Childhood Falls With Occipital Impacts

Norrell Atkinson, MD,† Rick R. van Rijn, MD, PhD,‡ and Suzanne P. Starling, MD**

Objectives: Falls are commonly reported in children who present with both accidental and inflicted brain injuries. Short falls rarely result in serious or life-threatening injuries. Our purpose is to describe a series of cases of short falls with occipital impact leading to subdural hemorrhage (SDH).

Methods: We present a series of 8 witnessed accounts of young children diagnosed as having SDHs after striking the back of their heads during a short fall. Child-abuse physicians were surveyed to determine if they had evaluated a child younger than 24 months diagnosed as having SDH, with or without retinal hemorrhages, following a witnessed fall with occipital impact. Submitted cases were analyzed.

Results: The median age of the children was 12.5 months. All fell backward from a standing or seated position onto a hard surface and immediately developed symptoms. There was an average of 4 witnesses per case. Physical examinations were normal; however, the majority of children had enlarged head circumferences. All were previously healthy. Six of 8 children had unilateral convexity SDH. All children had varying degrees of retinal hemorrhage but no retinoschisis. The majority of children had returned to their baseline within 24 hours of hospitalization.

Conclusions: Although a larger study is needed to identify the full spectrum of injuries, we postulate that, if a history of a fall with an occipital impact is elicited during a trauma workup, accidental injury should be considered.

Key Words: falls, occiput, retinal hemorrhage, subdural hemorrhage

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Child abuse is prevalent across the globe. The World Health Organization has reported that a quarter of all adults have been physically abused as a child.[1] One of the most devastating forms of physical abuse is abusive head trauma (AHT). Subdural hematomas and retinal hemorrhages are a hallmark sign of AHT.[2] These injuries lead to a wide range of symptoms ranging from mild neurocognitive disorders to severe physical and mental disability and death. Cases of potential AHT can pose a challenge to the clinician and medical examiner.

When faced with the differential diagnosis of AHT, perpetrators often attribute the child's injury to a short fall.[3–5] Children frequently fall short distances from furniture, such as beds or couches, but these falls seldom result in serious injuries. Multiple studies over the past 50 years have shown that injuries resulting from falls are associated with a mortality rate of less than 0.5 deaths per 1 million children per year.[6–8] Thus, when a child is diagnosed as having a subdural hemorrhage (SDH) and retinal hemorrhages (RHs) with a history of a short fall, there is a significant concern for inflicted trauma. Simple parietal skull fractures are the most common severe injury seen with short falls.[5] Little has been written about specific short-distance falls that could be related to serious intracranial trauma.

From the *Eastern Virginia Medical School/Children's Hospital of The King's Daughters, Norfolk, VA; †Children's National Medical Center, Washington, DC; and ‡Emma Children's Hospital-Academic Medical Center Amsterdam, the Netherlands.

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Reprints: Norrell Atkinson, MD, Children's National Medical Center, 111 Michigan Ave NW, Washington, DC 20010 (e-mail: natkinson@childrensnational.org).

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In this article, we present a series of 8 witnessed accounts of young children diagnosed as having SDH with and without RH after striking the back of their heads as a result of a short-distance backward fall. The purpose of this series is to describe cases with occipital impact leading to a presentation with a SDH. This case series will provide data that can be used in the medical and forensic evaluation of cases of potential AHT.

METHODS

Members of the Ray E. Helfer Society, a subspecialty society for physician specialists in child abuse, were surveyed electronically to determine if they had ever evaluated a child younger than 24 months diagnosed as having SDH with or without RH following a witnessed fall with an occipital impact. A directly witnessed event was defined as a fall that was observed by an adult or verbal child. An indirectly witnessed event was characterized as having been "witnessed" by a person who heard or observed some element of the fall, such as hearing the child hit the floor or hearing the child cry then finding him lying supine on the floor. Cases required medical evaluation reports by a child abuse pediatrician (CAP) and adequate investigation by police and social services. All cases required a final assessment that the child's presentation was determined to be accidental.

Institutional review board approval was required from all participants' institutions prior to submitting cases for this study. A detailed data collection tool was used by each contributor to retrospectively abstract case information. Deidentified radiographic images and ophthalmologic examination photographs were submitted when available. The data was analyzed for trends to define the type of injuries children sustain with occipital impacts. Statistical means, medians, and percentages of the data were performed.

RESULTS

Twenty-three members of the Ray E. Helfer Society reported experience with 1 or more of these case types. Among these initial respondents, case collecting forms and requests for local institutional review board approval were digitally distributed, after which only 9 cases were subsequently submitted by respondents for inclusion in this case cohort study. Eight of these cases met the study criteria; 1 case was excluded because the child had only RH without a SDH.

The median age was 12.5 months (range, 7–16 months) for the 4 boys and 4 girls included in this study. All were noted to be healthy prior to their fall. None of the children had a relevant prior medical history or a clinical history of either head trauma or suspected child abuse. All falls occurred within the home setting and were witnessed by adults and/or children related to the child. The objects from which the children fell were no more than 1 m in height, and in ground-level cases, the children were standing on the ground. All of the children landed onto a hard surface on impact. Table 1 details the case histories.

Observation of Trauma Mechanism

Table 2 describes the number and type of direct and indirect witnesses in each case.

TABLE 1. Case Summaries With Radiographic and Ophthalmologic Findings

Patient	Sex	Age, mo	Presenting History	Surface	Skeletal Survey	Follow-up Skeletal Survey	CT Finding	MRI Findings	Eye Findings
1	M	10	Fall backward from high chair	Concrete	(−)	N/A	B interhemispheric SDH	B SDH	R: IRH, SRH
2	M	9	Standing on couch, fell backward onto floor while reaching for bottle	Wood	(−)	(−)	L SDH	L SDH acute (performed 3 d postadmission)	L: IRH to posterior pole
3	F	13	Standing in large basket on floor; mom hears her crying and finds her lying in supine position in the tipped-over basket on the floor	Thin carpet over concrete	(−)	(−)	L parietotemporal SDH	Not done	B IRH
4	F	14	Standing on floor, pushed backward by 3-y-old brother	Concrete	(−)	(−)	R small to moderate SDH; mass effect with 7-mm midline shift	Acute R SDH; focal acute infarction of the splenium of the corpus callosum	L: Multiple peripapillary IRH R: Peripheral IRH
5	F	13	Fall backward from a standing position on a couch	Concrete	(−)	(−)	B (L > R) frontoparietal SDH with thin perifalcine/peritentorial R SDH; prominent B subarachnoid spaces, slightly prominent B ventricles	Subacute SDH; L subdural hygroma, R perifalcine hygroma, prominent subarachnoid space	L: Extensive IRH R: IRH "few and confined to central pole"
6	M	7	Seated on bed fell backward onto floor	Concrete	(−)	(−)	3-mm acute R frontoparietal SDH near coronal suture; blood in anterior interhemispheric fissure; small amount of bleeding at R vertex	Not done	L: IRH confined to posterior pole
7	M	12	Standing on couch, fell backward hitting back of head against wooden table before hitting the floor	Wood	(−)	(−)	L SDH with midline shift	Postsurgical evacuation; B (L > R) occipital and L frontal gyral ischemia; small B SDH	L: numerous PRH, IRH, SRH to posterior pole and periphery R: 25–30 PRH, IRH, SRH to posterior pole with scattered RH at periphery
8*	F	16	Standing in front yard with multiple other family members. One child pushes another child who then fell backward into 16-mo-old; 16-mo-old fell from standing to seated position then hit her head	Cobblestone pavement	Negative autopsy	N/A	L SDH overlying frontal, parietal, and temporal lobes. Diffuse but asymmetrical edema with marked loss of gray-white matter differentiation. Complete effacement of sulci with 6.2-mm midline shift from L to R and severe effacement of the L lateral ventricle, 3rd ventricle, and basilar cisterns. Serpiginous linear densities near vertex suggestive of possible subarachnoid hemorrhage	Not done	Visible only on autopsy

*Autopsy findings: Diffusely swollen brain. L SDH (cerebellar) and focal SAH, patchy brainstem SAH. Necrotic cerebellar tonsils with herniation into foramen magnum. L optic nerve sheath hemorrhages, few small focal RHs at the nerve fiber layer. Acute necrosis at the lumbar and thoracic levels of spinal cord with focal SAH and widespread white matter injury associated with swollen and degenerating oligodendroglial cells.

B indicates bilateral; CT, computed tomography; IRH, intraretinal hemorrhage; L, left; PRH, preretinal hemorrhage; R, right; SRH, subretinal hemorrhage.

TABLE 2. Case Witnesses

Patient	Directly Witnessed	Indirectly Witnessed	Others Present in Home (Excluding Witnesses)
1	Mother	0	Father upstairs
2	Mother	Father outside heard mother shouting	9-y-old sibling outside with father
3	0	Mother and maternal grandmother heard child crying and found child on floor	13-y-old sibling
4	Mother, mother's adult friend	9- and 6-y-old siblings heard fall	Incident involved 2 other 2-y-old children
5	15-y-old aunt	Mother, father, maternal grandmother, and 6-y-old heard fall	0
6	0	14-y-old sibling's back toward child (but heard fall and then cried)	7 children, father
7	1 adult relative, 3 day-care children (aged 5, 7, 9 y)	0	Multiple day-care children present
8	Grandmother, uncle, 4 children (aged 7–12 y)	0	0

Clinical Symptoms

Table 3 describes the progression of clinical symptoms and time of presentation to the hospital following each fall. Every child developed symptoms immediately after the fall, and medical attention was sought by all caretakers when the child became acutely symptomatic. Each child was described either to have a "stunned" appearance or to be crying at the time of the fall.

Examination Findings

The majority (5/7) of the children (1 child was not measured) had a head circumference greater than the 90th percentile for age. Cutaneous injuries (3/8) were the only significant findings identified on physical examination; 2 mobile children were found to have bruises and/or abrasions to the forehead, shins, and knees from prior accidental events. These bruises were all located at sites that are common for accidental injury in mobile children.[9] One child had a "rectangular-shaped bruise" on the back of his head after reportedly hitting a rectangular wood coffee table before striking the floor; none of the other children were reported to have evidence of head contact injuries (soft tissue swelling or bruising) on presentation.

Indirect ophthalmoscopy was performed by an ophthalmologist in all cases. Photographic images from these examinations were provided in 4 of 8 cases; the remainder of the examinations was limited to written descriptive findings (location and number). Retinal hemorrhages were present by ophthalmoscopy in 7 of 8 children; 4 of 7 were bilateral. In the 1 fatal case, the indirect retinal examination showed no RHs, but autopsy revealed left optic nerve sheath hemorrhages and a few small focal RHs at the nerve fiber layer. No retinoschisis was reported in any case.

No fractures were identified on 8 of 8 initial skeletal surveys, and 5 of 5 follow-up skeletal surveys were also negative (Table 1).

None of the children had skull fractures. Unilateral convexity SDHs were present in 6 of 8 children; 2 had large hemorrhages with mass effect on the brain, one of which required surgical evacuation. In the 5 children who had magnetic resonance imaging (MRI) scans, 2 children had areas of brain infarction (patients 4 and 7). One child (patient 5) had prominent subarachnoid spaces. Table 1 summarizes the computed tomography and MRI findings.

Outcomes

Most children in this study were alert and responsive and had returned to their baseline within 24 hours of hospitalization; however, 2 children were comatose/poorly responsive on admission to the hospital, and 1 required surgical evacuation of the brain hemorrhage. One child died. The median duration of hospitalization

TABLE 3. Clinical Symptoms Following Fall

Patient	Presentation to Hospital	Progression of Symptoms Following Fall
1	24 h	Quiet for several seconds ➔ inconsolable crying (>10 min) ➔ eye deviation/decreased alertness ➔ doctor evaluated ➔ looked well ➔ ↓alert in afternoon ➔ doctor evaluated ➔ looked well ➔ well overnight ➔ decreased alertness in morning ➔ vomited ➔ to hospital 24 h after fall
2	Immediate	Cried immediately ➔ difficult to console ➔ limp ➔ eyes roll back ➔ turned blue ➔ shaking/limp ➔ improved in hospital but with altered consciousness
3	Immediate	Cried immediately ➔ seizure ➔ multiple episodes of vomiting ➔ unconsciousness ➔ lethargic/unresponsive at hospital
4	Immediate	Cried immediately ➔ stood and walked to mother ➔ cry ➔ eyes rolled back ➔limp ➔ unresponsive ➔ seizure
5	8 h	Stunned appearance ➔ cried when picked up ➔ difficult to console ➔ looked well and then put down for bed ➔ woke up fussy 8 h after fall ➔ fed ➔ multiple episodes of emesis ➔ hospital (irritable)
6	Immediate	Cried 1 min ➔ limp ➔ eyes roll back ➔ altered mental status
7	Immediate	Crawled to caretaker ➔ limp a few minutes later ➔ unresponsive ➔ altered consciousness
8	Immediate	Attempted to stand ➔ appeared dizzy and fell over ➔ cried ➔ seizure ➔ apneic ➔ unresponsive ➔ to hospital ➔ died 19 h after fall

was 4.5 days. All surviving children returned to their baseline level of activity/behavior by discharge; 3 were prescribed antiepileptic medications for a brief duration following hospital discharge.

DISCUSSION

We describe a series of 8 witnessed occipital impact falls in young children resulting in SDH and RHs. All of the children in this series had short-distance falls onto a hard surface, with the majority of the children falling from an elevated surface. Several of the children were witnessed to hit the back of their heads against an object before striking the ground. A smaller number of children were pushed or fell backward from the standing position. The children's injuries all mimicked findings seen with AHT. If witnesses to the events had not been present, a high suspicion of abuse in these cases would have been justified. This high suspicion is justified because of the fact that short-distance falls generally do not cause serious intracranial injury.[6,10,11] Based on literature, AHT should be part of the differential diagnosis in a child with a SDH and history of a short fall. In a systematic review of literature, SDHs were significantly associated with AHT (odds ratio, 8.2; 95% confidence interval, 6.1–11).[2] In the same systematic review, unilateral SDHs were also significantly associated with AHT (odds ratio, 4.9; 95% confidence interval, 1.3–19.4; $P = 0.02$); however, the heterogeneity of the latter group of studies was high ($Q_2 = 8.1$, $P = 0.017$, $I^2 = 75.3\%$). Based on a pooled analysis of literature, Maguire et al[12] calculated that the presence of retinal hemorrhages in children with intracranial hemorrhage has a predicted probability for AHT of 20% to 95%.

Our cases all had a full investigation to exclude child abuse as cause of the injuries. Two single case reports have been published of children who fell backward with posterior head impacts sustaining similar intracranial findings.[13,14] In contrast to our cases, these cases lacked sufficient information to confidently exclude AHT as a cause for the injuries. A 1984 case series reported multiple children with similar findings; however, none of these cases were investigated for child abuse.[15]

Similar to the presentation of AHT, all of the children in this series immediately developed symptoms; there was no lucid interval. Two children had delayed hospital presentations but were described as immediately symptomatic at home and then slowly worsened. Previous studies on accidental and inflicted head trauma have found that children become symptomatic proximate in time to their injuries and that there is no lucid interval before symptoms appear.[16–20] Findings in our study suggest that children who strike their occiput also become symptomatic immediately after they are injured. Although there was a spectrum of clinical symptoms on presentation, 7 of 8 children returned to their baseline level of activity prior to discharge from the hospital.

Studies in adults report a higher proportion of significant intracranial injuries, including subdural and subarachnoid hemorrhages in snowboarders and female wrestlers with occipital impact.[21–25] Instability in the ventrodorsal position is thought to predispose snowboarders to backward falls, which are not easily braced by the upper limbs.[21] It is unclear why falls with occipital impacts result in more significant intracranial injuries; however, it is hypothesized that direct impact to the occiput of the skull during a posterior fall may introduce an inertial component of force to the brain that results in SDHs.[23] Although children and adults cannot be compared directly, there are similarities between the adult studies and this population. With a posterior fall, a child may be less likely to reflexively brace the fall. A fall in the anterior-posterior direction may also introduce a component of inertial force or angular moment that is not typically seen with a short linear fall. The one fatality in this series was pushed, likely introducing a greater rotational force than was introduced in the children who fell with no initial velocity. Retinal hemorrhages are hypothesized to result from vitreoretinal traction produced by repetitive acceleration-deceleration forces and are not typically seen with short falls.[26] All of the children in this study had varying degrees of RHs. We hypothesize that this could be the result of a rotational component involved with occipital impacts.

There were several limitations to our series. First, we required that medical evaluation reports by a CAP and adequate investigation by police and social services were required in order to be certain that the cases included in our series were indeed accidental. Although this is important from a clinical and forensic medical perspective, it introduces a selection bias in our study population. Second, our definition of a witnessed fall included directly or indirectly witnessed cases, sometimes witnessed by children. However, studies have shown that children have accurate contextual memories and are able to recount long and coherent narratives and free narratives.[27,28] In all cases, with indirect or child witnesses, a thorough evaluation by a CAP did not identify concerns for maltreatment. Third, we did not have data on the height of the child at the time of the accident, and we could not calculate the exact fall height at the level of the head. However, in all cases, the fall height is to be regarded as a short fall. Finally, this series contained only a small number of patients; although 28 cases were identified, only 8 were submitted. Most of the initial responders ultimately did not submit their cases for inclusion. Although a larger number of included cases would have strengthened our conclusion, our aim was to describe a trauma mechanism leading to SDH in young children.

In conclusion, if a pediatrician or a medical examiner is confronted with a child with a SDH and RH and a history of a fall with an occipital impact, in the absence of other signs of maltreatment, accidental injury should be considered. Further research should be conducted regarding this mechanism of head injury in young children.

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