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Incidental Findings in Children With Blunt Head Trauma Evaluated With Cranial CT Scans

WHAT’S KNOWN ON THIS SUBJECT: The evaluation of blunt head trauma in children who undergo cranial computed tomography will occasionally reveal incidental findings. These findings may require further evaluation or intervention. The prevalence of incidental findings has previously been described using small cohorts, limiting generalizability.

WHAT THIS STUDY ADDS: This study is the largest pediatric multicenter description of the prevalence of incidental findings on cranial computed tomography. Incidental findings are categorized by urgency to describe the spectrum of abnormalities, providing a context for clinicians faced with these unexpected results.

abstract

OBJECTIVE: Cranial computed tomography (CT) scans are frequently obtained in the evaluation of blunt head trauma in children. These scans may detect unexpected incidental findings. The objectives of this study were to determine the prevalence and significance of incidental findings on cranial CT scans in children evaluated for blunt head trauma.

METHODS: This was a secondary analysis of a multicenter study of pediatric blunt head trauma. Patients <18 years of age with blunt head trauma were eligible, with those undergoing cranial CT scan included in this substudy. Patients with coagulopathies, ventricular shunts, known previous brain surgery or abnormalities were excluded. We abstracted radiology reports for nontraumatic findings. We reviewed and categorized findings by their clinical urgency.

RESULTS: Of the 43,904 head-injured children enrolled in the parent study, 15,831 underwent CT scans, and these latter patients serve as the study cohort. On 670 of these scans, nontraumatic findings were identified, with 16 excluded due to previously known abnormalities or surgeries. The remaining 654 represent a 4% prevalence of incidental findings. Of these, 195 (30%), representing 1% of the overall sample, warranted immediate intervention or outpatient follow-up.

CONCLUSIONS: A small but important number of children evaluated with CT scans after blunt head trauma had incidental findings. Physicians who order cranial CTs must be prepared to interpret incidental findings, communicate with families, and ensure appropriate follow-up. There are ethical implications and potential health impacts of informing patients about incidental findings. Pediatrics 2013;132:e356–e363

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KEY WORDS
computed tomography, brain imaging, emergency department, congenital abnormalities/anomalies

ABBREVIATIONS
CT—computed tomography
ED—emergency department
PECARN—Pediatric Emergency Care Applied Research Network
TBI—traumatic brain injury

Dr Rogers conceptualized and designed the study, recoded the data, drafted the initial manuscript, and approved the final manuscript as submitted; Dr Maher assisted with data analysis and interpretation, reviewed and revised the manuscript, and approved the final manuscript as submitted; Dr Schunk assisted with drafting of the initial manuscript, coordinated and supervised data collection at a site, critically reviewed the manuscript, and approved the final manuscript as submitted; Drs Quayle, Jacobs, Lichenstein, and Powell coordinated and supervised data collection at a site, critically reviewed the manuscript, and approved the final manuscript as submitted; Ms Miskin conducted the data analysis, interpreted the data, critically reviewed the manuscript, and approved the final manuscript as submitted; Drs Dayan and Holmes assisted with study design, coordinated and supervised data collection at a site, critically reviewed the manuscript, and approved the final manuscript as submitted; and Dr Kuppermann conceived and designed the study, obtained grant funding, provided supervision of the overall study, and critically reviewed and revised the manuscript.

(Continued on last page)
Blunt head trauma is a frequent cause for emergency department (ED) visits in the United States, leading to >600,000 annual encounters. Cranial computed tomography (CT) is the most commonly used diagnostic technique for the emergent evaluation of blunt head trauma, because it is readily available, fast, and sensitive for clinically important traumatic brain injuries (TBIs). Although cranial CT can effectively show intracranial bleeding or skull fractures, it is also sensitive for a wide variety of nontraumatic findings that may be previously unknown to the patient or family. These incidental findings may also be unexpected by the clinician and provide a unique management challenge.

Incidental findings can be described as unsought information generated in the seeking of the information one desires. This incidental information can range from lifesaving to insignificant, with many findings being indeterminate, particularly when a test was not targeted to detect that finding. Incidental findings can lead to increased patient stress, additional diagnostic testing, and increased costs, whether or not the incidental finding is ultimately clinically important.

Pediatric studies of incidental findings on cranial imaging have reported a wide range of prevalences and vary in terms of incidental finding definitions and imaging modalities. The prevalence of incidental findings on MRI ranges from 2.6% to >20%. A recent 2-site study in 524 children undergoing CT for head trauma reported a prevalence of 26%. To date, there has not been a large multicenter study of incidental findings in children undergoing cranial CT scanning.

In 2009, our group published a prospective observational study of head-injured children in which we developed a prediction rule for the identification of children at low risk of clinically important TBIs after blunt trauma. That study, performed by the Pediatric Emergency Care Applied Research Network (PECARN), enrolled >43,000 children at 25 sites in the United States, 36% of whom underwent cranial CT scanning during their ED evaluations.

The primary aim of the current study was to identify the prevalence of incidental findings on cranial CT scans obtained in children during the ED evaluation of blunt head trauma. Our secondary aim was to categorize the incidental findings by acuity level to allow for greater understanding of the spectrum of these incidental findings. Information on the prevalence of incidental findings may help inform physicians faced with an unexpected cranial CT result in a child.

**METHODS**

We performed a planned secondary analysis of a large prospective cohort study in children younger than 18 years of age with blunt head trauma resulting from nontrivial mechanisms. Trivial mechanisms were defined by ground-level falls or walking or running into stationary objects, with no signs or symptoms of head trauma other than scalp abrasions or lacerations. The study was conducted in the EDs at 25 PECARN sites between 2004 and 2006. The study was approved by each participating site’s institutional review board. The methods of the primary study are described elsewhere, whereas specific methods related to this secondary analysis are described below.

**Inclusion/Exclusion Criteria**

For this analysis we enrolled all children who presented to the ED after nontrivial blunt head trauma, regardless of their Glasgow Coma Scale scores, within 24 hours of the traumatic event for whom a cranial CT scan was obtained. Patients were excluded from the parent study if they had a known brain tumor or preexisting neurologic disease that substantially affected their mental status or neurologic exam. We excluded patients with known ventricular shunts or coagulopathies. We also excluded patients who had a known brain abnormality or previous brain surgery listed by the treating physician as a reason to obtain the cranial CT.

**Data Collection**

All cranial CT scans were interpreted by board-certified/eligible faculty radiologists at the enrolling sites. These final CT interpretations were abstracted by trained research staff at individual sites. All nontraumatic CT findings detected by the site faculty radiologists were identified and entered into the database. Findings of fluid in the sinuses were excluded at the time of data collection because this finding was felt to be common and not significant.

**Incidental Finding Categorization**

We defined incidental findings as any nontraumatic abnormality identified on cranial CT scan. Normal variants were not considered incidental findings. A priori, we developed a categorization scheme of incidental findings by consensus between a pediatric emergency medicine physician (A.J.R.) and a pediatric neurosurgeon (C.O.M.) (Table 1). We divided findings into 3 urgency categories: (1) requiring immediate or urgent evaluation or treatment, (2) requiring appropriate timely outpatient follow-up, and (3) no specific follow-up or intervention required unless suggested by clinical presentation. All cranial CT reports that contained incidental findings were reviewed and categorized by the above-named pediatric emergency medicine physician and pediatric neurosurgeon. A given incidental finding was generally assigned to only 1 specific urgency category; however, as size and/or location affect the severity of some conditions, individual findings were occasionally
TABLE 1 A Priori Nontraumatic Incidental Finding Categorization

<table>
<thead>
<tr>
<th>Category 1: Immediate Evaluation/Treatment</th>
<th>Category 2: Appropriate Timely Outpatient Follow-up</th>
<th>Category 3: Benign, Follow-up Based on Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abscess</td>
<td>Arachnoid cyst</td>
<td>Bony cyst</td>
</tr>
<tr>
<td>Cysticercosis/other parasitic infection</td>
<td>Artério-venous malformation</td>
<td>Calcifications outside of pineal</td>
</tr>
<tr>
<td>Hydrocephalus</td>
<td>Chiari malformation</td>
<td>Cavernous malformations</td>
</tr>
<tr>
<td>Infarction</td>
<td>Craniosynostosis</td>
<td>Cerebellar abnormality</td>
</tr>
<tr>
<td>Severe foraminal stenosis</td>
<td>Dandy-Walker cyst</td>
<td>Choroid fissure cyst</td>
</tr>
<tr>
<td>Tumor/mass</td>
<td>Gliosis</td>
<td>Choroid plexus calcification</td>
</tr>
<tr>
<td></td>
<td>Lipoma</td>
<td>Choroid plexus cyst</td>
</tr>
<tr>
<td></td>
<td>Meningioma</td>
<td>Developmental abnormality/</td>
</tr>
<tr>
<td></td>
<td>Pineal enlargement/calcification</td>
<td>schizencephaly/encephalomalacia</td>
</tr>
<tr>
<td></td>
<td>Prominent subarachnoid</td>
<td>Fluid filled mastoids</td>
</tr>
<tr>
<td></td>
<td>space/extraaxial fluid</td>
<td>Germinal matrix cyst</td>
</tr>
<tr>
<td></td>
<td>Unknown with follow-up recommended</td>
<td>Mastoid opacification</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mega cisterna magna</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pineal cyst</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pneumocystis/scar abnormality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sinus thickening</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subacute infarct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tonsil/adenoidal hypertrophy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Venous angioma</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ventricular abnormality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White matter abnormality/gliosis</td>
</tr>
</tbody>
</table>

Categorized as more or less severe on the basis of size and/or location. Patients with multiple findings in different urgency groups were assigned to the higher risk category.

For the comparison of basic clinical characteristics between patient groups, a severe mechanism of injury was defined as follows: motor vehicle crash with patient ejection, death of another passenger, or rollover; pedestrian or bicyclist without helmet struck by a motorized vehicle; falls of >5 feet for children aged >2 years and falls of >3 feet for those younger than 2 years; or head struck by a high-impact object. Clinically important TBI was defined as death from the TBI, neurosurgery, intubation >24 hours for management of the TBI, or hospital admission of 2 nights’ duration or longer for management of the TBI in association with TBI on CT.

Statistical Methods

We described categorical data by using simple descriptive statistics. We used the Newcombe-Wilson continuity correction when calculating the differences in prevalence rates due to low prevalence of findings. Because this was a descriptive study of the prevalence of incidental findings, we did not perform comparisons between urgency categories. We used SAS/STAT software for the analyses (version 9.2; SAS Institute, Cary, NC).

RESULTS

In the parent study, we enrolled 43 904 head-injured children. Of these, 15 831 (36%) received cranial CT scans in the ED. A total of 654 (4%; 95% confidence interval: 3.8%-4.5%) patients had incidental findings on their CT scans (Fig 1).

The 654 patients with incidental findings had a median age of 8.6 years (interquartile range: 2.3-14.2 years) and 69% were male. We compared the clinical characteristics between those patients with and without incidental findings (Tables 2 and 3). There were no significant differences between the 2 groups in the percentages of those with documented Glasgow Coma Scale scores of 15, those with severe mechanisms of injury, rates of clinically important TBIs, or rates of neurosurgical intervention. Despite the similar clinical characteristics between the 2 groups, patients with incidental findings were significantly less likely to be discharged from the hospital from the ED.

Of the 654 patients with incidental findings, 22 (4%) were designated as category 1, the most urgent subgroup. Of these, the most common finding was tumor/mass. Patients with category 2 findings, which generally require follow-up, represented 26% of the cohort with incidental findings; and category 3 findings, which are most likely not to require additional workup, represented 70%. Overall, the most common incidental findings were sinusosal abnormalities (19%), ventricular abnormalities (12%), and intracranial cysts (12%). Table 4 lists the overall rate for each incidental finding by urgency category (for a more detailed breakdown of findings, see Supplemental Table 5). There were 20 patients with >1 incidental finding, with ventricular abnormality being most commonly identified. These patients with multiple incidental findings had a mean age of 7.6 years (interquartile range: 1.5-13.6 years), 75% were male, and 45% were discharged from the hospital after initial ED evaluation. (See Supplemental Table 6 for details on patients with multiple incidental findings.) Radiologists specifically documented recommendations for additional or follow-up imaging for 58 (9%; 95% confidence interval: 7%-11%) of the patients with incidental findings.

DISCUSSION

Blunt head trauma is a common reason for children to present to the ED for evaluation. Cranial CT imaging is frequently used in the evaluation of head injury, and its use has increased substantially over the previous decade.11 In this study, we evaluated and described the prevalence of incidental...
findings on cranial CT in children. Our study indicated that 4% of children imaged with cranial CT after blunt head trauma had incidental findings identified, and of these, 30% warranted either urgent action or timely outpatient follow-up.

Numerous studies pertaining to incidental findings on cranial CT focus on the adult population, with pediatric studies more commonly focusing on incidental findings identified with brain MRI.2,4,5,12–16 Previous studies in trauma patients have revealed a wide variation in the prevalence of incidental findings noted during cranial CT imaging, ranging from 1% to 6%.12,17 A 2010 study in 120 healthy Japanese children ages 5 to 8 years undergoing brain MRI for structural research and interpreted by a pediatric neurologist revealed a prevalence of incidental findings of 10.9% (excluding sinusitis and otitis media), with 27% of those patients requiring referral.18 A systematic review of adult and pediatric patients without neurologic symptoms undergoing brain MRI revealed that the prevalence of incidental findings increased with age and higher resolution MRI sequences.19 A more recent 2-site study reviewed radiologist reports of incidental findings on pediatric cranial CTs obtained for the evaluation of head trauma and revealed a prevalence of >26%, although 84% of these findings were sinus opacification. If sinus opacification was excluded, they revealed a prevalence of 4%,7 identical to that of the current study.

One reason for the variation reported in the literature is the lack of a standardized definition of what represents an incidental finding as opposed to a normal variant. In the current study, we included all nontraumatic incidental findings other than findings consistent with sinusitis. Because sinusitis is a common finding on pediatric cranial CT scans, our exclusion of sinusitis lowered the reported prevalence of incidental findings compared with other studies. However, our definition of incidental finding also increased our prevalence compared with studies focusing only on findings believed to require intervention. To our knowledge, our study is also the largest multicenter description of incidental findings on cranial CT in children. The multicenter nature of this study enhances the generalizability of our prevalence data.

Because the practice of medicine has embraced diagnostic imaging technologies that provide data beyond the actual clinical question, a need to develop strategies to handle unexpected and/or unsought information now exists. The American College of Radiologists has developed position papers regarding the management and evaluation of common "incidentalomas."20

### TABLE 2 Comparison of Clinical Factors Between Children With and Without Incidental Findings on CT

<table>
<thead>
<tr>
<th>Patients with Incidental Findings (n = 654)</th>
<th>Patients Without Incidental Findings (n = 15,177)</th>
<th>Percentage Difference in Rates (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age (IQR), y</td>
<td>8.8 (2.3–14.2)</td>
<td>8.2 (2.5–14.0)</td>
</tr>
<tr>
<td>Male, %</td>
<td>69</td>
<td>63</td>
</tr>
<tr>
<td>GCS score of 15, %</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>Severe mechanism of injury,a %</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>Clinically important TBI,b %</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Neurosurgery, %</td>
<td>0.3</td>
<td>1</td>
</tr>
<tr>
<td>Discharged from the hospital from ED, %</td>
<td>67</td>
<td>74</td>
</tr>
</tbody>
</table>

CI, confidence interval; GCS, Glasgow Coma Scale; IQR, interquartile range.

a Motor vehicle crash with patient ejection, death of another passenger, or rollover; pedestrian or bicyclist without helmet struck by a motorized vehicle; falls of >1.3 m (5 feet) for patients aged ≥2 years or falls of >0.9 m (3 feet) for those younger than 2 years; or head struck by a high impact object.

b Death from TBI, neurosurgery, intubation for >24 hours for TBI, or hospital admission of ≥2 nights associated with TBI on CT.
Institute has funded a consortium to define the management of incidental findings discovered in the research setting.\textsuperscript{21,22} These attempts to formalize the approach and management of incidental findings result from the ethical and medicolegal implications of disclosing incidental findings, which are challenging and potentially at odds with each other. From a medicolegal perspective, full disclosure of all findings, no matter how clinically insignificant, may be considered to be the safest course of action for the practitioner. The pursuit of these findings, however, can increase risks associated with additional (and potentially unnecessary) evaluation, costs, and anxiety to patients and families. The discovery of an incidental finding prompts questions regarding follow-up, additional imaging, or need for intervention, regardless of the apparent initial clinical significance of the finding. Further imaging may involve additional radiation exposure or risks associated with sedation. Invasive advanced diagnostic procedures have their own specific risks.

In 1986 Mold and Stein\textsuperscript{23} described the “cascade effect in the clinical care of patients,” in which an initiating factor triggers a series of events, often catalyzed by anxiety on the part of the patient and/or provider. Each step appears to be a reasonable, or even obvious, response to previous information, and yet the clinical care can “cascade” away from the initial goals of the patient and physician. In our study, 9% of incidental findings were noted to have a specific recommendation regarding follow-up imaging. This result is consistent with previous studies that have found a general increase in radiologist’s tendencies to recommend further radiographic imaging.\textsuperscript{24} There is also a general discomfort, both in the medical field and the general population, with the concept of medical uncertainty.\textsuperscript{25} Patients with potentially significant findings might undergo additional diagnostic testing, have their activities restricted long-term, or even undergo surgery, despite being asymptomatic, solely on the basis of the incidental finding.\textsuperscript{26} The anecdotal report of Casarella,\textsuperscript{27} an academic radiologist, is particularly enlightening and descriptive. In this report, he told of his personal experience of the well-intentioned pursuit of ultimately inconsequential incidental findings, which led to >$50,000 in costs and “a chest tube, a Foley catheter, a subclavian central venous catheter, a nasogastric oxygen catheter, an epidural catheter, an arterial catheter, subcutaneously administered heparin, a constant infusion of prophylactic antibiotics, and patient-controlled analgesia with intravenously administered narcotics.”

The potential ethical conflict regarding information disclosure to patients was recently summarized in an article in which the authors stated that “the right to autonomy must be balanced with the ethical obligations to do good for patients (beneficence) and not to harm them (nonmaleficence).”\textsuperscript{28} Giving too much unfiltered information about any test or therapy has the ability to confuse, rather than empower, subsequent decisions.\textsuperscript{29}
Underlying the difficulty in communicating incidental findings to patients and families is the challenge of effectively presenting concepts of risk. Previous studies revealed that individuals have a wide range of coping behaviors when presented with risks, and physicians differ from patients in the understanding and processing of such risks.20–32 It may be difficult to effectively communicate the risk associated with incidental findings, particularly when they fall outside the physician’s expertise. Whereas this study did not address specific risk levels associated with individual findings, knowledge of a general prevalence may help in general with communications when findings are unexpected.

Of the incidental findings we identified, most were likely inconsequential, although some findings, such as hydrocephalus or a tumor or a mass, could necessitate immediate and unexpected changes in management. For patients with potentially life-threatening incidental findings, early detection could provide a substantial benefit. In our cohort, however, patients with the most urgent of incidental findings represented only 0.1% of those receiving CT scans. With increasing awareness of radiation-induced malignancies from CT scans, and estimates that a single head CT scan in a young child could lead to a 0.07% chance of cancer mortality attributable to radiation exposure,33 we do not believe that the benefit of detection of these rare incidental findings warrants the economic and potential health costs of obtaining CT scans when they are not otherwise clinically indicated.

Given the frequent use of advanced imaging for the evaluation of blunt head trauma in children, incidental findings will continue to be a challenging issue. The decision about which incidental findings need to be disclosed to families will ultimately depend on the physician and, if known, families’ tolerance of risk and desire for “full disclosure.” Knowledge of prevalence of these findings may help physicians place incidental findings into a broader context when communicating with patients and families.

This study has several potential limitations. First, our reporting of incidental findings is based on the abstracted reports of the CT scans from participating institutions and not a dedicated secondary review of the actual scans. This reliance on institutional reports in the setting of trauma could lead to a lower estimate of incidental findings, but reflects routine clinical practice. Also, the prevalence of incidental findings we report is similar to previous studies, lending further credence to our findings. In addition, although site research coordinators were instructed to transcribe all nontraumatic CT findings (other than sinusitis), it is possible that some findings were not abstracted and documented. In the attempt to create a simple severity categorization scheme, findings were grouped into 3 categories. In reality, many of these findings can have a range of severity depending on size and location of the abnormality, although we adjusted for this variation in our categorization. Rates of patient discharge and outcomes from the acute traumatic events were reported; however, there were no data available regarding the (long-term) outcomes or follow-up of the incidental findings identified.

The case report forms used in this study prompted the clinicians to identify factors that influenced their decision to obtain a cranial CT, which included known brain abnormalities or surgeries. Patients with these known findings were excluded from our analysis to best represent the general pediatric population. However, there may have been more patients in whom nontraumatic findings were known before the decision to obtain a CT but whose data were not captured. There were likely not many of these children beyond those we reported, however, because our prevalence of incidental findings is similar to that in previous literature. Finally, this cohort of patients was evaluated for blunt head trauma. It is possible that some of the incidental findings may have predisposed to either blunt head trauma or the clinical appearance may have led clinicians to obtain CT scans. However, it is likely that this situation would represent a small minority of patients in this large sample and would not likely significantly affect prevalence rates.

CONCLUSIONS

A small but significant number of children who undergo cranial CT scan for the evaluation of blunt head injury have nontraumatic, incidental findings. Most of these findings require no specific follow-up, but some require either immediate or outpatient evaluation. Although the prevalence of incidental findings in this population is ~4%, the nature of these findings as outlined in this study does not warrant a more liberal approach to head imaging in general. Providers who order CTs for blunt head trauma in children must be prepared to interpret and communicate findings to families and manage unexpected incidental abnormalities, balancing the ethical and medicolegal implications of this unsought and unexpected information.

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