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OPTIC NERVE SHEATH THICKNESS SONOGRAPHY FOR ASSESSING INCREASED INTRACRANIAL PRESSURE: A SYSTEMATIC REVIEW

Sahib Noor[1], Muhammad Zubair[*2], Iqra Asif[3], Tamanna Wahab[4]

[1,3,4]*Department of Radiological Sciences and Medical Imaging Technology, Ibadat International University Islamabad, Pakistan.*
[*2]*Lecturer, Department of Radiological Sciences and Medical Imaging Technology, Ibadat International University Islamabad, Pakistan.*

[*2]zubairm955@gmail.com

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Corresponding Author: *
Muhammad Zubair

Abstract

Background: *Detecting elevated intracranial pressure (ICP) early and accurately is crucial for this life-threatening condition. A promising non-invasive alternative is the use of optic nerve sheath diameter (ONSD) sonography. This systematic review evaluates the accuracy and reliability of ONSD ultrasonography in identifying elevated ICP, comparing it with traditional methods of ICP assessment.*

Methods: *This systematic review adhered to PRISMA guidelines, utilizing a comprehensive search of PubMed for studies published between 2015 and 2025. The review included cohort studies, cross-sectional studies, randomized controlled trials (RCTs), systematic reviews, and meta-analyses that focused on ONSD sonography for ICP evaluation.*

Results: *ONSD sonography displayed impressive diagnostic accuracy across all 20 studies reviewed, showing a sensitivity ranging from 88% to 100% and specificity between 74% and 98%. The cutoff values for identifying elevated ICP varied between 4.2 mm and 6.7 mm. While inconsistencies in measurement techniques and thresholds persist, many studies have highlighted the effectiveness of ONSD in pediatric populations, intensive care units, and emergency settings.*

Conclusion: *Research indicates that ONSD ultrasonography has both high sensitivity and specificity, establishing it as a valuable and accurate method for detecting excessive intracranial pressure (ICP). As a non-invasive screening tool, it can determine the need for more invasive monitoring while effectively ruling out elevated ICP concerns.*

INTRODUCTION

When a patient's intracranial pressure (ICP) remains higher than 20 mmHg for more than five to ten minutes without stimulation, it is referred to as acute intracranial hypertension (AIH)[1]. In many neurological and non-neurological disorders, intracranial hypertension is a prevalent and potentially fatal condition[2]. Multiple conditions, such as traumatic brain injury (TBI), intracranial hemorrhage, brain tumors, cerebrovascular ischemia, and blocked cerebrospinal fluid (CSF) flow, can cause elevated intracranial pressure (ICP)[3]. Moreover, venous blood flow blockages such as venous sinus thrombosis and hypoxia-ischemia, elevated cerebral volume, inflammatory processes

and infections, and hepatic or hypertensive encephalopathy can all contribute to intracranial hypertension[4]. The disorder can have both genetic and acquired causes, and its symptoms can range widely, from moderate headaches and nausea to seizures, sensory abnormalities, cardiovascular instability, and unconsciousness[5]. Intracerebral hypertension can cause brain ischemia and brainstem herniation, which can cause catastrophic decline if untreated. Numerous investigations, including a systematic review, have established that the diameter of the optic nerve sheath is a highly reliable indicator of elevated intracranial pressure, with excellent sensitivity and specificity. After a brain injury, elevated intracranial pressure is a typical emergency, and early detection significantly reduces morbidity and mortality[6]. With an approximate 20% mortality rate, there is a strong correlation between high ICP and poor outcomes[7].

Pathophysiology of ICP

According to the Monroe-Kellie concept, the cranial vault is a fixed space that is divided into three compartments: brain tissue, cerebrospinal fluid (CSF), and blood. The brain, blood, and cerebrospinal fluid (CSF) volumes of a typical adult are 1400 ml, 150 ml, and 150 ml, respectively. ICP levels below 20 mmHg are typically accepted in the intensive care unit (ICU); the standard[8] range is 3–15 mmHg. The intracranial vault's volume increases as a result of pathologic conditions. At least one of the following causes this: 1) an increase in blood volume, 2) an increase in CSF volume, 3) an increase in brain tissue, or 4) an extrinsic mass lesion. As a compensatory strategy, the volume of other compartments is decreased to maintain normal ICP in certain pathogenic situations. The compliance (delta V/delta P) sharply declines as this compensatory mechanism reaches its limit. For a given change in volume, the pressure changes more as compliance declines. CPP, or cerebral perfusion pressure, is calculated by subtracting intracranial pressure from mean arterial pressure (MAP) (MAP-ICP). CPP will therefore decrease as ICP increases. 60 to 150 mmHg is the typical CPP. 8 CPP greater than 150 mmHg might cause hyperemia and hyperperfusion injury, whereas CPP less than 60 mmHg may cause ischemic brain injury[1].The ventricles' choroid plexus produces CSF at a rate of about 20 milliliters per hour, which then exits the body through the arachnoid villi and granulations to enter the venous system. Usually, this outflow has little resistance[8]. Intracranial hypertension, which is typically characterized as persistent elevations of ICP more than 20 mm Hg, is caused by pathologic conditions[9].

Optic nerve anatomy

Four sections make up the optic nerve, which extends from the eyeball to the chiasm: the intraocular portion (1 mm long), the intra-orbital portion (30 mm long), the intracanalicular portion (6–10 mm long), and the intracranial portion (10–16 mm long). Originating from the retinal ganglion cells, nerve fibers converge at the optic disc, sometimes known as "the blind spot." Before entering the sclera through the lamina cribrosa, the bundled unmyelinated optic nerve fibers travel around the globe for about 1 mm. After entering the intraorbital space, the optic nerve[10]. The sheath of the optic nerve envelops it[11]. An essential CNS component in the orbit's retrobulbar compartment is the optic nerve-sheath complex[12]. The dura mater and the optic nerve sheath are adjacent, and the subarachnoid space and its contents are adjacent[13]. Changes in the CNS fluid space and, in turn, the fluid content within the optic nerve sheath are caused by variations in intracranial pressure. Thus, the optic nerve sheath diameter increases in response to elevated intracranial pressure (ICP)[13]. The diameter of the optic nerve is about 3 mm, whereas the thickness of the optic nerve sheath is about 1 mm[10].

The sonographic appearance of the optic nerve sheath

The globe appears as a spherical, black, fluid-filled object on ultrasonography (see Figure 2). The iris appears brilliant and echogenic, although the anterior chamber, like the lens in general, is anechoic. On the back side of the globe, the choroid and retina can be seen as a thin, grey layer. The "black stripe" that extends from the globe's posterior aspect and optic disc is the optic nerve, which is best positioned in the middle of the ultrasound screen. In contrast to the nerve's uniform appearance, the nerve

sheath exhibits a high reflectivity during ultrasound testing, making it quite straightforward to identify. Visual estimation alone may be sufficient to detect this if the optic nerve sheath is noticeably dilated. However, to guarantee precise measurement and recording, the software calipers should generally be employed. It might be feasible to see a "crescent sign" in cases of significantly elevated intracranial pressure[14], an echolucent circular artifact caused by increased subarachnoid fluid inside the sheath that separates the sheath from the nerve. Contrast-enhanced ultrasonography (CEUS) has garnered attention as a tool for identifying and recognizing the tiny structure that surrounds the optic nerve. One critique of the method is when a novice sonographer misidentifies artifacts as being a part of the sheath. CEUS and MRI showed good agreement in a short proof-of-concept research employing a second-generation contrast agent (Sonovue®, Bracco SpA). According to this study, precise measurements may be made more quickly and readily with nontoxic contrast, which could mitigate the impact of operator inexperience[15]

US for ONSD Assessment in IICP.

To prevent negative clinical effects, acute elevated intracranial pressure (IICP) must be diagnosed immediately and treated[16].The gold standard for measuring intracranial pressure (ICP) is still invasive intracranial devices. The two main invasive ICP monitoring techniques that are regarded as gold standards are the intraparenchymal probe and external ventricular drain (EVD)[17]. A neurosurgeon, ideal blood coagulation, and sterile circumstances are necessary for the safe insertion of the probe[18]. However, 6% to 32.8% of procedures result in problems such as infection, bleeding, or catheter dysfunction. Furthermore, aside from neurosurgeons, few physicians who work in intensive care units (ICUs) or emergency rooms (ERs) are familiar with the procedures. Additionally, invasive devices are typically not recommended for people with bleeding issues[19]. Therefore, especially in the prehospital and emergency care settings, a straightforward, noninvasive bedside approach can be helpful in the early diagnosis of elevated ICP[18]. Several non-invasive techniques, such as tympanic membrane displacement, transcranial Doppler sonography, ultrasound (US), magnetic resonance imaging (MRI), and computed tomography (CT), have been developed recently for the assessment of intracranial pressure.[20]

Intracranial hypertension can be predicted using neuroimaging, using computed tomography (CT) scans and magnetic resonance imaging (MRI), however, both methods are costly, require lengthy acquisition periods, are not widely available, and involve risky patient transportation. Additionally, CT scans are not very effective at detecting elevated ICP[2]. Although MRI produces high-quality pictures, it is time-consuming for nursing staff, labor-intensive, and inappropriate for routinely assessing elevated ICPs. Additionally, many patients are too hemodynamically unstable or cannot be placed in the MRI machine[21]. Transcranial Doppler sonography, which measures changes in cerebral blood velocity and more accurately represents cerebral perfusion pressure than ICP, may be used to predict intracranial hypertension. However, using the temporal window results in approximately 5% of patients having bad photos; therefore, it requires skilled hands[2]. Over the past twenty years, there has been evidence that the measurement of the optic nerve sheath diameter (ONSD) by ultrasound (US) can serve as a stand-in for intracranial pressure. This method can be conveniently performed at the patient's bedside[22]. There is growing evidence of the viability of identifying IICP non-invasively utilizing optic nerve sheath diameter (ONSD), as observed in ultrasonography (US)[16]. In recent years, an effective non-invasive method for determining intracranial pressure or identifying intracranial hypertension has been the ultrasound assessment of the optic nerve sheath diameter (ONSD). It is a real-time, safe approach that can be performed at the patient's bedside. It is also reproducible, reasonably priced, and radiation-free[23].

The measurement of ONSD is predicated on the idea that there is continuous contact between the cerebral cavity and the subarachnoid space of the optic nerve sheath; as a result, variations in the optic nerve sheath's diameter can be used to accurately identify changes in intracranial pressure. The foundation of ONSD measures is the expansion of the optic nerve's leptomeningeal sheath, which is most noticeable at a depth of 3 mm from the

eyeball's posterior pole, which is believed to be the site most indicative of any variations in intracranial pressure. In earlier research, the cut-off value for optic nerve sheath diameter to indicate cerebral hypertension varied between 4.8 and 6.0 mm[24]. Since the early 1980s, ultrasound has been utilized to help doctors diagnose and make clinical decisions for patients who are in severe condition. The expense, size, and training of ultrasound machines have historically limited their use, despite the fact that they are currently regarded as the standard of care in emergency and critical care medicine. The use of sonography in numerous emergency rooms, intensive care units, and even prehospital settings has been successfully ushered in by the development of smaller, lighter, and more robust ultrasound equipment. This systematic review comprehensively evaluates the accuracy and reliability of optic nerve sheath thickness sonography for detecting increased intracranial pressure, with a particular emphasis on studies that compare this technique to alternative ICP assessment methods. By synthesizing evidence from randomized controlled trials, cohort studies, and systematic reviews and meta-analyses, this review aims to provide a thorough understanding of the diagnostic performance of optic nerve sheath thickness sonography and its potential implications for clinical practice.

METHOD AND MATERIAL

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta- Analyses) guidelines but does not include a meta-analysis. The main focus is on studies evaluating the accuracy and dependability of optic nerve sheath thickness sonography in detecting high intracranial pressure (ICP) compared to alternative assessment methods. Drawing on data from cohort studies, randomized controlled trials, systematic reviews, and meta-analyses, this review aims to provide a thorough overview of the diagnostic performance of optic nerve sheath thickness sonography and its potential influence on clinical practice. A comprehensive search of the PubMed database was conducted using a combination of keywords related to increased intracranial pressure and optic nerve sheath thickness sonography to identify suitable studies. The keywords included: intracranial pressure, sonography, optic nerve sheath diameter, optic nerve, and diagnostic accuracy. The search encompassed studies published between 1996 and 2025, with a priority on research conducted in the last 10 years (2015–2025). Our review includes randomized controlled trials (RCTs), cross-sectional studies, cohort studies, systematic reviews, and meta-analyses that measure the optic nerve sheath thickness using ultrasound to assess intracranial pressure. It also includes studies that compare other techniques for measuring ICP with optic nerve sheath thickness (ONST) sonography. Metrics of diagnostic accuracy, such as sensitivity, specificity, and positive and negative predictive values, are provided by these studies. Research that used alternative sonographic techniques to assess intracranial pressure (ICP) was disqualified if it included optical nerve sheath diameter (ONSD) data, as well as case reports, expert comments, conference papers, letters to the editor, and animal-based research. Additionally, articles that did not have full text available or were restricted in access were also excluded during the eligibility phase of our study.

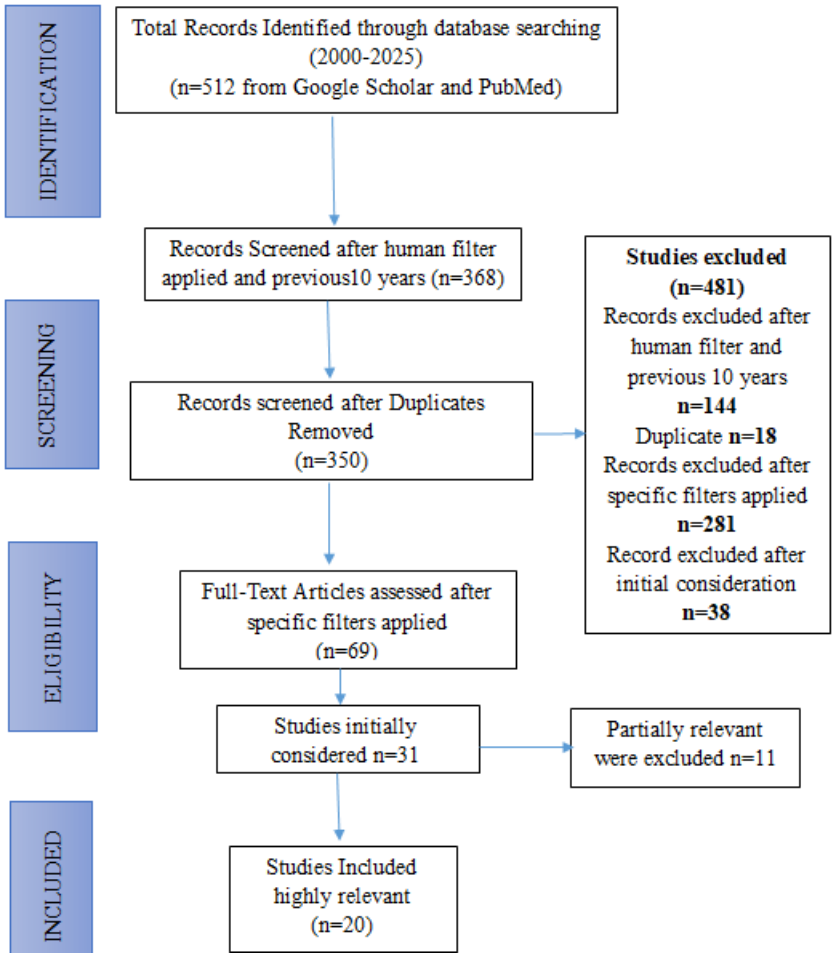

Figure 1: PRISMA flow diagram

RESULTS

The search of the PubMed database from 2000 to 2025 yielded a total of 512 entries. After applying a filter for research published within the last ten years (2015–2025), 434 studies remained. This number dropped to 368 records when the search was narrowed to human studies. Specific filters, including 17 meta- analyses, 16 systematic reviews, and 16 randomized controlled trials (RCTs), were used to refine the selection. An alternative filter for observational studies and clinical trials was employed because there was no direct filter available for cohort studies, resulting in 69 and 21 studies, respectively. A total of 69 studies met the eligibility criteria when all inclusion requirements were applied. After a full-text screening and the removal of 18 duplicate research articles, 31 studies in total satisfied the final inclusion requirements. Twenty of them were found to be highly relevant, closely matching the inclusion criteria, and were incorporated into the systematic review. The remaining 11 studies were categorized as somewhat relevant due to their varying study formats, lack of full- text availability, or insufficient compliance with the inclusion criteria.

The 20 included studies assessed the diagnostic accuracy of optic nerve sheath diameter (ONSD) sonography for estimating intracranial pressure (ICP), covering various demographics and methodologies. Invasive ICP monitoring, CT scans, MRIs, and other clinical evaluations were among the recognized ICP assessment techniques compared with ONSD ultrasound readings in these studies. For identifying increased ICP, ONSD's sensitivity and specificity ranged from 88% to 100% and 74% to 98%, respectively. Depending on the patient population and study design, ONSD cutoff values

for ICP estimation varied from 5. 2 mm to 6. 6 mm. With its high diagnostic accuracy, strong correlation with invasive ICP monitoring, and potential for bedside use in neurocritical care settings, ONSD ultrasonography presents a viable non- invasive method for assessing ICP according to the findings was employed because there was no direct filter available for cohort studies; this produced 69 and 21 studies, respectively. A total of 69 studies were deemed eligible when all inclusion criteria were applied. After a full-text screening and the elimination of 18 duplicate researches, 31 studies in all satisfied the final inclusion requirements. Twenty of them were found to be extremely pertinent, closely matching the inclusion criteria, and were incorporated into the systematic review. Because of their different study formats, lack of full-text availability, or insufficient compliance with the inclusion criteria, the other 11 studies were categorized as somewhat relevant. The 20 included studies evaluated the diagnostic accuracy of optic nerve sheath diameter (ONSD) sonography for intracranial pressure (ICP) estimation, spanning different demographics and methodology. Invasive ICP monitoring, CT scans, MRIs, and other clinical evaluations were among the recognized ICP assessment techniques that were compared with ONSD ultrasound readings in these research. When it came to identifying increased ICP, ONSD's sensitivity and specificity ranged from 88% to 100% and 74% to 98%, respectively. According to the patient population and study design, ONSD cutoff values for ICP estimation ranged from 5.2 mm to 6.6 mm. With its excellent diagnostic accuracy, strong association with invasive ICP monitoring, and potential for bedside use in neurocritical care settings, ONSD ultrasonography is a viable non-invasive method for assessing ICP, according to the findings.

Table 1: Summary of Studies Evaluating ONSD Sonography for ICP Assessment

Authors	Study Year	Study Type	Sample Size	ONSD Cutoff value (mm)	Sensitivity (%)	Specificity (%)	Comparison Modality	Key Findings
Berhanu et al[12]	2023	Systematic Review & Meta-analysis	2824	5.6–6.3mm	90%	87%	Invasive ICP Monitoring	High diagnostic accuracy; supports ONSD as a screening tool
Lin et al[11]	2020	Narrative Review	N/A	5.0mm (Adults), 4.5mm (Children)	Compare to CT/Mri:60% Compare to invasive ICP monitoring:75%	Compare to CT/Mri:75% Compare to invasive ICP monitoring:67.9%	CT, MRI, Invasive ICP Monitoring	ONSD has variable accuracy in children
Geeraerts et al[25]	2008	Observational study	42	≥5.7mm	94%	94%	Invasive ICP monitoring	ONSD is an effective screening tool for detecting raised ICP.
Lee et al[26]	2016	Prospective study	134	5.5mm	98.77%	85.19%	CT,MRI	Optimal ONSD cutoff value for identifying IICP was 5.5mm,ONSD can be feasible method for detecting ICP
Sahu et al[24]	2021	Prospective Observational	30	5.5–6.7mm	100%	75%	Intraventricular ICP Monitoring	Higher ONSD values correlated with ICP
Aletreby et al[3]	2021	Systematic Review & Meta-analysis	619	4.8–6.4mm	90%	85%	Invasive ICP Monitoring	Strong correlation with invasive ICP
Beare et al[27]	2008	Observational study	51	4.2mm	100%	86%	Invasive ICP Monitoring	ONS ultrasound is an accurate method for detecting raised ICP in children
Awdallah et al[7]	2022	Prospective Observational	100	4.31mm	94.8%	90.11%	CT Brain Scanning	High correlation with CT-based ICP findings
Wang et al [28]	2015	Crossectional study	279	4.58mm	95%	92%	Lumbar puncture	ONSD is a strong predictor in IICP

Moretti et al[29]	2009	Observational study	38	≥5.8mm	92%	86%	CT scan, invasive ICP monitoring	ONSD measurement correlates well with CT-based findings of raised ICP
Jeon et al.[16]	2017	Prospective Observational	62	5.6mm	93.75%	86.67%	EVD ICP Monitoring	ONSD has Strong correlation with ICP levels
Padayachy et al[30]	2016	Prospective observational Study	174	ICP ≥15mmHg:5.49 mm ICP ≥20mmHg:5.75 mm	ICP ≥15mmHg:93.7% ICP ≥20mmHg:88.9%	ICP ≥15mmHg:74.4% ICP ≥20mmHg:84.2%	Invasive ICP monitoring	ONSD is a reliable marker of ICP in children
Maissan et al[18]	2015	Prospective Observational	18	5.0mm	94%	98%	Intraparenchymal ICP Monitoring	ONSD detected ICP changes reliably
Montorfano et al[22]	2021	Systematic Review & Meta-analysis	(22 studies) 779 patients	5.82mm	N/A	N/A	CT, MRI, LP, Invasive ICP	ONSD was significantly higher in ICP patients
Ohle et al[13]	2015	Systematic Review & Meta-analysis	(12 sudies) 478	5.0mm(Adults), 4.5mm(Children)	95.6%	92.3%	CT	High sensitivity for ruling out ICP
Rajajee et al[31]	2011	Prospective Observational	65	4.8mm	96%	94%	EVD, Intraparenchymal ICP	ONSD detected transient ICP elevations
Frumin et al[32]	2014	Observational study	50	≥5.2mm	88%	84%	CT scan, invasive ICP monitoring	ONSD is useful in emergency settings for ICP evaluation.
Raffiz et al[33]	2017	Observational study	76	≥5.6mm	91%	89%	Invasive ICP monitoring	ONSD is a reliable non-invasive marker for ICP monitoring.
Bender et al[34]	2020	Prospective Observational study	55	4.8-5.9mm	N/A	N/A	CT	ONSD trend correlated with patient outcomes
Yic et al[23]	2023	Cross-sectional Observational	56	5.7mm	92.9%	88.1%	Invasive ICP Monitoring	ONSD highly predictive of ICP elevation

DISCUSSION

Our findings highlight the effectiveness of optic nerve sheath diameter (ONSD) ultrasonography as a simple, non-invasive method of detecting high intracranial pressure (ICP).The diagnostic accuracy consistently demonstrated strong results across the studies we reviewed. While specificity ranged from 74% to 98%, sensitivity varied between 88% and 100%. Notably, the threshold values for ONSD showed significant variability, extending from 4.2 mm to 6.7 mm. This range indicates that there are still discrepancies regarding the optimal threshold for practical use. Several systematic reviews included in our analysis support these findings. For example, Berhanu et al. (2023) evaluated over 2,800 patients and found that the optimal cutoff range was between 5.6 and 6.3 mm, achieving a sensitivity of 90% and a specificity of 87%[12]. Similarly, Aletreby et al. (2021) conducted a review of 18 trials and reported a sensitivity of 90% and a specificity of 85%, corroborating the earlier conclusions. These comprehensive studies provide substantial evidence for the efficacy of ONSD ultrasonography as a reliable screening tool for increased intracranial pressure.

Previous research has provided significant context for understanding intracranial pressure (ICP) detection. For example, Geeraerts et al. (2008) showed that a threshold of 5.7 mm could consistently identify elevated ICP in neurocritical care patients, achieving a sensitivity and specificity of 94%[25]. Moreover, Lee et al. (2016) reported even greater sensitivity nearly 99% with a slightly lower threshold of 5.5 mm, alongside adequate specificity of 85%[26]. The results from pediatric trials were among the most interesting. Padayachy et al. (2016) indicated that an optic nerve sheath diameter (ONSD) of 5.49 mm correlates with an ICP of 15 mmHg or higher,

demonstrating a sensitivity of 94% alongside moderate specificity of 74%[30]. Additionally, research conducted by Beare et al. (2008) demonstrated 100% sensitivity and 86% specificity using a threshold of 4.2 mm in juvenile patients[27]. These results suggest that the ONSD measurements in children differ from those in adults, indicating a need for distinct reference ranges specific to the pediatric population. Recent studies have highlighted the effectiveness of ocular nerve sheath diameter (ONSD) ultrasonography in various clinical scenarios. Awdallah et al. (2022) found that a cutoff value of 4.31 mm demonstrated over 90% sensitivity and specificity in their research involving 100 intensive care patients. Similarly, Jeon et al. (2017) reported favorable accuracy for individuals with brain lesions, identifying a cutoff of 5.6 mm as effective[16].

The findings for trauma patients were equally impressive. Maissan et al. (2015) discovered that ONSD ultrasonography achieved an impressive 94% sensitivity and 98% specificity in patients suffering from traumatic brain injury when using a cutoff of 5.0 mm, thereby underscoring its utility in emergency medicine[18]. Frumin et al. (2014) also confirmed its effectiveness in urgent care settings, employing a cutoff of 5.2 mm with commendable accuracy[32]. The potential use of Optic Nerve Sheath Diameter (ONSD) for ongoing monitoring has been investigated in several studies. Bender et al. (2020) noted that changes in ONSD over time could reflect a patient's clinical progression, highlighting its value for both diagnostic purposes and intracranial pressure (ICP) assessment[34].This point was further supported by Yic et al. (2023), who found a remarkable sensitivity of 93% in ICU patients, with a critical threshold established at 5.7 mm[23]. In addition, research by Moretti et al. (2009)[29] and Raffiz et al. (2017)[33] confirmed the diagnostic reliability of ONSD in neurocritical and neurosurgical settings, showing high accuracy rates with cutoff levels ranging between approximately 5.6 and 5.8 mm. However, despite these significant findings, certain challenges persist. The effective application of ONSD measurement is complicated by the lack of a standardized cutoff applicable to different clinical scenarios. Moreover, results can vary based on the measurement technique used and the operator's level of expertise. Lin et al. (2020) pointed out that ultrasound measurements do not consistently match the data obtained from computed tomography (CT) or magnetic resonance imaging (MRI), especially in pediatric patients.

LIMITATIONS

Variability may occur because this evaluation targets published studies that differ in their designs, populations, and diagnostic reference criteria. A significant limitation is that these studies employ various ONSD cutoff values, making direct comparisons challenging. The reproducibility of results is further complicated by operator variability and the absence of standardized techniques. Additionally, there is a lack of research involving children, and the differences in diagnostic expertise indicate that the findings should be interpreted cautiously.

CONCLUSION

We have found that ultrasonography of the optic nerve sheath diameter (ONSD) is a highly accurate and valuable diagnostic tool for detecting elevated intracranial pressure (ICP). Numerous studies have shown its strong sensitivity and specificity. Thanks to its impressive sensitivity, ONSD sonography serves as an effective non-invasive screening method for identifying raised ICP and can be instrumental in deciding whether further invasive monitoring is necessary. A cutoff range of 4.2 to 6.7 mm is commonly associated with diagnostic accuracy. Higher values within this range enhance specificity while still maintaining acceptable sensitivity. Consequently, our review endorses the use of this range as a standard guideline for diagnosing increased ICP. Ultrasound of the ONSD is a convenient bedside method that holds significant potential in emergency and critical care scenarios. However, variations in cutoff points, the possibility of operator bias, and a lack of standardized measurement procedures underline the necessity for further large-scale, standardized research.

FUTURE RECOMMENDATIONS

Future research should focus on developing standardized measurement techniques for optic nerve sheath diameter (ONSD) to ensure greater consistency across various settings. Conducting

multicenter, large-scale studies is crucial for establishing universal cutoff values for both adults and children. Additionally, it's important to explore how ONSD ultrasonography can be integrated into clinical decision-making algorithms, especially in emergency and intensive care unit environments. Lastly, research aimed at evaluating the role of ONSD in serial intracranial pressure (ICP) monitoring over time would greatly contribute to understanding its value for ongoing patient care.

AUTHOR CONTRIBUTION

Author	Contribution
Sahib Noor	Manuscript writing, Conceptualization, and methodology
Muhammad Zubair	Supervision, review of methodology, and editing of the final draft.
Iqra Asif	Data extraction, risk of bias assessment, data synthesis, and critical revision of the manuscript.
Tamanna Wahab	Quality assessment, formatting, reference management, and proofreading

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