ORIGINAL ARTICLE

Assessment of Pediatric Neurotrauma Imaging Appropriateness at a Level I Pediatric Trauma Center

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Abstract

Purpose: The aim of this study was to assess the prevalence of appropriate neuroimaging on the basis of the ACR Appropriateness Criteria among pediatric patients presenting after head trauma to a level I emergency department.

Methods: A retrospective emergency department record review was performed for patients <18 years of age undergoing head CT or MRI for the indication "head trauma" between January 2013 and December 2014. Clinical history and symptoms were compared with the ACR Appropriateness Criteria; the indication was deemed appropriate for ratings of ≥7. Patients were analyzed by age, gender, presentation, imaging obtained, follow-up, treatment, and outcomes.

Results: Among 207 patients, 120 (58%) were imaged with CT and 107 (52%) with MRI; 20 patients underwent both CT and MRI. One hundred eighty-seven patients (90.3%) were appropriately imaged, with 90.0% of CT studies (108 of 120) deemed appropriate and 91.6% of MRI studies (98 of 107) deemed appropriate. Younger patients were more likely to be inappropriately imaged with CT or MRI than older patients ($P = .02$ and $P < .01$, respectively). Patients undergoing CT were older (mean age 9.9 ± 5.8 years) and more likely to be male (85.2%) than those undergoing MRI (5.6 ± 5.6 years and 55.1%, respectively) ($P < .01$ and $P < .001$, respectively). The diagnostic yield of positive imaging findings for intracranial trauma was significantly lower in the MRI group ($P < .01$), and patients undergoing MRI were significantly more likely to return to baseline with conservative management ($P < .01$).

Conclusions: Most pediatric patients undergoing neuroimaging for head trauma did so appropriately per ACR guidelines and had symptom resolution with conservative management. The minority not imaged appropriately represent a target for quality improvement efforts.

Key Words: Radiology, appropriateness criteria, CT, MRI, head trauma, TBI, utilization, diagnostic radiation, Image Gently, pediatrics, concussion

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INTRODUCTION

Traumatic brain injury (TBI), both accidental and nonaccidental, is a leading cause of pediatric death and disability, resulting in more than half a million emergency department (ED) visits per year [1]. The imaging workup of pediatric head trauma can be particularly challenging, given the variety of imaging options and nonspecific clinical symptoms. The primary goal of imaging workup in trauma is to detect treatable complications of pediatric TBI and improve outcome prognostication. Multiple studies have been performed to better define the optimal clinical care of these complex patients, including the

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Pediatric Emergency Care Applied Research Network (PECARN) [2], the National Emergency X-Radiography Utilization Study [3], the Children's Head Injury Algorithm for the Prediction of Important Clinical Events [4], and the Canadian Assessment of Tomography for Childhood Head Injury [5] trials. For instance, the PECARN prospective trial demonstrated the low utility of CT imaging for pediatric patients with minor, uncomplicated head injury, with negative predictive values of >99.9 [2].

CT and MRI are the primary imaging modalities used in the clinical workup of pediatric patients with neurotrauma, with certain advantages and disadvantages that help define their unique utility in care algorithms. CT tends to be faster, less expensive, more accessible, and more sensitive for osseous fractures compared with MRI. The main disadvantage of CT is potential risk associated with ionizing radiation, particularly in younger children [6,7]. Although MRI offers a promising nonradiation alternative to CT, MRI tends to be less accessible, and children may require procedural sedation because of the length of the study and the motion sensitivity of MRI.

The ACR Appropriateness Criteria® (AC) for pediatric head trauma are meant to assist referring physicians in making the most appropriate imaging or treatment choices in the care of pediatric neurotrauma patients [8]. Recognizing the patient safety and economic implications of imaging utilization appropriateness, the purpose of our study was to assess the appropriateness of neurologic imaging in pediatric patients who presented with neurotrauma to a level I pediatric ED vis-à-vis the ACR AC.

METHODS

Study Site

This retrospective, HIPAA-compliant study was performed at a 950-bed tertiary care academic center with a dedicated pediatric ED certified as a level I pediatric trauma center by the American College of Surgeons. The study was approved by the institutional review board. The need for informed consent was waived.

The ED is staffed primarily by board-certified specialists in pediatric emergency medicine and services more than 12,000 pediatric emergency visits annually. Neurologic imaging is performed by a radiology department that performs approximately 27,000 CT studies and 7,000 MRI studies in the ED annually, interpreted by subspecialty-trained neuroradiologists. Order-entry clinical decision support (CDS) tools are not available for imaging studies ordered in the ED.

PATIENT SELECTION

Using custom text-searching software, the institution's radiology information system (Centricity; GE, Waukesha, Wisconsin) was queried for all head CT and head MRI examinations performed on ED patients younger than 18 years for the clinical indication of "head trauma" during a two-year study period from January 2013 to December 2014. Patients who were imaged for additional indications other than head trauma were excluded from this study.

Appropriateness Source and Determination

The ACR AC represent an expert panel's summation of the currently available evidence into a comprehensive set of evidence-based imaging guidelines. The guidelines provide appropriateness scores of various imaging or treatment options for common clinical scenarios, including minor head injury, uncomplicated and complicated; moderate or severe head injury; and suspected nonaccidental trauma, among others [8]. Scores are represented on an ordinal scale from 1 to 9, with 1, 2, and 3 in the "usually not appropriate" category (ie, the risks of doing the procedure likely outweigh the benefits); 4, 5, and 6 in the "may be appropriate" category (ie, the risk and benefit balance is equivocal); and 7, 8, and 9 in the "usually appropriate" category (ie, the benefits of the procedure likely outweigh the risks).

For all patients returned by the indications query, the electronic medical record (EMR; Partners Healthcare Longitudinal Medical Record, Boston, Massachusetts) was analyzed by a radiologist to determine the presence of clinical history and patient symptoms relevant to the ACR AC. On the basis of the clinical context garnered from the EMR, the radiologist determined the ACR AC score for the obtained head CT and/or head MRI study. The imaging was deemed appropriate if the ACR AC score was 7 or greater. The reports of all of the CT and/or MRI examinations were reviewed by a radiologist and characterized on the basis of the findings as follows: intracranial finding(s) of trauma (eg, skull fracture, intracranial hemorrhage, cerebral contusion), extracranial but no intracranial finding(s) of trauma (eg, subcutaneous laceration or soft tissue swelling or hematoma), or no intracranial or extracranial finding of trauma. Last, the EMR was analyzed for each patient to determine patient age, gender, presentation, follow-up, treatment (conservative or surgical), and outcome. Outcome was determined by reviewing clinic notes, if available, for up to 12 months after the initial trauma, and outcomes were classified as returned to baseline, residual deficit, or death.