BRIEF RESEARCH COMMUNICATION

Comparison between Transcranial Sonography and Computerized Tomography Scans to Assess the Midline Shift in Patients with Traumatic Brain Injury

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Abstract

Background: Midline shift (MLS) of the brain is an important clinical finding diagnosed on computed tomography (CT) imaging and transcranial sonography (TCS) can help diagnose MLS at the bedside and facilitate interventions to improve outcomes. The study aimed to find an association between TCS- and CT-based assessments of MLS in patients with traumatic brain injury (TBI).

Patients and methods: We included all adult patients with moderate-to-severe TBI of either gender, aged between 18 and 65 years, undergoing intracranial surgery under general anesthesia over a period of 3 months. Consciousness was assessed with the help of the Glasgow coma scale (GCS) and Glasgow coma scale-pupillary (GCS-P) score. We calculated MLS using a CT scan and TCS. Bland Altman graph along with Pearson's and Spearman's coefficient tests was used.

Results: A total of 17 patients were analyzed in this study. The MLS was 0.52 ± 0.90 cm using TCS and 0.58 ± 0.39 cm using CT scan. The Pearson's correlation coefficient (r^2) of the difference between MLS measured by TCS and CT imaging was 0.002 ($p < 0.05$).

Conclusion: Transcranial sonography could detect MLS in patients with TBI, provided a minimum time window is used between MLS measurements by TCS and CT scan.

Keywords: Computed tomography, Sonography, Traumatic brain injury.

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Highlights

Midline shift is an important finding in a patient with an acute neurological injury that affects both short-term and long-term outcomes. Transcranial sonography could detect midline shifts in patients with moderate-to-severe TBI, provided a minimum time window is used between MLS measurements by TCS and CT scans.

Introduction

Midline shift of the brain is an important clinical finding that can be diagnosed using different imaging modalities including CT imaging, magnetic resonance imaging (MRI), X-ray test, and ultrasound scan.[1,2] In patients with TBI, MLS of more than 0.5 cm is an indication of emergency surgery. Even though CT imaging is a gold standard technique, it can be associated with significant patient transport-related morbidity or mortality unless portable scanners are available. Transcranial sonography is a new advancement in this field. With help of TCS, one can evaluate the parenchymal structures of the brain as well as visualize blood flow velocity in basal cerebral arteries measuring Doppler shift. With the help of TCS, one can use the third ventricle as a reference to measure MLS. The TCS method could detect MLS with fair accuracy in patients admitted to the neurosurgical intensive care unit (ICU) and it could serve as a useful bedside tool to achieve early diagnosis and treatment for patients with a significant intracranial mass effect.[3,4] We hypothesized that TCS can be used as a bedside tool for early detection of MLS in patients with TBI in moderate-to-severe category. We aimed to find an association between MLS assessed by TCS and CT imaging in patients with moderate-to-severe TBI posted for surgery under general anesthesia.

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Conflict of interest: None

The secondary outcome of our study was to find the association between GCS, GCS-P score, and MLS by two techniques and the effect of time window on MLS measurement by two techniques.

Materials and Methods

We adhered to the applicable strengthening the reporting of observational studies in epidemiology (STROBE) guidelines for our manuscript. After getting approval from the Institutional Ethics Committee (IEC-537/05.10.2018, RP-30/2018) and getting registered in the Clinical Trial Registry of India (CTRI/2019/05/019004, registered on 09/05/2019, http://ctri.nic.in/Clinicaltrials/login.php), in this observational study, we included adult patients with moderate-to-severe TBI, between 18 and 65 years, of either gender, undergoing any emergency intracranial surgery under general anesthesia over a period of 3 months. We excluded patients with maxillofacial injury, poor temporal acoustic window, and whose relatives did not consent to participation. Written informed consent was taken from relatives for performing TCS on the patient. The standard anesthesia protocol was followed for all. Consciousness was assessed with the help of GCS and GCS-P scores. After attaching all standard monitors and before induction of anesthesia, we performed TCS with a low-frequency ultrasound probe of 1–5 MHz frequency (Sonosite S-Nerve, USA) through the temporal acoustic bone window. We also noted the time window between performing CT imaging and TCS assessment. The investigator performing TCS was blinded to the CT scan imaging report.

Transcranial Sonography Technique of MLS Measurement

The third ventricle is insonated at a depth of 6–8 cm by using a low-frequency ultrasound probe (1–5 MHz) with an overall insonation depth of 16 cm. The probe is titled approximately 10 degrees in an upward direction. The third ventricle on TCS appears as a double hyperechogenic image over the midbrain. On both sides, the distance between the duplex probe and the center of the third ventricle was measured. Midline shift is calculated as the difference between two measurements divided by 2 ($\alpha - \beta/2$), where α is the distance between the duplex probe to the center of the third ventricle on the ipsilateral side of brain pathology and β is the distance between duplex probe to the center of the third ventricle on the contralateral side of brain pathology.

Computed Tomography Scan MLS Measurement Technique

Midline shift on CT scan was measured by calculating the distance between the ideal midline and the septum pellucidum, where the largest deviation is observed.

Data were analyzed using the software STATA 15.0 (College Station, Texas, USA). Data are expressed as mean [standard deviation (SD)] or number (%). Bland Altman graph was used to find out the agreement between MLS values drawn from two different imaging techniques. Pearson's coefficient test was used to correlate between two normally quantitative variables. Spearman's coefficient test was used to correlate two abnormally quantitative variables. The value of $p < 0.05$ was considered significant.

Results

A total of 25 patients with varied diagnoses, namely, contusion (41%), subdural hematoma (35%), extradural hematoma (11%), frontal bleed (6%), and basal ganglia bleed (6%) were screened for eligibility. Out of 25 patients, 8 patients were excluded from the study for not meeting the inclusion criteria (Flowchart 1). A total of 17 patients were analyzed for the study. The mean time interval between CT imaging and TCS assessment was 6.59 ± 6.08 hours. The age of the patients was 45 ± 18 years, weight was 65 ± 10 kg, GCS was 8 ± 5, and GCS-P was 7 ± 5. All patients were males. The MLS was 0.52 ± 0.90 cm using TCS and 0.58 ± 0.39 cm using CT scan. The Pearson's correlation coefficient (r^2) of the difference between MLS measured by TCS and CT scan was 0.002 ($p < 0.05$). Figure 1 displays the Bland Altman plot showing the relationship between the observed differences among MLS values of TCS and CT scan and the mean of the two measures. Limits of agreement (shown by horizontal lines) indicate that 16 of the 17 estimates of the MLS value of TCS were within the limits. The calculated lower and upper limits for limits of agreement of TCS and CT scan are between –1.93 and +1.80 cm with a bias of 0.06 cm. There is an insignificant correlation (r_s) between either GCS or GCS-P with MLS measured by CT scan and TCS ($p > 0.05$) (Table 1).

Flowchart 1: STROBE flowchart

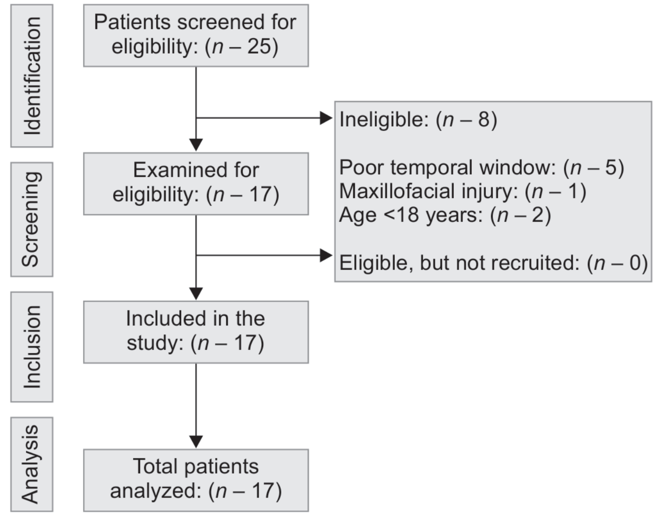

Table 1: Correlation between MLS measured by TCS and CT scan with GCS and GCS-P

	TCS		*CT scan*	
	Spearman's coefficient (r_s)	*p-value*	*Spearman's coefficient (r_s)*	*p-value*
GCS	0.22	0.38	0.17	0.49
GCS-P	0.19	0.45	0.23	0.35

Discussion

In patients with TBI, early detection of MLS has an important impact on short-term as well as the long outcome. This study suggests that TCS can be used to detect MLS in patients with TBI with reasonable accuracy. For the first time, the third ventricle was identified with sonography in 1990. Subsequently, the third ventricle was proposed to be used as a reference to measure MLS by TCS. Tang et al. in their study found a good linear correlation between MLS measured by transcranial color-coded sonography (TCCS) and CT scan ($\gamma = 0.81$, $p < 0.0.1$) in patients with acute spontaneous supratentorial intracranial hemorrhage.[5] In another prospective study of 10 patients who underwent decompressive craniectomy, authors observed a good correlation between CT scan and TCS for the third ventricle ($p = 0.8989$, $p < 0.0001$).[6] In our study, we found an insignificant correlation between MLS measured by TCS and CT scan. In fact, for the TCS method, with the usage of different ultrasound devices results can be reproducible, but the inter-observer variability cannot be excluded. The scatter diagram of our study shows the correlation between the two methods. The bias is smaller (0.06 cm) and the limit of the agreement is narrower (from –1.93 to +1.80 cm) (Fig. 1). Helmy et al. observed that the TCS value underestimates the CT scan value of MLS in neurocritical care patients measured by two methods (the MLS was 4.18 ± 2.15 mm with TCS, 5.06 ± 2.47 mm with CT method 1, and 5.23 ± 2.60 mm with CT method 2).[7] Our study also supports the findings of the above study by determining that TCS underestimates the MLS

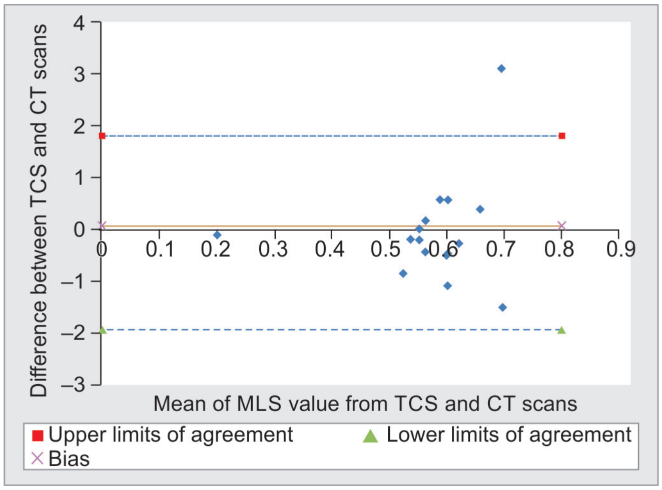

Fig. 1: Bland Altman plot of the relationship between the observed differences between MLS values of TCS and CT scan and the mean of the two measures

value of CT scan (MLS was 0.52 ± 0.90 cm using TCS and 0.58 ± 0.39 cm using CT scan).

There is a possibility that MLS can change rapidly over a period of time. In a prospective study in adult patients with TBI admitted into the ICU, the mean time interval between the cranial CT and the TCCDS study was 322 ± 216 min and the coefficient of linear correlation between the two methods studied was 0.88 ($p < 0.0001$).[8] In another study by Motuel et al., the authors compared TCS with CT scan in patients in neurosurgical ICU with a time interval of 80 ± 73 mins between the two methods with the Pearson's correlation coefficient (r^2) between TCS and CT scan of 0.65 ($p < 0.001$).[3] In our study, the time window between the two methods was 6.59 ± 6.08 hours with Pearson's correlation coefficient of 0.002 ($p > 0.05$). The longer time interval in our study in comparison to the above two studies could be the possible reason for the insignificant correlation between the two methods used for MLS measurement. We also aimed to find the correlation of the consciousness score in both GCS and GCP-P with MLS measured by TCS and CT scan and it was found to be an insignificant correlation ($p > 0.05$).

Like any other study, there is a limitation in our study. The time interval between the two methods to assess MLS is long. A minimum time window could further help in determining a significant correlation between two methods of measuring MLS in patients with TBI.

Conclusion

Our study suggests that TCS can be used in an emergent situation to detect MLS in patients with TBI with a shorter assessment time between the two methods. Consciousness scores GCS and GCS-P do not correlate with MLS measured by either modality.

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