Child Abuse Review (2020)
Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/car.2627

What Do Confessions Reveal about Abusive Head Trauma? A Systematic Review

George A. Edwards*
Formerly of Department of Pediatrics, Dell Medical School, University of Texas at Austin, Austin, Texas, USA

Sabine A. Maguire
School of Medicine, Cardiff University, Wales, UK

Julie R. Gaither

John M. Leventhal
Department of Pediatrics, Yale School of Medicine, New Haven, Connecticut, USA

Although confessions related to abusive head trauma (AHT) are reported, no detailed analysis exists. Therefore, we systematically reviewed studies of AHT confessions and examined the details, including country of origin, mechanisms and perpetrators' characteristics. Employing 36 search terms across three search engines, we searched Medline and CINAHL from 1963 to 2018. All relevant studies underwent two independent reviews and data extraction. Descriptive statistics were used to characterise the sample; chi square and Fisher's exact tests were used to assess differences in demographic and clinical characteristics. Of 6759 identified studies, 157 full texts were reviewed and 55 articles from 15 countries spanning four continents were included. Included articles contained 434 confessions. The mechanisms of abuse included shaking alone (64.1%), impact alone (17.1%), shaking plus impact (18.0%) and other (0.9%). There was no statistically significant difference in the percentage of confessions reporting shaking alone when comparing continents: North America (64.0%), Europe (64.2%) and Oceania (60.0%; p = 0.92), or when comparing circumstances in which the confession was obtained: medical evaluation (74.6%) vs police or judicial investigations (63.4%; p = 0.11). Of 119 cases with identified perpetrators, 67.2 per cent were cases with males alone. Confessions reveal striking similarities in the mechanism of AHT (predominantly shaking) that occur across the globe. © 2020 John Wiley & Sons, Ltd.

'We systematically reviewed studies of AHT confessions and examined the details, including country of origin, mechanisms and perpetrators' characteristics'

Key Practitioner Messages:

- Confessions can provide important information about AHT and have been reported in medical literature for over 40 years.
- The quality of evidence for the association of shaking with AHT has been questioned, but no systematic review of confessions of AHT has been performed previously.
- This systematic review of confessions of AHT reveals that shaking is the most common mechanism reported and that shaking and AHT occur together across the world.

Key Words: child abuse; abusive head trauma; shaken baby syndrome; confessions

*Correspondence to: George A. Edwards, MD, Pediatric Residency, Dell Children's Medical Center, 4900 Mueller Blvd, Austin, TX 78723, USA. E-mail geoa.edwards@gmail.com
Contract/grant sponsor: Contract/grant sponsor: National Institutes of Health; contract/grant numbers: contract/grant numbers: KL2TR001862.

Accepted: 26 February 2020

Introduction

In cases of abusive head trauma (AHT), confessions can provide important details about what happened, including the mechanism of the injury and the characteristics of the perpetrator. Because this information is important to clinicians, many studies have either described the details of confessions or relied, in part, on confessions to identify cases of abuse when developing a case series of children with AHT. There has been, however, no comprehensive, systematic review of AHT confessions that defines the full spectrum of mechanisms, perpetrators and circumstances.

One previous study reviewed articles with confessions related to AHT, but it examined publications before 2001 and focused only on confessions of shaking (Leestma, 2005). More recently, a review of the role of shaking as the cause of 'the triad' (subdural haematoma, retinal haemorrhages and encephalopathy) reported only two studies of confessions (SBU, 2016). This review questions the quality of evidence that associates 'isolated shaking' with 'the triad', and its authors have stated in a letter to the editor, '… it would be valuable to receive more background information on what the suspect actually confessed and the circumstances under which confessions were obtained' (Lynøe *et al.,* 2017, p. 732).

To improve on these previous studies and to examine the full range of published studies on confessions of AHT, we conducted a systematic review to determine the range of mechanisms described, country of origin, focus of the studies, perpetrator characteristics, antecedent circumstances, perpetrator motivation and the circumstances under which the confessions were made.

'There has been… no comprehensive, systematic review of AHT confessions that defines the full spectrum of mechanisms, perpetrators and circumstances'

Methods

An English language literature search was conducted using the search engines PubMed, Ovid and EBSCO. All three were used to search Medline, and EBSCO was used to search CINAHL. Primary studies were identified. The time of the first and last identified studies in Medline were from September 1963 to December 2018, respectively, and in CINAHL from March 1986 to November 2018. The initial search strategy was developed using PubMed and Medline with three sets of key words, including both search words and Medical Subject Headings (MeSH) (see Appendix S1 in the online Supporting Information). It was modified for use with the other search engines and for the other bibliographic database. The search sensitivity was augmented by using supplementary 'snowballing' techniques, including checking the references of all full-text articles. Identified articles, once scanned for duplicates and relevance, were transferred to a database to coordinate the review and collate critical appraisal data. Relevant studies with an English language version were scanned for eligibility by one author (GE) and selected for review (Figure 1). All eligible articles were independently reviewed by two authors (JL and SM), and a third review (GE) was undertaken to resolve disagreements relating to inclusion criteria.

We included all studies of children experiencing AHT in which the authors explicitly recorded a confession containing the mechanism of injury. Only cases within each study that had an explicit confession, as opposed to

'We included all studies of children experiencing AHT in which the authors explicitly recorded a confession containing the mechanism of injury'

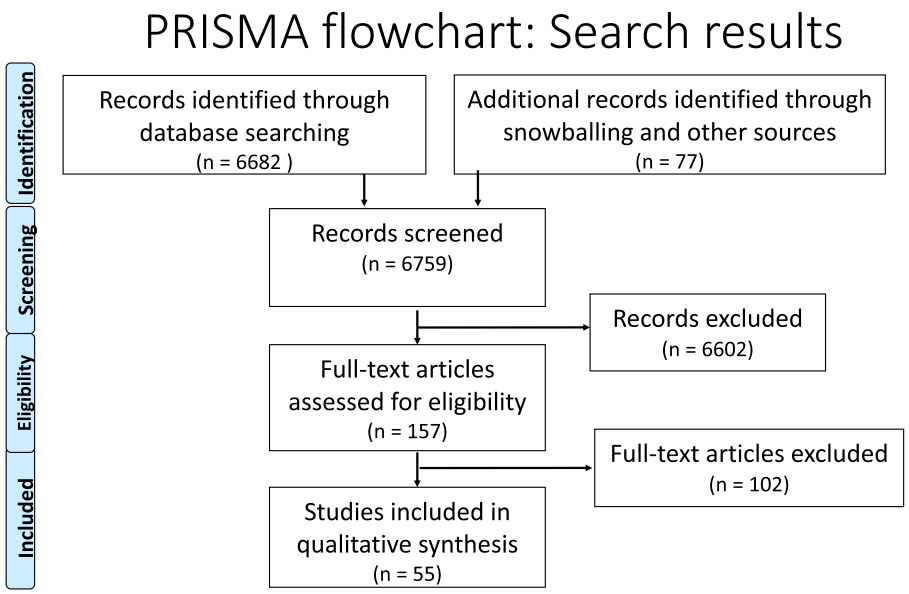

Figure 1. PRISMA flowchart: Search results [Colour figure can be viewed at wileyonlinelibrary.com]

witnessed events or an assumed mechanism, were included in the analysis. We also abstracted additional details when available: country of origin, focus of the study, age of the child, gender of the perpetrator, perpetrator's relationship to the child, antecedent circumstances, the perpetrator's motivation and the circumstances in which the confession was obtained. The ***focus of the study*** included shaking as the potential cause of AHT, a description of confessions of AHT or a case series that included at least one confession of AHT. ***Antecedent circumstances*** included crying, apnoea, seizures or feeding difficulty. ***Perpetrator's motivation*** included desire to stop the crying, anger/frustration and loss of control, or ensuring the child's obedience. The ***circumstances*** in which the confession was obtained included medical evaluation, investigation by law enforcement and/or child protective services, judicial process, or unclear. In the analysis, confessions reported in non-medical settings (law enforcement, protective services or judicial process) were combined and referred to as 'investigation'.

Quality Standards

The level of detail in a confession may be a reflection of the quality of the confession. However, no validated ranking system to capture the level of detail in confessions exists. Therefore, to categorise the level of detail in each confession, we devised a 4-point quality ranking scale (Table 1). Each

Table 1. Ranking of Confessions of AHT According to the Level of Detail

A	The mechanism of injury (shaking, impact, shaking/impact, other) is reported, and all details of the event are provided (antecedent circumstances, aftermath of the event, and the motivation of the confessor).
B	The mechanism of injury is reported and 2 details among antecedent circumstances, aftermath of the event, and the motivation of the confessor are provided.
C	The mechanism of injury is reported and only 1 detail is provided.
D	The mechanism of injury is reported, but no detail is provided.

confession was ranked independently by two authors (SM and JL); in cases of disagreement, a third author (GE) served to make the final determination.

Statistical Analysis

We used frequencies, means, and proportions to describe the sample, and chi-square and Fisher's exact tests to evaluate differences according to demographic and clinical characteristics. All analyses were conducted with SAS software, version 9.4 (SAS Institute Inc). A two-sided statistical significance level of .05 was applied to all results.

Results

Because the included studies used different designs, a meta-analysis was not possible; however, an individual confession-based analysis was feasible. There were 55 included studies that contained 434 individual confessions (range of one to 69 per study, with a median of two). A summary of all included studies is shown in Table 2. Over the five decades, there was an increasing number of confessions noted in the literature: four from 1971 to 1979; 46 from 1980 to 1989; 24 from 1990 to 1999; 145 from 2000 to 2009; and 215 from 2010 to 2018. The 55 studies originated from 15 countries, across four continents, and an international listserv: 61.5 per cent of confessions originated in North America, 31.6 per cent in Europe, 5.8 per cent in Oceania, 0.5 per cent in Asia and 0.7 per cent from the listserv. The studies were categorised into three groups: those that focused on whether shaking could cause AHT (yielding 89 confessions; 20.5% of the total studies analysed), those that focused on confessions (182; 41.9%), and those that focused on AHT and included at least one confession (163; 37.6%).

‘There were 55 included studies that contained 434 individual confessions (range of one to 69 per study, with a median of two)’

The level of detail provided in the confessions varied (Table 1), with 2.3 per cent ranked A (providing at least three details in addition to the mechanism), 4.8 per cent ranked B, 10.1 per cent ranked C, and 82.7 per cent ranked D (only the mechanism was described). Confessions published in older studies provided greater levels of detail: of 74 confessions published from 1971 to 1999, 33.8 per cent were ranked A, B or C as opposed to 19.3 per cent of 145 confessions published from 2000 to 2009, and 10.2 per cent of 215 published from 2010 to 2018 ($p < 0.001$). In addition, the European studies provided more detail with 20.4 per cent of confessions ranked A, B or C, whereas only 11.6 per cent of confessions published in North America ranked A, B or C ($p = 0.02$). More details were provided in confessions from studies that focused on shaking (39.3%) compared with studies that focused on confessions (3.3%) and studies on AHT more generally (20.9%) ($p < 0.001$).

The ***mechanism***s reported in the confessions were 64.1 per cent shaking alone, 17.1 per cent impact alone, 18.0 per cent shaking plus impact, and 0.9 per cent other mechanisms. Table 3 shows the mechanisms from the three continents where the majority (98.8%) of confessions were obtained. When shaking alone was compared to the other mechanisms from these three continents, there was no statistically significant difference in the percentages of shaking alone: 64.0 per cent of confessions from North America, 64.2 per

‘The mechanisms reported in the confessions were 64.1 per cent shaking alone, 17.1 per cent impact alone, 18.0 per cent shaking plus impact, and 0.9 per cent other mechanisms’

DOI: 10.1002/car

Table 2. Summary of Included Studies

Author	Year	Country	Number of included cases (study total)	Circumstances of confession	Perpetrator	Antecedent circumstances	Mechanism	Perpetrator motivation
Adamsbaum *et al.*	2010	France	29 (112)	29 investigation	12 fathers 1 stepfather 8 mothers 6 sitters 1 teenage brother 1 mother & stepfather	n/a	24 shaking 5 shaking & impact	n/a
Alexander *et al.*	1986	USA	1 (4)	1 n/a	father	irritability & shallow breathing	shaking	revive/ resuscitate
Arlotti *et al.*	2007	USA	3 (17)	2 medical evaluation 1 n/a	3 fathers	2 apnoea 1 unresponsive	3 shaking	1 revive/resuscitate 2 n/a
Barlow *et al.*	1999	UK	2 (12)	1 medical evaluation 1 n/a	1 parent 1 n/a	1 seizure 1 n/a	1 shaking 1 head compressed between knees	n/a
Bartschat *et al.*	2016	Germany	1 (1)	1 investigation	father	crying	shaking	stop crying
Becker *et al.*	1998	Germany	2 (5)	2 n/a	1 father 1 mother	1 crying 1 vomiting	2 shaking	1 stop crying 1 anger/frustration
Bell *et al.*	2011	Canada	1 (1)	1 medical/legal setting	stepfather	child upset	shaking	frustration
Bennett and French	1980	USA	1 (1)	1 n/a	father	n/a	shaking	n/a
Benstead	1983	UK	3 (3)	1 investigation 2 n/a	2 fathers 1 mother	2 n/a 1 crying	2 shaking 1 shaking & impact	1 anger/frustration 2 n/a
Benzel and Hadden	1989	USA	3 (23)	3 n/a	1 mother 2 n/a	1 n/a 1 seizure 1 choking	3 shaking	3 n/a
Biron and Shelton	2005	Australia	7 (52)	7 investigation	6 fathers 1 mother	5 crying 2 n/a	6 shaking 1 vigorously bouncing on knee	1 anger/frustration 5 stop crying 1 n/a
Breazzano *et al.*	2014	USA	1 (55)	1 n/a	father	n/a	shaking	n/a
Caffey	1974	USA	1 (5)	1 n/a	sitter	feeding difficulty	shaking	n/a
Caputo *et al.*	2008	France	2 (3)	2 n/a	1 father 1 sitter	1 crying 1 ALTE	2 shaking	1 stop crying 1 revive/resuscitate
Carter and McCormick	1983	Canada	3 (4)	3 n/a	1 mother 1 father 1 both parents	1 crying 1 apnea 1 n/a	3 shaking	1 stop crying 1 revive/resuscitate 1 n/a
Cordner *et al.*	2001	Australia	2 (6)	2 n/a	1 unrelated male 1 n/a	2 n/a	2 impact	1 lost control 1 n/a
De Leeuw *et al.*	2013	Belgium	19 (47)	19 investigation	3 fathers 16 n/a	3 crying 16 n/a	13 shaking & impact 6 impact	3 stop crying 16 n/a
Duhaime *et al.*	1987	USA	14 (48)	14 medical evaluation	n/a	n/a	1 shaking 3 impact 10 shaking & impact	n/a
Eagan*et al.*	1985	USA	2 (2)	1 medical evaluation 1 n/a	1 stepfather 1 father	1 toileting accident 1 crying	1 shaking 1 shaking & impact	1 anger/frustration 1 stop crying
Ellison *et al.*	1978	USA	1 (4)	n/a	1 father	n/a	1 shaking & impact	n/a
Esernio-Jenssen *et al.*	2011	USA	18 (48)	18 n/a	15 men 3 women	n/a	16 shaking 2 shaking & impact	n/a
Fanconi and Lips	2010	Switzerland	13 (49)	13 medical evaluation	n/a	n/a	13 shaking	5 resuscitate 1 stop crying

(Continues)

cent of confessions from Europe, and 60.0 per cent of confessions from Oceania ($p = 0.92$).

Confessions were obtained during the investigation in 50.9 per cent of cases and during the medical evaluation in 13.6 per cent of cases; this information was missing in 35.5 per cent of cases. When the frequencies of the mechanisms were compared in these three categories, there was no statistically significant difference ($p = 0.45$). For example, the percentage of cases due to shaking alone was 74.6 per cent in confessions from the medical evaluation, 63.4 per cent in confessions from investigation, and 61.0 per cent when the circumstances were unknown.

Age of the victim was provided in 134 cases; the ages ranged from two weeks to seven years, and 85.8 per cent were less than one year of age. Analysis of the children whose ages were known showed a significant difference in the occurrence of shaking alone, with 82.6 per cent of those less than a year old vs 42.1 per cent of those older ($p < 0.001$). There was a gradual reduction in the prevalence of shaking alone throughout the first 24 months: 85.1 per cent of those aged 0–5 months, 73.1 per cent of those 6–11 months, and 42.1 per cent of those at least 12 months ($p < 0.001$).

'85.8 per cent [of victims] were less than one year of age'

The ***gender of the perpetrators*** was available in 119 cases: men alone outnumbered women alone (67.2% vs 27.7%) with 5.0 per cent being a man and a woman together. When there was a sole perpetrator and shaking the only mechanism, men were more likely to shake the child than women, but this difference was not statistically significant (76.3% vs 66.7%, $p = 0.29$). Among the cases where there was a sole female perpetrator and the age of the child was known (n=28), 42.9 per cent abused children 0–5 months of age, 39.3 per cent abused children 6–11 months of age, and 17.9 per cent abused children at least 12 months of age. In contrast, males were more likely to abuse younger victims. Among the cases where there was a sole male perpetrator and the age of the child was known (n=59), the percentages by age group were 78.0 per cent, 6.8 per cent and 15.3 per cent, respectively ($p < 0.001$).

Data were available about the ***relationship of the perpetrator*** to the child in 111 cases, of which six involved two perpetrators. Of the 105 cases with a single perpetrator, 80 (76.2%) were biological parents, with twice as many fathers alone ($n = 51$) abusing their children as mothers ($n = 25$) (parents' gender was unspecified in four of the cases). In addition, 10 (9.5%) involved sitters, eight (7.6%) unrelated males, and three (2.9%) stepfathers. For grandmothers, aunts, siblings and foster mothers, there was only one (<1%) case per category. Biological fathers were more likely to abuse infants (92.0%) than older children (8.0%), while unrelated males/stepfathers were less likely to abuse infants (44.4%) compared to older children (55.6%) ($p < 0.001$).

'Biological fathers were more likely to abuse infants (92.0%) than older children (8.0%)'

Where the ***circumstances immediately prior*** to the abuse of the child were described ($n = 50$ cases), crying was the trigger in 60.0 per cent. Of the 30 cases where crying was cited, 76.7 per cent of the victims were shaken vs 90.0 per cent in the 20 cases where crying was not cited ($p = 0.23$). Of these 20 cases, the antecedent circumstances included eight (40%) cases involving respiratory difficulty (e.g., apnoea, shallow breathing, choking), three (15%) seizures, seven (35%) difficulties with either feeding or toilet training and two (10%) other. The ***perpetrator's motivation*** was reported in 49 cases. The two most common motivations were frustration and loss of control in 42.9

Table 2. *(Continued)*

Author	Year	Country	Number of included cases (study total)	Circumstances of confession	Perpetrator	Antecedent circumstances	Mechanism	Perpetrator motivation
Flaherty	2006	USA	19 (25)	19 investigation	1 man 18 n/a	1 crying 1 feeding difficulty & crying 17 n/a	2 shaking 17 shaking & impact	19 n/a
Frank *et al.*	1985	USA	2 (4)	2 n/a	1 both parents 1 father	1 crying 1 n/a	2 shaking	1 stop crying 1 anger/ frustration
Giangiacomo and Barkett	1985	USA	1 (2)	1 medical evaluation	1 unrelated male	n/a	shaking	n/a
Gill *et al.*	2009	USA	3 (46)	1 investigation 2 n/a	1 unrelated male 2 fathers	1 difficulty feeding 1 n/a 1 crying	3 shaking	n/a
Gleckman *et al.*	2000	USA	9 (9)	9 n/a	n/a	n/a	5 shaking 3 shaking & impact 1 impact	n/a
Greenwald *et al.*	1986	USA	2 (5)	2 n/a	1 foster mother 1 father	1 seizures 1 apnoea	2 shaking	1 n/a 1 resuscitate
Guthkelch	1971	UK	2 (13)	2 n/a	2 mothers	1 choking 1 crying	2 shaking	1 stop choking 1 n/a
Hadley *et al.*	1989	USA	13 (13)	13 medical evaluation	n/a	n/a	13 shaking	n/a
Haseler *et al.*	1997	USA	1 (3)	1 investigation	1 father	n/a	1 shaking	n/a
Kanik *et al.*	2015	Turkey	1 (2)	1 medical evaluation	1 father	1 crying	1 shaking	1 stop crying
Kauppi *et al.*	2012	Finland	8 (11)	8 n/a	2 fathers 6 mothers	3 crying 5 n/a	1 shaking 1 shaking & impact 6 impact	3 ensure obedience 2 losing control 3 n/a
Kelly *et al.*	2009	New Zealand	16 (39)	16 investigation	n/a	n/a	9 shaking 5 impact 2 other	6 resuscitate 2 quiet baby 8 n/a
Kivlin	1999	USA	1 (116)	1 n/a	grandmother	resisting toilet training	1 shaking	1 anger/frustration
Kleinman *et al.*	1989	USA	3 (6)	3 investigation	3 fathers	2 n/a 1 crying	2 shaking 1 shaking & impact	1 resuscitate 2 n/a
Klevens and Leeb	2010	USA	54 (375)	54 investigation	n/a	n/a	54 shaking	n/a
Koe *et al.*	2010	Ireland	3 (22)	3 n/a	n/a	n/a	3 shaking	n/a
Lam *et al.*	1996	Canada	1 (1)	1 investigation	n/a	n/a	1 shaking & impact	n/a
Lambert *et al.*	1986	USA	1 (1)	1 n/a	1 sitter	n/a	1 shaking	n/a
Lazoritz *et al.*	1997	USA	11 (71)	11 medical evaluation	n/a	n/a	11 shaking	n/a
Matlung *et al.*	2011	Netherlands	2 (5)	2 investigation	2 n/a	n/a	2 shaking	n/a
McKinney *et al.*	2008	USA	2 (11)	2 investigation	1 mother 1 unrelated male	n/a	2 impact	n/a
Molina *et al.*	2012	USA	12 (80)	12 investigation	n/a	n/a	10 impact 2 shaking & impact	n/a
Morad *et al.*	2004	Multiple countries	3 (8)	2 n/a 1 medical evaluation	1 father 1 unrelated male 1 aunt	2 n/a 1 crying	2 shaking 1 shaking & impact	3 n/a
Nambu *et al.*	2012	Japan	1 (1)	1 investigation	sitter	crying	1 shaking	n/a
Oral *et al.*	2008	USA	1 (38)	1 n/a	father	n/a	1 shaking	n/a

(Continues)

per cent of cases and reviving the child or stopping the choking in 30.6 per cent. The above findings are detailed in Table 2.

Discussion

In this comprehensive systematic review of studies detailing confessions of AHT, we identified 434 confessions in 55 articles, across four continents. The details provided by the perpetrators highlight the similarities as to how these children suffered AHT.

Our study has four key findings. First, shaking is by far the most frequently described mechanism of AHT in confessions; moreover, although shaking is most frequently described without impact (64%), both shaking and impact are described together (18%), and impact is described alone (17%). Second, studies of confessions are described in 15 different countries, indicating that AHT occurs across four continents, most commonly as the result of shaking. Furthermore, the percentage of confessions reporting shaking alone did not differ among the three major continents included in the study: North America, Europe and Oceania. Third, when confessions were obtained during the investigation (i.e. during police or child protective services investigation or the judicial process), they were no more likely to include shaking alone than when confessions were obtained during the medical evaluation. Finally, of the confessions with information about the gender of the perpetrator, 67 per cent were by males alone. Of the confessions by single perpetrators with information about the relationship to the victim, biological fathers were the most frequent (49%), followed by mothers (24%).

'Shaking is by far the most frequently described mechanism of AHT in confessions'

Previous Literature on Confessions of AHT

Although reports of confessions of AHT with shaking have appeared in medical literature for over four decades, the only previous review of confessions was conducted by Leestma (2005) based on studies published from 1969 to 2001. In that review, the author searched the literature for studies in which 'anyone was on record as having admitted to *shaking* the baby victim in any fashion, since this is the presumed independent variable of possible causality' (Leestma, 2005, p. 200). The aim of that study was to correlate confessions of shaking to specific clinical features, pathology and outcomes. From 57 published articles included by Leestma, there were 54 cases reported in which someone had shaken the victim in some manner, and detailed clinical information was given. Of the shaking cases, the author stated that 11 had no evidence of cranial impact (and therefore were cases of shaking alone), 12 had evidence of cranial impact (and presumably suffered from shaking and impact), and 18 provided no information aside from the confession about cranial impact. In addition, there were 13 cases from an article by Hadley *et al*. (1989), but these cases were discussed separately because Leestma felt that it could not be determined whether these cases included a confession of shaking. In our review of Hadley *et al*.'s (1989) article, however, we included these cases as the authors explicitly stated that these 13 cases had 'a

Table 2. *(Continued)*

Author	Year	Country	Number of included cases (study total)	Circumstances of confession	Perpetrator	Antecedent circumstances	Mechanism	Perpetrator motivation
Pierce *et al.*	2017	USA	8 (20)	8 n/a	3 fathers 2 mothers 2 unrelated males 1 mother & unrelated male	1 crying 1 resisting toilet training 6 n/a	4 shaking 1 shaking & impact 3 impact	3 anger/frustration 5 n/a
Porzionato *et al.*	2008	Italy	1 (1)	1 n/a	1 stepfather	1 n/a	1 shaking & impact	n/a
Ricci *et al.*	2003	USA	4 (19)	4 investigation	4 n/a	1 resisting toilet training 3 n/a	3 shaking 1 impact	1 anger/frustration 1 jealousy 1 stop crying 1 n/a
Saternus *et al.*	2000	Germany	3 (3)	3 investigation	3 n/a	n/a	3 shaking	n/a
Spaide *et al.*	1990	USA	1 (2)	1 n/a	1 mother	1 crying	1 shaking	n/a
Starling *et al.*	2004	USA	69 (171)	69 n/a	69 n/a	n/a	32 shaking 17 shaking & impact 20 impact	n/a
Vinchon *et al.*	2010	France	45 (124)	45 investigation	69 n/a	n/a	30 shaking 15 impact	n/a
Zepp *et al.*	1992	Germany	2 (2)	2 n/a	2 both parents	1 crying 1 n/a	2 shaking	n/a

n/a = not available

Table 3. Mechanism of Injury by Continent

	North America (*n* = 267)	Europe (*n* = 137)	Oceania (n = 25)	Total (*n* = 429)
Mechanism				
Shaking, n (%)	171 (64.0)	88 (64.2)	15 (60.0)	274
Impact, n (%)	40 (15.0)	27 (19.7)	7 (28.0)	74
Shaking & Impact, n (%)	56 (21.0)	21 (15.3)	0 (0.0)	77
Other, n (%)	0 (0.0)	1 (0.7)	3 (12.0)	4

documented history of infant shaking as admitted by the parent-boyfriend-babysitter perpetrator' (p. 538).

The other publication that examined confessions was the Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU) report (SBU, 2016), which accepted as valid only those studies of shaken baby syndrome exhibiting the 'triad' with either witnessed or confessed isolated traumatic shaking. By restricting themselves to the use of the term 'triad', which is used in legal but not medical settings, the authors then limited their included studies of confessions to only two published studies: Adamsbaum *et al*. (2010) and Vinchon *et al*. (2010). In our systematic review, we included any article that contained a confession of AHT with the mechanism of injury (not restricted to shaking alone), because our review focused on the question of whether the published literature included descriptions in which an adult acknowledged responsibility for the mechanism of injury in a child who had been diagnosed with traumatic brain injury. We did not limit ourselves to specific clinical features in the child.

Similarities in the Mechanism of AHT across Different Areas of the World

It is striking that we identified confessions of AHT in articles from 15 different countries representing four continents; moreover, the most commonly reported mechanism of trauma was shaking alone from every continent, and from 13 of the 15 countries. There were two studies that did not include confessions of shaking alone, one from Belgium (De Leeuw *et al.,* 2013) and one from Italy (Porzionato *et al.,* 2008). However, 13 of the 19 confessions from Belgium described shaking with impact, and the only confession reported from Italy described shaking with impact. The geographic diversity of the studies reporting confessions indicates that confessions of AHT and of shaking, most commonly shaking alone, occur across multiple countries. This finding may indicate a universal way that a frustrated and/or angry adult responds when stressed and overwhelmed by the behaviour of a young child.

Circumstances of the Confession

Because in some countries investigation occurs during the judicial process, in our analysis we combined investigations conducted by the police and/or child protective services, and investigations that occurred during the judicial process. Some authors have doubted the truthfulness of confessions of shaking obtained during interrogation and plea bargaining. For example, Findley *et al*. (2012) have argued that false confessions result partly from psychological techniques used in interrogation, such as the presentation of

real or fabricated proof of guilt that makes the suspect feel the situation is hopeless. Tuerkheimer (2014) has argued that during plea bargaining, an innocent suspect may be led to believe that it is in his/her best interest to confess falsely, if that person perceives that there is a high likelihood of conviction by the court. Neither psychological techniques of interrogation nor plea bargains are part of a medical evaluation. Therefore, if interrogation and plea bargaining increase the likelihood of false confessions of shaking, one would expect more confessions of shaking during investigation and the judicial process than during medical evaluation. Our finding that shaking was not reported more frequently in confessions obtained during investigation and judicial proceedings compared to those obtained during medical evaluations suggests that no overt bias is associated with the circumstances of the confession.

Perpetrator's Gender and Relationship to the Victim

Where the gender of the perpetrator was known, we found a substantial preponderance of men. This finding is similar to the results of previous studies that included perpetrators who never confessed (Starling *et al.,* 1995; Starling *et al.,* 2004; Starling and Holden, 2000), but it is not clear that our findings indicate that males are more likely to abuse than females. Esernio-Jenssen *et al*. (2011) reported that male perpetrators of AHT are more likely *to confess*, which, if correct, might explain our findings of male preponderance. Males who confessed were more likely to abuse younger victims than females who confessed. With regard to the relationship to the victim, of those who confessed, fathers were the most frequent; however, our data do not speak to whether fathers are actually more likely to commit abuse than others or whether they are simply more likely to confess. A substantial number of mothers were also the confessed abusers, and this should be borne in mind by those investigating such cases. We also found sitters and unrelated males among the perpetrators who confessed, but they represented a smaller percentage than in some studies (Starling *et al.,* 1995; Starling *et al.,* 2004; Starling and Holden, 2000).

‘Where the gender of the perpetrator was known, we found a substantial preponderance of men’

Only 17 per cent of the confessions provided at least one additional detail beyond the mechanism of the injury; within the limits of this analysis, we noted that crying was the most frequently reported antecedent circumstance, and frustration and loss of control were the perpetrators' most frequent motivations, consistent with findings by Barr *et al*. (2006), Barr (2012, 2014) and Brewster *et al*. (1998).

There are at least four limitations to our study. First, we searched two major databases, but no legal databases, so it is possible that some articles describing confessions were missed. However, the database search was supplemented by reference checking and a wide range of search terms to allow for historical and cultural differences in terminology. Second, most of the confessions did not include additional details beyond the mechanism of the injury. Third, a substantial number of confessions (n = 89) came from articles that focused on shaking as a mechanism. Of these confessions, 75 per cent reported shaking alone compared to confessions from articles that described all mechanisms of AHT, where 61 per cent reported shaking alone. The articles that focused on shaking were examining whether shaking alone could cause the symptoms, signs, or imaging findings of AHT. For example, Gill *et al*. (2009, p. 619)

designed their study to 'support or dispute pure shaking as the cause of death'. Also, Biron and Shelton (2005, p. 1350) stated that their goal was 'to identify instances of shaking in the absence of any impact evidence'. The approach used by these authors for selecting cases to include in an article may have resulted in a falsely elevated percentage of cases attributed to shaking alone. Finally, it is possible that some of the reported confessions were false. For example, it might be easier and more socially acceptable to confess to shaking an infant as opposed to slamming the infant on a surface. If this supposition is true, then there may be confessions in the literature that are not accurate.

In summary, despite scepticism by some regarding the role of shaking in AHT, this comprehensive systematic review clearly shows that confessions of AHT occur across different regions of the world, and that shaking alone is the most commonly reported mechanism of injury. Furthermore, shaking with or without impact accounts for over 80 per cent of the confessed mechanisms. Despite concern that investigation and the judicial process can lead to false confessions, we found no evidence that confessions during those circumstances were more likely to include shaking than those given during medical evaluation. While male caregivers are the most common confessed perpetrators, females (mothers, relatives, and sitters) account for over one-quarter of cases. Finally, the notable similarities in the description of shaking in confessions, regardless of country or circumstance, emphasise the significance of shaking in AHT; moreover, these similarities clearly refute the argument that there are insufficient data within the published literature to support shaking as an important cause of AHT.

'Shaking with or without impact accounts for over 80 per cent of the confessed mechanisms'

Acknowledgements

We gratefully acknowledge the assistance of Darlene M. Ennis, Medical Librarian, Dell Children's Medical Center, Austin, Texas in designing and executing the literature search. We also acknowledge that the Yale Department of Pediatrics has received payment for Dr Leventhal's expert testimony in child abuse cases. Dr. Gaither received partial funding support on this project from a grant (KL2TR001862) from the National Center for Advancing Translational Science, National Institutes of Health. The authors have no additional conflicts of interest to disclose.

References

Adamsbaum C, Grabar S, Mejean N, Rey-Salmon C. 2010. Abusive head trauma: Judicial admissions highlight violent and repetitive shaking. *Pediatrics* **126**: 546–555. https://doi.org/10.1542/peds.2009-3647

Alexander RC, Schor DP, Smith WL Jr. 1986. Magnetic resonance imaging of intracranial injuries from child abuse. *The Journal of Pediatrics* **109**(6): 975–979. https://doi.org/10.1016/S0022-3476(86)80279-7

Arlotti SA, Forbes BJ, Dias MS, Bonsall DJ. 2007. Unilateral retinal hemorrhages in shaken baby syndrome. *Journal of American Association for Pediatric Ophthalmology and Strabismus* **11**(2): 175–178. https://doi.org/10.1016/j.jaapos.2006.09.023

Barlow KM, Gibson RJ, McPhillips M, Minns RA. 1999. Magnetic resonance imaging in acute non-accidental head injury. *Acta Paediatrica* **88**(7): 734–740. https://doi.org/10.1111/j.1651-2227.1999.tb00034.x

Barr RG. 2012. Preventing abusive head trauma resulting from a failure of normal interaction between infants and their caregivers. *Proceedings of the National Academy of Sciences of the United States of America* **109**(Suppl 2): 17294–17301. https://doi.org/10.1073/pnas.1121267109

Barr RG. 2014. Crying as a trigger for abusive head trauma: A key to prevention. *Pediatric Radiology* **44**(Suppl 4): S559–S564. https://doi.org/10.1007/s00247-014-3100-3

Barr RG, Trent RB, Cross J. 2006. Age-related incidence curve of hospitalized Shaken Baby Syndrome cases: Convergent evidence for crying as a trigger to shaking. *Child Abuse & Neglect* **30**: 7–16. https://doi.org/10.1016/j.chiabu.2005.06.009

Bartschat S, Richter C, Stiller D, Banschak S. 2016. Long-term outcome in a case of shaken baby syndrome. *Medicine, Science, and the Law* **56**(2): 147–149. https://doi.org/10.1177/0025802415581442

Becker JC, Liersch R, Tautz C, Schlueter B, Andler W. 1998. Shaken baby syndrome: Report on four pairs of twins. *Child Abuse & Neglect* **22**(9): 931–937. https://doi.org/10.1016/S0145-2134(98)00069-6

Bell E, Shouldice M, Levin AV. 2011. Abusive head trauma: A perpetrator confesses. *Child Abuse & Neglect* **35**(1): 74–77. https://doi.org/10.1016/j.chiabu.2010.11.001

Bennett HS, French JH. 1980. Elevated intracranial pressure in whiplash-shaken infant syndrome detected with normal computerized tomography. *Clinical Pediatrics* **19**(9): 633–634. https://doi.org/10.1177/000992288001900912

Benstead JG. 1983. Shaking as a culpable cause of subdural haemorrhage in infants. *Medicine, Science, and the Law* **23**(4): 242–244. https://doi.org/10.1177/002580248302300403

Benzel EC, Hadden TA. 1989. Neurologic manifestations of child abuse. *Southern Medical Journal* **82**(11): 1347–1351. https://doi.org/10.1097/00007611-198911000-00005

Biron D, Shelton D. 2005. Perpetrator accounts in infant abusive head trauma brought about by a shaking event. *Child Abuse & Neglect* **29**: 1347–1358. https://doi.org/10.1016/j.chiabu.2005.05.003

Breazzano MP, Unkrich KH, Barker-Griffith AE. 2014. Clinicopathological findings in abusive head trauma: Analysis of 110 infant autopsy eyes. *American Journal of Ophthalmology* **158**(6): 1146–1154.e2. https://doi.org/10.1016/j.ajo.2014.08.011

Brewster AL, Nelson JP, Hymel KP, Colby DR, Lucas DR, McCanne TR, Milner JS. 1998. Victim, perpetrator, family, and incident characteristics of 32 infant maltreatment deaths in the United States Air Force. *Child Abuse & Neglect* **22**: 91–101. https://doi.org/10.1016/S0145-2134(97)00132-4

Caffey J. 1974. The whiplash shaken infant syndrome: Manual shaking by the extremities with whiplash-induced intracranial and intraocular bleedings, linked with residual permanent brain damage and mental retardation. *Pediatrics* **54**(4): 396–403

Caputo G, de Haller R, Metge F, Dureau P. 2008. Ischemic retinopathy and neovascular proliferation secondary to shaken baby syndrome. *Retina* **28**(3 Suppl): S42–S46. https://doi.org/10.1097/IAE.0b013e318159ec91

Carter JE, McCormick AQ. 1983. Whiplash shaking syndrome: Retinal hemorrhages and computerized axial tomography of the brain. *Child Abuse & Neglect* **7**(3): 279–286. https://doi.org/10.1016/0145-2134(83)90005-4

Cordner SM, Burke MP, Dodd MJ, Lynch MJ, Ranson DL, Robertson SD. 2001. Issues in child homicides: 11 cases. *Legal Medicine (Tokyo)* **3**(2): 95–103. https://doi.org/10.1016/S1344-6223(01)00016-5

De Leeuw M, Beuls E, Parizel P, Jorens P, Jacobs W. 2013. Confessed abusive blunt head trauma. *The American Journal of Forensic Medicine and Pathology* **34**: 130–132. https://doi.org/10.1097/PAF.0b013e31828629ca

Duhaime AC, Gennarelli TA, Thibault LE, Bruce DA, Margulies SS, Wiser R. 1987. The shaken baby syndrome. A clinical, pathological, and biomechanical study. *Journal of Neurosurgery* **66**(3): 409–415. https://doi.org/10.3171/jns.1987.66.3.0409

Eagan BA, Whelan-Williams S, Brooks WG Jr. 1985. The abuse of infants by manual shaking: Medical, social and legal issues. *The Journal of the Florida Medical Association* **72**(7): 503–507

Ellison PH, Tsai FY, Largent JA. 1978. Computed tomography in child abuse and cerebral contusion. *Pediatrics* **62**(2): 151–154

Esernio-Jenssen D, Tai J, Kodsi S. 2011. Abusive head trauma in children: A comparison of male and female perpetrators. *Pediatrics* **127**: 649–657. https://doi.org/10.1542/peds.2010-1770

Fanconi M, Lips U. 2010. Shaken baby syndrome in Switzerland: Results of a prospective follow-up study, 2002-2007. *European Journal of Pediatrics.* **169**(8): 1023–1028. https://doi.org/10.1007/s00431-010-1175-x

Findley KA, Barnes PD, Squier W. 2012. Shaken Baby Syndrome, Abusive Head Trauma, and Actual Innocence: Getting It Right. *12 Houston Journal of Health Law and Policy 209;* Univ. of Wisconsin Legal Studies Research Paper No. 1195. Available at SSRN: https://ssrn.com/abstract=2048374

Flaherty EG. 2006. Analysis of caretaker histories in abuse: Comparing initial histories with subsequent confessions. *Child Abuse & Neglect* **30**(7): 789–798. https://doi.org/10.1016/j.chiabu.2005.12.008

Frank Y, Zimmerman R, Leeds NM. 1985. Neurological manifestations in abused children who have been shaken. *Developmental Medicine & Child Neurology* **27**(3): 312–316. https://doi.org/10.1111/j.1469-8749.1985.tb04541.x

Giangiacomo J, Barkett KJ. 1985. Ophthalmoscopic findings in occult child abuse. *Journal of Pediatric Ophthalmology Strabismus* **22**(6): 234–237

Gill JR, Goldfeder LB, Armbrustmacher V, Coleman A, Mena H, Hirsch CS. 2009. Fatal head injury in children younger than 2 years in New York City and an overview of the shaken baby syndrome. *Archives of Pathology & Laboratory Medicine* **133**: 619–627. https://doi.org/10.1043/1543-2165-133.4.619

Gleckman AM, Evans RJ, Bell MD, Smith TW. 2000. Optic nerve damage in shaken baby syndrome: Detection by beta-amyloid precursor protein immunohistochemistry. *Archives of Pathology & Laboratory Medicine* **124**(2): 251–256. https://doi.org/10.1043/0003-9985(2000)124<0251:ONDISB>2.0.CO;2

Greenwald MJ, Weiss A, Oesterle CS, Friendly DS. 1986. Traumatic retinoschisis in battered babies. *Ophthalmology* **93**(5): 618–625. https://doi.org/10.1016/S0161-6420(86)33688-1

Guthkelch AN. 1971. Infantile subdural haematoma and its relationship to whiplash injuries. *British Medical Journal* **2**(5759): 430–431. https://doi.org/10.1136/bmj.2.5759.430

Hadley MN, Sonntag VK, Rekate HL, Murphy A. 1989. The infant whiplash-shake injury syndrome: A clinical and pathological study. *Neurosurgery* **24**: 536–540. https://doi.org/10.1227/00006123-198904000-00008

Haseler LJ, Arcinue E, Danielsen ER, Bluml S, Ross BD. 1997. Evidence from proton magnetic resonance spectroscopy for a metabolic cascade of neuronal damage in shaken baby syndrome. *Pediatrics* **99**(1): 4–14. https://doi.org/10.1542/peds.99.1.4

Kanik A, Ince OT, Yesiloglu S, Eliacik K, Bakiler AR. 2015. Abusive head trauma: Two case reports. *Turkish Archives of Pediatrics/Türk Pediatri Arşivi* **50**(3): 180–184. https://doi.org/10.5152/TurkPediatriArs.2015.1293

Kauppi AL, Vanamo T, Karkola K, Merikanto J. 2012. Fatal child abuse: A study of 13 cases of continuous abuse. *Mental Illness* **4**(1):5–9, e2. https://doi.org/10.4081/mi.2012.e2

Kelly P, MacCormick J, Strange R. 2009. Non-accidental head injury in New Zealand: The outcome of referral to statutory authorities. *Child Abuse & Neglect* **33**(6): 393–401. https://doi.org/10.1016/j.chiabu.2008.09.008

Kivlin JD. 1999. A 12-year ophthalmologic experience with the shaken baby syndrome at a regional children's hospital. *Transactions of the American Ophthalmological Soceiety* **97**: 545–581

Kleinman PK, Blackbourne BD, Marks SC, Karellas A, Belanger PL. 1989. Radiologic contributions to the investigation and prosecution of cases of fatal infant abuse. *The New England Journal of Medicine* **320**(8): 507–511. https://doi.org/10.1056/NEJM198902233200807

Klevens J, Leeb RT. 2010. Child maltreatment fatalities in children under 5: Findings from the National Violence Death Reporting System. *Child Abuse & Neglect* **34**(4): 262–266. https://doi.org/10.1016/j.chiabu.2009.07.005

Koe S, Price B, May S, Kyne L, Keenan P, McKay M, Nicholson AJ. 2010. Medical, social and societal issues in infants with abusive head trauma. *Irish Medical Journal* **103**(4): 102–105.

Lam CH, Montes J, Farmer JP, O'Gorman AM, Meagher-Villemure K. 1996. Traumatic aneurysm from shaken baby syndrome: Case report. *Neurosurgery* **39**(6): 1252–1255. https://doi.org/10.1097/00006123-199612000-00041

Lambert SR, Johnson TE, Hoyt CS. 1986. Optic nerve sheath and retinal hemorrhages associated with the shaken baby syndrome. *Archives of Ophthalmology* **104**(10): 1509–1512. https://doi.org/10.1001/archopht.1986.01050220103037

Lazoritz S, Baldwin S, Kini N. 1997. The Whiplash Shaken Infant Syndrome: Has Caffey's syndrome changed or have we changed his syndrome? *Child Abuse & Neglect* **21**(10): 1009–1014. https://doi.org/10.1016/S0145-2134(97)00061-6

Leestma JE. 2005. Case analysis of brain-injured admittedly shaken infants: 54 cases, 1969–2001. *The American Journal of Forensic Medicine and Pathology* **26**: 199–212. https://doi.org/10.1097/01.paf.0000164228.79784.5a

Lynøe N, Rosen M, Eriksson A. 2017. Questions about isolated traumatic shaking and confessions. *Child's Nervous System* **33**: 731–732. https://doi.org/10.1007/s00381-017-3404-3

Matlung SE, Bilo RA, Kubat B, van Rijn RR. 2011. Multicystic encephalomalacia as an end-stage finding in abusive head trauma. *Forensic Science, Medicine, and Pathology* **7**(4): 355–363. https://doi.org/10.1007/s12024-011-9236-7

McKinney AM, Thompson LR, Truwit CL, Velders S, Karagulle A, Kiragu A. 2008. Unilateral hypoxic-ischemic injury in young children from abusive head trauma, lacking craniocervical vascular dissection or cord injury. *Pediatric Radiology* **38**(2): 164–174. https://doi.org/10.1007/s00247-007-0673-0

Molina DK, Clarkson A, Farley KL, Farley NJ. 2012. A review of blunt force injury homicides of children aged 0 to 5 years in Bexar County, Texas, from 1988 to 2009. *The American Journal of Forensic Medicine and Pathology* **33**(4): 344–348. https://doi.org/10.1097/PAF.0b013e31821a88c4

Morad Y, Avni I, Capra L, Case ME, Feldman K, Kodsi SR, Esernio-Jenssen D, Lukefahr JL, Levin AV. 2004. Shaken baby syndrome without intracranial hemorrhage on initial computed tomography. *Journal of AAPOS* **8**(6): 521–527. https://doi.org/10.1016/j.jaapos.2004.07.009.

Nambu S, Nasu A, Nishimura S, Fujiwara S. 2012. Shaking-related child abuse: Vigorous shaking of pram. *Pediatrics International* **54**(3): 431–433. https://doi.org/10.1111/j.1442-200X.2011.03464.x

Oral R, Yagmur F, Nashelsky M, Turkmen M, Kirby P. 2008. Fatal abusive head trauma cases: Consequence of medical staff missing milder forms of physical abuse. *Pediatric Emergency Care* **24**(12): 816–821. https://doi.org/10.1097/PEC.0b013e31818e9f5d

Pierce MC, Kaczor K, Acker D, Webb T, Brenzel A, Lorenz DJ, Young A, Thompson R. 2017. History, injury, and psychosocial risk factor commonalities among cases of fatal and near-fatal physical child abuse. *Child Abuse & Neglect* **69**: 263–277. https://doi.org/10.1016/j.chiabu.2017.04.033

Porzionato A, Macchi V, Aprile A, De Caro R. 2008. Cervical soft tissue lesions in the shaken infant syndrome: A case report. *Medicine, Science, and the Law* **48**: 346–349. https://doi.org/10.1258/rsmmsl.48.4.346

Ricci L, Giantris A, Merriam P, Hodge S, Doyle T. 2003. Abusive head trauma in Maine infants: Medical, child protective, and law enforcement analysis. *Child Abuse & Neglect* **27**(3): 271–283. https://doi.org/10.1016/S0145-2134(03)00006-1

Saternus K, Kernbach-Wighton G, Oehmichen M. 2000. The shaking trauma in infants - kinetic chains. *Forensic Science International* **109**(3): 203–213. https://doi.org/10.1016/s0379-0738(00)00144-4

SBU. 2016. *Traumatic shaking – The role of the triad in medical investigations of suspected traumatic shaking: A systematic review (SBU report no 255E)*. Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU): Stockholm

Spaide RF, Swengel RM, Scharre DW, Mein CE. 1990. Shaken baby syndrome. *American Family Physician* **41**(4): 1145–1152

Starling SP, Holden JR. 2000. Perpetrators of abusive head trauma: A comparison of two geographic populations. *Southern Medical Journal* **93**: 463–465

Starling SP, Holden JR, Jenny C. 1995. Abusive head trauma: The relationship of perpetrators to their victims. *Pediatrics* **95**: 259–262

Starling SP, Patel S, Burke BL, Sirotnak AP, Stronks S, Rosquist P. 2004. Analysis of perpetrator admissions to inflicted traumatic brain injury in children. *Archives of Pediatrics and Adolescent Medicine* **158**: 454–458. https://doi.org/10.1001/archpedi.158.5.454

Tuerkheimer D. 2014. *Flawed convictions: Shaken baby syndrome and the inertia of injustice*. Oxford University Press: New York, NY

Vinchon M, de Foort-Dhellemmes S, Desurmont M, Delestret I. 2010. Confessed abuse versus witnessed accidents in infants: Comparison of clinical, radiological, and ophthalmological data in corroborated cases. *Child's Nervous System* **26**: 637–645. https://doi.org/10.1007/s00381-009-1048-7

Zepp F, Bruhl K, Zimmer B, Schumacher R. 1992. Battered child syndrome: Cerebral ultrasound and CT findings after vigorous shaking. *Neuropediatrics* **23**(4): 188–191. https://doi.org/10.1055/s-2008-1071338

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.