The Feasibility of Fast MRI to Reduce CT Radiation Exposure With Acute Traumatic Head Injuries

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Traumatic brain injuries (TBIs) are among the most common causes of pediatric morbidity and mortality globally. After acute head trauma, children at risk for clinical deterioration must be identified rapidly and accurately, usually in the emergency department (ED) setting. Neuroimaging by computed tomography (CT) for pediatric head trauma proliferated rapidly in the late 1990s[1] and remains the diagnostic gold standard for the identification of clinically important TBIs. Therein lies the problem: the risk of missing significant intracranial pathology must be weighted against the risks of radiation-induced malignancy associated with CT imaging.[2–4] Reducing CT scans for head-injured children has been the focus of international research[5–8] and educational campaigns for nearly 2 decades.[9–11] Despite these long-standing efforts, neuroimaging of head-injured children by CT remains elevated.[12]

MRI presents a potentially attractive alternative to CT that would not expose children to the harmful effects of ionizing radiation. However, the use of MRI for pediatric head trauma has traditionally been limited by the need to remain motionless for a prolonged period and frequently necessitates procedural sedation with its additional inherent risks. A fast MRI protocol that is motion tolerant and sensitive for brain injury would curtail the limitations of conventional MRI.

Previous studies comparing fast MRI and CT have produced mixed results but have been predominantly small, retrospective studies using variable MRI sequencing protocols.[13–19]

In this issue of *Pediatrics*, Lindberg et al[20] sought to assess the feasibility and accuracy of fast MRI to identify TBIs in a large prospective cohort of children <6 years old. All children included received imaging by both MRI and CT modalities. Feasibility was defined as the proportion of successfully completed studies, and imaging time measured the first to last sequence including repeated sequences. The authors also report the sensitivity of MRI for detecting radiographically apparent TBIs versus CT as the criterion standard. A broad definition of radiographic TBI was used, which included uncomplicated skull fractures, and the study was powered to achieve a 95% confidence interval between 96.7% and 100% for sensitivity if fast MRI captured all CT-identified TBIs.

In this well-conducted study, 223 of 225 (99%) enrolled children successfully completed fast MRI in a median time of 365 seconds (range 340–392) compared to 59 seconds (range 52–78) for CT. Fast MRI performed with 92.8% sensitivity, missing 8 of 111 injuries identified by CT, but those would in general not be considered clinically important TBIs.[7]

An important strength of this study is the fact that all enrolled children had

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CT scans to which fast MRI results could be compared. Moreover, 50% of the cohort had radiographic TBIs on CT, allowing a meaningful estimation of the precision of fast MRI sensitivity. The high rate of successfully completed fast MRIs is also noteworthy given the young age (median 12.6 months) of participants for whom imaging would be most expected to require sedation. Although 92.8% sensitivity for fast MRI did not meet the prespecified threshold (upper bound 96.8%), fast MRI identified an additional 5 TBIs missed by CT, suggesting that the test performance of fast MRI may even be underestimated when using CT as the gold standard.

The findings of this study suggest great promise for fast MRI; however, certain study limitations are worth consideration. More than half (56%) of children undergoing fast MRI were transferred from a referral center, none were "deemed clinically unstable," and the median interval for fast MRI was 243 minutes after CT. Children selected for fast MRI would have a low pretest probability of neurosurgical intervention, intubation, or intensive care observation. Thus, the reported feasibility reflects a highly selected cohort of stable patients in whom fast MRI is already likely to succeed. Feasibility results in a more generalizable population of head-injured children cannot be extrapolated.

The outcome definition of imaging time should also be placed in context. The median imaging time did not include the total time spent away from the ED (transport, immobilization positioning, imaging). Authors of previous studies have compared ED length of stay,[13] although the time to and from the ED might be the comparison of most interest and is generally the period of highest risk away from optimal medical observation. Moreover, the fast MRI sequencing protocol minimum imaging time was 229 seconds plus time for sequences "repeated as needed." No measure is reported for how frequently sequences were interrupted or repeated. This variable could significantly influence reproducibility of the reported 365-second imaging time, particularly among centers less adept at calming and repositioning young children in the scanner. Additionally, fast MRI was unavailable for 65 of 299 consenting, eligible patients because of lack of overnight staffing. Although not included among the outcome definitions of imaging time, this would be an important "feasibility" consideration in most centers.

It is not surprising that fast MRI identified 7 nontraumatic "incidentalomas" not resolved by CT.[21] Fast MRI may provide a radiation-sparing alternative to CT; however, the authors appropriately caution against the potential for increased unnecessary imaging for low-risk head injuries. Centers migrating toward this modality for neuroimaging children with head injuries should still use clinical judgment and highly sensitive, validated clinical decision rules when determining the need for any neuroimaging for head-injured children.[5,7]

So, is fast MRI ready for prime time? This study adds to the growing literature supporting the use of fast MRI in pediatric head trauma. The authors concluded that "fast MRI is a reasonable alternative to CT to identify radiographically evident TBI in clinically stable children." However, the remaining real-world challenge will be using fast MRI to identify clinically important TBIs among children who most need neuroimaging. This study is an important first step that should prompt additional well-designed and more generalizable future research using fast MRI for acutely head-injured children.

ABBREVIATIONS

CT: computed tomography
ED: emergency department
TBI: traumatic brain injury

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