Exploring Portable MR Brain Imaging in a Complex Clinical Scenario with Severe Head Trauma and Agitation Due to Increased Intracranial Pressure

This case report is a physician's account of a patient's journey while being treated for a traumatic brain injury with an explanation of the primary incident, the cascade of secondary injuries, and the immediate medical interventions and imaging used to stabilize the patient. Insights and expert commentary on the significance of prompt interventions and the impact of bedside neuroimaging on neurological outcomes are provided by Dr. Daniel Miulli, a specialist in Neurosurgery at Arrowhead Regional Medical Center.

Introduction

Traumatic brain injuries (TBIs) are a significant public health concern. A significant cause of neurological disability, TBI accounts for two million emergency department (ED) visits, 275,000 hospitalizations, and results in over 64,000 deaths annually in the United States[1,2,3]. The severity of TBI is measured by presenting clinical features, including assessment of a level of consciousness[4] with a Glasgow Coma Score (GCS) and duration of any post-traumatic amnesia (PTA)[5]. Initial assessments of TBI patients involve:

- Gathering their clinical history.
- Determining their Glasgow Coma Score (GCS).
- Conducting a neurological examination.
- Performing a CT scan.

Forty years ago, CT imaging changed how physicians assessed TBI, enabling a small group of patients to undergo required neurosurgical interventions. Today, CT remains the primary imaging modality when triaging TBI patients due to its faster access and shorter scan times. CT also has a much higher sensitivity in detecting fractures associated with epidural hematoma (EDH) and patients requiring neurosurgical intervention[6].

Some studies have demonstrated that MRI is more sensitive in revealing more occult pathological changes in the brain[7]. MRI can detect subtle injuries, such as diffuse axonal injury or hemorrhages, which may not be visible on CT scans.

When non-contrast CT is unremarkable, and the patient is still experiencing unexplained neurologic findings, it is current practice to perform an MRI (class I recommendation), which may provide prognostic information to support the patient's clinical management[8].

Patient History and Presentation

This case report involves a 26-year-old male patient transferred to the Arrowhead Regional Medical Center (ARMC) emergency department (ED) as a trauma patient with a suspected traumatic brain injury. Reports indicated the patient was involved in an altercation, resulting in head trauma after hitting the car's windshield. The force of this incident was significant enough to leave a deep impression on the glass. The patient was reportedly under the influence of alcohol and recreational drugs.

The patient was unconscious when emergency medical service (EMS) arrived. EMS resuscitated him before he arrived at the ED. The patient had a GCS of 13 and the trauma team, which includes neurosurgery, was brought in to assess the patient.

Initial Imaging Findings

A CT scan was performed shortly after arrival, and initial findings indicated multiple calvarial fractures, including fracture/diastasis of the right lambdoid and fracture crossing the superior sagittal sinus. CT venogram was normal. The patient was admitted to the neuro intensive care unit (ICU).

Ongoing Care and Interventions

The following day, the patient's mental status declined, and he became very agitated. Neurosurgery requested an MRI. However, the patient's current state would have made it difficult to obtain due to the agitation and it was felt not safe to further sedate the patient. Several hours later, the patient further deteriorated and experienced agonal respirations and desaturation. The patient was intubated, an external ventricular drain (EVD) was placed, and a repeat CT was performed. Following EVD placement, the patient's GCS improved to from 3 to 11.

By day three, the patient's intracranial pressure (ICP) had increased to 15, reflecting that the patient's injury was in the three-day window for maximum brain swelling. A third CT revealed evidence of further brain swelling.

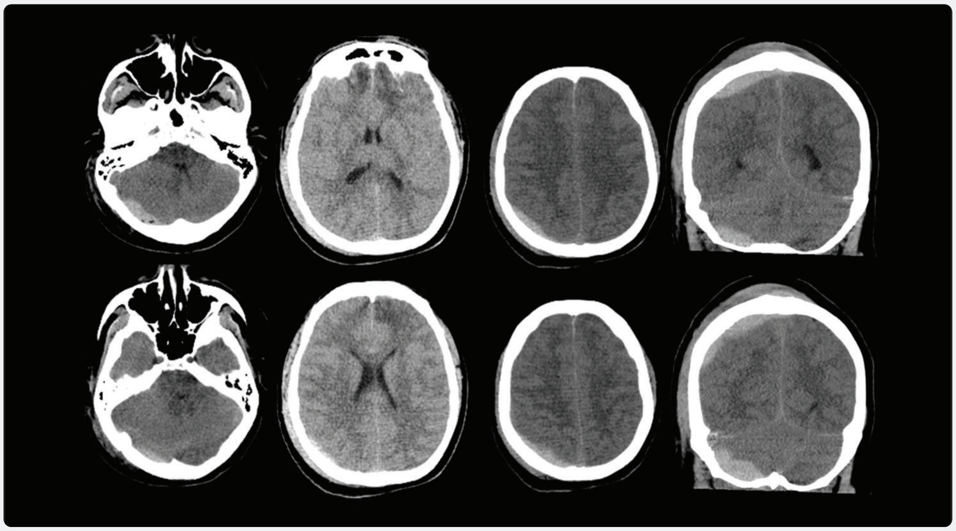

Figure 1. Initial admission CT. Imaging shows an epidural hematoma with air in the region of the right lambdoid fracture/diastasis, bifrontal contusions, cerebral edema with sulcal effacement and second epidural hematoma of the right parietal region.

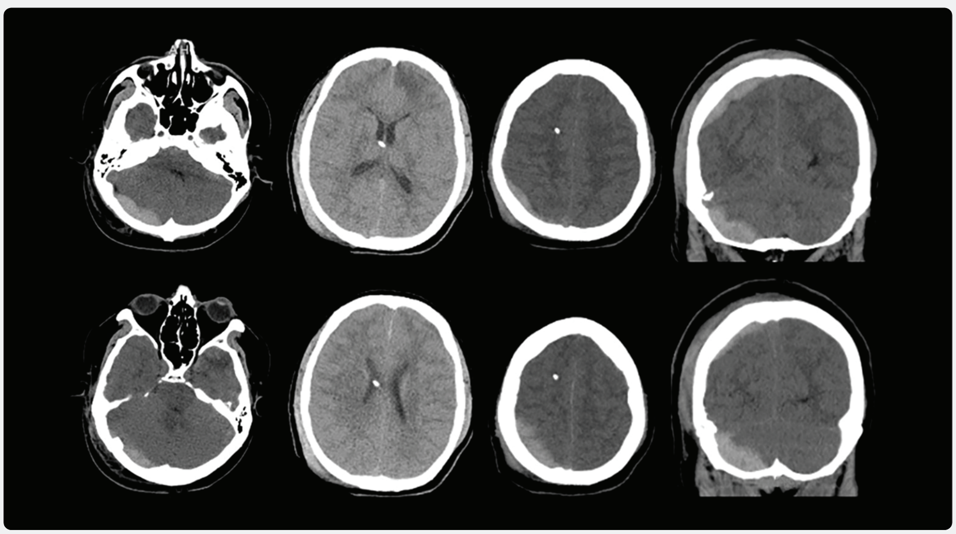

Figure 2. Second CT. Proper EVD placement confirmed by CT.

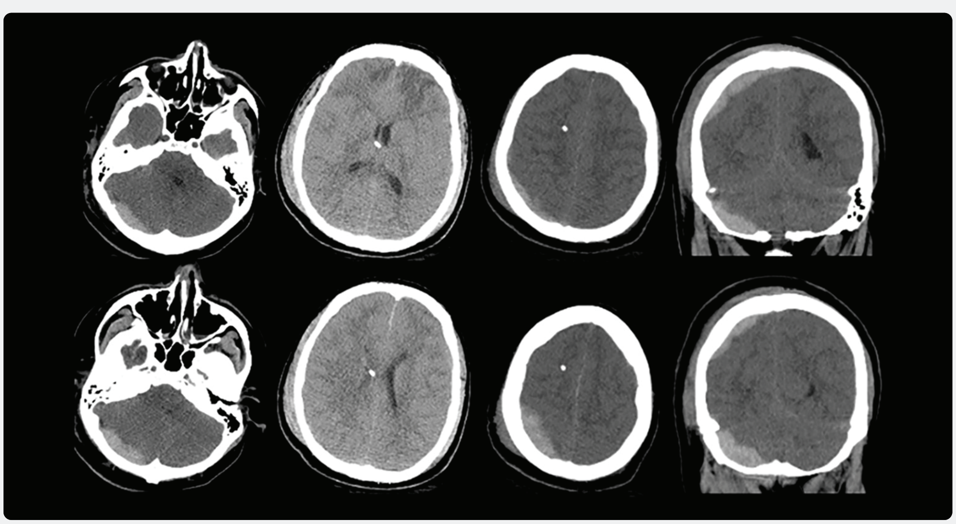

Figure 3. Third CT in the face of increasing ICP, with further decrease in ventricular size despite presence of EVD.

Ongoing Care and Interventions Using Portable MRI Brain Imaging

Ultimately, in the face of continued agitation, the patient was placed in a pentobarbital coma and a portable MRI (pMRI) exam was performed. The pMRI confirmed the underlying brain injuries with continued brain swelling leading the team to undertake bilateral hemicraniectomies to manage this patient's brain swelling.

Hours later, following bilateral craniectomies, the patient experienced hemodynamic instability, prompting a follow-up pMRI. That study shows not only the initial traumatic brain injuries and the surgical changes, but reveals unexpected, restricted diffusion of the right temporal lobe, with normal appearing FLAIR images, a stroke mismatch. Eight days later, a third pMRI confirmed this with abnormal signal on the FLAIR and T2 images.

This patient suffered severe head trauma with a skull fracture, two epidural hematomas, small bilateral subdural hematomas, and significant brain contusions. Agitation and increased ICP complicated management. Physicians performed bilateral craniectomies to relieve intracranial pressure related to the underlying injuries. Unfortunately, in addition to the primary injuries, the patient suffered a secondary right temporal lobe infarction, presumably due to pressure effect or vasospasm, as revealed on the post-operative pMRI exam images.

The patient had a GCS of 3 and was in a pentobarbital coma for several days. Physicians removed the patient from a coma with a GCS of 8 and weaned off the EVD. A few days later, the patient woke up with a CGS of 10.

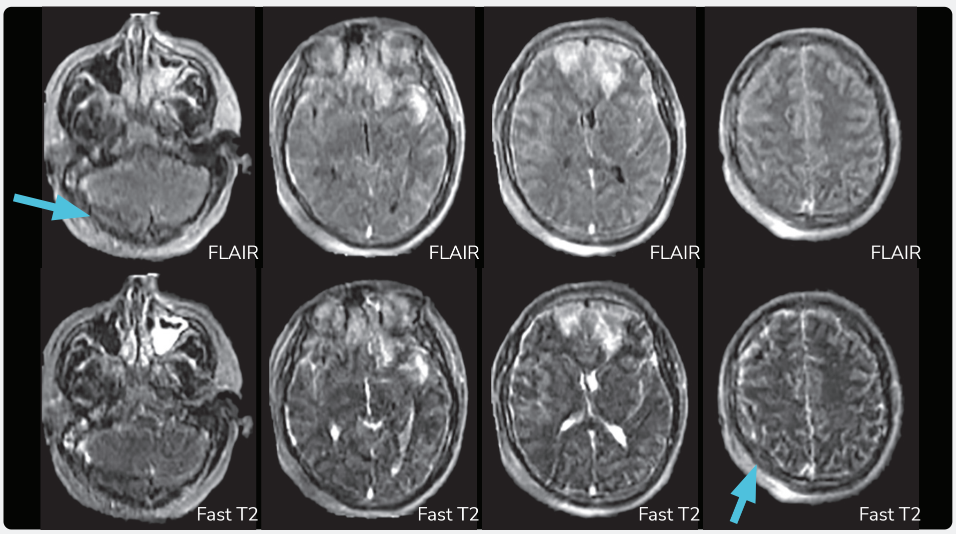

Figure 4. Initial pMRI findings on day four. Axial FLAIR and Fast T2 images show hypointense right parietal and right suboccipital epidural hematomas (arrows). Bifrontal hemorrhagic contusions are also evident.

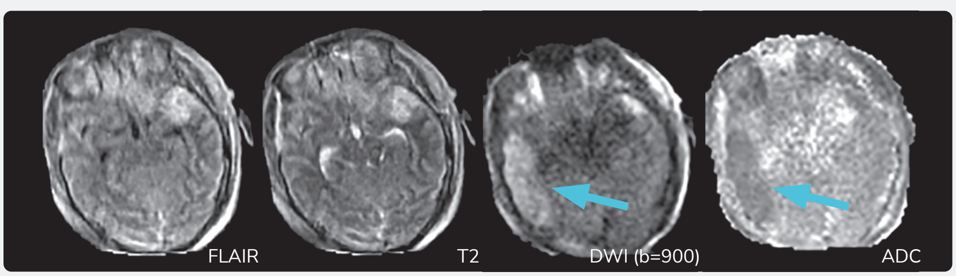

Figure 5. Axial FLAIR, T2, DWI b=900, and ADC images reveal unexpected stroke of the right temporal lobe with DWI-FLAIR mismatch (arrows).

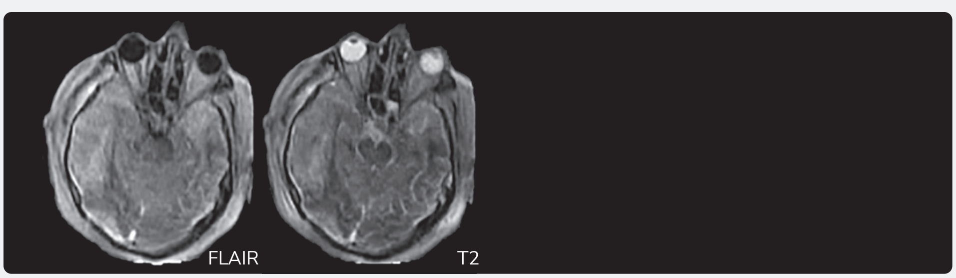

Figure 6. Eight days later, axial FLAIR and T2 images confirm the findings.

The Swoop® system is not intended to apply color overlays to images. Colors are added for clarity and are not reflective of the original images.

We invite you to watch our webinar with Dr. Miulli. This informative webinar highlights real-world case reviews involving portable MRI technology, including instances where the *Swoop® Portable MR Imaging®* system was crucial in monitoring patients' conditions and aiding medical decision-making.

Summary and Discussion

This patient presented complex challenges. Due to ongoing agitation, imaging was problematic. Three CT scans were performed. Every time a CT scan was needed the patient required a transport team to take him to the CT scanner. The physician also wanted to perform a conventional MRI scan but was unable to obtain one due to the patient's hemodynamic instability. Instead, the team opted for a pMRI exam, physicians noted an acute stroke, which resulted in a change of management in vasoactive medications. Because this patient was in a coma, there was little to no ability to perform a neurological exam. The portable MRI provided valuable information that serial CT scanning could not and helped assess the degree of brain injury and prognostication.

Most teams must rely on conventional CT, MRI, or portable CTs if they have one. However, serial imaging with CT is not ideal, as physicians may not see specific pathologies and the repeated CT scans expose the patient to ionizing radiation. MRI has been shown to provide greater detail of pathology and may aid in clinical decision-making or supporting a diagnosis, with zero exposure to ionizing radiation.

In this case, the physician performed three fixed CTs, transporting the patient out of the ICU each time. When the care team obtained access to a portable MRI system, they performed three pMRI exams at the patient's bedside to monitor the patient's condition at various time points post-injury and surgery without moving the patient out of the ICU.

The patient was discharged from the hospital approximately three weeks after the injury and is currently undergoing rehabilitation from multiple injuries.

Endnotes

1 Yue, JK et al. Neuroworsening in the Emergency Department Is a Predictor of Traumatic Brain Injury Intervention and Outcome: A TRACK-TBI Pilot Study. *Journal of clinical medicine* vol. 12,5 2024. 3 Mar. 2023, doi:10.3390/jcm12052024

2 Traumatic Brain Injury (TBI): Hospitalizations and Emergency Department Visits by Age and Payer, 2017. *Agency for Healthcare Research and Quality*, Apr. 2020, https://hcup-us.ahrq.gov/reports/statbriefs/sb255-Traumatic-Brain-Injury-Hospitalizations-ED-Visits-2017.jsp

3 Taylor, CA et al. Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths - United States, 2007 and 2013. *Morbidity and mortality weekly report. Surveillance summaries (Washington, D.C. : 2002)* vol. 66,9 1-16. 17 Mar. 2017. doi:10.15585/mmwr.ss6609a1

4 Saatman, KE et al. Classification of traumatic brain injury for targeted therapies. *Journal of neurotrauma* vol. 25,7 (2008): 719-38. doi:10.1089/neu.2008.0586

5 Definition of mild traumatic brain injury. ***Journal of Head Trauma Rehabilitation*** 8(3):p 86-87, September 1993. https://journals.lww.com/headtraumarehab/Abstract/1993/09000/Definition_of_mild_traumatic_brain_injury.10.aspx

6 Schweitzer, AD et al. Traumatic Brain Injury: Imaging Patterns and Complications. *Radiographics: a review publication of the Radiological Society of North America, Inc* vol. 39,6 (2019): 1571-1595. doi:10.1148/rg.2019190076

7 Jagoda, AS et al. Clinical policy: neuroimaging and decisionmaking in adult mild traumatic brain injury in the acute setting. *Journal of emergency nursing* vol. 35,2 (2009): e5-40. doi:10.1016/j.jen.2008.12.010

8 Wintermark, M et al. Imaging evidence and recommendations for traumatic brain injury: conventional neuroimaging techniques. *Journal of the American College of Radiology: JACR* vol. 12,2 (2015): e1-14. doi:10.1016/j.jacr.2014.10.014

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