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Association of perpetrator relationship to abusive head trauma clinical outcomes☆,☆☆

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ABSTRACT

The diagnosis of abusive head trauma (AHT) remains a significant public health problem with limited prevention success. Providing protection from further harm is often challenged by the difficulty in identifying the alleged perpetrator (AP) responsible for this pediatric trauma. The objective of this study was to evaluate demographic and clinical characteristics of children with AHT and the relationship between APs and their victims in a large, multi-site sample. Understanding the AHT risks from various caregivers may help to inform current prevention strategies. A retrospective review of all cases of AHT diagnosed by child protection teams (CPT) from 1/1/04 to 6/30/09 at four children's hospitals was conducted. Clinical characteristics of children with AHT injured by non-parental perpetrators (NPP) were compared to parental perpetrators (PP). There were 459 children with AHT; 313 (68%) had an identified AP. The majority of the 313 children were <1 year of age (76%), Caucasian (63%), male (58%), receiving public assistance (80%), and presented without a history of trauma (62%); mortality was 19%. Overall, APs were: father (53%), parent partner (22%), mother (8%), babysitter (8%), other adult caregiver (5%); NPP accounted for 39% of APs. NPPs were more likely to cause AHT in children ≥1 year (77% vs. 23%, $p < 0.001$) compared to PP. Independent associations to NPP included: older child, absence of a history of trauma, retinal hemorrhages, and male perpetrator gender. While fathers were the most common AP in AHT victims, there is a significant association for increased risk of AHT by NPPs in the older child, who presents with retinal hemorrhages, in the hands of a male AP. Further enhancement of current prevention strategies to address AHT risks of non-parental adults who provide care to children, especially in the post-infancy age seems warranted.

Introduction

Abusive head trauma (AHT) remains the most lethal form of child abuse. Efforts of well-established prevention strategies to educate parents on the risks to infants have demonstrated some effectiveness in reducing AHT prevalence (Dias et al.,

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2005), and attitudinal changes of caregivers regarding infant crying behaviors (Barr, Barr, et al., 2009; Barr, Rivara, et al., 2009). However, most prevention programs have failed to demonstrate successful replication (Keenan & Leventhal, 2010) despite legislative efforts to disseminate this education to parents in the newborn period ("National Conference of State Legislatures", 2009).

It is well recognized that non-parental caregivers are an important subset of APs of AHT with the mother's male partner, identified as second behind fathers, as the most common AHT AP (Kesler et al., 2008; Margolin, 1992; Ricci, Giantris, Merriam, Hodge, & Doyle, 2003; Salehi-Had, Brandt, Rosas, & Rogers, 2006; Starling, Holden, & Jenny, 1995; Starling et al., 2004). A similar AP relationship hierarchy has been recognized in other forms of child maltreatment (Bellamy, 2009; Berger, Paxson, & Waldfogel, 2009; Lee, Bellamy, & Guterman, 2009; Schnitzer & Ewigman, 2005; Starling, Sirotnak, Heisler, & Barnes-Eley, 2007; Turner, Finkelhor, & Ormrod, 2007). Since current prevention efforts almost exclusively focus on the newborn or young infant during the post-partum period, there has been little attention to ongoing prevention strategies focused on the older (>1 year old) child.

In our prior report of AHT over a 5½ year period in 3 regions of the U.S., 26% of the 459 subjects were >1 year of age at the time of their injury and this prevalence was relatively consistent over time and across the three regions (Berger et al., 2011). Certain clinical characteristics such as low initial GCS score, retinal hemorrhages, intraparenchymal hemorrhage, and cerebral edema were independently associated with AHT mortality (Shein et al., 2012). While AHT is recognized in older children, it is unclear whether there is a difference in the mortality risk (Salehi-Had et al., 2006; Schnitzer & Ewigman, 2005). One major factor which may increase the mortality risk in the older child ($\geq$1 year old) is the presence of non-parental caretaker in homes of these children (Schnitzer & Ewigman, 2005). Biological fathers, on the other hand, may be more likely to have some relationship to, and contact with the young child (<1 year old) in the early months of life. Comparing rates of non-parental perpetration against children for all types of maltreatment, Turner et al. (2007) found a significantly greater risk of victimization in single parent and step-family homes compared to homes with two biologic parents.

Additionally, mother's partner may have limited experience in addressing the needs of a child, lack of legitimate authority in their partner's family with the potential for a perceived affront to respect, and a rivalry mentality of the partner and her children which can pose greater risk to that child (Margolin, 1992). Additionally, unemployment or under-employment may necessitate a parent to utilize an unprepared partner for child care due to limited access to affordable childcare.

Given the current AHT prevention approach, we sought to evaluate a population of children with AHT and determine whether the AP relationship is related to the child's age, and whether there are differences in the clinical characteristics of children with AHT who are injured by non-parental perpetrators (NPP) vs. parental perpetrators (PP). We hypothesized that a greater proportion of older children (>1 year) with AHT would be injured from a NPP. Additionally, we hypothesized that clinical characteristics of children injured by a NPP would indicate a more severe brain injury. If our hypotheses were supported, the public health implications would necessitate the development of new AHT prevention interventions to focus more heavily on families with children $\geq$1 year and in families in which there are non-parental caretakers.

Methods

Subjects

In a 5½ year, multi-site study which evaluated whether AHT was associated with increased unemployment due to the economic recession (Berger et al., 2011), demographic and clinical data were collected in children with a clinical diagnosis of AHT. Children were eligible for inclusion in the parent study if they were <60 months of age and diagnosed with AHT by the participating hospitals' respective Child Protection Team (CPT) between 1/1/2004 and 6/30/2009. The diagnosis of AHT was made by the contributing hospitals' CPT, and determined by the study child abuse pediatrician (CAP), based on the child's entire evaluation, including history, injuries, initial multidisciplinary team (MDT) evaluation which included child protection and law enforcement investigation, and when available, ongoing investigation. As a standard practice in all sites, child protective services and law enforcement investigations were included as part of the CPT's information which was considered in making the diagnosis of AHT. These investigators may have begun their investigation prior to the CPT's effort, as children may have been identified as a potential victim of AHT from initial presentation and other mandated reporters activating an MDT investigation.

The current study compares the clinical presentations and associated findings of children where an AP was identified. APs were identified based primarily upon forensic evaluation by the hospital's CPT and included collateral information such as AP confession, and/or law enforcement investigation efforts when the timing of injury limited concern to a single suspect. Only cases in which an AP could be identified during the initial hospitalization and investigation were included in the current analysis.

Study setting and design

Hospitals which participated in this study were part of a larger project evaluating the relationship between an economic recession and rates of AHT. In order to be eligible for that primary study, hospitals needed to meet the following criteria: (1) there was an established CPT with stable personnel throughout the 5 ½ year study period; (2) the hospital was the only regional pediatric level I trauma center; and, (3) the University-affiliated IRB approved collection of county residence

for each subject for the purpose of conducting analyses related to other study questions within the larger research effort. The following hospitals were included in the study: Cincinnati Children's Hospital and Medical Center (Cincinnati, OH), Nationwide Children's Hospital (Columbus, OH), Children's Hospital of Pittsburgh of UPMC (Pittsburgh, PA), and Seattle Children's' Hospital & Harborview Medical Center (Seattle, WA). Charts were abstracted by the PI of each site for relevant demographic and clinical variables and entered into a centralized database managed by the primary site (Children's Hospital of Pittsburgh). Institutional review board approval with a waiver of informed consent was received from all participating hospitals.

Data collection

For each subject, the following demographic and clinical data were collected: age (in months); race/ethnicity; gender; insurance (public, private, self-pay); gestational age; year/month of hospital admission; reason for presentation to the hospital and whether a history of trauma was provided as part of the history (i.e. found unresponsive- no history of trauma vs. fell down stairs); Glasgow Coma Scale score (on arrival); admission to a pediatric intensive care unit (PICU); clinical or radiographic support of prior abuse (e.g. healing fractures, chronic subdural hemorrhages); and, mortality at hospital discharge.

AP data included gender, and relationship to the child. AP relationship was categorized as: biological mother, biological father, parent partner, babysitter, other related adult caregiver, or other unrelated adult caregiver. If the AP status could not be determined during the hospitalization or initial law enforcement investigation, it was coded as unknown. AP status was dichotomized to either parental perpetrator (PP: biological father and/or, biological mother) or non-parental perpetrator (NPP: parent partner, babysitter, other related or unrelated adult caregiver).

Statistical analysis

Categorical variables were described using frequencies and Chi-square analyses for all comparisons. Continuous variables were described using means and standard deviation when data were normally distributed, and medians and range when data were nonparametric. For comparisons of parametric continuous variables, *t*-test was used; for nonparametric continuous variables, the Wilcoxon rank sum test was used. Multiple regression analyses were used to determine crude and independent variables associated with NPP relationship status. Only variables at a significance of <0.05 in the univariate analyses were included in the final multivariate models. Adjusted odds ratios and 95% confidence intervals were calculated to a best fit model. The data were analyzed using STATA statistical software, version 11.1 (StataCorp, 2009).

Results

There were 459 cases of AHT identified during the 5½ year study period across all sites; 313 (68%) of had an identifiable AP; these 313 subjects comprise the study population of the current study. There were no differences between cases which had an identifiable AP compared to no identified AP with regard to: patient age, patient gender, or race. Cases with identified APs were more likely to: be receiving medical assistance ($p = 016$), have lower GCS scores ($p < 0.001$) and higher mortality ($p < 0.001$).

Of the 313 AHT cases with a known alleged perpetrator, the majority (76%) were <1 year old (mean 9.4 months, SE 0.64); Caucasian (69%); publicly insured (86%); and male gender (58%). Sixty-two percent (193/313) presented without a history of trauma as part of the presenting history. Seventy-two percent of subjects (224/313) required admission to the PICU. Two hundred sixty-nine (86%) subjects had evidence of acute subdural or subarachnoid hemorrhage; 122 (39%) had cerebral edema; 192 (62%) had retinal hemorrhages. The mortality rate was 19% (60 subjects; Table 1).

Relationship of alleged perpetrators to victims

In 53% (167/313), the biologic father was the AP. Mothers accounted for 8% (24/313) of APs and both mother and father together were identified in 4% (12/313); 35% (110/313) of APs were NPP. NPPs included parent partner (22%), babysitter (8%), and other adult caregiver (5%). In 77% of cases there was a male AP, in 18% it was a female, and in 5% there was both a male and female AP. Fathers were the AP for 66% of children <1 year old, compared to being responsible for 13% of AHT injuries in children ≥1 year old, $p < 0.0001$. In contrast, parent partners were the AP for 10% of children <1 year old, compared to being identified as the AP in 52% of children ≥1 year old, $p < 0.0001$ (Fig. 1). During the study period, there was no significant change in the relationship between AP and victim ($p = 0.58$).

Factors associated with non-parental perpetrator status

Univariate analysis. NPP was significantly associated with several clinical and demographic factors (Table 2). Older children were more likely to be injured by a NPP than by a PP (53% vs. 8%; $p < 0.001$). Children injured by NPPs were: more likely to present with a GCS score <13 (60% vs. 37%; $p = 0.039$); more likely to sustain acute SDH/SAH (90% vs. 85%; $p = 0.024$); more likely to have cerebral edema (55% vs. 37%; $p = 0.003$); and, more likely to have retinal hemorrhages (81% vs. 58%; $p = 0.001$),

Table 1
Demographics and clinical characteristics of children with AHT and an identified alleged perpetrator.[a]

N = 313	(No.)	(%)
Age		
<1 year	238	76
≥1 year	75	24
Race/ethnicity		
Caucasian	206	69
African-American	47	16
Hispanic	20	7
Asian	8	2
Other (multi-racial)	19	6
Patient gender		
Male	180	58
Female	133	42
Alleged perpetrator gender		
Male	250	80
Female	63	20
Insurance		
Medicaid	266	86
Private	31	10
Self-pay	11	4
Trauma as part of the presenting history		
Yes	120	38
No	193	62
PICU admission		
Yes	224	72
No	89	28
GCS		
Mild (≥13)	142	48
Moderate-severe (<13)	151	52
Skull fracture(s)		
Yes	118	38
No	195	62
Acute non-cranial fracture(s)		
Yes	92	29
No	221	71
Healing non-cranial fracture(s)		
Yes	94	30
No	219	70
Acute SDH/SAH		
Yes	286	92
No	26	8
Chronic SDH		
Yes	69	24
No	238	76
Cerebral edema		
Yes	135	43
No	177	57
Retinal hemorrhages		
Yes	194	62
No not evaluated	99	32
	20	6
Death		
Yes	61	19
No	252	81

[a] Some fields with missing data; less than 100% frequencies.

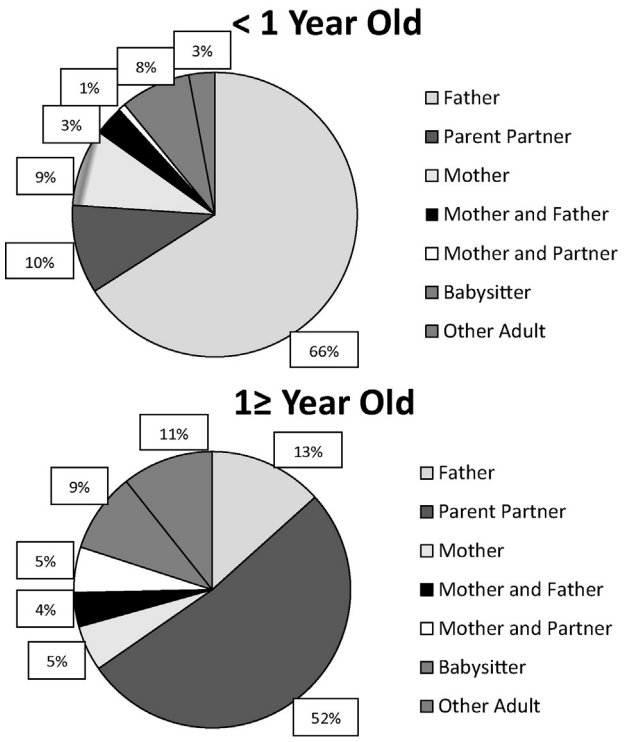

Fig. 1. Alleged perpetrator relationships to children with AHT.

compared to children injured by PPs. The mortality rate was also significantly higher in children injured by a NPP compared with a PP (27% vs. 15%, $p = 0.011$).

Children injured by NPP were less likely to present to the hospital with a history of trauma to explain the child's injuries (32% vs. 45%; $p = 0.027$); and, less likely to have healing fractures (20% vs. 35%; $p = 0.004$). There was no difference in the proportion of children with NPP vs. PP who had chronic SDH (19% vs. 25%; $p = 0.226$) or in the rate of PICU admission (75%, vs. 71%, $p = 0.464$).

Multivariate analysis. Multiple logistic regression models identified several independent variables associated with NPP (Table 3). Significant adjusted odds ratios demonstrated independent associations to NPP: in older children (AOR 15.1, 95% CI 6.7, 33.8); in children with retinal hemorrhages (AOR 2.3, 95% CI 1.1, 4.8); and, in APs who were male (AOR 3.0, 95% CI 1.4, 6.4). While not reaching significance, a trend was noted in NPP cases not having a presenting history of trauma (AOR 1.9, 95% CI 0.95, 3.7).

Table 2
AHT characteristics stratified by alleged perpetrator relationship.[a]

	PP	NPP	*p* Value
Patient age (% ≥1 year old)	23	77	<0.001
Patient race (% Caucasian)	65	67	0.689
Patient gender (% male)	59	55	0.435
Alleged perpetrator gender (% male)	82	65	0.001
Insurance (% Medicaid)	91	88	0.341
Gestational age (% <35 weeks gestation)	14	9	0.346
Trauma as part of the presenting history (%)	45	32	0.027
PICU admission (%)	71	75	0.464
GCS score <13	47	60	0.039
Skull fracture(s) (%)	39	33	0.246
Acute non-cranial fracture(s) (%)	33	25	0.187
Healing non-cranial fracture(s) (%)	35	20	0.004
Acute SDH/SAH (%)	85	90	0.024
Chronic SDH (%)	25	19	0.226
Cerebral edema (%)	37	55	0.003
Retinal hemorrhages (%)	58	81	<0.001
Death (%)	15	27	0.011

[a] PP = parental (biologic mother, father) perpetrator; NPP = non-parental perpetrator.

Table 3
Adjusted odds ratios of AHT characteristics of NPP.

	AOR	(95% CI)	*p* Value
Older child (≥1 year old)	15.1	6.7, 33.8	<0.001
Male alleged perpetrator gender	3.0	1.4, 6.4	<0.001
Trauma as part of the presenting history	1.9	0.95, 3.7	0.07
GCS score <13	1.26	0.60, 2.6	0.53
Healing non-cranial fractures	0.90	0.45, 1.8	0.77
Acute SDH/SAH	1.5	0.70, 3.0	0.31
Cerebral edema	1.2	0.41, 1.8	0.65
Retinal hemorrhages	2.3	1.1, 4.8	0.02
Death	1.6	0.68, 3.6	0.29

Discussion

This is the largest AHT dataset currently available which provides information regarding specific demographics, clinical injury details, and perpetrator relationship to the injured child. Overall and consistent with previous data, we demonstrated that biological fathers are the most common AP of AHT, followed by mothers' boyfriends, babysitters, biological mothers, and other adult caregivers. However, in children >1 year of age, fathers are not the most common AP; non-parental caretakers are the most common AP with a parent's partner being the most common NPP. The risk of AHT by NPPs to older children is a compelling public health finding as it relates to safe child care. Furthermore, the findings of this study provide greater justification to recommend development of additional AHT prevention efforts to what currently exist for the young infant. We found similar results to previous work regarding the relationship of perpetrators to the children they injure (Margolin, 1992; Ricci et al., 2003; Starling et al., 1995; Starling et al., 2007) in studies of physical abuse and abusive head trauma. However, those studies were limited in reporting frequencies only, and did not include univariate analyses to evaluate the clinical features associated with perpetrator status. Because of the large sample size, we were able to analyze the perpetrator relationship in children of different ages and evaluate AHT clinical characteristics. Of particular interest was the finding that male gender was independently associated with NPP. Despite the significant risk posed to older children by male NPP, minimal prevention interventions currently exist to target the older child and/or non-parental caretakers. The finding of disproportionate perpetrators being male NPP is consistent with prior literature (Margolin, 1992; Ricci et al., 2003; Starling et al., 1995) which describes the male partner as the predominant safety threat to young children; however, those studies did not distinguish child age within this vulnerable period when AHT is most prevalent.

We also demonstrated that the injuries sustained by children from NPPs are more severe. In the univariate analysis, children with NPP had lower GCS scores higher rate of subdural hemorrhage, subarachnoid hemorrhage and cerebral edema, higher rate of retinal hemorrhages, and higher mortality. In the multivariate analysis, the rate of retinal hemorrhage, an indicator of injury severity, was independently associated with NPP. This is consistent with the concept that the presence of retinal hemorrhages may be considered a proxy for severity of injury. Interestingly, there was a lower incidence of healing fractures in children with a NPP, suggesting perhaps a single, severe episode of AHT rather than multiple incidents of abuse. This scenario of injury circumstance is thought to occur frequently in AHT (Adamsbaum, Grabar, Mejean, & Rey-Salmon, 2010).

Lastly, a trend was observed in which children with NPPs were less likely to offer a history of trauma as an explanation for the child's symptoms when the child presented to the hospital for care. In a study evaluating AHT perpetrators (Esernio-Jenssen, Tai, & Kodsi, 2011), the most common history provided was a short fall in 47% of the 34 cases in that series; however, mothers comprised the most common perpetrator (29% of the cases). It may be that in some of the cases in which there is a NPP, the non-offending parent may be the adult who brings the child to the hospital and is therefore providing second-hand information to health care providers. In light of our findings in the older child, coupled by the unintended consequences of placing greater expectation of the male partner to provide child care in many homes, we believe this may further exacerbate child safety concerns warranting a concerted effort to address this risk to children.

Prior work in New York has demonstrated some success in reducing AHT prevalence through educational interventions targeted at the biological parents (predominantly the mother) during the neonatal period (Dias et al., 2005). Yet, another study showed no difference in outcome using a similar intervention to reduce AHT in Utah (Keenan & Leventhal, 2010). Our results support the need to evaluate AHT risks as it relates to non-parental caretakers, and enhance prevention efforts beyond the current strategies focused on the birth period. As such, it is not surprising that an educational effort directed at the mother in the immediate post-partum period would likely show no effect in lowering the incidence of AHT by a NPP in an 18-month old, for example.

Since most existing prevention efforts focus almost exclusively on mothers, the current data suggests the need to expand the prevention paradigm. Prevention interventions focusing on a broader caregiver group to include risks posed to children from non- parental adults in a care giving role, and reinforcement of the prevention message beyond the "teachable moment" to mothers in birthing hospitals seems warranted.

This study has several limitations. Subjects were eligible for inclusion only if they were identified as having a clear diagnosis of AHT. This was done in order to ensure high reliability in the diagnosis of AHT. As a result of this stringent

definition, some children with AHT may not have met the study definition and, would not have been included. There is no reason to believe that the relationship of the AP to the victims would be different in this group of infants and this is supported by the fact that overall, the relationship of perpetrator to victim was the same as in previously published studies (Ricci et al., 2003; Starling et al., 1995; Starling et al., 2004). However, our data suggest that cases with an NPP may demonstrate worse injury. Almost a third of our overall study cohort did not have an identified AP and could not be included in the current study. There were no differences in the demographic characteristics between children with and without a known AP. However, AHT victims with an identified AP had more severe injury as measured by higher rates of subdural hemorrhage, cerebral edema, retinal hemorrhage, and mortality. This is not surprising. Child protective services and law enforcement investigators may be more likely to investigate a case more thoroughly and completely when the child is more seriously injured. Lastly, we may have missed some AHT cases that did not survive to admission to an emergency department or hospital. Given the standard approach in these children's hospitals' regions to transport children in full arrest, the likelihood of missing severe AHT cases that die prior to arriving at a hospital would be extremely low.

Conclusion

In conclusion, the results of our study demonstrate that the alleged perpetrator relationship and injury severity is very different based upon child victim age with a significant association of NPPs injuring older children compared to fathers in younger children. Our data suggest that enhancing current AHT prevention strategies is necessary in order to specifically target non-parental caretakers in children who have passed their 1st birthday. Instituting a booster intervention when children are most likely to be exposed to a non-parental caretaker would most likely have the potential to reduce overall prevalence of maltreatment injury and severity in the older child.

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