

AMERICAN ACADEMY OF PEDIATRICS

Committee on Child Abuse and Neglect

Shaken Baby Syndrome: Rotational Cranial Injuries—Technical Report

ABSTRACT. Shaken baby syndrome is a serious and clearly definable form of child abuse. It results from extreme rotational cranial acceleration induced by violent shaking or shaking/impact, which would be easily recognizable by others as dangerous. More resources should be devoted to prevention of this and other forms of child abuse.

ABBREVIATIONS. CT, computed tomography; MRI, magnetic resonance imaging.

INTRODUCTION

Physical abuse is the leading cause of serious head injury in infants.^{1,2} Although physical abuse in the past has been a diagnosis of exclusion, data regarding the nature and frequency of head trauma consistently support the need for a presumption of child abuse when a child younger than 1 year has suffered an intracranial injury.^{1,2}

Shaken baby syndrome is a serious form of child maltreatment most often involving children younger than 2 years but may be seen in children up to 5 years old.²⁻⁵ It occurs commonly, yet may be misdiagnosed in its most subtle form and underdiagnosed in its most serious form.⁶ Caretakers may misrepresent or claim to have no knowledge of the cause of the brain injury. Caretakers who are not responsible for the injuries may not know how they occurred. Externally visible injuries are often absent. Given possible difficulties in initially identifying an infant as having been abusively shaken and the variability of the syndrome itself, physicians must be extremely vigilant when dealing with any brain trauma in infants and be familiar with radiologic and clinical findings that support the diagnosis of shaken baby syndrome.

HISTORY

In 1972, pediatric radiologist John Caffey⁷ popularized the term "whiplash shaken baby syndrome" to describe a constellation of clinical findings in infants, which included retinal hemorrhages, subdural and/or subarachnoid hemorrhages, and little or no evidence of external cranial trauma. One year earlier, Guthkelch⁸ had postulated that whiplash forces caused subdural hematomas by tearing cortical bridging veins. In the mid-1970s, computed tomography (CT) began to be used to help with diagnosis.

The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

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The advent of magnetic resonance imaging (MRI) in the mid-1980s has furthered the diagnostic capabilities.⁹

ETIOLOGY

The act of shaking leading to shaken baby syndrome is so violent that individuals observing it would recognize it as dangerous and likely to kill the child. Shaken baby syndrome injuries are the result of violent trauma. The constellation of these injuries does not occur with short falls, seizures, or as a consequence of vaccination. Shaking by itself may cause serious or fatal injuries.^{10,11} In many instances, there may be other forms of head trauma, including impact injuries.¹⁰⁻¹² Thus, the term shaken/slam syndrome (or shaken-impact syndrome) may more accurately reflect the age range of the victims (who are not always babies) and the mechanisms of injury seen. Such shaking often results from tension and frustration generated by a baby's crying or irritability, yet crying is not a legal justification for such violence.¹³ Caretakers at risk for abusive behavior generally have unrealistic expectations of their children and may exhibit a role reversal whereby caretakers expect their needs to be met by the child.¹⁴

Additionally, parents who are experiencing stress as a result of environmental, social, biological, or financial situations may also be more prone to impulsive and aggressive behavior. Those involved with domestic violence and/or substance abuse may also be at higher risk of inflicting shaken baby syndrome. Small children are particularly vulnerable to such abuse because of the large disparity in size between them and an adult-sized perpetrator.

EPIDEMIOLOGY

Head injuries are the leading cause of traumatic death and the leading cause of child abuse fatalities. Homicide is the leading cause of injury-related deaths in infants younger than 4 years.² Serious injuries in infants, particularly those that result in death, are rarely accidental unless there is another clear explanation, such as trauma from a motor vehicle crash. Billmire and Meyers¹⁵ found that when uncomplicated documented severe trauma such as that resulting in skull fractures were excluded, 95% of serious intracranial injuries and 64% of all head injuries in infants younger than 1 year were attributable to child abuse. Bruce and Zimmerman⁵ documented that 80% of deaths from head trauma in infants and children younger than 2 years were the result of nonaccidental trauma. Contrary to early

speculations,^{7,8} shaken baby syndrome is unlikely to be an isolated event. Evidence of prior child abuse is common.¹⁶ Specific evidence of previous cranial injuries (eg, old intracranial hemorrhages) from shaking episodes is found in about 33% to 40% of all cases.^{16,17} As with other forms of physical abuse, males are more often perpetrators than are females.^{2,18} However, in an individual case, gender should not be considered when trying to identify a possible perpetrator.

CLINICAL FEATURES AND EVALUATION

Signs of shaken baby syndrome may vary from mild and nonspecific to severe and immediately identifiable clinically as head trauma.⁶ There is a spectrum of the consequences of shaken baby syndrome, and less severe cases may not be brought to the attention of medical professionals and may never be diagnosed. A shaken infant may suffer only moderate ocular or cerebral trauma. A victim of sublethal shaking may have a history of poor feeding, vomiting, lethargy, and/or irritability occurring for days or weeks. These clinical signs of shaken baby syndrome are immediate and identifiable as problematic, even to parents who are not medically knowledgeable.¹⁹ However, depending on the severity of clinical signs, this may or may not result in caretakers seeking medical attention. These nonspecific signs are often minimized by physicians or attributed to viral illness, feeding dysfunction, or colic.⁶ In these relatively milder cases, signs may resolve without the true cause being discovered. If the child presents later with indications for cerebral imaging (eg, altered consciousness and other physical signs of head trauma), signs of older intracranial trauma may retrospectively explain previously seen nonspecific signs and also serve as markers of previous assaults.^{10,16} In the most severe cases, which usually result in death or severe neurologic consequences, the child usually becomes immediately unconscious and suffers rapidly escalating, life-threatening central nervous system dysfunction.

A caretaker who violently shakes a young infant, causing unconsciousness, may put the infant to bed hoping or expecting that the baby will later recover.⁵ Thus, the opportunity for early therapeutic intervention may be lost.⁶ When brought to medical attention, the brain-injured infant may be convulsing, may have altered consciousness, may not be able to suck or swallow, and may be unable to track with eye movements, smile, or vocalize. Occasionally, the comatose state may be unrecognized by caretakers or medical providers who assume that the infant is sleeping, lethargic, or suffering from a minor acute ailment or possibly an infection. Respiratory difficulty progressing to apnea or bradycardia, which requires cardiorespiratory resuscitation, results from severe injuries.^{4,5}

Evidence of other injuries, such as bruises, rib fractures, long-bone fractures, and abdominal injuries, should be meticulously searched for and documented. Any external injuries should be documented

with forensic photographs labeled with the patient's name and the date. Repeated physical examinations may reveal additional signs of trauma. In 75% to 90% of cases, unilateral or bilateral retinal hemorrhages are present but may be missed unless the child is examined by a pediatric ophthalmologist, pediatric neurologist, pediatric neurosurgeon, or other experienced physician who is familiar with such hemorrhages, has the proper equipment, and dilates the child's pupils.^{4,5,21} The number, character, location, and size of retinal hemorrhages after a shaking injury vary from case to case. More severe retinal hemorrhages are associated with more dire brain injury.²² Retinal and vitreous hemorrhages and nonhemorrhagic changes, including retinal folds and traumatic retinoschisis, are characteristic of shaken baby syndrome.^{21,23,24}

At times, the clinical signs suggest meningitis, and a spinal tap yields bloody cerebrospinal fluid.⁴ Centrifuged spinal fluid that is xanthochromic should raise the suspicion of cerebral trauma that is at least several hours old and not the result of a traumatic spinal tap. Because of confusing respiratory symptoms, chest roentgenograms may be obtained and may appear normal or show unexplained rib fractures. The shaken infant is often mildly to moderately anemic.²⁵ Clotting dysfunction from cerebral trauma should be assessed initially and followed up. Mild to moderate changes in coagulation studies are common with brain trauma and occasionally severe (eg, disseminated intravascular coagulation).²⁶ High amylase levels may signify pancreatic damage, and elevated transaminase levels may indicate occult liver injury.²⁷

RADIOLOGY

CT has the first-line role in the imaging evaluation of a brain-injured child, adequately demonstrating injuries that need urgent intervention. CT often fails to reveal some aspects of the injury, and some false-negative results occur, particularly early in the evolution of cerebral edema.²⁸ The initial CT evaluation should be performed without intravenous contrast and should be assessed using bone and soft-tissue windows. CT is generally the method of choice for demonstrating subarachnoid hemorrhage, mass effect, and large extra-axial hemorrhages.²⁸ CT should be repeated after a time interval or if the neurologic picture changes rapidly.²⁹

MRI is of great value as an adjunct to CT in the evaluation of brain injuries in infants.³⁰ Because of the lack of universal availability of the technology, physical limitations of access to MRI when life support is required for critically ill infants or children, and relative insensitivity to subarachnoid blood and fractures, MRI is considered complementary to CT and should be obtained 2 to 3 days later if possible. Sato et al²⁸ have demonstrated a 50% greater rate of detection of subdural hematomae using MRI, compared with CT. The ability to detect and define intraparenchymal lesions of the brain is substantially improved by use of MRI, yet in the study by Sato et

al,²⁸ CT did not miss any surgically treatable injuries. MRI and CT can assist in determining when injuries occurred and substantiating repeated injuries by documenting changes in the chemical states of hemoglobin in affected areas.²⁸

A skeletal survey of the hands, feet, long bones, skull, spine, and ribs should be obtained as soon as the infant's medical condition permits. Skull films complement CT bone windows in detection of skull fractures. In a retrospective series of abused children, skull films were more sensitive and improved the confidence of diagnosis of skull fracture, compared with CT.³¹ Skull fractures that are multiple, bilateral, diastatic, or that cross suture lines are more likely to be nonaccidental.³¹ Single or multiple fractures of the midshaft or metaphysis of long bones or rib fractures may be associated findings. Specialized views may be needed to delineate subtle fractures.³⁰ In selected patients, a skeletal survey should be repeated after 2 weeks to better delineate new fractures that may not be apparent until they begin to heal (a process that does not become radiologically apparent for 7–10 days).³⁰

PATHOLOGY

Subdural hemorrhage caused by the disruption of small bridging veins that connect the dura to the pia arachnoid is a common result of shaking.^{7,8} Such hemorrhage may be most prominent in the interhemispheric fissure and minimal over the convexities of the hemispheres.⁵ Cerebral edema with subarachnoid hemorrhage may be the only finding. A child may have subdural hemorrhages, subarachnoid hemorrhages, or both. Intracranial or retinal hemorrhages may be unilateral or bilateral. Visible cerebral contusions are unusual, but diffuse axonal injury is common.³² However, for technical reasons, it is often not possible to demonstrate this pathologically or radiologically in individual cases. Isolated or concomitant hypoxic-ischemic damage may result in mild to severe cerebral edema initially and cerebral atrophy and/or infarction as a later finding. Chronic extra-axial fluid collections, cerebral atrophy, and cystic encephalomalacia are common late sequelae.²⁹ Sequential cranial imaging studies are recommended. The diagnostic entity of "benign subdural effusions" should be viewed with caution, because multidisciplinary evaluations in previously described cases were lacking.³³

OUTCOME AND CONSEQUENCES

There is a high rate of morbidity and mortality among infant victims of shaken baby syndrome.^{2,4,11,16} Mortality rates range from 15%⁴ to 38%,¹⁰ with a median of 20% to 25%. In one series, of those infants who were comatose when initially examined, 60% died or had profound mental retardation, spastic quadriplegia, or severe motor dysfunction. Other infants initially had seizures, irritability, or lethargy but had no lacerations or infarctions of brain tissue. These children did not have severely elevated intracranial pressure, subtle neurologic se-

quelae, or persistent seizures.²⁹ When severely brain-injured children survive, they may be cortically blind; have spasticity, seizure disorders, or microcephaly; or have chronic subdural fluid collections, enlarging ventricles, cerebral atrophy, encephalomalacia, or porencephalic cysts.²⁸ The outcome of shaken infants who do not receive medical attention is presently unknown but may be revealed later as learning, motor, or behavior problems of unknown cause.

CLINICAL AND COMMUNITY MANAGEMENT OF ABUSIVE HEAD INJURIES

Because the differential diagnosis of head trauma is predominately that of accidental versus inflicted injury, prompt and accurate investigation is essential. A carefully recorded time line of the child's condition is of great assistance in determining when injuries may have occurred. Suspicion of serious head injury as a result of abuse must be reported immediately to the appropriate authorities. This facilitates a thorough investigation before the histories become clouded by time or caregivers compare or invent explanations. The clinical team should include a physician who can immediately resuscitate and stabilize the baby while diagnostic radiologic studies are being done. Specialists in pediatric radiology, pediatric neurology and/or pediatric neurosurgery, and ophthalmology and a pediatrician who specializes in child abuse should form the diagnostic team. Many children will need to be followed in a pediatric intensive care unit. In rural or medically underserved areas in which one or more of these specialists are not available, a regional consultation network for child abuse cases should be developed. Careful follow-up by this same team is desirable to document and treat ocular, developmental, and neurologic sequelae of the trauma. Ideally, a physician who works with a multidisciplinary child abuse team should be available to take a broad but detailed history from the caretakers. Information regarding symptom onset and information regarding the chain of caretakers needs to be quickly passed on to mandated law enforcement and child protection investigators. Physicians can provide interpretation of the likely scenario, timing, and nature of the injuries involved.³⁴ If notified promptly, investigators may be able to explore the scene of the injury and elicit detailed information from the caretaker before defensive reactions develop. A psychosocial assessment of the caretakers should be a part of this comprehensive team approach. Siblings or other children in the same environment may have signs of inflicted trauma or repeated shaking.⁹ Therefore, medical and child protection assessments need to be available immediately to ensure the current and future safety of these children.

PREVENTION

As a part of anticipatory guidance, the pediatrician should ask about caretaker stress, discipline practices, substance abuse, and response to the crying infant. The efficacy of home visitation programs in

preventing intrafamilial physical abuse is established. Nationwide home visitation programs have been repeatedly recommended by the US Advisory Board on Child Abuse and Neglect.^{2,35} Because males commit most physical abuse, special programs should also be developed to target them. Shaken baby syndrome awareness programs that erroneously state that shaken baby syndrome may be caused by bouncing a child on a knee, by tossing him in the air, or even by rough play are to be discouraged, because they are inaccurate and may cause parents who have not abused their child to feel guilty.¹ Whether or not educational efforts will prevent critically stressed or homicidal adults from violently shaking babies needs to be evaluated. The prevention of extrafamilial abuse in out-of-home care settings is more problematic. Careful checking of references, frequent unannounced visits, and conversations with others who use the same caretaker may be valuable, but there are no data available to verify the efficacy of these preventive measures as there are for home visitation programs.

SUMMARY

Shaken baby syndrome is a clearly definable medical condition. A proper response requires integration of specific clinical management and community intervention in an interdisciplinary fashion. Greater attention and resources should be devoted to prevention of abusive injuries.

RECOMMENDATIONS

The American Academy of Pediatrics recommends that pediatricians:

1. Become educated about the recognition, diagnosis, treatment, and outcome of shaken baby and abusive head-impact injuries in infants and children;
2. Be aware of and exercise their responsibility to report these injuries to appropriate authorities;
3. Provide pertinent medical information to other members of multidisciplinary teams investigating these injuries;
4. Support home visitation programs and any other child abuse prevention efforts that prove efficacious; and
5. Provide or have appropriate referrals to resources to educate parents about healthy coping strategies when dealing with their child.

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REFERENCES

1. Alexander R, Levitt C, Smith W. Abusive head trauma. In: Reece RM, Ludwig S, eds. *Child Abuse: Medical Diagnosis and Management*. 2nd ed. Philadelphia, PA: Lippincott, Williams & Wilkins; 2001:47–80
2. US Advisory Board on Child Abuse and Neglect. *A Nation's Shame: Fatal Child Abuse and Neglect in the United States*. Washington, DC: US Department of Health and Human Services; 1995. Report No. 5
3. Alexander R, Smith W, eds. *Abusive Head Trauma: Proceedings of a Consensus Conference. Funded by Brain Trauma Foundation*. Iowa City, IA: University of Iowa; 1991
4. Ludwig S, Warman M. Shaken baby syndrome: a review of 20 cases. *Ann Emerg Med*. 1984;13:104–107
5. Bruce DA, Zimmerman RA. Shaken impact syndrome. *Pediatr Ann*. 1989;18:482–494
6. Jenny C, Hymel KP, Ritzen A, Reinert SE, Hay TC. Analysis of missed cases of abusive head trauma. *JAMA*. 1999;281:621–626
7. Caffey J. On the theory and practice of shaking infants. Its potential residual effects of permanent brain damage and mental retardation. *Am J Dis Child*. 1972;124:161–169
8. Guthkelch AN. Infantile subdural haematoma and its relationship to whiplash injury. *Br Med J*. 1971;2:430–431
9. Alexander RC, Schor DP, Smith WL Jr. Magnetic resonance imaging of intracranial injuries from child abuse. *J Pediatr*. 1986;109:975–979
10. Alexander R, Sato Y, Smith W, Bennett T. Incidence of trauma with cranial injuries ascribed to shaking. *Am J Dis Child*. 1990;144:724–726
11. Gilliland MG, Folberg R. Shaken babies—some have no impact injuries. *J Forens Sci*. 1996;41:114–116
12. Duhaime AC, Gennerelli TA, Thibault LE, Bruce DA, Margulies SS, Wisner R. The shaken baby syndrome. A clinical, pathological, and biomechanical study. *J Neurosurg*. 1987;66:409–415
13. Dykes LJ. The whiplash shaken infant syndrome: what has been learned? *Child Abuse Negl*. 1986;10:211–221
14. Steele BF, Pollock CB. A psychiatric study of parents who abuse infants and small children. In: Helfer RE, Kempe CH, eds. *The Battered Child*. 2nd ed. Chicago, IL: University of Chicago Press; 1974:89–133
15. Billmire ME, Myers PA. Serious head injury in infants: accident or abuse? *Pediatrics*. 1985;75:340–342
16. Alexander R, Crabbe L, Sato Y, Smith W, Bennett T. Serial abuse in children who are shaken. *Am J Dis Child*. 1990;144:58–60
17. Ewings-Cobb L, Kramer L, Prasad M, et al. Neuroimaging, physical, and developmental findings after inflicted and non-inflicted traumatic brain injury in young children. *Pediatrics*. 1998;102:300–307
18. Starling SP, Holden JR, Jenny C. Abusive head trauma: the relationship of perpetrators to their victims. *Pediatrics*. 1995;95:259–262
19. Duhaime AC, Christian CW, Rorke LB, Zimmerman R. A non-accidental head injury in infants—the “shaken baby syndrome.” *N Engl J Med*. 1998;338:1822–1829
20. Chadwick DL, Chin S, Salerno C, Landsverk J, Kitchen L. Deaths from falls in children: how far is fatal? *J Trauma*. 1991;31:1353–1355
21. Levin AV. Ocular manifestations of child abuse. *Ophthalmol Clin North Am*. 1990;3:249–264
22. Wilkinson WS, Han DP, Rappley MD, Owings CL. Retinal hemorrhage predicts neurologic injury in the shaken baby syndrome. *Arch Ophthalmol*. 1989;107:1472–1474
23. Greenwald MJ, Weiss A, Oesterle CS, Friendly DS. Traumatic retinopathy in battered babies. *Ophthalmology*. 1986;93:618–625
24. Levin AV. Retinal hemorrhages: a review. In: David TJ, ed. *Recent Advances in Paediatrics*. London, United Kingdom: Churchill-Livingstone; 1999:151–219
25. Hadley MN, Sonntag VK, Rekatte HL, Murphy A. The infant whiplash-shake injury syndrome: a clinical and pathological study. *Neurosurgery*. 1989;24:536–540
26. Hymel KP, Abshire TC, Luckey DW, Jenny C. Coagulopathy in pediatric abusive head trauma. *Pediatrics*. 1997;99:371–375
27. Coant PN, Kornberg AE, Brody AS, Edwards-Holmes K. Markers for occult liver injury in cases of physical abuse in children. *Pediatrics*. 1992;89:274–278
28. Sato Y, Yuh WT, Smith WL, Alexander RC, Kao SC, Ellerbroek CJ. Head injury in child abuse: evaluation with MR imaging. *Radiology*. 1989;173:653–657
29. Sinal SH, Ball MR. Head trauma due to child abuse: serial computerized

- tomography in diagnosis and management. *South Med J*. 1987;80:1505–1512
30. American Academy of Pediatrics, Section on Radiology. Diagnostic imaging of child abuse. *Pediatrics*. 2000;105:1345–1348
 31. Meservy CJ, Towbin R, McLaurin RL, Myers PA, Ball W. Radiographic characteristics of skull fractures resulting from child abuse. *AJR Am J Roentgenol*. 1987;149:173–175
 32. Vowles GH, Scholtz CL, Cameron JM. Diffuse axonal injury in early infancy. *J Clin Pathol*. 1987;40:185–189
 33. Aoki N, Masuzawa H. Infantile acute subdural hematoma. Clinical analysis of 26 cases. *J Neurosurg*. 1984;61:273–280
 34. Hymel KP, Bandak FA, Partington MD, Winston KR. Abusive head trauma? A biomechanics-based approach. *Child Maltreatment*. 1998;3:116–128
 35. US Advisory Board on Child Abuse and Neglect. *Creating Caring Communities: Blueprint for an Effective Federal Policy on Child Abuse and Neglect*. Washington, DC: US Department of Health and Human Services; 1991:141–146