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Article

The Significance of Ultrasonographic Measurement of Optic Nerve Sheath Diameter in Assessing Cerebral Edema and Intracranial Hypertension in Neurocritical Care Patients

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Abstract: Cerebral edema and intracranial hypertension are among the life-threatening complications in critically ill neurological patients, and their timely detection and dynamic monitoring are of particular importance in neurocritical care. In cases where invasive intracranial pressure monitoring is unavailable or technically infeasible, the use of non-invasive methods becomes especially important. Ultrasonographic measurement of the optic nerve sheath diameter (ONSD) is considered a bedside method that allows indirect assessment of increased intracranial pressure. In this study, the optic nerve sheath diameter was assessed using ultrasonography in 50 patients treated in the neurocritical care unit, and the obtained findings were compared with brain computed tomography (CT) data. The study included patients aged 35–70 years. Of the 50 patients, 33 (66%) were male and 17 (34%) were female. The obtained clinical and instrumental data indicate that ultrasonographic assessment of the optic nerve sheath diameter may be useful for rapid bedside screening and dynamic monitoring of patients with suspected cerebral edema and intracranial hypertension, as well as a complementary method to CT examination.

Keywords: cerebral edema, intracranial hypertension, intracranial pressure, optic nerve sheath diameter, ultrasonography, computed tomography, neurocritical care

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1. Introduction

Cerebral edema may develop in various neurological and neurosurgical conditions, including traumatic brain injury, hemorrhagic and ischemic stroke, subarachnoid hemorrhage, brain tumors, and infectious diseases [1]. An increase in brain volume may lead to elevated intracranial pressure, reduced cerebral perfusion, and, in severe cases, brain displacement and herniation [2]. In neurocritical care, early detection of intracranial hypertension enables timely modification of patient management and treatment strategies [3]. Computed tomography (CT) provides important information regarding cerebral edema, midline shift, compression of the basal cisterns, and other radiological signs. However, repeated CT examinations during dynamic monitoring of critically ill patients are not always feasible [4].

From this perspective, ultrasonographic measurement of the optic nerve sheath diameter (ONSD) has attracted increasing interest as a convenient, rapid, non-invasive, and repeatable bedside method in neurocritical care settings. Scientific studies have demonstrated a significant association between ONSD and intracranial pressure [5]. Meta-analyses frequently report an ONSD threshold of approximately 5.0 mm for identifying

intracranial hypertension; however, no single universally accepted cut-off value has been established [6]. A meta-analysis published in 2025 reported that, among non-traumatic neurocritical care patients, ONSD ultrasonography demonstrated a pooled sensitivity of 92%, specificity of 90%, and an area under the receiver operating characteristic curve (AUC) of 0.925 for detecting intracranial hypertension [7]. These findings highlight the potential clinical value of this method for screening and dynamic monitoring of patients at risk of increased intracranial pressure [8].

AIM OF THE STUDY

The aim of the study was to investigate the diagnostic and practical significance of ultrasonographic measurement of the optic nerve sheath diameter (ONSD) in assessing cerebral edema and intracranial hypertension in neurocritical care patients and to evaluate its correlation with computed tomography (CT) findings [9].

2. Materials and Methods

The study included 50 patients treated in the neurocritical care unit.

Of the 50 patients, 33 (66%) were male and 17 (34%) were female. The patients ranged in age from 35 to 70 years.

All patients underwent clinical and neurological assessment as well as brain computed tomography (CT). CT examinations were evaluated for cerebral edema, midline shift, the condition of the basal cisterns, and other radiological signs suggestive of intracranial hypertension.

The optic nerve sheath diameter was assessed ultrasonographically through the closed eyelid. ONSD measurements were performed approximately 3 mm posterior to the optic disc. Measurements obtained from both eyes were compared with the patients' clinical findings and CT data.

According to the literature, ONSD values of approximately 5.0 mm or greater in adults are commonly used as a threshold indicating an increased likelihood of elevated intracranial pressure. However, this value should not be considered an independent or definitive diagnostic criterion and should be interpreted in conjunction with clinical and other instrumental findings.

3. Results

Of the 50 patients included in the study, 33 were male and 17 were female. The patients ranged in age from 35 to 70 years, with middle-aged and older neurocritical care patients predominating in the study group [10].

The optic nerve sheath diameter (ONSD) was assessed using ultrasonography, and the obtained measurements were compared with brain computed tomography (CT) findings. Increased ONSD was particularly relevant in patients who demonstrated radiological signs of cerebral edema and intracranial hypertension on CT [11]. An important practical aspect of the study was that ONSD ultrasonography could be performed directly at the bedside without transferring the patient from the neurocritical care unit and could be repeated when necessary for dynamic monitoring. CT, however, remains an important reference imaging modality for assessing cerebral edema and its morphological consequences [12].

A systematic review published in 2025 reported an overall agreement between ONSD measurements obtained by ultrasonography and CT. Analysis of data from eight studies involving 273 patients revealed no statistically significant mean difference between the two measurement methods [13].

Furthermore, changes in ONSD may be associated with the dynamics of the clinical condition in neurocritical care patients. A prospective study published in 2024 reported that an ONSD cut-off value of 5.23 mm demonstrated 82% sensitivity and 78% specificity for predicting intracranial hypertension [14].

4. Discussion

The obtained findings, together with an analysis of the current literature, indicate that ultrasonographic assessment of the optic nerve sheath diameter (ONSD) may serve as an additional non-invasive tool for the early detection of intracranial hypertension in neurocritical care [15].

The main advantages of this method include rapid examination, the possibility of performing the assessment directly at the patient's bedside, the absence of ionizing radiation exposure, and its suitability for repeated measurements during dynamic monitoring. However, ONSD measurements may be influenced by operator experience, ultrasound equipment and measurement protocols, as well as individual anatomical characteristics of the patient. Therefore, ONSD findings should be interpreted comprehensively in conjunction with the patient's clinical condition and computed tomography (CT) findings.

In patients with cerebral edema, treatment strategies should not be based solely on ONSD measurements. Neurocritical care management should be individualized according to the patient's clinical condition, CT findings, hemodynamic parameters, ventilation status, electrolyte balance, and, when indicated, invasive intracranial pressure (ICP) monitoring.

According to the recommendations of the Neurocritical Care Society, hyperosmolar therapy, including mannitol and hypertonic sodium chloride solutions, may be used to reduce elevated intracranial pressure or cerebral edema in selected neurological conditions. When administering these therapies, careful attention should be paid to treatment safety, appropriate patient selection, and regular laboratory monitoring.

PRACTICAL RECOMMENDATIONS

In patients with suspected cerebral edema or intracranial hypertension in the neurocritical care unit, ultrasonographic measurement of the optic nerve sheath diameter (ONSD) using a standardized technique is recommended in conjunction with clinical assessment and computed tomography (CT) findings. In patients with increased ONSD values, the clinical condition, neurological status, and CT findings should be reassessed, and, when indicated, comprehensive intensive therapy aimed at managing intracranial hypertension should be intensified.

5. Conclusion

Timely detection of cerebral edema and intracranial hypertension in neurocritical care patients is essential for determining appropriate treatment strategies. Ultrasonographic measurement of the optic nerve sheath diameter (ONSD) is a promising bedside method for the non-invasive assessment of intracranial hypertension. Comparison of ultrasonographic ONSD measurements with brain computed tomography (CT) findings may improve the comprehensive assessment of patients with suspected intracranial hypertension. Dynamic monitoring of ONSD may provide additional information for evaluating the progression of cerebral edema and changes in the patient's clinical condition. ONSD ultrasonography should not be considered a complete replacement for CT or invasive intracranial pressure (ICP) monitoring; rather, it should be regarded as a complementary non-invasive monitoring method.

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