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CLINICAL ARTICLE

Use of magnetic resonance imaging in severe pediatric traumatic brain injury: assessment of current practice

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OBJECTIVE There is no consensus on the optimal timing and specific brain MRI sequences in the evaluation and management of severe pediatric traumatic brain injury (TBI), and information on current practices is lacking. The authors performed a survey of MRI practices among sites participating in a multicenter study of severe pediatric TBI to provide information for designing future clinical trials using MRI to assess brain injury after severe pediatric TBI.

METHODS Information on current imaging practices and resources was collected from 27 institutions participating in the Approaches and Decisions after Pediatric TBI Trial. Multiple-choice questions addressed the percentage of patients with TBI who have MRI studies, timing of MRI, MRI sequences used to investigate TBI, as well as the magnetic field strength of MR scanners used at the participating institutions and use of standardized MRI protocols for imaging after severe pediatric TBI.

RESULTS Overall, the reported use of MRI in pediatric patients with severe TBI at participating sites was high, with 40% of sites indicating that they obtain MRI studies in > 95% of this patient population. Differences were observed in the frequency of MRI use between US and international sites, with the US sites obtaining MRI in a higher proportion of their pediatric patients with severe TBI (94% of US vs 44% of international sites reported MRI in at least 70% of patients with severe TBI). The reported timing and composition of MRI studies was highly variable across sites. Sixty percent of sites reported typically obtaining an MRI study within the first 7 days postinjury, with the remainder of responses distributed throughout the first 30-day postinjury period. Responses indicated that MRI sequences sensitive for diffuse axonal injury and ischemia are frequently obtained in patients with TBI, whereas perfusion imaging and spectroscopy techniques are less common.

CONCLUSIONS Results from this survey suggest that despite the lack of consensus or guidelines, MRI is commonly obtained during the acute clinical setting after severe pediatric TBI. The variation in MRI practices highlights the need for additional studies to determine the utility, optimal timing, and composition of clinical MRI studies after TBI. The information in this survey describes current clinical MRI practices in children with severe TBI and identifies important challenges and objectives that should be considered when designing future studies.

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KEYWORDS magnetic resonance imaging; pediatric traumatic brain injury; survey; trauma

Traumatic brain injury (TBI) is the leading cause of death or disability in children. Each year in the US, pediatric TBI results in an estimated 630,000 emergency room visits, 59,000 hospitalizations, and 7000 deaths.[5] The incidence of long-term disability after severe TBI is high, and an estimated 60% of children require educational or community-based supportive services 1 year after their injury.[21] Approximately 145,000 US children are currently living with disabilities after a severe TBI,[36] with an annual overall cost, accounting for

ABBREVIATIONS ACR = American College of Radiology; ADAPT = Approaches and Decisions after Pediatric TBI; DAI = diffuse axonal injury; DTI = diffusion tensor imaging; DWI = diffusion-weighted imaging; GCS = Glasgow Coma Scale; GOS-E Peds = Pediatric Glasgow Outcome Scale–Extended; GRE = gradient recalled echo; ICP = intracranial pressure; MRS = MR spectroscopy; PICU = pediatric intensive care unit; PWI = perfusion-weighted imaging; SWI = susceptibility-weighted imaging; TBI = traumatic brain injury.

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long-term care and lost productivity, approaching $60 billion.[4]

CT scanning is the gold standard neuroimaging modality for diagnosing brain injury after trauma and plays a vital role in rapid detection of intracranial injuries requiring immediate intervention. However, the relative insensitivity of CT to detect early ischemia, diffuse axonal injury (DAI), and brainstem injury limits its use for prognosis of long-term neurological function.[2] MRI may offer several important benefits over CT imaging alone, including enhanced spatial resolution and increased sensitivity for detection of DAI, contusions, cytotoxic edema, and microhemorrhages.[14]

Recently, MRI has been reported to improve outcome prediction after mild TBI in adults,[34,35] and MRI measures of lesion burden and DAI have been related to outcome after moderate and severe TBI in a number of studies.[26,27] Similarly, studies of MRI findings in pediatric TBI suggest that MRI measures may be correlated with outcome and may improve outcome prediction over Glasgow Coma Scale (GCS) score alone.[1,6,13,28,31] Despite these recent advances, the utility of MRI in children with severe TBI remains unclear. Consequently, current guidelines for the management of severe pediatric TBI do not include recommendations for MRI, and further study is needed to establish clinically relevant MRI markers for use in prognostication and directing of therapies after severe pediatric TBI.

In order to plan and design a study of acute MRI predictors of functional outcome after severe pediatric TBI, we collected information on MRI practices at sites expressing interest in participating in a research study of MRI markers in pediatric TBI. Survey responses provided information on the current use and variation in practice of MRI methods in the population with severe pediatric TBI.

Methods

All institutions participating in the Approaches and Decisions after Pediatric TBI (ADAPT) Trial were invited to participate in preparing for a multisite study of MRI markers of outcome after severe pediatric TBI. Twenty-seven of 48 ADAPT sites participated and provided information on current MRI practices and resources at their institutions. Participation in the MRI ancillary study was voluntary and separate from participation in the overall ADAPT Trial. The principal investigator at each site was asked to complete the survey, based on their knowledge of typical practice at their institution. No chart review or audit was required. Participating ADAPT site principal investigators were physicians in pediatric critical care, neurology, and neurosurgery. Multiple-choice questions addressed the following areas: the percentage of TBI subjects who have early MRI, the timing of MRI post-TBI, the specific MRI sequences acquired in TBI patients, as well as the magnetic field strength of MR scanners available for clinical use at their institution and the use of standardized MR protocols for imaging after severe pediatric TBI.

The ADAPT Trial is an international multicenter prospective observational study investigating the effectiveness of therapies for severe pediatric TBI,[13] which has enrolled 1000 children with the following inclusion criteria: TBI with a postresuscitation GCS score ≤ 8, intracranial pressure (ICP) monitor placed, and age 0–18 years. The primary outcome measure is the Pediatric Glasgow Outcome Scale–Extended (GOS-E Peds) score at 6 months postinjury, with secondary outcomes of GOS-E Peds at 3 months and a neuropsychological test battery at 1 year postinjury.

The assessment of current imaging practices was distributed from the ADAPT Data Coordinating Center. Additionally, an organizational assessment form was distributed annually to each ADAPT site from the ADAPT Data Coordinating Center, and was completed by the medical director, nursing director, or the site's principal investigator. The form provided information about each site including hospital information (i.e., whether the hospital is a freestanding children's hospital, university-affiliated teaching hospital, or community hospital, and whether the hospital serves primarily an adult population); unit information (i.e., total number of pediatric intensive care unit [PICU] beds, annual number of PICU admissions, annual number of PICU patients supported on mechanical ventilation, and whether the PICU is open or closed); and medical staff information (i.e., number of attending physicians, fellows, and residents). For this work we used the organizational assessment results from the year this assessment of current MRI practices was conducted.

Descriptive statistics were summarized as frequencies for categorical data or as median and interquartile range for continuous data, as appropriate. Fisher's exact test was used to compare the frequency distribution of categorical variables. Fisher's exact test or Wilcoxon-Mann-Whitney test, as appropriate, were used to compare site characteristics between survey responding and nonresponding sites. All tests were 2-sided and the significance level was set to $p < 0.05$. All analyses were conducted using SAS version 9.3 statistical software (SAS Institute, Inc.).

Results

The 27 participating sites represented a spectrum of size and affiliation, from the US (67%) and internationally (33%) (Table 1). International sites included centers in India (n = 1), the Netherlands (n = 3), Spain (n = 1), and the United Kingdom (n = 4). No significant differences in site characteristics were observed between those ADAPT sites participating in the MRI study and nonparticipating sites.

Use of MRI in Children With Severe TBI

When asked what percentage of pediatric patients with severe TBI at their institution have MRI performed during the acute hospitalization, 12 sites indicated that they obtain an MRI study in > 95% of children with severe TBI (Fig. 1A), 10 sites reported performing MRI in 70% of patients, and 5 sites reported that MRI is obtained in ≤ 50% of pediatric patients with severe TBI. A significant difference ($p = 0.025$) was found in the incidence of MRI between US and international ADAPT sites (Fig. 1B). Among the US centers, 47% of sites indicated that they obtain an MRI study in > 95% of children with severe TBI compared to 22% of the international sites. Nearly all US

TABLE 1. Site characteristics for 27 institutions participating in the ADAPT Trial

Characteristic	Value
Location of site	
US sites	18 (66.67%)
International sites	9 (33.33%)
Type of hospital	
Freestanding children's hospital	15 (55.56%)
Community hospital	4 (14.81%)
Primarily adult hospital	9 (33.33%)
24/7 in-house attending coverage	14 (51.85%)
Median PICU beds/site (IQR)	23 (14)
Median PICU admissions/yr (IQR)	1400 (1804)

IQR = interquartile range.

sites (94%) reported MRI during the acute hospitalization in at least 70% of patients with severe TBI. The incidence of MRI was more variable across international sites, and only 44% of these sites indicated performing MRI in at least 70% of their pediatric population with severe TBI. Freestanding children's hospitals were more likely to indicate that an MRI study was obtained (in > 95% of subjects with severe TBI) when compared to nonfreestanding children's hospitals (Fig. 1C).

Timing of MRI After Severe TBI in Children

Sites were asked to report at what point during the acute hospitalization a brain MR scan is typically obtained in pediatric patients with severe TBI. A high variability in the timing of MRI in subjects with severe TBI was seen across sites (Fig. 2A). Most sites (60%) indicated that MRI is performed beyond the initial 72-hour postinjury period, but within 2 weeks of injury. A single site reported routinely performing an MRI study in the first 24 hours postinjury, and an additional 4 sites indicated that a scan is obtained 24–72 hours postinjury. Among US centers, the reported timing of MRI was variable throughout the postinjury period (Fig. 2B). Nine US sites reported typically obtaining MRI in patients with TBI in the 1st week postinjury, with 4 of these sites indicating that an MRI study is usually obtained within 72 hours of injury. Responses from international sites demonstrated a similar variability with respect to timing of MRI, and were distributed throughout the postinjury period. A single international site reported routinely obtaining an MRI study within 72 hours of injury. No significant differences were found in the distribution of MRI timing between US and international ADAPT sites ($p = 1.0$) or between freestanding and nonfreestanding children's hospitals ($p = 0.96$) (Fig. 2C).

MR Sequences Used in Children With Severe TBI

Sites were asked to indicate how often various MR sequences are obtained when MRI is performed in pediatric patients with severe TBI at their institution. The percentage of sites indicating that a particular sequence was frequently obtained (survey response of "always" or "often") is shown in Fig. 3A. Regarding sequences sensitive for microhemorrhages associated with DAI, 67% of sites frequently obtain T2*-weighted gradient recalled echo (GRE) scans, and 71% frequently obtain susceptibility-weighted imaging (SWI). Altogether, approximately 80% of centers indicated that they obtain at least one of these sequences sensitive for DAI in their patients with severe TBI. Interestingly, many sites (37%) reported that they always perform both of these sequences in children with severe TBI. Nearly all sites (93%) indicated that they include diffusion-weighted imaging (DWI) in their patients with TBI. Respondents indicated that other MR techniques such as perfusion-weighted imaging (PWI; e.g., dynamic susceptibility contrast enhanced or arterial spin labeling), diffusion tensor imaging (DTI), and MR spectroscopy (MRS) are performed much less frequently in their patients with TBI (29%, 39%, and 7% of sites indicating an always or often response for PWI, DTI, and MRS, respectively). No differences were seen in the makeup of MRI sequences obtained at international sites or freestanding children's hospitals (Fig. 3B and C).

Additional Information on Imaging Practices After Severe Pediatric TBI

Sites were asked to indicate whether a standardized MRI protocol was used for imaging brain injuries after pediatric TBI at their center. Only 32% of sites indicated that a standardized MRI protocol was used for imaging pediatric patients with TBI. Sites were additionally asked to report the magnetic field strengths of the MRI systems available for imaging in children. Sixty percent of sites indicated that a 3-T MR scanner was available for use in their pediatric TBI population. No differences were observed in the percentage of sites using a standardized MRI protocol or in the availability of 3-T MR scanners in the international sites or in the freestanding children's hospitals.

Discussion

This survey provides information on the self-reported current practices for early MRI in children with severe TBI from 27 medical centers participating in a multicenter clinical study. Overall, the respondents indicated that the clinical use of MRI in the care of the pediatric TBI population at their institutions is high, and suggest that most children with severe TBI that they care for will have an MRI study during the acute hospitalization. Beyond the prevalent use of MRI, the survey results also characterize a wide variation in the timing of MRI post-TBI, and in the composition of MRI sequences obtained for evaluation of severe TBI in children.

The use of neuroimaging to determine prognosis after TBI has been heavily investigated. CT remains the gold standard imaging modality for diagnosing TBI, and plays an important role in emergency detection of intracranial processes such as cerebral edema and epidural hematomas, which may require immediate and targeted intervention. Whereas CT findings of basal cistern effacement, extraaxial hematoma, and intracerebral hemorrhage correlate with worse outcomes,[3] in many studies CT offers no

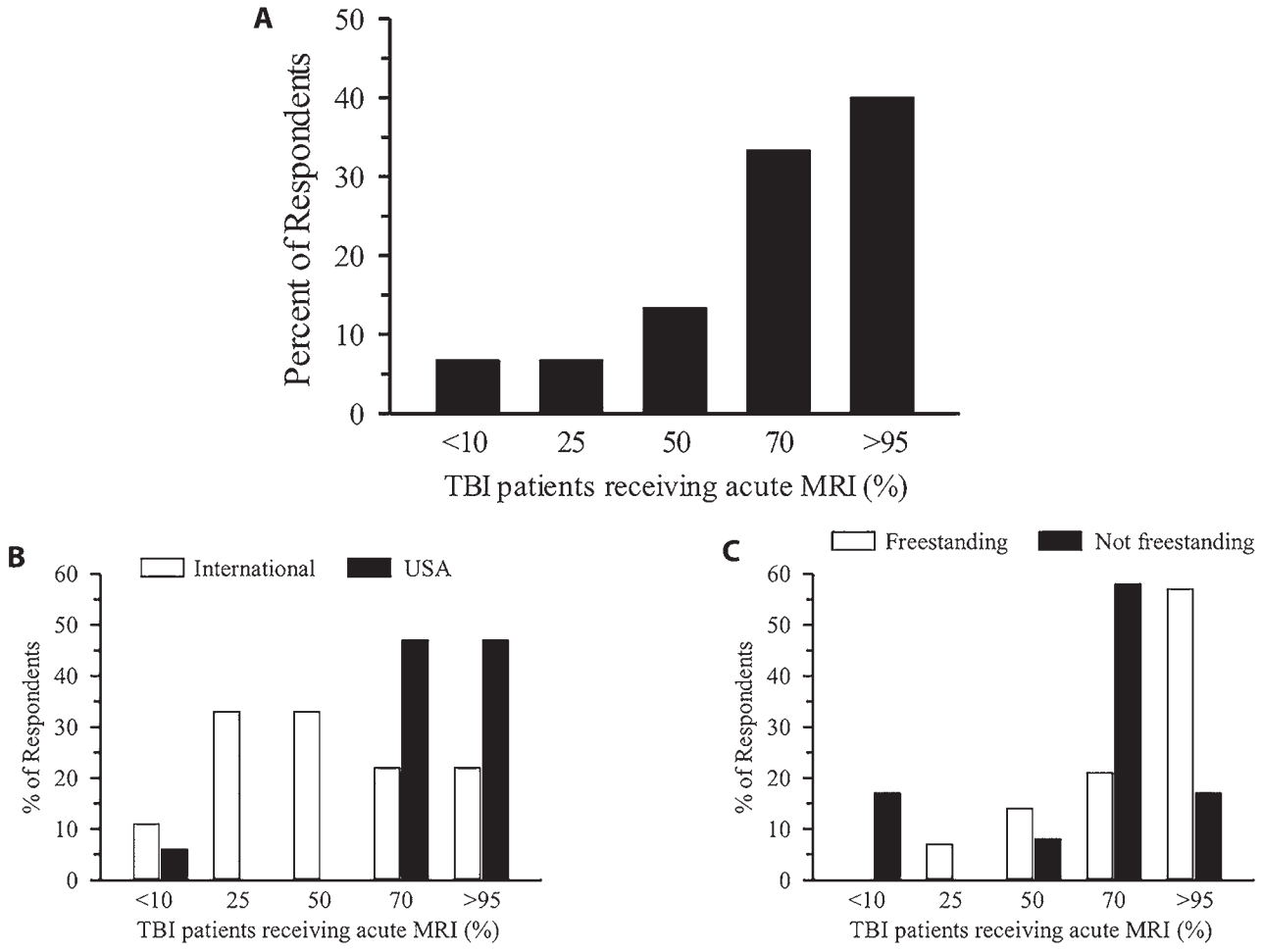

FIG. 1. Bar graphs showing the proportion of patients with severe TBI who undergo MRI. Sites were asked to select which of the 5 shown percentages best represents the proportion of their population with severe TBI that undergoes MRI during the acute hospitalization. **A:** The percentage of sites that selected each option. **B:** The distribution of responses among US and international sites. **C:** Freestanding children's hospitals and nonfreestanding children's hospitals.

improvement over GCS score and other clinical variables for predicting outcome in survivors of pediatric and adult TBI.[2,11] This may be due to the relative insensitivity of CT for the detection of TBI-related pathology such as early ischemia, subtle bleeds, and DAI, thereby limiting its use for prognostication and for directing therapies outside the acute time frame. The enhanced resolution of MRI and increased sensitivity for detection of DAI, cytotoxic edema, and microhemorrhages[14] make it a promising modality for identifying TBI subtypes and predictors of long-term outcome after TBI.

In studies conducted in adults, total lesion burden and depth of the lesion on conventional MR sequences have demonstrated an association with functional outcomes.[26] The addition of T2* GRE, SWI, and DWI has improved the detection of axonal injury and has also been shown to correlate with neurological outcomes.[6] Several pediatric studies have assessed the value of acute MRI in predicting outcome after severe TBI, similarly indicating that lesion depth and burden of DAI are correlated with outcome and that MRI findings may improve outcome prediction over GCS score alone.[1,6,31] In the largest study of MRI predictors of outcome after pediatric TBI conducted to date, Smitherman et al. used FLAIR images to assess lesion volume and location in the first weeks after injury.[28] FLAIR is an MRI technique in which tissue contrast is used similar to T2-weighted MRI, but using very long repetition time (TR) and echo time (TE) to suppress signal from CSF. The authors demonstrated a high correlation between total lesion volume and outcome at 1 year postinjury as assessed by the GOS-E Peds. Additionally, the lesion volume in the brainstem accurately discriminated between children with favorable and unfavorable outcomes in this study.

Despite these promising clinical studies, consensus is lacking regarding the utility of MRI in the evaluation and management of severe pediatric TBI, and there remains significant clinical uncertainty when counseling families regarding prognosis. Thus far, studies of early MRI predictors of outcome after pediatric TBI have been limited by retrospective study design, small sample sizes, varying outcome measures and follow-up time points, and inclusion of children with all severities of brain injury. Accordingly, recently published guidelines for the management of pediatric TBI cited insufficient evidence to support a

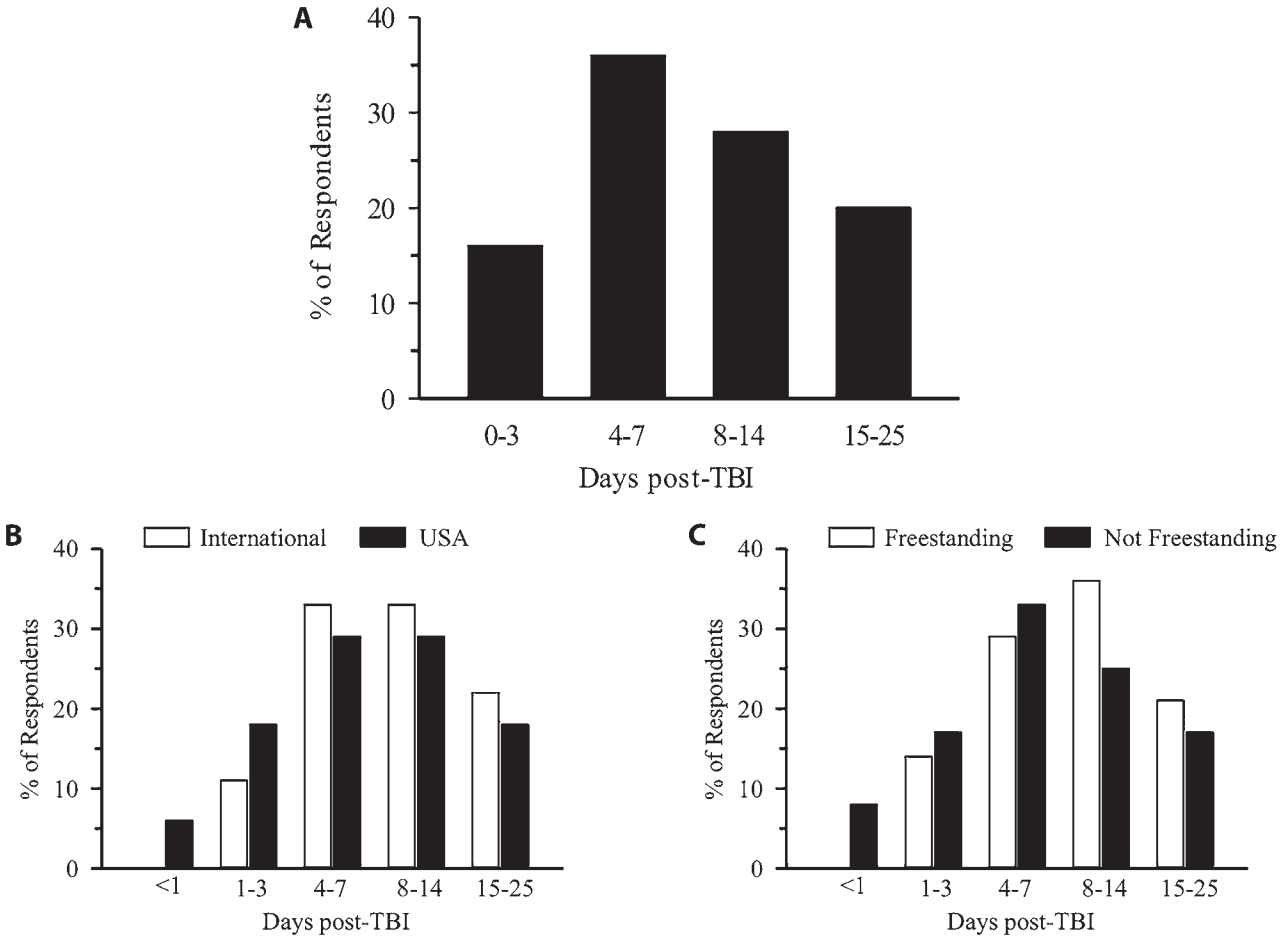

FIG. 2. Bar graphs showing the timing of MRI post-TBI. Sites were asked to select which option best represents the time point at which an MRI study is typically obtained in children with severe TBI at their institution. Percentage of sites selecting each response is shown for all sites (**A**), for US and international sites (**B**), and for freestanding and nonfreestanding children's hospitals (**C**).

recommendation for routine use of MRI, and called for additional studies to establish the value of MRI in prognostication and directing therapy.[12] The American College of Radiology (ACR) has recently published recommendations regarding the appropriateness of various neuroimaging modalities after pediatric TBI.[22] The ACR rated MRI as "usually appropriate" in children with moderate to severe TBI, and primarily cited the improved prognostication afforded by detection of DAI using MRI. The ACR further highlighted the utility of MRI in evaluation of suspected nonaccidental TBI, citing the increased sensitivity of MRI to detect subtle injuries and DAI, which may not be apparent on CT. Beyond this, no recommendations were provided regarding the optimal timing or composition of MRI scans in children with severe TBI. Our survey responses suggest that despite the lack of detailed guidelines, but in line with the ACR recommendations, clinicians frequently use MRI as part of their standard management of children with severe TBI. The use of MRI was particularly prevalent among US sites, where most sites report obtaining an MRI study in at least 70% of their pediatric patients with TBI.

The lack of guidelines for imaging after TBI, combined with the promising clinical studies described above, may account for the striking heterogeneity in timing and composition of MRI sequences reported in our survey. Although most sites reported obtaining an MRI study in the first 2 weeks postinjury, responses were distributed throughout the first 30-day postinjury period. Interestingly, 20% of sites report that MRI is typically performed within 72 hours of injury. During this early postinjury period, hemodynamic instability, intracranial hypertension, use of continuous infusions, and the need for invasive and noninvasive monitors all serve to increase the complexity of intrahospital transport and MRI. Although these factors may be seen as a barrier to MRI early after TBI, this modality is frequently used in a similar setting to diagnose and direct therapy in potentially unstable patients during the first hours after onset of stroke symptoms.[20] The DWI sequences used in imaging after early stroke may similarly be used to identify cytotoxic edema associated with ischemia at very early time points after TBI. For example, Shakir et al. recently reported that DWI whole-brain apparent diffusion coefficient values discriminate between good and poor outcome within 48 hours of TBI in adults.[25] Similarly, Galloway et al. reported on the use of DWI in

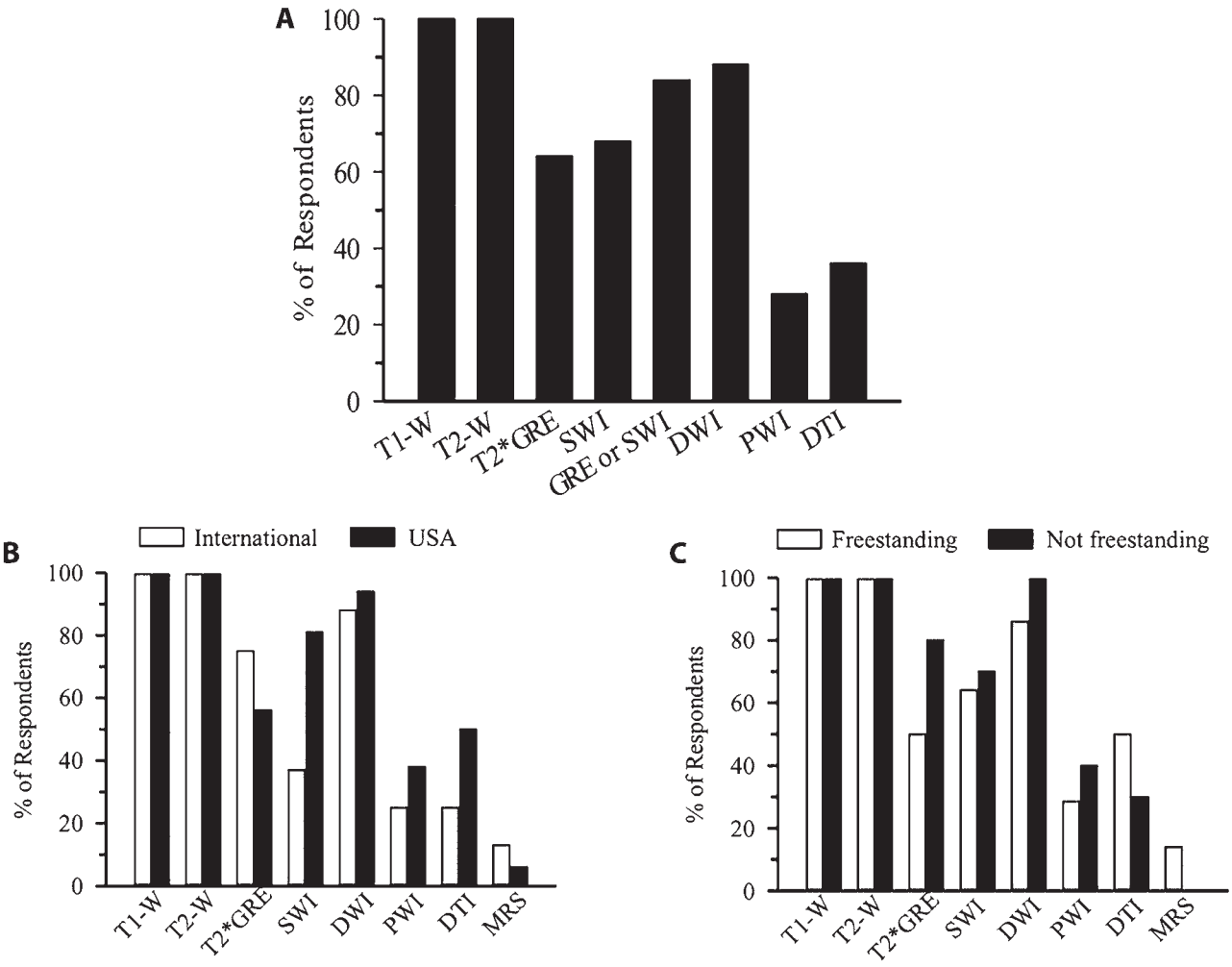

FIG. 3. MR sequences used in acute clinical MRI studies. Sites were asked how often each MR sequence is included when MRI is performed in children with severe TBI at their institution. Available responses were: Always, Often, Sometimes, and Never. The percentage of all sites responding "always" or "often" is shown for each MR sequence (**A**). The distribution of responses is compared between US and international sites (**B**), and between freestanding and nonfreestanding children's hospitals (**C**). MR sequences shown: T1-weighted MRI (T1-W), T2-weighted (T2-W), T2* GRE, SWI, DWI, PWI, DTI, and MRS.

children as early as day 0 after TBI and found a significant difference in deep white matter apparent diffusion coefficient values between children with good and poor outcome after severe injury.[6]

Conventional T1-weighted and T2-weighted imaging alone, which can be acquired in a short duration of scan time, may be useful at early time points after injury. Woischneck et al. performed T1-weighted and T2-weighted MRI as early as 10 hours after injury in comatose children after TBI, and found that brainstem lesions correlated with duration of coma and long-term disability.[33] In addition to diffusion imaging, MR techniques such as SWI may be used to detect microbleeds associated with DAI within 24 hours of injury.[32] MRI may therefore aid in diagnosis by identifying TBI when the etiology of coma is uncertain and the head CT is negative, and may also help with prognostication even when performed at very early time points after severe pediatric TBI. However, in contrast to the use of MRI to direct thrombolysis and thrombectomy in the setting of acute stroke, no studies have yet demonstrated an impact of early MRI on directing therapy after TBI. Although the use of early MRI to improve prognostication and direct therapies will require additional study, early MRI may also have a role in future clinical trials of new TBI therapies, allowing for stratification of subjects by lesion type (i.e., DAI vs non-DAI); location (i.e., brainstem vs cortex); or severity (i.e., total lesion burden). Most sites reported obtaining MRI beyond 72 hours postinjury, which is most compatible with the current use of MRI for improved prognostication, and potentially to direct and track the effect of rehabilitation strategies in future studies.

Institutional differences in ICP monitoring practices may also account for the observed heterogeneity of timing of MRI. Some monitoring devices are unsafe for use within an MR scanner due to the risk of thermal burn or device displacement, precluding early MRI at institutions using these monitors. Monitors that can be used safely require specific configurations of monitor wires and head coils[19]

to avoid resonance-induced generation of current within the monitor wires and heating of the wires and transducer tip. This may result in a perceived barrier to performing MRI in patients with an ICP monitor in place, leading to similar delays in MRI after TBI. Clearly, these actual and perceived barriers to MRI of patients with ICP monitors will need to be considered in future clinical studies hoping to use MRI for subject stratification or to monitor the effect of therapy.

When asked about the types of MRI sequences typically acquired in patients with TBI, survey responses indicated a wide variation in practice. However, most sites reported that at least one or a combination of sequences sensitive for DAI are obtained in patients with TBI. DAI results from acceleration-deceleration forces and the resultant stretching or shearing of axonal fibers,[7] and is thought to underlie many of the cognitive deficits seen in survivors of severe TBI.[15,24] In fatal cases of TBI, DAI is nearly universally present, and it is common in moderate and severe TBI as well.[27] A grading system describing the location and extent of DAI was developed from neuropathological studies and was modified for use with neuroimaging:[8] stage 1, lesions confined to lobar white matter; stage 2, lesions in the corpus callosum; and stage 3, lesions within the brainstem. Over the past several years of investigation into DAI in adults and children, the burden of DAI lesions and stage of DAI has been consistently associated with outcomes.[1,16,17,23]

T2* GRE and SWI are MRI sequences that exploit the paramagnetic properties of deoxyhemoglobin and the iron present in the products of blood breakdown for detection of small hemorrhages. The Transforming Research and Clinical Knowledge in Traumatic Brain Injury (TRACK-TBI) investigators recently reported that MRI studies performed within 3 weeks of mild TBI identified many more lesions than CT scans, which was largely attributable to microhemorrhages seen on T2* GRE, and these investigators found that the use of MRI improved outcome prediction in this patient population.[35] The white matter microhemorrhages identified on T2* GRE are associated with long-lasting alterations in white matter microstructure. Moen et al. recently used coregistration of T2* GRE scans acquired at a median of 7 days after TBI with DTI maps of fractional anisotropy acquired 3 years postinjury, to demonstrate persistent reductions in fractional anisotropy values in white matter regions with acute microhemorrhages.[18]

SWI is a 3D modality with increased sensitivity for microhemorrhages over GRE imaging,[9] although at the expense of longer acquisition times. A number of studies have related the number of white matter lesions on SWI to injury severity and outcome. For example, Tong et al.[31] studied 40 children with TBI by using SWI and found a significant relationship between the total number of microhemorrhages and both the admission GCS score and the Pediatric Cerebral Performance Category score at 6–12 months postinjury. As mentioned, SWI achieves increased resolution over T2* GRE at the expense of increased scan time, making SWI more susceptible to motion artifact and leading to increased overall duration of MRI.[29] This may explain the widespread use of T2* GRE in children with severe TBI at participating institutions, despite the improved resolution and increased sensitivity for DAI lesions afforded by SWI. Indeed, 37% of institutions indicated that they always obtain both sequences in children with severe TBI. Using this strategy may help to ensure that in the event the SWI sequence is motion degraded or unable to be obtained, the more reliable but less sensitive T2* GRE image will be available for evaluating DAI.

Some limitations must be considered when interpreting the results of our study. Participating sites contributed information in preparation for a multisite study of MRI markers in TBI, and therefore represent a subset of institutions with interest in participating in MRI research. The institutional practices and resources at these sites may differ from institutions not interested or equipped to participate in MRI research, so caution should be taken in generalizing our findings However, the sites participating in our study represent a spectrum of size and affiliation, both from the US and internationally, and characteristics of the MRI sites did not differ significantly from the nonparticipating ADAPT sites. Last, information on clinical indications for MRI, scanning-related adverse events, and the impact of MRI findings on management decisions was beyond the scope of this study and will be important to address in future studies.

The results of our survey highlight a number of issues that need to be considered in designing clinical studies using MRI to assess TBI. First, the variability in scanning practices and infrequent use of standardized TBI imaging protocols reported among the sites participating in this large TBI trial presents a barrier to the use of MRI in clinical studies. Determining best practice for MRI after TBI and establishing TBI neuroimaging protocols will be a necessary first step for the future use of MRI to stratify patients or monitor effects of therapy in clinical trials of TBI. Identification of clinically useful MRI markers of long-term outcome, and determining the optimal timing and MR sequences for clinical MRI after TBI will require a large sample size and should include comprehensive neurocognitive and neuropsychological outcome assessments in addition to scores of global function. Given the relatively small numbers of severe pediatric TBI subjects admitted to academic centers,[30] such a study will need to be conducted across many sites, and our study suggests that the scans will be very heterogeneous in regard to the composition of MR sequences and scanner magnet strength. In a large data set of clinical MRI studies, this variability in scanning practices presents an opportunity to compare the utility of specific MR sequences and to assess the optimal timing of scans. However, the heterogeneity of a clinical MRI data set will present challenges for semiautomated software analyses, and will therefore require a radiographic read by humans of each scan included in the study, with imaging findings ideally coded to the NIH/NINDS (National Institutes of Health/National Institute of Neurological Disorders and Stroke) Common Data Elements for Neuroimaging, a standardized set of data terms and definitions for neuroimaging studies.[10]

Conclusions

This assessment of current MRI practices at medical

centers participating in a multicenter clinical study reveals the prevalent use of MRI in the clinical care of children with severe TBI at these institutions. Survey responses suggest a wide variability in the timing and composition of MRI studies after severe pediatric TBI. The results of this survey provide new information on current imaging practices in the population with severe TBI, an important first step in designing future studies to determine optimal timing and protocols for MRI in children with severe TBI.

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Appendix

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Conception and design: Ferrazzano, Bell. Acquisition of data: Ferrazzano, Bell. Analysis and interpretation of data: all authors. Drafting the article: all authors. Critically revising the article: Ferrazzano, Rosario, Wisniewski, Bell. Reviewed submitted version of manuscript: all authors. Statistical analysis: Rosario, Wisniewski.

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