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Diagnostic Imaging of Child Abuse

*Portable Guides to
Investigating Child Abuse*

Foreword

Abuse of any kind is always disturbing. When the victim is a defenseless child, our moral indignation naturally intensifies. Evidence of child abuse must be investigated thoroughly and conscientiously in order that its perpetrators may be stopped and its victims protected.

Diagnostic imaging studies may provide the first clues to physical abuse. Although their scope is somewhat restricted, such studies often prove critical in determining whether abuse has occurred.

While the techniques described in this guide are noninvasive and entail minimal risk, they are important tools in examining skeletal and intracranial injuries and other trauma. The contributing authors' diagnostic recommendations regarding shaken baby syndrome are particularly timely.

The purpose of investigating potential cases of child abuse, as with all law enforcement investigations, is to determine the truth accurately and impartially. It is my hope that *Diagnostic Imaging of Child Abuse* will aid in that crucial determination.

Shay Bilchik

Administrator

Office of Juvenile Justice and
Delinquency Prevention

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In cases of child abuse and neglect, the overall incidence of physical alterations documentable by diagnostic imaging is relatively small. However, imaging studies are often critical for infants and young children with evidence of physical injury, and they also may be the first indication of abuse in a child who is seen initially for an apparent natural illness.

As most conventional imaging studies performed in this setting are noninvasive and entail minimal radiation risks, recommendations regarding imaging should focus on examinations that provide the highest diagnostic yield at acceptable costs and should consider their potential use as courtroom evidence of child abuse.



Skeletal Injuries



Although skeletal injuries rarely pose a threat to the life of the abused child, they are the strongest radiological indicators of abuse. In infants less than 1 year of age, certain radiological abnormalities are sufficiently characteristic to allow a firm diagnosis of inflicted injury in the absence of other clinical information. Therefore, imaging surveys performed to identify skeletal injury must be carried out with the same level of technical excellence utilized in examinations routinely performed to evaluate accidental injuries.

In general, the radiographic (x-ray) skeletal survey is the method of choice for skeletal imaging in cases of suspected abuse. A skeletal survey is critical in all cases of suspected physical abuse in children less than 2 years of age. In children older than 5 years, a skeletal survey is of little value in screening for injuries. In children between the ages of 2 and 5 years, the specific clinical indicators of abuse determine whether a skeletal survey should be performed. Skeletal scintigraphy (bone scan) is an excellent adjunct to radiographic skeletal surveys, but extreme caution is indicated in using scintigraphy as a primary screening tool in infants. Whatever the child's age, when the clinical findings point to a specific site of injury, the customary protocol for imaging that region should be followed. Application of these guidelines to cases of neglect and sexual abuse is appropriate when physical maltreatment is also suspected.

Intracranial Injuries

All infants and children suspected of having an intracranial injury must undergo cranial computed tomography (CT) and/or magnetic resonance imaging (MRI). Ultrasonography (ultrasound) also may reveal intracranial abnormalities, but it does not provide imaging that is adequate for excluding or fully evaluating intracranial injury. CT has been the accepted method for initial evaluation of intracranial injury in child abuse, and was recently described as the key diagnostic study

for identifying or confirming shaken baby syndrome. The advantages of this method of diagnostic imaging are:

- * Speed — A CT scan requires from 5 to 15 minutes, in comparison to 30 minutes for an MRI scan. CT is also usually more readily available than MRI.
- * Cost — A CT scan costs less than an MRI scan. The cost of CT is approximately two-thirds the cost of MRI (however, technological refinements may further reduce the time and cost of MRI).
- * Better imaging of bone (although skull fractures are better detected by conventional radiographic techniques).
- * Better detection of subarachnoid hemorrhage (bleeding into the ventricles—the cavities within the brain—and into the fluid that normally surrounds the brain), although MRI appears to provide a better indication of the ages of the areas of hemorrhage.

However, the extent of injuries may sometimes be underestimated by CT imaging. Preliminary studies indicate that MRI is substantially more sensitive than CT in identifying and characterizing most intracranial conditions resulting from abusive assaults. In patients with minimal external signs of injury, the increased sensitivity of MRI may provide evidence for shaking-induced injury that is not obtainable by CT scanning. MRI provides superior imaging of small subdural hematomas (blood clots), which may be the only objective imaging evidence of child abuse. Other types of intracranial injury—contusions on the cerebral cortex, cerebral edema, hypertension, injuries involving the posterior fossa (the internal base of the skull), and white-matter injuries—are also better imaged using MRI, as are conditions involving the spinal cord.

In addition to greater imaging sensitivity, MRI provides the following advantages over CT:

- * Increased contrast resolution (clarity) — The visual impact of an MRI scan can lead to greater appreciation of the findings of abuse in a courtroom situation.
- * Absence of ionizing radiation — This makes MRI especially attractive for repeated examinations of the brain and for use in children.
- * Multiplanar imaging — Altering the magnetic field allows images to be obtained in multiple planes of view without repositioning the patient.

MRI should be performed in all cases of suspected intracranial injury when CT does not adequately explain the clinical findings. MRI examination is also indicated for children who exhibit chronic alterations in central nervous system (CNS) function and for infants who have symptoms of shaken baby syndrome but no clinical evidence of CNS injury. Because MRI may miss recent collections of blood if the examination is performed too soon after the injury, it should be delayed until several days after the suspected traumatic event.

Thoracoabdominal Trauma

Major blunt and penetrating thoracoabdominal injury (injury involving the chest and abdomen) is uncommon in the infant; thus, imaging strategies are the most critical for toddlers and older children. In a child who has suffered massive trauma, protocols similar to those used for accidental injury apply. Initial roentgenograms (x-rays) in the emergency department include a chest x-ray to evaluate for flail chest (loss of stability of the rib cage following fracture of the breast bone or ribs), pneumothorax (air or gas inside the pleural cavity), pleural effusion (fluid in the pleural cavity), and pulmonary parenchymal injury (damage to the lung tissue). Abdominal x-rays are not good indicators of injury to the viscera (solid internal organs), but they will show gross pelvic fractures. A lateral (sideways view) x-ray of the cervical spine should be obtained before further diagnostic studies are performed.

When the patient has been stabilized, examination by CT is indicated. CT is the most effective and sensitive imaging technique for identifying injuries of the lungs, pleura, and solid abdominal organs. It is particularly good for assessing pancreatic injury and duodenal hematomas (blood clots in the upper part of the small intestine), two characteristic findings in abused children.

In children less than 1 year of age, ultrasonography may be a reasonable preliminary study to perform if abdominal injury is suspected. Ultrasonography is an acceptable initial procedure in a child who shows lesser signs of injury or a constellation of nonspecific abdominal signs and symptoms that cannot be explained by the history or a unifying diagnosis. It is also a

reasonable examination to perform to diagnose occult (hidden) duodenal hematomas and injuries to the pancreas and kidneys. The diagnosis of duodenal hematoma, particularly if chronic, may be difficult with ultrasonography or CT. On occasion, x-rays of the upper gastrointestinal tract may be required to delineate the injury. Radionuclide (a radioactive material used in imaging) scintigraphy plays a relatively small role in the diagnosis of visceral injury, but it is of value in cases of renal (kidney) contusion and myoglobinuria (blood products in the urine due to muscle injury).

Investigative Guidelines

- * In the acutely injured patient with significant neurological impairment, CT remains the primary screening method.
- * If available, MRI is the method of choice for the detection of intracranial injuries, particularly those associated with shaking-induced trauma.
- * If evidence of child abuse is being sought and the CT scan is negative (shows no evidence of injury), an MRI scan should be strongly considered if available. Even when the findings of the CT scan are positive, MRI may be advisable to portray the injury fully.
- * When the patient's clinical symptoms indicate more substantial injury than that shown by CT, an MRI examination should also be performed.
- * In patients who are more clinically stable, MRI is superior to CT in the screening of subacute or chronic head injury and should be the primary imaging technique whenever possible.
- * When an MRI examination shows significant intracranial injuries such as subdural hematoma, cortical contusion, and shearing injury (tearing of brain tissue) that are out of proportion to the history of injury given by the caretakers, the MRI findings should be considered to indicate child abuse, and appropriate evaluation of the social situation should be undertaken.
- * Obtaining the most thorough diagnostic imaging assessment possible requires advance preparation of the caretakers who accompany the child to the radiology department. The reason for the diagnostic study (e.g., to identify other injuries or underlying conditions) should be explained, and the caretakers should know what to expect.

- * Achievement of adequate studies in young children may require restraint or sedation and, in cases of skeletal surveys, numerous exposures. Excessive apprehension, hostility, and resistance on the part of the child usually will result in an inadequate examination. The technician performing the study should have experience in working with young children.
- * Clinical personnel should treat the caretakers in a professional and nonjudgmental manner.
- * Caretakers' questions regarding either the reasons for the study or the results should be directed to the referring physician.
- * Imaging examinations must be viewed in the context of other clinical findings. The implications of the examinations are best addressed by physicians and other healthcare workers familiar with the family and skilled in these sensitive interactions.
- * A single view of the entire infant ("babygram") is inadequate.

Shaken Baby Syndrome

The term "shaken baby syndrome" (SBS) was developed to explain those instances in which severe intracranial trauma occurred in the absence of signs of external head trauma. SBS is the severe intentional application of violent force (shaking) in one or more episodes, resulting in intracranial injuries to the child. Physical abuse of children by shaking usually is not an isolated event. Many shaken infants show evidence of previous trauma. Frequently, the shaking has been preceded by other types of abuse.

Mechanism of Injury

The mechanism of injury in SBS is thought to result from a combination of physical factors, including the proportionately large cranial size of infants, the laxity of their neck muscles, and the vulnerability of their intracranial bridging veins, which is due to the fact that the subarachnoid space (the space between the arachnoid membrane and the pia mater, which are the inner two of the three membranes that cover the brain) are somewhat larger in infants. However, the primary factor is the proportionately large size of the adult relative to the child. Shaking by admitted assailants has produced remarkably similar injury patterns:

- * The infant is held by the chest, facing the assailant, and is shaken violently back and forth.
- * The shaking causes the infant's head to whip forward and backward from the chest to the back.
- * The infant's chest is compressed, and the arms and legs move about with a whiplash action.
- * At the completion of the assault, the infant may be limp and either not breathing or breathing shallowly.
- * During the assault, the infant's head may strike a solid object.
- * After the shaking, the infant may be dropped, thrown, or slammed onto a solid surface.

The last two events likely explain the many cases of blunt injury, including skull fractures, found in shaken infants. However, although blunt injury may be seen at autopsy in shaken infants, research data suggest that shaking in and of itself is often sufficient to cause serious intracranial injury or death.

Indicators and Symptoms

Crying has come under increasing scrutiny as a stimulus for abusive activity. Because shaking is generally a response to crying, a previous illness causing irritability may increase the likelihood that the infant will be shaken. The occurrence of infant abuse is a product of a delicate balance between the severity of the stimulus of crying and the threshold for violent action by potential abusers. The effects of drugs, alcohol, and environmental conditions may trigger this interaction.

The average age of infants abused by shaking is 6 months. The physical alterations characteristic of SBS are uncommon in children older than 1 year. Many symptomatic shaken infants have CNS findings of seizures, lethargy, or coma. Many are resuscitated at home or en route to the hospital and arrive there in serious condition, with a tense fontanelle (the soft spot covered by a membrane, at the top of an infant's head, where the skull bones have not yet joined). Some patients have milder changes in consciousness or a history of choking, vomiting, or poor feeding. Although gross evidence of trauma is usually absent, careful inspection may reveal sites of bruising.

Most infants in whom shaking has been documented have retinal hemorrhage (bleeding along the back inside layer of the eyeball). Other intracranial injuries ascribed to shaking trauma include extra-axial fluid collections (fluid between the skull and brain, e.g., subdural hematoma), axonal shearing injuries at the gray-matter/white-matter interfaces (tearing of brain tissue), and cerebral edema (swelling of the brain).

Diagnostic Recommendations in Cases of Suspected Shaken Baby Syndrome

Although retinal hemorrhage implies that shaking was a factor in causing an injury, physical examination, imaging studies, and pathological examination are needed to determine whether evidence of direct external trauma also exists. While medically such causative distinctions are not crucial to documenting physical abuse, legally, the mechanism of injury is useful for the physician confronted with the necessity of testifying as to the cause of a child's injuries.

- * All infants suspected of being abused should undergo a radiological skeletal survey. This should be performed with high-detail systems and with painstaking attention to technique. A single view of the entire infant ("babygram") is inadequate.
- * Repetition of skeletal imaging 2 to 3 weeks after the initial examination may provide evidence of a healing injury that was not apparent on initial studies, and should be performed in all infants when abuse is strongly suspected.
- * High-quality, state-of-the-art skeletal scintigraphy may be an important supplement to radiological skeletal surveys and has been advocated by some physicians as a primary screening tool in cases of suspected abuse. In the toddler and young child, scintigraphy poses a practical alternative to x-rays; however, caution should be exercised in using scintigraphy as a primary screening tool in infants.
- * All infants with clinical neurological findings should undergo cranial CT. This will be sufficient to define any surgically correctable condition.
- * Most patients should undergo MRI eventually to define the extent of the injury fully, determine the prognosis, and provide evidence for intervention and criminal proceedings.
- * Abdominal injuries are uncommon in abused infants, and imaging studies should be tailored to the specific clinical concern. CT and ultrasound are helpful in establishing whether internal abdominal trauma has occurred in infants thought to have been shaken.

Investigative Guidelines for Cases of Shaken Baby Syndrome

- * The use of MRI has helped detect old and new intracranial injuries and has aided recognition of subtle instances of repetitive shaking.
- * Repetitive abuse has important legal and clinical implications. If abuse is repetitive, the child is at high risk for further injury unless legal action is taken. Establishing that there has been a pattern of abuse can also help in identifying potential perpetrators and may lead to increased legal penalties.
- * The fact that shaken children, and possibly their siblings, often have been previously abused should dispel the notion that shaking is an isolated and somewhat “unintentional” event.
- * From the perspective of the protection of the child or the criminal prosecution of the abuser, it is not as important to distinguish the precise mechanism of injury as it is to be certain that the event was nonaccidental.
- * Pediatricians should not be deterred from testifying when the cause of the nonaccidental injury is not entirely clear.
- * Shaking a child creates an imminent risk for an acute injury.
- * Injuries that appear to be caused by shaking create a high index of suspicion of child abuse and should be followed by intensive efforts (e.g., skeletal survey, CT, and MRI) to identify concurrent and previous abuse of the patient and any siblings.
- * If an infant’s injuries are fatal, an autopsy should be performed by a forensic pathologist. Autopsies of all infants who die of causes other than known natural illness should include thorough skeletal imaging.

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Supplemental Reading

Kleinman PK. Diagnostic imaging in infant abuse. *American Journal of Radiology* 155:703-712, 1990.

Kleinman PK. *Diagnostic Imaging of Child Abuse*. Baltimore: Williams & Wilkins, 1987.

The Pediatric Trauma and Forensic Newsletter. A centralized source of information on the medical/legal aspects of childhood trauma and disease (505-281-8109).

Reece RM (ed). *Child Abuse: Medical Diagnosis and Management*. Malvern, PA: Lea and Febiger, 1994.

Reece RM (ed). *The Quarterly Child Abuse Medical Update*. Published by the Institute for Professional Education of the Massachusetts Society for the Prevention of Cruelty to Children (MSPCC). Abstracts of the latest information on the subject of child abuse from more than 40 medical journals (617-587-1500).

Organizations

Missing and Exploited Children's Training Programs
Fox Valley Technical College
Criminal Justice Department
P.O. Box 2277
1825 North Bluemound Drive
Appleton, WI 54913-2277
800-648-4966
920-735-4757 (fax)
Internet: www.foxvalley.tec.wi.us/ojjdp

Participants are trained in child abuse and exploitation investigative techniques, covering the following areas:

- * Recognition of signs of abuse.
- * Collection and preservation of evidence.
- * Preparation of cases for prosecution.
- * Techniques for interviewing victims and offenders.
- * Liability issues.

Fox Valley also offers intensive special training for local child investigative teams. Teams must include representatives from law enforcement, prosecution, social services, and (optionally) the medical field. Participants take part in hands-on team activity involving:

- * Development of interagency processes and protocols for enhanced enforcement, prevention, and intervention in child abuse cases.
- * Case preparation and prosecution.
- * Development of the team's own interagency implementation plan for improved investigation of child abuse.

National Center for Prosecution of Child Abuse
American Prosecutors Research Institute (APRI)
99 Canal Center Plaza, Suite 510
Alexandria, VA 22314
703-739-0321
703-549-6259 (fax)

The National Center for Prosecution of Child Abuse is a nonprofit and technical assistance affiliate of APRI. In addition to research and technical assistance, the Center provides extensive training on the investigation and prosecution of child abuse and child deaths. The national trainings include timely information presented by a variety of professionals experienced in the medical, legal, and investigative aspects of child abuse.

National Children's Alliance
1319 F Street NW., Suite 1001
Washington, DC 20004-1106
800-239-9950 or
202-639-0597
202-639-0511 (fax)
Internet: www.nca-online.org

Regional Children's Advocacy Centers (CAC's):

- * Midwest Regional Children's Advocacy Center, St. Paul, MN, 888-422-2955, 651-220-6750 www.nca-online.org/mrcac.
- * Northeast Regional Children's Advocacy Center, Philadelphia, PA, 215-387-9500, www.nca-online.org/nrcac.

- * Southern Regional Children's Advocacy Center, Rainbow City, AL, 256-413-3158, www.nca-online.org/srcac.
- * Western Regional Children's Advocacy Center, Pueblo, CO, 719-543-0380, www.nca-online.org/wrcac.

OJJDP funds the National Children's Alliance and the four regional CAC's to help communities establish and strengthen CAC and multidisciplinary team programs. The Alliance conducts national training events and provides grants for CAC program development and support. The four regional CAC's provide information, onsite consultation, and intensive training and technical assistance to help establish and strengthen CAC's and facilitate and support coordination among agencies responding to child abuse. The Alliance also publishes a number of manuals and handbooks of use to MDT's.

Parents Against Child Abuse (PACA)

Cheri Robertson
 P.O. Box 890095
 Temecula, CA 92589
 909-699-4800

Other Titles in This Series

Currently there are 12 other Portable Guides to Investigating Child Abuse. To obtain a copy of any of the guides listed below (in order of publication), contact the Office of Juvenile Justice and Delinquency Prevention's Juvenile Justice Clearinghouse by telephone at 800-638-8736 or e-mail at puborder@ncjrs.org.

Recognizing When a Child's Injury or Illness Is Caused by Abuse, NCJ 160938

Sexually Transmitted Diseases and Child Sexual Abuse, NCJ 160940

Photodocumentation in the Investigation of Child Abuse, NCJ 160939

Battered Child Syndrome: Investigating Physical Abuse and Homicide, NCJ 161406

Interviewing Child Witnesses and Victims of Sexual Abuse, NCJ 161623

Child Neglect and Munchausen Syndrome by Proxy, NCJ 161841

Criminal Investigation of Child Sexual Abuse, NCJ 162426

Burn Injuries in Child Abuse, NCJ 162424

Law Enforcement Response to Child Abuse, NCJ 162425

Understanding and Investigating Child Sexual Exploitation, NCJ 162427

Forming a Multidisciplinary Team To Investigate Child Abuse, NCJ 170020

Use of Computers in the Sexual Exploitation of Children, NCJ 170021

Additional Resources

American Bar Association
(ABA)
Center on Children and the
Law
Washington, DC
202-662-1720
202-662-1755 (fax)

American Humane Association
Englewood, Colorado
800-227-4645
303-792-9900
303-792-5333 (fax)

American Medical Association
(AMA)
Department of Mental Health
Chicago, Illinois
312-464-5066
312-464-5000
(AMA main number)
312-464-4184 (fax)

American Professional Society
on the Abuse of Children
(APSAC)
Chicago, Illinois
312-554-0166
312-554-0919 (fax)

C. Henry Kempe National
Center for the Prevention
and Treatment of Child
Abuse and Neglect
Denver, Colorado
303-864-5250
303-864-5179 (fax)

Federal Bureau of Investigation
(FBI)
National Center for the
Analysis of Violent Crime
Quantico, Virginia
703-632-4400

Fox Valley Technical College
Criminal Justice Department
Appleton, Wisconsin
800-648-4966
920-735-4757 (fax)

Juvenile Justice Clearinghouse
(JJC)
Rockville, Maryland
800-638-8736
301-519-5212 (fax)

National Association of Medical
Examiners
St. Louis, Missouri
314-577-8298
314-268-5124 (fax)

National Center for Missing
and Exploited Children
(NCMEC)
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703-274-2222 (fax)

National Center for
Prosecution of Child Abuse
Alexandria, Virginia
703-739-0321
703-549-6259 (fax)

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800-239-9950
202-639-0597
202-639-0511 (fax)

National Clearinghouse on
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Information
Washington, DC
800-FYI-3366
703-385-7565
703-385-3206 (fax)

National SIDS Resource
Center
Vienna, Virginia
703-821-8955, ext. 249
703-821-2098 (fax)

Prevent Child Abuse America
Chicago, Illinois
800-835-2671
312-663-3520
312-939-8962 (fax)

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