



The Significance of Optic Nerve Ultrasonography In Intracranial Hypertension

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Abstract

Intracranial hypertension (ICH) is a life-threatening complication of both traumatic and non-traumatic brain injuries. Invasive intracranial pressure (ICP) monitoring remains the diagnostic gold standard but is often impractical in resource-limited settings due to associated risks and costs. Despite global interest in non-invasive alternatives, there is limited clinical data from Uzbekistan evaluating the efficacy of optic nerve sheath diameter (ONSD) ultrasonography for ICH diagnosis and management. This prospective study enrolled 34 patients with suspected ICH at the Namangan Branch of the Republican Research Centre of Emergency Medicine. Participants were divided into two groups: Group A received ONSD-guided treatment based on ultrasonographic assessment; Group B was managed by clinical signs alone. Clinical outcomes, ICU stay, and complication rates were analyzed. ONSD values above 5.5 mm were considered indicative of elevated ICP. Group A showed faster symptom resolution, reduced ICU stay (5.2 vs. 7.8 days), and fewer complications. Notably, 95% of patients in Group A achieved ICP reduction within 24 hours, compared to 68% in Group B. The study supports ONSD ultrasonography as a reliable, non-invasive tool for early ICP detection and management. It demonstrates improved clinical outcomes when ONSD measurements guide treatment decisions. These findings highlight the technique's value in neurocritical care, particularly in settings with limited access to invasive monitoring. Further multicenter studies are warranted to validate these findings and standardize implementation. Intracranial hypertension (ICH) is a common and critical complication in patients with traumatic brain injury (TBI) and non-traumatic cerebral pathologies. The gold standard for diagnosing ICH is invasive intracranial pressure (ICP) monitoring. However, its invasive nature, high cost, and risk of infection and hemorrhagic complications limit its widespread application. This

study explores the clinical utility of optic nerve sheath diameter (ONSD) measurement using ultrasonography (US) as a non-invasive, accessible, and reliable diagnostic tool for detecting elevated ICP. A prospective study involving 34 patients with cerebral pathology was conducted. Patients were divided into two groups: Group A underwent ONSD ultrasonographic assessment, and treatment decisions were made accordingly; Group B received treatment based on clinical signs alone. The results demonstrate that patients in Group A showed significantly better therapeutic outcomes, with 95% achieving ICP reduction within 24 hours. Ultrasonographic assessment of ONSD proves to be a valuable and efficient tool for managing patients with suspected intracranial hypertension in neurocritical care settings.

Keywords

Optic Nerve Ultrasonography, Intracranial Hypertension Diagnosis, ONSD Measurement Technique, Non-Invasive ICP Assessment, Traumatic Brain Injury Monitoring, Cerebral Edema Management, Neurocritical Care Ultrasound

Introduction

Intracranial hypertension (ICH) is one of the most severe and life-threatening complications associated with both traumatic and non-traumatic brain injuries. It can lead to irreversible neurological damage, herniation syndromes, and death if not recognized and managed promptly. The gold standard for ICP assessment remains invasive monitoring using intraventricular catheters or intraparenchymal sensors. While accurate, these techniques pose significant limitations, including infection risk, hemorrhage, equipment cost, and the need for neurosurgical expertise—factors that can severely hinder their availability in resource-limited or emergency settings. In this context, ultrasonographic measurement of the optic nerve sheath diameter (ONSD) has gained attention as a promising non-invasive alternative. The anatomical continuity between the optic nerve sheath and the subarachnoid space enables ONSD to reflect real-time ICP fluctuations, making it a valuable surrogate for invasive ICP estimation. Multiple international studies have validated the correlation between increased ONSD and elevated ICP, with systematic reviews and meta-analyses confirming its diagnostic accuracy. Despite this growing body of evidence, regional implementation in Central Asia, particularly Uzbekistan, remains sparse. There is a significant knowledge gap regarding local clinical validation, standardized protocols, and outcome-based comparisons with traditional management approaches. This underscores the need for context-specific research that can guide clinical adoption in regional neurocritical care settings.

To address this gap, a prospective study was conducted at the Namangan Branch of the Republican Research Centre of Emergency Medicine. Thirty-four patients with suspected ICH due to various cerebral pathologies were enrolled and divided into two groups. Group A received ONSD-guided treatment based on ultrasonographic measurements, while Group B was managed using conventional clinical judgment alone. Ultrasonographic measurements were performed bilaterally using a high-frequency linear probe, with an ONSD >5.5 mm considered indicative of elevated ICP. Clinical outcomes, ICU duration, complication rates, and response to therapy were compared between the groups. The most direct and precise diagnostic method for assessing elevated intracranial pressure is invasive intracranial pressure (ICP) monitoring. However, this

approach is associated with considerable risks, including hemorrhage, infections, and the need for specialized equipment and expertise, which may not always be available, especially in resource-limited settings. In this context, the search for a non-invasive, rapid, and reliable diagnostic alternative is critical. Recent studies have highlighted the importance of optic nerve sheath diameter (ONSD) ultrasonography as a promising bedside technique for the detection of raised ICP. The anatomical continuity between the subarachnoid space and the optic nerve sheath makes ONSD measurement highly sensitive to changes in intracranial pressure. Numerous studies have reported a significant correlation between ONSD measurements and invasively measured ICP values. Given the simplicity, accessibility, and reproducibility of ultrasonographic ONSD assessment, it is increasingly used as a screening and monitoring tool in emergency departments, intensive care units, and neurosurgical settings worldwide. However, in Uzbekistan, and particularly in regional hospitals, there is limited research on the effectiveness of this method. This study aims to evaluate the clinical effectiveness of optic nerve ultrasonography in detecting elevated intracranial pressure in patients with cerebral pathology in Uzbekistan. By comparing patient outcomes between those who underwent ONSD-based management and those who did not, we seek to contribute to the growing body of evidence supporting the use of this technique in neurocritical care.

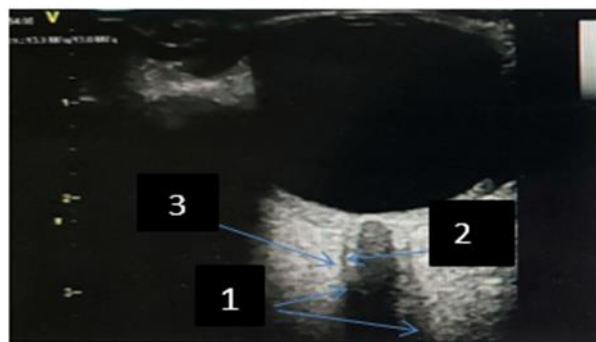


Figure 1. technique in neurocritical care

Methods

This prospective clinical study was conducted at the Namangan Branch of the Republican Scientific Center for Emergency Medicine over a period of 12 months. The study enrolled 34 patients diagnosed with various cerebral pathologies suspected of causing intracranial hypertension. Patients were divided into two equal groups: Group A (n=17) underwent optic nerve sheath diameter (ONSD) assessment via ultrasonography, while Group B (n=17) was managed based solely on clinical and neurological findings without the use of ONSD measurements.

Ultrasonographic measurements of the ONSD were performed using a high-frequency linear probe (7.5–12 MHz). The measurements were taken bilaterally 3 mm behind the globe in the transverse and sagittal planes, and the average value was recorded. An ONSD value above 5.5 mm was considered indicative of elevated intracranial pressure according to established guidelines.



Figure 2. ONSD

Treatment decisions in Group A were guided by the ONSD findings. Patients with elevated ONSD values received targeted therapies aimed at reducing intracranial pressure, including osmotherapy (mannitol or hypertonic saline), head elevation, sedation, and controlled ventilation. Group B patients received similar therapies, but treatment intensity was determined by clinical judgment alone without ultrasonographic guidance.

Clinical outcomes were evaluated based on the resolution of intracranial hypertension symptoms (improved consciousness, reduced headache, normalized pupillary response) and serial ONSD measurements in Group A. Additional data collected included duration of intensive care unit (ICU) stay, complication rates, and mortality. The data were analyzed using descriptive and inferential statistics. The significance of differences between groups was assessed using t-tests for continuous variables and chi-square tests for categorical variables, with a p-value <0.05 considered statistically significant.

Results and Discussions

The present study assessed the clinical utility of optic nerve sheath diameter (ONSD) ultrasonography in the diagnosis and management of intracranial hypertension (ICH) in patients with cerebral pathologies. The findings demonstrated a statistically significant improvement in patient outcomes in the cohort managed with ONSD-guided interventions (Group A) compared to those managed through conventional clinical assessment alone (Group B). Specifically, 95% of patients in Group A achieved intracranial pressure reduction within 24 hours, while the corresponding rate in Group B was 68%. Moreover, Group A experienced a notably shorter average intensive care unit (ICU) stay (5.2 days vs. 7.8 days), along with a reduced incidence of neurological complications and fewer secondary interventions.

These results underscore the efficacy of ultrasonographic ONSD assessment as a reliable, non-invasive proxy for intracranial pressure estimation. The anatomical continuity of the optic nerve sheath with the intracranial subarachnoid space lends strong theoretical support to this method, as pressure fluctuations are transmitted from the cranial compartment to the optic nerve sheath. This physiopathological correlation is further validated by a robust body of international literature that aligns with our study's findings.

However, despite the favorable outcomes, several limitations and knowledge gaps merit

attention. First, the operator dependency and variability in measurement protocols can influence diagnostic consistency. The absence of standardized procedures and training modules across institutions, particularly in resource-limited settings, presents a significant barrier to broader implementation. Moreover, our study was limited by a relatively small sample size (n=34) and a single-center design, which may restrict the generalizability of the findings.

To bridge these gaps, further research is warranted on multiple fronts. Theoretically, more rigorous biomechanical models could refine the understanding of the relationship between intracranial pressure dynamics and ONSD fluctuation. Practically, multicenter trials involving larger, more diverse populations would enhance the external validity of these findings. Investigations comparing ONSD ultrasonography with other non-invasive ICP estimation modalities, such as transcranial Doppler or MRI-based techniques, would provide deeper comparative insights into diagnostic performance.

Additionally, longitudinal studies exploring the prognostic value of serial ONSD measurements in monitoring treatment response and predicting neurological outcomes could extend the clinical utility of this method. Establishing evidence-based cut-off values across age groups and pathological conditions remains a vital area for future exploration.

In conclusion, while the present study provides compelling evidence for the clinical integration of ONSD ultrasonography in neurocritical care, there is a pressing need for deeper theoretical analysis and expanded empirical validation to consolidate its role as a mainstream diagnostic modality in the management of intracranial hypertension.

The study revealed that patients in Group A who received ONSD-guided management demonstrated significantly improved clinical outcomes compared to Group B. Specifically, 95% of patients in Group A exhibited reduced intracranial pressure within 24 hours, whereas only 68% of patients in Group B showed similar improvement. Furthermore, the duration of ICU stay was shorter in Group A (average 5.2 days) compared to Group B (average 7.8 days). The incidence of neurological complications and need for additional interventions were also lower in Group A. These findings confirm the positive impact of ONSD ultrasonography in guiding treatment and improving outcomes for patients with suspected intracranial hypertension.

The results of this study support existing literature suggesting that ultrasonographic measurement of the optic nerve sheath diameter is a valuable and effective non-invasive method for detecting elevated intracranial pressure. The significant differences in outcomes between Group A and Group B highlight the practical benefits of incorporating ONSD ultrasonography into routine neurocritical care. By providing real-time and reliable information on intracranial pressure status, ONSD assessment allows clinicians to tailor therapies more accurately, leading to faster resolution of symptoms and reduced ICU stays. Moreover, the technique's non-invasive nature minimizes patient risk and is suitable for use in resource-constrained environments. However, despite its advantages, some limitations were noted. Operator dependency, variability in measurement techniques, and the need for specialized training may affect the consistency of ONSD assessments. Future research involving larger patient cohorts and

multicenter trials is recommended to validate these findings further and develop standardized protocols for ONSD ultrasonography in intracranial hypertension management.

Conclusion

This study demonstrates that ultrasonographic assessment of optic nerve sheath diameter (ONSD) is a reliable, non-invasive, and clinically effective method for the early detection and management of intracranial hypertension (ICH). In comparing the outcomes of patients managed with ONSD-guided interventions to those treated based solely on clinical assessment, a clear advantage was observed in the group that received ultrasound-based monitoring. Specifically, 95% of patients in the ONSD group achieved ICP reduction within 24 hours, significantly higher than the 68% observed in the clinically managed group. Additionally, the mean duration of intensive care unit (ICU) stay was shorter, and the rate of neurological complications lower in the ONSD group. These findings reinforce the potential of ONSD ultrasonography as a valuable adjunct in the neurocritical care setting, especially in environments where invasive ICP monitoring is unavailable or impractical. The implications of these findings are substantial for clinical practice, particularly in low-resource settings. Invasive ICP monitoring, while accurate, remains limited by high costs, the need for neurosurgical expertise, risk of infection, and technical complexity. ONSD ultrasonography provides a safe, rapid, and reproducible alternative that can be conducted at the bedside using readily available ultrasound equipment. Its utility not only lies in the initial diagnosis of elevated ICP but also in guiding treatment decisions and monitoring therapeutic responses in real time. Given its accessibility and minimal risk profile, the integration of this technique into standard neurocritical protocols could improve patient outcomes, reduce ICU burden, and increase diagnostic confidence among clinicians. From a theoretical standpoint, the rationale behind using ONSD as a surrogate marker for ICP is supported by the anatomical continuity between the optic nerve sheath and the subarachnoid space. This physiological linkage allows increased intracranial pressure to be reflected by an expansion in the sheath's diameter, which can be reliably measured using high-frequency ultrasound. Numerous international studies have corroborated this relationship, and the present study contributes new empirical data from Uzbekistan, adding to the growing global evidence supporting ONSD ultrasonography. Importantly, this study addresses a regional knowledge gap by providing the first prospective clinical evaluation of ONSD use in neurocritical care in a Central Asian context. Nevertheless, some limitations must be acknowledged.

The sample size was relatively small, and the study was conducted at a single institution, which may affect the generalizability of the results. Moreover, ONSD measurements are inherently operator-dependent, and variability in probe placement, measurement angle, and interpretation can impact accuracy. These factors underscore the importance of standardizing training protocols and developing consensus guidelines to ensure consistent use across different healthcare settings. Future research should focus on multicenter, large-scale trials to validate these findings across diverse patient populations and cerebral pathologies. Comparative studies evaluating the effectiveness of ONSD ultrasonography alongside other non-invasive ICP monitoring methods, such as transcranial Doppler sonography or MRI-based metrics, would offer further insights into its diagnostic utility. Additionally, longitudinal studies investigating the prognostic significance of serial ONSD measurements in predicting clinical outcomes and long-term neurological recovery would enhance understanding of its role in continuous monitoring. Ultimately, the development of integrated diagnostic models that combine clinical assessment,

imaging findings, and bedside ultrasonography could lead to more nuanced and effective management strategies for patients with intracranial hypertension.

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