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CASE REPORT

Imaging

Intracranial hemorrhage detected through a craniotomy site with point of care ultrasound

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Abstract

A 60-year-old male presented to the emergency department with acute change in mental status while recovering from a recent hemicraniectomy. During evaluation by the emergency physician, a point-of-care ultrasound (POCUS) was performed using the patient's existing craniectomy site as a sonographic window. Multiple areas of intracranial hemorrhage were visualized on POCUS and head computed tomography scan ultimately requiring urgent neurosurgical intervention. Our case report demonstrates an innovative application of POCUS in the emergency department- setting that has potential to expedite diagnosis and management of life-threatening neurosurgical etiologies, such as hemorrhage and midline shift, in a unique patient population.

KEYWORDS
brain, craniotomy, emergency, intracranial hemorrhage, neurosurgery, POCUS, point of care ultasound, TCUS, transcranial ultrasound, ultasound

1 | INTRODUCTION

Decompressive hemicraniectomy is increasingly used for both therapeutic and prophylactic indications in traumatic brain injury and stroke and in the setting of space-occupying lesions.[1–2] Several case reports in neurocritical care literature have suggested the use of transcranial ultrasound to monitor postoperative subdural collections and midline shift after hemicraniectomy.[3–6] A positive correlation between computed tomography (CT) scans and transcranial ultrasound in assessing volumes of hyperdense lesions such as acute hemorrhage is reported in a number of small studies; this correlation is particularly good in the first 4–7 days from onset of hemorrhage.[7–9] However, no literature to date has cited use of point-of-care ultrasound (POCUS) by emergency medicine clinicians during initial evaluation of the patient using a craniectomy site for visualization of suspected hemorrhage. We describe such a case here.

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2 | CASE REPORT

A 60-year-old male presented to the emergency department of a large tertiary care hospital via an air ambulance at ≈9:00 am for altered mental status. The patient was being transferred from another emergency department (ED) because of the lack of neurosurgical service availability. The patient's medical history was complicated and included intracerebral hemorrhage secondary to metastatic prostate cancer related pancytopenia. Two weeks before this presentation, the patient had a hemicraniectomy and evacuation of subdural hemorrhage (SDH). Of note, he presented to his neurosurgeon 1 day before this ED visit for a postsurgical staple removal. Per his neurosurgeon, the patient was at his baseline mental status and was recovering well. On the morning of arrival, the patient developed nausea, right-sided weakness, confusion, and periorbital swelling of his left eye. Upon initial evaluation, the patient was noted to be awake with decreased alertness and not oriented. He had serosanguinous oozing from the craniectomy incision

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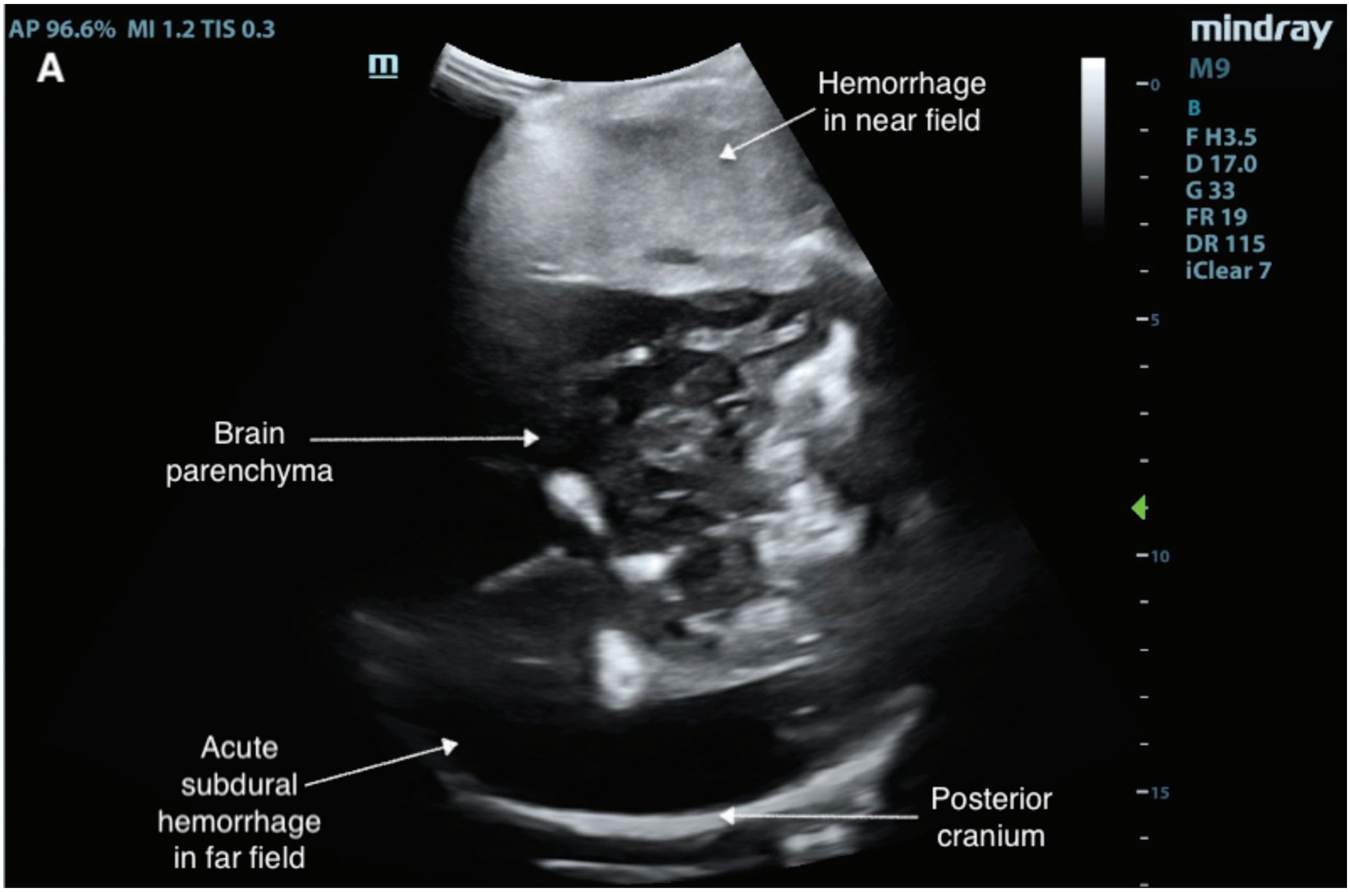

FIGURE 1 POCUS demonstrating intracranial bleed through a craniotomy site with a curvilinear C5-1s Transducer. Near field: a mixed-echogenicity layer of postoperative edematous soft tissues, fluid, and clotted blood; Brain parenchyma: complex fluid with varying echogenicities suggesting different stages of hemorrhage; Far field: an anechoic layer concerning for acute hemorrhage

site, ecchymosis over the left side of his face/temple, and edema over face/eyelids. His speech was slurred and he had difficulty finding words. No objective unilateral weakness was appreciated. The right and left pupils were 2 and 3 mm, respectively. Vital signs were as follows: blood pressure 178/91, pulse 72 beats/min, respiration 18 breaths/min, SpO2 98%.

There was a delay in sending the patient to CT scan because of the coronavirus disease 2019 (COVID-19) pandemic related precautions and staff availability. Even though a prompt code stroke was called, the patient did not depart for the radiology suite until ≈9:35 am. While awaiting the CT scan result, the emergency physician performed B-mode ultrasound of the brain through the craniectomy site revealing what appeared to be multiple areas of hemorrhage (see Figure 1, Video S1). The results were shared with the consulting neurosurgeon at the patient's bedside. The consultant was familiar with the ultrasound evaluation having used a similar modality intraoperatively.

A critical non-contrast head CT scan result was reported at 9:55 am and indicated postoperative changes related to recent hemicraniectomy with a 10 cm acute hemorrhage at the surgical site causing 1.0 cm mass effect and subfalcine herniation. Metastatic disease was noted throughout osseous structures. Bilateral SDHs 8 mm (left) and 4 mm (posterior right) also were noted (see Figure 2).

The patient was transported to the operating room at10:20 am. A successful evacuation of the hemorrhage and extension of craniectomy was performed. According to the neurosurgery documentation, ultrasound was used. Patient recovered well and was discharged 5 days later without neurologic deficits.

2.1 | POCUS technique and findings

The examination was performed using a Mindray M9 device (Mindray, Nanshan, Shenzhen, China) with a C5-1s curved array (curvilinear, 1–5 MHz) transducer. Before the procedure, keyboard, screen, and transducer equipment were disinfected and the transducer was covered with a protective sheath. With intention to insonate intracranial structures and evaluate for hemorrhage and midline shifts, the physician scanned the surface of skin overlying the patient's existing craniectomy. The prior removal of the calvaria provided a window to visualize the brain parenchyma. Close attention was paid to not apply unnecessary compression with the probe. Similar to an ocular POCUS examination, a generous amount of sterile ultrasound gel was applied at the craniectomy site and a pencil-grip hand placement with anchoring of the operator's fifth digit on the solid skull was used to scan

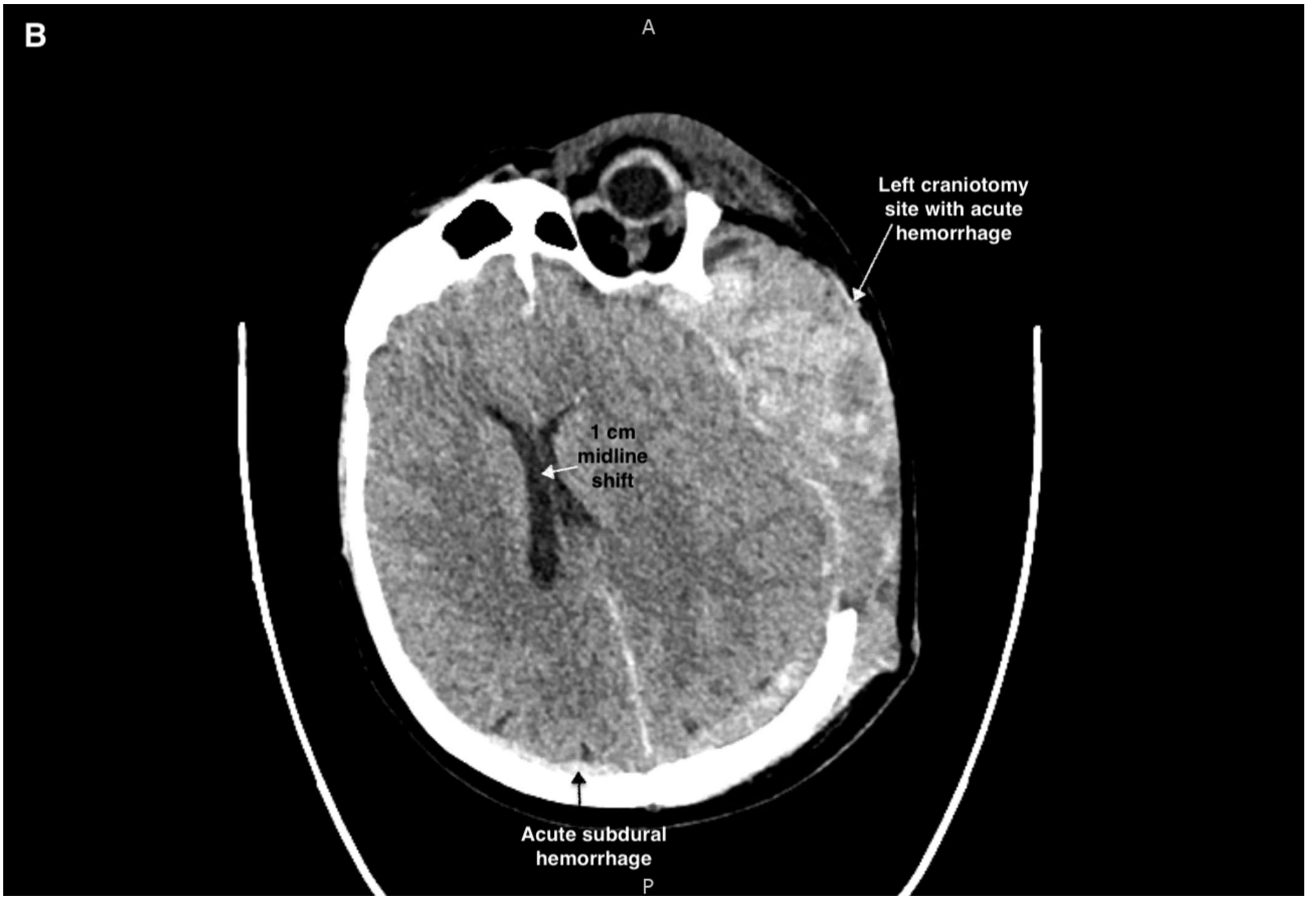

FIGURE 2 Critical non-contrasted computed tomography image

through the entire surface of the craniectomy. Both the sagittal and transverse planes were insonated as the operator fanned through the brain parenchyma. The L12-4s linear array transducer was used with an intention to insonate more detailed images and provide further diagnostic detail. However, it proved to be ineffective likely owing to the lack of appropriate depth necessary to visualize the brain in its entirety (see Figure S1). Neither color nor spectral dopplers were used because of the time constraints.

Structures displayed in the near field demonstrated a mixed-echogenicity layer ≈5–6 cm in thickness immediately below the clinician's transducer placement. This layer was suggestive of postoperative edematous soft tissues, fluid, and clotted blood. Within the brain parenchyma there also appeared to be complex fluid with varying echogenicities suggestive of different stages of hemorrhage. In the far field there was an anechoic layer ≈0.5-2.5 cm in thickness adjacent to the posterior skull also concerning for acute hemorrhage. The POCUS examination overall was highly suggestive of a neurosurgical emergency demonstrating multiple areas of acute hemorrhage. No midline shift was appreciated on this examination (see Figure 1). The entire procedure required ≈3 minutes to capture the necessary images/clips. The patient did not experience discomfort nor did the procedure delay his diagnostic evaluation or medical care.

3 | DISCUSSION

Transcranial ultrasound (TCUS) in patients undergoing decompressive craniectomy has been used by neurosurgeons for monitoring of intra/postoperative neurological decompensation. In the absence of parts of the skull or an existing open fontanelle in infants, TCUS has been shown to identify multiple pathological intracranial states. These encompass traumatic and non-traumatic intracranial hemorrhage, midline shifts, space occupying lesions, and hydrocephalus.[10]

To our knowledge TCUS has not been used as a bedside screening examination in the ED to evaluate for acute intracranial bleeding. Our case is noteworthy as an unconventional use of POCUS in a unique clinical scenario. The patient presented with an acute neurologic decompensation having recently undergone a craniectomy. This presentation is relatively rare in the ED setting but carries a strong likelihood of developing into a life-threatening emergency necessitating swift surgical intervention. We used POCUS, a non-invasive, rapidly available modality, as a tool to diagnose a concerning neurologic etiology. Because of the COVID-19 associated ED constraints, a delay in transferring our patient to the CT scanner was anticipated. POCUS was available to make a swift diagnosis at the bedside and correlated well with the patient's CT scan results. Evaluation for intracranial bleeding through a craniectomy site using POCUS in a limited-resource setting or when advanced imaging is delayed may have implications on a patient's treatment and disposition. Because some neurosurgeons are familiar with this technique, the results of ED bedside ultrasound may be discussed with the specialist and help expedite definitive care.

Neurosurgical and neurologic literature has described visualization of intracranial structures using TCUS through a thin part of the intact temporal bone located above the zygomatic arch. This sonographic "transtemporal window" has been used for identification of stroke, hydrocephalus, and space occupying lesions.[11]

Caricato et al described a step-by-step approach to TCUS imaging and implied its usefulness and theoretical accuracy when craniectomy site is unavailable[12] (see Figure S2 and Table S1). Kern et al used a multiplanar approach to the TCUS exam studying 3-D ultrasound linked magnetic resonance imaging images in healthy individuals using a transtemporal window.[13] Similarly to the Caricato et al, identifying the mesencephalon with TCUS was the best strategic starting point of the examination.

A method to detect SDH in adults was outlined by Niesen et al.[14] Their technique was based on ultrasound imaging of infant brains through open fontanelles with SDH reliably detected in 88% of cases (see Figure S3 and S4). Seidel et al compared CT scan and TCUS in adults with and without intracranial disease to demonstrate the accuracy of ventricular measurements. They showed high correlation between these 2 imaging modalities along with good inter/intraobserver reliability and reproducibility.[15]

This case demonstrates an innovative use of POCUS in the ED to identify acute intracranial hemorrhage through a craniectomy site. This non-invasive diagnostic modality may be considered for use in circumstances where either no CT scan is readily available or there is a significant delay in its acquisition. Further studies are needed to analyze craniectomy site POCUS for quality, accuracy, and feasibility in ED settings. Thereafter, a standardized operator approach may be developed to address transducer choice, depth, sequence of measurements, and scanning technique.

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CONFLICT OF INTEREST

Authors have no conflicts of interest to disclose.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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