Two equal-sized groups of patients emerged: those in Group A don't show any indication of a high ICP on a brain CT scan, but those in Group B do.

Prior to processing and assessing the pictures, the physician was blinded to ICP values. The principal author, who was blinded to the results of the variables until after measurement, performed all measurements.

All patients underwent a thorough history taking, general assessment (including the Glasgow Coma Scale (GCS), pupils assessment for size, light reflex, and asymmetry, motor evaluation for power and asymmetry, and clinical features of raised ICP), as well as US guided axial and coronal measurement of the optic nerve sheath diameter, mean ONSD of both eyes, and clinical characteristics of raised ICP by ultrasonography, correlation the accuracy between ONSD measured by both methods (axial and coronal) and other parameters.

If the basal cisterns and/or ventricles were missing or condensed if the midline shifted by at least 3 mm, if the sulci were effaced, or if there was a lack of a distinction between the grey and white matter on a brain CT scan, the ICP was elevated.

15 minutes after brain CT scans, an ultrasound was utilised to determine the Optic Nerve sheath diameter (ONSD). In

order to shield the retina and lens from harm, the ultrasonography system's acoustic output was modified in accordance with the (as low as reasonably practicable) principle and the specifications for orbital sonography.

With the head of the bed raised by 30 degrees, patients were assessed while supine using a high-resolution linear array probe. The closed upper eyelid was softly touched by the probe, and a thick coating of ultrasonography gel was put over it to prevent pressure from being applied to the eye. The probe's location was altered such that it could plainly see where the optic nerve entered the globe. With a Sonosite X-porte ultrasound, ONSD measurements were taken using two distinct techniques. The patient's upper eyelid was horizontally positioned with a Sonosite L25xp 13-6 MHz linear probe (Fujifilm Sonosite, Bothell, WA) to create an axial line through the eyelid until the optic nerve might be seen longitudinally behind the orbit at its greatest diameter. Behind the retina, the diameter was calculated at 3 mm. In the second technique (coronal), the identical ultrasonic probe was placed at the lateral canthus in a vertical (cephalad-caudal) orientation and pointed nasally and posteriorly until a circular optic nerve was visible at its highest level diameter.

To reduce artefact, measurements were conducted in a superior-inferior orientation. The opposite eye was then utilised to replicate each measurement.

Statistical analysis

The following statistics were applied to the data using an IBM personal computer with the Statistical Package of Social Science (SPSS) version 20 (IBM Corporations, 2011), Armonk, NY and Epi Info 2000 programmes.

Mean, standard deviation, and range were used to provide quantitative data, whereas numbers and percentages (%) were used to present qualitative data. Two qualitative variables are studied for association using the Chi-Square test (2). The Mann-Whitney test is used to compare two groups with quantitative variables that are not normally distributed, whereas the Student's t test is used to compare two groups with quantitative parametric variables that are normally distributed. The Spearman correlation coefficient (r-test) is used to study the correlation between non-parametric quantitative variables. Its results, which can be positive (+) or negative (-), are used to measure the strength of the linear relationship between two variables. The Pearson correlation coefficient is used to study the correlation between parametric quantitative variables. Statistics was judged significant at a P-value of (≤ 0.05).

Results

Seven patients who were among the 77 patients in this research who were evaluated for eligibility did not fit the bill. The remaining 70 patients were divided into two equal groups, each with 35 patients. All patients that were allotted were tracked down and statistically analysed. The first figure

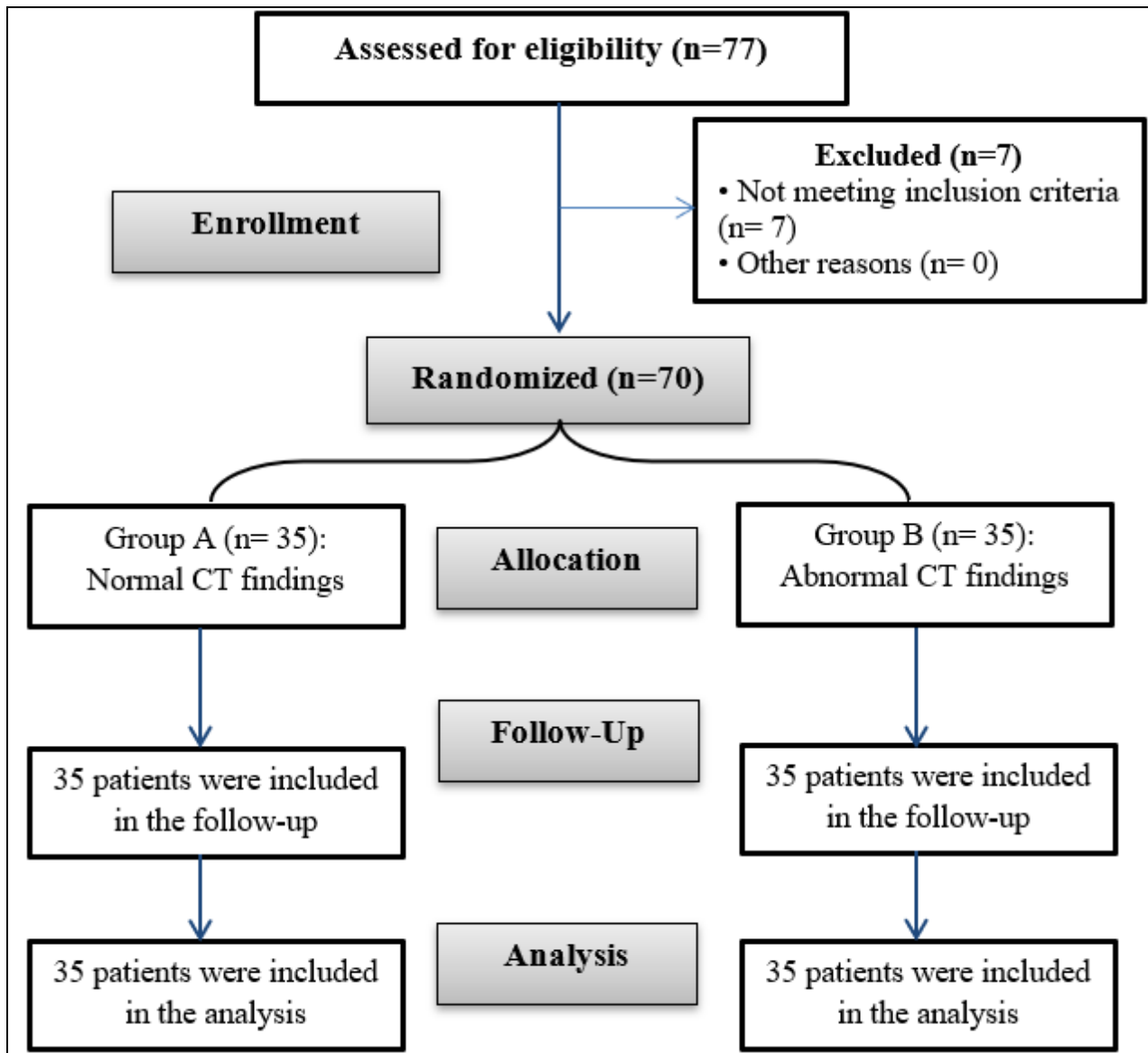


Fig 1: Patient flowchart in the research protocol, illustrating patient enrolment, allocation, follow-up, and analysis

Between the two study groups, there was no discernible difference in age or sex. There were statistically significant more patients with signs of increased ICP difference in group B. non-significant higher mean coronal ONSD in

comparison to mean axial ONSD in both groups. significant higher mean ONSD in patients of group B. The GCS was significantly lower in patients of group B Table 1

Table 1: Age, sex characteristics, clinical features of raised ICP, Mean ONSD (mm), mean axial ONSD (mm) and mean coronal ONSD (mm) of studied groups (N=70)

Parameters	Groups			T-Test	
	Group A N= (35)	Group B N= (35)	Total	Tests	P-value
Age (years)	35.8±11.6	34.7±12.037		t =0.394	0.695
Sex	Male	25 (71.4%)	23 (65.7%)	X ² =0.607	0.797
	Female	10 (28.6%)	12 (34.3%)		
Clinical Features of raised ICP	Yes	9 (25.7%)	27 (77.1%)	X ² =18.5	0.00**(<0.001)
	No	26 (74.3%)	8 (22.9%)		
Mean ONSD (mm)	5.5±0.16	6.5±0.44		t =12.6	0.00**(<0.001)
Mean ONSD	Axial	5.5±0.17	6.5±0.54	group (A) t =1.9	group (A)=0.064(>0.05)
	Coronal	5.6±0.25	6.6±0.62	group (B) t =0.79	group (B)=0.427(>0.05)
GCS	9.4±1.7	6±1.9		-	≤0.001

Data are displayed as Mean, SD, or frequency (%), with a * beside any difference that is statistically significant at P.value <0.05.

The GCS of patients in both groups was significantly inversely correlated with the mean ONSD, mean coronal ONSD, and mean axial ONSD (mm). Figure 2.

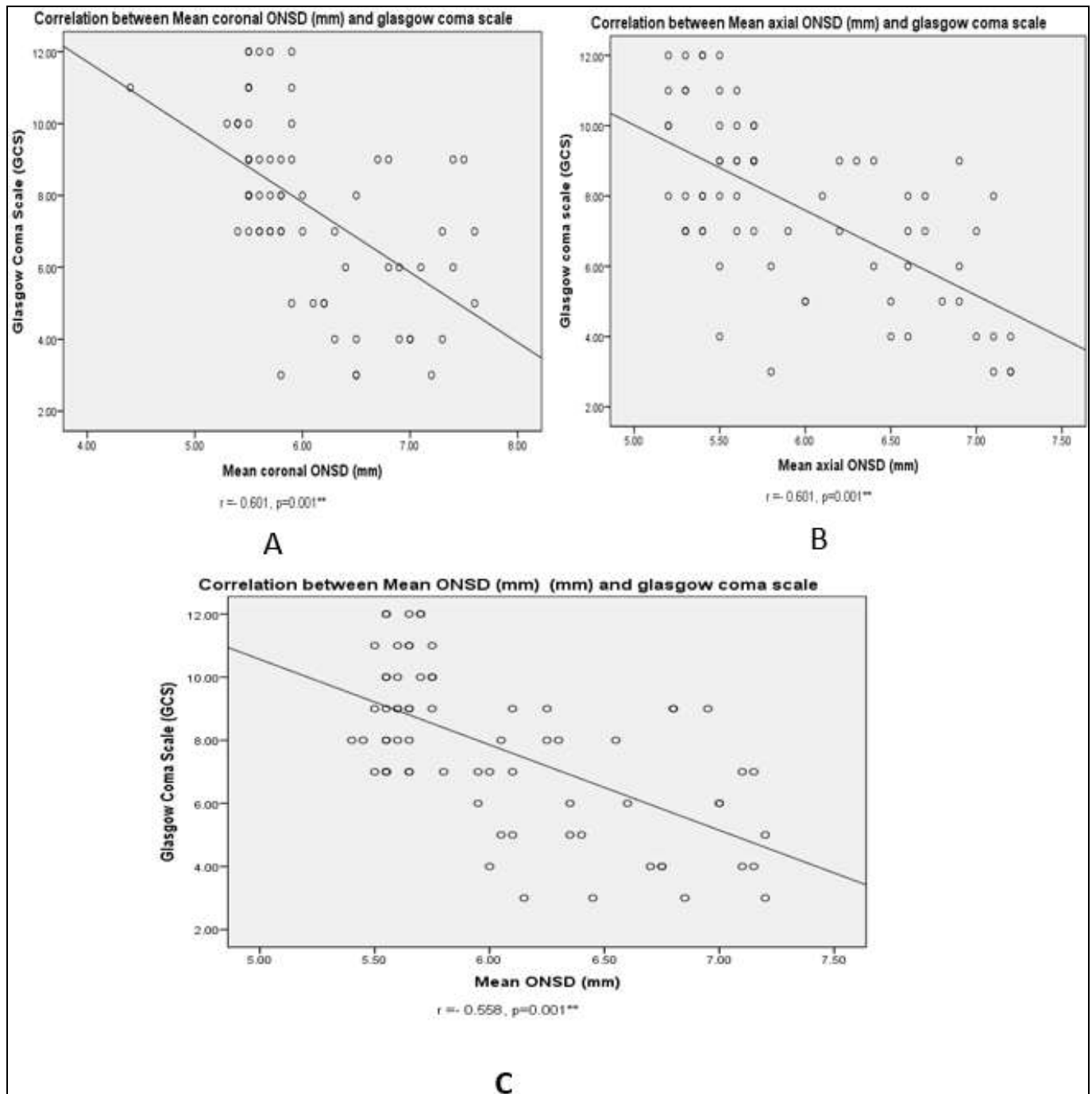


Fig 2: Correlation between Mean coronal ONSD (mm), Mean axial ONSD (mm) and mean ONSD and GCS in both groups.

The class of TBI, the mean ONSD, and the patients who had clinical signs of elevated ICP showed an established connection. Table 2

Table 2: Correlation between mean ONSD (mm), the degree of traumatic brain damage (TBI), and the patients' clinical signs of elevated ICP

	TBI Severity			Clinical features of increased ICP			P-value
	Moderate (no=29)	Severe (no=41)	Mann Whitney	Yes (no=36)	No (no=34)	Mann Whitney	
Mean ONSD (mm)	5.7±0.47	6.2±0.59	3.3	6.2±0.54	5.8±0.60	3.9	**(<0.001)

Data are provided as Mean SD, with * denoting a difference that is statistically significant at P <0.05.

Discussion

Because of the reality that it is a quick, noninvasive, radiation-free, easy to learn, bedside procedure, it has become a crucial feature of the emergency room [11]. In this particular research, patients in group B had substantially lower GCS scores than those in group A. Mahmoud *et al.*'s work [12], which indicated that group 1 had

substantially greater mean GCS values while exhibiting no evidence of elevated ICP in CT, is in line with our study's findings. In line with our study, Canakci *et al.* [13] found that patients with elevated ICP on the CT had a substantial decline in GCS. In contrast to our investigation, Altayar *et al.* [14] found no statistically significant difference between the two groups' GCS levels which can be explained by their

smaller sample size (48 patients).

Regarding clinical features of increased ICP, In contrast to group A, group B had statistically substantially more patients with symptoms of elevated ICP difference (P 0.001). According to Mathews *et al.*,^[15], who witnessed the same thing as we did, every patient who had previously had loss of consciousness, post-traumatic vomiting, and post-traumatic seizures showed intracranial pathology with raised ICP and expanded ONSD that was shown on a CT scan of the brain. Similarly, Othman *et al.*^[16], determined that those with higher ICP radiological findings on CT included those who had prior headaches, vomiting, and visual field impairment. Fernando *et al.*^[17], in contrast to our findings, discovered that certain physical indicators of high ICP were insufficiently sensitive to identify the illness.

Regarding the mean axial ONSD, Its mean value in our study was 5.5 ± 0.17 mm in group A and $6.50.54$ mm in group B. those in group B had substantially greater mean axial and coronal ONSDs and mean ONSDs than those in group A. Moreover, there was non-significant mean coronal ONSD in comparison to mean axial ONSD in both groups.

In accordance with our results Sitanaya *et al.*^[18], discovered that groups with raised intracranial pressure had mean optic nerve sheath diameters that were larger than those in the control groups. Similar to our study, Wang *et al.*'s^[19] findings showed a substantial difference in external ONSD in trauma patients.

Furthermore, Kerscher *et al.*^[20] came to the conclusion that the assessment of ONSD by ultrasonography is a trustworthy non-invasive method for determining children's elevated ICP in all clinical circumstances. The mean ONSD was also considerably greater (P 0.001) in patients with elevated ICP (group B), according to Mabrouk *et al.*^[21].

Contrary to our findings, Cour-Andlaue *et al.*^[22] came to the conclusion that axial ONSD measurement did not predict the 24-hour incidence of intracranial hypertension in children with severe brain damage. The severity of the trauma, timing, and circumstances of the measurements can all be used to explain this. besides Biggs *et al.*^[23] discovered that ICP was not substantially linked with ONSD across all measures. Loss of flexibility of the ONSD may be one explanation for the absence of correlation between ICP and ONSD in both adult and paediatric studies. Additionally, Biggs *et al.*^[23] discovered that the most accurate predictor of individuals with high ICP is the axial assessment of optic nerve sheath diameter. Additionally, Gao *et al.*^[24] found that the ultrasound-guided axial ONSD measurement was not a trustworthy indicator in the noninvasive assessment of ICP.

In our investigation, there was an intense inverse correlation between the patients' GCS and the mean coronal and mean axial ONSD (mm). This was supported by Çelik *et al.*^[25] who detected negative correlation between ONSD values and GSC values. Similarly, Güzeldağ *et al.*^[26] 44 adult individuals with acute middle cerebral artery stroke were shown to have an adverse link between ONSD and the GCS. In addition, Yang *et al.*^[27] observed that in 90 adult critical care patients, ONSD demonstrated a strong negative connection with the GCS score.

In disagreement with our results, Du *et al.*^[28], who did not identify a correlation between ONSD with indices such as age and GCS score.

Furthermore, our findings demonstrated a substantial correlation between the mean ONSD and the kind of TBI as

well as the clinical indicators of elevated ICP. Mahmoud *et al.*'s findings that the mean ONSD was substantially linked with the severity of TBI and clinical indicators of elevated ICP are consistent with our findings. Additionally, Mabrouk *et al.*^[21] discovered a strong correlation between the mean ONSD and the severity of TBI.

In addition, Othman *et al.*^[16] found that patients with clinical symptoms of elevated ICP, such as nausea, vomiting, headaches, disrupted conscious level, and visual field affection, had a statistically significant increase in mean ONSD. It is advised that this non-invasive, easily accessible, quick, straightforward, and bedside diagnostic modality may be useful in a variety of clinical settings, such as pre-hospital care, military settings, centres without CT scans, long transport times, disaster scenes, intensive care unit settings, and even in the operating room, especially in the developing world where the availability and utilisation of invasive monitoring is limited. The applications and indications of this approach in a clinical situation, as well as a more precise definition of the cut-off value that most accurately predicts high intracranial pressure, still require more investigation and bigger, multidisciplinary, multiinstitutional investigations. can also be designed to determine ONSD values which predict the need for surgery and outcome.

Conclusions

An effective, non-invasive approach for determining the diameter of the optic nerve sheath in adult patients with traumatic brain injury is bedside ocular ultrasonography. Correlation between the two methods (axial and coronal) allows for more precise readings.

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Author's Contribution

Not available

Conflict of Interest

Not available

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