Efficacy of optic nerve sheath diameter by ultrasound as a non-invasive method to determine elevated intracranial pressure in Indian population

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ABSTRACT

Introduction: It is important to assess use of Optic Nerve sheath Diameter (ONSD) measurement by point of care ultrasonography (POCUS) as a non-invasive method for detecting elevated Intracranial Pressure (ICP) and to compare with Brain Computed Tomography (CT) findings of Elevated ICP in Indian population

Methods: This study was a Prospective Observational Study done in emergency Department of a tertiary care hospital in western India .Adult patients within 18-60 years age group, with Head trauma presenting with headache, vomiting, convulsions, loss of consciousness, and altered sensorium were included in the study.Non-trauma patients with focal neurological changes and history suggestive of possible spontaneous intracranial hemorrhage were also included. Data was recorded after stabilizing patients as per standard trauma and non-trauma protocol.

Patients underwent a POCUS study to measure the ONSD. Based on clinical judgment and ONSD measurement above the expected cut-off range, medical management for Elevated ICP was started. A Plain Brain CT Scan was obtained. Definitive treatment was planned after confirming on CT scan.

ONSD measurement more than 6mm was suggestive of Elevated ICP

Results: 108 patients were studied. A normal range of ONSD found was 3.5mm – 5.4mm.

26 patients had CT results consistent with Elevated ICP. All cases of CT-determined Elevated ICP were correctly predicted by ONSD. The sensitivity and specificity of this study is 98.75 % and 92.86% respectively.

Conclusion: POCUS has the advantages of cost, time effective, non-invasive and reproducibility. It can be used as an additional diagnostic tool.

Keywords: Optic nerve sheath diameter, Point of care Ultrasound, Intracranial pressure

INTRODUCTION

Traumatic Brain Injury (TBI) is defined as impairment in brain function as a result of mechanical force. The dysfunction can be temporary or permanent, and may or may not result in underlying structural changes in the brain. [1] Any changes to the volume of the intracranial contents affect the Intracranial Pressure (ICP). Normal ICP is <15 mm Hg and is determined by the volume of the three intracranial compartments: the brain parenchyma (1300 ml), cerebrospinal fluid (CSF) (100 to 150 ml), and intravascular blood (100 to 150 ml). When one compartment expands, there is a compensatory reduction in the volume of another and/or the baseline ICP will increase (Monroe Kellie Hypothesis).[2] Rapid rises in ICP may lead to a phenomenon known as the Cushing Reflex (hypertension, bradycardia, and respiratory irregularity). This triad is classic for an acute rise in ICP. [3]

If ICP rises to the level of the systemic arterial pressure, cerebral brain perfusion ceases and brain death occurs. Uncontrollable ICP is defined as an ICP of 20 mm Hg or higher refractory to treatment. If ICP is not controlled, herniation syndromes can occur, resulting in brainstem compression and subsequent cardiorespiratory arrest. [4]

Of the various traditional means of detecting EICP in an acutely ill patient, none except physical examination can be performed rapidly and non-invasively at bedside. However, the physical examination has significant limitations if the patient is unconscious or intubated and paralyzed. Papilledema from EICP is delayed in its appearance from Intracranial Pressure Elevation, by up to several hours. Performing a lumbar puncture to measure pressure on a patient with potentially EICP may be dangerous. Thus, for most patients in the Emergency Department setting, Head Contrast Tomography scanning is often the best option available for the detection of EICP.

In situations like a disaster scene where multiple casualties are being triaged, and the ability to detect EICP in one out of several critical patients may help select the patient requiring the most rapid care also in times of scarce resources, when a decision has to be made regarding which trauma victim is most likely to survive.[5]

Ultrasound is a readily available imaging modality in most critical care areas, and examination of the optic nerve sheath by bedside ultrasound allows detection of changes in diameter which may indicate intracranial hypertension.[6] Elevated ICP is a common emergency following brain injury, with prompt diagnosis having a significant impact on morbidity

and mortality. [7] Ultrasound measures the optic nerve sheath diameter (ONSD) and facilitates evaluation of the response to treatment. In addition to its diagnostic goal, there is some limited evidence to suggest that ONSD can also be used for prognostication. [8][9] This measurement is also used to diagnose or assess the severity of other pathologies, including meningitis, stroke, hepatic encephalopathy, epilepsy, and acute mountain sickness. [10][11][12][13].

MATERIALS AND METHODS:

The Study was done in emergency Department in a tertiary care hospital. It was prospective observational study . Sample size for the study was 108. Approval of the institutional ethics committee was taken at the start of study.An informed consent from patient or nearest kin was taken prior to enrolling the subject in the study. Inclusion criteria was adult patients within 18 to 60 years, who visited the Emergency Department with history of head trauma presenting with headache, vomiting, convulsions, loss of consciousness, and altered sensorium.

Non-trauma patients with focal neurological changes and history suggestive of a possible spontaneous intracranial hemorrhage were also included. Exclusion criteria were patients with facial trauma, eye trauma, brain neoplasms and Patients not willing to give consent.

Patient demographic details were recorded.All the patients were clinically assessed with detailed clinical examination.A systematic primary & secondary survey was done in all the trauma patients following the Advanced Trauma Life support guidelines and appropriate management given to stabilize the patient. The non-trauma patients went through a detailed systemic and neurological examination.

After primary evaluation and treatment the patients underwent a bedside ultrasound to measure the ONSD. B mode of the portable m-turbo model of the sonosite ultrasound machine was used in the study.

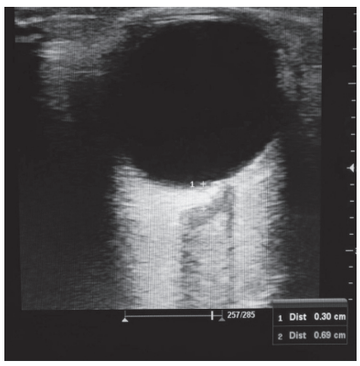
A layer of water-soluble ultrasound transmission gel applied on the transducer was used as a coupling agent. The focus, depth and gain were adjusted appropriately.

(a) (b)

Proper transducer placement to obtain
(a) transverse & (b) sagittal

ONSD was measured 3mm posterior to the globe using a 13-6 mhz transducer placed on closed eyelids of both the eyes. Moving the transducer slightly temporal and angulating the beam nasally gave an accurate view of the optic nerve.

Based on clinical judgment and ONSD diameter above the expected cutoff range, medical management of Elevated ICP was started. The measurement did not interfere with patient care or treatment. A plain CT scan of the brain done within 2 hours of admission to evaluate the findings.Definitive treatment for Elevated ICP was planned after confirming on CT scan of brain.



Results :

Headache correlated to ONSD & CT findings

Out of 57 patients having headache, 19 patients had both increased ONSD and abnormal CT findings (33.33%).

Out of 49 patients not having headache, 8 patients had both increased ONSD and abnormal CT findings (15.69%).

LOC correlated with ONSD and CT findings

Inference:

Out of 47 patients having LOC, 20 patients have increased ONSD and abnormal CT findings (42.55%).

Out of 59 patients not having LOC, 7 have increased ONSD and abnormal CT findings (11.48 %).

Altered sensorium correlated with ONSD and CT findings

Inference:

Out of 40 patients having altered sensorium, 24 patients have increased ONSD and abnormal CT findings (57.14%).

Out of 66 patients not having altered sensorium, 3 patients have increased ONSD and abnormal CT findings (4.55%).

Focal neurological sign correlated to ONSD and CT findings

Inference:

Out of 36 patients having focal neurological signs, 8 patients have increased ONSD and abnormal CT findings (25.81%).

Out of 75 patients not having focal neurological signs, 24 patients have increased ONSD and abnormal CT findings (31.17%).

GCS correlated to ONSD and CT findings

Inference:

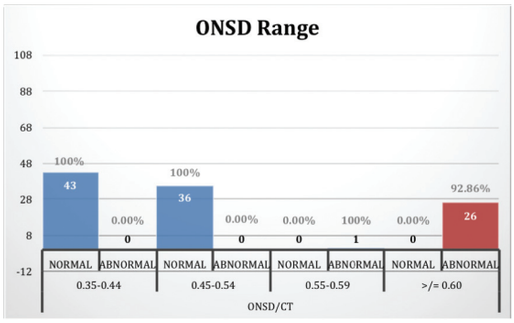
Out of 84 patients having Mild Brain injury, 7 had increased ONSD and abnormal CT findings (8.24%).

Out of 12 patients having Moderate Brain injury, 10 had increased ONSD and abnormal CT findings (76.92%).

Out of 10 patients having Severe Brain injury, all 10 had increased ONSD and abnormal CT findings (100%)

ONSD Range correlated to ONSD and CT findings:

ONSD Range	No.		ONSD/CT		ONSD/CT %	
	Out Of 108	%	Normal	Abnormal	Normal	Abnormal
Varley[17] (1976)		39.81%	43	0	100%	
Hadid A[18] (1983)		33.33%	36	0	100%	
Kang Jk[2] (1989)		0.93%	0	1	0.00%	
Karak[19] (1991)		25.93%	0	26	0.00%	



Inference:

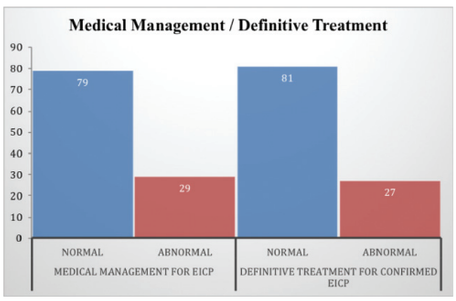
Out of 28 patients, 26 had ONSD >/=6 mm and abnormal CT findings (92.86%).

1 patient had ONSD between 5.5 to 5.9 mm and abnormal CT findings (100%).

There were no patients having ONSD in ranges between 3.5 to 4.4 mm and 4.5 to 5.4 mm with abnormal CT findings (0.00%).

Medical Management versus Definitive Treatment:

No.	Medical Management For EICP		Definitive Treatment For Confirmed EICP	
	Normal	Abnormal	Normal	Abnormal
108	79		81	27



Inference:

Sensitivity = 98.75%
Specificity = 92.86%

DISCUSSION:

In this study, 108 patients were enrolled; 26 had CT results consistent with Elevated ICP. All cases of CT determined Elevated ICP was accurately predicted by ONSD over 5.5 mm on Ultrasound. The sensitivity and specificity of this study is 98.75 % and 92.86% respectively compared to Blaivas et al[14] study where35 patients were enrolled; [14] had CT results consistent with EICP. All cases of CT-determined EICP were correctly predicted by ONSD over 5 mm on Ultrasound. The sensitivity and specificity of the study is 100% and 95%.

In Shirodkar et al [11] study, Radiological signs of EICP was confirmed in 35 patients with high ONSD value. The mean ONSD for the 14 patients with CT evidence of EICP was 6.27

mm. The sensitivity and specificity for ONSD, when compared with CT results, were 100% and 95%, respectively.

In Geeraerts et al [15] study the largest ONSD value was significantly higher in EICP patients. There was a significant relationship between the largest ONSD and ICP at admission. The largest ONSD was a suitable predictor of high ICP.ONSD was well prognosticated with treatment modalities. The sensitivity was 100%.

In Claire Shevlin et al [4] study of ONSD values greater than 5 mm, and certainly greater than 5.8 mm, have been shown to be highly specific and sensitive for the presence of EICP. EICP should be considered in the presence of an ONSD greater than 5mm, and if greater than 5.5 mm urgent consideration should be given to medical management.

Tayal et al[7], 59 patients were selected for the study, cutoff was kept to be 5 mm. Patients with EICP had ONSD > 5.5 mm. 8 patients with an ONSD of 5 mm or more had CT findings suggestive of EICP. Sensitivity 100%, specificity 63%.

Altered sensorium and focal neurological signs also showed significance with clinical correlation.92.31% patients having bradycardia had increased ONSD and abnormal CT findings.

51.02% patients having Irregular respiratory pattern had increased ONSD and abnormal CT findings.100% patients having a poor GCS between 3-8, had increased ONSD and abnormal CT findings.76.92% patients having a Moderate GCS between 9-12, had increased ONSD and abnormal CT findings.

CONCLUSION:

92.86% patients had ONSD >/=6 mm and abnormal CT Brain findings.

100%patients had ONSD between 5.5 to 5.9 mm and abnormal CT findings.

There were no patients having ONSD in ranges between 3.5 to 4.4 mm and 4.5 to 5.4 mm with abnormal CT findings (0.00%).

Elevated ICP should be considered in the presence of an ONSD greater than 5.5 mm, and if greater than 6 mm, urgent consideration should be given to medical management pending further diagnostic workup.

A poor GCS at the time of presentation to the ED is associated with Elevated ICP and has Increased ONSD with abnormal CT findings.

Bradycardia, Hypertension and Irregular breathing pattern are associated with Elevated ICP with Increased ONSD and abnormal CT findings. This defines the Cushings Reflex.

93.10% patients who had Increased ONSD and were started on Medical Management had EICP confirmed on CT Brain and Definitive treatment given.

ONSD value can thus be prognosticated with Treatment.

Thus Increased ONSD and Abnormal findings on CT scan Brain are statistically significant with Elevated ICP.

Bedside ultrasound has the advantages of Expense, time-effective, non-invasive and does not require moving a critical patient from the ED. In acute care settings, Ultrasound can be used for early detection and to prioritize patients in the setting of trauma. It is a rapid and reproducible modality and the method could be applied as an additional diagnostic tool in Emergency and Intensive care settings.

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