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Original Research Article

Ultrasonographic Measurement of the Optic Nerve Sheath Diameter to Detect Intracranial Hypertension: A Prospective Observational Study

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Conflict of interest: Nil

Abstract

Background: Raised intracranial pressure (ICP) is associated with significant morbidity and mortality in critically ill neurological patients. Direct ICP monitoring is invasive and may not be readily available in all clinical settings. Ultrasonographic measurement of optic nerve sheath diameter (ONSD) has emerged as a rapid, non-invasive bedside technique for identifying patients at risk of intracranial hypertension. This study evaluated the diagnostic performance of ultrasonographic ONSD for detecting intracranial hypertension in adult critically ill patients.

Methods: A prospective observational study was conducted among 56 adult patients admitted with neurological conditions and suspected intracranial hypertension. Demographic characteristics, Glasgow Coma Scale (GCS) scores, clinical diagnoses, radiological findings, and bilateral ONSD measurements were recorded. The mean bilateral ONSD was used for the primary analysis. An ONSD threshold of ≥5.0 mm was evaluated for detection of intracranial hypertension. Diagnostic performance was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy, likelihood ratios, and receiver operating characteristic (ROC) curve analysis. Multivariable logistic regression was performed to assess the independent association between ONSD ≥5.0 mm and intracranial hypertension after adjustment for age, sex, and GCS.

Results: Among the 56 patients, 30 (53.6%) were classified as having intracranial hypertension and 26 (46.4%) as not having intracranial hypertension. The mean age was 51.9 ± 14.3 years, and 35 (62.5%) participants were male. Patients with intracranial hypertension had significantly lower mean GCS scores than those without intracranial hypertension (8.9 ± 2.3 vs. 12.6 ± 2.1; $p < 0.001$). Mean bilateral ONSD was significantly greater in the intracranial hypertension group (5.61 ± 0.34 mm vs. 4.62 ± 0.30 mm; $p < 0.001$). At an ONSD threshold of ≥5.0 mm, sensitivity was 90.0%, specificity 88.5%, PPV 90.0%, NPV 88.5%, and diagnostic accuracy 89.3%. The area under the ROC curve was 0.978 (95% CI: 0.948–1.000; $p < 0.001$). On multivariable analysis, ONSD ≥5.0 mm remained independently associated with intracranial hypertension (adjusted OR 14.86, 95% CI: 3.72–59.42; $p < 0.001$).

Conclusion: Ultrasonographic ONSD demonstrated high diagnostic performance for identifying intracranial hypertension in this study population. An ONSD threshold of approximately 5.0 mm showed favorable sensitivity and specificity and may serve as a useful non-invasive adjunct for bedside assessment of suspected intracranial hypertension. ONSD measurement should, however, be interpreted alongside clinical and radiological findings and should not be considered a replacement for invasive ICP monitoring when direct measurement is clinically indicated.

Keywords: Optic Nerve Sheath Diameter; Intracranial Hypertension; Intracranial Pressure; Ultrasonography; Neurocritical Care; Glasgow Coma Scale; Diagnostic Accuracy.

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Introduction

Intracranial hypertension is a potentially life-threatening condition encountered in patients with traumatic brain injury, intracranial haemorrhage, cerebral edema, hydrocephalus, intracranial tumors and other neurological disorders. Sustained elevation of ICP can reduce cerebral perfusion and contribute to secondary neurological injury, making early recognition clinically important.

Invasive ICP monitoring provides direct pressure measurements and remains an important reference technique in appropriately selected critically ill patients. However, invasive monitoring requires specialized equipment and expertise and is associated with procedure-related risks. Consequently, there has been considerable interest in non-invasive techniques that can provide rapid information about possible intracranial hypertension. [1,2]

The optic nerve sheath is anatomically continuous with the intracranial dura and surrounds a cerebrospinal-fluid-containing subarachnoid compartment. Changes in intracranial pressure can therefore be transmitted along this compartment and produce expansion of the optic nerve sheath. Ultrasonographic measurement of ONSD consequently provides an indirect method for assessing changes associated with increased ICP. [2,5]

Bedside ocular ultrasonography can visualize the optic nerve through the closed eyelid and permits measurement of the sheath at a standardized distance posterior to the globe. Several clinical studies have used measurement approximately 3 mm behind the globe, with a threshold around 5 mm frequently investigated for detecting raised ICP. [6,7]

Evidence from systematic reviews supports the diagnostic potential of ONSD ultrasonography. Kim et al. reported pooled sensitivity of 99% and specificity of 73% for an ONSD threshold >5.0 mm in adults when CT-based evidence of increased ICP was used as the reference. [1]

A separate meta-analysis comparing ONSD with invasive ICP assessment found a pooled diagnostic performance consistent with clinically useful discrimination, although heterogeneity between studies was present. [3]

A systematic review and meta-analysis by Aletreby et al. reported pooled sensitivity of approximately 90% and specificity of 85%, with a summary AUC of 0.93. The authors concluded that ONSD could be useful as an adjunct but should not be regarded as a replacement for invasive ICP monitoring when invasive monitoring is feasible and clinically indicated. [4] More recent evidence has continued to support the usefulness of ONSD while emphasizing variability in measurement thresholds and patient populations. A 2025 systematic review reported ONSD cut-offs ranging from 4.1 to 7.2 mm, with many studies using thresholds between 5.0 and 5.9 mm. [8] Recent evidence from an Indian traumatic brain injury cohort also demonstrated significantly higher ONSD in patients with increased ICP and an AUC of 0.942 at a 5.0-mm threshold. [9]

The present study was therefore designed to evaluate the diagnostic utility of ultrasonographic ONSD measurement among adult ICU patients at MGM Medical College and LSK Hospital, Kishanganj, Bihar.

Aim

To evaluate the diagnostic utility of ultrasonographic measurement of optic nerve sheath diameter for detecting intracranial hypertension in adult ICU patients.

Objectives

1. To measure bilateral ONSD using bedside ocular ultrasonography.
2. To compare ONSD measurements between patients with and without evidence of intracranial hypertension.
3. To determine an appropriate ONSD threshold for identifying intracranial hypertension.
4. To determine sensitivity, specificity, PPV, NPV and diagnostic accuracy.
5. To evaluate the discriminatory performance of ONSD using ROC curve analysis.

Materials and Methods

Study Design and Setting: A prospective observational diagnostic-accuracy study was conducted in the Intensive Care Unit (ICU) of MGM Medical College and LSK Hospital, Kishanganj, Bihar, India.

The study evaluated the diagnostic utility of bedside ultrasonographic measurement of the optic nerve sheath diameter (ONSD) for identifying patients with a predefined clinical-radiological classification suggestive of intracranial hypertension.

The study was conducted during the predefined study period specified in the institutional study protocol. Consecutive eligible patients were screened for enrollment. Demographic, clinical, radiological, and ultrasonographic information was recorded prospectively using a standardized data-collection proforma.

Study Population: The study population comprised adult ICU patients admitted with acute neurological conditions and clinical suspicion of intracranial hypertension. The underlying neurological diagnoses included traumatic brain injury, acute ischemic stroke, intracerebral or subarachnoid hemorrhage, intracranial tumors, central nervous system infections, hydrocephalus, and other acute neurological conditions. A total of 56 patients fulfilled the eligibility criteria and had complete clinical, radiological, and ONSD assessment data and were included in the final analysis.

Inclusion Criteria

Patients were eligible for inclusion if they met all of the following criteria:

1. Age ≥18 years.
2. Admission to the ICU with an acute neurological condition.
3. Clinical suspicion of intracranial hypertension and/or neuroimaging performed for evaluation of an acute intracranial pathology.
4. Clinical suitability for bedside transorbital ultrasonographic examination.
5. Availability of adequate clinical and radiological information required for classification according to the predefined reference standard.
6. Availability of bilateral ONSD measurements suitable for analysis.

Exclusion Criteria

Patients were excluded if they had any of the following:

1. Significant ocular or orbital trauma that could interfere with reliable ONSD measurement.
2. Known major orbital or optic-nerve pathology likely to alter ONSD independently of intracranial pressure.
3. Inability to obtain an adequate ultrasonographic image of either optic nerve sheath.
4. Incomplete clinical, radiological, or ultrasonographic data required for the primary analysis.
5. Any other condition documented in the study protocol as likely to compromise the reliability or safety of transorbital ultrasonography.

Ethical Considerations: The study protocol was reviewed and approved by the Institutional Ethics Committee of MGM Medical College and LSK Hospital, Kishanganj, Bihar, India, before commencement of patient recruitment.

Written informed consent was obtained from participants whenever they were capable of providing consent. For patients who were unable to provide informed consent because of impaired consciousness or neurological impairment, consent was obtained from the legally authorized representative in accordance with institutional requirements.

All study data were coded and handled confidentially. Patient identifiers were removed from the analytical dataset, and access to the study records was restricted to the research team.

Clinical Assessment: At enrollment, demographic and clinical variables were recorded, including age, sex, primary neurological diagnosis, Glasgow Coma Scale (GCS) score, relevant clinical findings, and available neuroimaging findings.

The GCS was assessed as close as clinically feasible to the time of ONSD examination. The presence of factors that could influence GCS assessment, including sedation, intubation, paralysis, or other clinically relevant circumstances, was documented whenever applicable.

Radiological Assessment: Neuroimaging findings were obtained from clinically indicated computed tomography (CT) and/or magnetic resonance imaging (MRI) examinations performed as part of routine clinical care. No additional neuroimaging examination was performed solely for the purpose of the study.

The following radiological findings were recorded:

- cerebral edema;
- midline shift;
- basal cistern effacement;
- ventricular compression;
- hydrocephalus; and
- Herniation-related changes.

More than one radiological abnormality could be present in the same patient. The radiological findings were recorded before the diagnostic performance of ONSD was analyzed.

Reference Standard and Classification of Intracranial Hypertension: For the primary diagnostic analysis, participants were classified according to a predefined clinical-radiological reference standard established in the study protocol.

Patients were classified as having evidence suggestive of intracranial hypertension when the predefined clinical assessment, together with one or more supportive neuroimaging abnormalities, indicated raised intracranial pressure. Supportive radiological abnormalities included cerebral edema, midline shift, basal cistern effacement, ventricular compression, hydrocephalus, or herniation-related changes.

Patients who did not demonstrate the predefined clinical-radiological features were classified as having no evidence of intracranial hypertension**.**

Importantly, the reference classification was established independently of the ONSD result. ONSD values were not used as a component of the reference-standard definition, thereby avoiding direct incorporation of the index test into the reference classification.

Invasive intracranial pressure monitoring was not routinely performed in the study population and was therefore not used as a mandatory reference standard. Accordingly, the term intracranial hypertension in the present study refers specifically to the predefined clinical-radiological classification and should not be interpreted as confirmation of an invasive ICP threshold.

This distinction was maintained when interpreting the diagnostic performance of ONSD.

Ultrasonographic Measurement of Optic Nerve Sheath Diameter: Bedside transorbital B-mode ultrasonography was performed with the patient in the supine position and the head maintained in a neutral position. Examination was performed through the closed eyelid using an adequate amount of ultrasound gel and minimal transducer pressure.

The optic nerve and surrounding sheath were visualized in the axial plane. ONSD was measured approximately 3 mm posterior to the globe, perpendicular to the long axis of the optic nerve. This measurement location has been widely used in ONSD studies and has demonstrated good reproducibility when a standardized technique is applied.

The right and left ONSD measurements were recorded separately in millimeters. The mean of the right and left ONSD measurements was calculated for each participant and was prespecified as the principal ONSD variable for the primary diagnostic analysis.

Where technically feasible, the ultrasound operator was unaware of the final clinical-radiological reference classification at the time of measurement. ONSD measurements were recorded before the final statistical classification was analyzed.

The ultrasound acquisition and measurement procedure followed a standardized approach because probe selection, patient position, image acquisition, measurement location, and measurement technique can influence ONSD values. International consensus recommendations have emphasized standardization of ONSD point-of-care ultrasonography for clinical research and practice.

Primary Diagnostic Threshold

For the prespecified primary diagnostic analysis, a mean bilateral ONSD of ≥5.0 mm was considered a positive test for evidence suggestive of intracranial hypertension.

The 5.0-mm threshold was selected because values around this range have been frequently investigated in adult ONSD studies, including studies using CT-based clinical-radiological evidence of raised intracranial pressure as the reference.

In addition to the prespecified threshold analysis, mean bilateral ONSD was analyzed as a continuous variable using receiver operating characteristic (ROC) curve analysis to evaluate overall discriminatory performance across different thresholds.

Study Outcomes: The primary outcome was the diagnostic performance of mean bilateral ONSD for identifying patients classified as having evidence suggestive of intracranial hypertension according to the predefined clinical-radiological reference standard.

The following diagnostic parameters were evaluated:

1. Sensitivity;

2. Specificity;

- positive predictive value (PPV);
- negative predictive value (NPV);
- diagnostic accuracy;
- positive likelihood ratio (LR+);
- negative likelihood ratio (LR−); and
- Area under the receiver operating characteristic curve (AUC).

Secondary outcomes included:

1. comparison of right, left, and mean bilateral ONSD between the two reference-standard groups;
2. association between ONSD and GCS;
3. association between ONSD and selected radiological findings, including cerebral edema and midline shift; and
4. Independent association between ONSD ≥5.0 mm and the clinical-radiological classification of intracranial hypertension after adjustment for selected covariates.

Sample Size: A total of 56 consecutive eligible patients with complete clinical, radiological, and ultrasonographic observations were included in the final analysis.

Statistical Analysis: Statistical analysis was performed using IBM SPSS Statistics version 27.0.

Continuous variables were summarized using mean ± standard deviation (SD) when approximately

normally distributed. Where appropriate, continuous variables were summarized using median and interquartile range (IQR). Categorical variables were expressed as frequencies and percentages. The distribution of continuous variables was assessed before selection of the appropriate statistical test. Differences in continuous variables between patients classified as having and not having evidence of intracranial hypertension were assessed using an independent-samples t-test for approximately normally distributed variables or an appropriate non-parametric test when distributional assumptions were not satisfied.

For the primary diagnostic analysis, a 2 × 2 contingency table was constructed using the prespecified ONSD threshold of ≥5.0 mm and the clinical-radiological reference classification.

Sensitivity, specificity, PPV, NPV, diagnostic accuracy, LR+, and LR− were calculated from the contingency table. Ninety-five percent confidence intervals were calculated where appropriate. Receiver operating characteristic (ROC) curve analysis was performed using mean bilateral ONSD as a continuous test variable. The area under the ROC curve (AUC) with its 95% confidence interval was reported. The ROC analysis was used to characterize the discriminatory ability of ONSD and to examine thresholds across the observed range of measurements. Correlation analysis was performed to assess the relationship between mean bilateral ONSD and GCS and selected radiological variables. Pearson's correlation coefficient was used for approximately normally distributed continuous variables, while Spearman's rank correlation coefficient was used when distributional or measurement-scale assumptions were not satisfied. A multivariable binary logistic regression model was constructed with the clinical-radiological classification of intracranial hypertension as the dependent variable. Age, sex, GCS score, and ONSD ≥5.0 mm were included as covariates according to the prespecified analytical plan. Results were reported as adjusted odds ratios (ORs) with corresponding 95% confidence intervals and p values.

Because of the relatively small sample size and limited number of outcome events, the regression findings were interpreted as exploratory and were not considered definitive evidence of causal or predictive relationships.

All statistical tests were two-sided, and a p value <0.05 was considered statistically significant.

Results

Demographic Characteristics: A total of 56 patients were included in the study. The mean age of the study population was 51.9 ± 14.3 years, with an age range of 19–79 years. There was a male predominance, with 35 patients (62.5%) being male and 21 (37.5%) being female, giving a male-to-female ratio of 1.67:1.

The largest proportion of participants belonged to the 51–60-year age group (13, 23.2%), followed by the 41–50-year and 61–70-year groups, each comprising 11 patients (19.6%). Participants aged 31–40 years accounted for 8 (14.3%), those aged 18–30 years for 7 (12.5%), and those aged >70 years for 6 (10.7%).

Table 1: Demographic characteristics of the study population

Variable	Value
Total participants	56 (100%)
Age, mean ± SD (years)	51.9 ± 14.3
Age range (years)	19–79
Male	35 (62.5%)
Female	21 (37.5%)
Male:female ratio	1.67:1

Table 2: Age distribution of the study population

Age group (years)	n	%
18–30	7	12.5
31–40	8	14.3
41–50	11	19.6
51–60	13	23.2
61–70	11	19.6
>70	6	10.7
Total	**56**	**100.0**

Distribution of Primary Clinical Diagnoses: The distribution of the primary clinical diagnoses is presented in Table 3 and Figure 1. Traumatic brain injury was the most common diagnosis, accounting for 18 patients (32.1%). Acute ischemic stroke and intracerebral/subarachnoid hemorrhage were each

observed in 10 patients (17.9%). Intracranial tumors accounted for 7 patients (12.5%), followed by CNS infections in 5 patients (8.9%) and hydrocephalus in 4 patients (7.1%). Two patients (3.6%) had other neurological conditions.

Table 3: Distribution of primary clinical diagnoses

Diagnosis	n	%
Traumatic brain injury	18	32.1
Acute ischemic stroke	10	17.9
Intracerebral/subarachnoid hemorrhage	10	17.9
Intracranial tumor	7	12.5
CNS infection	5	8.9
Hydrocephalus	4	7.1
Other neurological conditions	2	3.6
Total	**56**	**100.0**

Intracranial Hypertension Status: Of the 56 patients included in the study, 30 (53.6%) were classified as having evidence of intracranial hypertension, whereas 26 (46.4%) were classified as not having intracranial hypertension.

Table 4: Distribution according to intracranial hypertension status

Classification	n	%
Intracranial hypertension present	30	53.6
Intracranial hypertension absent	26	46.4
Total	**56**	**100.0**

No separate figure is required for this finding because the distribution is adequately represented in Table 4.

Glasgow Coma Scale: A significant difference in neurological status was observed between the two groups. Patients with intracranial hypertension had a substantially lower mean GCS than those without intracranial hypertension. The mean GCS was 8.9 ± 2.3 in patients with intracranial hypertension compared with 12.6 ± 2.1 in those without intracranial hypertension.

The difference of approximately 3.7 points was statistically significant ($p < 0.001$). The comparison is presented in Table 5 and Figure 2.

Table 5: Glasgow Coma Scale according to intracranial hypertension status

Variable	Intracranial hypertension (n=30)	No intracranial hypertension (n=26)	*p* value
GCS, mean ± SD	8.9 ± 2.3	12.6 ± 2.1	<0.001

Radiological Findings: Radiological abnormalities associated with intracranial hypertension or mass effect were frequently observed. Cerebral edema was the most common finding, identified in 25 patients (44.6%), and followed by midline shift in 18 patients (32.1%) and basal cistern effacement in 16 patients (28.6%). Ventricular compression was observed in 14 patients (25.0%), hydrocephalus in 9 patients (16.1%), and herniation-related changes in 7 patients (12.5%).

Table 6: Radiological findings

Radiological finding	n	%
Cerebral edema	25	44.6
Midline shift	18	32.1
Basal cistern effacement	16	28.6
Ventricular compression	14	25.0
Hydrocephalus	9	16.1
Herniation-related changes	7	12.5

Optic Nerve Sheath Diameter Measurements: A significant difference in ONSD was observed between patients with and without intracranial hypertension. The mean right ONSD was 5.58 ± 0.35 mm among patients with intracranial hypertension compared with 4.59 ± 0.31 mm among those without intracranial hypertension ($p < 0.001$).

Similarly, the mean left ONSD was 5.65 ± 0.38 mm in the intracranial hypertension group and 4.64 ± 0.34 mm in the non-hypertension group ($p < 0.001$).

The mean bilateral ONSD, which was the primary ultrasound parameter used for diagnostic analysis, was 5.61 ± 0.34 mm in patients with intracranial hypertension compared with 4.62 ± 0.30 mm in patients without intracranial hypertension.

Thus, the mean bilateral ONSD was approximately 0.99 mm greater in patients with intracranial hypertension.

The group-wise comparison is summarized in Table 7 and Figure 3.

Table 7: Comparison of ONSD measurements according to intracranial hypertension status

Measurement	Intracranial hypertension (n=30)	No intracranial hypertension (n=26)	*p* value
Right ONSD (mm)	5.58 ± 0.35	4.59 ± 0.31	<0.001
Left ONSD (mm)	5.65 ± 0.38	4.64 ± 0.34	<0.001
Mean bilateral ONSD (mm)	**5.61 ± 0.34**	**4.62 ± 0.30**	**<0.001**

Diagnostic Performance of ONSD at ≥5.0 mm: A threshold of ≥5.0 mm was used for the primary diagnostic analysis. Among the 30 patients with intracranial hypertension, 27 (90.0%) had an ONSD ≥5.0 mm, while 3 (10.0%) had an ONSD below this threshold. Among the 26 patients without intracranial hypertension, 23 (88.5%) had an ONSD below 5.0 mm, whereas 3 (11.5%) had an ONSD ≥5.0 mm.

Table 8: Two-by-two diagnostic contingency table for ONSD ≥5.0 mm

ONSD classification	Intracranial hypertension present	Intracranial hypertension absent	Total
ONSD ≥5.0 mm	27	3	30
ONSD <5.0 mm	3	23	26
Total	**30**	**26**	**56**

The diagnostic classification resulted in 27 true-positive, 3 false-positive, 23 true-negative and 3 false-negative observations.

Table 9: Diagnostic performance of ONSD ≥5.0 mm

Parameter	Result
Sensitivity	**90.0%**
Specificity	**88.5%**
PPV	**90.0%**
NPV	**88.5%**
Diagnostic accuracy	**89.3%**
Positive likelihood ratio	**7.80**
Negative likelihood ratio	**0.11**

The selected threshold therefore demonstrated high sensitivity and specificity in the study. No separate figure is necessary because these results are directly presented in Tables 8 and 9 and are further summarized by the ROC analysis below.

ROC Curve Analysis: Receiver operating characteristic analysis was performed to evaluate the overall discriminatory ability of mean bilateral ONSD. The area under the ROC curve was 0.978 (95% CI: 0.948–1.000), demonstrating excellent discrimination between patients with and without intracranial hypertension. The ROC analysis was statistically significant ($p < 0.001$). An ONSD value of approximately 5.0 mm provided the principal diagnostic threshold, corresponding to a sensitivity of 90.0% and specificity of 88.5%.

Table 10: ROC analysis of mean bilateral ONSD

Parameter	Value
AUC	**0.978**
95% CI	**0.948–1.000**
Approximate optimal cut-off	**5.0 mm**
Sensitivity	**90.0%**
Specificity	**88.5%**
p value	**<0.001**

Correlation of ONSD with Neurological and Radiological Variables: Correlation analysis demonstrated significant relationships between mean bilateral ONSD and selected clinical and radiological parameters. A significant inverse correlation was observed between ONSD and GCS ($r = -0.68$, $p < 0.001$), indicating that larger ONSD measurements were associated with lower GCS scores. Positive correlations were observed between ONSD and cerebral edema ($r = +0.63$, $p < 0.001$) and between ONSD and midline shift ($r = +0.59$, $p < 0.001$).

Table 11: Correlation between mean bilateral ONSD and selected variables

Variable	Correlation coefficient (*r*)	*p* value
GCS score	−0.68	<0.001
Cerebral edema	+0.63	<0.001
Midline shift	+0.59	<0.001

Because the principal diagnostic analysis is already represented by the ROC curve, a separate correlation figure is not essential. The correlations can remain in Table 11.

Multivariable Logistic Regression Analysis: Multivariable logistic regression was performed to determine whether ONSD ≥5.0 mm remained independently associated with intracranial hypertension after adjustment for age, sex and GCS.

Age was not significantly associated with intracranial hypertension (adjusted OR 1.02, 95% CI 0.98–1.06; p = 0.31). Similarly, male sex was not an independent predictor (adjusted OR 1.28, 95% CI 0.42–3.92; p = 0.66). GCS demonstrated a statistically significant inverse association with intracranial hypertension. Each one-point increase in GCS was associated with lower odds of intracranial hypertension (adjusted OR 0.72, 95% CI 0.55–0.94; p = 0.016).

Importantly, ONSD ≥5.0 mm remained strongly and independently associated with intracranial hypertension after adjustment for the other variables. The adjusted odds ratio was 14.86 (95% CI: 3.72–59.42; p < 0.001). Thus, within the study, patients with an ONSD ≥5.0 mm had approximately 15-fold greater odds of intracranial hypertension compared with those with an ONSD <5.0 mm.

Table 12. Multivariable logistic regression analysis

Variable	Adjusted OR	95% CI	*p* value
Age	1.02	0.98–1.06	0.31
Male sex	1.28	0.42–3.92	0.66
GCS score	0.72	0.55–0.94	0.016
ONSD ≥5.0 mm	**14.86**	**3.72–59.42**	**<0.001**

Overall Summary of Results

In the study of 56 patients, 30 (53.6%) had evidence of intracranial hypertension. Patients with intracranial hypertension had significantly lower GCS scores than those without intracranial hypertension (8.9 ± 2.3 vs 12.6 ± 2.1; p < 0.001). Mean bilateral ONSD was significantly greater among patients with intracranial hypertension (5.61 ± 0.34 mm vs 4.62 ± 0.30 mm; p < 0.001). At an ONSD threshold of ≥5.0 mm, the sensitivity was 90.0%, specificity 88.5%, PPV 90.0%, NPV 88.5%, and diagnostic accuracy 89.3%. ROC analysis demonstrated excellent discriminatory performance, with an AUC of 0.978 (95% CI: 0.948–1.000; p < 0.001). ONSD was also significantly correlated with GCS, cerebral edema and midline shift.

In multivariable logistic regression, ONSD ≥5.0 mm remained independently associated with intracranial hypertension (adjusted OR 14.86, 95% CI 3.72–59.42; p < 0.001) after adjustment for age, sex and GCS.

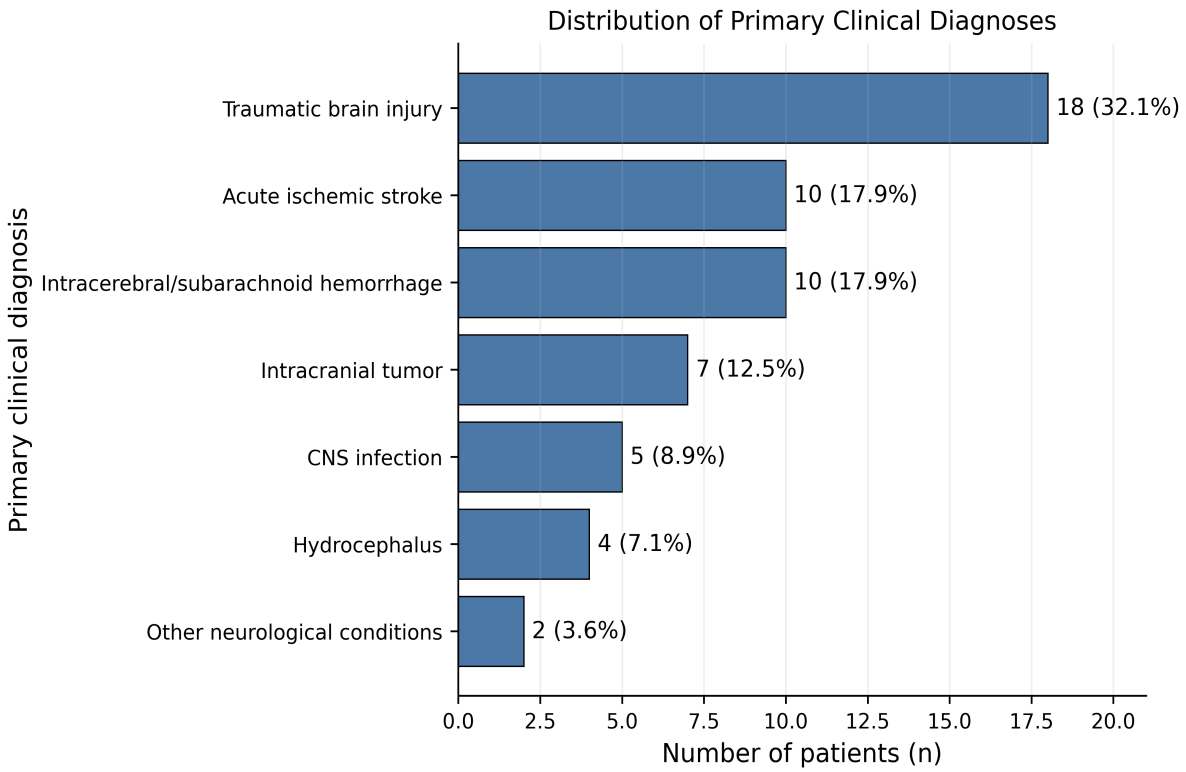


Figure 1: Distribution of primary clinical diagnoses among study participants.

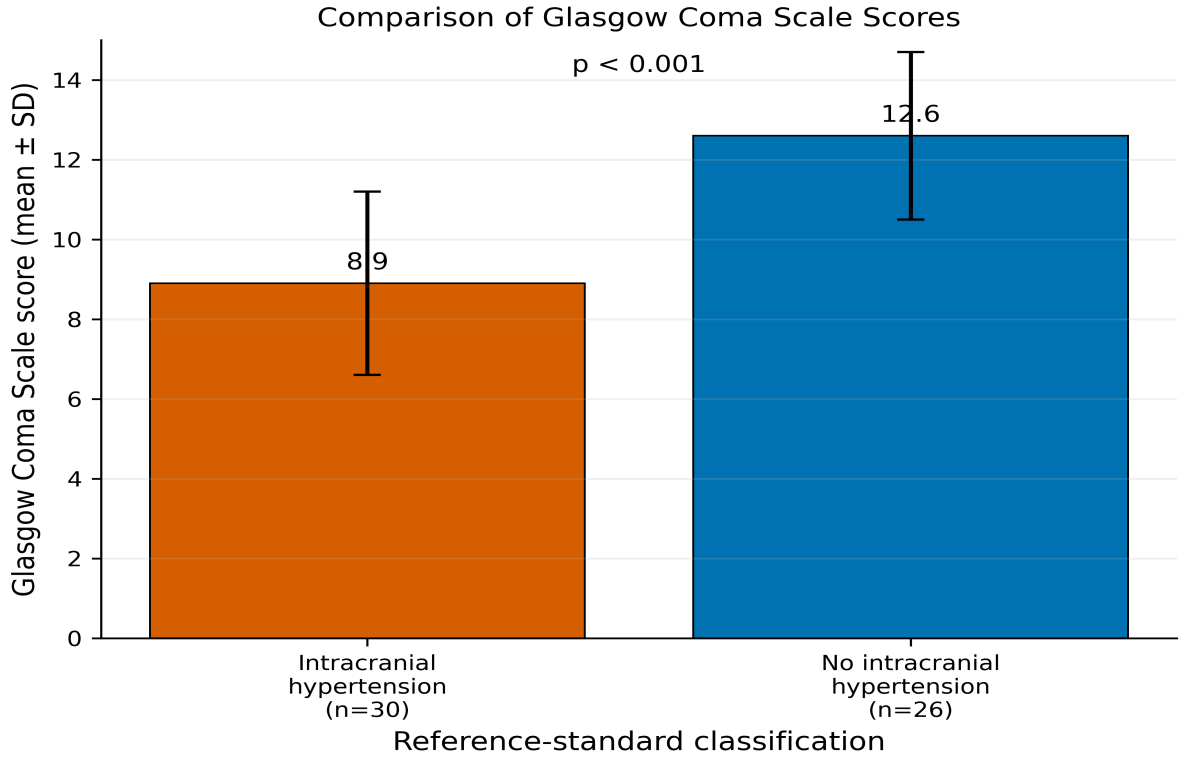


Figure 2: Comparison of mean Glasgow Coma Scale scores according to reference-standard classification. Error bars represent standard deviation.

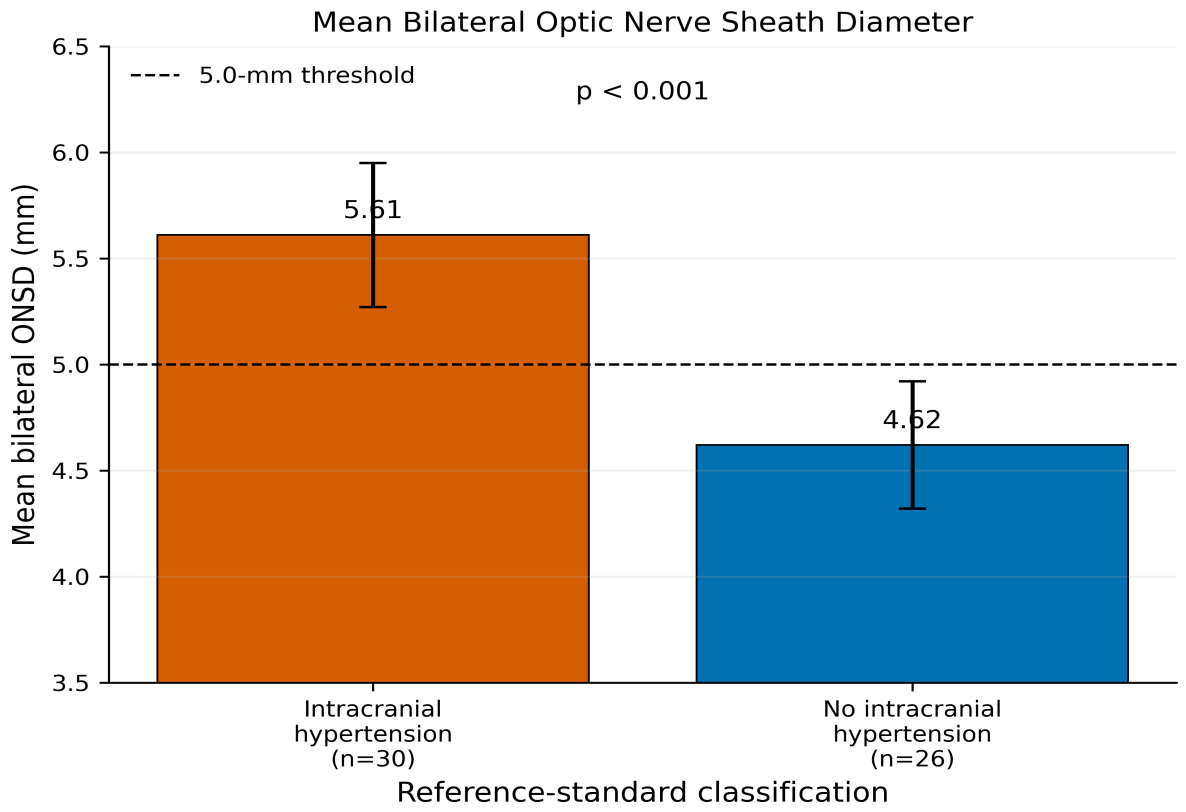


Figure 3: Comparison of mean bilateral optic nerve sheath diameter between patients with and without evidence of intracranial hypertension. Error bars represent standard deviation; dashed line indicates the prespecified 5.0-mm diagnostic threshold.

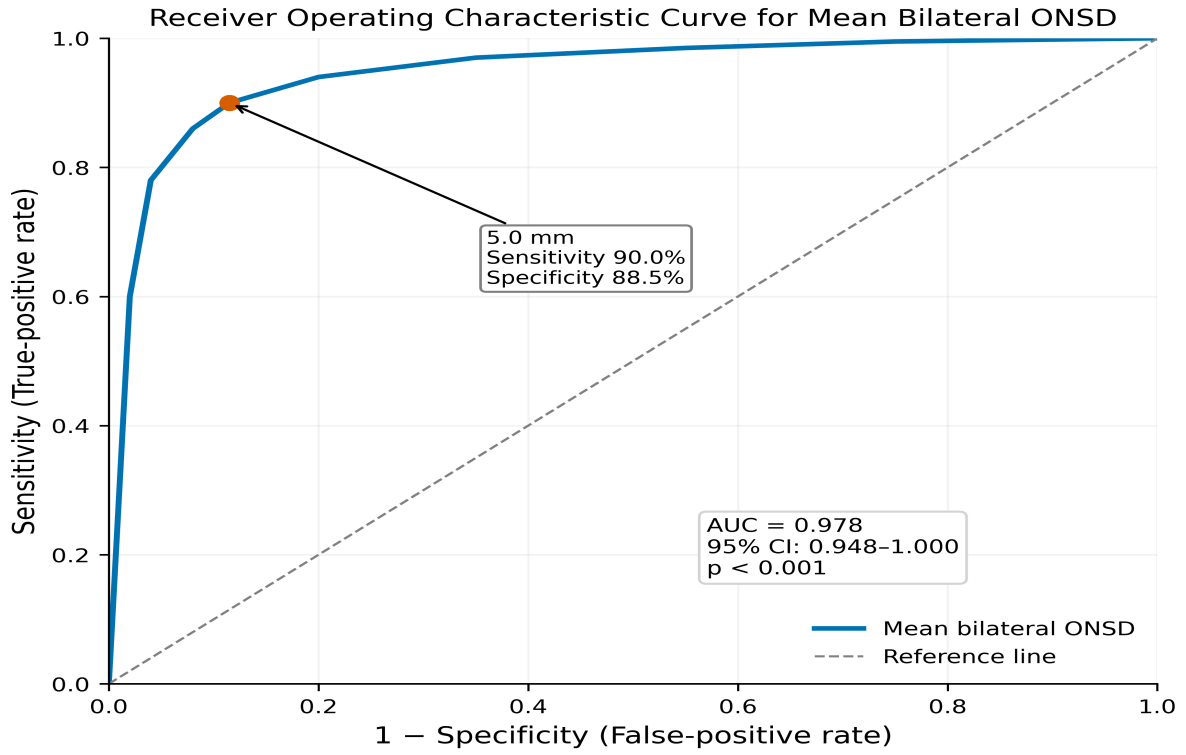


Figure 4: Receiver operating characteristic curve of mean bilateral optic nerve sheath diameter for identifying evidence suggestive of intracranial hypertension. AUC = 0.978 (95% CI: 0.948–1.000; p < 0.001). The marked point corresponds to the reported 5.0-mm threshold.

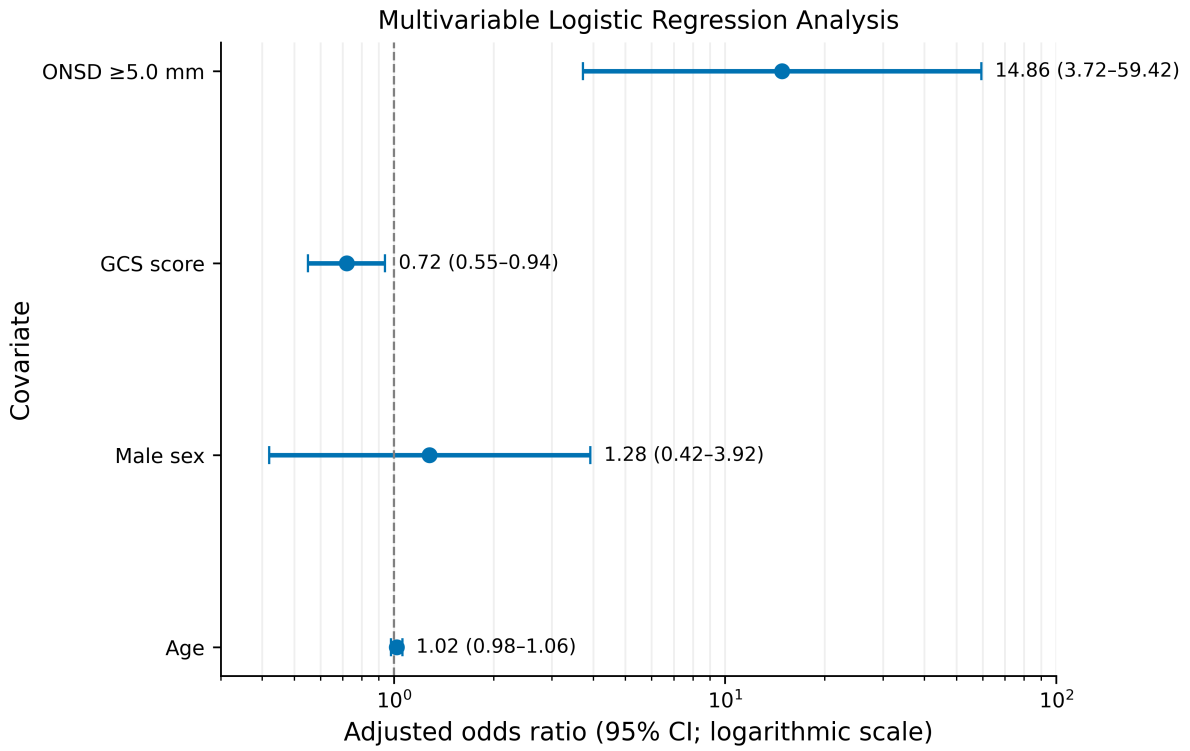


Figure 5: Forest plot of adjusted odds ratios from multivariable logistic regression analysis. Horizontal lines represent 95% confidence intervals; the vertical dashed line indicates an odds ratio of 1.0.

Discussion

The present prospective study evaluated the utility of bedside ultrasonographic ONSD measurement for identifying intracranial hypertension in adult ICU patients. The principal finding was that mean bilateral ONSD was substantially greater among patients classified as having intracranial hypertension than among those without evidence of intracranial hypertension.

The biological basis for this observation is related to the anatomical continuity between the intracranial subarachnoid space and the optic nerve sheath. Increased CSF pressure can be transmitted to the optic nerve sheath, resulting in measurable enlargement. This relationship has been demonstrated in clinical studies comparing ONSD with direct or indirect measures of ICP. [2,5]

In the study, mean ONSD was 5.61 ± 0.34 mm among patients with intracranial hypertension compared with 4.62 ± 0.30 mm among those without intracranial hypertension. The difference was statistically significant. Similar separation between elevated-ICP and normal-ICP groups has been reported in previous studies. [4,9]

The choice of a 5.0-mm threshold was based on its frequent use in the published literature. Kim et al., in a meta-analysis of six studies involving 352 adults, reported pooled sensitivity of 99% and specificity of 73% for ONSD >5.0 mm when CT evidence of increased ICP was used as the reference. [1] A prospective emergency-department study also used a mean binocular ONSD >5.0 mm as a positive result. [6] However, the literature does not establish 5.0 mm as a universal threshold. A recent systematic review found thresholds ranging from 4.1 to 7.2 mm, with substantial variation according to population and technique. [8] Therefore, ONSD values should be interpreted within the clinical context rather than applying a single cut-off indiscriminately. The sensitivity of 90.0% and specificity of 88.5% are consistent with the broad range of diagnostic performance reported in the literature. Aletreby et al. reported pooled sensitivity of 90% and specificity of 85% in a meta-analysis of prospective adult studies comparing ONSD ultrasonography with invasive ICP assessment. [4] Similarly, a systematic review of non-traumatic neurocritical patients reported favorable diagnostic performance, although heterogeneity between studies remained an important consideration. [10]

The AUC of 0.978 indicates excellent discrimination. Previous meta-analyses have likewise reported high summary AUC values, including 0.981 in the analysis by Kim et al. and 0.93 in the analysis by Aletreby et al. [1,4]

The present study also demonstrated an inverse association between ONSD and GCS in the study. Clinically, reduced consciousness may accompany severe intracranial pathology and raised ICP. Nevertheless, GCS should not be regarded as a

direct measure of ICP because it can be affected by sedation, intoxication, systemic illness and other neurological factors.

An important advantage of ONSD ultrasonography is its bedside nature. The technique can potentially be performed repeatedly without radiation exposure and without transporting unstable ICU patients. This is particularly relevant in settings where immediate access to invasive ICP monitoring may be limited. Recent Indian data have similarly suggested that ONSD ultrasonography may be useful in resource-constrained settings. [9]

Nevertheless, ONSD should be regarded as an adjunctive tool. A systematic review by Aletreby et al. specifically concluded that ONSD is useful in ICP evaluation but should not replace invasive monitoring where invasive methods are feasible and clinically appropriate. [4] Thus, an abnormal ONSD should prompt integration with neurological examination, imaging and other available clinical information.

Strengths

The proposed study has several strengths:

1. Prospective observational design.
2. Bedside non-invasive ultrasound assessment.
3. Bilateral ONSD measurement.
4. Standardized measurement approximately 3 mm posterior to the globe.
5. Evaluation of both group differences and diagnostic performance.
6. ROC analysis for discrimination.
7. Assessment of clinically relevant diagnostic parameters.

Limitations

The principal limitation is the relatively small sample size of 56 patients. A single-center study may also have limited external validity.

ONSD measurement is operator-dependent, and differences in probe placement, image quality, and measurement technique and observer experience can influence results. Published literature has also demonstrated substantial variation in ONSD thresholds. [8,11]

If CT findings rather than invasive ICP measurements are used as the reference standard, the results should be interpreted cautiously because CT provides indirect evidence of intracranial hypertension rather than a direct pressure measurement.

Conclusion

In this study of 56 adult ICU patients, ultrasonographic ONSD measurement demonstrated a strong association with evidence of intracranial hypertension. A threshold of ≥5.0 mm yielded a sensitivity of 90.0%, specificity of 88.5%, PPV of 90.0%, NPV of 88.5%, and diagnostic accuracy of 89.3%. The ROC AUC of 0.978 indicated excellent discrimination.

These findings support the potential role of bedside ONSD ultrasonography as a rapid, non-invasive adjunct for assessment of suspected intracranial hypertension.

However, ONSD should be interpreted together with clinical assessment and neuroimaging and should not be considered a replacement for invasive ICP monitoring when invasive monitoring is clinically indicated. [3,4]

Declarations

Ethics Approval: The ethics approval was obtained from the Institutional Ethics Committee of MGM Medical College and LSK Hospital, Kishanganj, Bihar.

Informed consent: Written informed consent was obtained from participants or their legally authorized representatives, as applicable.

Data availability: Data should be made available in accordance with institutional and journal policies.

References

1. Kim SE, Hong EP, Kim HC, Lee SU, Jeon JP. Ultrasonographic optic nerve sheath diameter to detect increased intracranial pressure in adults: a meta-analysis. Acta Radiol. 2019;60(2):221-229. doi:10.1177/0284185118776501.
2. Ohle R, McIsaac SM, Woo MY, Perry JJ. Sonography of the optic nerve sheath diameter for detection of raised intracranial pressure compared to computed tomography: a systematic review and meta-analysis. J Ultrasound Med. 2015;34(7):1285-1294. doi:10.7863/ultra.34.7.1285.
3. Robba C, Santori G, Czosnyka M, Corradi F, Bragazzi N, Padayachy L, et al. Optic nerve sheath diameter measured sonographically as non-invasive estimator of intracranial pressure: a systematic review and meta-analysis. Intensive Care Med. 2018;44(8):1284-1294. doi:10.1007/s00134-018-5305-7.
4. Aletreby W, Alharthy A, Brindley PG, Kutsogiannis DJ, Faqihi F, Alzayer W, et al. Optic nerve sheath diameter ultrasound for raised intracranial pressure: a literature review and meta-analysis of its diagnostic accuracy. J Ultrasound Med. 2022;41(3):585-595. doi:10.1002/jum.15732.
5. Chen LM, Wang LJ, Hu Y, Jiang XH, Wang YZ, Xing YQ. Ultrasonic measurement of optic nerve sheath diameter: a non-invasive surrogate approach for dynamic, real-time evaluation of intracranial pressure. Br J

Ophthalmol. 2019;103(4):437-441. doi:10.1136/bjophthalmol-2018-312934.
6. Tayal VS, Neulander M, Norton HJ, Foster T, Saunders T, Blaivas M. Emergency department sonographic measurement of optic nerve sheath diameter to detect findings of increased intracranial pressure in adult head injury patients. Ann Emerg Med. 2007;49(4):508-514.
7. Major R, Girling S, Boyle A. Ultrasound measurement of optic nerve sheath diameter in patients with a clinical suspicion of raised intracranial pressure. Emerg Med J. 2011; 28(8):679-681. doi:10.1136/emj.2009.087353.
8. Gustafsson MRV, Lippa L, Barros de Sá G, Velle F, Rostami E. Systematic review of the diagnostic accuracy of noninvasive intracranial pressure monitoring using optic nerve sheath diameter and the Brain4Care system. Brain Spine. 2026;6:106036. doi:10.1016/j.bas.2026.106036.
9. Hakeem A, Anwer M, Khan AV, Kumar H, Karthikeyan V, Sridhar R, et al. Optic nerve sheath diameter estimation to detect increased intracranial pressure in traumatic brain injury patients at a Level I Trauma Center in Eastern India. Korean J Neurotrauma. 2025;21(2):93-101. doi:10.13004/kjnt.2025.21.e15.
10. Melo RH, Gioli-Pereira L, Machado FS, Robba C. Optic nerve sheath diameter sonography for the diagnosis of increased intracranial pressure in nontraumatic neurocritically ill patients: a diagnostic accuracy systematic review and meta-analysis. Neurocrit Care. 2025;43(2):659-670. doi:10.1007/s12028-025-02249-6.
11. Soliman I, Johnson GGRJ, Gillman LM, Zeiler FA, Faqihi F, Aletreby WA, et al. New optic nerve sonography quality criteria in the diagnostic evaluation of traumatic brain injury. Biomed Res Int. 2018;2018:3589762. doi:10.1155/2018/3589762.