Editorial

Optic nerve sheath diameter measurement using bedside ultrasound: Is it accurate?

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Raised intracranial pressure (ICP) is a complication not just of traumatic brain injury and other acute cerebral insults, but also of a number of general medical conditions. Monitoring of ICP is of paramount importance in Neurointensive Care Unit. Increased ICP causes brain insult which may be associated with increased mortality and poor neurological outcomes.[1-3] Bedside clinical diagnosis can be difficult as early clinical signs may be misinterpreted, and heavy reliance on cross-sectional imaging studies may further delay diagnosis.

Ultrasound is a bedside imaging modality that is increasingly available in most critical care units. The diameter of the optic nerve sheath has been found to be a strong predictor of raised ICP, with a high sensitivity and specificity in multiple studies and in a systematic review.[4] The optic nerve sheath is bound more loosely to the optic nerve closer to the globe. This loose binding creates a much larger, and potentially more distensible, subarachnoid space in this region, which can appear bulbous on ultrasound.[5] Consistent with this, the optic nerve sheath is at its most distensible anteriorly, where it is potentially most reflective of raised ICP. As per a 1996 study, using modern ultrasonography (USG) techniques showed that optic nerve sheath diameter (ONSD) increased by up to 60% at a distance of 3mm behind the globe in comparison to only 35% at 10 mm.[6] This has been confirmed in subsequent studies, indicating that a position 3 mm behind the globe is preferred for measurement.[7] Measurements made at this point are more reproducible since ultrasound contrast is greater at this depth with a linear probe.

While papilloedema viewed by funduscopy may take the time to develop, dilatation of the optic nerve sheath occurs much earlier and may be a near instantaneous manifestation of raised ICP.[6,8]

Studies of sonographic ONSD have mainly correlated findings with clinical and radiological signs and symptoms of elevated ICP. Intraventricular measurement is the gold standard for measuring ICP. These measurement devices carry many risks, including hemorrhage and infection. These complications partly account for increasing interest in noninvasive methods such as neuroimaging, transcranial Doppler sonography, ONSD USG and computed tomography/magnetic resonance imaging (CT/MRI). In addition, invasive methods may not be available to individual patients due to contraindications, such as coagulopathy, thrombocytopenia, or the lack of local facilities.

The optic nerve and its surrounding sheath can be accurately imaged and measured on MRI using a

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fat-suppressed T2-weighted sequence. MRI is often spoken of as a reference test for ONSD, as it has a higher spatial resolution, and the images offer a more representative calculation of the mean diameter than CT. While Lagrèze *et al*. contend the accuracy of MRI exceeds sonographic methods for determining ONSD,[9] Bauerle showed good scan-rescan reproducibility and good observer agreement in 15 healthy volunteers.[10]

Two questions that need to be answered when we talk about bedside measurement of ONSD by ultrasound for diagnosis of raised ICP: First, does the bedside ultrasound measurement of ONSD correlate strongly with a neuroimaging technique such as an orbital MRI; and secondly what should be the cut-off of ONSD values to determine raised ICP.

The authors of the current study[11] have attempted to resolve the first question regarding the correlation of ONSD measured by bedside ultrasound and MRI. They have studied 100 adult patients of either sex, diagnosed with meningoencephalitis who were to undergo MRI of the brain and measured the ONSD 3 mm behind the globe using a bedside ultrasound and correlated its measurement with that measured by MRI at the same point.

They found a high level of correlation between the ultrasound measurement and MRI measurement of ONSD. A Bland-Altman analysis was done to show agreement between both methods of measurement of ONSD, the analysis showed a significant correlation between ocular sonography and MRI. Previous Studies performed between both modalities to measure ONSD were done in subjects with normal ICP or in cadavers. This is the first study done with a relatively large group subjects with meningoencephalitis and it adds further proof that bedside ultrasound readings of ONSD may be as accurate as MRI, given the proper technique and training.

With regards to the second question, there is wide variation in the literature regarding in the optimal cut-off values, when ONSD was compared with invasive ICP monitoring, ranging from 4.8 to 5.9 mm.[12,13] The reasons cited for these varied cut-off include: Heterogeneous patient populations, varied methods for confirming raised ICP, and ethnic difference among the patient population. The current authors have selected cut-off values of 4.6 mm for females, and 4.8 mm for males in accordance to a study by Shirodkar *et al*.[14] on 101 Indian patients who demonstrated a high level of sensitivity and specificity with these cut-off values for the diagnosis of intracranial hypertension as evident on CT or MRI imaging. However, the current authors have limited themselves to comparing the numerical accuracy of ONSD values obtained with USG and MRI. They have not commented on the presence or absence of MRI findings of raised ICP and hence have not corroborated the cut-off values of ONSD for raised ICP in Indian patients which as per Shirodkar *et al*.[14] was found to be somewhat less than those from previous studies.

Nevertheless, the high level of correlation between MRI and a bedside ultrasound found in this study suggests that ultrasound can be used to detect acute rise in ICP with a high level of accuracy and despite its limitations, USG ONSD measurement is likely to be more reliable than clinical assessment in the diagnosis of intracranial hypertension and has the potential to become one of the first line modalities in detecting increased ICP especially in situations when altered sensorium or administration of sedative medication precludes such assessment.[15]

Further, larger studies need to be performed on Indian population to decide an optimal cut-off value for raised ICP and that needs to be correlated with a standard which could be either direct measurement of ICP or by means of characteristic findings on neuroimaging.

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