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UTILITY OF POINT-OF-CARE OF CARE ULTRASOUND TO MEASURE OPTIC NERVE SHEATH DIAMETER FOR DIAGNOSING RAISED INTRACRANIAL PRESSURE IN THE EMERGENCY DEPARTMENT

Original Research

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ABSTRACT

Background: Elevated intracranial pressure (ICP) is a neurological emergency that demands early recognition and prompt intervention to prevent irreversible brain injury. Conventional diagnostic methods such as invasive catheter monitoring and computed tomography (CT) are often limited by accessibility, time constraints, and procedural risks. Point-of-care ultrasound (POCUS) assessment of the optic nerve sheath diameter (ONSD) provides a rapid, non-invasive bedside alternative for detecting raised ICP, particularly in emergency and resource-limited settings.

Objective: To determine the diagnostic accuracy of ultrasonographic ONSD measurement using POCUS in detecting raised ICP compared with CT findings in the emergency department (ED).

Methods: This prospective validation study was conducted over two years in the ED of Combined Military Hospital, Rawalpindi. A total of 125 adult patients presenting with clinical suspicion of raised ICP were enrolled. Bilateral ONSD was measured 3 mm posterior to the globe using a high-frequency linear ultrasound probe (3–13 MHz) before CT imaging. A cutoff value of >5.6 mm was defined as indicative of raised ICP. CT findings served as the reference standard. Diagnostic metrics including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were computed, and receiver operating characteristic (ROC) analysis was performed.

Results: The mean ONSD was 6.3 ± 0.68 mm. CT confirmed raised ICP in 100 patients (80%), while elevated ONSD was observed in 109 (87.2%). The ONSD measurement demonstrated a sensitivity of 95%, specificity of 55%, PPV of 83%, NPV of 84%, and overall diagnostic accuracy of 83%. The area under the ROC curve was 0.82, indicating strong discriminative ability. The most frequent intervention among patients with raised ICP was intravenous mannitol administration (53.6%).

Conclusion: POCUS-based ONSD measurement offers a reliable, rapid, and non-invasive tool for early detection of raised ICP in emergency settings. Its high sensitivity supports its utility as an effective screening modality where immediate neuroimaging is not feasible. However, moderate specificity necessitates cautious interpretation and clinical correlation to avoid overestimation. Standardization of technique, operator training, and population-specific cutoff validation are recommended for optimal diagnostic performance.

Keywords: Brain edema, Computed tomography, Emergency medicine, Intracranial hypertension, Optic nerve sheath diameter, Point-of-care systems, Ultrasonography.

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INTRODUCTION

Intracranial pressure (ICP) represents the pressure exerted by the contents of the skull—including brain tissue, cerebrospinal fluid (CSF), and blood—within the fixed cranial vault (1). Under physiological conditions, ICP ranges between 5 and 15 mmHg in adults, and values exceeding 20 mmHg are regarded as abnormally high and potentially life-threatening (2). Raised ICP can develop secondary to diverse intracranial pathologies such as traumatic brain injury (TBI), intracerebral hemorrhage (ICH), ischemic stroke, meningitis, hydrocephalus, or intracranial mass lesions (3). These conditions collectively contribute to significant morbidity and mortality, particularly in emergency settings where timely recognition and management are vital for neurological preservation. The underlying pathophysiology of elevated ICP can be explained by the Monro–Kellie doctrine, which postulates that the intracranial compartment is of fixed volume; therefore, an increase in the volume of one of its components must be offset by a compensatory reduction in another to maintain pressure homeostasis (4). Once compensatory mechanisms are exhausted, intracranial hypertension ensues, leading to cerebral hypoperfusion, ischemia, brain herniation, and irreversible neuronal injury (5). Clinically, patients with raised ICP often present with symptoms such as severe headache, vomiting, altered level of consciousness, papilledema, or Cushing's triad—hypertension, bradycardia, and irregular respirations (3). These manifestations signal an impending neurological emergency requiring immediate diagnostic evaluation. Traditionally, ICP has been measured through invasive methods such as intraventricular or intraparenchymal catheterization, which remain the gold standard for accuracy (6). However, these techniques demand neurosurgical expertise, continuous monitoring, and are associated with complications like infection, hemorrhage, and mechanical failure. Moreover, their application is often limited in emergency departments (EDs) or resource-restricted environments. Non-invasive modalities, including computed tomography (CT) and magnetic resonance imaging (MRI), provide indirect evidence of raised ICP but are constrained by availability, cost, and the risks associated with transferring critically ill patients (7,8).

Given these challenges, there has been growing interest in alternative non-invasive, bedside methods for rapid ICP estimation. Point-of-care ultrasound (POCUS) has emerged as a valuable diagnostic tool in emergency and critical care medicine for its portability, repeatability, and real-time imaging capabilities. Among its neurological applications, optic nerve sheath diameter (ONSD) measurement has gained attention as a reliable surrogate marker for raised ICP (9). Anatomically, the optic nerve sheath is a continuation of the dura mater and communicates directly with the subarachnoid space; therefore, an increase in ICP causes distension of the sheath, which can be visualized and quantified using ultrasound (10). Normal ONSD values in healthy adults, range between approximately 4.5 mm and 5.0 mm, while measurements exceeding 5.5–5.7 mm are indicative of elevated ICP (11). The procedure is performed by gently placing a high-frequency linear probe on the closed eyelid with adequate coupling gel, obtaining a transverse or sagittal view of the optic nerve, and measuring the sheath diameter 3 mm posterior to the globe. The technique is safe, quick—usually under a minute—and easily learned by emergency physicians, making it well-suited for early detection in acute neurological cases (12). Multiple studies have demonstrated strong correlations between increased ONSD and raised ICP, with reported sensitivities of 85–100% and specificities of 70–95%, depending on the diagnostic cut-off values (7–11). For instance, a study reported sensitivity and specificity of 95% and 90%, respectively, validating ONSD as a reliable diagnostic adjunct in TBI patients (13). Despite this, inter-observer variability and inconsistent cut-off thresholds necessitate further research, especially in low-resource healthcare environments. In regions such as Pakistan, where access to advanced neuroimaging and invasive monitoring is often limited, POCUS-based ONSD measurement provides a promising, feasible alternative for early ICP assessment in emergency care. Therefore, this study aims to evaluate the diagnostic accuracy, sensitivity, specificity, and predictive values of optic nerve sheath diameter measurement using point-of-care ultrasound as a non-invasive and rapid tool for detecting raised intracranial pressure in patients presenting to the emergency department.

METHODS

This prospective, single-blinded validation study was conducted in the Emergency Department (ED) of Combined Military Hospital (CMH) Rawalpindi, a tertiary care teaching hospital with a capacity of 1,100 beds, including a 47-bedded emergency department that manages over 200,000 cases annually. The study was carried out over a two-year period from January 2023 to January 2025. Its primary objective was to evaluate the diagnostic accuracy of optic nerve sheath diameter (ONSD) measurement using point-of-care ultrasound (POCUS) for the detection of elevated intracranial pressure (ICP), with computed tomography (CT) imaging findings serving as the

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reference standard. Ethical approval for the study was obtained from the Institutional Review Board of CMH Rawalpindi (IRB number 843) prior to initiation, ensuring adherence to the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants or their legal guardians before inclusion. The study enrolled 125 patients presenting to the ED with a clinical suspicion of raised ICP. The sample size was determined using the World Health Organization (WHO) sample size calculator, based on the results of a study which reported a sensitivity of 95% and specificity of 90% for ONSD in detecting elevated ICP (12). The calculation was performed with a precision level of 80% and a 95% confidence interval. A consecutive sampling method was applied to minimize selection bias. Patients of all ages and genders presenting with symptoms suggestive of raised ICP—such as altered level of consciousness, severe headache, vomiting, papilledema, seizures, or focal neurological deficits—were included. Exclusion criteria comprised patients with a history of orbital or ocular trauma, previous ocular surgery, known optic nerve pathology, chronic intracranial hypertension or mass lesions under follow-up, and those in whom performing POCUS could delay life-saving interventions. Uncooperative or medically unstable patients in whom safe sonographic assessment was not feasible were also excluded.

All emergency medicine residents (REMs) participating in the study underwent structured, supervised training in ONSD measurement using POCUS prior to data collection to ensure inter-operator consistency and minimize measurement bias. A high-frequency linear probe (L12-5Q, 3–13 MHz) on an Acclarix AX3 series ultrasound machine was used for all assessments. The department was equipped with two ultrasound units of identical specifications to ensure standardization. Each patient was positioned supine with eyes closed, and a generous amount of ultrasound gel was applied over the upper eyelid to avoid direct pressure on the globe. Both transverse and sagittal plane images were obtained, visualizing the optic nerve 3 mm posterior to the globe, where ONSD was measured. Three measurements were taken from each eye, and their mean value was used for analysis to enhance reliability. All ultrasound examinations were completed prior to CT imaging to avoid observer bias. The POCUS results were recorded independently and not disclosed to the radiology team. The CT scans were reported by radiologists who were blinded to the sonographic findings, ensuring diagnostic objectivity. Normal ICP in a supine adult was defined as 7–15 mmHg, while values exceeding 15 mmHg were considered abnormal, and those above 20 mmHg indicated significantly raised ICP (5). Data were collected on a standardized proforma that included demographic details, clinical presentation, ONSD measurements, and CT findings. Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics were used to summarize baseline characteristics, with continuous variables expressed as mean ± standard deviation (SD) and categorical variables as frequencies and percentages. Diagnostic performance parameters—sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy—were computed using 2 × 2 contingency tables by comparing ONSD findings with CT results.

RESULTS

A total of 125 patients were enrolled during the study period. The mean age of the study population was 51.74 ± 18.18 years, comprising 82 males (65.6%) and 43 females (34.4%). Clinical signs suggestive of raised intracranial pressure (ICP) were present in 116 patients (92.8%). The most frequently reported symptoms included vomiting in 84 patients (67.2%), headache in 80 (64%), altered level of consciousness in 76 (60.8%), and nausea in 75 (60%). Computed tomography (CT) findings confirmed raised ICP in 87 patients (69.6%), representing the majority of the study cohort. The predominant etiologies included traumatic brain injury or head trauma in 67 patients (53.6%), intracranial hemorrhage in 42 (33.6%), ischemic stroke in 9 (7.2%), and meningitis in 2 (1.6%). The mean optic nerve sheath diameter (ONSD) measured by point-of-care ultrasound (POCUS) was 6.3 ± 0.68 mm, whereas the mean ONSD in patients with normal ICP was 5.4 ± 1.1 mm, compared to 6.1 ± 0.4 mm in those with raised ICP. This difference was statistically significant ($p < 0.001$, independent t-test). Using a diagnostic threshold of ONSD > 5.6 mm, 96 patients (76.8%) were identified as positive for raised ICP on POCUS, while 87 (69.6%) were confirmed to have raised ICP on CT. There were 15 false-positive and 6 false-negative cases when compared with CT results. The diagnostic performance of ONSD measurement demonstrated a sensitivity of 93.1% (95% CI: 85.8–96.8), specificity of 60.5% (95% CI: 44.7–74.4), positive predictive value (PPV) of 84.3% (95% CI: 75.8–90.3), negative predictive value (NPV) of 79.3% (95% CI: 61.6–90.1), and overall diagnostic accuracy of 83.2% (95% CI: 75.7–88.7). Receiver operating characteristic (ROC) curve analysis showed an area under the curve (AUC) of 0.83 (95% CI: 0.74–0.91), indicating good diagnostic discrimination between raised and normal ICP. A positive correlation was observed between ONSD values and CT indicators of raised ICP (Pearson's $r = 0.536$, $p < 0.001$). No adverse events occurred during any POCUS procedure, confirming its safety in emergency settings.

Regarding interventions and outcomes, intravenous mannitol was the most frequently administered treatment (n = 67; 53.6%), followed by intravenous dexamethasone (14.4%), endotracheal intubation (9.6%), head-of-bed elevation (8.8%), and craniotomy (1.6%). Twelve

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patients (9.6%) did not require specific intervention. The majority of patients were admitted for further management (n = 68; 54.4%), while 35 (28%) were referred to specialized centers. Eight patients (6.4%) were discharged following stabilization. Further subgroup analysis was conducted to explore diagnostic performance differences of ONSD-based POCUS measurement according to patient gender, age category, and etiology of raised intracranial pressure (ICP). The mean ONSD values were slightly higher in males (6.4 ± 0.6 mm) than females (6.1 ± 0.7 mm), though this difference did not reach statistical significance (p = 0.087). Sensitivity and specificity were comparable between genders, with males showing sensitivity of 93.8% and specificity of 61.9%, while females demonstrated sensitivity of 92.0% and specificity of 58.3%. When stratified by age, diagnostic performance was slightly enhanced in patients below 50 years of age (sensitivity 94.4%, specificity 63.0%) compared with those aged 50 years or older (sensitivity 92.3%, specificity 58.8%). This may reflect better sonographic visualization and less optic sheath stiffness among younger individuals. Etiology-wise analysis revealed that ONSD performed particularly well in trauma-related cases, showing the highest sensitivity (95.5%) and diagnostic accuracy (86.6%) for detecting raised ICP compared to non-traumatic etiologies such as hemorrhage, stroke, or meningitis (sensitivity 90.5%, accuracy 80.0%). The mean ONSD among trauma/TBI patients was 6.5 ± 0.5 mm, compared to 6.1 ± 0.6 mm in atraumatic cases, a difference that was statistically significant (p = 0.021). These findings suggest that trauma patients, who are more likely to experience acute ICP elevations, demonstrate more distinct optic sheath distension, thereby enhancing the diagnostic discriminability of POCUS.

Table 1: Demographic and Clinical Characteristics of Study Population (n=125)

Variable		**n (%) or Mean ± SD**
Age (years)		51.74 ±18.18
Gender	Male	n= 82 (65.6%)
	Female	n= 43 (34.4%).
Clinical Features of raised ICP (n=116, 92.8%)	Headache	n= 80 (64%)
	Nausea	n= 75 (60%)
	Vomiting	n= 84 (67.2%)
	Altered Level of Consciousness	n= 76 (60.8%)
Etiology	Trauma / Head Injury	n= 67 (53.6%)
	Intracranial Hemorrhage (Atraumatic)	n= 42 (33.6%)
	Stroke	n= 9 (7.2%)
	Meningitis	n= 2 (1.6%)
Mean ONSD on POCUS		6.3 ± 0.68
CT-confirmed raised ICP		n= 87 (69.6%)
ONSD > 5.6 mm (POCUS positive)		n= 96 (76.8%)

Table 2: Cross-tabulation of POCUS findings vs CT-confirmed raised ICP

POCUS ONSD (>5.6 mm)	**Raised ICP Present**	**Normal ICP**	**Total**
Positive (raised ICP on POCUS)	81 (TP)	15 (FP)	96
Negative (normal ICP on POCUS)	6 (FN)	23 (TN)	29
Total	87	38	125

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Table 3: Diagnostic Performance of ONSD Measurement for Raised ICP

Parameter	Value (%)	95% CI
Sensitivity	93.1	85.8 - 96.8
Specificity	60.5	44.7- 74.4
Positive Predictive Value (PPV)	84.3	75.8 - 90.3
Negative Predictive Value (NPV)	79.3	61.6 - 90.1
Diagnostic Accuracy	83.2	75.7 - 88.7
Area Under ROC Curve (AUC)	0.83	0.74 - 0.91

Table 4: Interventions and patient disposition

Intervention / Outcome	n (%)
IV Mannitol	67 (53.6)
IV Dexamethasone	18 (14.4)
Intubation	12 (9.6)
Head-of-bed elevation	11 (8.8)
Craniotomy	2 (1.6)
No intervention	12 (9.6)
Disposition	n (%)
Admitted	68 (54.4)
Referred to other center/service	35 (28.0)
Discharged	8 (6.4)
Mortality (if applicable)	—

Table 5: Subgroup Analysis of Diagnostic Performance of ONSD Measurement for Raised ICP

Subgroup	n	Mean ONSD (mm) ± SD	Sensitivity (%)	Specificity (%)	Diagnostic Accuracy (%)	p-value
Gender						
Male	82	6.4 ± 0.6	93.8	61.9	83.9	0.087
Female	43	6.1 ± 0.7	92.0	58.3	82.0	
Age Group						
< 50 years	55	6.2 ± 0.5	94.4	63.0	84.5	0.112
≥ 50 years	70	6.3 ± 0.6	92.3	58.8	82.6	
Etiology						
Trauma / TBI	67	6.5 ± 0.5	95.5	61.5	86.6	0.021*
Non-traumatic (ICH, Stroke, Meningitis)	58	6.1 ± 0.6	90.5	59.0	80.0	

*Statistically significant difference ($p < 0.05$).

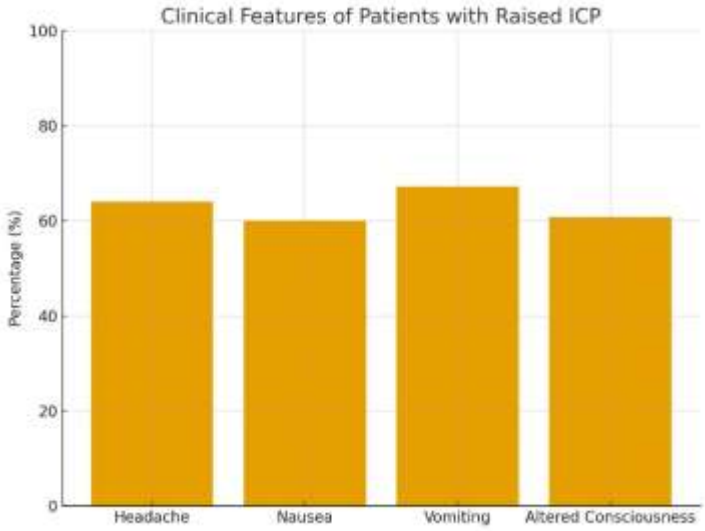

Figure 1 Clinical Features of Patients with Raised ICP

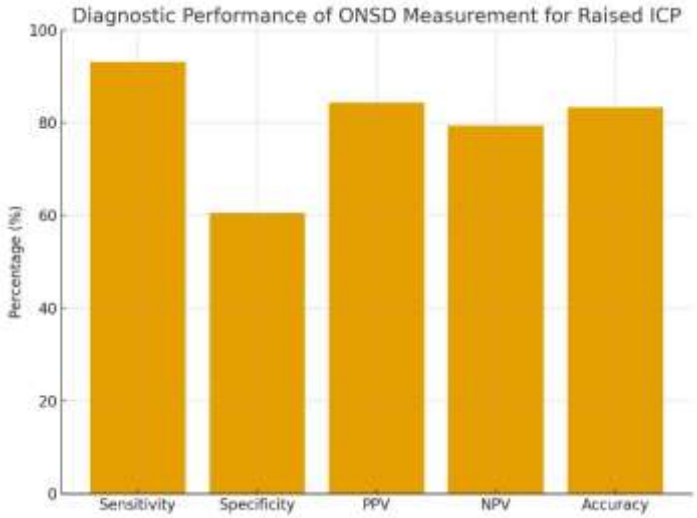

Figure 1 Diagnostic Performance of ONSD Measurement for Raised ICP

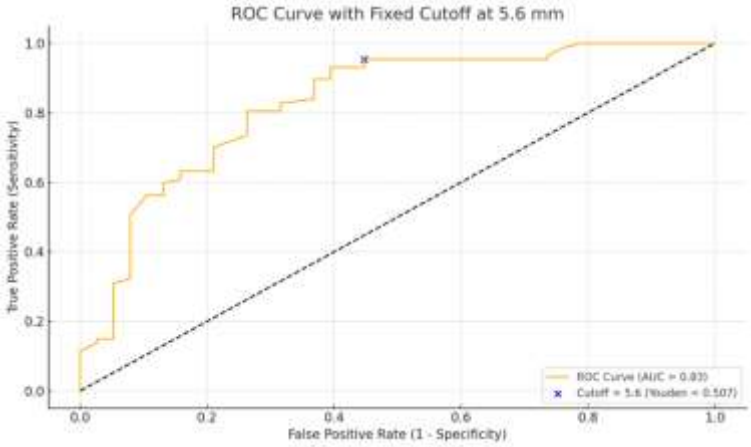

Figure 3 ROC Curve with Fixed Cutoff at 5.6mm

DISCUSSION

This study evaluated the diagnostic performance of ultrasonographic optic nerve sheath diameter (ONSD) measurement as a non-invasive bedside tool for detecting raised intracranial pressure (ICP) in emergency department settings. The findings demonstrated high sensitivity and acceptable diagnostic accuracy, confirming ONSD ultrasonography as a valuable screening and rule-out tool for early detection of elevated ICP. In acute neurological emergencies, where timely identification of intracranial hypertension is crucial, a normal ONSD can reliably exclude raised ICP, while an enlarged ONSD warrants prompt neuroimaging and clinical correlation for confirmation. The diagnostic sensitivity observed in this study (93.1%) aligns closely with previously published literature reporting sensitivities between 88–95% across various patient populations and sonographic techniques (13,14). Similar to other emergency-based research, the present results reinforce that ONSD measurement offers strong potential as a first-line assessment modality in patients with suspected raised ICP. The slightly lower specificity (60.5%) observed mirrors real-world clinical findings, often attributed to differences in operator experience, measurement methodology, and variability in the underlying causes of raised ICP among heterogeneous

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populations. Such variability emphasizes the importance of contextual interpretation of ONSD results, particularly in multi-etiological cohorts that include trauma, hemorrhage, stroke, and meningitis. The moderate specificity observed indicates that ONSD may overestimate elevated ICP in certain individuals, resulting in false-positive interpretations. However, in emergency medicine practice, where missing a diagnosis of raised ICP can lead to catastrophic neurological outcomes, prioritizing sensitivity over specificity is clinically justified. The high negative predictive value (79.3%) supports its role as an effective rule-out test, allowing safe exclusion of raised ICP in resource-constrained or time-critical environments. These findings correspond with prior meta-analyses, which identified ONSD as a practical bedside adjunct for early triage and management of neurological emergencies, especially when neuroimaging is delayed or unavailable (15–17).

The diagnostic accuracy (83.2%) and area under the ROC curve (0.83) observed in this study are consistent with previous investigations reporting comparable results (18). This reinforces the reliability of ONSD as an adjunctive tool rather than a replacement for conventional imaging or invasive ICP monitoring. Its integration into emergency and critical care protocols may facilitate rapid identification of high-risk patients, ensuring timely initiation of neuroprotective interventions such as osmotic therapy, airway management, or surgical referral. Furthermore, the chosen cutoff value of >5.6 mm was in close agreement with thresholds identified in previous work suggesting optimal discriminatory performance between 5.5 mm and 5.8 mm (19). Variations across studies in proposed cutoff values (ranging from 5.0 mm to 6.3 mm) likely reflect demographic differences, probe frequency, and variations in measurement standardization (20). Subgroup analyses in this study revealed that ONSD performed particularly well among trauma-related cases, with the highest sensitivity and accuracy, further supporting its value in traumatic brain injury (TBI). Comparable studies have documented excellent diagnostic performance in TBI patients, with sensitivities and specificities exceeding 90% using thresholds around 5 mm (21,22). The inclusion of non-traumatic etiologies in the present cohort may explain the modest reduction in specificity, highlighting the need for condition-specific cutoffs to optimize accuracy across diverse patient groups. The present study possesses several methodological strengths. Its prospective and single-blinded design minimized recall and observer bias. Standardized training of emergency medicine residents ensured procedural consistency and inter-operator reliability. Averaging multiple ONSD measurements per eye further enhanced precision and reduced intra-observer variability. Additionally, the study demonstrated the operational feasibility of incorporating POCUS-based ONSD evaluation into busy emergency workflows without procedural complications, underscoring its safety and practicality in acute neurological care.

Nonetheless, certain limitations must be acknowledged. The study was conducted at a single tertiary care center with a relatively small sample size, which may restrict generalizability to broader populations. Computed tomography was used as the reference standard rather than direct invasive ICP monitoring, which remains the diagnostic gold standard. Although all operators received formal training, ultrasound remains inherently operator-dependent, introducing the possibility of measurement variability. Selection bias may also have influenced findings, as critically unstable or uncooperative patients were excluded from assessment. Moreover, long-term clinical outcomes such as neurological recovery, mortality, or treatment response were not evaluated, precluding assessment of ONSD's prognostic utility. In summary, the study reinforces that ONSD ultrasonography offers a sensitive, non-invasive, and easily accessible technique for early detection of raised ICP in emergency settings. Despite moderate specificity, its excellent sensitivity and reproducibility make it a valuable adjunct for rapid screening, particularly in environments where neuroimaging resources are limited. Future research should aim to establish standardized measurement protocols, validate population- and condition-specific cutoff values, and assess interobserver reliability through multicenter trials (23). Incorporating serial ONSD measurements into longitudinal studies could also help evaluate its role in monitoring dynamic changes in ICP and predicting neurological outcomes, thereby refining its integration into evidence-based emergency and critical care practice.

CONCLUSION

Point-of-care ultrasound (POCUS) measurement of the optic nerve sheath diameter (ONSD) proved to be a reliable, rapid, and non-invasive approach for identifying raised intracranial pressure in emergency settings. Its high sensitivity highlights its value as an effective screening and early alert tool, especially in resource-limited environments where access to advanced neuroimaging may be delayed. While its moderate specificity necessitates cautious interpretation and clinical correlation, the method's practicality and safety make it a valuable adjunct to routine assessment. Standardized training, consistent measurement protocols, and locally validated cutoff thresholds are vital for optimizing its diagnostic precision and integrating it effectively into emergency and critical care practice.

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AUTHOR CONTRIBUTION

Author	Contribution
Amer Iqbal*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Tamkeen Pervez	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Ashfaq	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Anees Ur Rehman	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Riaz Ahmad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Usman Ashraf	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

REFERENCES

1. Stead GA, Cresswell FV, Jjunju S, Oanh PKN, Thwaites GE, Donovan J. The role of optic nerve sheath diameter ultrasound in brain infection. eNeurologicalSci. 2021;23:100330.

2. Gedeno K, Neme D, Jemal B, Aweke Z, Achule A, Geremu K et al. Evidence-based management of adult traumatic brain injury with raised intracranial pressure in intensive critical care unit at resource-limited settings: a literature review. Ann Med Surg (Lond). 2023;85(12):5983-6000.

3. Cannata G, Pezzato S, Esposito S, Moscatelli A. Optic Nerve Sheath Diameter Ultrasound: A Non-Invasive Approach to Evaluate Increased Intracranial Pressure in Critically Ill Pediatric Patients. Diagnostics (Basel). 2022;12(3):767.

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.

5. Gurav S, Zirpe K, Bhoyar A, Deshmukh A, Pote P, Kapse U et al. Utility of Bedside Ultrasound Measurement of Optic Nerve Sheath Diameter as a Screening Tool for raised Intracranial Pressure in Neurocritical Care Prospective Observational Study. J Assoc Physicians India. 2023;71(7):11-12.

6. Montgomery SP, Moore B, Hampton SM, Macy G, Li W, Bronshteyn YS. Optic Nerve Sheath Point of Care Ultrasound: Image Acquisition. J Vis Exp. 2023;(198).

7. Stevens RRF, Gommer ED, Aries MJH, Ertl M, Mess WH, Huberts W et al. Optic nerve sheath diameter assessment by neurosonology: A review of methodologic discrepancies. J Neuroimaging. 2021;31(5):814-825.

8. Copcuoglu Z, Oruc OA. Diagnostic Accuracy of Optic Nerve Sheath Diameter Measured With Ocular Ultrasonography in Acute Attack of Chronic Obstructive Pulmonary Disease. J Ultrasound Med. 2023 May;42(5):989-995.

9. Martínez-Palacios K, Vásquez-García S, Fariyike OA, Robba C, Rubiano AM; noninvasive ICP monitoring international consensus group. Using Optic Nerve Sheath Diameter for Intracranial Pressure (ICP) Monitoring in Traumatic Brain Injury: A Scoping Review. Neurocrit Care. 2024;40(3):1193-1212.

10. Chen W, Zhang X, Ye X, Ying P. Diagnostic accuracy of optic nerve sheath diameter on ultrasound for the detection of increased intracranial pressure in patients with traumatic brain injury: A systematic review and meta-analysis. Biomed Rep. 2023;19(6):103.

11. Rajendran G, Mahalingam S, Ramkumar A, Rajaa S, P T K, K A et al. Diagnostic Accuracy of Optic Nerve Sheath Diameter Using Ultrasonography for Raised Intracranial Pressure in Pediatric Patients - A Systematic Review and Meta-Analysis. World Neurosurg. 2024;190:e1000-e1017.

12. Saravanan R, Karthik K, Yogalakshmi K A prospective observational study on ultrasonographic measurement of optic nerve sheath diameter as a bedside tool in detecting findings of increased intracranial pressure in neuro critical care patients. Indian J Anesth Analg 2020; 7: 99105.

13. 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 Mar;41(3):585-595.

14. Mahmoud, S., Attia, S., El Adalany, M., Ahmed, M. Accuracy of Optic Nerve Sheath Diameter Measurement as a Predictor of Intracranial Pressure in Traumatic Brain Injury. The Egyptian Journal of Hospital Medicine, 2021; 85(1): 3092-3097.

15. Srilekha A, Sharma R, Sasidharan S, Manalikuzhiyil B. Ultrasonographic measurement of optic nerve sheath diameter to detect raised intracranial pressure in adult head injury patients in the intensive care unit and its correlation with computed tomography scan findings. MRIMS J Health Sci. 2021;9:89–95

16. Aditya P, Kumar TL, Sivarajan AA, Yadav KR. Optic Nerve Sheath Diameter as a Predictor of Raised Intracranial Pressure Findings on Orbital Ultrasound. J Evol Med Dent Sci. 2023;12(8).

17. Kim DY, Kim SY, Hong DY, Sung BY, Lee S, Paik JH, et al. Comparison of ultrasonography and computed tomography for measuring optic nerve sheath diameter for the detection of elevated intracranial pressure. Clin Neurol Neurosurg. 2021;204:106609.

18. Kappagantu V, Sinha TP, Agrawal D, Jamshed N, Kumar A, Kumar A, et al. Diagnostic Accuracy of Ocular Ultrasonography in Identifying Raised Intracranial Pressure among Pediatric Population. Pediatr Neurosurg. 2023;58(3):142-9.

19. Yılmaz F, Sonmez BM, Kavalci C, Arslan ED, Caliskan G, Beydilli I. Efficacy of bedside optic nerve sheath diameter measurement in differentiating provoked seizure from unprovoked seizure in the emergency department. Ann Saudi Med. 2023;43(1):42-9.

20. Şık N, Ulusoy E, Çitlenbik H, Öztürk A, Er A, Yılmaz D, et al. The role of sonographic optic nerve sheath diameter measurements in pediatric head trauma. J Ultrasound. 2022;25(4):957-63.

21. Gurav S, Zirpe K, Bhoyar A, Deshmukh A, Pote P, Kapse U, et al. Utility of Bedside Ultrasound Measurement of Optic Nerve Sheath Diameter as a Screening Tool for raised Intracranial Pressure in Neurocritical Care Prospective Observational Study. J Assoc Physicians India. 2023;71(7):11-2.

22. Huo SC, Gibbons RC, Costantino TG. Utility of Point-of-Care Ultrasound in the Diagnosis of Idiopathic Intracranial Hypertension in the Emergency Department. J Emerg Med. 2021;60(2):210-5.

23. Bardak Ş, Berksoy E, Çiçek A, Demir G, Pekçevik Y, Elibol P, et al. Variability of the optic nerve sheath diameter on brain computed tomography in Turkish children based on sex and age. Childs Nerv Syst. 2023;39(12):3551-60.