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SONOGRAPHIC MEASUREMENT OF OPTIC NERVE SHEATH DIAMETER TODETECT FINDINGS OF INCREASED INTRACRANIAL PRESSURE IN ADULT HEAD INJURY PATIENTS IN EMERGENCY DEPARTMENT OF TERTIARY CARE HOSPITAL

Emergency Medicine

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ABSTRACT

Introduction: Raised intracranial pressure (ICP)is important to determine in traumatic & non-traumatic neurological and neurosurgical patients as it may cause significant neurological deterioration due to secondary brain damage. Intra cranial pressure means exerted by fluids such as cerebrospinal fluid (CSF) inside the skull and on the brain tissue. So, a quick evaluation of increased ICP is important for the management of patients with traumatic brain injury (TBI) to allow timely intervention to decrease the ICP and maintain adequate cerebral perfusion. **Aims:** The aim was to evaluate use of bedside sonographic measurement of optic nerve sheath diameter (ONSD) to detect findings of increased intracranial pressure in adult head injury patients in Emergency department. **Methods:** This prospective study was conducted at Emergency Medicine department of Mahatma Gandhi medical college & Hospital, Jaipur. Total 108 adult head injury patientswith suspected raised ICP were included in this study. Bedside ultrasound was done for ONSD measurement, followed by a computed tomography (CT) of brain. Mechanism of injury, GCS, TBI classification, clinical featuresof increased ICP, mean ONSD of both eyes by USG and brain CT findings of increased ICP were recorded.A mean bipolar ONSD > 5mm was considered abnormal. **Result:** Present study found Moderate head injury (57.4 %) as most common head injury. Mean ONSD in right eye was 5.964 with SD 0.822 and mean ONSD in left eye was 5.957 with SD 0.822.Total mean ONSD was >5mm was found in 84.25 % patients. Raised ICP features was present in 82.4 % CT brain.GCS score was inversely correlated with mean ONSD. **Conclusion:** We concluded that thesonographic measurement of optic nerve sheath diameter has excellent diagnostic accuracy to predict increased intracranial pressure in adult head injury patients in Emergency department.

KEYWORDS

Intracranial pressure, Emergency department, Optic nerve sheath diameter

INTRODUCTION

The intracranial pressure (ICP) is the constant pressure in the skull caused by the total volume of blood, cerebrospinal fluid, and brain. The ICP will increase as a result of an increase in any of the intracranial structures due to events such as head trauma, ischemic stroke, haemorrhagic stroke, mass lesion, and infection.[1] ICP normally ranges from 7 to 15 mm Hg, while in the vertical position, it does not exceed 15 mm Hg.[2]Typically, ICP lowering therapy initiates when ICP is greater than 20 to 25 mm Hg. Refractory elevated ICP reduces cerebral perfusion pressure (CPP), thereby accounting for cerebral ischemia and initiating herniation syndromes that eventually lead to death.[3,4]Therefore, the diagnosis of an elevated ICP is crucial for the treatment of patients with traumatic brain injury (TBI), enabling prompt intervention to lower the ICP and maintain appropriate cerebral perfusion.

Many non-invasive techniques for the detection of elevated ICP are there like Computed tomography (CT) of the head, Magnetic resonance imaging (MRI), Trans-cranial Doppler sonography (TCD). Sometimes these tests are not readily available in emergency or the patient is non-transferable and along with this, there is a risk of radiation exposure with these techniques.[5]

Ultra-sonographyguided retro-bulbar optic nerve sheath diameter (ONSD) measurement by a trained Sonologist is an alternative non-invasive bed side method to estimate ICP in comparison to various invasive and other non-invasive ICP measurement techniques .Ocular sonography is quick, cost effective, bed side and non-invasive method for measurement of optic nerve sheath diameter and can lead to more timely interventions for raised ICP, especially in hemodynamically unstable patients in ICU and ED, where CT scan is unavailable and invasive monitoring is contraindicated.[6,7,8]

The use of point-of-care ultrasound (POCUS) for diagnostic assessment has recently become widespread in emergency and critical care area, representing a valuable extension of the physical examination. As an noninvasive, radiation-free bedside tool for assessing elevated ICP, optic nerve sheath diameter ultrasound correlates with increased ICP. Optic nerve sonography has been applied in a variety of paediatric diseases at risk for intracranial hypertension, including: traumatic and nontraumatic brain injury, intracranial haemorrhage, diabetic ketoacidosis, metabolic disorders (hepatic failure)ventriculoperitoneal shunts, hydrocephalus, suspected intracranial lesions, hypoxic injury, meningoceles, spina bifida and craniosynostosis.[9,10,11]

There is increasing evidence that optic nerve sheath diameter (ONSD) can be used as a noninvasive means to detect increased ICP using ultra sonography (US). Several studies have reported a correlation between optic nerve sheath diameter and ICP, and Their results showed that normal optic nerve sheath diameter should range between 3.5 and 5.1 mm, with a cut-off value between 4.1 and 5.7 mm for identifying increased ICP.[12,13,14]

Therefore, the present study is aimed to evaluate the use of bedside ultrasonographic measurement of ONSDin the assessment of raised ICP in head injury patients in Emergency department.

MATERIALS AND METHODS

The present study was a prospective observational study. This Study was conducted during a period of one & half year between February 2021 to June 2022 at Department of Emergency Medicine, Mahatma Gandhi Medical College & Hospital, Jaipur. Total 108 patients were included in this study and All adult traumatic brain injury patients who presented to the Emergency Medicine Department with suspected elevated ICP (defined by the presence of 1 or more clinical features which include altered mental status , loss of consciousness, headache, nausea , vomiting, seizure, anisocoria).

Patients of age < 18 years, patients with penetrating trauma to head or significant ocular trauma, history of glaucoma or current medication that might have affected CSF pressure, ophthalmic diseases such as tumors, poisoning by drugs or substances that cause impaired consciousness, patients allergic to gel ,and those who are not willing to consent were excluded from the study.

METHODOLOGY

All patients who presented to Emergency Medicine Department and satisfy eligibility criteria were recruited in our study. Patients were approached according to ATLS protocol and stabilized. After

stabilizing patient, informed consent was obtained and patients were examined in the supine position.

Ultra-sonographic measurement of ONSD wasperformed using handheld portable ultrasound machine (Sonosite) with a 10–13 MHz linear probe placed in an axial plane over temporal side of closed upper eyelid which is covered with a sterile dressing tegaderm. After selecting B modein a transverse sonographic section globe and structures of retrobulbar area including optic nerve were seen. An optical nerve with defined margins was visible posterior to the globe as a linear hypo echoic structure .The transverse ONSD was measured 3 mm behind the retina in each eye. Three measurement were taken for each eye.A mean binocular ONSD >5 mm or equal will be considered raised ICP in this study.[14,15,16]

Cranial CT Scan was obtained within 20 mins of ONSD measurement and was reviewed by radiologist. Cranial CT scan findings of significant edema, mid line shift of 3 mm or more, mass effect, sulci effacement, collapse of ventricles or compression of cisterns are suggestive of elevated ICP was used to evaluate ONSD accuracy by sonography.[15]

Statistical Analysis

SPSS software (v23.0, Armonk, NY, USA: IBMCorp.) was used for all statistical analyses. A sample sizewas calculated with 95% confidence level (CI) and 7.5%margin of error. Mean and standard deviation (SD) werecomputed for continuous variables, while descriptive statistics,frequency analysis, and percentage analysis were done forcategorical variables. P-value ≤ 0.05 was considered for statistically significant.

RESULTS

In the present study of 108 patients, maximum patients were between 21-30 age group with a mean age of 38.0370± 14.9272. Male patients were 79.6%. There was a significant difference regarding type of head injury as most of patients had Moderate head injury (57.4%).Loss of consciousness (66.66%) and nausea/vomiting (55.55%) were most common clinical symptoms among head injury patients. Mean ONSD in right eye was 5.96 ± 0.82 and Mean ONSD in left eye 5.95 ± 0.82.Total mean ONSD > 5mm was found in 84.25 %. Which was statistically significant ($p < 0.00001$).Total 89 patients (82.40%) had features of raised ICP in CT head ($p < .00001$). In our study,there was a significant strong inversecorrelation between the mean ONSD and the GCS of patients.

Table1: Age distribution of study patients

Age in group	Frequency	Percent
≤20	8	7.4%
21-30	31	28.7%
31-40	21	19.4%
41-50	29	26.9%
51-60	13	12.0%
≥61	6	5.6%
Total	108	100.0%

Table 2:Gender distribution of study patients

Sex	Frequency	Percent
Female	22	20.4%
Male	86	79.6%
Total	108	100.0%

Table 3:Mechanism of Injury distribution of study patients

Mechanism of Injury	Frequency	Percent
Fall from height	21	19.44%
Self-fall	2	1.8%
Motor Vehicle Collision (MVC)	83	76.85%
Heavy object falls on head	2	1.9%
Total	108	100.0%

Table4 : Distribution of type of head injury according to GCS

Types of head injury	GCS	Frequency	Percent
Mild	13-15	26	24.07%
Moderate	9-12	62	57.40%
Severe	4-8	20	18.51%
Total		108	100%

Table 5 : Distribution of mean ONSD Eyes

	Number	Mean	SD	Minimum	Maximum	Median
ONSD Right Eye	107	5.9645	.8220	3.3000	8.0000	6.1000
ONSD Left Eye	108	5.9574	.8223	3.2000	8.0000	6.1000

Table 6 : Total mean ONSD measurement in both eyes

ONSD measurement	Frequency	percent
<5	17	15.74%
>5	91	84.25%
Total	108	100%

Table 7: Number of patients with CT features of raised ICP

CT features of raised ICP	Frequency	Percent
Yes	89	82.40%
No	19	17.59%
Total	108	100%

Table8: Distribution of Total mean ONSD (right/left) correlation with GCS score

	Type of Head Injury	Number	Mean	SD	Minimum	Maximum	Median	p-value
Total mean ONSD (right/ left)	Mild (13-15)	26	5.0635	.6286	3.2500	6.4500	4.9500	<0.0001
	Moderate (9-12)	62	6.1065	.5864	3.6500	7.2500	6.2000	
	Severe (4-8)	20	6.6700	.6522	4.7000	8.0000	6.8000	

DISCUSSION

The majority of patients with head injuries presenting to the emergency department have multiple injuries that need to be detected and treated as soon as possible. Traumatic brain injury is still associated with raised ICP.

Raised ICP remains a significant prognostic factor for poor outcome following traumatic brain insult.[17]**Helmke andHansen** proposed that optic nerve that is a part of the brain, is surrounded by subarachnoid CSF and dural mater; variation in CSF pressure was associated with ONSD, which was widenedin patients with raised ICP.[18] The aim of our study was to to evaluate use of bedside sonographic measurement of ONSD to detect findings of increased intracranial pressure in adult head injury patients in Emergency department.

In our study, out of 108 patients most of the patients (31) were between 21-30year age group (28.7%)which was statistically significant ($p<.00001$).Total 86 (79.6%) patients were male compared to 22 (20.4%) female patients,which was statistically significant ($p<.00001$). Mean age of patients was 38.03±14.92 in our study. Our study results were comparable to other studies.**Amini A, et al** [19] showed that there were 222 patients (65.3% male), with mean age of 42.2±19.5 years (range: 16-90 years). In **Robin M et al** [20]examined that all adult male patients with severe TBI on mechanical ventilation and monitored for ICP were included in this study.

Most of the patients (83) had motor vehicle collision (76.85%) in our study, followed by fall from height (21). In a prospective study by **Tayal et al.**[21], of 59 patients,76% of patients were involved in motor vehicle crash, 12% had fallen from height, and 9% had assault.

In our study Severe head injury patients were associated with greater increase of mean total ONSD diameter compared to moderate head injury patient (6.6700± .6522vs. 6.1065± .5864.).This shows ONSD diameter is associated with severity of injury.

These findings agree with **ÇanakçiY, et al.**[22] who performed a study to investigate thevalue of the measurement of ONSD in patientspresenting to the ED with headache and a significantdrop in GCS was seen in patients with increased ICP.Moreover, there was a significant inverse correlationbetween the mean ONSD and the GCS of patients.This agree with and Çanakçi Y, et al, who alsoobserved similar results in their studies.

Mean ONSD in right eye was 5.964 with SD 0.822 and mean ONSD in left eye was 5.957 with SD 0.822.Total mean ONSD was >5mm was found in 84.25 % patients. Raised ICP features was present in 82.4 % CT brain.

In **Nash *et al.*'s**[23] study, 9 (45%) out of 20 patients, hadsigns of raised ICP and their ONSD ranged from approximately5.2–6.2 mm with a

mean of 5.8 mm (SD: 0.62). Rightversus left eyes again did not show significant variabilityin these patients. Eleven (55%) patients were determined tohave normal ICP with mean ONSD in this group averaged4.9 mm (SD: 0.49).[18]

In **Blaivas*et al.*'s** [24] study, out of 35 patients, 14 had CT resultsconsistent with elevated intracranial pressure. In 14 patientswith raised ICP, the mean ONSD was 6.27 mm (95% CI: 5.6–6.89).In patients with normal ICP on the CT brain, the mean ONSDwas 4.42 (95% CI: 4.15–4.72). The difference in mean ONSDbetween normal and raised ICP was 1.85 mm (95% CI: 1.23–2.39)which was statistically significant with a $P = 0.001$, sensitivityof 100% and specificity of 95%. The positive predictive valuewas 93%, and the negative predictive value was 100%.[19]

Dubourg J and colleagues[25] did a systematicreview and meta-analysis composed of 231 patientsfrom 6 studies and concluded that US ONSD shows agood level of diagnostic accuracy for detectingincreased ICP as compared to invasive monitoring. The pooled sensitivity and specificity in this studywas determined to be 90% and 85% respectively. They emphasized on the enormous potential thisdiagnostic method has in clinical decisionmaking, whether it be the triage of patients requiring transfer to specialized centres or the need to place an invasivedevice in situations where there is a lack of specificrecommendations for their placement.

Our study showed strong relationship between raised ICP finding on CT brain and dilated optic nerve sheath on ocular ultrasound in adult head injury patients in the ED.This non-invasive test for detecting raised ICP can also be done when CT imaging is not available.The measurement of ONSD in this manner is easy to learn,precise, and inexpensive. A cut-off value of 5 mm can be usedto screen for raised ICP.

CONCLUSION:

Bedside ocular sonography is non-invasive, repeatable,cost effective bedside test for early diagnosing raised ICP in head injury patients presenting to emergency Department.

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