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CLINICAL APPLICATIONS OF POINT-OF-CARE BRAIN SONOGRAPHY IN THREE DIFFERENT NEUROSURGICAL SCENARIOS - A CASE SERIES

Neuroscience

Dr. Teena Desai*	M.D. DNB Anaesthesia, PDF Neuroanaesthesia, Assistant Professor, Department of Emergency Medicine, Jawaharlal Nehru Medical College, Belagavi, India. *Corresponding Author
Dr. Abhishek Patil	M.Ch. Neurosurgery, Assistant Professor, Department of Neurosurgery, Jawaharlal Nehru Medical College, Belagavi, India
Dr. Thamadapalle Gnana Neha Sunil	Junior Resident, Department of Anaesthesia, Jawaharlal Nehru Medical College, Belagavi, India
Dr. Abhishek Gautam	M.Ch. Neurosurgery Resident, Department of Neurosurgery, Jawaharlal Nehru Medical College, Belagavi, India
Dr. Ela Sharma	M.D. Radiodiagnosis, Senior Resident, Department of Radiodiagnosis, Jawaharlal Nehru Medical College, Belagavi, India

ABSTRACT

Background: Point-of-care ultrasound is an important alternative, non-invasive bedside modality for patients' rapid diagnosis and management. Transcranial ultrasound has been used as a real-time measuring tool for cerebrovascular function assessment and rapid assessment of pathological changes in neurocritical ill patients. **Methodology:** We present a series of 12 cases with three types of neurosurgical case scenarios namely chronic subdural hemorrhage, reconstructive cranioplasty, and ventriculoperitoneal shunt in whom the third ventricle width was assessed using transcranial ultrasound as a marker for change in brain volume pre and post-procedure. It was performed by placing a low-frequency ultrasound probe through the temporal acoustic bone window, with the third ventricle being visualized as two hyperechogenic lines. The third ventricle width (TVW) was assessed as the maximum distance between the inner boundaries of both hyperechogenic lines. Assessment was done pre and post-procedure to monitor the change in brain volume. The values were correlated to the preoperative and postoperative non-contrast computed tomography (NCCT) scans. **Result:** The readings obtained via transcranial ultrasonography were comparable to the values on Computed Tomography (CT) (as shown in the table). Transcranial ultrasonography offers insight on brain volume, cranial pressures, and midline shift which can be assessed almost immediately after the indicated surgical procedure is performed. **Conclusion:** Assessment of TVW to detect changes in brain volume by trans-cranial sonography remains a simple, reproducible, non-invasive tool and has a good correlation with CT scans which are expensive and time-consuming.

KEYWORDS

Third ventricle width, Transcranial ultrasound, Point of care ultrasound

INTRODUCTION

In a variety of therapeutic contexts, point-of-care ultrasound (PoCUS) is an invaluable bedside technique for quick diagnosis and treatment. Its non-invasive, real-time imaging helps rule out alternative diagnoses, directs treatment, and tracks clinical progress, making it useful in a variety of specializations. Recent advancements in handheld ultrasound devices have enhanced the accessibility and practicality of PoCUS, making it an essential tool in both emergency and critical care environments. Transcranial sonography, a specific application of PoCUS, is particularly significant in neurocritical care. The advantages of transcranial sonography include its ability to perform rapid bedside evaluations, making it indispensable for patients with acute neurological conditions. It can be performed using a commonly used ultrasound system for rapid bedside assessment of pathological changes in neurocritical ill patients.

OBJECTIVE

To determine the feasibility and reliability of Transcranial ultrasonography in determining third ventricle width (TVW) compared to CT imaging.

METHODOLOGY

Transcranial ultrasound was conducted through the temporal acoustic bone window using a 1-5 MHz cardiac probe of a Sonosite M-Turbo in 2D mode. The third ventricle appeared as two hyperechogenic lines, and the third ventricle width (TVW) was measured as the maximum distance between the inner boundaries of these lines. The average of the measurements from both sides was taken as the final value. This assessment was performed both before and after the procedure. The measured values were then compared with preoperative and postoperative NCCT studies respectively.

Case Scenario 1

Case of calvarial defect post decompressive craniectomy posted for reconstructive cranioplasty. (Figure 1)

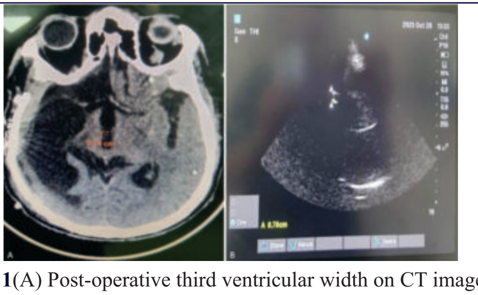

Figure 1(A) Post-operative third ventricular width on CT image; (B) Post-operative third ventricular width on ultrasonography.

Case Scenario 2

Case of hydrocephalus secondary to colloid cyst, posted for ventriculoperitoneal shunt placement. (Figure 2)

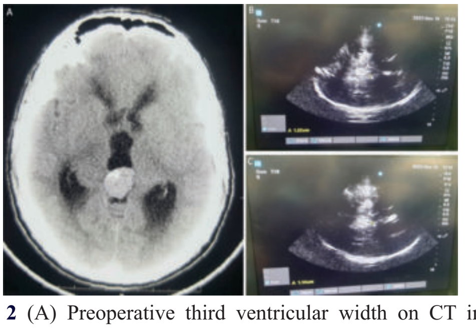

Figure 2 (A) Preoperative third ventricular width on CT image; Preoperative (B) and Postoperative (C) third ventricular width on ultrasonography.

Case Scenario 3

Case of chronic subdural hemorrhage, posted for burr hole and SDH evacuation. (Figure 3)

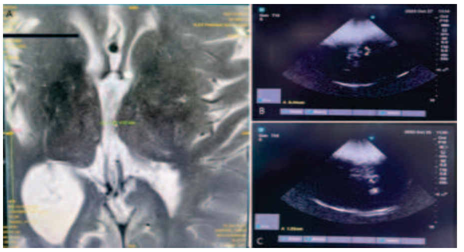

Figure 3- (A) Preoperative third ventricular width on CT image; Preoperative (B) and Postoperative (C) third ventricular width on ultrasonography.

RESULTS

In various clinical scenarios, including cranioplasty, hydrocephalus, and chronic subdural hemorrhage, third ventricle width (TVW) measurements obtained via ultrasound (USG) and computed tomography (CT) were closely examined preoperatively and postoperatively, demonstrating a strong correlation between the two imaging modalities. For cranioplasty, Case One showed a preoperative TVW of 0.98 cm on USG and 1.05 cm on CT, with a difference of 0.07 cm, and a postoperative difference of 0.04 cm (USG 0.70 cm, CT 0.74 cm). Case Two had a preoperative difference of 0.03 cm (USG 0.77 cm, CT 0.74 cm) and a postoperative difference of 0.03 cm (USG 0.68 cm, CT 0.71 cm). Case Three demonstrated a preoperative difference of 0.02 cm (USG 1.04 cm, CT 1.02 cm) and a postoperative difference of 0.01 cm (USG 0.99 cm, CT 1.00 cm). Case Four revealed a preoperative difference of 0.04 cm (USG 0.92 cm, CT 0.96 cm) and a postoperative difference of 0.02 cm (USG 0.87 cm, CT 0.85 cm). The mean differences between USG and CT measurements for TVW were 0.03 cm preoperatively and 0.02 cm postoperatively.

For hydrocephalus, Case One had a preoperative difference of 0.08 cm (USG 1.22 cm, CT 1.30 cm) and a postoperative difference of 0.09 cm (USG 1.14 cm, CT 1.23 cm). Case Two showed a preoperative difference of 0.03 cm (USG 1.48 cm, CT 1.45 cm) and a postoperative difference of 0.03 cm (USG 1.42 cm, CT 1.45 cm). Case Three exhibited a preoperative difference of 0.05 cm (USG 1.37 cm, CT 1.42 cm) and a postoperative difference of 0.04 cm (USG 1.31 cm, CT 1.27 cm). Case Four had a preoperative difference of 0.08 cm (USG 1.52 cm, CT 1.60 cm) and a postoperative difference of 0.04 cm (USG 1.47 cm, CT 1.51 cm). The mean differences were 0.06 cm preoperatively and 0.05 cm postoperatively.

For chronic subdural hemorrhage, Case One showed a preoperative difference of 0.04 cm (USG 0.44 cm, CT 0.48 cm) and a postoperative difference of 0.12 cm (USG 1.10 cm, CT 1.22 cm). Case Two had a preoperative difference of 0.04 cm (USG 0.35 cm, CT 0.31 cm) and a postoperative difference of 0.02 cm (USG 0.70 cm, CT 0.72 cm). Case Three revealed a preoperative difference of 0.04 cm (USG 0.32 cm, CT 0.36 cm) and a postoperative difference of 0.05 cm (USG 0.56 cm, CT 0.61 cm). Case Four showed a preoperative difference of 0.02 cm (USG 0.46 cm, CT 0.44 cm) and a postoperative difference of 0.04 cm (USG 0.62 cm, CT 0.66 cm). The mean differences were 0.03 cm preoperatively and 0.05 cm postoperatively. Overall, these cases illustrate the close agreement between USG and CT measurements of TVW, highlighting the reliability of both imaging techniques in clinical practice.

These consistent findings highlight the reliability of ultrasound in measuring TVW compared to CT, making it a valuable tool for preoperative and postoperative assessments of neurological conditions.

DISCUSSION

Brain sonography is a safe, non-invasive, and cost-effective neuromonitoring method that is readily applicable at the bedside. This technique is particularly useful for assessing brain parenchyma, evaluating cerebral blood flow, and monitoring cerebral hemodynamics in critically ill patients. Its versatility makes it suitable for a variety of settings, including neuro-intensive units, operating rooms, and emergency departments. By providing real-time insights into cerebral conditions, brain sonography supports the timely and effective management of neurological issues[1].

Frank Arne et al. demonstrated that the width of the third ventricle (TVW) is a reliable marker for monitoring brain atrophy using transcranial sonography (TCS). This technique allows for the effective tracking of TVW enlargement over time, which is a promising tool for early detection of cognitive decline. While MRI studies have previously highlighted TVW enlargement as a useful indicator for cognitive issues, TCS provides a non-invasive, time- and cost-effective alternative for similar monitoring in clinical settings[2].

K. Mursch et al. demonstrated that transcranial real-time sonography can effectively measure rapid changes in the diameter of the third ventricle during episodes of rising intracranial pressure (ICP). Their study found that, during increased ICP, the diameter of the third ventricle decreased in some patients following head trauma[3].

The measurement of tissue volume weight (TVW) using transcranial ultrasound (TCS) was found to be consistent with the results obtained from computed tomography (CT) scans. This alignment in measurements supports the findings of the retrospective study conducted by Oliveira et al. The study by Oliveira et al. demonstrated that TCS could serve as a reliable alternative to CT for assessing TVW, potentially offering a more accessible and less invasive option for monitoring changes in tissue volume weight in neurocritical care settings. This consistency suggests that TCS can effectively complement or, in some cases, substitute CT imaging, aligning with the study's conclusions on its diagnostic efficacy[4].

It provides a non-irradiating method for evaluating brain parenchyma and cerebral blood flow, thus avoiding the risks associated with repeated CT scans. This is particularly advantageous in reducing the risks related to patient transport and monitoring in the CT room[5].

Transcranial ultrasound (TCS) could be valuable for monitoring external ventricular drain (EVD) management and weaning directly at the bedside. Additionally, it can assist in detecting clinically occult hydrocephalus, potentially identifying subtle changes in cerebrospinal fluid dynamics that might not be apparent through other methods[6].

TCS can help reduce the number of CT scans performed, thereby minimizing patient exposure to radiation and the logistical challenges associated with CT imaging.

Currently, TCS is a still underestimated imaging modality that requires a wider diffusion and a qualified training process[7].

CONCLUSION

Assessment of TVW to detect changes in brain volume by transcranial sonography remains a simple, reproducible, non-invasive tool and has a good correlation with CT scans which are expensive and time-consuming. Scope for further research: Prospective studies with larger sample sizes required

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