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CASE REPORT

Traumatic Brain Contusion Assessment by Bedside, Portable MRI

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Abstract

Traumatic brain injury (TBI) continues to be "the leading cause of death and disability in children" [1]. Computed tomography (CT) is the first line imaging study in every hospital emergency department. A delayed CT scan at 6-24 hours is typically performed as well. However, more recently, there has been interest in the use of a portable, bedside magnetic resonance (MR) scanner to avoid the additional radiation, to reduce the workflow demands of bundling and transporting children with TBI to a fixed CT or MR scanner elsewhere in the medical center, and to reduce the risk of adverse events during transport. In this report, we describe a child who suffered a brain contusion and for whom a portable, point-of-care MR scan was performed in the pediatric intensive care unit (PICU). The MR scan revealed new information not originally gleaned from the admission CT scan.

Key Words

Low field MRI, Brain contusion

Introduction

Despite years of progress improving the safety of children, traumatic brain injury continues to be "the leading cause of death and disability in children" [1]. In the emergency room setting, children with suspected TBI undergo various assessments, including neuroimaging of the head (and often cervical spine). In the acute setting, that imaging involves CT scanning with review of soft tissue, subdural and bone windows, as well as multiplanar reconstructions and occasionally 3D reformatted views to look at the skull for occult in-plane injuries. CT is useful both for primary, such as hemorrhage, contusion and foreign bodies, and secondary injuries, such as cerebral edema, herniation and infarction [2,3].

In the adult population, patients suffering TBI undergo not only an initial CT scan, but commonly, and often algorithmically, a second imaging study, approximately 6 to 24 hours later [4]. This study is performed to look for evolution or new, delayed findings, such as interval enlargement of hemorrhage previously detected, development of new hemorrhage (such as shear hemorrhage or bleeding into contused brain), worsening of edema surrounding such a hemorrhage or contusion, development of global cerebral edema, hydrocephalus, midline shift, brain herniation, and/or arterial (or venous) infarction.

In most hospitals, that second study is another CT scan. However, concern for radiation exposure has encouraged many clinicians and radiologists to shift the follow-up examination to MRI, especially for pediatric patients. Typically, the child is transported to the MR scanner, often at quite a distance from the PICU, with the additional risk of adverse events during transport, including elevator travel. Moreover, in the Covid/post-Covid era, both the availability and additional expense of nurses, respiratory therapy and anesthesia personnel during transport has increasingly strained hospital resources. Recently, the deployment of portable, point-of-care MR scanners has offered a change to the traditional paradigm, offering radiation-free MR at the

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bedside as well as streamlined workflow and obviation of such risks of transport [5]. In this report, we describe a child for whom a portable, point-of-care MR scan was performed in the PICU. The MR scan revealed new information not originally gleaned from the admission CT scan.

Case Description

A 12-year-old female with no significant past medical history was seen in an outside emergency department (ED) following an unwitnessed fall from an electric scooter. The child was not wearing a helmet. Per the child's mother, the patient complained of headache, but could not remember the accident, and loss of consciousness was unconfirmed. The child began vomiting at home, whereupon she was taken to the outside ED. The work-up at the outside facility included an unenhanced head CT which was reported as showing intracranial injuries, whereupon the child was transferred to our facility, albeit without the CT scan.

In our ED, the patient complained of headache, but was otherwise alert and oriented and hemodynamically stable. Laboratory values and chest radiograph were normal. Head CT (Siemens Somatom Edge Plus 128 slice, Erlangen, Germany), reviewed in soft tissue, subdural and bone windows, revealed a 10 × 11 mm, focus of intraparenchymal hemorrhage within the right temporal lobe with perilesional edema, a 4 mm subdural hematoma overlying the right temporal region with extendion along the tentorial dura, a tiny amount of subdural hemorrhage in the right frontal parafalcine region, and 5 mm right to left midline shift.

Neurosurgery consult suggested observation in the pediatric intensive care unit (PICU) with repeat imaging at 6 hours were recommended.

Throughout her stay in PICU, the child remained on room air, afebrile, hemodynamically stable and neurologically appropriate, although she complained of intermittent headaches. Delayed imaging with bedside low field MR (0.064T: Swoop®, Hyperfine, Guilford, CT, USA) at approximately 6 hours showed stable subdural hemorrhage and contusion, without significant progression of the hemorrhagic component. The patient was discharged to home on day 3. Repeat MR at 2 months (not shown) confirmed significant resolution of the contusion (Figure 1 and Figure 2).

Conclusion

Bedside use of portable low field MRI has been described in various populations and settings [5]. However, most such publications included very early images which often raised as many questions as they answered. More recent software versions offer considerably improved image quality and may better demonstrate the clinical and economic benefits of this approach. In this report, we present a child who suffered a traumatic brain contusion of the right temporal lobe consequent to a fall from a scooter. Instead of a delayed CT, bedside MR was performed. The images offered improved conspicuity of the contusion and subdural hematoma, much better delineation of the subarachnoid hemorrhages and a tiny intraventricular hemorrhage not readily apparent on the admission CT. The patient did not undergo additional radiation and followed an uneventful hospital course with complete recovery. By performing the MR examination at the bedside, the workflow in this case was performed

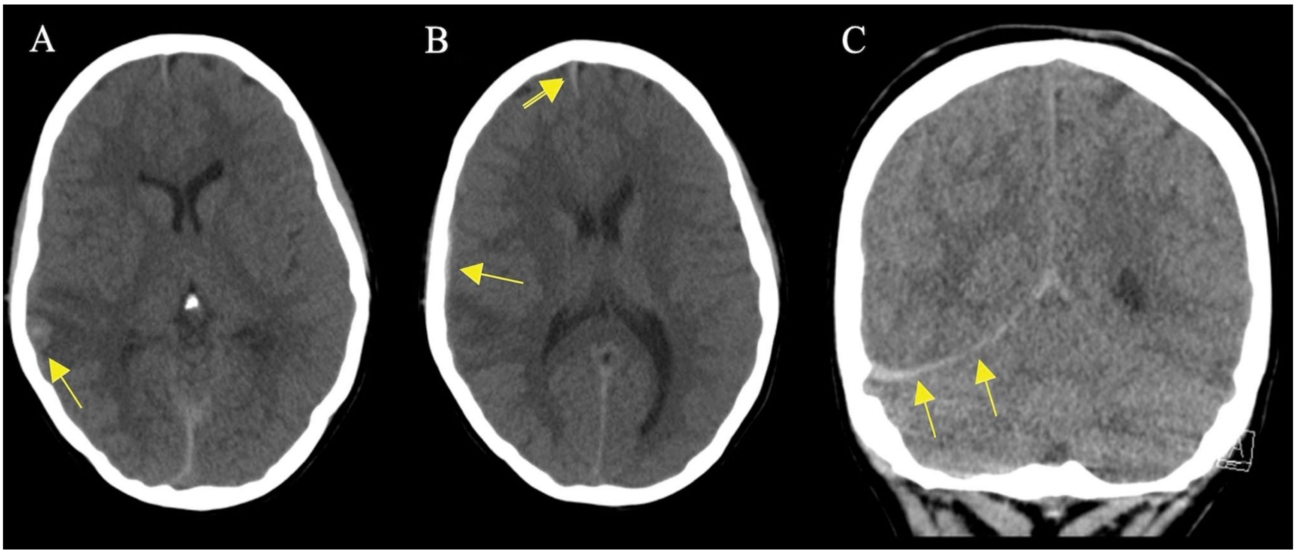

Figure 1: Admission CT reveals hemorrhage (arrow, A) within right temporal lobe contusion on subdural windows. Perilesional edema extends into deep white matter. Thin subdural hematoma (arrow, B) and either small frontal component of subdural or small focus of subarachnoid hemorrhage (double arrows, B) are also detected. Mild midline shift to the left is apparent. No intraventricular hemorrhage is seen on image through dependent occipital horn. Right occipital horn is effaced. Soft tissue window of coronal multiplanar reformatted image reveals tentorial subdural hemorrhage (arrows, C) and effacement of right occipital horn. Bone windows (not shown) do not reveal temporal bone fracture.

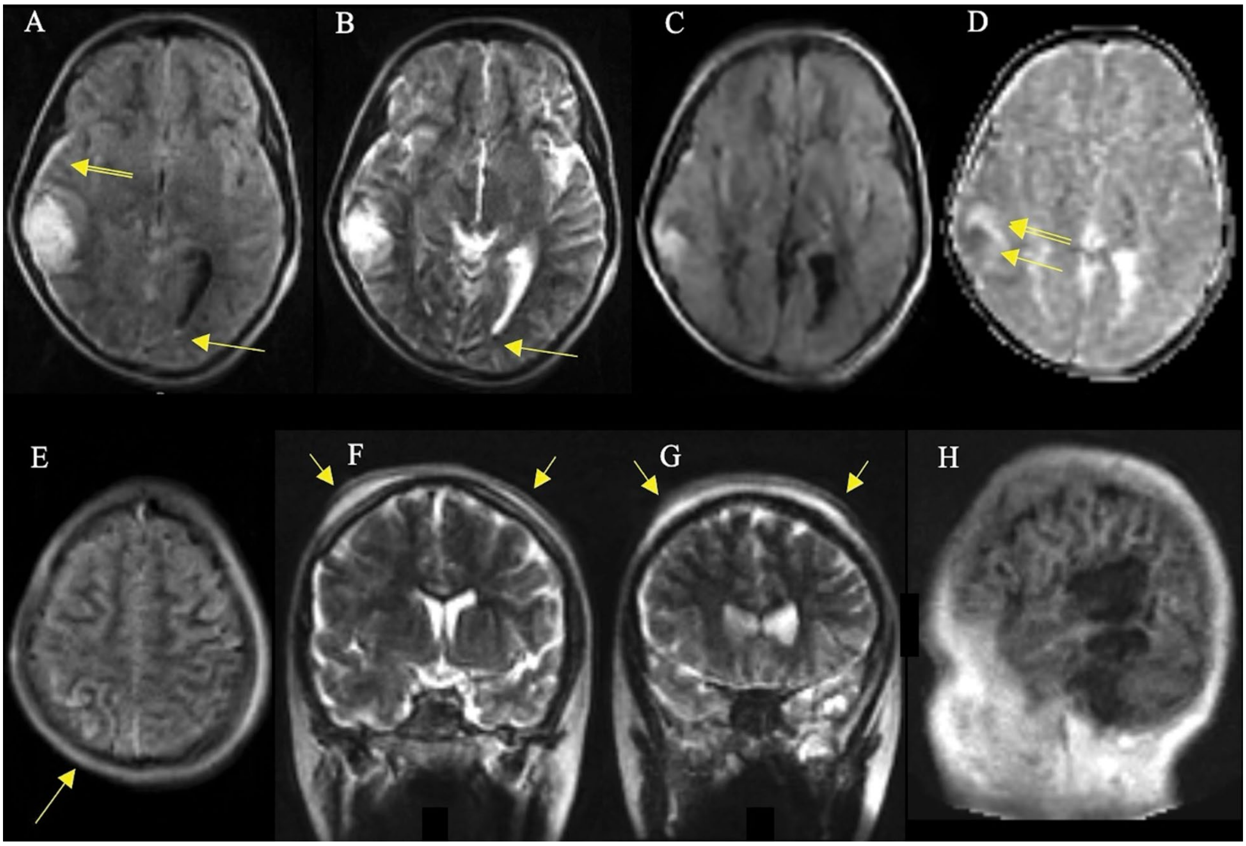

Figure 2: Axial flair image (A) performed at 14:19 pm, approximately 6 hours following admission CT, reveals better delineation of the right temporal lobe contusion with compression of right temporal (not shown) and occipital horns. Thin right-sided subdural hemorrhage (double arrows, B) is readily apparent on flair image. A tiny focus of dependent intraventricular hemorrhage is seen on both flair (bright signal, arrow A) and T2-weighted (dark signal, arrow B) images are now evident. A small area of intralesional hyperintensity on the diffusion-weighted image (C) matches the area of diffusion restriction (long arrow, D) on apparent diffusion coefficient (ADC) image (D) and corresponds to the small amount of hemorrhage on the earlier CT. Note hyperintense perilesional edema anterior to hemorrhage on ADC (double arrow D). Hyperintense sulci reflecting subarachnoid hemorrhage are also revealed on flair image (arrow D). Hyperintense scalp edema over frontal convexities is also appreciated on coronal T2-weighted images (small arrows E and F). Sagittal T1-weighted image (H) shows hypointense contusion extending from superior to inferior temporal gyri, also noted on coronal T2-weighted images (not shown). Follow-up imaging (not shown) at 2 months showed significant resolution.

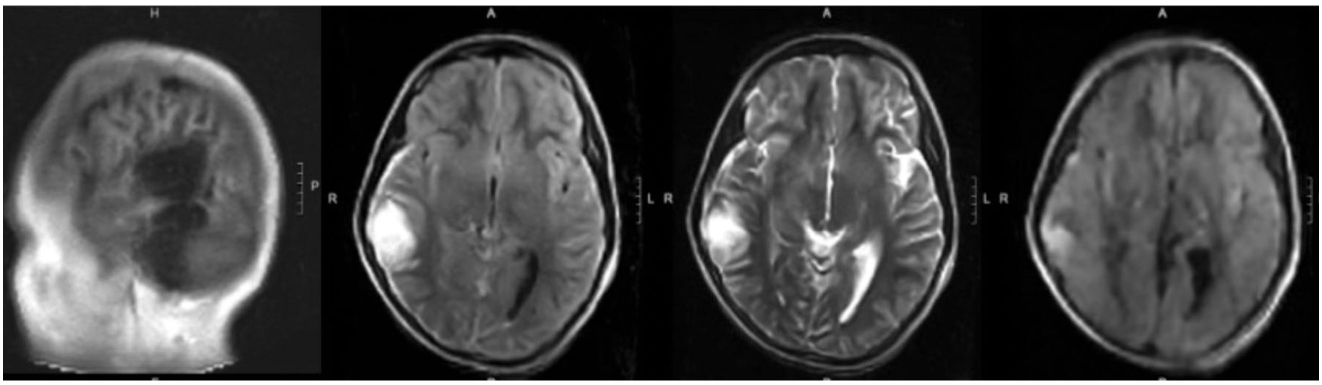

Figure 3: Reprocessed images with research software. Note increased clarity across all images, compared to standard images in Figure 2: (left to right: T1-weighted, flair, T2-weighted and diffusion-weighted images), with permission.

without commandeering additional personnel (nursing and transport, and often respiratory therapy and/or anesthesia) and medical supplies, nor superimposing the well-known additional risks of adverse events in the case of transport to a fixed MR scanner elsewhere in the medical center.

In conclusion, recent improvements in bedside portable MR scanning of the head offer a new approach to the workup and care of pediatric patients that suffer TBI. Unfortunately, in the present case, the patient underwent two CT scans, as the initial CT at an outside institution was not transferred either with the patient

(CD/DVD) or by secure internet, resulting in a repeat scan upon transfer. Nevertheless, the delayed CT scan in the PICU was obviated by the use of a point-of-care, portable, head only MR scanner. This both delimited further radiation exposure but also successfully demonstrated the relative stability of the injury, allowing the patient to recover without neurosurgical intervention [6].

Addendum

Since the submission of this case report, Hyperfine has developed research software that further improves image clarity. Hyperfine images (Figure 3) were obtained using standard FDA cleared software and reprocessed with research software.

Author Contributions

1. Analysis/interpretation: All.
2. Drafting/revising: All.
3. Final approval: All.

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