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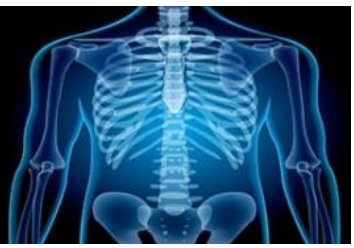

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Role of ultrasound as diagnostic tool in evaluation of optic nerve thickness in cases of raised intracranial pressure

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Abstract
Head trauma and intracranial pathologies can result in the increased Intra Cranial Pressure (ICP). Early diagnosis is important in the clinical outcome. As the optic nerve has a dural continuation, any increase in ICP will increase the thickness of Optic nerve Sheath Diameter (ONSD). Ultrasound plays a vital role, as it is a non-invasive, portable, reliable, and an economical tool to measure the ONSD.
We aim to assess the role of ultrasound as a diagnostic tool in the measurement of ONSD in subjects with raised ICP All patients with CT signs of raised intracranial pressure were taken as cases. Normal CT brain patients were considered as the control group. It was a prospective study that included data of 60 patients (30 Test, 30 Control) for 1 year. Linear probe of high resolution 10MHz on Philips HD 15 ultrasound machine was employed in the evaluation of ONSD in both groups. From the entry point of optic nerve to globe 3mm distance was considered standard in measurement of ONSD.
In the control group 14(46.6%) were females, 16(53.3%) were males and in the test group 11(36.6%) females, 19(63.3%) were males. In the control group upper limit of ONSD was 4.8 mm, lower limit 4.3mm, and mean was 4.49 mm. In the test group, the upper limit of ONSD was5.7mm, lower limit 4.8mm, and mean 5.14mm. There is an obvious raise in the thickness of ONSD in the individuals with positive signs of raised ICP in comparison with normal individuals. Being a non-invasive, and economical, portable ultrasound has a pivot role in the diagnosis of the thickness of ONSD thickness earlier than the onset of papilledema.

Keywords: Optic nerve sheath diameter (ONSD), ultrasound, and intracranial pressure

Introduction
Raised ICP can be secondary to idiopathic i.e pseudotumor cerebri, head injury, intracranial space-occupying lesion, CSF flow disturbance and venous sinus obstruction. Headache, projectile vomiting, visual field defects, and low Glasgow Coma Scale are the signs of raised ICP clinically. Raised ICP, if not detected early will result in permanent neurological sequelae [1]. Identification of increased ICP is crucial, as it hinders the blood supply to brain. Clinical evaluation is not accurate in assessing the raised intracranial pressure as these findings overlap with other conditions. The gold standard in the evaluation of ICP is Invasive intraventricular monitoring, although repeated measurements may not be possible especially if a manometer is used for recording. Lumbar puncture is most commonly used in ICU for ICP monitoring. However the use of lumbar puncture is limited as it requires skilled professional, cooperative patients, and most of the time the sample is never collected on the first attempt. Also, their usage is limited by cost and is associated with complications like infection and bleeding. The ultrasound is a widely available tool, portable, non-invasive, economical, and is easy to perform, reproducible, and with low Intra- and inter-observer variability [2, 3]. Ultrasound with high- frequency probes has a high axial and lateral precision [4]. Several studies stated that the measured values of ONSD in patients with raised ICP have strong correlation [5, 6, 7]. The CSF is continuous with the optic nerve. In raised ICP, the pressure is transmitted along CSF to the optic nerve and optic disc which results in the thickening of ONSD and papilledema. The onset of papilledema will be delayed compared to the onset of appearances of changes in ONSD [8, 9]. In our study, the case group was selected with CT signs of raised ICP and subjects with normal CT brains were taken as the control group. Both the groups were subjected to the ONSD measurement in both eyes and the accuracy of ultrasound was evaluated in the detection of raised ONSD in patients with raised ICP.

AIM: To assess the role of ultrasound as a diagnostic tool in the measurement of ONSD in subjects with raised ICP

Materials and Methods: It was a Prospective study that included data of 60 patients (30 Test, 30 Control) for a period of 1 year(1st Aug2018 to 31st July 2019) in Kamineni Institute of Medical Sciences, Narketpally. CT of the brain was done using Toshiba Alexion 16 slice. Raised intracranial pressure was established in the test group if the CT findings had an intra-parenchymal hemorrhage or subarachnoid hemorrhage with effacement of cisterns & ventricles, midline shift equal to or greater than 3mm and diffuse cerebral edema. Both the diagnosed patients of raised intracranial pressure and normal brain study individuals were subjected to the Ultrasound evaluation of ONSD in both eyes. Examination was done in supine position with the linear probe of high frequency 10 MHz using Philips HD 15 machine on both eyes with closed eyelids. The optic nerve was aligned parallel to the long axis of high frequency probe and the ONSD measurements were taken perpendicular to the scanning plane. 3 readings were taken from each eye and average was calculated. All the measurements were taken 3mm posterior to globe was considered as a standard in measurement of ONSD.

Inclusion criteria: All patients with a history of head injury, recurrent headaches, screening for space-occupying lesion, paranasal sinus evaluation and stroke.

Exclusion criteria: All patients with optic nerve pathologies like optic nerve glioma, optic neuritis, and other orbital pathologies like orbital cavernous hemangioma were excluded. Figure1 Representative case showing the measurement of ONSD on ultrasound.

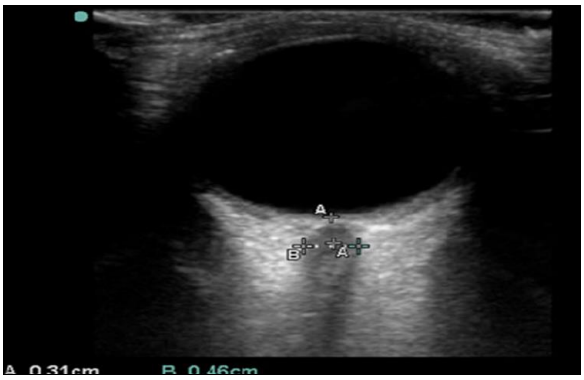

Fig 1: Shows the optic nerve sheath diameter measurement taken 3mm behind the globe

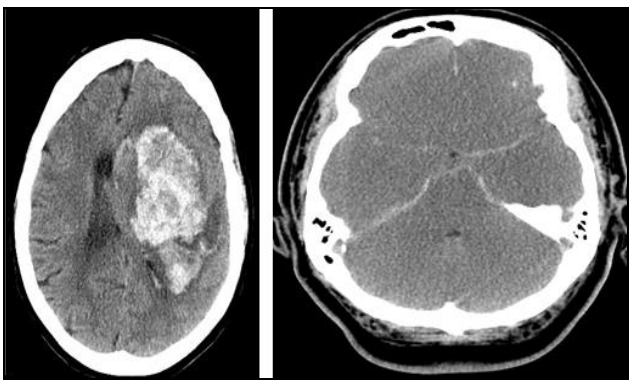

Fig 2: Plain CT axial sections of the brain in a trauma patient.

Figure 2 Shows Intra parenchymal hemorrhage in left cerebral hemisphere with midline shift to right & diffuse cerebral edema with extension of bleed into cisternal spaces, findings suggestive of positive raised Intra cranial pressure.

Statistical Analysis: Qualitative data were expressed in frequency and percentages (%). Quantitative data were expressed using mean, standard deviation, or median. ANOVA test was used to determine the variance in groups whereas Levene's test was used to determine the homogeneity of variance within and between the groups. As the p-value was below 0.05, the homogeneity between the groups is not accepted therefore the null hypothesis was rejected.

Results

The total study population is 60 of which 30 were the control group and 30 were Test group, in the control group 14(46.6%) were females, 16(53.3%) were males and in the test group 11(36.6%) females, 19(63.3%) were males.(Figure-3). The minimum age of the subjects was 23 years in both test and control groups. The maximum age was 63 years in the control group, 58 years in the test group; the mean age was 39years and 37years in control and test groups respectively.

ONSD mean of both eyes was measured; the details of the data were mentioned in Table-1 & 2. In the control group ONSD upper limit was4.8 mm, lower limit 4.3mm, and mean 4.49 mm, in the test group the ONSD was upper limit 5.7mm, lower limit 4.8mm, and mean 5.14mm.

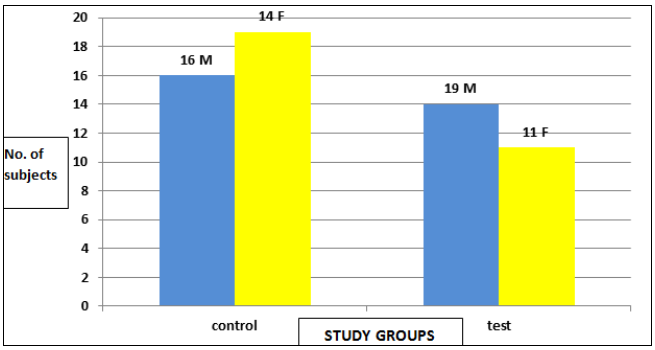

Fig 3: Gender wise distribution in the present study

Table 1: ONSD measurements in millimetres in the control group (n=30)

Mean	4.49
Median	4.5
Range	0.5
Upper limit	4.8
Lower limit	4.3
Total no. of the control group	30

Mean in the control group was 4.49mm

Table 2: ONSD measurements in millimetres in the case group (n=30)

Mean	5.14
Median	5.1
Range	0.9
Upper limit	5.7
Lower limit	4.8
Total no. of the test group	30

Mean in the test group 5.14mm

Table 3: Levene's test variance

Source	SS	Df	MS	F ratio
Between groups	0.1263	1	0.1263	8.569
Within groups	0.8551	58	0.0147	
total	0.9815	59		

Levene's test show homogeneity is not met between the groups with statistical significance of P=0.004876 (<0.05). Therefore the null hypothesis was rejected.

T independent test for the test group with CT findings of raised intracranial pressure (Mean=4.49 SD=0.259) compared with the control group (Mean=5.14 SD=0.147) demonstrated significantly raised ONSD irrespective of gender status in groups.

Table 4: One way ANOVA test

Source variation	Sum of Squares	Degree of freedom	Mean Square	F ratio	F – critical
Between groups	6.3375	1	6.3375	142.23	4.007
Within groups	2.5843	58	0.0446		
Total	8.9218	59			

The F-ratio is 142.23; F ratio is >1 and F ratio is > F critical, the null hypothesis of no variance between the groups stands to be rejected. Also, since the p-value is <0.05, One way ANOVA test shows the means of control and test groups are statistically significant

Discussion

Early detection and treatment of the raised ICP in critical conditions are important [10, 11]. Rajajee V *et al*., and Dubourgh J *et al*., stated that any raised ICP patients had a 51 times increased probability to have increased ONSD [12, 13]. The signs of the raised intracranial pressure are the effacement of sulci, partial or complete obliteration of ventricles & basal cisterns. Ventriculomegaly and dilated temporal horns are seen in hydrocephalus. Also in presence of unilateral pathology a midline shift and the herniation can be noted [14]. Increased ONSD not only correlates with CT findings of raised ICP in traumatic brain patients but also in the non-traumatic brain with cerebral edema with 95% sensitivity, 92% specificity [15, 16]. Dubourg *et al*., stated that ONSD between than 5mm and 5.7mm had ICP greater than 20 mmHg with sensitivity of 90%, and specificity 85%. Dubourg *et al*., mentioned the normal ONSD value for different age groups i.e infants <4mm, children (between 1-15years) <4.5mm, adults<5mm [17]. Steinborn *et al*., studied the children with raised ICP using MRI and USG, and they stated that there was a reliable correlation between USG and MRI in measurement of ONSD [18].

Helmke H *et al*., and Steinborn *et al*. worked on cadaver studies and demonstrated a 60% increase of ONSD at 3mm behind the globe compared to values taken at 10mm and also established that there was no significant difference in measurement of ONSD by lateral, axial, or transverse projections [19, 20]. In the measurement of ONSD, Linear probes of greater than 7.5MHz have high accuracy [21].Wang *et al*. and Mehrpour *et al*. concluded that measurement ONSD has strong correlation with ICP [22, 23]. Dubost C *et al*., in a study showed a significant increase in the ONSD in pre-eclampsia patients (5.4mm) in comparison to normal pregnant women(4.5mm) [24]. Rajajee V *et al*. showed the ONSD equal to or greater than 4.8mm had a sensitivity 96%, specificity of 94% in the detection of ICP >20mmHg [25]. More than 5mm of ONSD had strong correlation with ICP more than 20 cm of water [26].

Conclusion

Significant increase in an ONSD is well documented in the patients with raised ICP in comparison with normal individuals. With USG as diagnostic tool in the measurement of ONSD, earlier diagnosis of ICP is possible before the onset of papilledema. Moreover ultrasound is a non-invasive, economical, and a portable tool which can play a pivot role in minimizing the morbidity and mortality of patients in intensive stations.

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