# OPTIC NERVE SHEATH DIAMETER (ONSD) MEASUREMENT WITH OPTIC NERVE ULTRASOUND (ONUS) IN THE EVALUATION OF ELEVATED INTRACRANIAL PRESSURE: A COMPARATIVE STUDY WITH CT SCAN IN HEAD TRAUMA PATIENTS.

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**ABSTRACT**

**BACKGROUND & OBJECTIVE:** Elevated intracranial pressure (ICP) is a challenging and potentially fatal complication of acute head trauma in patients who present to the emergency department. Although computed tomography scanners are the most common diagnostic tests for these patients in hospital, there are situations in which a rapid bedside means of evaluating intracranial pressure would be advantageous. These situations include unstable multiorgan-system trauma patients, remote settings with prolonged transport time, or mass casualty occurrences. The optic nerve sheath diameter has been suggested as a possible indicator of elevated intracranial pressure.[1-9] Optic Nerve Ultrasonography (ONUS) may help us to identify raised intracranial pressure. Our objective is to determine whether a bedside ultrasonographic measurement of optic nerve sheath diameter can accurately predict elevated intracranial pressure in adult head injury patients in the emergency department (ED),taking CT scan as gold standard test. **Methods:** We conducted a prospective, blinded observational study on adult patients in ED patients with suspected intracranial injury. Using a 7.5-MHz ultrasonographic probe on the closed eyelids, a single optic nerve sheath diameter was measured 3 mm behind the globe in each eye. Cranial CT findings of midline shift, edema, or effacement suggestive of elevated intracranial pressure were used to evaluate the accuracy of optic nerve sheath diameter.

**RESULTS:** The sensitivity of mean binocular ONSD $\geq$5mm measured by ONUS for raised ICP was found to be 100% with specificity of 89%.The Positive predictive value was 68% & the negative predictive value was 100%.

**CONCLUSION:** Bedside ONSD measurement, performed by ED physicians can provide accurate, non-invasive method to identify raised ICP in patients with acute brain injury.

**KEY-WORDS**: ONSD, ONUS, Elevated ICP, Head Trauma, Emergency Department.

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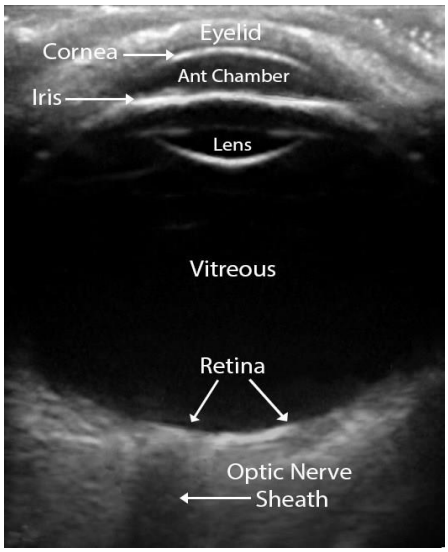
## INTRODUCTION

Raised intracranial pressure is a complication of traumatic brain injury. Early identification of elevated intracranial pressure (ICP) is helpful to ensure timely and appropriate treatment. Ultrasound is a readily available imaging modality and examination of optic nerve sheath by bedside ultrasound allows detection of changes in diameter which may indicate intracranial hypertension.[1,] The optic nerve sheath anatomy is identical to that of the brain coverings (Dura, Arachnoid & Pia), and therefore, it has potential to provide a window on changes within the intracranial cerebrospinal fluid space.[2,3, 4, 5]

- **THE ANATOMY OF OPTIC NERVE SHEATH :** The intra orbital section of optic nerve extends from the globe, where it inserts medially, to the optic canal located in the lesser wing of sphenoid bone. It is encased by a meningeal sheath consisting of dura mater, arachnoid mater and piamater. Cerebro-spinal fluid is contained in the trabeculated subarachnoid space and is continuously and slowly filtered. As a result, the optic nerve sheath is in direct communication with the intracranial subarachnoid space. It is this relationship that forms the physiological basis for using the optic nerve sheath as a surrogate for intracranial pressure measurement. The optic nerve sheath is bound more loosely to the optic nerve closer to the globe. This loose binding creates a much larger and potentially more distensible, subarachnoid space in this region, which can appear bulbous on ultrasound. While papilloedema may take time to develop, dilation of the optic nerve sheath occurs much earlier and may be a near instantaneous manifestation of elevated ICP. [6]




**Ultrasound Images of Globe and Optic Nerve and its Sheath**

The aim of this study is to determine whether the bedside sonographic measurement of ONSD can accurately predict the CT scan results of elevated intracranial pressure (ICP) in head injury patients at the emergency department.

## MATERIAL & METHODS

We conducted a cross sectional, observational study over a period of two months, enrolling 60 patients with head injury. Patients or their relatives were asked to give informed & written consent before their inclusion in the study.

INCLUSION CRITERIA... Patients presented to the ED with head injury.

EXCLUSION CRITERIA... Age younger than 18 years.

Patients with penetrating ocular trauma.

History of neurological or hypertensive disease.

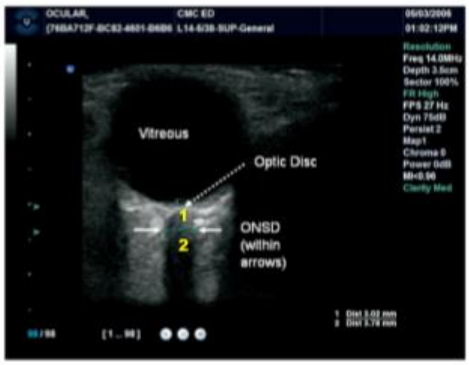
ONUS WAS PERFORMED BY USING THE FOLLOWING PROTOCOL...

- Patient Position - The patient was placed supine with 30° head up position.
- Probe Position - Gel was applied on the upper eyelid with closed eyes and a linear (7.5 MHZ) probe was lightly placed horizontal over the closed upper eyelid of the patient on both the sides.

The structures of the eye were visualized align the optic nerve directly opposite the probe. Sonographic measurement of ONSD was Perpendicular to the vertical axis of the scanning plane, 3.00 mm behind the globe in each eye[2,7,8]. A single ONSD was measured and then the ONSD from each eye were averaged to create a Mean Binocular ONSD measurement. Based on prior literature, an ONSD above 5 mm on ultrasound considering abnormal, binocular ONSD $\geq$ 5.00 mm was considered abnormal[4,5,6]. CT scan was performed in all patients and the results evaluated by radiologists blinded to the ONSD results. The CT scan result was considered to be positive for elevated ICP if the results like significant edema, midline shift of 3 mm or more, mass effect, effacement of sulci, collapse of ventricles, or compression of cisterns.[6]

**Figure illustrating patient position (30 degree head up)**

**Figure showing horizontal probe position**




Ultrasonographic image of normal optic nerve sheath diameter measurement. Distance 1 is the distance (3 mm) behind the optic disc where the optic nerve sheath diameter (ONSD) is measured in its width. Distance 2 (between the white arrows) is the ONSD (3.78 mm).


Ultrasonographic image of abnormal optic nerve sheath diameter measurement. Distance 1 is the distance (3 mm) behind the optic disc where the optic nerve sheath diameter (ONSD) is measured in its width. Distance 2 (between the black arrows) is the ONSD (6 mm).

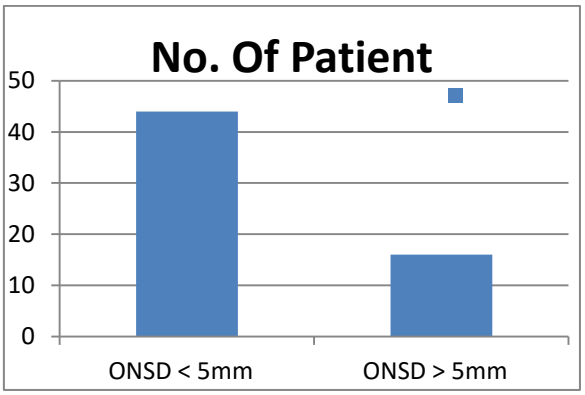
## RESULTS

60 patients were enrolled in the study, with an average age of 38±17 Years. The majority of the patients in our study were having a

history of motor vehicle crash & remaining were having a history of blunt assault & fall.

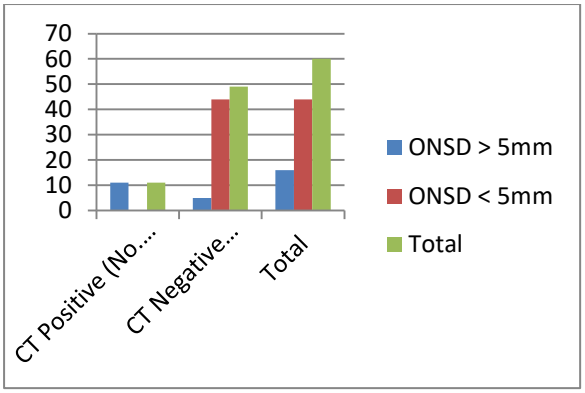
**Mean Binocular ONSD of All study Patients..**

| | No. Of Patient | Mean Binocular ONSD (mm) ± SD |
|---|---|---|
| ONSD < 5mm | 44 | 4.28 ± 0.6 |
| ONSD ≥ 5mm | 16 | 5.91 ± 0.7 |




**Comparison Between Mean Binocular ONSD & CT Scan results**

| | CT Positive (No. Of Patients) | CT Negative (No. Of Patients) | Total |
|---|---|---|---|
| ONSD ≥ 5mm | 11 | 5 | 16 |
| ONSD < 5mm | 0 | 44 | 44 |
| Total | 11 | 49 | 60 |




The Sensitivity of mean binocular ONSD in patients with elevated ICP detected by CT scan results was 100% & the specificity was 89%. The positive predictive value(PPV) was 68% & the negative predictive value(NPV) was 100%.

## DISCUSSION

Our study finds similar values of Sensitivity, Specificity, PPV and NPV as the study performed by Blavias M, Theodoro D et al. [6] in 2003, which showed 100% sensitivity, 95% specificity, 93% PPV and 100% NPV. The study performd by Tayal VS, Neulander M et al[9]. also yielded Sensitivity of 100% and specificity of 63%.

The result of our study suggested that optic nerve ultrasonography (ONUS) can serve as an adequate screening tool for elevated ICP.[10,11] Same result was obtained in other studies.

- Sensitivity of our result is 100 %, which suggests that ONUS can detect nearly all patients with raised ICP, but Specificity is 89% which tells patients can be misclassified as having elevated ICP.
- Negative predictive value of our result is 100%, which suggests ONSD<5 mm definitely rules out elevated ICP.

Similar to the results of the study performed by Goel R, Goyal N et al,[1] Soldatos T, Karakistos D et al,[3] and Geeraerts T, Merceron S et al,[8] ONSD can be a good guide for triage, early decision making for management of patients with head injury.

❖ **ADVANTAGES OF STUDY...**

- Help to diagnose the patient with elevated ICP following head injury.
- In the setting of disaster, a rapid bedside ONSD measurement would be helpful to triage patients who urgently need to undergo CT scan.
- ONUS can be helpful when CT is not available.
- ONUS is radiation-free, non-invasive, portable, bedside and easy to apply in patients with unstable vital findings[10,11].

❖ **LIMITATIONS**

- The Sample Size in our study was small & included convenience samples. So we need to perform this study on larger scale before extrapolating in the ED Setting.
- ONUS is highly operator dependent.

## CONCLUSION

Our study demonstrates a close correlation between optic nerve sheath dilation on ocular ultrasound and evidence of elevated intracranial pressure on head computed tomography in patients with Head injury. The ONSD of $< 5$ mm measured at distance of 3 mm behind the globe definitely rules out raised ICP. ONSD of $\geq 5$ is suggestive of raised ICP and need to be further confirmed with other tests. Thus, ONSD measurement with ONUS can be a very useful screening test to detect raised ICP in Head injury patients and to start measures to reduce ICP.

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