American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

POLICY STATEMENT

Diagnostic Imaging of Child Abuse

Organizational Principles to Guide and Define the Child Health Care System and/or Improve the Health of All Children

Section on Radiology

ABSTRACT

The role of imaging in cases of child abuse is to identify the extent of physical injury when abuse is present and to elucidate all imaging findings that point to alternative diagnoses. Effective diagnostic imaging of child abuse rests on high-quality technology as well as a full appreciation of the clinical and pathologic alterations occurring in abused children. This statement is a revision of the previous policy published in 2000. *Pediatrics* 2009;123:1430–1435

www.pediatrics.org/cgi/doi/10.1542/peds.2009-0558

doi:10.1542/peds.2009-0558

All policy statements from the American Academy of Pediatrics automatically expire 5 years after publication unless reaffirmed, revised, or retired at or before that time.

Key Words

diagnostic imaging, child abuse, injury, trauma

Abbreviations

CT—computed tomography

DWI—diffusion-weighted imaging

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

INTRODUCTION

The concept of child abuse as a medical entity has an origin in the studies of pediatric radiologist John Caffey, MD,[1] as well as many other specialists in the field of diagnostic imaging.[2–4] Kempe et al[5] relied heavily on the work of Caffey and his protégé, Frederick Silverman, MD,[6] when developing the now-familiar concept of the "battered-child syndrome."

When all cases of child abuse and neglect are studied, the incidence of physical evidence documented by diagnostic imaging studies is relatively small. However, imaging studies are often critical, particularly in the assessment of the infant and young child with evidence of physical injury. Imaging alterations may also be the first indication of abuse in a child who is seen with an apparent natural illness. When viewed in conjunction with clinical and laboratory studies, imaging findings commonly provide additional objective evidence in the evaluation of possible inflicted injury or abuse.[7] For severely abused infants, the imaging findings alone may form the basis for a diagnosis of the inflicted injury. The role of imaging in cases of suspected abuse is not only to identify the extent of physical injury when abuse has occurred but also to elucidate all imaging findings that point to alternative diagnoses.[8,9] All imaging studies involving use of ionizing radiation should be performed in accordance with the ALARA ([using an exposure] as low as reasonably achievable) principle.[10] Because the detection of inflicted skeletal injury depends on the technical quality of the radiographs and the imaging protocol, recommendations regarding imaging should focus on examinations that provide the highest diagnostic yield at acceptable patient risk and cost.[11] Certain diagnostic imaging studies entail additional risks associated with sedation, and these risks should be weighed against the benefit of the study.[12]

SKELETAL TRAUMA

Although skeletal injuries rarely pose a threat to the life of the abused child, they are often the strongest radiologic indicators of abuse. In fact, in an otherwise normal infant, certain patterns of injury are sufficiently characteristic to permit a firm diagnosis of inflicted injury in the absence of clinical information.[13] Furthermore, dating of skeletal injuries may provide investigators with critical temporal data, which may help in identifying potential assailants. These facts mandate that imaging surveys performed to identify skeletal injury be acquired with at least the same level of technical excellence routinely used to evaluate accidental injuries. The "baby gram" (a study that encompasses the entire infant or young child on 1 or 2 radiographic exposures) or abbreviated skeletal surveys have no role in the imaging of these subtle but highly specific bony abnormalities.[14]

THE RADIOGRAPHIC SKELETAL SURVEY

Equipment

In general, the radiographic skeletal survey is the method of choice for global skeletal imaging in cases of suspected abuse.[14] General-purpose (medium-speed) pediatric imaging systems provide insufficient anatomic detail to image the skeleton of the abused infant or young child. The American College of Radiology has published standards for skeletal survey imaging in cases of suspected abuse. Modern pediatric imaging systems commonly use special film cassettes and intensifying screens to minimize exposure. Although these low-dose systems are adequate for chest and abdominal imaging, they fail to provide the necessary detail (contrast and spatial resolution) to image subtle metaphyseal, rib, and other high-specificity injuries that are characteristic of abuse. According to the American College of Radiology, high-detail imaging systems should be used for suspected abuse in infancy.[14] These systems should be used without an antiscatter grid. Beyond infancy, faster general-purpose systems are required for thicker body regions (eg, skull, lateral lumbar spine).

Digital or filmless radiography has replaced screen/film imaging in most pediatric health care facilities in the United States.[15] A wide array of digital systems are available, including direct and indirect technologies. Data suggest that despite its lower spatial resolution, digital radiography, with its wide dynamic range and high contrast capabilities, can provide diagnostic performance comparable to high-detail screen/film systems in the evaluation of skeletal injury.[16,17] High-detail digital systems are being used successfully in the rigorous field of mammography, and efforts are currently underway to apply similar techniques to demanding skeletal applications.[18] Unfortunately, most digital systems currently used for skeletal surveys in the United States operate at relatively low spatial resolutions, and they are not routinely optimized for the demanding practice of imaging for suspected child abuse.[15] Imaging departments should use digital systems with sufficient spatial resolution and signal-to-noise characteristics to detect subtle skeletal injuries. Image detail and diagnostic performance can be improved by optimizing exposure to diminish system noise. Acceptable diagnostic accuracy with traditional screen/film imaging has required higher radiation exposures than for routine pediatric radiography, and similarly, an increase in exposure over standard digital radiography can be expected if maximal diagnostic accuracy is to be preserved with the digital medium. However, recent data have suggested that a performance comparable to the high-detail screen/film gold standard may be achievable with high-detail digital imaging at a substantially lower patient dose.[17] Digital facilities should optimize their acquisition and display parameters for high diagnostic performance,[19] and if the resultant images provide insufficient bony detail, an acceptable alternative should be sought. A radiologist should monitor the skeletal survey to ensure that appropriate high-quality images are obtained and to determine if additional views are required to fully define the pathologic alterations.

Imaging Protocol

Once the appropriate imaging system is chosen, a precise protocol for skeletal imaging must be developed to ensure consistent quality. In routine skeletal imaging, an accepted principle is that film must be coned or restricted to the specific anatomic area of interest. It is common practice to encompass larger anatomic regions when skeletal surveys are performed, which results in areas of underexposure and overexposure as well as loss of resolution resulting from geometric distortion and other technical factors. The standard skeletal survey imaging protocol that has been developed by the American College of Radiology[14] is provided in Table 1. Of special note is the inclusion of lateral views of the spine to assess for vertebral fractures and dislocations and separate views of the hands and feet to identify subtle digital injuries. Anteroposterior and lateral views of the skull are mandatory even when cranial computed tomography (CT) has been performed, because skull fractures coursing in the axial plane may be missed with axial CT.[11] A full 4-view examination of the skull (right and left lateral, Townes, and anteroposterior) should be obtained when head injury is present. Skeletal injuries, especially those requiring orthopedic management, necessitate at least 2 radiographic projections. Oblique views of the thorax increase the yield for the detection of rib fractures.[20] At a minimum, right and left oblique views of the thorax should be obtained when rib fractures are evident, and consideration should be given to including obliques in the standard survey protocol. A follow-up skeletal survey approximately 2 weeks after the initial study increases the diagnostic yield[21,22] and should be performed when abnormal or equivocal findings are found on the initial study and when abuse is suspected on clinical grounds. A repeat study may permit more precise determination of the age of individual injuries. Lack of interval change may indicate that the initial radiographic finding is a normal anatomic variant or is related to a bone dysplasia. Views of the skull can be omitted from the follow-up study.

TABLE 1 Complete Skeletal Survey Table[14]

Appendicular skeleton
Arms (AP)
Forearms (AP)
Hands (PA)
Thighs (AP)
Legs (AP)
Feet (PA or AP)
Axial skeleton
Thorax (AP and lateral), to include thoracic spine and ribs
AP abdomen, lumbosacral spine, and bony pelvis
Lumbar spine (lateral)
Cervical spine (AP and lateral)
Skull (frontal and lateral)

AP indicates anteroposterior; PA, posteroanterior.

Radionuclide Bone Scans

When performed by staff experienced with pediatric nuclear imaging, skeletal scintigraphy may offer an alternative or adjunct to the radiographic skeletal survey in selected cases, particularly for children older than 1 year. Scintigraphy can provide increased sensitivity for detecting rib fractures, subtle shaft fractures, and areas of early periosteal elevation. However, scintigraphy is less sensitive than radiography for detection of classic metaphyseal lesions, which are fractures that carry a high specificity for abuse in infants.[23–25] Skeletal scintigraphy usually requires sedation and is generally more expensive than radiographic surveys. Bone scans are used to supplement radiographic skeletal surveys in the acute-care setting,[24] but for the child who is placed in a "safe" environment, a follow-up skeletal survey is an attractive alternative to initial scintigraphy. If radionuclide bone scans are performed as the initial study, all positive areas must be evaluated further with radiography. Because scintigraphy is insensitive for detecting cranial injuries, skull radiography in at least 2 projections must supplement the bone scan.

Imaging Guidelines

The skeletal survey is mandatory in all cases of suspected physical abuse in children younger than 2 years; its utility diminishes thereafter.[8,26] The screening skeletal survey or bone scan has little value in children older than 5 years. Decisions about which types of imaging to perform for patients in the 2- to 5-year-old age group must be made individually on the basis of the specific clinical indicators of abuse. At any age, when clinical findings point to a specific site of injury, the customary radiographic protocol for imaging that anatomic region should be used. MRI and ultrasonography may be indicated when epiphyseal separations are suspected on the basis of plain-film radiography.[2,27] Evidence suggests that if 1 infant twin is injured, the other is at risk and should also undergo a skeletal survey.[28] Although there seems to be an association between physical and sexual abuse, the prevalence of fractures in sexually assaulted children is low; thus, skeletal surveys should be performed only in selected cases on the basis of specific clinical indications.[29,30] Although the high-quality skeletal survey is essential in the evaluation of suspected physical abuse in infants and toddlers, it may not be available in the emergency department setting during evening hours.[15] The American Academy of Pediatrics has stated that hospitalization of the abused child may be medically necessary for diagnosis,[31] and in some instances it may be advisable to place a child in a safe haven until a proper skeletal survey can be performed.[31] A skeletal survey may be difficult to obtain in a critically injured child on life support. Efforts should be directed at performing an adequate examination in a timely manner, because the results may have an effect on the early investigation of the case.

HEAD TRAUMA

High-energy forces associated with impact or violent shaking result in a variety of central nervous system injuries that can be detected by modern neuroimaging techniques. The evolution of these injuries, as well as processes that develop secondary to the original insult, are often effectively displayed on serial imaging studies.[2,32–35]

All infants and children with suspected intracranial injury must undergo cranial CT, MRI, or both. Strategies should be directed toward the detection of all intracranial sequelae of abuse and neglect with a thorough characterization of the extent and age of the abnormalities.[36] In the acute-care setting, efforts are directed toward rapid detection of treatable conditions. Subsequent studies are designed to more fully delineate all abnormalities, determine the timing of the injuries, and monitor their evolution.

Computed Tomography

CT without intravenous contrast should be performed as part of the initial evaluation for suspected acute inflicted head injury. CT has high sensitivity and specificity for diagnosing acute intraparenchymal, subarachnoid, subdural, and epidural hemorrhage. Abnormalities that require emergency surgical intervention generally are well demonstrated. CT is readily available and rapidly performed for critically ill patients and is generally better than MRI for evaluation of acute hemorrhage. Skull fractures, associated soft tissue swelling, and facial fractures also can be diagnosed on CT images with appropriate bone window and level settings. With modern multidetector CT scanners, the brain can be imaged in a few seconds, usually obviating the need for sedation.

Ultrasonography

Ultrasonography via the anterior fontanelle in young infants has gained an important role in clarifying the nature of extra-axial fluid collections in infancy. Because ultrasonography reliably differentiates convexity subdural from subarachnoid collections, it is particularly useful for the infant with macrocephaly or any infant with large hypodense cerebral convexity collections demonstrated by CT.[37] Subcortical white matter tears in the frontal and anterior parietal parasagittal regions can be demonstrated with ultrasonography.[38] These lesions are less well defined by axial CT, and ultrasonography provides the advantage of a bedside technique. Because ultrasonography is insensitive for detecting small acute subdural hematomas, particularly within the interhemispheric fissure, and many other acute intracranial injuries, it must be performed in conjunction with CT or MRI when traumatic injury is suspected.[29,39]

Magnetic Resonance Imaging

Although cranial MRI has some limitations in the acute-care setting, it remains the best modality for fully assessing intracranial injury, including extra-axial collections, intraparenchymal hemorrhages, contusions, shear injuries, and brain swelling or edema. A strong argument can be made for MRI in all cases with positive cranial CT findings and in selected cases with normal CT results but strong clinical concerns. MRI should be performed with T_1 and T_2 weighting with proton-density or inversion-recovery sequences to differentiate cerebrospinal fluid collections from other water-containing lesions. Gradient echo sequences should be included to detect hemorrhage or mineralization not demonstrable by other MRI techniques. Although the specific type and order of pulse sequences may vary, imaging must be performed at least in the axial and coronal planes. Acute subarachnoid and subdural hemorrhage may be inconspicuous on MRI, and consideration should be given to delaying the examination for 5 to 7 days, permitting subacute blood to become hyperintense on T1-weighted sequences.

Diffusion-weighted imaging (DWI) is a relatively new and valuable technique for the evaluation of stroke and is gaining a role in the assessment of inflicted cerebral injury. When performed early in the critically injured infant, DWI may provide information regarding cerebral injury before parenchymal abnormalities are visible on CT or conventional MRI sequences.[40,41] The value of the potential findings revealed with DWI must be weighed against the lower sensitivity of MRI in the detection of acute extra-axial blood collections and the practical problems encountered when performing MRI in severely ill infants.

Abused infants may not demonstrate neurologic signs and symptoms despite significant central nervous system injury.[2,42,43] MRI offers the highest sensitivity and specificity for diagnosing subacute and chronic injury and should be considered whenever typical skeletal injuries associated with shaking or impact are identified.[39,44]

SPINAL TRAUMA

Plain radiographs are often sufficient to evaluate vertebral compression and spinous process fractures. Complex fractures may require helical CT with multiplanar reformatted images. If a fracture or subluxation may compromise the spinal contents or if clinical findings indicate spinal cord or nerve root injury, MRI should be performed. Increasing attention has been directed toward a possible association of cervical spinal cord injury and extra-axial hemorrhage with inflicted head injury, and some centers include the cervical region in their cranial MRI trauma protocols.[45,46]

THORACOABDOMINAL TRAUMA

Blunt thoracoabdominal injury may occur in victims of child abuse. The evaluation and management of acute thoracoabdominal injury is the same as for children with accidental injuries.[47] However, when an infant or child sustains serious injury to the chest or abdomen without a known or observed mechanism or when the imaging findings are inconsistent with the purported history, investigation of potential child abuse is warranted. Failure to recognize inflicted blunt abdominal trauma contributes to higher morbidity and mortality rates than those seen with accidental abdominal injury.[48] Pancreatitis, duodenal hematomas, bowel perforation, and thoracoabdominal injury associated with rib fracture heighten the suspicion of child abuse. Chest, abdominal, and cervical spine radiographs often are obtained in the initial assessment of injured children. If internal chest or abdominal injury is suspected and the patient's condition is stable, a CT scan should be performed. A CT scan will best demonstrate many of the injuries associated with child abuse. The chest should be included if serious chest trauma is suspected.

The use of oral contrast is debatable. Oral contrast in the stomach and small bowel is useful to better define the lesser sac of the peritoneum, pancreas, duodenum, and jejunum. However, oral contrast may place the patient at greater risk of aspirating, especially if the patient is obtunded, sedated, or immobilized. If surgery or general anesthesia is likely, it is better to have an empty stomach.

TABLE 2 **Imaging Recommendations for Thoracoabdominal Trauma**

1.	Helical CT[a] of abdomen and/or thorax with intravenous contrast; nonionic is preferable; gastrointestinal contrast optional
2.	Ultrasonography of abdomen, usually as a follow-up examination
3.	Upper-gastrointestinal series

[a] Relative contraindication: strong history of allergy to iodine, severe shock, and renal failure.

Intravenous contrast is used routinely. Vascular injuries and injuries to the liver, spleen, pancreas, and kidneys are best demonstrated after administration of intravenous contrast material. Helical scanning with proper timing of the intravenous contrast bolus is important for accurate diagnosis. Given the heightened awareness of cancer risks associated with CT scanning in childhood, care should be taken to adjust technical factors to achieve diagnostic quality images at an exposure as low as reasonably achievable.[49,50] The only relative contraindications for intravenous contrast are a strong history of allergy to iodine, severe shock, and renal failure.

Abused children suffer some of the same injuries as children with accidental blunt trauma. In the chest, pulmonary contusion, pneumothorax, pleural effusion, rib fractures, and vascular or tracheobronchial injuries may occur. Abused children have an increased occurrence of pancreatic injuries and duodenal hematomas. Bowel injury should be suspected when there is peritoneal fluid without evidence of solid organ injury and assumed when free intraperitoneal air or extraluminal contrast is observed.[51] Bone windows should be monitored not only for rib fractures but also for signs of pelvic or spine fractures.

Peritoneal lavage rarely is used in pediatric practice. If performed before CT, it may decrease the diagnostic usefulness. Peritoneal lavage sometimes is used when emergency surgery is required to treat a patient whose condition is not stable enough for a CT scan.[49]

The use of ultrasonography in pediatric trauma is controversial. Some institutions have used ultrasonography successfully for a more detailed, comprehensive evaluation of organ injury. However, for seriously injured children and those with suspected child abuse, CT scanning is the preferred initial diagnostic modality in most institutions. Peritoneal fluid alone, which can be detected well with both ultrasonography and CT scanning, is a poor predictor of major trauma in children. An upper-gastrointestinal series sometimes is used to evaluate and follow-up duodenal hematomas.

Nonoperative management of injury to the liver, spleen, kidney, or pancreas is common in most pediatric centers. Follow-up imaging usually is limited but may be useful to help determine recommendations for the level of physical activity (Table 2).

CONCLUSIONS

The diagnostic imaging of suspected inflicted injury in infancy and childhood should be performed with at least the same rigor used in the imaging evaluation of accidental trauma and naturally occurring disease. To be confident that the imaging studies are acquired and interpreted in a thorough and informed manner, clinicians charged with reporting and providing evidence in cases of suspected abuse should work in close collaboration with radiologists experienced in pediatric imaging. This approach will help ensure that child abuse is accurately identified and reliably differentiated from conditions that may simulate abuse.[14]

SECTION ON RADIOLOGY, 2006–2007

Michael A. Di Pietro, MD, Chairperson
Alan S. Brody, MD
Christopher I. Cassady, MD
Paul K. Kleinman, MD*
John B. Wyly, MD
Kimberly E. Applegate, MD
Beverly P. Wood, MD
Jeffrey M. Zerin, MD
Maria G. Mercado-Deane, MD
Joanna J. Seibert, MD

STAFF

Aleksandra Stolic, MPH

*Lead authors

REFERENCES

1. Reece RM, Ludwig S, eds. *Child Abuse: Medical Diagnosis and Management*. Philadelphia, PA: Lippincott Williams & Wilkins; 2001
2. Kleinman PK. *Diagnostic Imaging of Child Abuse*. St Louis, MO: Mosby; 1998
3. Kuhn JP, Slovis TL, Haller JO. *Caffey's Pediatric Diagnostic Imaging*. Philadelphia, PA: Mosby; 2004
4. Caffey J. Multiple fractures in the long bones of infants suffering from chronic subdural hematoma. *AJR Am J Roentgenol.* 1946;56(2):163–173
5. Kempe CH, Silverman FN, Steele BF, Droegemueller W, Silver HK. The battered-child syndrome. *JAMA.* 1962;181(Jul 7): 17–24
6. Silverman F. The roentgen manifestations of unrecognized skeletal trauma in infants. *Am J Roentgenol.* 1953;69(3): 413–427
7. Kleinman PK, Blackbourne BD, Marks SC, Karellas A, Belanger PL. Radiologic contributions to the investigation and prosecution of cases of fatal infant abuse. *N Engl J Med.* 1989;320(8): 507–511
8. Ablin DS, Sane SM. Non-accidental injury: confusion with temporary brittle bone disease and mild osteogenesis imperfecta. *Pediatr Radiol.* 1997;27(2):111–113
9. Merten DF, Radkowski MA, Leonidas JC. The abused child: a radiological reappraisal. *Radiology.* 1983;146(2):377–381
10. Brateman L. Radiation safety considerations for diagnostic radiology personnel. *Radiographics.* 1999;19(4):1037–1055
11. American College of Radiology, Expert Panel on Pediatric Imaging. American College of Radiology: ACR appropriateness criteria. Suspected physical abuse—child. In: American College of Radiology. *ACR Appropriateness Criteria*. Reston, VA: American College of Radiology, 2005
12. American Academy of Pediatrics; American Academy of Pediatric Dentistry, Work Group on Sedation; Coté CJ, Wilson S. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: an update. *Pediatrics.* 2006;118(6):2587–2602
13. Kleinman PK, Marks SC, Blackbourne B. The metaphyseal lesion in abused infants: a radiologic-histopathologic study. *AJR Am J Roentgenol.* 1986;146(5):895–905
14. American College of Radiology. ACR practice guideline for skeletal surveys in children (Res. 47, 17, 35). In: American College of Radiology. *ACR Standards*. Reston, VA: American College of Radiology; 2006:203–207.
15. Kleinman PL, Kleinman PK, Savageau JA. Suspected infant abuse: radiographic skeletal survey practices in pediatric health care facilities. *Radiology.* 2004;233(2):477–485
16. Kleinman PK, O'Connor B, Nimkin K, et al. Detection of rib fractures in an abused infant using digital radiography: a laboratory study. *Pediatr Radiol.* 2002;32(12):896–901
17. Kleinman P, Zurakowski D, Strauss K, Perez-Rosello J, Cleveland R, Kleinman PK. Dose reduction and image optimization with CR in the detection of simulated inflicted metaphyseal fractures in a fetal pig model. Presented at: Radiological Society of North America, 92nd Scientific Assembly and Annual Meeting; November 30, 2006; Chicago, IL.
18. Ludwig K, Schulke C, Diederich S, et al. Detection of subtle undisplaced rib fractures in a porcine model: radiation dose requirement—digital flat-panel versus screen-film and storage-phosphor systems. *Radiology.* 2003;227(1):163–168
19. Peer R, Lanser A, Giacomuzzi SM, et al. Storage phosphor radiography of wrist fractures: a subjective comparison of image quality at varying exposure levels. *Eur Radiol.* 2002;12(6): 1354–1359
20. Ingram JD, Connell J, Hay TC, Strain JD, Mackenzie T. Oblique radiographs of the chest in nonaccidental trauma. *Emerg Radiol.* 2000;7(1):42–46
21. Zimmerman S, Makoroff K, Care M, Thomas A, Shapiro R. Utility of follow-up skeletal surveys in suspected child physical abuse evaluations. *Child Abuse Negl.* 2005;29(10):1075–1083
22. Kleinman PK, Nimkin K, Spevak MR, et al. Follow-up skeletal surveys in suspected child abuse. *AJR Am J Roentgenol.* 1996; 167(4):893–896
23. Sty JR, Starshak RJ. The role of bone scintigraphy in the evaluation of the suspected abused child. *Radiology.* 1983; 146(2):369–375
24. Mandelstam SA, Cook D, Fitzgerald M, Ditchfield MR. Complementary use of radiological skeletal survey and bone scintigraphy in detection of bony injuries in suspected child abuse. *Arch Dis Child.* 2003;88(5):387–390
25. Conway JJ, Collins M, Tanz RR, et al. The role of bone scintigraphy in detecting child abuse. *Semin Nucl Med.* 1993;23(4): 321–333
26. Belfer RA, Klein BL, Orr L. Use of the skeletal survey in the evaluation of child maltreatment. *Am J Emerg Med.* 2001;19(2): 122–124
27. Nimkin K, Kleinman PK, Teeger S, Spevak MR. Distal humeral physeal injuries in child abuse: MR imaging and ultrasonography findings. *Pediatr Radiol.* 1995;25(7):562–565
28. Becker JC, Liersch R, Tautz C, Schlueter B, Andler W. Shaken baby syndrome: report on four pairs of twins. *Child Abuse Negl.* 1998;22(9):931–937
29. Johnson K, Chapman S, Hall CM. Skeletal injuries associated with sexual abuse. *Pediatr Radiol.* 2004;34(8):620–623
30. Hobbs CJ, Wynne JM. The sexually abused battered child. *Arch Dis Child.* 1990;65(4):423–427
31. American Academy of Pediatrics, Committee on Hospital Care and Committee on Child Abuse and Neglect. Medical necessity

for the hospitalization of the abused and neglected child. *Pediatrics.* 1998;101(4 pt 1):715–716
32. American Academy of Pediatrics, Committee on Child Abuse and Neglect. Shaken baby syndrome: rotational cranial injuries—technical report. *Pediatrics.* 2001;108(1):206–210
33. Chabrol B, Decarie JC, Fortin G. The role of cranial MRI in identifying patients suffering from child abuse and presenting with unexplained neurological findings. *Child Abuse Negl.* 1999; 23(3):217–228
34. Duhaime AC, Christian CW, Rorke LB, Zimmerman RA. Nonaccidental head injury in infants: the "shaken-baby syndrome." *N Engl J Med*. 1998;338(25):1822–1829
35. Sinal SH, Ball MR. Head trauma due to child abuse: serial computerized tomography in diagnosis and management. *South Med J.* 1987;80(12):1505–1512
36. Merten DF, Osborne DR, Radkowski MA, Leonidas JC. Craniocerebral trauma in the child abuse syndrome: radiological observations. *Pediatr Radiol.* 1984;14(5):272–277
37. Chen CY, Chou TY, Zimmerman RA, Lee CC, Chen FH, Faro SH. Pericerebral fluid collection: differentiation of enlarged subarachnoid spaces from subdural collections with color Doppler US. *Radiology.* 1996;201(2):389–392
38. Jaspan T, Narborough G, Punt JA, Lowe J. Cerebral contusional tears as a marker of child abuse: detection by cranial sonography. *Pediatr Radiol.* 1992;22(4):237–245
39. Ball WS Jr. Nonaccidental craniocerebral trauma (child abuse): MR imaging. *Radiology.* 1989;173(3):609–610
40. Ichord RN, Naim M, Pollock AN, Nance ML, Margulies SS, Christian CW. Hypoxic-ischemic injury complicates inflicted and accidental traumatic brain injury in young children: the role of diffusion-weighted imaging. *J Neurotrauma.* 2007;24(1): 106–118
41. Suh DY, Davis PC, Hopkins KL, Fajman NN, Mapstone TB. Nonaccidental pediatric head injury: diffusion-weighted imaging findings. *Neurosurgery.* 2001;49(2):309–318, discussion 318–320
42. Laskey AL, Holsti M, Runyan DK, Socolar RR. Occult head trauma in young suspected victims of physical abuse. *J Pediatr.* 2004;144(6):719–722
43. Rubin DM, Christian CW, Bilaniuk LT, Zazyczny KA, Durbin DR. Occult head injury in high-risk abused children. *Pediatrics.* 2003;111(6 pt 1):1382–1386
44. Sato Y, Yuh WT, Smith WL, Alexander RC, Kao SC, Ellerbroek CJ. Head injury in child abuse: evaluation with MR imaging. *Radiology.* 1989;173(3):653–657
45. Feldman KW, Weinberger E, Milstein JM, Fligner CL. Cervical spine MRI in abused infants. *Child Abuse Negl.* 1997;21(2): 199–205
46. Ghatan S, Ellenbogen RG. Pediatric spine and spinal cord injury after inflicted trauma. *Neurosurg Clin N Am.* 2002;13(2): 227–233
47. Sivit CJ, Taylor GA, Eichelberger MR. Visceral injury in battered children: a changing perspective. *Radiology.* 1989;173(3): 659–661
48. Ledbetter DJ, Hatch EI Jr, Feldman KW, Fligner CL, Tapper D. Diagnostic and surgical implications of child abuse. *Arch Surg.* 1988;123(9):1101–1105
49. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. *AJR Am J Roentgenol.* 2001;176(2):289–296
50. Frush DP, Yoshizumi T. Conventional and CT angiography in children: dosimetry and dose comparisons. *Pediatr Radiol.* 2006; 36(suppl 14):154–158
51. Sivit CJ, Taylor GA, Bulas DI, Bowman LM, Eichelberger MR. Blunt trauma in children: significance of peritoneal fluid. *Radiology.* 1991;178(1):185–188

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Diagnostic Imaging of Child Abuse

Section on Radiology

Pediatrics 2009;123;1430
DOI: 10.1542/peds.2009-0558