Vol. 3 No. 11 (2025)
ISSN: 2995-5483

Imaging Techniques and in Management of Severe Head Injury in the ICU, Transcranial Scanning and its Clinical Relevance in a Poor Setting

Ojum S., Otokwala JG
Department of Anaesthesia, Rivers State University Teaching Hospital, Port Harcourt

Abstract: Traumatic brain injury (TBL) is one of the leading causes of mortality and disability in Nigeria especially with the poor resources and worldwide as a whole. Due to the cost of computer tomography, transcranial sonography will be helpful in managing patient in a poor setting. This study reviews the role of transcranial sonography (TCS) in the management of patients with TBL. This study will also share our own experience in management of traumatic brain injured cases. The use of TCS is good and informative especially in low resource countries as it diagnoses patients with TBL, assessing midline shift, detects intracranial hematomas. The TCS is readily available for usage, is non-invasive, cheap compared to computed tomography (CT). TCS is very helpful in monitoring patients progress as it offers rapid neurovascular monitoring of patients who cannot be moved easily to the CT, thereby providing effective alternative initial diagnosis and monitoring. TCS is limited by its being operator dependent and little window for viewing the brain tissues in few cases. Despite this limitation, there is a high level of correlation between TCS and CT in detecting midline shift and other findings but confirmation is still needed using CT which is the gold standard. Our clinical case demonstrates that TCS is a fast and simple method for determining midline shift in a patient with TBL.

Key words: Traumatic brain injury, transcranial sonography, intracranial hematomas, midline shift, ultrasound.

Introduction

Head injury or Traumatic brain injury (TBL) is one of the leading causes of mortality and disability worldwide (1). This study reviews the role of transcranial sonography (TCS) in the management of patients with TBL. It is also aimed to sharing personal experience using this method in managing clinical cases in the ICU.

METHODS

In the reviews of literature, the advantages of bedside TCS include its immediate 24/7 availability, non-invasive nature, and low cost (2,13) this actually is important for low cost countries. It also allows the physician to spend more time at the patient's bedside, this is an additional advantage in patient management.

TCS is affordable with reduced risk of radiation, no risk of transportation associated with moving patients the critically ill to computer tomography so it provides easy examination of the neurovascular system (3). In settings with limited resources, where access to other imaging methods is restricted, CT can be particularly useful (2). In other obtaining perform TCS, is recommended to start with positioning the patient lying on their back with a slight elevation of the head end of the bed

Vol. 3 No. 11 (2025)
ISSN: 2995-5483

(30-45°) (Fig. 1) (4). TCS has a special probe but a phased array probe of 1-5 MHz can be used. Most modern ultrasound devices have a compatible probe, this makes it easy to carry out TCS.

For comprehensive TCD study, three transcranial views can be used: trans orbital, trans temporal and trans-foramina. Trans temporal view is widely used for bedside TCD primarily. (4).

To obtain an image, patient is properly position in supine position with slight elevation of the head of the bed at (30-45°) angle (Fig. 1) (4). Although there are specialized transcranial probes, a phased-array probe of 1-5 MHz can be used. Most modern ultrasound devices have settings for TCS. The Trans temporal view is most appropriate, favourable as it aligns with the middle cerebral artery (MCA) (4).

IMAGE ACQUISITION:

1. It is recommended to start the examination by locating the trans temporal space (Fig. 1A) [4]. The goal is to perform an ultrasound examination through the temporal bone at the level of the thinnest part of the skull – the period [6]. To locate this spot, place the probe on the temporal bone at the level of the eye, slightly in front of the patient's ear. With the probe marker pointing forward (toward the patient's eye) (Fig. 1A), use probe movements to scan the adjacent brain tissue until the relevant intracranial structures are identified [18]. These structures serve as landmarks for further adjustments. A starting depth of 16cm is usually sufficient [4].

2. The first important structure to identify is the temporal bone itself, which can be seen in both the near and far fields. The ipsilateral temporal bone is usually visible at a depth of about 1cm. The contralateral temporal bone has a more variable depth (depending on the width of the patients' skull), but it is often visible at a depth of 14-16cm. Both bones appear as bright, linear, hyperechoic structures, often with a slight curvature (more typical for the deep, contralateral temporal bone) (Fig. 1B) [4].

3. The next structure to identify is the midbrain. Usually, two hypoechoic structures can be seen: the bilateral thalamus (a paired organ) and the bilateral cerebral peduncles, which resemble a butterfly or a heart (Fig. 1C). Depending on the scanning angle, either the thalamus (higher) or the cerebral peduncles (lower) can usually be visualized.

4. Next, we look for the third ventricle --- a midline structures with a thin hypoechoic stripe (representing cerebrospinal fluid) within thin, hyperechoic walls (Fig. ID.)

With both temporal bones in view, the third ventricle should be visible precisely in the middle between these two structures, provided there is no midline shift. In most patients, this corresponds to a depth of 6-8cm. after identifying the temporal bones and the third ventricle, the operator can be confident in having achieved an adequate trans temporal window and in the presence of the main landmarks for further TCD monitoring.

LITERATURE REVIEW OF BRAIN USING TRANSCRANIAL SONOGRAPHY

Midline shift (MLS) is a life-threatening condition that requires urgent diagnosis and treatment. In 1996, Seidel et al. [3] described a simple sonographic method for detecting MLS in patients with ischemic stroke: it involved measuring the bilateral distance between the skull and the third ventricle. MLS can be calculated as the difference between the two sides divided by 2. MLS determined by sonography correlates well with CT data and serves as an early prognostic indicator in patients with acute stroke [2]. Recent authors have found that there is correlation between MLS assessment using CT and sonography in neuro-critical care patients has been confirmed (Pearson correlation 0.65; $p < 0.001$) [1]. In most studies ultrasound assessment of midline shift (MLS) have been detected in stroke and supratentorial intracerebral hemorrhage [15]. In patients with traumatic brain injury (TBI). The result in imaging have shown correlation between MLS measurements using ultrasound and CT [9]. All midline shift is considered pathological, but a poor neurological outcome may be associated with a clinically significant midline shift of 0.5cm (positive predictive value (PPV) 78% with the presence of midline shift [3. 17]. A double increase in mortality was also observed, associated with a midline shift of more than 1cm (53 and 25%) [16].

Bedside assessment of MLS can be useful for detecting early cerebral complication, but there is need for further imaging before any neurosurgical intervention. It important to know results showing MLS ultrasound should not be an “absolute” [13].

In practice detecting midline shift using transcranial sonography is done after identifying the main structures first, then detect the presence or absence of MLS [3, 12] As described earlier, the third ventricle should be located exactly in the middle between the two temporal bones (Fig. 2) if this is not the case, then the midline is displaced, provided that the measurements were performed accurately.

The following steps can be applied in detecting the Midline shift (MLS) begin by placing the sensor in the trans temporal window. Identify the temporal bones and the third ventricle. Then adjust the scan angle so that the ipsilateral and contralateral temporal bones are parallel to each other. Measure the distance from the ipsilateral temporal bone to the wall of the third ventricle (distance A) (Fig. 2) and compare it with the same measurement on the contralateral side (distance B). The following equations is used to calculate MLS: MLS = (distance A – distance B)/2 [4] if the CSL value is positive, distance A is greater than distance B, and the midline is displaced away from the side where distance A was measured. If the CSL value is negative, the displacement occurs in the opposite direction. A zero CSL value is normal and indicates the absence of displacement [4].

In calculating CSL values, in general there is limitations due to the thickness of the skull bones, which causes absorption of Ultrasound waves through the bone. Approximately in 5% - 20% of patients there may be difficulties in obtaining clear images, in those patients’ interpretation of results becomes difficult and TCS becomes impossible.

In other to measure ICP trans temporal approach are used [9, 8] the results obtained should be confirmed by other methods, usually, CT [4].

Intracranial hematomas can be identified using transcranial sonography, they appear as hyperechoic structures during the first five days. Later, they become hypoechoic with a surrounding hyperechoic lesion [11]. Hematomas can be visible if they are within the trans temporal view (for example, a subdural hematoma or intracerebral hemorrhage) [11].

The case report is a patient with TBI in a patient with severe head injury. Patient K, 48 years old. A pedestrian, was involved in an accident with a passenger car. He presented as follows on examination airway was patent, spontaneous breathing, Sp02 = 98%. Breathing: chest was clinically clear, chest movement symmetrical on both sides, normal breath sound on auscultation, symmetrical on both sides. Circulation: hemodynamically stable. BP =140/80mmHg, HR = 81, rhythm sinus, regular.

Patient was found to have 10 points on the Glasgow Coma Scale, temperature 36.4^{0c} , further examination and investigation was done and a diagnosis of closed traumatic brain injury, Brain contusion, Acute subdural hematoma intracerebral hemorrhage. Compression dislocation syndrome. Traumatic subarachnoid hemorrhage. Fracture of the right clavicle. Fracture of the left ankle joint.

A decision was made to perform surgical intervention. Before the surgery, we measured ICP using transcranial Doppler (TCD) (Figures 5, 6). When measured using transcranial sonography the midline shift (MLS) was 0.92cm (Fig 6), while measured by CT showed 1.1cm (Fig. 7). A midline shifts of 0.5cm or more is considered significant and is an indication for surgical intervention in the presence of an intracerebral hematoma [11].

DISCUSSION

TCS can be a useful tool in the management of patients with TBI. This method can be used to determine midline brain structure shifts, the presence of intracerebral hematomas, and conduct monitoring. Among the advantages of this diagnostic method are round-the-clock availability, the ability to repeat examinations at short intervals, its non-invasive nature, and low cost. TCD also allows dynamic assessment of the neurovascular system in patients at high risk during transport for CT scanning.

In resource-limited settings, TCD can be an effective tool for rapid diagnosis and monitoring of brain lesion. Among the limitations of this method, it should be noted that, like all ultrasound examinations, it is operator-dependent, and in approximately 5-20% of patients, it is impossible to obtain an adequate view to visualize structures.

Although there is literature reporting a high correlation between TCD and CT results in determining midline shift of the brain, currently there is insufficient data to assert that TCD can be used in decision-making regarding the treatment strategy for patients with TBI and it should be confirmed by the “gold standard” – CT.

In this article, we decided not to address the issue of using transcranial Doppler to determine elevated intracranial pressure (ICP), since in our practical work we do not have the opportunity to compare the results of this study with the “gold standard” – invasive ICP measurement. Our clinical case demonstrates that performing TCD to determine MLS is a fairly simple and quick method, but we still do not have enough data to assert a correlation between MRI and CT in detecting intracerebral hematomas in patients with TBI.

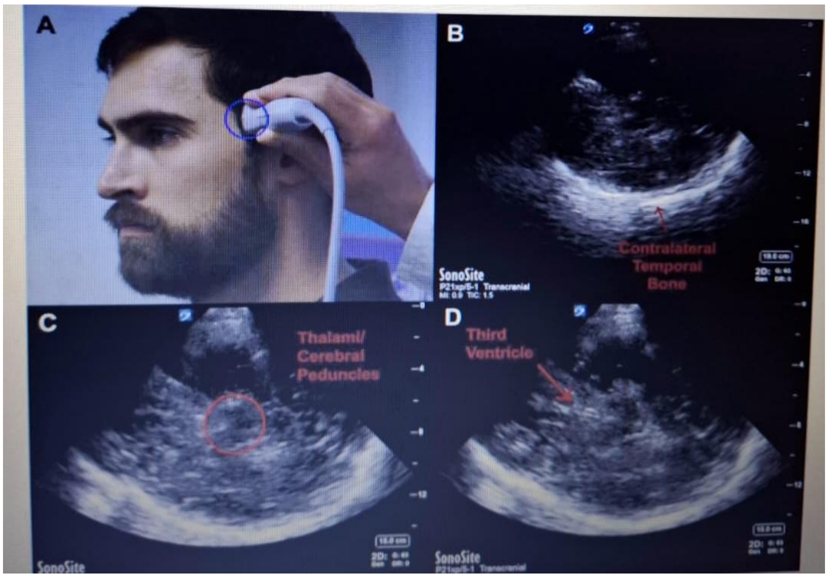

Fig 1:

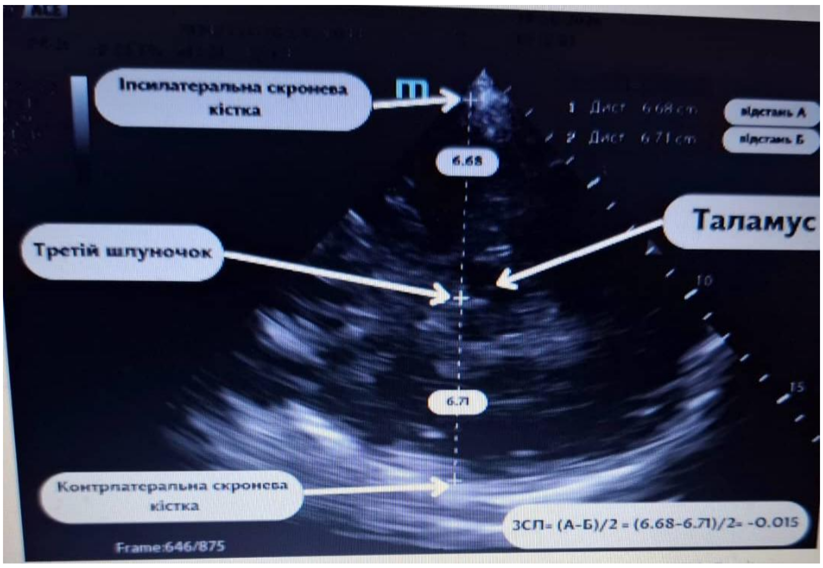

Fig 2

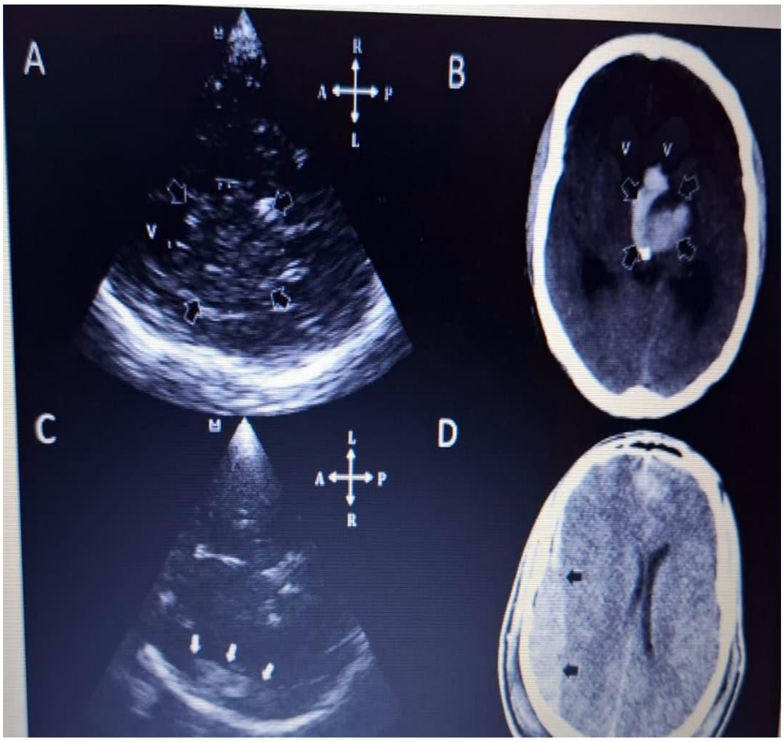

Fig 3

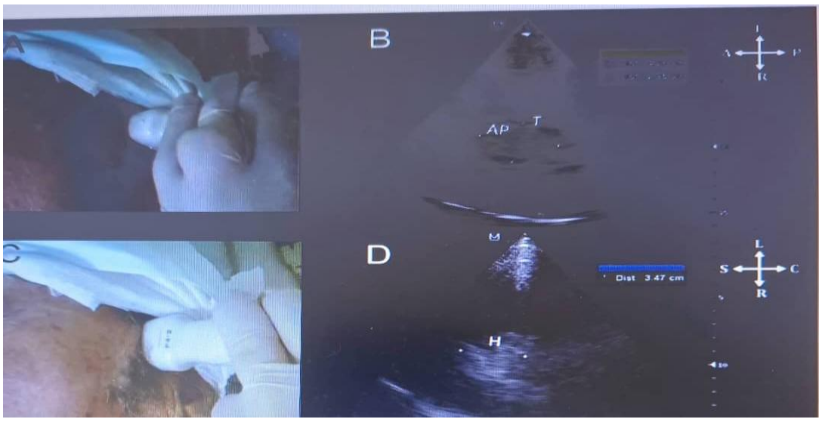

Fig 4

Fig 5

Vol. 3 No. 11 (2025)
ISSN: 2995-5483

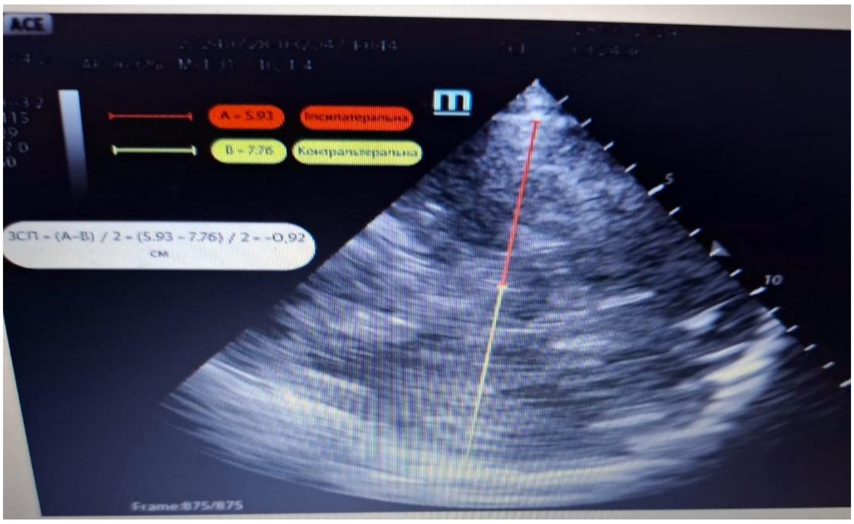

Fig 6

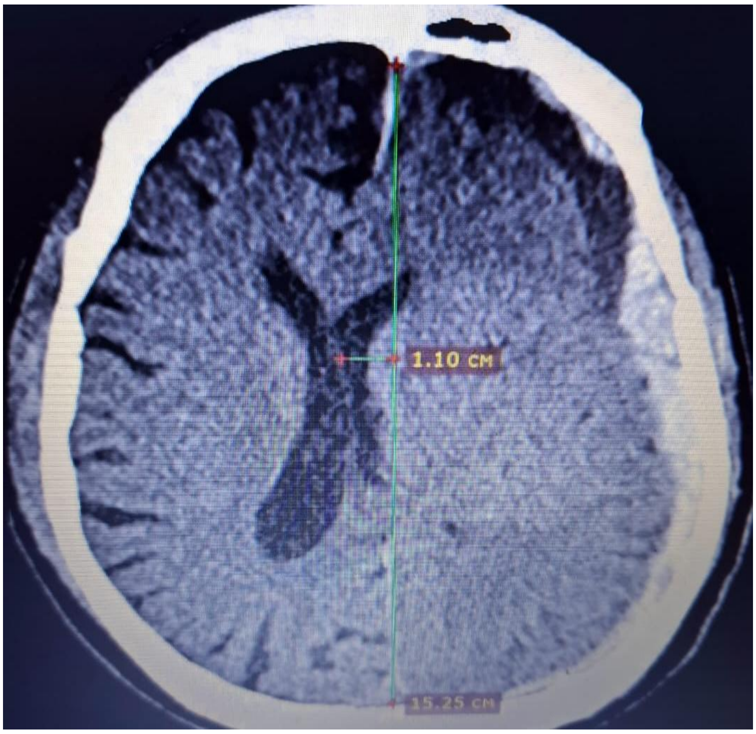

Fig 7

REFERENCES

1. AIUM (2013) Practice guideline for the performance of a transcranial Doppler ultrasound examination for adults and children. *J Ultrasound Med*. 31(9):1489-1500.

2. American College of Radiology (ACR). *Society for Pediatric Radiology (SPR)*; Society of Radiologists in Ultrasound (SRU).

3. Bales J, Bonow R, Ellenbogen R. (2018) Closed Head Injury. Principles of Neurological Surgery. 366-389.e4 doi; 10.1016/b978-0-323-43140-8.00023-1.

4. Blanco P, Blaivas M. (2017) Applications of Transcranial Color-Coded Sonography in the Emergency Department. *J Ultrasound Med*. 36(6):1251-1266. Doi:10.7863/ultra.16.04

5. Esterov D, Bellamkonda E, Mandrekar J, Ransom JE, Brown AW. (2021) Cause of Death after Traumatic Brain Injury: A Population-Based Health Record Review Analysis Referenced for Nonhead Trauma, *Neuroepidemiology*, 55(3): 180-197.doi: 10.1159/000514807.

6. Gerriets T, Stolz E, Konig S, Babacan S, Fiss I, Jauss M, Kaps M. (2001) Sonographic monitoring of midline shift in space-occupying stroke; an early outcome predictor. *Stroke*,32(2):4423-7, doi: 10.1161/01.str.32.2.442.
7. GERRIETS t, Stolz E, Modrau B, Fiss I, Seidel G, Kaps M. (1999) Sonographic monitoring of midline shift in hemispheric infarctions. *Neurology*. 52(1):45-9. Doi:10.1212/wnl.52.1.45.
8. Kaups KL, Davis JW, Parks SN. (2004) Routinely repeated computed tomography after blunt head trauma: does it benefit patients? J Trauma. 56(3):475-80; discussion 480-1, doi: 10.1097/01. ta0000114304. 56006.d4.
9. Lan VI, Jaidaka A, Wiskae K, Packer N, Tang JE, Koenig S, Millington SJ, Arntifi eld RT (2020) Better with Ultrasound: Transcranial Doppler. Chest, 157(1):142-150, doi: 10.1016/j.chest.2019.08.2204
10. Lau VI, Arntfi eld RT. (2017) Point-of-care transcranial Doppler by intensivisits. *Crit Ultrasound J*. 13;9(1):21. Doi: 10.1186/s13089-017-0077-9.
11. Liao CC, Chen YF, Xiao F. (2018) Brain midline shift measurement and its automation: A review of techniques and algorithms. Int J Biomed Imaging. 4303161. doi: 10.1155/2018/4303161
12. Moppett IK. (2004) Transcranial Doppler ultrasonongraphy in anaesthesia and intensive care. *Br J Anaesth*. 93(5):710-724.
13. Motuel J, Biette I, Srairi M, Mrozek S, Kurreck MM, Chaynes P, Cognard C, Fourcade O, Geeraerts T. (2014) Assesment of brain midline shift using sonography in neurosurgical ICU patients. *Crit Care*.:18(1):676. doi: 10.1186/s13054-014-0676-9
14. Quattrocchi KB, Prasad P, Willits NH, Wagner FC (1991) Quantification of midline shift as a predictor of poor outcome following head injury. Surg Neurol 35 (3):183-188
15. Robba C, Goffi A, Geeraerts T, Cardim D, Via G, Czosnyka M, Park S, Sarwal A, Padayachy L, Rasulo F, Citerio G. (2019) brain ultrasonography: methodology, basic and advanced principles and clinical applications. A narrative review. *Intensive Care Med*. 45(7):913-927. Doi:10.1007/s00134-019-05610-4
16. Savers S. (2000) Guidelines for cerebral perfusion pressure. J Neurotrauma. 17(6-7):507-511.
17. Seidek G, Gerriets T, Kaps M, Missler U. (1996) Dislocation of the third ventricle due to space-occupying stroke evaluated by transcranial duplex sonography. *J Neuroimaging*, 6(4):227-30, doi 10.1111/jon19964227
18. White H, Venkatesh B. (2006) Applications of transcranial Doppler in the ICU: a review. *Intensive Care Med*. 32(7):981-994