Emergency Department Use of Neuroimaging in Children and Adolescents Presenting with Headache

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Objectives To evaluate emergency department use and outcomes of neuroimaging for headache in a free-standing children's hospital system.

Study design We prospectively enrolled children aged 6-18 years who presented to the emergency department with a chief complaint of headache from September 2015 to September 2016. Standardized data collection was performed in real time, including telephone follow-up as needed, and imaging outcome was determined through a chart review. Using multivariable logistic regression, we estimated the associations between clinically important patient characteristics and neuroimaging.

Results Of 294 enrolled patients, 53 (18%) underwent neuroimaging (computed tomography or magnetic resonance imaging) and 2 (0.7%) had clinically important intracranial findings. Presenting with abnormal neurologic examination findings (OR, 11.55; 95% CI, 3.24-41.22), no history of similar headaches (OR, 2.13; 95% CI, 1.08-4.18), and white race (OR, 3.04; 95% CI, 1.51-6.12) were significantly associated with an increased odds of undergoing imaging in multivariable regression models.

Conclusions Our observed emergency department imaging rate was 26.5 times higher than our positive result rate, suggesting there is room to decrease unnecessary neuroimaging. Associations for abnormal examination and new headache type are consistent with the American Academy of Neurology clinical imaging recommendations. The increased odds of imaging white patients suggests bias that should be addressed. The low rate of positive findings supports the need for an evidence-based clinical decision tool for neuroimaging in the acute care setting. *(J Pediatr 2018;■■:■■-■■).*

Imaging has become an integral part of the emergency department (ED) evaluation of patients with acute medical and surgical emergencies.[1] That practice has accelerated in recent years because of the relatively easy access to computed tomography (CT) scans and magnetic resonance imaging (MRI).[2] Increased CT scanning rates have generated concerns regarding the risks associated with unnecessary irradiation, and the increased use of MRI exposes patients to risks of sedation and higher healthcare costs.[3] The nature of care in the ED often requires rapid assessment and evaluation, potentially exposing these patients to unnecessary testing.

Headaches are the second most common chief complaint in those undergoing intracranial CT scans[1] and are the most common reason for neuroimaging with MRI in the ED.[2] The increasing trend to obtain neuroimaging is reflected by the finding that children with headache who are evaluated in the ED are 4 times more likely to have a CT scan performed compared with those seen in a clinic setting.[4] A portion of this variation can be attributed to the type of facility where a child is seen, with higher imaging rates at non–pediatric-focused EDs.[1] Other studies have shown disparate ED use of radiologic imaging based on age, race, or admission status.[5-7]

The vast majority of children and adolescents with headaches are otherwise neurologically normal. Imaging of such patients is known to yield relatively few actionable results; for example, across 9 retrospective chart review studies, <5% of included patients had an intracranial finding.[4,8-15] Many of these investigations were limited by incomplete data on personal medical history, neurologic examination, and indications for imaging; the majority of studies were performed retrospectively. Additionally, there was no follow-up of patients to determine if there were any missed findings at the index visit. We, therefore, aimed to examine prospectively rates, predictors, and outcomes of neuroimaging in pediatric and adolescent patients who presented to the ED with headache.

AAN	American Academy of Neurology
CT	Computed tomography
ED	Emergency department
MRI	Magnetic resonance imaging
RA	Research assistant

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Methods

We conducted a prospective cohort study aimed at evaluating the ED use and outcomes of neuroimaging for headaches in a free-standing children's hospital system. The institutional review board approved the study protocol and provided a waiver of written informed consent for data abstraction from the medical record, but required verbal informed consent for the optional telephone follow-up. All patients and families were provided written material during their ED visit describing the study.

Our study was conducted in a free-standing pediatric hospital system composed of 2 urban hospital campuses in the Midwestern US. The 2 EDs combined cared for >96 600 patients in 2016. This prospective cohort study was conducted at both EDs, which are staffed by the same group of providers and research assistants (RAs). Patient enrollment was performed over a 12-month period from September 2015 to September 2016.

Children and adolescents aged 6-18 years who presented to 1 of the 2 participating EDs with a chief complaint of headache, including migraine, were eligible for enrollment during the hours of 9 a.m. to 11 p.m., when the EDs are staffed with RAs. Those patients with both new and recurrent headache were eligible. Patients were excluded if they met any of the following criteria: head trauma within 7 days; previous neurosurgery; known tumor or intracranial pathology; history of stroke, sickle cell disease, thrombophilia, coagulopathy; temperature >38°C; known neurologic disorder; imaging at an outside institution within 24 hours; or non-English, non-Spanish speakers.

Study Protocol

At the time of the index ED visit, RAs screened potentially eligible patients and supplied families of confirmed eligible patients with an information sheet that introduced the study and informed them that they may receive a follow-up phone call from study personnel at a future date. Families that did not actively refuse participation were enrolled in the study. Providers then completed a standardized paper history and examination evaluation report form, which included quality and timing of symptoms, patient history, and examination findings. A log was maintained by the RAs to track any eligible patients not enrolled in the study, either owing to refusal or because they were not approached.

After the patient encounter, the electronic medical record was accessed to gather patient demographics, timing of the index visit, disposition, whether any head imaging was performed, and the outcome of imaging.

If a patient had undergone head imaging with either MRI or CT scan during the initial visit, no further follow-up was performed. For patients with no imaging at the initial visit, parents/guardians were contacted by telephone 12-14 weeks later and asked for verbal consent to participate in our optional follow-up questionnaire, a series of 4 questions regarding subsequent medical care and neuroimaging. If a parent or guardian would not consent to telephone follow-up or was unable to be reached by phone after 6 attempts, the electronic medical record was reviewed for pertinent follow-up information. At any point if a parent/guardian requested to be removed from the study, the patient's information was removed from the study database.

Measures

To measure outcomes, we recorded whether or not patients received head imaging either at the initial ED visit or follow-up visit, and whether they had clinically important intracranial findings on their scans. Clinically important intracranial findings were defined a priori as any imaging finding that required immediate neurosurgical intervention, change in disposition, or change in medical management. Neurologist input was used to clarify any imaging findings that were of unclear significance.

Statistical Analyses

To characterize the study sample, continuous variables were described by the median and interquartile range and were compared with Mann-Whitney U tests. Categorical variables were described with proportions and were compared with χ^2 tests.

Both univariable and multivariable logistic regression models were constructed to evaluate associations between patient characteristics, selected a priori, and imaging (yes vs no); associations were described by ORs and 95% CIs. Parsimony was used in selecting the best multivariable model, such that variables that did not materially change the regression coefficients and collinear variables were not included in the final model. For example, we avoided inclusion of both self-reported or parent-reported symptoms and neurologic examination findings, because there was substantial overlap in these measures; we gave preference to the neurologic examination results as the more objective measure.

IBM SPSS Statistics for Windows, Version 23 (IBM Corp, Armonk, NY) was used to perform all data analysis. Two-sided P values of <.05 were considered statistically significant.

Results

Over the 12-month study period, a total of 626 eligible patients presented to our EDs, representing 0.6% of our total ED visits. We enrolled 294 patients (47%) in our study; 1 (0.2%) refused participation and 331 (53%) were eligible but not approached (**Figure**). The enrolled and nonenrolled subjects were similar in age, sex, race/ethnicity, and payor type; the only significant difference observed was the time of the ED visit, with a smaller proportion of enrolled patients presenting in the overnight shift when RAs were unavailable for screening ($P < .001$; **Table I**).

In the enrolled sample, 53 patients (18%) underwent neuroimaging with either CT scanning or MRI. Among those patients who underwent neuroimaging, only 2 (0.7% of the enrolled sample) had clinically important intracranial findings, both of which were intracranial tumors (**Figure**). Of the 241 patients eligible for phone follow-up, 126 (52%) consented and responded to the telephone interview and 17 (13%)

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