Professionals' Toolkit

Pediatric Head Injury from Falls

Kathi Makoroff, MD has authored a PowerPoint® Presentation on this topic.

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When evaluating a child with head trauma, a clinician must know when inflicted trauma should be included in the differential diagnosis. It may be difficult to differentiate abusive head trauma from accidental injury since accidental falls are common occurrences in infants and children. In addition, falls or accidental injuries are frequently offered as explanations when abuse has occurred. It is therefore important to become familiar with the published literature regarding the severity and type of injuries sustained from children who have fallen from various objects and heights.

The Child Abuse and Neglect Team at Children's Hospital Medical Center of Cincinnati provides the following clinical update of literature, organized by types of falls and by mechanism of fall, specifically falls from beds, falls down stairs, falls in walkers, falls from heights and fatal falls.

Falls from beds
Helfer (1977), Nimityungskul (1987) and Lyons (1993) each performed similar studies of children falling from beds/cribs, etc. while in the hospital. Combining these series produces 368 children who fell about 2 - 4 feet and had no or minor injuries (total of 3 skull fractures; 1 clavicle fracture). The children in these series are older which limits the applicability to infants.

Falls down stairs
Joffe (1988) and Chiaviello (1994) examined injuries that result when children fall down stairs. Both studies noted that single injuries to the head or extremities predominate. Both also noted a greater occurrence of injury in infants who fell while being carried (Joffe reported that 4/10 infants who fell while being carried sustained a skull fracture). Chiaviello's series had a higher frequency of significantly injured children (7% had skull fractures vs. 2% in the Joffe series, and one child had a subdural hematoma). Joffe also noted that there was no correlation between severity of injury and number of steps fallen down. They postulate that stairway injuries are less severe than free falls of the same total distance and consist of a mild-moderately severe impact followed by a series of low-energy falls.

Falls in walkers
Studies in younger children were performed in the evaluation of falls sustained while in a walker. Chiaviello (1994) studied 65 patients in walkers who or tipped over fell down steps, and Smith (1997) performed a similar study on 271 children. The mean age of patients was about 9 months. In these series, 10% (Smith) and 15% (Chiaviello) of patients suffered skull fractures and 1% and 8% respectively had intracranial bleeds. There was also one clavicular fracture, one radius/ulna fracture and one cervical spine fracture. In addition, Smith found that the number of steps fallen down was significantly associated with skull fractures. Those patients who struck concrete were also more likely to have a skull fracture (not significant). One limitation of both of these studies is that there is not adequate

documentation that intentional trauma was investigated (for example, none of the patients had retinal exams recorded).

Falls from heights

Barlow (1983) and Roshkow (1990) both studied falls from heights, again in older patients. Barlow found that that the shortest falls that resulted in death were from approximately 30 feet. Roshkow had slightly different findings: that the pattern of injury, including the presence of a head injury, did not relate to the height of the fall and that significant head injury was not uncommon after falls from heights >10 feet.

Tarantino (1999) studied 167 patients 10 months of age or younger who sustained vertical falls four feet or lower. Fifteen percent of patients suffered significant injuries including 7 long bone fractures and 12 linear skull fractures. The patients had evaluation for inflicted injury (but some was lacking or omitted, i.e., skeletal surveys). The authors also found that a child with significant injury was more likely to have been dropped from the arms of a caretaker ($p=.003$). In this study, no child sustained a significant intracranial injury from a short vertical fall.

Williams (1991) reports on 106 children who fell from a height of less than 10 feet and were witnessed by a non-caretaker. Three children in this series suffered a depressed skull fracture from falling against surfaces. All of the children in this series are older, which limits the applicability to infants.

Leventhal (1993) found that it is common for children to suffer fractures from falls (60% of children in their study sustained a fracture from falls). The greater the height of the fall, the more common it was to incur a skull fracture.

Deaths from falls

Chadwick (1991) looked at 317 children admitted to a trauma center with the mechanism of injury being a "fall". They found that 7/100 children died from a fall of 1 - 4 feet, 0/65 children died from a fall of 5 - 9 feet and 1/118 children died from a fall of 10 - 45 feet. Three of the children who died from a fall of 1 - 4 feet also had associated injuries such as bruising to the head and trunk, old fractures and retinal hemorrhages. They conclude that the best explanation of these findings is that the history was incorrect for the seven children who died following a fall of 1 - 4 feet.

Reiber (1993) reports on a smaller series of patients who suffered a fatal head injury with the history of a "fall". The series is divided into two groups: those with a history of a minor fall (<5 - 6 feet) and those with a history of a major fall (>10 feet). Seventy four percent of patients in the "minor fall" category were later found to be victims of non-accidental trauma. Thirty-two percent in the "minor fall" group were also found to have retinal hemorrhages, axonal injury or both. Sixteen percent in the "minor fall" group also had evidence of a torn frenulum, and another sixteen percent had old fractures. Reiber comes to the same conclusion as Chadwick above, that cases with extensive injury and a history of a short fall may not have an accurate history.

Hall (1989) reviewed records of pediatric deaths from a history of a fall. He found that 18 children died from a fall <3 feet; 18 children died from a fall >3 feet but <4 stories and 8 children died from a fall >5 stories. Falls accounted for 5.9% of pediatric trauma deaths. He did not report if non-accidental trauma was considered and excluded.

Plunkett (2001) examined more than 75,000 cases from the United States Consumer Product Safety Commission and revealed 18 fall-related head injury deaths over an 11 year period. The age range of the 18 children is 1-13 years. Seven of the children fell from a swing, and eleven of the children fell from a horizontal surface, ladder or see-saw.

Article Summaries

Falls from beds

Selbst, SM, et al. Bunk bed injuries. AJDC 1990;144:721-723.

Methods:

- Injury group: 68 children presenting to emergency department with bunk bed related injury
- Control group: 54 children presenting to emergency department with another complaint and also have a bunk bed (those with previous bunk bed injuries were excluded)
- Mean ages: 5.1 years (injury group); 6.2 years (control group)

Findings:

- Most frequently injured body parts: Head (52%), Lower extremity (13%), Face (12%), Upper extremity (10%)
- Most common injuries: Lacerations (40%), Skin Contusions (28%), Concussions (12%), Fractures (10%)
- Those injured were much less likely to have carpet under bed (42% injured vs. 67% controls)
- Six children who required hospitalization (4 concussions, 1 skull fracture/subdural, 1 laceration near eye) all fell from the top bunk

Conclusions:

- Bunk bed injuries are common and may be serious
- More serious injuries occurred from top bunk

Helfer RE, et al. Injuries resulting when small children fall out of bed. Pediatrics. 1977;60:533-535.

Methods:

- 246 children <5 yrs old divided into two groups:survey group:parents filled out survey in doctor's office whether child had fallen off bed or sofa (n=161)
- hospital group: fall in hospital from bed, crib or exam table (n=85)

Results:

- Survey group: (all falls <90cm)
  - 3 clavicular fractures (ages: 6 months - 5 years)
  - 2 skull fractures (ages: <6 months)
  - 1 humerus fracture (age: <6 months)
- Hospital group (fall = 90cm) 1 skull fracture ("no serious sequeale")

Conclusions:

- Severe head injuries did not occur when these children fell out of bed.
- Fractures can occur when children fall out of bed

Lyons TJ, Oates RK. Falling out of bed: A relatively benign occurrence. Pediatrics 1993;92:125-127.

Methods:

- 207 children <6 years of age who fell from a hospital crib (n=124) (32 inches with sides down; 54 inches with sides up) or bed (n=83) (25 inches; 41inches with bed rails)
- 15% who fell from cribs and 18% who fell from beds fell over the side rails

Results:

- 31 injuries: 29 trivial injuries (skin contusions and small lacerations), 1 linear skull fracture (10 m.o. fell out of crib), 1 clavicle fracture (21 m.o. fell out of crib with rails up)
- 26 (84%) injuries were to the head
- Not all patients received a radiograph

Conclusions:
Clinically significant head injuries are uncommon with falls from these heights

Nimityongskul P, Anderson LD. The likelihood of injuries when children fall out of bed. J Ped Ortho 1987;7:184-186.

Methods:
76 children <16 years of age (23 were less than 1 year of age) who fell out of bed/crib/chair/wagon while in hospital (1 - 3 foot fall)

Results:

- Most of the patients sustained minor injuries (bruises, minor lacerations)
- 1 pt (1 year of age) had an occipital skull fracture
- 1 pt (with Osteogenesis Imperfecta) had a non-displaced tibial fracture
- Total of 9 radiographs performed (7 skull films) in all patients

Conclusions:
Severe head injuries were not seen in these children who fell out of hospital bed, crib or chair

Wheeler DS, Shope TR. Depressed skull fracture in a 7-month-old who fell from bed. Pediatrics 1997;100:1033-1034.

Methods:
Case report of 7 month old fall from bed who sustained a 2 x 4 x 0.5 cm depressed right parietal skull fracture

Results:

- No underlying brain injury, no retinal hemorrhages, no other fractures
- Scene investigation revealed a car toy-roof fit the dimensions of skull depression

Conclusion:
Depressed skull fractures may occur when children fall short distances onto an object.

Stairway falls

Joffe M, Ludwig S. Stairway injuries in children. Pediatrics 1998;82:457-461.

Methods:

- 363 patients 1 month - 18.7 years of age with injuries from falls down steps who presented to the emergency department
- Mean age was 55 months (54 patients were <1 year of age)
- "cases of child abuse definitely identified by social workers or physicians were withdrawn"

Results:

- 6% of patients had fractures: 72% extremity fractures and 28% skull fractures
- No rib or vertebrae or pelvis or femoral fractures were seen
- No intracranial hemorrhages or cerebral contusions were seen
- Of infants who fell in the arms of caretakers, 40% (4/10) sustained skull fractures

Conclusions:

- No correlation between severity of injury and number of steps fallen down
- Stairway injuries are much less severe than free falls of the same total vertical distance; they consist of mild-moderately severe inital impact followed by a series of low-energy non-injurious falls down the remaining steps.
- Multiple, truncal and proximal extremity injuries are unusual in stairway falls

Chiaviello CT, et al. Stairway-related injuries in children. Pediatrics 1994;94:679-681.

Methods:

- Sixty-nine children <5 years of age who presented to emergency department with history of fall down stairs
- walker-related injuries were excluded

Results:

- 15 (22%) suffered significant injuries:
  - 11 (16%) concussions
  - 5 (7%) skull fractures
  - 2 (3%) cerebral contussion
  - 1 subdural hematoma
  - 1 C-2 fracture
- Included in this group are 3 infants who fell while being carried:
  - 1 sustained a skull fracture
  - 1 sustained a skull fracture and brain contusion
  - 1 sustained a subdural hematoma

Conclusions:

- Significant injuries can occur when children fall down steps
- There were more significant injuries in this study compared to Joffe's study. This may be due to different thresholds for obtaining imaging studies in 1994 compared to 1988.

Falls from walkers and shopping carts

Chiaviello CT, et al. Infant walker-related injuries: a prospective study of severity and incidence. Pediatrics 1994;93:974-976.

Methods:

- 65 patients ages 3 - 17 months (95%<1 year of age) who presented to ED with a walker related injury
- 46 (71%) fell down steps while in a walker
- 14 (21%) tipped over while in a walker
- "Infants with suspected non-accidental trauma were excluded from the study"

Results:

- 19(29%) patients had a serious injury: 10 (15%) skull fractures, 8 (12%) concussions, 5 (8%) intracranial hemorrhage, 2 (3%) full thickness burns, 1 (2%) C-spine fracture
- 1 patient died (infant with c-spine fracture, skull fracture and subdural hematoma)

Conclusions:

- Majority of walker-related injuries involve the head and neck
- Most of serious injuries resulted from stairway falls in walkers

Smith GA, et al. Babywalker-related injuries continue despite warning labels and public education. Pediatrics 1997;100(2) electronic

Methods:
271 children 4 - 36 months of age (mean 9.2 months) treated in the emergency department for baby-walker related injuries

Results:

- 26/271 patients had skull fractures: 17 parietal, 8 frontal, 1 occipital
- 3/26 patients had depressed skull fractures (two of these also had a second non-depressed skull fracture)
- 3 patients had intracranial bleeds (two had subdurals)
- Also: 3 patients with clavicular fractures and 1 patient had ulnar/radial fractures
- The number of steps the child fell down was significantly associated with skull fractures
- 14.6% of patients who struck concrete sustained a skull fracture compared to 8.1% in the non-concrete group (p=.21).

Conclusions:

- Number of stairs a child falls down when in a walker is significantly associated with sustaining a skull fracture (independent of the influence of landing surface).
- Extremity injuries uncommon in babywalker-related falls.

Smith GA, et al. Injuries to children related to shopping carts. Pediatrics 1996;97:161-165.

Methods:
62 children aged 4 months - 10 years (mean 2.8 years) treated in the emergency department for shopping cart-related injury. 58% of cases fell out of the shopping cart

Results:

- 11(18%) patients had fractures: 5 skull fractures, 2 femur fractures, 1 metatarsal fracture, 1 clavicle fracture, 1 distal phalynx fracture (hand), and 1 radius/ulna fracture
- 49 (79%) of patients had injuries to the head
- Skull films were obtained in 11 patients (18%)
- CT scan obtained in 9 patients (14%), no abnormalities detected

Conclusion:
Injuries from shopping cart falls can be serious. These falls from shopping carts onto a hard non-energy-absorbing surface did not cause any serious head injury

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Free/vertical falls

Williams RA. Injuries in infants and small children resulting from witnessed and corroborated free falls. J Trauma 1991;31:1350-1352.

Methods:

- Witnessed group: 106 patients <3 years who had a free fall from a stationary object and witnessed by 2 or more people or by non-caretaker
- Unwitnessed group: 53 patients <3 years who had a free fall that was not witnessed or witnessed by a single caretaker only

Results:

- Witnessed group:
  - For falls <10 feet :
  - No patients suffered LOC
  - 3 serious injuries: (depressed skull fractures following falls against edged surfaces)
  - Only mild injuries occurred in patients falling between 10 - 22 feet (bruises, abrasions, lacerations, simple fractures)
  - One death occurred in an infant who fell 70 feet
- Unwitnessed group:
  - For falls <5 feet:
  - 18 severe injuries: (intracranial bleed, cerebral edema, cerebral contusion, depressed skull fracture, ruptured organ, compound or comminuted fracture)
  - 2 deaths

Conclusions:

- The children whose were observed to fall by non-caretakers sustained much less severe injury compared to the group who fell from a shorter height and who were not observed by a non-caretaker.
- The substantial injuries sustained by the children who fell from low heights were not expected, based on studies by Selbst, Lyons and Smith.
- Therefore, many of the severe injuries sustained by infants who were said to have fallen <5 feet may have been injured by other mechanisms.

Barlow B, et al. Ten years of experience with falls from a height in children. J Ped Surg 1983;18:509-511.

Methods:
Sixty-one patients between 1-16 years of age who fell from a height were evaluated

Results:

- Head injuries were second to fractures in frequency of injuries
- 56 patients had head injury: 25 concussions, 17 skull fractures, 13 brain contusions, and 1 subdural hematoma
- Survival: 100% survival if fell <= 3 floors and 50% survival between 5th and 6th floors

Conclusions:

- No mortality if fall <3 floors
- No correlation between age and survival

Roshkow JE, et al. Imaging evaluation of children after falls from a height: review of 45 cases. Radiology 1990;175:359-363.

Methods:
Forty-five patients aged 1 - 12 years who fell from a height of 10 feet or greater were evaluated(patients who were not admitted or dead on arrival to hospital were not included)

Results:

- Head injuries occurred in 42% of patients
- 31 patients had skull films and 11 revealed fractures: 4 linear and 7 depressed
- 25 patients had head CT scans: 7 linear skull fractures, 9 depressed skull fractures, 1 epidural hemorrhage, 4 subdural hemorrhages, 7 subaracnoid hemorrhages, 2 intraventricular hemorrhages, and 1 shearing injury
- The occurrence of head injury was not related to the height of the fall
- Intracranial injury was not necessarily associated with a skull fracture

Conclusions:

- Injury pattern did not correlate with height of fall
- Significant intracranial injury occurred with falls > 10 feet

Tarantino CA, et al. Short vertical falls in infants. Ped Emerg Care 1999;115:5-8.

Methods:

- 167 patients <10 months of age (mean 5.2 months) who suffered a vertical fall <=4 feet
- Falls were off bed/couch/surface or dropped by caretaker
- Excluded trajectory falls, striking surfaces or walker-related falls

Results:

- 15% of patients had significant injury:
    - 7 long bone fractures (3 femur fractures; 1 humerus fracture, 2 tibia fractures; 1 clavicle fracture)
    - 18 patients sustained head injuries:
        - 2 had intracranial hemorrhages (both found to be victims of child abuse)
        - 12 had linear skull fractures
        - 4 had symptoms of closed head injury but no skull fractures
- 4/7 of patients with long bone fractures had a referral to Department of Family Services (DFS); all 4 were discharged to parents.
- 2/2 of the patients with intracranial hemorrhages were found to be victims of child abuse (both confessions).
- 3/12 patients with linear skull fractures had a referral to DFS; 1 was placed in foster care.
- A child with a significant injury was statistically more likely to have been dropped from the arms of a caaretaker (p=.003)

Conclusion:

- Significant although not life-threatening injuries were not uncommon in short falls
- In this series, no child sustained intracranial, visceral or multiple significant injury from a fall from a surface
- Being dropped from a caretaker's arms resulted in a more significant injury than falling from a surface

Leventhal JM, Thomas SA, Rosenfield NS, Markowitz RI. Fractures in young children Distinguishing child abuse from unintentional injuries. AJDC 1993;147:87-92.

Objective:
To determine what features would be helpful in distinguishing unintentional from intentional (i.e. abusive) fractures in children.

Methods:
Retrospective study of the medical charts and roentgenograms of children < 3 years of age with fractures.

Assessments were made using a seven point scale to rate the likelihood that the fracture was due to abuse.

The location of fractures resulting from falls as well as the height of the fall as it relates to the presence of a complicated skull fracture were specifically examined.

Results:

- 215 patients had confirmed fractures; mean age 15.7 months
- 130 children suffered fractures from falls (60%)
  - In 14 (11%) children the cause was classified as abuse
  - In 12 (9%) children the cause was classified as unknown
  - In 104 (80%) children the cause was classified as unintentional

Number of complicated skull fractures from falls in 104 children in which the cause was classified as unintentional:		
Height of fall (cm)	*Number of children(total)*	*Number with skull fractures (%)*
Running	6	0 (0%)
< 60	24	8 (33%)
60-119	33	23 (70%)
120-210	26	17 (65%)
>210	7	5 (71%)
Unknown	8	1 (12.5%)

Conclusions:

- It is common for children to suffer fractures from falls.
- The greater the height of the fall, the more common it is to suffer a skull fracture.

Fatal falls

Chadwick DL, et al. Deaths from falls in children: how far is fatal? J Trauma 1991;31:1353-1355.

Methods:
317 patients who presented to a trauma center with the mechanism of injury being a "fall"

*Results:*Case fatality rate by fall height:

Fall Height (feet)	*Number died*	*Total*	*Case fatality rate (%)*
1-4	7	100	7.0
5-9	0	65	0.0
10-45	1	118	0.8

For patients who died from a fall from 1-4 feet, histories given for the type of fall:

Type of fall	*Number*	*Associated Injuries*
Standing fall	2	(none)
Fall from bed/table	2	(none)
Fall down stairs	1	bruising on arms, labia majora, thighs
Fall in arms of adult	2	(1) bruising on scalp, ear; SDH; RH and (2) RH; SDH; old tibia fracture

Conclusions:

- If the histories are correct then the risk of death in children who fell from a height of 1 - 4 feet was eight times greater than for those who fell from 10 - 45 feet.
- The findings above may be explained by assuming that the histories of short falls were false and that the children died from other, untold, trauma. In fact, 3 of the 7 children who died from alleged short falls had physical findings on examination which suggested child abuse.
- There may be a sample bias in this study, i.e. probably more children who fall from heights >5 feet, regardless of symptomatology, are taken to a doctor, compared to children who fall from a short height. However, given the results of other studies looking at the injuries sustained by children who fall from low heights, these injuries are still unexpected.

Reiber GD. Fatal falls in childhood. Am J Forensic Med Path 1993;14:201-207.

Methods:

- Reviewed cases of fatal head injury in children <=5 years of age where a history of "fall" was given.
- "major fall": >10 feet (3 cases)
- "minor fall": <= 5-6 feet (19 cases)

Results:

- Skull fractures:
  - "major fall" -- all had skull fractures
  - "minor fall" -- 6/19 (31.5%) had skull fractures
- Landing surface:
  - "major fall" -- all landed on concrete
  - "minor fall" -- 3/19 (16%) landed on concrete
- Other findings:
  - "major fall" -- none had evidence of RH or axonal injury
  - "minor fall" -- 6/19 (31.5%) had RH, axonal injury or both. Also had torn frenulum (16%) and old fractures (16%)
- Witnessed
  - "major fall" 2/3 were witnessed
  - "minor fall" none were witnessed
- 74% of the "minor fall" cases were later found to represent N.A.T

Conclusions:

- There are significant differences between these two groups. However, the "major fall" group includes only 3 patients. Abuse was found to be the cause of death in 75% of the "minor fall" group.
- Death following short falls should be questioned and investigated for possible child abuse.

Hall JR, Reyes HM, Horvat M, et al. The mortality of childhood falls. J Trauma 1989;29:1273-1275.

Methods:
Records of pediatric deaths due to falls were reviewed from ME's office.

Results:

- Falls accounted for 5.9% of pediatric trauma deaths and was the seventh most frequent cause of death in traumatic deaths of all children (but third leading cause in ages 1 - 4)
- 3 groups of reported heights of fatal falls: 8 children from >5 stories, 18 children from <=4 stories but >3 feet, and 18 children from <3 feet

In the group who fell <3 feet:

- All died from head injury without associated injuries
- 6/18 had parental-induced delay of care >4 hours
- 76% had mass lesions (subdurals, epidurals)
- 1 patient was DOA (8 month old who fell off couch on to wooden floor; had a subdural hematoma)

Conclusions:
Child abuse evaluations were not documented in this study that reviewed findings in pediatric deaths following short distance falls.

Plunkett J. Fatal pediatric head injuries caused by short-distance falls. Am J Forens Med Pathol 2001;22:1-12.

Objective:
To determine if there are witnessed and/or investigated fatal short distance falls that are concluded to be accidental.

Methods:
Retrospective review of the United States Consumer Product Safety Commission National Injury Information Clearinghouse data from January 1, 1988 through June 30, 1999 for deaths resulting from the use of playground eqipment.

For all deaths, the author reviewed each original record from hospitals, emergency medical services, law enforcement and medical examiner offices (one autopsy was not available but it was discussed with the coroner).

Results:

More than 75,000 cases were reviewed:
18 deaths from head injury secondary to a fall associated with the use of playground equipment were recorded.

Age range of patients: 1-13 years

- 5 children: 12-24 months
- 5 children: 25-60 months
- 8 children: 6-13 years

Cases:
Fall distance = "distance of closest body part from ground at beginning of fall"

- in 10 cases the distance reported is the actual distance
- in 8 cases the distance was estimated

12 of the 18 cases were witnessed by a non-caretaker or videotaped

6 of the 18 children had an eye examination documented in the medical record, but none of the children had a "formal retinal evaluation".

Case 1
Age: 12 months
Mechanism: Fell sideways and backwards off of a porch swing
Fall distance: 5-6 feet
Witnessed*: No
Conscious: "unconscious immediately"
CT Imaging: Subgaleal hematoma at vertex; comminuted fracture of vault; parafalcine subdural hemorrhage; right parietal subdural hemorrhage
Eye exam: Not recorded
Autopsy: None

* definition of witnessed: by a non-caretaker

Case 2
Age: 14 months
Mechanism: Fell backwards off of a see-saw
Fall distance: 22.5 inches
Witnessed: No
Conscious: "conscious but crying...Within 10 to 15 minutes he became lethargic and limp, vomited"
CT Imaging: Occipital subgaleal hematoma; left sided cerebral edema
Eye exam: Normal
Autopsy: None

Case 3
Age: 17 months
Mechanism: Fell from swing on its downstroke
Fall distance: (estimated) 5-6 feet
Witnessed: No
Conscious: "immediately unconscious"
CT Imaging: Left sided subdural hematoma with extension to the intrahemispheric fissure and falx
Eye exam: Not recorded
Autopsy: Symmetrical contusions on buttocks and posterior thorax; left subdural hematoma; cerebral edema with anoxic encephalopathy; uncal and cerebellar tonsillar herniation

Case 4
Age: 20 months
Mechanism: Fell from platform of jungle gym striking head on support post
Fall distance: 67 inches from ground; 42 inches from support post
Witnessed: No
Conscious: "initially conscious and talking, but within 5 to 10 minutes became comotose"
CT Imaging: Right occipital depressed skull fracture; right subdural and subarachnoid hemorrhage along the tentorium and posterior falx
Eye exam: "extensive bilateral retinal and preretinal hemorrhage"
Autopsy: (limited) Impact subgaleal hematoma overlying the fracture

Case 5
Age: 23 months
Mechanism: Fell head-first off of a plastic gym set on to plush carpet over a concrete floor
Fall distance: 28 inches
Witnessed: Yes (videotaped)
Conscious: "cried after the fall but was alert and talking...approximately 5 minutes later she vomited and became stuporous"
CT Imaging: Right-sided subdural hematoma and minimal subfalcine herniation
Eye exam: "Bilateral retinal hemorrhhages"
Autopsy: Right subdural hematoma; cerebral edema with cerebellar tonsillar herniation

Case 6
Age: 26 months
Mechanism: Fell backwards off of a playground swing
Fall distance: 3-6 feet
Witnessed: Yes
Conscious: "immediately unconscious"
CT Imaging: Subdural hematoma; acute cerebral edema

Eye exam: "extensive bilateral retinal hemorrhage, vitreous hemorrhage in the left eye"
Autopsy: Right parietal impact injury; small bilateral subdural hemorrhage; cerebral edema with herniation; focal hemorrhage in the right posterior midbrain and pons; retinal hemorrhage

Case 7
Age: 3 years, History of thrombocytopenia-absent radius syndrome
Mechanism: Fell off of platform, striking his face
Fall distance: 3 feet
Witnessed: Yes
Conscious: "initially conscious and able to walk; approximately 10 minutes later he had projectile vomiting and became comotose"
CT Imaging: Subdural hematoma; diffuse cerebral edema with uncal herniation
Eye exam: Not recorded
Autopsy: None
Other findings: Platelet count 24,000

Case 8
Age: 3 years
Mechanism: Fell forward off of a slide ladder step striking her head
Fall distance: 22 inches
Witnessed: Yes
Conscious: "crying...Approximately 15 minutes later she began to vomit"
CT Imaging: Performed but results not described
Eye exam: Not recorded
Autopsy: Complex fracture of left frontal bone and bilateral temporal bones; associated subgaleal hematoma; small epidural and subdural hematomas; marked cerebral edema with uncal herniation

Case 9
Age: 4 years
Mechanism: Fell off slide landing on buttocks then falling on left side striking head
Fall distance: 7 feet
Witnessed: Yes
Conscious: "no loss of consciousness...began vomiting and complained of left neck and head pain approximately 3 hours later"
CT Imaging: Left parietal epidural hematoma with a midline shift
Eye exam: Not recorded
Autopsy: Small epidural hematoma; cerebral edema with cerebellar tonsillar and uncal herniation and hypoxic encephalopathy

Case 10
Age: 5 years
Mechanism: Fell off of horizontal ladder of monkey bar
Fall distance: 7 feet
Witnessed: No
Conscious: "laying face down on the ground and not moving"
CT Imaging: Right temporal fracture with underlying subdural hematoma; subdural hematoma along right parietal and temporal lobes; right sided edema with midline shift
Eye exam: Not recorded
Autopsy: None

Case 11
Age: 6 years
Mechanism: Fell off swing but actual fall not witnessed
Fall distance: 2-8 feet
Witnessed: No
Conscious: "initially conscious and talking but within 10 minutes became comotose"
CT Imaging: Left frontoparietal subdural hematoma with extension into the intrahemispheric fissure and midline shift
Eye exam: "no retinal hemorrhages"
Autopsy: None

Case 12
Age: 6 years

Mechanism: Fell from crossbar of monkey bars landing flat on his back
Fall distance: (approximately) 10 feet
Witnessed: No
Conscious: "was conscious and alert" Approximately 30 minutes later "he suddenly collapsed"
CT Imaging: (initially) Normal
(20 hours after the fall) Diffuse cerebral edema
Eye exam: Not recorded
Autopsy: None

Case 13
Age: 6 years
Mechanism: Slid quickly down pole of monkey bar striking ground with feet, buttocks, back and then head
Fall distance: 7 feet 10 inches
Witnessed: Yes
Conscious: "seemed fine" following incident, but 6 hours later "was incoherent and 'drooling'"
CT Imaging: Right parieto-occipital skull fracture, subdural and subarachnoid hemorrhage; right cerebral hemisphere infarct"
Eye exam: Not recorded
Autopsy: Right parietotemporal subgaleal hematoma; right parietal skull fracture; subdural hematoma and cerebral edema

Case 14
Age: 7 years
Mechanism: Fell off horizontal bar of monkey bars; unclear if hit forehead on bars of ladder
Fall distance: 4-8 feet
Witnessed: Yes
Conscious: Unclear if initial loss of consciousness; 2 days after fall was stumbling and had slurred speech
CT Imaging: (initial) Occipital subgaleal hematoma
(2 days later) Left carotid artery occlusion and left parietal and temporal lobe infarcts
Eye exam: Not recorded
Autopsy: Infarcts of left parietal, temporal and occipital lobes; acute cerebral edema with herniation; thrombosis of left vertebral artery

Case 15
Age: 8 years
Mechanism: Fell from a retaining wall striking back and head after swinging to wall from monkey bars
Fall distance: 34 inches
Witnessed: Yes
Conscious: "initially cried and complained of a headache but continued playing" Approximately 14.5 hours later "complained of a severe headache then became unresponsive and had a seizure"
CT Imaging: Not done
Eye exam: Not reported
Autopsy: Right temporoparietal subdural hematoma

Case 16
Age: 10 years
Mechanism: Fell off swing (seat detached from chain) striking the back of his head
Fall distance: 3-5 feet
Witnessed: Yes
Conscious: "remained conscious although groggy...He suddenly lost consciousness approximately 10 minutes later"
CT Imaging: Right frontoparietal subdural hematoma with transtentorial herniation
Eye exam: "extensive bilateral confluent and stellate, posterior and peripheral preretinal and subhyaloid hemorrhage"
Autopsy: Right parietal subarachnoid arteriovenous malformation; subdural hemorrhage; cerebral edema with herniation

Case 17
Age: 12 years
Mechanism: Fell off swing while standing on seat as it was twisting; struck

back and back of head
Fall distance: 3-6 feet
Witnessed: Yes
Conscious: "immediately unconnscious"
CT Imaging: Not performed
Eye exam: Not recorded
Autopsy: Comminuted occipital fracture and contusions of inferior frontal and temporal lobes

Case 18
Age: 13 years
Mechanism: Fell backwards while standing on the seat of a swing
Fall distance: 2-6 feet
Witnessed: Yes
Conscious: "immediately unconnscious"
CT Imaging: Interhemispheric subdural hemorrhage and generalized cerebral edema
Eye exam: Not recorded
Autopsy: Linear occipital skull fracture; subdural hemorrhage; contusion of left cerebellar hemisphere and bifrontal lobes; cerebral edema

- In 13 of the 18 patients, there was evidence of a subdural hemorrhage
- In 13 of the 18 patients, there was evidence of cerebral edema
- In 10 of the 18 patients, there was evidence of a contact injury (skull fracture, subgaleal hemorrhage and/or contusion)

- 6 patients were reported to be immediately unconscious following the fall
- 8 patients were reported to develop symptoms between 5-30 minutes after the fall
- 4 patients were reported to develop symptoms between 3 hours and 2 days following the fall (3 hours, 6 hours, 14.5 hours and 2 days)

Conclusions:

- In a review of more than 75,000 cases of injury resulting from falls associated with playground equipment in the United States over 11 years, 18 children aged 1-13 years suffered fatal head injuries.
- If the two children who had thrombocytopenia-absent radius syndrome or an arterio-venous malformation are removed, 6 children suffered fatal falls associated with a swing and 10 children suffered fatal falls from a horizontal surface, ladder or see-saw in this series.