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ARTICLE

Characteristics That Distinguish Abusive From Nonabusive Head Trauma Among Young Children Who Underwent Head Computed Tomography in Japan

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What’s Known on This Subject

Researchers have found several characteristics and clinical presentations to distinguish AHT and non-AHT, but these findings were based on the comparison among admitted cases. In addition, few studies have reported markers of AHT other than in Western countries.

What This Study Adds

This study highlights several clinical markers to detect AHT at a medical visit, including an absence of injury history, neurologic symptoms, subdural hemorrhage, and retinal hemorrhage in Japan, where CT is widely and easily available.

ABSTRACT

OBJECTIVE. Distinguishing abusive head trauma in young children from other diseases by symptoms is difficult in practice. Comparisons between abusive and nonabusive head trauma in young children in Japan, where computed tomography is widely and easily available, might contribute to identifying markers of abusive head trauma that differ from that in Western countries. The objective of this study was to compare the characteristics of abusive and nonabusive head trauma in young children in Japan.

METHODS. A comparative case series study involving a retrospective medical chart and social work record review of children who were aged 0 to 2 years, visited the National Center for Child Health and Development (Tokyo, Japan) from March 1, 2002, to December 31, 2005, and underwent computed tomography scanning because of suspected intracranial injury was performed. Patients (N = 260) were identified and classified as having either abusive or non abusive head trauma on the basis of the published definition. Demographic and perinatal characteristics, injury history, clinical presentation, and outcomes were compared by using $\chi^2$ and Fisher’s exact tests.

RESULTS. Patients with abusive head trauma were significantly younger than patients with nonabusive head trauma and had a peak at 2 to 4 and 7 to 9 months. Patients with abusive head trauma more likely presented no injury history by the caregiver, neurologic symptoms (unconsciousness, seizure, paralysis), subdural hemorrhage, and retinal hemorrhages. Although patients with abusive head trauma had severe clinical outcomes, only 32% of them were separated from the caregiver by social welfare services.

CONCLUSIONS. This study highlights several clinical markers to detect abusive head trauma at a medical visit, including an absence of injury history, neurologic symptoms, subdural hemorrhage, and retinal hemorrhage. These markers can be used to detect abusive head trauma cases by physicians and social welfare workers to protect children from additional abuse. Pediatrics 2008;122:e841–e847

IT IS KNOWN that inflicted head injury is the leading cause of death among children as a result of abuse.¹ Although it can be serious, the diagnosis seems to be frequently unsuspected, up to 30% at initial visits, because clinicians are often not able to determine whether the trauma was inflicted on the basis of presentation of the child.²,³ Almost half of patients with inflicted traumatic brain injury had previous brain injuries,⁴ and repeated traumatic brain injury can induce serious disability, even death.³

Previous researchers found several characteristics and clinical presentations to distinguish abusive head trauma (AHT) and non-AHT. With regard to the child’s characteristics, a young age (<1 year), prematurity at birth, and multiple births were known as risk factors.⁵-¹⁰ As for family characteristics, a younger mother, unmarried, low socioeconomic status, late or no prenatal care, and being the first child in a family were reported.⁵,⁷ In terms of
presentation at a hospital, child abuse should be suspected when the patient had no history of injury or minor trauma history in comparison with the seriousness of the injury and had a seizure, subdural hemorrhage (SDH), multiple skull fractures, retinal hemorrhage, and positive skeletal survey findings.4,5,9–17 Other studies identified biological markers of AHT by using serum and/or cerebrospinal fluid concentrations of neuron-specific enolase, S100B, and myelin-basic protein;16,17 however, these studies were based on the comparison of “hospitalized” patients. As Keenan et al mentioned,3 many abused children who visited a hospital may be unsuspected because of the nonspecificity of complaints in infants with head trauma; therefore, it is essential to compare the characteristics of AHT and non-AHT cases among both outpatients and inpatients.

In addition, previous research is mostly from Western countries. Investigation of characteristics of AHT in different health care systems and cultures from Western countries might contribute to the literature on identifying AHT markers. In Japan, computed tomography (CT) scanning is widespread and available. In 2000, Japan had the highest number of CT scanners per capita, with 84 CT scanners per 1 million population, whereas the average number of Organization for Economic Cooperation and Development countries was 18.20 The greater availability of CT enables doctors to order head CT for children who have head injuries, especially when they have neurologic symptoms, regardless of the suspicion of abuse. In addition, the cost of CT scanning is covered by health insurance. Japan uses a universal health insurance system, and medical expenditures for children, especially infants, are often covered by municipality subsidies. This may affect doctors’ decisions to order head CT, because in this system, doctors can order head CT without concern for a patient’s economic status, because the cost of head CT is not cheap; therefore, CT scanning is relatively easy to be performed when clinicians suspect intracranial injury, including minor injury cases in which Western physicians may not order CT scanning. Thus, it is hypothesized that AHT might be detected among children with minor head injuries in Japan, regardless of the suspicion of abuse. That is, better availability of CT resources and universal coverage of medical expenditures for infants in Japan may improve the detection of AHT cases. Thus, a review of all head injury cases for which the patient underwent head CT scans provides us with a precious opportunity to identify the distinctive characteristics of AHT and non-AHT. The purpose of this article was to compare characteristics of AHT and non-AHT and find markers that help identify AHT cases.

METHODS

Participants

This was a retrospective study of all children who were aged 0 to 2 years, visited the National Center for Child Health and Development (Tokyo, Japan) under the condition that the patient had symptoms to suspect head injury (eg, unconsciousness, seizures, vomiting without known reason, history of head injury, recognition of enlargement of head circumference), and underwent head CT scanning from March 1, 2002, to December 31, 2005 (N = 260). Cases in which the intracranial lesion was of medical origin or secondary to another disease process were excluded. This study was approved by the institutional review board as a secondary use of medical charts (ie, we could report our sample under the condition of nondisclosure of any individual cases).

Data Collection

From medical charts, gender and age of the child, perinatal information (birth weight, gestational age, multiple birth), history of injury presented by caregivers, place of injury occurred, symptoms at visit, physical and neurologic findings, hospitalization, operations, and mortality were extracted. In addition, from social work records, any decisions by the Child Guidance Center (CGC) (similar to Child Protective Services in the United States or the United Kingdom) were extracted.

Classification of AHT or Non-AHT

Classification of AHT or non-AHT was based on the definition by Reece and Sege.6 AHT was classified when there was a witness to the abuse, the abuse was confessed, there was no history accounting for the patient’s serious head injury, there was a positive skeletal survey coupled with serious head injury, and physical findings were consistent only with abusive injuries coupled with serious head injury. Retinal hemorrhage was not used to diagnose AHT primarily. Non-AHT was defined as a motor vehicle crash, pedestrian/vehicle crash, witnessed accident, and isolated or unique incidents. Suspected Child Abuse and Neglect team, a multidisciplinary team composed of a child abuse specialist, a radiologist, an ophthalmologist, nurses, and social workers in the National Center for Child Health and Development, reviewed each case and classified it accordingly. Social workers were able to obtain psychosocial information that is usually difficult to acquire (eg, abusive history of sibling by caregiver or domestic violence), and information was used for Suspected Child Abuse and Neglect team reviews. Cases in which there was poor supervision or caregiver neglect that resulted in unintentional injury (eg, falls from windows) were included in the non-AHT group.

Statistical Analysis

Descriptive statistics were calculated for the AHT and non-AHT groups. For categorical variables, χ² or Fisher’s exact test when any expected cell size was < 5 was used to compare these groups. For continuous variables, t tests were used. All statistical tests were 2-sided and used an α level of .05 to determine significance. The data analyses were performed by using Stata SE 9.0 (Stata Corp, College Station, TX).

RESULTS

Among 260 cases, a total of 28 (11%) were categorized as AHT. As shown in Table 1, the mean age of children...
with AHT was 7.5 months, whereas children with non-AHT were 11.3 months on average \((P = .005, t\) test). It is interesting that the median age of children with AHT was 7.7 months, which is higher than the group’s mean age. Figure 1 shows a histogram of 260 head injury cases by months of age, divided by AHT and non-AHT categorization. The AHT group had 2 peaks: at \(\sim 2\) to 4 months and 7 to 9 months. The non-AHT group showed no specific peak of months of age. Boys were predominant among AHT (78.6%), which is significantly higher than the non-AHT group \((P = .037, \chi^2\) test). With regard to perinatal history, 14.3% of the AHT group were born as a multiple birth, whereas only 1.7% were born as a multiple birth among non-AHT group \((P = .006, \text{Fisher's exact test})\). Prematurity did not distinguish AHT from non-AHT cases.

With regard to injury history, 60.7% of the AHT group had an absence of injury history (Table 2). No injury history was prevalent in both children who had AHT and were younger than 6 months (6 [54.6%] of 11) and children who had AHT and were \(\geq 6\) months of age (11 [64.7%] of 17). Conversely, 62.9% of the non-AHT group presented falls as the injury mechanism. Short falls were present in only 0.9% among the children with AHT, whereas SDHs were found in 64.3% of the children with AHT, whereas vomiting and blunt trauma signs were not. With regard to head CT, SDHs were found in 64.3% of the children with AHT, whereas SDHs were present in only 0.9% among the children with non-AHT \((P < .001, \text{Fisher's exact test})\). In particular, specific SDH types were found only among the children with AHT: intrahemispheres, under tentorium cerebelli, multilayer, and mix of acute and chronic. SDHs were prevalent in both the children who had AHT and were younger than 6 months (7 of 11 [63.6%]) and the children who had AHT and were \(\geq 6\) months of age (11 of 17 [64.7%]); however, even the unilateral SDH distinguished AHT from non-AHT: 21.4% among children with AHT and 0.4% among children with non-AHT. Skull fracture, subarachnoid hemorrhage, and epidural hematoma did not distinguish AHT from non-AHT. Retinal hemorrhages were found only among the AHT group, although retinal hemorrhage was not used to diagnose AHT. Among children with non-AHT, 11 received fundoscopy, and no retinal hemorrhage was found. Thus, bilateral and multilayer retinal hemorrhages were found only among the AHT group, although these specific retinal hemorrhage differences showed no statistical significance. Three positive skeletal surveys were found among the AHT group, and all the cases were rib fractures. Among children with non-AHT, 13 received skeletal survey, and no fracture was found. The positive skeletal survey also failed to show statistical significance.

### Table 1: Comparison of Demographic and Perinatal Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>AHT ((n = 28))</th>
<th>Non-AHT ((n = 232))</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, mo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>7.5</td>
<td>11.3</td>
<td>.005</td>
</tr>
<tr>
<td>Median</td>
<td>7.7</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>22 (78.6%)</td>
<td>135 (58.2%)</td>
<td>.037</td>
</tr>
<tr>
<td>Perinatal history</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight, mean, g</td>
<td>2758.5</td>
<td>2985.0</td>
<td>.059</td>
</tr>
<tr>
<td>Gestational age, wk</td>
<td>38.5</td>
<td>38.7</td>
<td>.614</td>
</tr>
<tr>
<td>Multiple birth, n (%)</td>
<td>4 (14.3%)</td>
<td>4 (1.7%)</td>
<td>.006</td>
</tr>
</tbody>
</table>

### Table 2: Comparison of Injury History Presented by Caregiver

<table>
<thead>
<tr>
<th>Injury History, n (%)</th>
<th>AHT ((n = 28))</th>
<th>Non-AHT ((n = 232))</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanism of injury presented by caregiver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No history</td>
<td>17 (60.7)</td>
<td>9 (3.9)</td>
<td></td>
</tr>
<tr>
<td>Admitted/witnessed assault</td>
<td>5 (17.9)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Struck by object</td>
<td>0 (0.0)</td>
<td>11 (4.7)</td>
<td></td>
</tr>
<tr>
<td>Motor vehicle crash</td>
<td>0 (0.0)</td>
<td>8 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Walking fall</td>
<td>0 (0.0)</td>
<td>58 (25.0)</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>6 (21.4)</td>
<td>146 (62.9)</td>
<td></td>
</tr>
<tr>
<td>(\leq 4) ft</td>
<td>5 (17.9)</td>
<td>134 (57.8)</td>
<td></td>
</tr>
<tr>
<td>&gt; 4 ft</td>
<td>1 (3.6)</td>
<td>36 (15.5)</td>
<td></td>
</tr>
<tr>
<td>Place of injury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>13 (46.4)</td>
<td>127 (54.7)</td>
<td></td>
</tr>
<tr>
<td>Outside home</td>
<td>0 (0.0)</td>
<td>93 (40.1)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>15 (53.6)</td>
<td>12 (5.2)</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 1**

Age distribution of patients who had AHT and non-AHT and underwent head CT for investigation of intracranial injury in the National Center for Child Health and Development (Tokyo, Japan), 2002–2005 \((N = 260)\).
Outcomes of the children with AHT were worse than those of the children with non-AHT (Table 4). Overall, among the children with AHT, 1 in 3 underwent an operation, and 1 in 10 died, whereas only 1.3% of the children with non-AHT underwent an operation, and 1 in 10 died, whereas only 1.3% of the children with non-AHT died from non-AHT. Despite the severity of AHT cases, 68% of children with AHT remained with their families, according to decisions by the CGC.

**DISCUSSION**

The retrospective comparative study at 1 children’s hospital located in Tokyo, Japan, found that victims of AHT were younger in age and that instances peaked at 2 distinct age ranges: ~2 to 4 months and 7 to 9 months. Boys were dominant among the children with AHT; 3 of 4 were boys. Only multiple birth among the perinatal factors examined was associated with AHT. Characteristics that distinguished AHT from non-AHT were the absence of an injury history, neurologic symptoms (eg, unconsciousness, seizure, paralysis), SDH, serious damage on the brain, and retinal hemorrhage. The clinical outcomes of the children with AHT were worse, but decisions made by the CGC may not appropriately reflect this increased severity.

The identified clinical characteristics that distinguished AHT from non-AHT were consistent with previous studies in Western countries. SDH, serious brain damage, and retinal hemorrhage were reported as distinguishing characteristics.6,11,14,17 In addition, specific type of SDH, such as intrahemispheres, under tentorium cerebelli, multilayer, mix of acute and chronic,4,21–25 and bilateral and multilayer retinal hemorrhage,13,14,26,27 were more likely to be found among inflicted cases. These CT and retinal hemorrhage findings were confirmed as AHT markers as well.

Neurologic symptoms, especially seizures, were more likely to be found among the AHT cases. Specifically, the percentage of seizures in our study (32.1%) was within the range of the percentage reported from previous studies (12.5%–53%).14,17,28 Neurologic symptoms are independently associated with AHT cases, because the symptoms were not considered for AHT/non-AHT categorization. One possible mechanism for these findings is that children with AHT are often not brought to medical attention until they have significant injuries with dramatic symptoms, such as a seizure. It is of note that when the young child with head injury had a seizure, even before admission, this symptom predicts abusive infliction in 56.3% of the cases, which should be kept in a pediatrician’s or family doctor’s mind.

The percentage of AHT cases that lacked an injury history as presented by the caregiver in our study (60.7%), in other words, sensitivity of no injury history to detect AHT (0.61), is similar to previous findings that examined admitted cases.6,14,17 The positive predictive value of no injury history to detect AHT among those who underwent head CT was 65.4% in our study, which is moderately high, although a previous study showed higher positive predictive value (0.92) among admitted head trauma cases.28 The caveat of this finding is that the absence of previous injury history with serious head injury cases was used in the categorization of AHT/non-AHT cases. Despite this caveat, in clinical settings, it would be useful to know that the absence of an injury history distinguishes AHT from non-AHT because its sensitivity is high.

With regard to age and gender, our findings were equivocal. Population-based studies found that younger boys are more likely to have inflicted brain injury or SDH,6,8–10,17 whereas other hospital-based studies among
admitted cases found that age and/or gender were not associated with AHT.6,7,11,14,28 Our study might be similar to a population-based study because nonadmitted patients were included. In other words, younger, male children were more likely to sustain head injuries and be brought to the hospital, but they were also more likely to receive a misdiagnosis as benign and not to be admitted to the hospital.

The mean and median ages of the AHT cases, 7.5 and 7.7 months, respectively, are higher than the mean and median ages of inflicted traumatic brain injury among 0- to 2-year-olds in North Carolina: 5.9 and 4.0 months, respectively. The existing 2 peaks of age in our sample—2 to 4 months and 7 to 9 months—contributed to the older age of the children with AHT. The first peak, ~3 months, is consistent with previous literature, suggesting the association between shaken infant syndrome and peak of crying.29,30 Aoki and Masuzawa31 reported that infants acute SDH had a peak age at ~7 to 10 months in Japan; however, their rationale to consider the cases as non-AHT were based on the caregiver’s explanation of injury history (eg, short fall on to Tatami mat, Japanese traditional mat made of woven straw), lack of external signs (eg, bruise), and better follow-up outcomes,32 which were criticized as reporting the abused cases.33 If these cases were abused cases, then our findings would be consistent with previous SDH peak of age, because more than half of older AHT children (≥6 months of age) had SDH (11 [64.7%] of 17) in our sample. Additional studies on the peak age of AHT among infants in Japan are needed to ascertain whether the bimodal peak of age is replicable.

There might be 4 possible mechanisms to explain why there is an older peak age of ~8 months for AHT in Japan, which was not found in Western countries. First, at the age of 7 to 10 months, infants start sitting, crawling, and pulling to stand up, and, subsequently, they are more likely to be injured, especially by short falls. This increases the likelihood of caregivers’ bringing infants to a hospital, and because head CTs are easily taken in Japan, this enables physicians to find serious intracranial injury, probably caused by abuse, because short falls rarely cause serious intracranial injury34–38; however, in our study, a few number of cases (5.9%) presented short falls as the history of injury among children who had AHT and were ≥6 months of age. Second, sleep-related nighttime crying, called Yonaki, might be a trigger of AHT. Yonaki emerges by 4 to 24 months of age and is manifested in most children in Japan.39 The higher prevalence of co-sleeping behavior in Japan, which is associated with nighttime waking,40,41 might accelerate the parental frustration during nighttime. Third, the start of weaning food at ~6 months of age might also make caregivers frustrated,42 especially when an infant refuses cooked weaning food. Parental or caregiver frustration might accumulate and affect inflicted abuse rates in infants at ~7 to 9 months of age. Fouth, infants’ crying a lot after 3 months of age, which is conceptualized as “persistent mother–infant distress” or “difficult infant,”43 may be prevalent in Japan. Additional research is needed to elucidate the triggers that are associated with AHT during the 7- to 9-month age range in Japan.

The percentage of children who were returned to their home after AHT in our study (68%) was higher than what was reported in previous studies in Western countries (eg, 32% in Cleveland, OH). In Japan, as a result of a rapid increase of reported child abuse44 and lack of sufficient staff at the CGC, ~80% of abused children remain with their family of origin.45 The decision process regarding separation or returning home is as follows: First, in collaboration with medical staff, CGC staff notify parents of the CGC’s suspicion that the child might be experiencing child abuse, which would incent parents not to commit additional abuse. Then, CGC assesses the risk for additional abuse in the family and decides whether the child should be separated or returned home if parents of the abused child accept services by CGC or other related agencies, such as a health or child care center. Then, CGC plays a major role in providing services to the family of AHT victims, mostly with regard to the coordination or networking with other related agencies. Some CGCs provide services to teach parenting skills at home visits. Because a perpetrator, mostly the mother or father, still lives with the child who was afflicted with AHT, the CGC periodically assesses the risk for child abuse in the family, including the acceptance of services, to ensure future safety.

Several limitations need to be addressed. First, our study used retrospective design, which induces misclassification because missing values occur frequently. For example, symptoms were collected from medical charts, but not all of the head injury cases had the symptoms recorded at visits, especially when these were negative. In addition, fundoscopy and skeletal surveys were not completed in some cases. Second, although we used the criteria of our sample as children who underwent head CT with suspected intracranial injury, the threshold to suspect intracranial injury and order head CT was not clearly defined a priori; however, in an actual setting, the threshold of suspected intracranial injury varies by physician. A third limitation could be the manner in which children were classified as having AHT or non-AHT. We used the criteria suggested by Reece and Sege,6 which is based on historical and physical examination findings and an evaluation of psychosocial factors from social work records, unlike the classification scheme used by Duhaime et al.31 The criteria used in our study might inflate the number of AHT cases, because criteria by Duhaime et al31 were more conservative in diagnosing AHT. In addition, we did not include an indeterminate category, which was used in another study.10 Despite the limitation in terms of categorization, characteristics of AHT reported in our study were similar to the previous literature, and outcomes of AHT cases were worse. A fourth limitation is the small sample size. The failure of positive skeletal surveys as a marker of AHT might be attributable to lack of power, because a previous study found that positive skeletal surveys distinguished AHT from non-AHT. Fifth, this study was implemented only in 1 hospital, suggesting lower generalizability. A larger, multicenter study in Japan is
needed to replicate the characteristics that distinguish AHT from non-AHT.

CONCLUSIONS
Similar clinical presentations of AHT with previous studies in Western culture (ie, the absence of an injury history, seizures, SDHs, and retinal hemorrhages) were also found in Japan. The 2 peaks of age, at 2 to 4 months and 7 to 9 months, might be a characteristic unique to Japan. These markers can be used to detect AHT cases by physicians and social welfare workers to protect children from additional abuse. Specifically, the CGC should be encouraged to consider these findings for making better informed decisions regarding children who are referred to CGC.

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