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A prospective observational study on evaluating the efficacy of bedside optic nerve sheath diameter in assessing clinical progression of patients admitted in neurosurgical ICU with comparisons to CT scans and GCS score

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Abstract

Background: Ultrasound of the optic nerve sheath diameter (ONSD) is a non-invasive, repeatable tool that can be used to measure intracranial pressure in a dynamic way with high diagnostic accuracy. The goal of this study was to find out if a bedside ultrasonographic measurement of optic nerve sheath diameter (ONSD) can accurately predict the computed tomography (CT) findings of high intracranial pressure (ICP) and changes to the Glasgow Coma Scale (GCS) in adult head injury patients in the Neurosurgery ICU.

Methods: For 54 patients in the neurosurgical intensive care unit, we conducted a retrospective analysis of the results of cranial ultrasounds. Those under the age of 18 and those with apparent visual injuries were ineligible. Both horizontal and vertical optic nerve sheath diameters were measured 3 mm beneath the globe in each eye using a 7.5-10MHz ultrasonographic probe. A binocular change in optic nerve sheath diameter of more than 2.00 mm was deemed abnormal in two consecutive readings in the same patient. Patients in the neurosurgical ICU were given a GCS score, which was used to classify their level of brain damage as mild, moderate, or severe. The accuracy of the optic nerve sheath diameter was evaluated using cranial CT findings of shift, oedema, or effacement that suggested an increased intracranial pressure.

Results: The research has 54 participants. According to the results, 68.5% of those who took the study were men, while 31.5% of those who did so were women. Nearly 16.7 per cent of respondents were between the ages of 18 and 40, while 40.7% of respondents were between the ages of 40 and 60, and 42.6% of respondents were above 60. The significant change in ONSD- fall in GCS and CT-progression scan-findings correlation was very strong. When compared to CT scan progression, the ONSD bedside sonographic test had an 86.7% sensitivity and an 89.7% specificity for detecting elevated ICP. The Positive Predictive Value of the reduction in GCS with advancement in CT scan was 80% and the Negative Predictive Value was 89.7%, respectively.

Conclusions: The sensitivity, specificity, and positive predictive value of bedside ONSD ultrasonography in predicting high intracranial pressure are significant to those of progression in CT scan and drop in GCS. An ONSD bedside measurement may be used to determine elevated ICP since it is non-invasive and repeatable.

Keywords
intracranial pressure,
optic nerve,
ultrasonography

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Introduction

Detection of increasing intracranial pressure (ICP) has been a common non-invasive approach for evaluating optic nerve sheath diameter (ONSD). A frequent emergency is increased intracranial pressure. Poor clinical outcomes, such as a high mortality rate from various neurological illnesses, are associated with an elevated ICP [1].

This portion of the optic nerve is contained by cerebrospinal fluid as well as the optic nerve sheath (ONS), which is a membrane that is attached to the brain's dura mater (the outer membrane). To put it another way, the optic nerve sheath diameter varies within minutes when cerebrospinal fluid pressure changes in the perioptic subarachnoid space, which is an extension of the intracranial subarachnoid space [2-5].

Several factors, including age, gender, and severity of the injury, co-morbidities and concurrent anticoagulation, secondary insults and the initial Glasgow Coma Scale (GCS) score, the motor score and pupil reactivity, the type of lesion visualized on brain computed tomography (CT) scan, changes in intracranial pressure (ICP), and blood levels of specific proteins, influence the prognosis of a brain injury. According to research conducted using ultrasonography, there is an excellent link between intracranial pressure and the diameter of the optic nerve sheath [6,7].

The ICU routinely performs at least one first brain CT scan on patients with serious head trauma. The first ONSD measurement has not been studied in conjunction with the brain CT scan and GCS to our knowledge. Current research examined the relationship between first brain CT scan ONSD and GCS and the outcome of brain injury patients admitted to the ICU. When it comes to identifying high ICP and comparing it to CT findings of higher ICP and GCS alterations, this research was developed. If bedside ultrasonography guided measurement of ONSD could predict higher ICP in patients with any form of brain illness, then this research was successful.

Materials and methods:

In the Neurosurgery ICU of a tertiary care teaching hospital, this retrospective study was carried out between January 2019 and October 2020 after it was approved by the hospital's ethical committee. Those who had provided written informed consent and were suspected of having an elevated ICP were allowed to participate in this research. Patients came in all shapes and sizes, with a wide range of medical conditions. GCS and early CT scan data were used to estimate the extent of brain injury. Both eyes were examined using ONSD before a CT scan was performed on the head of all participants. All patients over the age of 18 who were admitted to a neurosurgical ICU with a suspected increase in ICP were included in the study. There was a strict exclusion policy for patients with serious head traumas, substantial eye injury, or a history of glaucoma or optic nerve illness. A linear ultrasonic probe with a 7.5-10 MHz bandwidth was used to assess ONSD. While laying down, all patients were screened. Over an upper eyelid that was completely closed, an ultrasound gel was placed without exerting any pressure. There was an anomalous mean binocular ONSD more than 5mm and a transverse ONSD of 3mm behind the retina. As long as the patient's midline shift was more than 3 millimeters and the CT scan result indicated an elevated ICP, the CT scan was considered to be positive. (GCS 13-15), (GCS 9-12), or (GCS severe) GCS scores were classed as mild, moderate, or severe (GCS 8 or less).

Age, gender, clinical diagnosis, GCS, and death were all recorded. In order to determine if there was any correlation between various parameters and ONSD levels, the collected data was analyzed. A binocular change in optic nerve sheath diameter of more than 2.00 mm was deemed abnormal in two consecutive readings in the same patient. On the basis of sensitivity and specificity, the ROC curve was utilized to determine the optimal ONSD cutoff point. Shorthand for data analysis is "bringing facts and figures together to address the research question." Analyzes a study on "optic nerve sheath diameter measures in neurosurgical intensive care unit (ICU) for ICP with connection to GCS and CT scan progression" Based on demographic and statement questions, a well-known instrument was created. This survey had a total of 54 answers. SPSS version 25 was used to record, tabulate, and analyze the data statistically. The Chi-square test was done, and a P value of less than 0.05 was thought to be significant. A ROC curve was made to find the ONSD cutoff point with respect to CT progression relation with drop in GCS that gives the best balance of sensitivity and specificity for this modality.

Results

Descriptive analysis is used to characterize the fundamental properties of the data in the research. The quantitative method is a field in which the descriptive data analysis takes its significance. It aims at summarizing a sample accessible to the researcher. It gives concise summaries of the Sample and also about the observation conducted on them. The descriptive analysis analyses the data to generate descriptions of the population, either via numerical computations or tables. They constitute the fundamental basis of any quantitative study of data. The summary data of the researcher is presented in the following tables that are exhibited and detailed below Table 1.

Table 1. Descriptive analysis of gender and age

Variables	*N (sample)*	Frequency	Percentage %
Gender	54		
Male		37	68.5%
Female		17	31.5%
AGE	54		
18-40		9	16.7%
40-60		22	40.7%
>60		23	42.6%

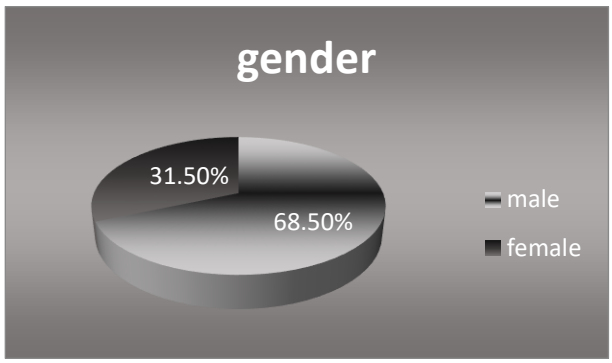

Figure 1. Pie chart showing distribution of participants according to gender.

From the Figure 1, we conclude the gender that about 68.5% of the respondents were males and 31.5% of the respondents were females participate in the survey.

From the Figure 2, we conclude the age of respondents almost 16.7% of the respondents were of age group between 18 and 40 years, 40.7% of the respondents were of age group between 40 and 60 years and 42.6% of the respondents age was more than 60 years.

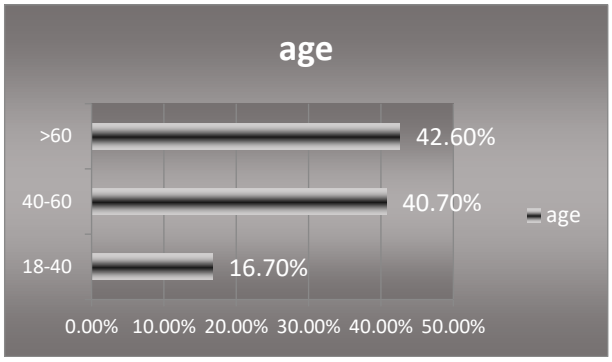

Figure 2. Bar Graph showing distribution of participants according to age groups

Inferential analysis:

Inferential statistics uses a sample of data from a population to draw inferences and predictions about that group. The estimate of hypotheses, parameters, or the testing of hypotheses are included in this section. Assessing the strength of a link between variables is made easier with its assistance the researcher conducts a series of tests to determine the importance of their findings.

Hypothesis:

H1: there's relation between change in ONSD with fall of GCS and CT scan progression

Table 2. Relationship between CT progression and drop in GCS

Crosstab relation between CT progression with Drop in GCS

			CT progression		Total
			No	Yes	
Drop GCS	No	Count	35	3	38
		% within CT progression	89.7%	20.0%	70.4%
	Yes	Count	4	12	16
		% within CT progression	10.3%	80.0%	29.6%
Total		Count	39	15	54
		% within CT progression	100.0%	100.0%	100.0%

From Table 2 we conclude that the sensitivity of drop in GCS to detect raised ICP was found to be approximately 80% and specificity was 89.7% when compared with progression in CT scan. The chi-square tests from table 3 shows highly significant (P-value <0.05) which indicates drop in GCS has significant relationship with the progression in CT scan.

Table 3. Chi-square tests with the relation of drop in GCS and progression in CT scan

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	25.273[a]	1	.000		

Table 4. Relationship between change in ONSD and progression in CT scan

Crosstab relation between CT progression with change in ONSD

			CT progression		
			No	Yes	Total
Change in ONSD	No	Count	35	2	37
		% within CT progression	89.7%	13.3%	68.5%
	Yes	Count	4	13	17
		% within CT progression	10.3%	86.7%	31.5%
Total		Count	39	15	54
		% within CT progression	100.0%	100.0%	100.0%

Table 5. Chi-square tests with the relation of change in ONSD and progression in CT scan

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	29.323[a]	1	.000		

From Table 4 we conclude that the sensitivity of significant change in ONSD to detect raised ICP was found to be approximately 86.7% and specificity was 89.7% when compared with progression in CT scan. The chi-square tests from table 5 shows highly significant (P-value <0.05) which indicates change in ONSD has significant relationship with the progression in CT scan.

Table 6. Area under the curve for change in ONSD with relation of drop in GCS and progression in CT scan.

Area Under the Curve

Test Result Variable(s)	Area
Drop in GCS	.849
Change in ONSD	.882

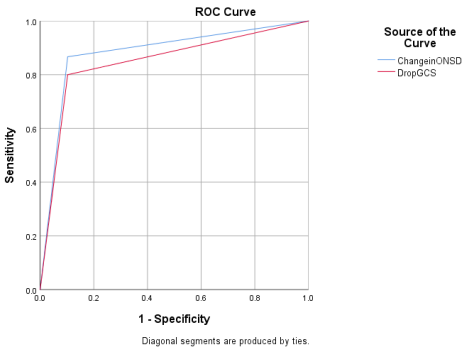

Figure 3. Receiver Operating Characteristic curve (ROC) analysis of change in ONSD with relation of drop in GCS and progression in CT scan.

The ROC for the change in ONSD had a high ability to discriminate between normal and high ICP, where the area under curve (AUC) value was 0.882 [Table 6] whereas drop in GCS while increasing ICP with respect to CT progression has AUC value was 0.849 [Table 6} and shows a good separation between true positives and false positives. Change in ONSD more than 2mm in consecutive times and drop in GCS in a same patient relation with CT progression has a good negative as well as positive predictive value [Figure 3].

Discussion

Even though there are other reliable ways to measure ICP, none of them are as good as ultrasonographic ONSD in a number of ways. For example, places that focus on neurocritical care are the only ones that offer invasive ICP monitoring [8].

It's possible that many institutions lack the specialized, high-priced equipment needed for this procedure, and the If a patient has coagulopathy, for example, invasive ICP monitoring may be impossible. It is possible to identify elevated ICP with CT and MRI scans without the need for intrusive procedures. The procedure may be challenging and time-consuming for patients in the critical care unit who need mechanical breathing or monitoring devices. There is a need to investigate noninvasive bedside techniques to ICP evaluation in clinical settings. An increase in intracranial pressure (ICP) may be accurately measured using noninvasive imaging techniques [9-11].This means that ultrasonographic ONSD evaluation is in high demand and may become the primary method of determining increased ICP [12].

An increase in intraocular pressure has been proven to prevent optic disc enlargement even in the presence of a high intraocular pressure (ICP), according to Brodsky et al. [13]. An A scan has been used by many groups to investigate the connection between ONSD and ICP, and different echography techniques have been used to do so. There is a positive linear association between these two variables in neurosurgical patients, as shown by Cennamo et al.[14], Gangemi et al.[15], and Tamburelli [16].

In our study, we took the reference of 2mm change in ONSD in consecutive measurement of the same patients. To verify this, Helmke and Hansen[17] used cadaver testing and found that the ONSD climbed by up to 60 percent when the globe was three millimeters away from the body, whereas it only rose by 35 percent when the globe was 10 millimeters away according to Liu and Kahn [18].

More than 2mm of ONSD change was detected in the control group over the age of 18 in our research (n=54). Neuropathology patients in the Neurosurgery ICU may be consistently predicted to have an elevated ICP using ultrasound-based ONSD estimate (about 86.7% sensitivity, and 89.7% specificity). Study results by Kimberly et al. found a strong agreement between the values of the ICP catheter and the results of the ONSD ultrasonographic examination, with a sensitivity of 88% and a specificity of 93% [19]. In their investigation, Tayal et al. found that ONSD had 100% sensitivity and 63% specificity for identifying increased ICP [20].

Using adult emergency room patients who had suffered head injuries, Tayal et al. performed a prospective, blinded observational research. They compared the ONSD results from USG with the elevated ICP seen on CT. In order to identify elevated ICP, the sensitivity was 100%, while the specificity was 63% [21]. An ultrasonographic assessment of the ONS diameter of detection for elevated ICP showed that ONSD>5.00mm had a higher ICP >20 mm, with pooled sensitivity of 90% (95 percent confidence interval: 80-95 percent) and specificity of 85%, as shown by Dubourg et al (95 percent CI: 73-93 percent). A positive ONSD is 51 times more common in individuals with elevated ICP [22].

We examined 54 individuals and found no correlation between ONSD results with the age or gender of the group. We also found a correlation between ONSD results and hemodynamic parameters, CT progression, and the patient's GCS at the time of evaluation, which may be attributed to the pathophysiological impact of these factors on intracranial pressure and ONSD. We utilized CT progression as a reference standard for comparing ONSD outcomes since CT scans of the head are used on a regular basis in neurosurgical ICUs to identify elevated ICP. CT scan has also been used as a reference diagnostic test in other research [23,24]. Neurosurgical competence, time for insertion, and lack of experience in all institutions make invasive monitoring of ICP the gold standard [25].

In our study, we also used a reference standard of change in ONSD 2mm while measuring consecutive time in the same patients was considered to be abnormal. The ROC for the change in ONSD readings had an AUC value of 0.882 with respect to CT progression and The ROC for drop in GCS relation with CT progression shows 0.849 and both test showed a good separation between true positives and false positives

These findings show that ultrasound measurements of ONSD may be an effective substitute for invasive ICP measurements or other imaging modalities. It is possible to estimate the ICP value of patients whose ICP measurement through lumbar puncture is problematic (in high risk, such as a hemodynamically unstable patient using this noninvasive technique [26]. A research found a substantial correlation between invasive ICP and both ONSD ultrasound and straight sinus systolic flow velocity. According to Robba et al. [27], ultrasonographic assessment of ONSD is noninvasive, safe, and rapid due to the easy visibility of the orbital window and the absence of problems. CT scans of the brain need time and money, and in certain emergency cases, there is a shortage of time for this procedure. An ultrasound-guided ONSD assessment may help identify increased ICP in the early stages of traumatic brain injury (TBI) and avoid further brain damage. There was no added advantage to therapy based on intracranial catheter measurement of ICP compared to clinical and imaging results alone, according to a major trial [28].

We do not use intrusive monitoring at our institution, and if we suspect that a patient's ICP is elevated, we do repeated CT scans. ONSD may be quite useful in detecting elevated ICP in these types of health care institutions so that efforts to lower ICP

can be taken as soon as possible. There are a number of ways in which ONSD may be used to evaluate ICP, determine the next course of therapy, and send patients to higher facilities, and in situations when a CT scan is not accessible or if a tertiary care facility is a considerable distance away.

Conclusion

For identifying elevated ICP, ONSD measurement using ultrasound has a high degree of sensitivity, specificity, and connection with CT brain advancement and a decrease in GCS. Bedside measurement of ONSD is a good way to find out if ICP is too high because it is non-invasive, can be done more than once, doesn't use ionizing radiation, and can be used in many different situations. More research is needed to prove that it helps people with raised ICP. It also helps start treatment for a high ICP as soon as possible. It is quick, can be done at the bedside, doesn't hurt the patient, doesn't cost much, and doesn't use any ionizing radiation.

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