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## Ultrasound assessment of optic nerve sheath diameter for evaluation of elevated intracranial pressure in patient with head trauma: A comparative study with CT head

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### Abstract

**Purpose:** Increased intracranial pressure (ICP) is complication of traumatic brain injury. Early detection of raised ICP is helpful in timely treatment. Bed side ultrasound of optic nerve sheath is easier for detection of raised intracranial pressure by measuring its diameter. Our aim was to determine whether bedside ultrasound measurement of optic nerve sheath diameter (ONSD) can accurately predict raised intracranial pressure in head injury patients and to calculation of validity of test.

**Methods and Materials:** Total 150 patients with head injury was first examined by ultrasound. The ONSD was measured 3 mm behind the globe perpendicular to long axis of globe in both eyes than mean binocular ONSD was calculated. Diameter more than 5 mm was considered abnormal. CT scan was performed in all patients and result was considered positive for elevated ICP if mid line shift, effacement of sulci, ventricles and cisterns are seen.

**Results:** Out of total 150 patients 61 was female and 89 was male, age was ranging from 23-61 years. 30 patients showed mean binocular ONSD >5mm by ultrasound out of them 26 patients showed positive signs of raised intracranial pressure on CT. Sensitivity and negative predictive value of ultrasound to detect raised ICP was 100%, Specificity was 96.7 % and negative predictive value was 86.6 %.

**Conclusions:** Ultrasound can be used as bed side screening tool to detect raised ICP in ICU patients and head trauma patients especially in hospital with high patient flow in emergency department.

**Keywords:** Optic nerve sheath diameter, intracranial pressure, ultrasound

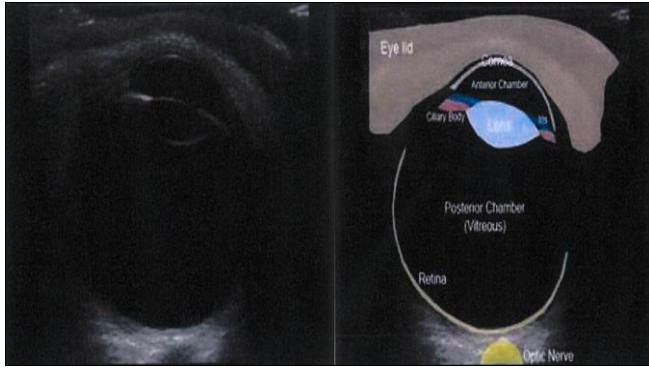
### Introduction

Increased intracranial pressure (ICP) is complication of traumatic brain injury. Early detection of elevated intracranial pressure (ICP) is helpful to ensure timely and appropriate treatment. Ultrasound is a readily available imaging modality can be used bedside. It allows detection of changes in diameter of optic nerve sheath which can give idea about increased intracranial pressure [2]. Here we have taken optic sheath anatomy as a basis for its potential to provide a window to look for changes within the intracranial cerebrospinal fluid space through the technique of ONSD measurement and the comparison of ONSD with gold standard noninvasive method of intracranial pressure assessment that is CT scan.

### Anatomy of optic nerve sheath

The intra-orbital portion of optic nerve extends from the globe to optic canal which is located in lesser wing of sphenoid bone. It is encased by meningeal sheath consisting dura matter, arachnoid matter and pia matter. Cerebrospinal fluid is present in subarachnoid space. Optic nerve sheath is in direct communication with intracranial subarachnoid space [1]. This direct communication forms physiological basis for using optic nerve sheath as a surrogate for intracranial pressure measurement. The optic nerve sheath is bounded more loosely to optic nerve close to the globe [1, 3]. This loose binding creates a much larger and potentially more distensible. While papilloedema may take time to develop, dilatation of the optic nerve sheath occurs much earlier and may be a near instantaneous manifestation of elevated intracranial pressure [4, 5].

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**Fig 1:** showing anatomy of eyeball and optic nerve sheath.

**Aim**

Our aim was to determine whether bedside ultrasound measurement of optic nerve sheath diameter (ONSD) can accurately predict raised intracranial pressure in head injury patients and calculation of validity of test.

**Material and Method**

We conducted a cross sectional, observational study on 150 patients with head injury. They were first examined by ultrasound. The ONSD was measured 3 mm behind the globe perpendicular to long axis of globe in both eyes than mean binocular ONSD was calculated. Diameter more than 5 mm was considered abnormal.

Patients or their relatives were provided informed & written consent before their inclusion in the study.

CT scan was performed in all patients and result was considered positive for elevated ICP if mid line shift, effacement of sulci, ventricles and cisterns are present.

**Inclusion Criteria**

Patient presented to emergency department with head injury were included in this study

**Exclusion Criteria**

- Age younger than 18 years.
- Patients with penetrating ocular trauma.
- History of neurological or hypertensive disease.

**Protocol to perform optic nerve ultrasound**

**Patient Position:** The patients were examined in supine with 30° head up position.

**Probe Position:** Gel was applied on the upper eyelid with closed eyes and a linear (7.5 MHZ) array. Ultrasound 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.

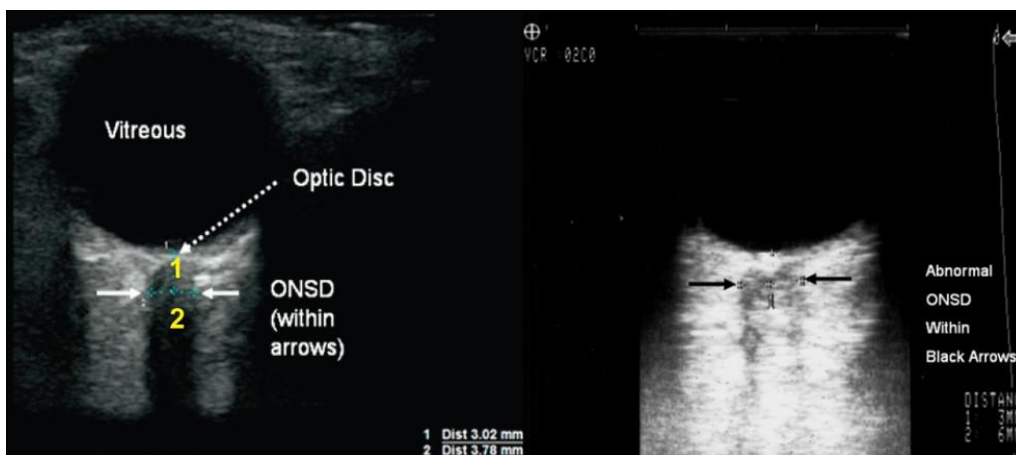
Sonographic measurement of ONSD was perpendicular to the vertical axis of the scanning plane, 3.00 mm behind the globe in each eye. A single ONSD was measured & then the ONSD from each eye were averaged to create a Mean Binocular ONSD measurement.

A binocular ONSD greater than 5.00 mm was considered abnormal.

CT scan was performed in all patients & result was considered to be positive for elevated ICP if the results like significant midline shift, effacement of sulci, effacement of ventricles, or compression of cisterns.



**Fig 2:** Showing placement of high frequency linear probe over closed eye to look for optic nerve sheath.



**Fig 3:** Showing normal anatomy of optic nerve sheath and globe (Left image). Optic nerve sheath diameter (ONSD) taken 5 cm behind the globe. Another image (Right) is showing abnormal ONSD.

**Observation and Analysis**

Out of total 150 patients 61 was female and 89 was male, age was ranging from 23-61 years. 30 patients showed mean binocular ONSD >5mm by ultrasound out of them 26

patients showed positive signs of raised intracranial pressure on CT. Sensitivity and negative predictive value of ultrasound to detect raised ICP was 100%, Specificity was 96.7% and negative predictive value was 86.6%.

ONSD	No of patients	Mean binocular ONSD (mm) ± SD
ONSD <5mm	120	4.52 ± 0.37
ONSD >5mm	30	6.1 ± 0.53

Patient	Ultrasound		CT		
	Mean Binocular ONSD	Shift	Effacement of sulci	Effacement of ventricles	Effacement of cisterns
1	5.74	+	+	+	-
2	6.38	+	+	+	+
3	5.79	-	+	+	-
4	5.45	-	-	-	-
5	6.08	-	+	+	-
6	5.49	-	-	-	-
7	6.82	-	+	+	+
8	5.48	-	-	-	-
9	5.7	-	+	+	-
10	5.22	-	-	-	-
11	5.89	+	+	+	-
12	7.36	+	+	+	+
13	5.48	-	+	+	-
14	5.57	+	+	+	-
15	5.69	+	+	+	-
16	6.46	+	+	+	+
17	6.12	+	+	+	-
18	5.56	-	+	-	-
19	5.8	-	+	-	-
20	5.84	-	+	-	-
21	6.22	+	+	+	+
22	6.34	+	+	+	+
23	6.58	+	+	+	-
24	6.2	+	+	+	+
25	6.46	+	+	+	-
26	6.52	+	+	+	-
27	6.18	+	+	+	-
28	5.94	-	+	-	-
29	6.52	+	+	+	+
30	5.98	+	+	+	-

	CT Positive (No of patients)	CT Negative (No of patients)	Total
ONSD >5mm	26	4	30
ONSD <5mm	0	120	120
Total	26	124	150

Sensitivity	100%
Specificity	96.70%
Positive predictive value	86.60%
Negative predictive value	100.00%

**Discussion**

The evaluation of the head injury patient with elevated intracranial pressure in the setting of multiple traumatic injuries is challenge. Bed side ultrasound of optic nerve can be done to look for intracranial pressure.

Sensitivity of ultrasound is 100 %, so optic nerve ultrasonography (ONUS) can serve as a adequate screening tool for detection of elevated ICP.

Negative predictive value of ultrasound is 100%, which suggests ONSD<5 mm, rules out elevated ICP.

**Advantage of study**

It can help to detect elevated ICP following head injury. In the setting of disaster, a rapid bedside ONSD measurements would be helpful to triage patients who urgently need to undergo CT scan. ONUS is radiation-free, non-invasive, portable, bedside and easy to apply in patients admitted in ICU.

### **Limitations of study**

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. Which may have visualized error in Interpretation

### **Conclusion**

Ultrasound can be used as bed side screening tool to detect raised ICP in head trauma patients especially in hospital with high patient flow in emergency department.

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