Yield of Retinal Examination in Suspected Physical Abuse With Normal Neuroimaging
Jonathan D. Thackeray, Philip V. Scribano and Daniel M. Lindberg
Pediatrics 2010;125:e1066; originally published online April 12, 2010;
DOI: 10.1542/peds.2009-2184

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Yield of Retinal Examination in Suspected Physical Abuse With Normal Neuroimaging

WHAT’S KNOWN ON THIS SUBJECT: It is the practice of many physicians to obtain specialty retinal examination in any child when there is any suspicion of physical abuse, regardless of type. Such practice may lead to unnecessary testing, increased costs, and inappropriate use of resources.

WHAT THIS STUDY ADDS: Our data demonstrate that in children younger than 2 years being evaluated for physical abuse without brain injury, retinal hemorrhages are rare. We believe, therefore, that dedicated ophthalmologic examination should not be considered mandatory in this population.

abstract

OBJECTIVE: In some centers, dedicated ophthalmologic examination is performed for all children who are evaluated for potential physical abuse. Although retinal hemorrhages have been reported in rare cases of abused children with normal neuroimaging results, the utility of ophthalmologic examination in this group is currently unknown. The objective of this study was to determine the prevalence of retinal hemorrhages in children younger than 2 years who were evaluated for physical abuse and who had no evidence of traumatic brain injury (TBI) on neuroimaging.

PATIENTS AND METHODS: We performed retrospective analysis of data obtained from 1676 children younger than 5 years who were evaluated for potential physical abuse as a part of the Using Liver Transaminases to Recognize Abuse research network. We reviewed results of dedicated ophthalmologic examination in all children younger than 2 years with no evidence of TBI on neuroimaging.

RESULTS: Among 282 children who met inclusion criteria, only 2 (0.7% [95% confidence interval: 0.1%–2.5%]) had retinal hemorrhages considered “characteristic” of abuse. Seven other children (2.5% [95% confidence interval: 1.0%–5.1%]) had a nonspecific pattern of retinal hemorrhages. Both children with characteristic retinal hemorrhages in the absence of TBI showed evidence of head or facial injury on physical examination and/or altered mental status.

CONCLUSIONS: In children younger than 2 years being evaluated for physical abuse without radiographic evidence of brain injury, retinal hemorrhages are rare. Dedicated ophthalmologic examination should not be considered mandatory in this population. Pediatrics 2010;125:e1066–e1071

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KEY WORDS
retinal hemorrhages, child physical abuse, abusive head trauma, traumatic brain injury

ABBREVIATIONS
AHT—abusive head trauma
TBI—traumatic brain injury
ULTRA—Using Liver Transaminases to Recognize Abuse
CI—confidence interval
OR—odds ratio

www.pediatrics.org/cgi/doi/10.1542/peds.2009-2184
doi:10.1542/peds.2009-2184

Accepted for publication Jan 8, 2010

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

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FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.
Abusive head trauma (AHT) is the leading cause of inflicted traumatic death in children, with an estimated annual incidence rate of between 7.1 and 17 per 100,000 children younger than 2 years. These incidence rates are even higher among infants. Despite a variety of clinical tools and subspecialty consultation available to aid in the detection of AHT, the diagnosis is often missed. It becomes important, therefore, to educate clinicians on the appropriate use of diagnostic tools in screening for AHT for optimal detection in the relevant clinical situation of patients at risk.

The presence of retinal hemorrhages with neuroimaging evidence of traumatic brain injury (TBI) has been well described in the medical literature. It is also evident that retinal hemorrhages can be present in select children with abnormal neurologic examinations, even when initial neuroimaging studies show no evidence of intracranial injury. Yield of the retinal examination has also been reported from 2 studies of occult head trauma in populations at high risk in which there is suspicion of physical abuse. Although no pattern of retinal injury can be considered “pathognomonic” of inflicted injury, certain patterns of retinal hemorrhage, such as extensive retinal hemorrhages in the subretinal, intraretinal, and preretinal layers, are extremely uncommon in accidental injury and are highly specific for inflicted injury. Certain patterns of retinal hemorrhages, therefore, can drastically alter the perceived likelihood of abuse. When conducted by nonophthalmologists, however, the detection of retinal hemorrhages is suboptimal. To avoid a missed diagnosis of AHT, some centers have adopted the practice of undertaking specialty retinal examination in any child when there is a suspicion of physical abuse, regardless of the type of abuse. Such practice may lead to unnecessary testing, increased costs, and inappropriate use of resources.

The purpose of this study was to estimate the prevalence of retinal hemorrhages in children younger than 2 years who received subspecialty evaluation for suspected physical abuse and who showed no radiographic evidence of TBI.

**PATIENTS AND METHODS**

We undertook a retrospective analysis of data obtained for the Using Liver Transaminases to Recognize Abuse in Children (ULTRA) research network. Methods for the ULTRA study have been described previously. Briefly, ULTRA was a prospective observational cohort study of 19 subspecialty child abuse consultation teams that enrolled 1676 children throughout 12 months between April 1, 2007, and March 31, 2008. Each center obtained approval to collect data for the original ULTRA study from the center’s local institutional review board. This retrospective analysis was determined to be exempt from review by the coordinating center institutional review board. Eligible subjects for the ULTRA study were children younger than 5 years who underwent subspecialty evaluation for concerns of physical abuse. All subjects who underwent consultation were included regardless of the ultimate level of concern for abuse. Data collected at the time of disposition included demographic information; physical examination findings; and presence of fractures, TBI, retinal hemorrhages, cutaneous injury, or other injuries. For each possible injury, the responsible child abuse consultant was asked to determine if the injury was “present,” “absent,” or “not evaluated.” When retinal hemorrhages were reported, the child abuse consultant characterized the hemorrhages as “characteristic,” “few, posterior pole,” or “other.” Clinicians had the ability to add free-text descriptions of the hemorrhages as well. Although the term “characteristic” was not defined further, hemorrhages characteristic of AHT are commonly described as extensive and seen throughout the entire retina, including the subretinal, intraretinal, and preretinal layers. Investigators were only able to select 1 of the 3 descriptions to describe the hemorrhages. Data were entered from the individual sites into an online, Web-based central repository for data collection and management.

Each center implemented an independent, redundant system for tracking the number of consultations undertaken. A priori, only centers that successfully enrolled >90% of eligible consultations were included in the study.

For this analysis, data were retrospectively abstracted for children meeting the following inclusion criteria: age younger than 2 years, no evidence of TBI on neuroimaging, and completion of a retinal examination. The presence of a skull fracture without intracranial injury was not considered as TBI for the purposes of this study.

Data were analyzed by using Stata 9.0 (Stata Corp, College Station, TX). The study population was described by using frequencies for categorical variables. The prevalence of retinal hemorrhage was calculated with its associated 95% confidence interval (CI). Univariate χ² statistics were used to explore the association of selected demographics and injury variables with the presence of retinal hemorrhage.

**RESULTS**

The original ULTRA study sample included 1676 children (Fig 1). Within this population, 393 (23.5%) had radiographic evidence of TBI identified, and 662 (39.4%) underwent dedicated retinal examination. Among all subjects, 151...
were found to have retinal hemorrhages of any type, and 97 (5.8%) had characteristic retinal hemorrhages. Of the 1676 children included in the original study, 1300 (77.6%) were younger than 24 months. Available demographic information for both the original ULTRA population and the cohort of children younger than 24 months is listed in Table 1. Of the children younger than 24 months, 1029 (79.2%) underwent neuroimaging, and 676 (65.7%) of them were found to show no evidence of TBI. Of the 676 children younger than 2 years without radiographic evidence of TBI, 282 (41.7%) underwent retinal examination. Of these children, 273 (96.8% [95% CI: 94.0%–98.5%]) had no retinal hemorrhages, 7 (2.5% [95% CI: 1.0%–5.1%]) had a nonspecific pattern of retinal hemorrhages, and 2 (0.7% [95% CI: 0.1%–2.5%]) had retinal hemorrhages characteristic of AHT. Additional details of the 7 children with nonspecific retinal hemorrhages are listed in Table 2. The following are descriptions of the 2 children without TBI who were found to have characteristic retinal hemorrhages.

**Case 1**
An 8-month-old boy presented to the emergency department after his mother noted that he developed a facial rash while feeding him. Physical examination revealed facial bruising and a lingual frenum tear. The Glasgow Coma Scale score was 15, and the remainder of the examination was normal. A skeletal survey demonstrated a healing fracture of the left humeral shaft, periosteal reaction of the right distal humerus, and healing buckle fractures of the right proximal tibia and fibula. Results of coagulation studies and platelet count were normal.

**Case 2**
An 18-month-old girl presented to the emergency department after reportedly falling backward down 5 wooden stairs onto a thin carpet overlying concrete. Caretakers denied that the child had loss of consciousness. Physical examination revealed tachycardia and an oxygen saturation of 94%. The child had bruising and petechiae of the face and bruising of the anterior chest. The Glasgow Coma Scale score was 14

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**TABLE 1** Demographics of the ULTRA Cohort and Children Younger Than 24 Months

<table>
<thead>
<tr>
<th></th>
<th>ULTRA Cohort (N = 1676)</th>
<th>All Consults &lt;24 mo (N = 1300)</th>
<th>Consults &lt;24 mo, No TBI, With Retinal Examination (N = 282)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White, %</td>
<td>58.7</td>
<td>45.5</td>
<td>49.3</td>
</tr>
<tr>
<td>Male, %</td>
<td>57.3</td>
<td>57.0</td>
<td>59.2</td>
</tr>
<tr>
<td>Age, median (interquartile range), mo</td>
<td>9 (3.5–21.0)</td>
<td>6 (3–11)</td>
<td>4 (2–8)</td>
</tr>
<tr>
<td>GCS score &lt;15 (%)</td>
<td>253 (15.1)</td>
<td>219 (15.1)</td>
<td>47 (16.7)</td>
</tr>
</tbody>
</table>

GCS indicates Glasgow Coma Scale.
Skeletal survey demonstrated fractures of the femoral shaft, distal clavicle, and distal tibia. The results of coagulation studies were normal, and her platelet count was 84,000.

In children younger than 24 months who had neuroimaging performed, including those both with and without TBI detected, 133 (10.2%) had retinal hemorrhages (Table 3). The presence of any retinal hemorrhages (odds ratio [OR]: 20.8 [95% CI: 10.2–47.5]) and characteristic retinal hemorrhages (OR: 55.0 [95% CI: 14.4–464.2]) were more likely in children with TBI seen on neuroimaging than children with normal neuroimaging results.

Table 4 lists ORs for the association of certain injuries among children with retinal hemorrhages, relative to children in whom retinal examination revealed no retinal hemorrhages. Of the 600 children younger than 2 who underwent ophthalmology examination, 349 (58.2%) had at least 1 associated fracture. Of these children, 174 (49.9%) had skull fractures, 98 (28.1%) had rib fractures, and 62 (17.8%) had metaphyseal fractures. There were no significant associations for any of the associated injuries and retinal hemorrhages, with the exception of skull fractures (OR: 0.6 [95% CI: 0.4–0.9]).

DISCUSSION
Although the isolated finding of retinal hemorrhages is neither necessary nor sufficient to diagnose AHT, the role of ophthalmologic examination undeniably plays a critical role in the assessment of such cases. In the appropriate clinical context, retinal hemorrhages may be highly indicative of AHT. Because retinal hemorrhages are seen in a variety of other medical and traumatic conditions, it becomes important to not only document their presence but also describe the specific pattern of retinal hemorrhages seen. A characteristic pattern of extensive retinal hemorrhages seen throughout the entire retina (subretinal, intraretinal, and preretinal layers) is rarely reported in any condition other than AHT. Bechtel et al19 studied 87 children, 67 of whom were determined to have accidental head injuries and 15 of whom were thought to have abusive head injuries. Not only were the abused children significantly more likely to have retinal hemorrhages and bilateral retinal hemorrhages, but none of the children with accidental head injury had preretinal, premacular, or retinal hemorrhages extending to the periphery of the retina. These results are consistent with previously
published work that demonstrated that children with accidental head injuries are less likely to have retinal hemorrhages, much less retinal hemorrhages in the specific patterns described above. Although the purpose of this study was not to evaluate the diagnostic utility of retinal hemorrhages in the assessment of AHT, it was designed to evaluate the utility of retinal examination as a diagnostic tool in the specific population of children suspected of having been physically abused but without radiographically evident TBI. Rubin et al studied the role of retinal examination in a population of children younger than 24 months with injuries suspicious for child abuse and found it to be a “poor screening method” for occult head injury. Similarly, Laskey et al examined children younger than 48 months and found the presence of retinal hemorrhages not to be a sensitive marker for occult head injury. Our study adds to the existing literature by revealing the yield of retinal examination when examining a representative sample of all children evaluated for suspected physical abuse. Our results demonstrate that the yield of retinal examination of children being evaluated for physical abuse who show no evidence of TBI, regardless of other injury, was extremely low. Fewer than 1% of the children in this cohort were found to have characteristic retinal hemorrhages. Furthermore, the clinical and/or forensic significance of nonspecific retinal hemorrhages seems limited and does not seem to enhance the diagnostic determination of abuse. Although the study design limited the identification of clinical predictors of children who will have retinal hemorrhages, it is interesting to note that the 2 children with characteristic retinal hemorrhages both had sustained obvious injury to the face and head. Some providers may favor a targeted approach to requesting ophthalmology consultation, choosing to obtain such a consult only for children with selected injuries commonly associated with AHT, such as metaphyseal fractures or rib fractures. We failed to demonstrate any association between the 136 children with metaphyseal and/or rib fractures and the presence of retinal hemorrhages. Our data demonstrate that children with skull fractures were less likely to have retinal hemorrhages. It is important to note, however, that this study was not designed to evaluate thoroughly the association between retinal hemorrhages and associated injuries; therefore, the significance of these findings is unclear.

Several limitations with this study should be noted. First, these data represent a retrospective, nested cohort obtained from the ULTRA study. The ULTRA study was a prospective, observational cohort study designed with the primary aim of evaluating the utility of liver transaminase testing in screening for abdominal injury in children with suspected abuse. Although it was not designed to answer the clinical questions addressed in this study, these data do offer the opportunity to evaluate other clinical questions in this population. Second, our definition of the word “characteristic” in describing retinal hemorrhages was not explicit in the original ULTRA study. As a result, different clinicians almost certainly used different standards in determining which patterns of retinal hemorrhages should be considered as characteristic. It is possible that a misclassification could have resulted with regard to an individual provider’s interpretation of the retinal hemorrhage pattern or that investigators may have been more likely to describe retinal hemorrhages as “characteristic” in children with evidence of brain injury on neuroimaging. With a conservative approach to these data, one could assume that each child with “nonspecific” retinal hemorrhages was misdiagnosed and in actuality had a characteristic pattern. Analysis of this group, however, demonstrates that 8 of the 9 children with retinal hemorrhages, regardless of how they were described, showed either external evidence of injury to the face/head or altered mental status. Either of these findings, in our opinion, would be a reasonable indication to obtain ophthalmology consultation. Even with this conservative approach, in the absence of face/head injury or altered mental status only 1 child of 282 would have been found to have any retinal hemorrhages.

Conversely, our approach of determining the child abuse consultant’s opinion about the significance of the hemorrhages is not without advantages. Regardless of the specific pattern of hemorrhages, dedicated ophthalmology is probably unwarranted if it fails to influence the ultimate opinion of abuse likelihood. However, our study did have limitations. We did not evaluate the specificity of any pattern of retinal hemorrhages. We specifically chose the term “characteristic” in preference to the term “pathognomonic” to avoid any misinterpretation of whether any pattern of hemorrhages ought to be relied on in determining the likelihood of abuse. Finally, this study was limited by the potential for selection bias. Ethically, it is not possible to subject all patients to neuroimaging and/or retinal examination. It is possible, therefore, that retinal hemorrhages in children in the setting of normal neuroimaging would have been missed within this population. Only 15 subjects in the ULTRA study underwent retinal examination...
without neuroimaging having been performed. All were found not to have retinal hemorrhages. In addition, not only did participating hospitals have a variable threshold for obtaining subspecialty child abuse consultation, but also it is likely the child abuse specialist had varying thresholds for consulting ophthalmology. In many locations, ophthalmology consultation may have been requested by someone other than the child abuse specialist, including the emergency department, hospitalist, general surgeon, neurosurgeon, or trauma surgeon. It seems reasonable that if a clinician is ordering both head computed tomography and an ophthalmology consult to evaluate for abuse, then the local child abuse specialist would be notified. However, we undoubtedly missed capturing data on cases in which the clinician considered, then rejected, the diagnosis of abuse without including a consultation with the child abuse specialist.

CONCLUSIONS

In this study, the yield of retinal examination in the assessment of physical abuse of children younger than 24 months without radiographic evidence of TBI was low. When evaluating children without TBI, mental status change, or head/face injury, clinicians should, at the very least, thoughtfully consider whether ophthalmology consultation is necessary in the assessment and diagnosis of AHT.

REFERENCES

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