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Original Research Article

A Comparative Study of Ultrasonography and Computed Tomography for Measuring Optic Nerve Sheath Diameter in Patients of Hemorrhagic Stroke

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Conflict of interest: Nil

Abstract:

Objective: The primary aim of this study was to compare optic nerve sheath diameter (ONSD) measured using ultrasonography (USG) and computed tomography (CT) in patients with hemorrhagic stroke. The secondary aim of this study was to evaluate the diagnostic ability for detecting elevated intracranial pressure using ONSD measured by USG (USG-ONSD) and by CT (CT-ONSD).

Patients and Methods: This prospective, observational study was undertaken from April 2022 to July 2022 in the Radiology Department of IQ City Medical College, Durgapur, West Bengal. ONSD was measured by USG and CT at 3 mm behind the posterior aspect of the globe.

Result: A total of 69 patients have been studied. The median USG-ONSD and CT-ONSD were significantly higher in patients with haemorrhagic stroke. ROC plotting showed the significant agreement between CT & USG Measurements.

Conclusion: The ONSD measured using USG and CT was increased in patients with elevated intracranial pressure in hemorrhagic stroke. Measurement of ONSD by USG and CT showed positive correlation.

Keywords: ONSD, CT, US, ICP, Optic nerve sheath diameter, Computed tomography scan, Ultrasound, Intra Cranial Pressure.

Introduction

The rise in intracranial pressure affects optic nerve head as swelling of the optic disc and papilledema because of accumulation of CSF. Since papilledema develops over time and may be a late manifestation, dilatation of the optic nerve sheath has been shown to be a muchearlier manifestation of ICP rise. [1, 2]

As a non-invasive, rapid diagnostic ability, Ultrasonography (USG) is growing to be an essential diagnostic tool for emergency conditions. As compared other modalities, USG is free of radiation exposure and economical. The optic never sheath can be visualized by ultrasound easily across the orbit in axial plane. With evolved technology of USG and High frequency (>7.5Hz) linear probes with improved spatial resolution allow excellent views of the optic nerve sheath. The optic nerve sheath diameter (ONSD) is measured at 3mm posterior from the globe.

Materials and Method

This study was a prospective observational study done on patients older than 18 years old, with acute (less than 48 h) presentations of hemorrhagic stroke.

Exclusion criteria were: unwillingness to participate in our study, discharge against medical advice, severe orbital or facial trauma, history of ocular disease (especially in the optic nerve or orbital cavity), history of glaucoma, any previous history of having space occupying lesions, neurologic deficits due to previous diseases. This study was conducted for a period of 4 months in a Medical College of a tertiary referral center of west Bengal. The study was approved by the ethics committee of the Institute.

Duration of study: April 2022 to July 2022

Study Variable: Optic nerve sheath diameter (ONSD) measured using ultrasonography (USG) and CT.

Study Tools: The ultrasound machine used in our

study is Wipro GE Voluson S8 BT18. The CT Machine is Philips Ingenuity 128.

Study Methods

Sample Size: Based on the Confidence Interval formula for sample size calculation, the researcher in the present studyjustified that 69 samples are adequate to generalize the result.

The formula is

$n = z^2(p \times q)] / d2$
n = Sample size
N = Size of the eligible population
Z α= Level of confidence Interval at 95% Level of Significance
t = 1-96: it is Standard Deviation score for 95% set interval p = assumed or estimated prevalence rate of USG in WestBengal, q = 1 – p
d = Confidence Interval, that is 10% (0.1) which is allowable error So n = 69 Study participants.

Data Collection: After informed consent by each patient, we assess the GCS and the ONSD by ultrasonography (USG) at predefined time points within 24 hours of admission. ONSD is measure using a 7.5-MHz linear probe and US device. Closed eye method is usedto examine and to take measurements of ONSD by USG. The USG gel is applied either within the protective cover or directly onto the closed eye and done by linear probe. The eyeball is then viewed in both the sagittal and axial planes. Once ONS is identified through US imaging, the ONSD measurements are taken 3 mm posterior from the globe. Each optic nerve is measured three times and the mean number is recorded. The arithmetic mean values of right and left ONSDs are entered in the analysis.

The normal ranges of measurements of right/left ONSD are 4.94±1.51/5.17±1.34 mm at 3 mm from the globe [3].

Patients were screened using our departmental 128 slice thickness Philips CT scan machine. The scan extent was done caudo-cranial from C2 to vertex with slice thickness of <1mm. The tube voltage was 120 KVp, mAs 375 and scan time was 6-7 sec. The CT Dose Index for the study was 48-90mGy. Informed consent was taken from all patients before the performing CT scan.

The findings of routine CT were compared to the sonographic ONSD findings. The measured ONSD in the CT image, 3 mm behind the globe was done, similar to measurement of USG ONSD [Figure 1]. CT images were also assessed for signs of raised ICP.

The evaluation for thepresence of elevated ICP in CT was based on the following criteria: Midline shift from mass effect, collapse of third ventricle, hydrocephalus, effacement of sulci with evidence of significant edema, optic nerve tortuosity, collapse of mesencephalic cisterns, or evidence of herniation.

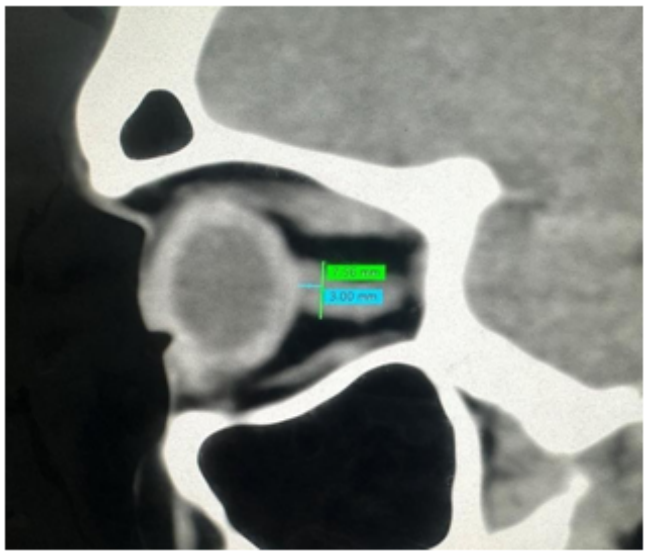

Figure 1: CT brain sagittal section showing measurement of ONSD

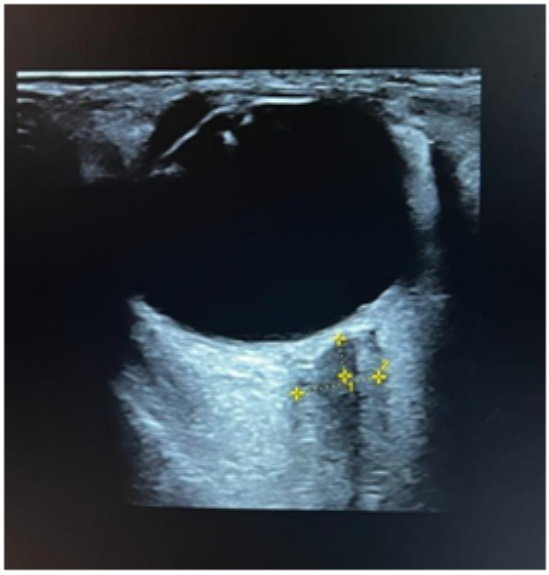

Figure 2: Real time grey scale USG measurement of ONSD

Statistical Analysis: Statistical package for the Social Sciences (SPSS) 21 was used for data analysis. Normally distributed data were presented as mean ± standard deviation, while non-normally distributed data were presented as median (minimum–maximum value). Parametric comparisons were performed using the T-test. The threshold and diagnostic values were explored using receiveroperating characteristics (ROC) analysis.

Result

There were 69 subjects included in this study and their baseline characteristics: Gender and age were presented in Table 1.

Table 1: Baseline and socio demographic of patients (N= 69)

Variable		Number(n)	Percentage (%)
Gender	Male	39	56
	Female	30	44
Age	Mean±SD	56.36±1.59	

Table 2: Measurements of ONSD CT diameter and ONSD ULTRASOUNDdiameter among the patients (N= 69)

Parameters		CT	Ultrasound	T, DF	P value
ONSD (Right)	Mean±SD	5.11±0.56	6.42±1.57	1.57,68	0.001*
ONSD (LEFT)	Mean±SD	6.1 ± 1.59	6.87±1.17	1.29,68	0.003*

Consider the Level of confidence Interval at 95% Level of Significance, such that $p < 0.05$.

Table 3: Correlation between ONSD Ultrasound and ONSD CT scan among the patients (N= 69)

Correlation	R value	Remarks
ONSD (R) ultrasound and ONSD (R) CT scan	0.684	Moderate Correlation
ONSD (L) ultrasound and ONSD (L) CT scan	0.712	Strongly Positive

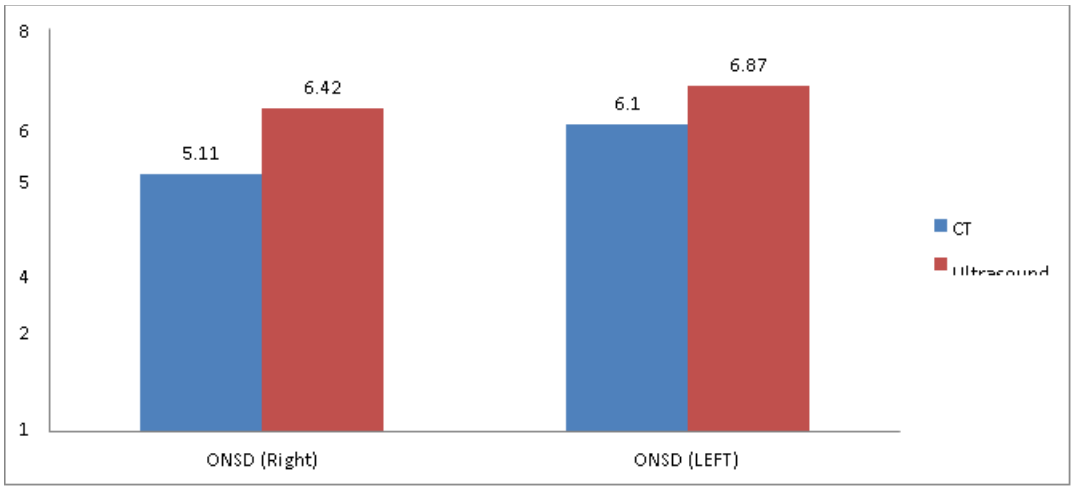

Figure 1: Bar diagram shows that the distribution of mean value of ONSD right and left according to CT & USG

We made ROC curves of mean ONSD in CT scan and in ONSD in USG and measure their area under the curve (AUC) to determine their diagnostic ability for predicting elevated.

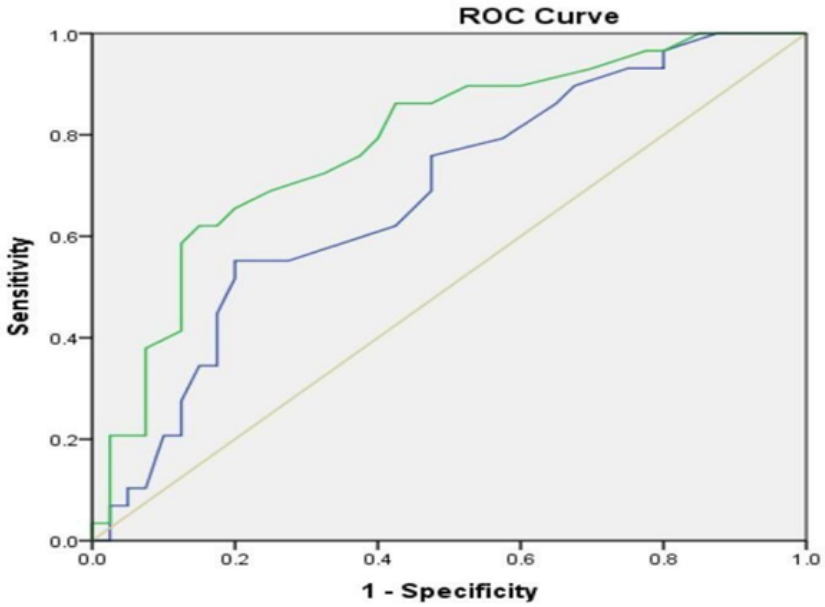

Figure 2: ROC curve for mean Right ONSD (blue line) and Left ONSD (green line) in CT scan

Figure 2 shows that ONSD by using CT scan (AUC 0.81 [95% CI 0.64– 0.88]) is more accurate than ONSD Ultrasound (AUC 0.58 [95% CI 0.45–0.72]) in predicting intracranial hypertension. From the ROC curve coordinates, the best cut-off value to predict elevated ICP is 0.62 cm. The interclass correlation coefficient between USG ONSD vs CT ONSD was 0.69 (95% CI (0.57-0.74). ROC plotting shows that significant agreement between CT & USG Measurements.

Discussion

The current study supports the use of ONSD as a tool to diagnose intracranial hypertension. CT measurement of ONSD is more reliable in predicting raised ICT than USG. Study done by Salikhova et al suggested that CT measurement of ONSD had higher sensitivity and specificity compared to ultrasound [4]. In a study done by liu et all showed that CT had a higher overall sensitivity and specificity compared to ultrasound for detecting increased ICP[5].

There is strong correlation between ONSD measurements done by USG and CT, and more on left side as left hemispheric strokes appear to be more frequent than right and tend to haveworse outcome. [6]

USG measurement of ONSD for detecting raised ICP has recently gained attention. Apart from its non-invasiveness and radiation safe, USG screening has many advantages like easy portability, lower cost (relative to brain imaging) and repeatability [7]. USG can be considered for screening when invasive measurements of ICP are not available or when the patients are too critically ill to be mobilized for radio-imaging. Study done by Wang et al. [8] found that dilated ONSDs decreased along with the reduction of raised ICP. So OSND measurement can be done for follow up therapy administration.

Munawar et al. [9] found that USG ONSD of >0.58 cm was associated with elevated ICP in stroke patients with mass effect. Another study done by Jeon et al. [10] found that USG ONSD measurement of 5.6 mm was the best cut-off to detect elevated ICP in mixed cases ofintracranial hypertension cases (e.g. stroke, tumor, and hydrocephalus).

In patients who are critically ill to move for CT imaging and in whom invasive ICP assessment is contra-indicated, ocular ultrasonography can be done for prediction of raisedICP [11].

The present study suggests that CT measurement is more sensitive than USG for ONSD in raised ICP haemorrhagic patients. But USG and CT have good correlation in measurement ofONSD. USG measurement can be used as secondary when CT facility is not available, as part of bedside assessment in ICU patients.

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