

Correlation of Ultrasonographic Optic Nerve Sheath Diameter with Direct Measurement of Intracranial Pressure

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Type of Publication: Original Research Paper

Conflicts of Interest: Nil

ABSTRACT

Background: Raised intracranial pressure (ICP) is an emergency condition with an exhaustive list of causes and should be detected within time to avoid any poor clinical outcomes. The aim of our study was to correlate cerebrospinal fluid (CSF) pressure measured via lumbar puncture with ultrasound measured optic nerve sheath diameter (ONSD) and find out a measurement which correlates best with CSF pressure of >20 cm of water.

Materials and methods: This hospital based retrospective study was conducted in the department of Radio-diagnosis and neurosurgery wards of GMC Hospital Jammu from September 2017 to August 2019. A total of 100 patients with diagnosis of raised ICP, undergoing lumbar puncture for ICP measurement in the wards of Neurosurgery were studied with the help of ocular B-mode ultrasonography.

Results: Our study included 100 patients. The male to female ratio was 3.1:1. Maximum patients were in the age group of 51–60 years (40%). The mean age was 52 years. Scatter plot was used to depict the correlation between CSF pressure and average ONSD. Significant positive correlation was found between the average ONSD and CSF pressure. Correlation coefficient (r) was 0.721 (P < 0.001). The cutoff of ONSD > 4.8 mm yielded the most favorable balance of test characteristics, with a resulting sensitivity of 85% (95% CI = 48% to 99%) and specificity of 88% (95% CI = 76% to 99%).

Conclusion: On the basis of present study, it can be concluded that a significant correlation existed between ophthalmic ultrasound measurement of ONSD and ICP measurement via lumbar puncture. ONSD of > 4.8mm suggests a CSF pressure of > 20 cm of water with 85% sensitivity and 88% specificity.

Keywords: Optic nerve sheath diameter, lumbar puncture, intracranial pressure, ultrasound

INTRODUCTION

Elevated intracranial pressure (ICP) is an emergency condition caused by many traumatic, neurological as well as non-neurological diseases. If it is not detected within time, it can lead to many poor clinical outcomes and even death. It is recommended to keep ICP <20-25 mmHg in the setting of traumatic and non-traumatic brain injury.^[1,2] Clinical suspicion is strong when headache, vomiting, reduced conscious, or papilledema is noted. Invasive procedures such as ICP monitor probe insertion in the ventricles or via lumbar puncture are standard modalities for

measuring ICP. However, procedure-related complications such as infection, haemorrhage, catheter malfunction or brainstem herniation are not uncommon besides they are expensive and require highly specialized equipment with these methods of invasive measurement of ICP are greatly concerned.^[3] Cross-sectional non-invasive diagnostic imaging are being used to detect signs of raised ICP such as effacement of basal cisterns and sulcal spaces and the presence of any significant midline shift.

Recently non-invasive modality B-scan ocular ultrasonography (US) is being used as an emerging novel technique to detect elevated ICP in patients. It has several advantages like the accessibility, opportunity, cheapness, monitoring and not being invasive in critical patient. In general, the optic nerve sheath diameter (ONSD) measurement is one of the parameters used for indirect prediction of ICP in patients with increased ICP as optic nerve sheath diameter (ONSD) increases due to its continuity with meninges and subarachnoid space, detected on B-scan ocular ultrasonography (USG). It has also been shown that ONSD is increased before manifestation of papilledema. Optic nerve sheath diameter increases much earlier and may be a near-instantaneous manifestation of raised ICP whereas papilledema may take time to develop.^[4] Therefore, the aim of our study was to evaluate the association of the ultrasonographic ONSD with direct measurement of ICP and whether ONSD can be used for the indirect measurement of ICP.

MATERIALS AND METHODS

This hospital based retrospective study was conducted in the department of Radio-diagnosis and neurosurgery wards of GMC Hospital Jammu from September 2017 to August 2019. A total of 100 patients with diagnosis of raised ICP, undergoing lumbar puncture for ICP measurement in the wards of Neurosurgery were studied with the help of ocular B-mode ultrasonography. The inclusion criteria were as follows: 1) age > 18 years, 2) abnormal results on brain computed tomography (CT) or magnetic

resonance imaging (MRI). The exclusion criteria were as follows: 1) age < 18 years, 2) significant ocular trauma, 3) mass lesions in the orbital area 4) patients who failed the ICP measurement by lumbar puncture for any reasons and 5) history of any intracranial surgery.

High frequency linear USG probe was used for ONSD measurement employing Salami cut technique. The subjects were examined in the supine position. Conductive US gel was placed over a closed eyelid. The scan was performed with the patient fixing in primary gaze for obtaining a cross section of the retrobulbar optic nerve by placing the probe temporally on the eye to obtain a posterior transverse scan and ONSD was measured 3 mm posterior to the orbit.^[Figure 3]

Statistical Analysis

Data was entered in Microsoft excel and analysis was done using SPSS version 20. Descriptive statistical analysis was done. Results on categorical measurements are presented as percentages. A P-value < 0.05 was regarded as statistically significant.

RESULTS

Our study included 100 patients, out of whom there were 76 male (76%) and 24 female (24%) patients. The male to female ratio was 3.1:1. Maximum patients were in the age group of 51–60 years (40%). There were two patients of age <30 years. One of them was 28 years old. The mean age was 52 years. Figure 1 shows age distribution of patients.

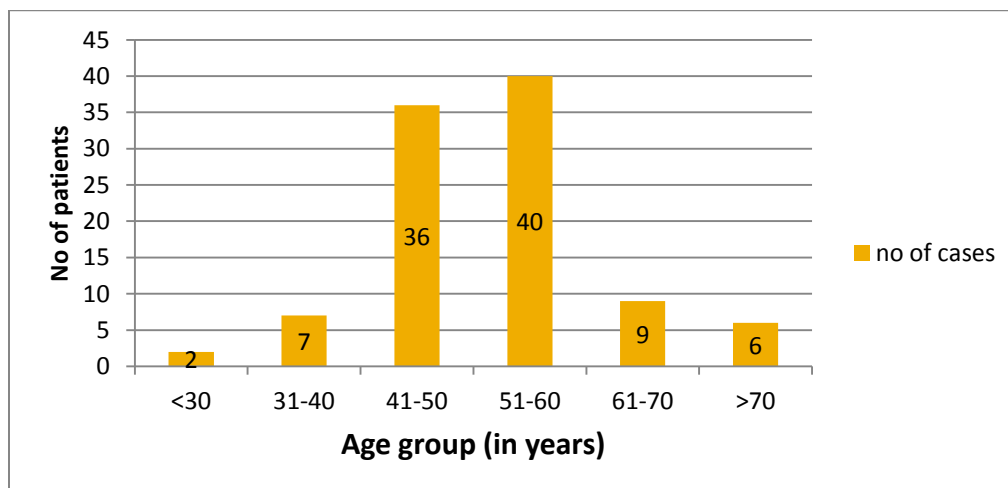


Figure 1: Age distribution of patients

Scatter plot was used to depict the correlation between directly measured CSF pressure and average ONSD [Figure 2]. Significant positive correlation was found between the average ONSD and CSF pressure. Correlation coefficient (r) was 0.721 ($P < 0.001$). The cutoff of ONSD > 4.8 mm yielded the most favorable balance of test characteristics, with a resulting sensitivity of 85% (95% CI = 48% to 99%) and specificity of 88% (95% CI = 76% to 99%).

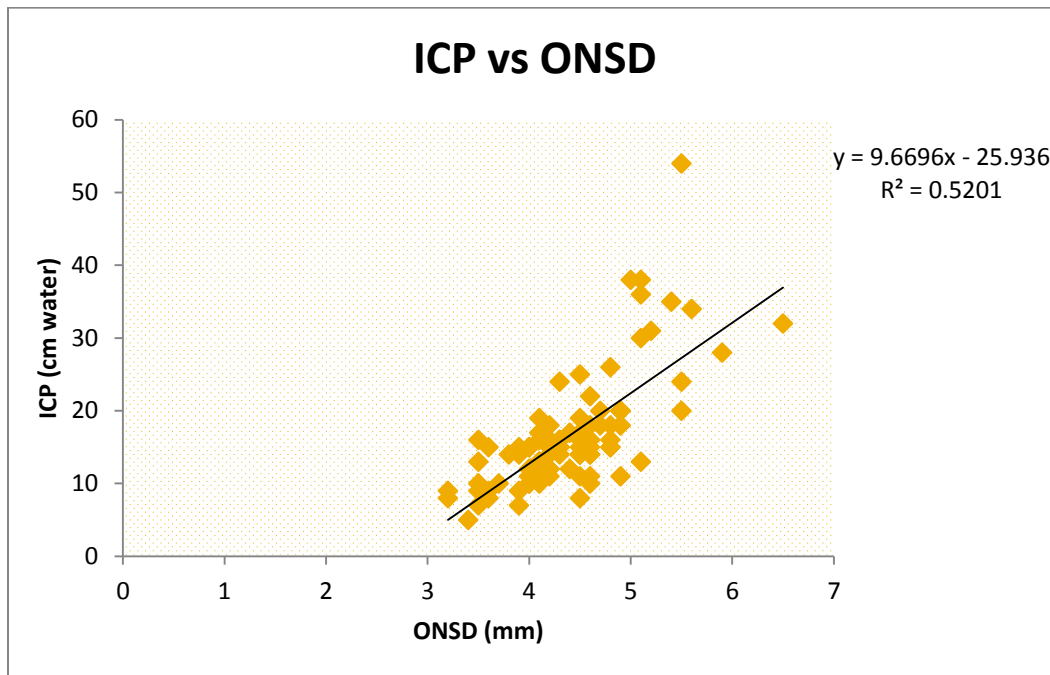


Figure 2: Scatter plot showing correlation between ONSD and CSF pressure

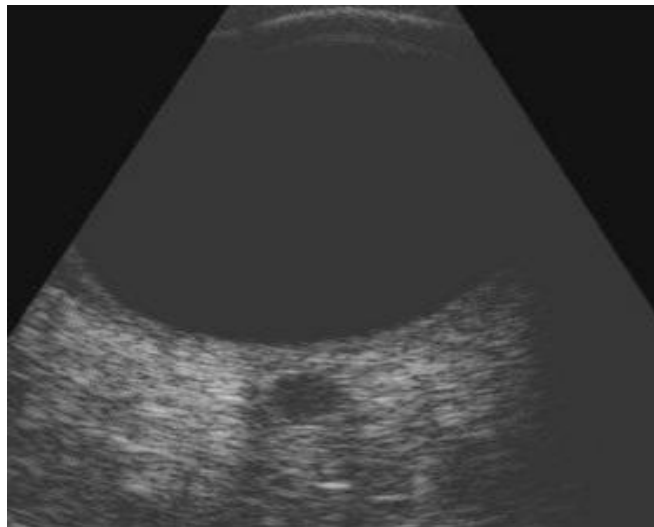


Figure 3: B-scan ultrasound picture showing an oval echolucent focus displayed just behind the globe indicating the cross section of the optic nerve.

DISCUSSION

Increased intracranial pressure due to any reason will be transmitted to optic nerve sheath causing

papilloedema. Raised ICP leads to distension of the optic nerve sheath without any delay leading to early detection of acute elevation in ICP.^[5] In our study, a

significant correlation was found between raised ICP and ONSD measured by B-scan ocular ultrasound. ICP measured through lumbar puncture and ONSD values obtained were strongly correlated. Patients who suffer from intracranial bleed or any space occupying lesion can experience a significant increase of ONSD due to CSF accumulation.^[6,7]

Tayal et al.^[8] reported that the mean ONSD associated with increased ICP seen on brain CT was 6.27 mm, which is significantly higher than that seen in patients without abnormal CT findings (mean, 4.94 mm). Blaivas et al.^[9] also showed that increased ICP as demonstrated by CT was associated with an elevated mean ONSD of 6.27 mm (5.6–6.89 mm), in contrast to that in the control group (mean, 4.42 mm). Soldatos et al.^[10] found a 0.68 correlation coefficient and an optimal ONSD cut-off point of 5.7 mm in 32 patients with severe traumatic brain injury. However according to Amini et al.^[11], the correlation coefficient was 0.88 and the cut-off point was 5.5 mm with sensitivity and specificity of 100%. Frumin et al.^[12], found out that ONSD ≥ 5.2 mm was a good predictor of ICP (>20 mmHg) with a sensitivity of 83.3% (95% CI 35.9%–99.6%) and specificity of 100% (95% CI 84.6%–100%). They measured ICP through an external ventricular device. Kimberly et al., found a significant correlation of ONSD, as measured by US, with ICP, as measured by ventriculostomy in their 15 patients.^[13] Using ROC curve analysis, they found that an ONSD >5 mm correlated with ICP >20 mmHg with a sensitivity of 88% (95% CI 47%–99%) and specificity of 93% (95% CI 78%–99%). Moretti et al.^[14], showed that the optimal ONSD cut-off point to define ICP (>20 mmHg) was 5.2 mm with a 93.1% sensitivity and 73.9% specificity in 63 patients with spontaneous intracerebral hemorrhage. Dubourg et al.^[15], in their systematic review and meta-analysis that the normal values of ONSD, as measured by US in an adult, a child aged 1–15 years, and an infant are 5.00–5.70 mm had ICP >20 mmHg with the diagnostic odds ratio of 51, sensitivity of 90% (95% CI 80%–95%), and specificity 85% (95% CI 73%–93%). Shirodkar et al.^[16] correlated ultrasonographic findings of ONSD measurement with the ONSD measured by MRI, concluding that USG is as good as MRI.

Brain imaging studies, such as CT or MRI, though are accurate means of diagnosing intracranial

hypertension, USG measurement of ONSD can be used as a screening method in settings where these expensive brain imaging machines are not readily available. USG can be helpful to the practicing clinician in diagnosing raised ICP using a non-invasive tool at bedside. They are also helpful in follow up of a patient by serial recordings to assess the effect of treatment.

Our study concluded that ocular ultrasonographic measurement of optic nerve sheath is a simple tool for detection of raised ICP. It can be used as a good alternative of invasive ICP measurement. This non-invasive method may be an alternative approach to predict the ICP value of patients whose ICP measurement is via high risk lumbar puncture method.

CONCLUSION

On the basis of present study, it can be concluded that a significant correlation exists between ophthalmic ultrasound measurement of ONSD and ICP measurement via invasive lumbar puncture. It has also shown that an ONSD of >4.8 mm suggests a CSF pressure of >20 mmHg of water with 85% sensitivity and 88% specificity.

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