



Abusive Head Trauma

A Bibliography

September 2016

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Preferred citation: National Children's Advocacy Center (2016). Abusive head trauma: A bibliography. Huntsville, AL: Author.

This project was supported by a grant awarded by the Office of Juvenile Justice and Delinquency Prevention, Office of Justice Programs, U.S. Department of Justice. Points of view or opinions in this document are those of the author and do not necessarily represent the official position or policies of the U.S. Department of Justice.

Scope

This bibliography is a compilation of citations and abstracts to research articles, books, and reports covering a wide range of issues related to abusive head trauma/shaken baby syndrome. All publications are English language. This bibliography is not comprehensive.

Organization

This bibliography is arranged in date descending order. Links to full text publications are provided when possible.

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Abusive Head Trauma

A Bibliography

Berger, R. P., Fromkin, J., Herman, B., Pierce, M. C., Saladino, R. A., Flom, L., & ... Kochanek, P. M. (2016). Validation of the Pittsburgh infant brain injury score for abusive head trauma. *Pediatrics*, *138*(1), 1. doi:10.1542/peds.2015-3756.

Abusive head trauma is the leading cause of death from physical abuse. Misdiagnosis of abusive head trauma as well as other types of brain abnormalities in infants is common and contributes to increased morbidity and mortality. We previously derived the Pittsburgh Infant Brain Injury Score (PIBIS), a clinical prediction rule to assist physicians deciding which high-risk infants should undergo computed tomography of the head. Well-appearing infants 30 to 364 days of age with temperature <38.3°C, no history of trauma, and a symptom associated with an increased risk of having a brain abnormality were eligible for enrollment in this prospective, multicenter clinical prediction rule validation. By using a predefined neuroimaging paradigm, subjects were classified as cases or controls. The sensitivity, specificity, and negative and positive predictive values of the rule for prediction of brain injury were calculated. A total of 1040 infants were enrolled: 214 cases and 826 controls. The 5-point PIBIS included abnormality on dermatologic examination (2 points), age ≥3.0 months (1 point), head circumference >85th percentile (1 point), and serum hemoglobin <11.2g/dL (1 point). At a score of 2, the sensitivity and specificity for abnormal neuroimaging was 93.3% (95% confidence interval 89.0%–96.3%) and 53% (95% confidence interval 49.3%–57.1%), respectively. Our data suggest that the PIBIS accurately identifies infants who would benefit from neuroimaging to evaluate for brain injury. An implementation analysis is needed before the PIBIS can be integrated into clinical practice.

Boop, S., Axente, M., Weatherford, B., & Klimo Jr, P. (2016). [Abusive head trauma: An epidemiological and cost analysis](#). *Journal of Neurosurgery: Pediatrics*, 1-8.

Research on pediatric abusive head trauma (AHT) has largely focused on clinical presentation and management. The authors sought to review a single-institution experience from a public health perspective to gain a better understanding of the local population affected, determine overall incidence and seasonal trends, and provide details on the initial hospitalization, including extent

of injuries, neurosurgical interventions, and hospital charges. All cases of AHT involving patients who presented to Le Bonheur Children's Hospital (LBCH) from 2009 through 2014 were identified. AHT was defined as skull fracture or intracranial hemorrhage in a child under the age of 5 years with a suspicious mechanism or evidence of other intentional injuries, such as retinal hemorrhages, old or new fractures, or soft-tissue bruising. Injuries were categorized as Grade I (skull fracture only), Grade II (intracranial hemorrhage or edema not requiring surgical intervention), or Grade III (intracranial hemorrhage requiring intervention or death due to brain injury). Two hundred thirteen AHT cases were identified. The demographics of the study population are similar to those reported in the literature: the majority of the patients involved were 6 months of age or younger (55%), male (61%), African American (47%), and publicly insured (82%). One hundred one neurosurgical procedures were performed in 58 children, with the most common being bur hole placement for treatment of subdural collections (25%) and decompressive hemicraniectomy (22%). The annual incidence rate rose from 2009 (19.6 cases per 100,000 in the population under 5 years of age) to 2014 (47.4 cases per 100,000) and showed seasonal peaks in January, July, and October (6-year average single-month incidence, respectively, 24.7, 21.7, and 24.7 per 100,000). The total hospital charges were \$13,014,584, with a median cost of \$27,939. Treatment costs for children who required surgical intervention (i.e., those with Grade III) were up to 10 times those of children with less severe injuries. In the authors' local population, victims of AHT are overwhelmingly infants, are more often male than female, and are disproportionately from lower socioeconomic ranks. The incidence is increasing and initial hospitalization charges are substantial and variable. The authors introduce a simple 3-tiered injury classification scheme that adequately stratifies length of hospital stay and cost.

Christian, C. W., & AAP Committee on Child Abuse and Neglect (2016). [Understanding abusive head trauma in infants and children: Answers from America's Pediatricians.](#) American Academy of Pediatrics.

Karibe, H., KaMeyaMa, M., HayasHi, T., Narisawa, A., & Tominaga, T. (2016). [Acute subdural hematoma in infants with abusive head trauma: A literature review.](#) *Neurologia medico-chirurgica*, 56(5), 264.

The number of cases with child abuse is increasing in Japan, and abusive head trauma (AHT) is a major cause of death in abused children. Child abuse has been recognized by the late 19th century, and widely accepted as battered child syndrome in the middle of the 20th century. As terms, there had been considerable mechanistic controversies between shaken-baby and -impact syndrome until the beginning of the 21st century. In recent years, AHT has been utilized as a less mechanistic term. Most of the characteristics of AHT in Japan have been similar to those in the United States as follows: infant is the most common victim, acute subdural hematoma (SDH) is the most common intracranial lesion, and retinal hemorrhage is often complicated. On the other hand, several characteristics have been different as follows: mother is the most common perpetrators, impact is a more common mechanism of trauma than shaking, and external trauma is more common reflecting the existence of impact. Since AHT as well as child abuse is a social pathological phenomenon influenced by victims, perpetrators, socioeconomic circumstances, and so on, various aspects of AHT as well as child abuse can be changed with times. Actually, a recent paper suggests such changes in infants with acute SDH due to AHT. In this review article, AHT, abusive infantile acute SDH in particular, are reviewed from the aspect of neurosurgical perspectives, including its mechanisms of trauma, biomechanics, clinical features, management, and prognosis, to update the trend in Japan. (Author Abstract

Letson, M. M., Cooper, J. N., Deans, K. J., Scribano, P. V., Makoroff, K. L., Feldman, K. W., & Berger, R. P. (2016). Practice implications: Prior opportunities to identify abuse in children with abusive head trauma. *Child Abuse & Neglect*. Online ahead of print. doi:10.1016/j.chiabu.2016.09.001

Infants with minor abusive injuries are at risk for more serious abusive injury, including abusive head trauma (AHT). Our study objective was to determine if children with AHT had prior opportunities to detect abuse and to describe the opportunities. All AHT cases from 7/1/2009-12/31/2011 at four tertiary care children's hospitals were included. A prior opportunity was defined as prior evaluation by either a medical or child protective services (CPS) professional when the symptoms and/or referral could be consistent with abuse but the diagnosis was not made

and/or an alternate explanation was given and accepted. Two-hundred-thirty-two children with AHT were identified; median age (IQR) was 5.40 (3.30, 14.60) months. Ten percent (22/232) died. Of the 232 patients diagnosed with AHT, 31% (n=73) had a total of 120 prior opportunities. Fifty-nine children (25%) had at least one prior opportunity to identify abuse in a medical setting, representing 98 prior opportunities. An additional 14 (6%) children had 22 prior opportunities through previous CPS involvement. There were no differences between those with and without a prior opportunity based on age, gender, race, insurance, mortality, or institution. Children with prior opportunities in a medical setting were more likely to have chronic subdural hemorrhage (48 vs. 17%, $p<0.01$) and healing fractures (31 vs. 19%, $p=0.05$). The most common prior opportunities included vomiting 31.6% (38/120), prior CPS contact 20% (24/120), and bruising 11.7% (14/120). Improvements in earlier recognition of AHT and subsequent intervention might prevent additional injuries and reduce mortality.

Burkhart, Z. N., Thurber, C. J., Chuang, A. Z., Kumar, K. S., Davis, G. H., & Kellaway, J. (2015). [Risk factors associated with retinal hemorrhage in suspected abusive head trauma](#). *Journal of American Association for Pediatric Ophthalmology and Strabismus*, 19(2), 119-123.

Colbourne, M. (2015). [Abusive head trauma: Evolution of a diagnosis](#). *British Columbia Medical Journal*, 57(8), 331-335.

Over the past 60 years, the diagnosis of abuse in children has been challenged within both the medical and the legal communities. Nowhere has this been more apparent than in the literature addressing abusive head trauma in infants and children. The diagnostic terminology used currently, while more encompassing than terminology used in the past, has contributed to confusion about the strength of scientific evidence for inflicted injuries. Fortunately, a variety of medical disciplines, including pediatrics, emergency medicine, radiology, ophthalmology, pathology, biomechanics, neurosurgery, and neurology, have contributed to an unprecedented growth in our understanding of inflicted head trauma in children. We can now confirm that abusive head trauma does occur, that it is a leading cause of traumatic death in children under 2 years of age, that it has a characteristic clinical presentation and injury pattern, and that it can involve a variety of different

injury mechanisms. Awareness of these mechanisms and rigorous efforts to ensure comprehensive clinical assessments will best inform the diagnostic process. Being able to identify abusive head trauma and finding answers to the challenging questions that remain, including how to mitigate damage when a young patient presents with head trauma, will lead ultimately to improvements in both outcomes and prevention.

Cowley, L. E., Morris, C. B., Maguire, S. A., Farewell, D. M., & Kemp, A. M. (2015).
Validation of a prediction tool for abusive head trauma. *Pediatrics*, *136*(2), 290-298.

Abusive head trauma (AHT) may be missed in the clinical setting. Clinical prediction tools are used to reduce variability in practice and inform decision-making. From a systematic review and individual patient data analysis we derived the Predicting Abusive Head Trauma (PredAHT) tool, using multilevel logistic regression to predict likelihood of AHT. This study aims to externally validate the PredAHT tool. Consecutive children aged ,36 months admitted with an intracranial injury, confirmed as abusive or nonabusive, to 2 sites used in the original model were ascertained. Details of 6 influential features were recorded (retinal hemorrhage, rib and long -bone fractures, apnea, seizures, and head or neck bruising). We estimated the likelihood of an unrecorded feature being present with multiple imputation; analysis included sensitivity, specificity, and area under the curve, with 95% confidence intervals (CIs). Data included 133 non-AHT cases and 65 AHT cases, 97% of children were ,24 months old. Consistent with original predictions, when \$3 features were present in a child ,36 months old with intracranial injury, the estimated probability of AHT was .81.5% (95% CI, 63.3–91.8). The sensitivity of the tool was 72.3% (95% CI, 60.4–81.7), the specificity was 85.7% (95% CI, 78.8–90.7), area under the curve 0.88 (95% CI, 0.823–0.926). When tested on novel data, the PredAHT tool performed well. This tool has the potential to contribute to decision-making in these challenging cases. An implementation study is needed to explore its performance and utility within the child protection process.

Graves, J. M., Rivara, F. P., & Vavilala, M. S. (2015). [Health care costs 1 year after pediatric traumatic brain injury](#). *American Journal of Public Health, 105*(10), e35-e41.

Objectives: This study sought to estimate total health care costs for mild, moderate, and severe pediatric traumatic brain injury (TBI) and to compare individual- and population-level costs across levels of TBI severity. Methods: Using 2007 to 2010 MarketScan Commercial Claims and Encounters data, we estimated total quarterly health care costs 1 year after TBI among enrollees (aged < 18 years). We compared costs across levels of TBI severity using generalized linear models. Results: Mild TBI accounted for 96.6% of the 319 103 enrollees with TBI; moderate and severe TBI accounted for 1.7% and 1.6%, respectively. Adjusted individual health care costs for moderate and severe TBI were significantly higher than mild TBI in the year after injury ($P < .01$). At the population level, moderate and severe TBI costs were 88% and 75% less than mild TBI, respectively. Conclusions: Individually, moderate and severe TBI initially generated costs that were markedly higher than those of mild TBI. At the population level, costs following mild TBI far exceeded those of more severe cases, a result of the extremely high population burden of mild TBI. (Author Abstract)

Kelly, P., John, S., Vincent, A. L., & Reed, P. (2015). [Abusive head trauma and accidental head injury: A 20-year comparative study of referrals to a hospital child protection team](#). *Archives of Disease in Childhood, 100*(12), 1123-1300.

Aim: To describe children referred for suspected abusive head trauma (AHT) to a hospital child protection team in Auckland, New Zealand. Methods: Comparative review of demographics, histories, injuries, investigations and diagnostic outcomes for referrals under 15 years old from 1991 to 2010. Results: Records were available for 345 children. Referrals increased markedly (88 in the first decade, 257 in the second), but the diagnostic ratio was stable: AHT 60%, accidental or natural 29% and uncertain cause 11%. The probability of AHT was similar regardless of socio-economic status or ethnicity. In children under 2 years old with accidental head injuries (75/255, 29%) or AHT (180/255, 71%), characteristics of particular interest for AHT included no history of trauma (88/98, 90%), no evidence of impact to the head (84/93, 90%), complex skull fractures with intracranial injury (22/28, 79%), subdural haemorrhage (160/179, 89%) and hypoxic ischaemic injury (38/39, 97%). In children over 2 years old, these characteristics did not differ

significantly between children with accidental head injuries (21/47, 45%) and AHT (26/47, 55%). The mortality of AHT was higher in children over 2 years old (10/26, 38%) than under 2 years (19/180, 11%). Conclusions: The striking increase in referrals for AHT probably represents increasing incidence. The decision to refer a hospitalised child with a head injury for assessment for possible AHT should not be influenced by socio-economic status or ethnicity. Children over 2 years old hospitalised for AHT are usually injured by mechanisms involving impact and should be considered at high risk of death. (Author Abstract)

Peterson, C., Xu, L., Florence, C., & Parks, S. E. (2015). Annual cost of US hospital visits for pediatric abusive head trauma. *Child Maltreatment*, 20(3), 162-169.

We estimated the frequency and direct medical cost from the provider perspective of U.S. hospital visits for pediatric abusive head trauma (AHT). We identified treat-and-release hospital emergency department (ED) visits and admissions for AHT among patients aged 0–4 years in the Nationwide Emergency Department Sample and Nationwide Inpatient Sample (NIS), 2006–2011. We applied cost-to-charge ratios and estimated professional fee ratios from Truven Health MarketScan1 to estimate per-visit and total population costs of AHT ED visits and admissions. Regression models assessed cost differences associated with selected patient and hospital characteristics. AHT was diagnosed during 6,827 (95% confidence interval [CI] [6,072, 7,582]) ED visits and 12,533 (95% CI [10,395, 14,671]) admissions (28% originating in the same hospital's ED) nationwide over the study period. The average medical cost per ED visit and admission were US\$2,612 (error bound: 1,644–3,581) and US\$31,901 (error bound: 29,266–34,536), respectively (2012 USD). The average total annual nationwide medical cost of AHT hospital visits was US\$69.6 million (error bound: 56.9–82.3 million) over the study period. Factors associated with higher per-visit costs included patient age <1 year, males, coexisting chronic conditions, discharge to another facility, death, higher household income, public insurance payer, hospital trauma level, and teaching hospitals in urban locations. Study findings emphasize the importance of focused interventions to reduce this type of high-cost child abuse.

Stephens, A., & Oates, K. (2015). [The placement of children following non-accidental head injuries: Are they protected from further harm?](#) *Child Abuse Review*, 24(1), 67-76.

Few studies have examined the social outcomes for these children – their trajectories through child protection systems and their placements (Cobley and Sanders, 2007; Kelly et al., 2009). This paper provides descriptive data on a cohort of 68 children with suspected NAHI seen at a large paediatric hospital in Sydney, Australia, and discusses the outcomes for these children in terms of placements and re-notifications to the statutory authority and the implications for potential future harm. This paper is part of a retrospective study that followed 68 suspected NAHI cases from hospital presentation through the child protection and criminal justice systems of New South Wales (NSW), Australia.

Wood, J. N., French, B., Song, L., & Feudtner, C. (2015). [Evaluation for occult fractures in injured children](#). *Pediatrics*, 136(2), 232-240.

Objectives: To examine variation across US hospitals in evaluation for occult fractures in (1) children <2 years old diagnosed with physical abuse and (2) infants <1 year old with injuries associated with a high likelihood of abuse and to identify factors associated with such variation. Methods: We performed a retrospective study in children <2 years old with a diagnosis of physical abuse and in infants <1 year old with non-motor vehicle crash-related traumatic brain injury or femur fractures discharged from 366 hospitals in the Premier database from 2009 to 2013. We examined across-hospital variation and identified child- and hospital-level factors associated with evaluation for occult fractures. Results: Evaluations for occult fractures were performed in 48% of the 2502 children with an abuse diagnosis, in 51% of the 1574 infants with traumatic brain injury, and in 53% of the 859 infants with femur fractures. Hospitals varied substantially with regard to their rates of evaluation for occult fractures in all 3 groups. Occult fracture evaluations were more likely to be performed at teaching hospitals than at nonteaching hospitals (all $P < .001$). The hospital-level annual volume of young, injured children was associated with the probability of occult fracture evaluation, such that hospitals treating more young, injured patients were more likely to evaluate for occult fractures (all $P < .001$). Conclusions: Substantial variation in evaluation for occult fractures among young children with a diagnosis of abuse or injuries associated with a high likelihood of abuse highlights opportunities for quality improvement in this vulnerable population. (Author Abstract)

Allen, K. A. (2014). [The neonatal nurse's role in preventing abusive head trauma](#). *Advances in Neonatal Care: Official Journal of the National Association of Neonatal Nurses*, 14(5), 336-342.

Background: Abusive head trauma in infants occurs in 24.6 to 39.8 per 100,000 infants in developed countries. Abusive head trauma refers to any type of intentional head trauma an infant sustains, as a result of an injury to the skull or intracranial contents from a blunt force and/or violent shaking. Clinical Question: What evidence-based interventions have been implemented by neonatal nurses to prevent abusive head trauma in infants? Search Strategy: PubMed was search to obtain English language publications from 2005 to May 2014 for interventions focused on preventing abusive head trauma using key terms 'shaken baby syndrome'. Search Yield: A total of 10 studies were identified that met the inclusion criteria. All of the interventions targeted prevention of abusive head trauma with information about abusive head trauma/shaken baby syndrome and the 'normal' infant crying behaviors. Main Findings: Interventions taught parents why infants cried, how to calm the infants, ways to cope with inconsolable infants, and how to develop a plan for what to do if they could not cope anymore. Parents who participated in the interventions were consistently able to explain the information and tell others about the dangers of shaking infants compared to the control parents. Only two studies calculated the pre-intervention abusive head trauma rate and the post-intervention frequency of abusive head trauma. Each found significant differences in abusive head trauma. (Author Abstract)

Imagawa, K. K., Hamilton, A., Ceschin, R., Tokar, E., Pham, P., Bluml, S., ... & Panigrahy, A. (2014). [Characterization of microstructural injury: A novel approach in infant abusive head trauma—initial experience](#). *Journal of Neurotrauma*, 31(19), 1632-1638.

Abusive head trauma (AHT) is the leading cause of morbidity and mortality among abused children, yet the neuroanatomical underpinnings of AHT outcome is incompletely understood. The aim of this study was to characterize white matter (WM) abnormalities in infants with AHT using diffusion tensor imaging (DTI) and determine which microstructural abnormalities are associated with poor outcome. Retrospective DTI data from 17 infants (>3 months) with a diagnosis of AHT and a comparison cohort of 34 term infants of similar post-conceptual age (PCA) were compared using a voxel-based DTI analysis of cerebral WM. AHT cases were dichotomously classified into mild/moderate versus severe outcome. Clinical variables and conventional imaging findings were

also analyzed in relation to outcome. Outcomes were classified in accordance with the Pediatric Cerebral Performance Category Score (PCPCS). Reduced axial diffusivity (AD) was shown in widespread WM regions in the AHT infants compared with controls as well as in the AHT severe outcome group compared with the AHT mild/moderate outcome group. Reduced mean diffusivity (MD) was also associated with severe outcome. Radial diffusivity (RD), conventional magnetic resonance findings, brain metric measurements, and clinical/laboratory variables (with the exception of Glasgow Coma Scale) did not differ among AHT outcome groups. Findings support the unique role of DTI techniques, beyond conventional imaging, in the evaluation of microstructural WM injury of AHT. Reduced AD (likely reflecting axonal damage) and MD were associated with poor clinical outcome. DTI abnormalities may uniquely reflect AHT patterns of axonal injury that are not characterized by conventional imaging, which may have both therapeutic and prognostic implications. (Author Abstract)

Levin, A. V., Cordovez, J. A., Leiby, B. E., Pequignot, E., & Tandon, A. (2014). [Retinal hemorrhage in abusive head trauma: Finding a common language](#). *Transactions of the American Ophthalmological Society*, 112, 1.

Purpose: To assess the performance of a refined Web-based tool for documenting retinal hemorrhage characteristics in suspected abusive head trauma. Methods: Using a comprehensive tabular secure platform, with access to digital images in color, black and white, and 4-zone system schematic overlay, four pediatric ophthalmologists performed pilot testing with 80 images for tool refinement. In a second phase, retinal hemorrhages were documented by number, zone, and type. Interobserver agreement was calculated using the Fleiss kappa coefficient. Intraobserver agreement was calculated using Cohen's kappa statistic. We used surface area mapping software for further analysis. Results: Interobserver agreement was good (kappa 0.4–0.6) and very good (kappa 0.6–0.8) for all questions in Zone A (peripapillary). For zones C (midperiphery) and D (peripheral retina), agreement was very good for all questions except number of hemorrhages, for which agreement was good. Zone B (macula) showed good and fair agreement except for superficial hemorrhage, for which agreement was poor. There was very good intraobserver agreement for number (kappa 0.68, 0.65, 0.67) and type of hemorrhages in zones A, B, and C. Surface area mapping results revealed no significant differences between zones A and B. Zones C and D had significantly less hemorrhage than A and B. Conclusions: Our tool performed with good

or very good interobserver and intraobserver agreement in almost all domains. We attribute zone B underperformance to the significant increased area covered by hemorrhages compared to zones C and D and the lack of contrast with normal anatomical structures in zone A. (Author Abstract)

Peterson, C., Xu, L., Florence, C., Parks, S. E., Miller, T. R., Barr, R. G., ... & Steinbeigle, R. (2014). [The medical cost of abusive head trauma in the United States](#). *Pediatrics*, *134*(1), 91-99.

Objectives: Health consequences of shaken baby syndrome, or pediatric abusive head trauma (AHT), can be severe and long-lasting. We aimed to estimate the multiyear medical cost attributable to AHT. Methods: Using Truven Health MarketScan data, 2003-2011, we identified children 0 to 4 years old with commercial or Medicaid insurance and AHT diagnoses. We used exact case-control matching based on demographic and insurance characteristics such as age and health plan type to compare medical care between patients with and without AHT diagnoses. Using regression models, we assessed service use (ie, average annual number of inpatient visits per patient) and inpatient, outpatient (including emergency department), drug, and total medical costs attributable to an AHT diagnosis during the 4-year period after AHT diagnosis. Results: We assessed 1209 patients with AHT and 5895 matched controls. Approximately 48% of patients with AHT received inpatient care within 2 days of initial diagnosis, and 25% were treated in emergency departments. AHT diagnosis was associated with significantly greater medical service use and higher inpatient, outpatient, drug, and total costs for multiple years after the diagnosis. The estimated total medical cost attributable to AHT in the 4 years after diagnosis was \$47,952 (95% confidence interval [CI], \$40,219-\$55,685) per patient with AHT (2012 US dollars) and differed for commercially insured (\$38,231 [95% CI, \$29,898-\$46,564]) and Medicaid (\$56,691 [95% CI, \$4290-\$69,092]) patients. Conclusions: Children continue to have substantial excess medical costs for years after AHT. These estimates exclude related nonmedical costs such as special education and disability that also are attributable to AHT. (Author Abstract)

Risen, S. R., Suskauer, S. J., DeMatt, E. J., Slomine, B. S., & Salorio, C. F. (2014). [Functional outcomes in children with abusive head trauma receiving inpatient rehabilitation compared with children with nonabusive head trauma](#). *The Journal of Pediatrics*, 164(3), 613-619.

Objective: To compare clinical features and functional outcomes of age and sex matched children with abusive and non-abusive head trauma receiving inpatient rehabilitation. Study Design: Children with abusive head trauma (n = 28) and age, sex matched children with non-abusive head trauma (n = 20) admitted to one inpatient pediatric rehabilitation unit from 1995–2012 were studied. Acute hospitalization and inpatient rehabilitation records were retrospectively reviewed for pertinent clinical data: initial GCS score, signs of increased intracranial pressure, neuroimaging findings, and presence of associated injuries. Functional status at admission to and discharge from inpatient rehabilitation was assessed using the Functional Independence Measure for Children (WeeFIM). Outcome at discharge and outpatient follow-up was described based on attainment of independent ambulation and expressive language. Results: Children with abusive and non-abusive head trauma had similar levels of injury severity although associated injuries were greater in abusive head trauma. Functional impairment upon admission to inpatient rehabilitation was comparable and functional gains during inpatient rehabilitation were similar between groups. More children with non-abusive than abusive head trauma attained independent ambulation and expressive language after discharge from rehabilitation; the difference was no longer significant when only children greater than 12 months of age at injury were examined. There was variability in delay to obtain these skills and quality of gained skills in both groups. Conclusions: Despite more associated injuries, children with abusive head trauma make significant functional gains during inpatient rehabilitation comparable with an age and sex matched sample with non-abusive head trauma. Key functional skills may be gained by children in both groups following discharge from inpatient rehabilitation. (Author Abstract)

Simonnet, H., Laurent-Vannier, A., Yuan, W., Hully, M., Valimahomed, S., Bourennane, M., & Chevignard, M. (2014). Parents' behavior in response to infant crying: Abusive head trauma education. *Child Abuse & Neglect*, 38, 1914-1922.

Abusive head trauma (AHT) is still too common, and probably underestimated. It is the leading cause of death from child abuse. Crying is thought to contribute to the act of shaking. Objectives

of this study were to (a) assess parents' knowledge about infant crying, their ability to manage crying, and their knowledge about AHT; and (b) assess the feasibility and the impact of a simple educational intervention about crying and AHT with parents shortly after their child's birth. A short questionnaire was completed orally by the parents of 190 consecutive newborns in a maternity hospital at day 2 of life. Then, during the routine examination of the child, the pediatrician gave parents a short talk about infant crying and AHT, and a pamphlet. Finally, parents were contacted by phone at 6 weeks for the post-intervention questionnaire assessing their knowledge about crying and AHT. Among 202 consecutive births, parents of 190 children were included (266 parents; 70% mothers) over a 1-month period and answered the pre-intervention questionnaire. The intervention was feasible and easy to provide. Twenty-seven percent of mothers and 36% of fathers had never heard of AHT. At 6 weeks, 183 parents (68% of the sample; 80% mothers) answered the post-intervention questionnaire. Parents' knowledge improved significantly post-intervention. Parents found the intervention acceptable and useful. Health care professionals such as pediatricians or nurses could easily provide this brief talk to all parents during systematic newborn examination.

Binenbaum, G., Christian, C. W., Ichord, R. N., Ying, G. S., Simon, M. A., Romero, K., ... & Forbes, B. J. (2013). [Retinal hemorrhage and brain injury patterns on diffusion-weighted magnetic Resonance imaging in children with head trauma](#). *Journal of American Association for Pediatric Ophthalmology and Strabismus*, 17(6), 603-608.

Purpose: To evaluate associations between retinal hemorrhage severity and hypoxic-ischemic brain injury (HII) patterns by diffusion-weighted magnetic resonance imaging (DW-MRI) in young children with head trauma. Methods: DW-MRI images of a consecutive cohort study of children under age 3 years with inflicted or accidental head trauma who had eye examinations were analyzed by two independent masked examiners for type, severity, and location of primary lesions attributable to trauma, HII secondary to trauma, and mixed injury patterns. Retinal hemorrhage was graded retrospectively on a scale from 1 (none) to 5 (severe). Results: Retinal hemorrhage score was 3–5 in 6 of 7 patients with predominantly post-traumatic HII pattern and 4 of 32 who had traumatic injury without HII ($P < 0.001$) on DW-MRI imaging. Severe retinal hemorrhage was observed in absence of HII but only in inflicted injury. Retinal hemorrhage severity was correlated with HII severity ($\rho = 0.53$, $P < 0.001$) but not traumatic injury severity ($\rho = -0.10$, $P = 0.50$). HII severity was associated with retinal hemorrhage score 3–5 ($P = 0.01$), but

traumatic injury severity was not ($P = 0.37$). Conclusions: During inflicted head injury, a distinct type of trauma occurs causing more global brain injury with HII and more severe retinal hemorrhages. HII is not a necessary factor for severe retinal hemorrhage to develop from inflicted trauma. (Author Abstract)

Gordy, C., & Kuns, B. (2013). Pediatric abusive head trauma. *Nursing Clinics of North America*, 48(2), 193-201.

Pediatric abusive head trauma is a significant contributor to pediatric morbidity and mortality in the United States. Signs and symptoms can be vague, nonspecific, and difficult to recognize. This article increases the healthcare provider's level of suspicion and ability to recognize early warning signs of abuse. It also addresses evidence-based prevention strategies. This information is useful to nurses, advanced practice nurses, and physicians who work with children and families in any capacity. Copyright © 2013 Elsevier Inc. All rights reserved.

Hasbani, D. M., Topjian, A. A., Friess, S. H., Kilbaugh, T. J., Berg, R. A., Christian, C. W., ... & Abend, N. S. (2013). [Nonconvulsive electrographic seizures are common in children with abusive head trauma](#). *Pediatric Critical Care Medicine*, 14(7), 709.

Objective: To determine the prevalence of nonconvulsive seizures in children with abusive head trauma. Design: Retrospective study of children with abusive head trauma undergoing clinically indicated continuous electroencephalographic monitoring. Setting: PICU of a tertiary care hospital. Subjects: Children less than or equal to 2 years old with evidence of abusive head trauma determined by neuroimaging, physical examination, and determination of abuse by the Child Protection Team. Interventions: None. Measurements and Main Results: Thirty-two children with abusive head trauma were identified with a median age of 4 months (interquartile range 3, 5.5 months). Twenty-one of 32 children (66%) underwent electroencephalographic monitoring. Those monitored were more likely to have a lower admission Glasgow Coma Scale (8 vs 15, $p = 0.05$) and be intubated (16 vs 2, $p = 0.002$). Electrographic seizures occurred in 12 of 21 children (57%) and constituted electrographic status epilepticus in 8 of 12 children (67%). Electrographic seizures were entirely nonconvulsive in 8 of 12 children (67%). Electroencephalographic background

category (discontinuous and slow-disorganized) ($p = 0.02$) and neuroimaging evidence of ischemia were associated with the presence of electrographic seizures ($p = 0.05$). Subjects who had electrographic seizures were no more likely to have clinical seizures at admission (67% electrographic seizures vs 33% none, $p = 0.6$), parenchymal imaging abnormalities (61% electrographic seizures vs 39% none, $p = 0.40$), or extra-axial imaging abnormalities (56% electrographic seizures vs 44% none, $p = 0.72$). Four of 21 (19%) children died prior to discharge; none had electrographic seizures, but all had attenuated-featureless electroencephalographic backgrounds. Follow-up outcome data were available for 16 of 17 survivors at a median duration of 9.5 months following PICU admission, and the presence of electrographic seizures or electrographic status epilepticus was not associated with the Glasgow Outcome Scale score ($p = 0.10$). Conclusions: Electrographic seizures and electrographic status epilepticus are common in children with abusive head trauma. Most seizures have no clinical correlate. Further study is needed to determine whether seizure identification and management improves outcome. (Author Abstract)

Hymel, K. P., Willson, D. F., Boos, S. C., Pullin, D. A., Homa, K., Lorenz, D. J., ... & Narang, S. K. (2013). [Derivation of a clinical prediction rule for pediatric abusive head trauma](#). *Pediatric Critical Care Medicine*, 14(2), 210-220.

The objective was to reduce missed cases of pediatric abusive head trauma (AHT), Pediatric Brain Injury Research Network investigators derived a 4-variable AHT clinical prediction rule (CPR) with sensitivity of .96. Our objective was to validate the screening performance of this AHT CPR in a new, equivalent patient population. We conducted a prospective, multicenter, observational, cross-sectional study. Applying the same inclusion criteria, definitional criteria for AHT, and methods used in the completed derivation study, Pediatric Brain Injury Research Network investigators captured complete clinical, historical, and radiologic data on 291 acutely head-injured children <3 years of age admitted to PICUs at 14 participating sites, sorted them into comparison groups of abusive and nonabusive head trauma, and measured the screening performance of the AHT CPR. In this new patient population, the 4-variable AHT CPR demonstrated sensitivity of .96, specificity of .46, positive predictive value of .55, negative predictive value of .93, positive likelihood ratio of 1.67, and negative likelihood ratio of 0.09.

Secondary analysis revealed that the AHT CPR identified 98% of study patients who were ultimately diagnosed with AHT. Four readily available variables (acute respiratory compromise before admission; bruising of the torso, ears, or neck; bilateral or interhemispheric subdural hemorrhages or collections; and any skull fractures other than an isolated, unilateral, nondiastatic, linear, parietal fracture) identify AHT with high sensitivity in young, acutely head-injured children admitted to the PICU.

Maguire, S. A., Watts, P. O., Shaw, A. D., Holden, S., Taylor, R. H., Watkins, W. J., ... & Kemp, A. M. (2013). [Retinal haemorrhages and related findings in abusive and non-abusive head trauma: A systematic review](#). *Eye*, 27(1), 28-36.

Aim: To report the retinal signs that distinguish abusive head trauma (AHT) from non-abusive head trauma (nAHT). **Methods:** A systematic review of literature, 1950–2009, was conducted with standardised critical appraisal. Inclusion criteria were a strict confirmation of the aetiology, children aged <11 years and details of an examination conducted by an ophthalmologist. Post mortem data, organic disease of eye, and inadequate examinations were excluded. A multivariate logistic regression analysis was conducted to determine odds ratios (OR) and probabilities for AHT. **Results:** Of the 62 included studies, 13 provided prevalence data (998 children, 504 AHT). Overall, retinal haemorrhages (RH) were found in 78% of AHT vs 5% of nAHT. In a child with head trauma and RH, the OR that this is AHT is 14.7 (95% confidence intervals 6.39, 33.62) and the probability of abuse is 91%. Where recorded, RH were bilateral in 83% of AHT compared with 8.3% in nAHT. RH were numerous in AHT, and few in nAHT located in the posterior pole, with only 10% extending to periphery. True prevalence of additional features, for example, retinal folds, could not be determined. **Conclusions:** Our systematic review confirms that although certain patterns of RH were far commoner in AHT, namely large numbers of RH in both the eyes, present in all layers of the retina, and extension into the periphery, there was no retinal sign that was unique to abusive injury. RH are rare in accidental trauma and, when present, are predominantly unilateral, few in number and in the posterior pole. (Author Abstract)

Niederkröthaler, T., Xu, L., Parks, S. E., & Sugerman, D. E. (2013). Descriptive factors of abusive head trauma in young children—United States, 2000–2009. *Child Abuse & Neglect*, 37, 446–455.

Abusive head trauma (AHT) is a leading cause of severe injury in maltreated children in the United States. There is little research from nationally representative datasets available to characterize young children who had AHT compared to non-abusive head trauma (NAHT). Using the recent CDC AHT case definition, we performed a retrospective analysis of 2000, 2003, 2006 and 2009 hospitalization data using the Kids' Inpatient Database (KID) from the Healthcare Cost and Utilization Project. Logistic regression was used to compare AHT to NAHT patients <2 years of age. Socio-demographic data and indicators of socioeconomic status (i.e., insurance status and household income), presence of chronic conditions, injury severity (i.e., length of hospital stay and vital status), hospital specialization (i.e., hospital type), hospital region, and season of admission were used as independent variables. A weighted sample of 7,603 AHT and 25,339 NAHT patients was identified. National rates for AHT were 39.8 per 100,000 population for children <1 year and 6.8 per 100,000 population for children 1 year old. Compared to NAHT, children with AHT were more often <1 year of age (adjusted odds ratio [aOR]=2.66; 95% confidence interval [CI]: 2.35–3.01), male (aOR=1.10; 95% CI: 1.01–1.20), enrolled in Medicaid (aOR=2.78; 95% CI: 2.49–3.11), hospitalized longer (aOR=8.26; 95% CI: 7.24–9.43), died during hospitalization (aOR=5.12; 95% CI: 4.01–6.53), and seen at children's hospitals (aOR=1.97; 95% CI: 1.63–2.38) and hospitals outside the Northeast [aOR=2.65 (95% CI: 2.10–3.33) for the Midwest, 1.90 (95% CI: 1.52–2.38) for the South and 1.93 (95% CI: 1.45–2.57) for the West, respectively]. The results confirm that injuries from AHT are more severe and more often lethal than other head injuries. Socioeconomically disadvantaged families with children <1 year are an important focus for primary prevention. The associations of AHT, compared to NAHT with hospital type and hospital region warrant further investigation. Referral or reporting patterns, or true differences in the incidence may contribute to the identified associations.

Scribano, P. V., Makoroff, K. L., Feldman, K. W., & Berger, R. P. (2013). Association of perpetrator relationship to abusive head trauma clinical outcomes. *Child Abuse & Neglect*, 37, 771-777.

The diagnosis of abusive head trauma (AHT) remains a significant public health problem with limited prevention success. Providing protection from further harm is often challenged by the difficulty in identifying the alleged perpetrator (AP) responsible for this pediatric trauma. The objective of this study was to evaluate demographic and clinical characteristics of children with AHT and the relationship between APs and their victims in a large, multi-site sample. Understanding the AHT risks from various caregivers may help to inform current prevention strategies. A retrospective review of all cases of AHT diagnosed by child protection teams (CPT) from 1/1/04 to 6/30/09 at four children's hospitals was conducted. Clinical characteristics of children with AHT injured by non-parental perpetrators (NPP) were compared to parental perpetrators (PP). There were 459 children with AHT; 313 (68%) had an identified AP. The majority of the 313 children were <1 year of age (76%), Caucasian (63%), male (58%), receiving public assistance (80%), and presented without a history of trauma (62%); mortality was 19%. Overall, APs were: father (53%), parent partner (22%), mother (8%), babysitter (8%), other adult caregiver (5%); NPP accounted for 39% of APs. NPPs were more likely to cause AHT in children ≥ 1 year (77% vs. 23%, $p < 0.001$) compared to PP. Independent associations to NPP included: older child, absence of a history of trauma, retinal hemorrhages, and male perpetrator gender. While fathers were the most common AP in AHT victims, there is a significant association for increased risk of AHT by NPPs in the older child, who presents with retinal hemorrhages, in the hands of a male AP. Further enhancement of current prevention strategies to address AHT risks of non-parental adults who provide care to children, especially in the post-infancy age seems warranted.

Ward, M. K., King, W. J., & Bennett, S. (2013). From bruises to brain injury: The physician's role in the assessment of inflicted traumatic head injury. *Paediatrics & Child Health* (1205-7088), 18(8), 423-424.

The article presents a case study of a four-month-old boy with two small brown-yellow bruises on the right arm superior to the antecubital fossa. It mentions that the baby was in the emergency department because of vomiting due to each feed for 24 hours without diarrhea. It also discusses computed tomography (CT) scan, diagnosis of viral gastroenteritis and baby's hydration status.

Barr, R. G. (2012). [Preventing abusive head trauma resulting from a failure of normal interaction between infants and their caregivers.](#) *Proceedings of the National Academy of Sciences, 109(Supplement 2)*, 17294-17301.

Head trauma from abuse, including shaken baby syndrome, is a devastating and potentially lethal form of infant physical abuse first recognized in the early 1970s. What has been less recognized is the role of the early increase in crying in otherwise normal infants in the first few months of life as a trigger for the abuse. In part, this is because infant crying, especially prolonged unsoothable crying, has been interpreted clinically as something wrong with the infant, the infant's caregiver, or the interactions between them. Here, we review an alternative developmental interpretation, namely, that the early increase in crying is a typical behavioral development in normal infants and usually does not reflect anything wrong or abnormal. We also review evidence indicating that this normal crying pattern is the most common trigger for abusive head trauma (AHT). Together, these findings point to a conceptualization of AHT as the consequence of a failure in an otherwise common, iterative, and developmentally normal infant-caregiver interaction. They also imply that there is a window of opportunity for prevention of AHT, and potentially other forms of infant abuse, through a public health primary universal prevention strategy aimed at changing knowledge and behaviors of caregivers and society in general concerning normal development of infants and the significance of early increased infant crying. If effective, there may be important implications for prevention of infant abuse nationally and internationally. (Author Abstract)

Parks, S. E., Annett, J. L., Hill, H. A., & Karch, D. L. (2012). [Pediatric abusive head trauma: Recommended definitions for public health surveillance and research.](#) *Atlanta, GA: Centers for Disease Control and Prevention*, 5-16.

The current report focuses on standard data elements for abusive head trauma—a specific category of child maltreatment that presents unique definitional and measurement challenges. These challenges are discussed followed by a presentation of recommended uniform operational definitions of fatal and nonfatal abusive head trauma based on International Classification of Diseases (ICD-9-CM for morbidity coding and ICD-10 for mortality coding) diagnosis and external- cause-of-injury codes (2001; 2005). Similar processes and formats to that of the Child Maltreatment Surveillance Uniform Definitions and Data Elements have been used in order to maintain consistency and facilitate ease of use.

Parks, S., Sugerman, D., Xu, L., & Coronado, V. (2012). [Characteristics of non-fatal abusive head trauma among children in the USA, 2003–2008: application of the CDC operational case definition to national hospital inpatient data.](#) *Injury Prevention*, 18(6), 392-398.

Objective: An International Classification of Diseases code-based case definition for non-fatal abusive head trauma (AHT) in children <5 years of age was developed in March 2008 by an expert panel convened at the Centers for Disease Control and Prevention (CDC). This study presents an application of the CDC recommended operational case definition of AHT to US hospital inpatient data to characterise the AHT hospitalisation rate for children <5 years of age. Methods: Nationwide Inpatient Sample (NIS) data from the Healthcare Cost and Utilisation Project from 2003 to 2008 were examined. Results: Inspection of the NIS data resulted in the identification of an estimated 10 555 non-fatal AHT hospitalisations with 9595 classified as definite/presumptive AHT and 960 classified as probable AHT. The non-fatal AHT rate was highest among children aged <1 year (32.3 per 100 000) with a peak in hospitalisations between 1 and 3 months of age. Non-fatal AHT hospitalisation rates for children <2 years of age were higher for boys (21.9 per 100 000) than girls (15.3 per 100 000). The non-fatal AHT hospitalisation rate showed little variation across seasons. Conclusions: To reduce the burden of AHT in the USA, a preventable public health problem, concerted prevention efforts targeting populations at risk should be implemented. This report demonstrates a model procedure for using the new CDC definition for public health surveillance and research purposes. Such findings can be used to inform parents and providers about AHT (eg, dangers of shaking, strategies for managing infant crying) as well as to monitor better the impact of prevention strategies over time. (Author Abstract)

Piteau, S. J., Ward, M. G., Barrowman, N. J., & Plint, A. C. (2012). [Clinical and radiographic characteristics associated with abusive and nonabusive head trauma: A systematic review.](#) *Pediatrics*, 130(2), 315-323.

The objective was to systematically review the literature to determine which clinical and radiographic characteristics are associated with abusive head trauma (AHT) and nonabusive head trauma (nAHT) in children. We searched MEDLINE, EMBASE, PubMed, conference proceedings, and reference lists to identify relevant studies. Two reviewers independently selected studies that compared clinical and/or radiographic characteristics including historical features, physical exam and imaging findings, and presenting signs or symptoms in hospitalized children

≤6 years old with AHT and nAHT. Twenty-four studies were included. Meta-analysis was complicated by inconsistencies in the reporting of characteristics and high statistical heterogeneity. Notwithstanding these limitations, there were 19 clinical and radiographic variables that could be meta-analyzed and odds ratios were determined for each variable. In examining only studies deemed to be high quality, we found that subdural hemorrhage(s), cerebral ischemia, retinal hemorrhage(s), skull fracture(s) plus intracranial injury, metaphyseal fracture(s), long bone fracture(s), rib fracture(s), seizure(s), apnea, and no adequate history given were significantly associated with AHT. Epidural hemorrhage(s), scalp swelling, and isolated skull fracture(s) were significantly associated with nAHT. Subarachnoid hemorrhage(s), diffuse axonal injury, cerebral edema, head and neck bruising, any bruising, and vomiting were not significantly associated with either type of trauma. Clinical and radiographic characteristics associated with AHT and nAHT were identified, despite limitations in the literature. This systematic review also highlights the need for consistent criteria in identifying and reporting clinical and radiographic characteristics associated with AHT and nAHT.

Robertson, B. D., McConnel, C. E., & Green, S. (2012). [Charges associated with pediatric head injuries: A five-year retrospective review of 41 pediatric hospitals in the US.](#) *Journal of Injury and Violence Research*, 5(1), 51-60.

Background: Brain injuries are a significant public health problem, particularly among the pediatric population. Brain injuries account for a significant portion of pediatric injury deaths, and are the highest contributor to morbidity and mortality in the pediatric and young adult populations. Several studies focus on particular mechanisms of brain injury and the cost of treating brain injuries, but few studies exist in the literature examining the highest contributing mechanisms to pediatric brain injury and the billed charges associated with them. Methods: Data were extracted from the Pediatric Health Information System (PHIS) from member hospitals on all patients admitted with diagnosed head injuries and comparisons were made between ICU and non-ICU admissions. Collected data included demographic information, injury information, total billed charges, and patient outcome. Results: Motor vehicle collisions, falls, and assaults/abuse are the three highest contributors to brain injury in terms of total numbers and total billed charges. These three mechanisms of injury account for almost \$1 billion in total charges across the five-year

period, and account for almost half of the total charges in this dataset over that time period. Conclusions: Research focusing on brain injury should be tailored to the areas of the most pressing need and the highest contributing factors. While this study is focused on a select number of pediatric hospitals located throughout the country, it identifies significant contributors to head injuries, and the costs associated with treating them. (Author Abstract)

Shein, S. L., Bell, M. J., Kochanek, P. M., Tyler-Kabara, E. C., Wisniewski, S. R., Feldman, K., ... & Berger, R. P. (2012). [Risk factors for mortality in children with abusive head trauma](#). *The Journal of Pediatrics*, 161(4), 716-722.

Objective: We sought to identify risk factors for mortality in a large clinical cohort of children with abusive head trauma. Study design: Bivariate analysis and multivariable logistic regression models identified demographic, physical examination and radiologic findings associated with in-hospital mortality of children with abusive head trauma at four pediatric centers. An initial Glasgow Coma Scale (GCS) ≤ 8 defined severe abusive head trauma. Data are shown as OR (95% CI). Results: Analysis included 386 children with abusive head trauma. Multivariable analysis showed children with initial GCS either 3 or 4 – 5 had increased mortality versus children with GCS 12 – 15 (OR 57.8 [12.1 – 277.6] and 15.6 [2.6 – 95.1], respectively, $p < 0.001$). Additionally, retinal hemorrhage (RH), intraparenchymal hemorrhage and cerebral edema were independently associated with mortality. In the subgroup with severe abusive head trauma and RH ($n = 117$), cerebral edema and initial GCS of 3 or 4 – 5 were independently associated with mortality. Chronic subdural hematoma was independently associated with survival. Conclusions: Low initial GCS score, RH, intraparenchymal hemorrhage and cerebral edema are independently associated with mortality in abusive head trauma. Knowledge of these risk factors may enable researchers and clinicians to improve the care of these vulnerable children. (Author Abstract)

Altman, R. L., Canter, J., Patrick, P. A., Daley, N., Butt, N. K., & Brand, D. A. (2011). [Parent education by maternity nurses and prevention of abusive head trauma](#). *Pediatrics*, 128(5), e1164-e1172.

A consortium of the 19 community hospitals and 1 tertiary care children's hospital that provide maternity care in the New York State Hudson Valley region implemented a program to teach

parents about the dangers of shaking infants and how to cope safely with an infant's crying. This study evaluated the effectiveness of the program in reducing the frequency of shaking injuries. The educational program, which was delivered by maternity nurses, included a leaflet explaining abusive head trauma (“shaken baby syndrome”) and how to prevent it, an 8-minute video on the subject, and a statement signed by parents acknowledging receipt of the information and agreeing to share it with others who will care for the infant. Poisson regression analysis was used to compare the frequency of shaking injuries during the 3 years after program implementation with the frequency during a 5-year historical control period. Sixteen infants who were born in the region during the 8-year study period were treated at the children's hospital for shaking injuries sustained during their first year of life. Of those infants, 14 were born during the 5-year control period and 2 during the 3-year postimplementation period. The decrease from 2.8 injuries per year (14 cases in 5 years) to 0.7 injuries per year (2 cases in 3 years) represents a 75.0% reduction ($P = .03$). Parent education delivered in the hospital by maternity nurses reduces newborns' risks of sustaining an abusive head injury resulting from shaking during the first year of life.

Berger, R. P., Fromkin, J. B., Stutz, H., Makoroff, K., Scribano, P. V., Feldman, K., ... & Fabio, A. (2011). [Abusive head trauma during a time of increased unemployment: A multicenter analysis](#). *Pediatrics*, *128*(4), 637-643.

The objective was to evaluate the rate of abusive head trauma (AHT) in 3 regions of the United States before and during an economic recession and assess whether there is a relationship between the rate of AHT and county-level unemployment rates. Clinical data were collected for AHT cases diagnosed in children younger than 5 years from January 1, 2004 until June 30, 2009, by hospital-based child protection teams within 3 geographic regions. The recession was defined as December 1, 2007 through June 30, 2009. Quarterly unemployment rates were collected for every county in which an AHT case occurred. During the 5½-year study period, a total of 422 children were diagnosed with AHT in a 74-county region. The overall rate of AHT increased from 8.9 in 100 000 (95% confidence interval [CI]: 7.8–10.0) before the recession to 14.7 in 100 000 (95% CI: 12.5–16.9) during the recession ($P < .001$). There was no difference in the clinical characteristics of subjects in the prerecession versus recession period. There was no relationship between the rate of AHT and county-level unemployment rates. The rate of AHT increased significantly in 3

distinct geographic regions during the 19 months of an economic recession compared with the 47 months before the recession. This finding is consistent with our understanding of the effect of stress on violence. Given the high morbidity and mortality rates for children with AHT, these results are concerning and suggest that prevention efforts might need to be increased significantly during times of economic hardship

Kemp, A. M. (2011). [Abusive head trauma: Recognition and the essential investigation](#). *Archives of disease in childhood-Education & practice edition*, 96(6), 202-208.

Abusive head trauma (AHT) affects one in 4000–5000 infants every year and is one of the most serious forms of physical child abuse that has a high associated mortality and morbidity. Differentiating this form of abuse from another potential cause of brain injury is of utmost importance to the welfare of the child concerned and it is essential that the condition is correctly diagnosed. This article describes the evidence base behind the associated historical, clinical and neuroradiological features of AHT and spinal injury in physical abuse and sets out an algorithm of essential investigations that should be performed in any infant or young child where AHT is suspected.

Kemp, A. M., Jaspán, T., Griffiths, J., Stoodley, N., Mann, M. K., Tempest, V., & Maguire, S. A. (2011). Neuroimaging: what neuroradiological features distinguish abusive from non-abusive head trauma? A systematic review. *Archives of Disease in Childhood*, 96(12), 1103-1112.

The objective was to identify the evidence base behind the neuroradiological features that differentiate abusive head trauma (AHT) from non-abusive head trauma (nAHT). Literature search of 14 databases, websites, textbooks, conference abstracts and references (1970–February 2010). Studies had two independent reviews (three if disputed) and critical appraisal. Patients Primary comparative studies of children <11 years old hospitalised with AHT and nAHT diagnosed on CT or MRI. Main outcome measures Neuroradiological features that differentiated AHT from nAHT. 21 studies of children predominantly <3 years old were analysed. Subdural haemorrhages (SDH) were significantly associated with AHT (OR 8.2, 95% CI 6.1 to 11). Subarachnoid haemorrhages were seen equally in AHT and nAHT and extradural haemorrhages (EDH) were significantly

associated with nAHT (OR for AHT 0.1, 95% CI 0.07 to 0.18). Multiple (OR 6, 95% CI 2.5 to 14.4), interhemispheric (OR 7.9, 95% CI 4.7 to 13), convexity (OR 4.9, 95% CI 1.3 to 19.4) and posterior fossa haemorrhages (OR 2.5, 95% CI 1 to 6) were associated with AHT. Hypoxic-ischaemic injury (HII) (OR 3.7, 95% CI 1.4 to 10) and cerebral oedema (OR 2.2, 95% CI 1.0 to 4.5) were significantly associated with AHT, while focal parenchymal injury was not a discriminatory feature. SDH of low attenuation were more common in AHT than in nAHT. Multiple SDH over the convexity, interhemispheric haemorrhages, posterior fossa SDH, HII and cerebral oedema are significantly associated with AHT and should be considered together with clinical features when identifying the condition.

Maguire, S. A., Kemp, A. M., Lumb, R. C., & Farewell, D. M. (2011). [Estimating the probability of abusive head trauma: A pooled analysis](#). *Pediatrics*, *128*(3), e550-e564.

The objective was to determine which combinations of clinical features assist in distinguishing abusive head trauma (AHT) from nonabusive head trauma. Individual patient data from 6 comparative studies of children younger than 3 years with intracranial injury were analyzed to determine the association between AHT and combinations of apnea; retinal hemorrhage; rib, skull, and long-bone fractures; seizures; and head and/or neck bruising. An aggregate analysis of data from these studies used multiple imputation of combined clinical features using a bespoke hotdeck imputation strategy, which accounted for uncertainty arising from missing information. Analyzing 1053 children (348 had AHT), excluding nonsignificant variables (gender, age, skull fractures), for a child with an intracranial injury and 1 or 2 of the 6 features, the positive predictive value (PPV) of AHT varies from 4% to 97% according to the different combinations. Although rarely recorded, apnea is significantly associated with AHT (odds ratio [OR]: 6.89 [confidence interval: 2.08–22.86]). When rib fracture or retinal hemorrhage was present with any 1 of the other features, the OR for AHT is >100 (PPV > 85%). Any combination of 3 or more of the 6 significant features yielded an OR of >100 (PPV for AHT > 85%). Probabilities of AHT can be estimated on the basis of different combinations of clinical features. The model could be further developed in a prospective large-scale study, with an expanded clinical data set, to contribute to a more refined tool to inform clinical decisions about the likelihood of AHT.

Narang, S. (2011). [Daubert Analysis of Abusive Head Trauma/Shaken Baby Syndrome, Part II. An examination of the differential diagnosis.](#) *Hous. Journal of Health Law & Policy*, 11, 505.

For reasons inexplicable to many physicians, and unbeknownst to many others, the diagnosis of Abusive Head Trauma/Shaken Baby Syndrome (AHT/SBS) remains a lightning rod for controversy. Recent legal commentary has suggested that there is insufficient science girding this diagnosis. In Part I of the analysis on this topic, Dr. Narang presented a relatively comprehensive analysis of the current science surrounding AHT/SBS, and more specifically, surrounding two of the most common injuries found in AHT/SBS — subdural hemorrhages (SDHs) and retinal hemorrhages (RHs). Dr. Narang asserted that the diagnosis of AHT is supported by "at least 700 peer-reviewed, clinical medical articles comprising thousands of pages of medical literature, published by over one thousand different medical authors, from at least twenty-eight different countries." In response to this article, Findley et al reiterated an insufficient scientific basis for the diagnosis, citing, amongst other things, logical fallacies (such as "circularity" and "the prosecutor's fallacy") as premises for the fallacious literature. In Part II of this analysis, Narang et al swing the microscope in the opposite direction. Narang et al scrutinize the "differential diagnosis" of AHT, and the differential diagnosis methodology itself, to ascertain whether the scientific process of coming to the AHT diagnosis meets reliability and relevancy criteria under Daubert.

Adamsbaum, C., Grabar, S., Mejean, N., & Rey-Salmon, C. (2010). Abusive head trauma: Judicial admissions highlight violent and repetitive shaking. *Pediatrics*, 126(3), 546-555.

Confessions are uncommon in abusive head trauma (AHT) cases, and there is debate over whether shaking alone can cause the injuries characteristic of AHT. The objective of this article is to correlate legal statements by perpetrators with medical documentation to offer insights into the mechanism of injury. In this retrospective observational study we examined forensic evidence from 112 cases referred for AHT over a 7-year period. We compared 29 cases in which a perpetrator confessed to violence toward the child with 83 cases in which there was no confession. Inclusion criteria were subdural hematoma (SDH) on computed tomography and perpetrator admission of a causal relationship between the violence inflicted and the child's symptoms. Groups were compared by using Student's *t* test for age and Fisher's exact test for gender, death, fractures,

retinal hemorrhages, ecchymoses, symptoms, and SDH patterns. All medical records from birth to diagnosis, imaging studies, and written investigation reports were reviewed. All confessions came from forensic investigations. There was no statistically significant difference between the 2 groups for any of the variables studied. Shaking was described as extremely violent (100%) and was repeated (55%) from 2 to 30 times (mean: 10) because it stopped the infant's crying (62.5%). Impact was uncommon (24%). No correlation was found between repeated shaking and SDH densities. This unique forensic case series confirms the violence of shaking. The high frequency of habitual AHT is a strong argument for reporting suspected cases to judicial authorities and helps to explain the difficulty in dating the injuries.

Bhardwaj, G., Chowdhury, V., Jacobs, M. B., Moran, K. T., Martin, F. J., & Coroneo, M. T. (2010). A systematic review of the diagnostic accuracy of ocular signs in pediatric abusive head trauma. *Ophthalmology*, *117*(5), 983-992.

The objective was to review systematically the diagnostic accuracy of various ocular signs for pediatric abusive head trauma (AHT). Intraocular hemorrhages (IOH), perimacular retinal folds, traumatic retinoschisis and optic nerve sheath hemorrhages have been reported as cardinal signs of AHT. The evidence base supporting the accuracy of this interpretation, however, has not been systematically reviewed. A systematic keyword search of MEDLINE, EMBASE, and Evidence-Based Medicine Reviews was conducted for original studies reporting ocular findings in AHT. Articles were graded using a checklist for systematic reviews of diagnostic accuracy. The initial search yielded 971 articles, of which 55 relevant studies were graded, and 20 studies met inclusion criteria and were included in the review. The overall sensitivity of IOH for AHT was 75% and their specificity was 94%. Intraretinal hemorrhage at the posterior pole was the most common finding, although extensive, bilateral, and multilayered IOH were the most specific for AHT. Optic nerve sheath hemorrhages had a sensitivity and specificity for AHT of 72% and 71%, respectively. Traumatic retinoschisis and perimacular retinal folds were reported in 8% and 14% of AHT, respectively, but were not reported in other conditions. Prospective, consecutive studies confirm that IOH in infants—particularly bilateral, extensive, and multilayered—are highly specific for AHT. Optic nerve sheath hemorrhages are significantly more common in AHT than in other

conditions, in autopsy studies. Traumatic retinoschisis and perimacular folds are present in a minority of AHT, but rarely seen in other conditions

Levin, A. V. (2010). Retinal hemorrhage in abusive head trauma. *Pediatrics*, *126*(5), 961-970.

Retinal hemorrhage is a cardinal manifestation of abusive head trauma. Over the 30 years since the recognition of this association, multiple streams of research, including clinical, postmortem, animal, mechanical, and finite element studies, have created a robust understanding of the clinical features, diagnostic importance, differential diagnosis, and pathophysiology of this finding. The importance of describing the hemorrhages adequately is paramount in ensuring accurate and complete differential diagnosis. Challenges remain in developing models that adequately replicate the forces required to cause retinal hemorrhage in children. Although questions, such as the effect of increased intracranial pressure, hypoxia, and impact, are still raised (particularly in court), clinicians can confidently rely on a large and solid evidence base when assessing the implications of retinal hemorrhage in children with concern of possible child abuse.

Chiesa, A., & Duhaime, A. C. (2009). Abusive head trauma. *Pediatric Clinics of North America*, *56*(2), 317-331.

Christian, C. W., & Block, R. (2009). Abusive head trauma in infants and children. *Pediatrics*, *123*(5), 1409-1411.

Shaken baby syndrome is a term often used by physicians and the public to describe abusive head trauma inflicted on infants and young children. Although the term is well known and has been used for a number of decades, advances in the understanding of the mechanisms and clinical spectrum of injury associated with abusive head trauma compel us to modify our terminology to keep pace with our understanding of pathologic mechanisms. Although shaking an infant has the potential to cause neurologic injury, blunt impact or a combination of shaking and blunt impact cause injury as well. Spinal cord injury and secondary hypoxic ischemic injury can contribute to poor outcomes of victims. The use of broad medical terminology that is inclusive of all

mechanisms of injury, including shaking, is required. The American Academy of Pediatrics recommends that pediatricians develop skills in the recognition of signs and symptoms of abusive head injury, including those caused by both shaking and blunt impact, consult with pediatric subspecialists when necessary, and embrace a less mechanistic term, abusive head trauma, when describing an inflicted injury to the head and its contents. Copyright © 2009 by the American Academy of Pediatrics

Pickerd, N., Farewell, D., Mann, M. K., Tempest, V., & Kemp, A. M. (2009). Which clinical features distinguish inflicted from non-inflicted brain injury? A systematic review. *Archives of Disease in Childhood*, 94, 860-867.

A systematic review of the scientific literature to define clinical indicators distinguishing inflicted (iBI) from non-inflicted brain injury (niBI). Methods: An all language literature search of 20 electronic databases, websites, references and bibliographies from 1970–2008 was carried out. Relevant studies were independently reviewed by two trained reviewers, with a third review where required. Inclusion criteria included primary comparative studies of iBI and niBI in children aged ,18 years, with high surety of diagnosis describing key clinical features. Multilevel logistic regression analysis was conducted, determining the positive predictive value (PPV) and odds ratios (OR) with p values for retinal haemorrhage, rib/long bone/skull fractures, apnoea, seizures and bruising to head/neck. Results: 8151 studies were identified, 320 were reviewed and 14 included, representing 1655 children, 779 with iBI. Gender was not a discriminatory feature. In a child with intracranial injury, apnoea (PPV 93%, OR 17.06, p,0.001) and retinal haemorrhage (PPV 71%, OR 3.504, p=0.03) were the features most predictive of iBI. Rib fractures (PPV 73%, OR 3.03, p=0.13) had a similar PPV to retinal haemorrhages, but there were less data for analysis. Seizures and long bone fractures were not discriminatory, and skull fracture and head/neck bruising were more associated with niBI, although not significantly so. Conclusions: This systematic review shows that apnoea and retinal haemorrhage have a high odds ratio for association with iBI. This review identifies key features that should be recorded in the assessment of children where iBI is suspected and may help clinicians to define the likelihood of iBI.

Oral, R., Yagmur, F., Nashelsky, M., Turkmen, M., & Kirby, P. (2008). Fatal abusive head trauma cases: Consequence of medical staff missing milder forms of physical abuse. *Pediatric Emergency Care, 24*(12), 816-821.

Missed diagnosis of child abuse may lead to chronic abuse with potential for death. This paper reports 3 such cases. This is a retrospective chart review of 38 cases diagnosed as abusive head trauma between January 1, 2004 and December 31, 2006 at a university hospital. We sought to identify fatal cases with a past medical history of physical abuse that was missed by the medical staff. Three cases (7.9%) had a past medical history of physical abuse that was missed by the medical staff. Infants were 2 males and 1 female. Their ages were 2.5, 3.5, and 6 months, respectively. Missed abuse episodes involved rib fractures, a metaphyseal tibial fracture, and a shaking episode, respectively. The intervals that had elapsed between the missed and the fatal abuse episodes were 24 hours, 12 days, and 6 weeks, respectively. Perpetrators of fatal head trauma were all biological fathers. One pled guilty, and 2 were convicted of involuntary manslaughter. The infants were in the care of the perpetrators of the fatal abuse episodes at the time the missed abuse episodes occurred. Physicians assessing children, especially infants, should be alert to indicators of abusive trauma to recognize abuse early on. Including abusive trauma in the differential diagnostic list and taking appropriate steps to rule out or confirm the diagnosis are of paramount importance in establishing child protective services and preventing further abuse and neglect that may at times be fatal.

Gerber, P., & Coffman, K. (2007). Nonaccidental head trauma in infants. *Child's Nervous System, 23*(5), 499-507.

Nonaccidental head trauma in infants is the leading cause of infant death from injury. Clinical features that suggest inflicted head trauma include the triad of the so-called shaken baby syndrome, consisting of retinal hemorrhage, subdural, and/or subarachnoid hemorrhage in an infant with little signs of external trauma. Studies have shown that, in general, the average short fall in the home is extremely unlikely to produce either subdural or retinal hemorrhage, although focal injuries such as skull fractures and epidural hemorrhage may be seen. Acceleration/deceleration, especially of the rotational type, is believed to be the most probable mechanism of injury in cases of nonaccidental head trauma. Damage to the cervicomedullary junction and the respiratory centers,

with subsequent hypoxia and intracerebral edema, has also been implicated. After the initial trauma and hemorrhage, loss of cerebral autoregulation, breakdown of the blood-brain barrier, and disruption of ionic homeostasis occur, leading to brain edema and cytotoxicity. Cellular damage can involve large volumes of tissue, without respecting vascular territories. Overall, a satisfactory biomechanical model is lacking, and the criminal nature of abusive injury makes it difficult to perform systematic, controlled studies. Unfortunately, outcomes are poor, and the rate of repeated abusive episodes is high. Future research should focus on the development of a satisfactory research model and on prevention strategies.

Salehi-Had, H., Brandt, J. D., Rosas, A. J., & Rogers, K. K. (2006). Findings in older children with abusive head injury: Does shaken-child syndrome exist?. *Pediatrics*, *117*(5), e1039-e1044.

Shaken-baby syndrome (SBS) has been hypothesized to occur after shaking by an adult during the first 2 years of life. We wondered whether it is possible to achieve rotational forces sufficient to cause SBS-like injuries in children >2 years of age. The present study describes cases of child abuse in older children who presented with the classic ophthalmologic and intracranial findings of SBS. In this case series, 4 cases of older children (2.5–7 years old; 11.8–22 kg) who died from abusive head injuries and who had diffuse retinal hemorrhages identified antemortem were selected for review. The cases were abstracted from hospital charts, records from autopsies, coroners' and district attorneys' offices, and court transcripts. In all 4 cases the history provided by the primary caregiver did not match the severity of the injuries. Three case subjects presented with patterned bruises. Multilayered retinal hemorrhages and acute subdural hematoma were observed in all 4 cases. At autopsy, diffuse axonal injury was evident in 3 of the 4 cases; all 4 cases had optic nerve sheath hemorrhages. None of the victims had skeletal fractures on radiologic examination or at autopsy. This case series demonstrates that it is possible to observe SBS-like retinal and central nervous system findings in the older and heavier child. Our findings underscore the need for providers to consider intentional shaking as a mechanism of injury in the evaluation of abusive head injury in older children.

Tung, G. A., Kumar, M., Richardson, R. C., Jenny, C., & Brown, W. D. (2006). Comparison of accidental and nonaccidental traumatic head injury in children on noncontrast computed tomography. *Pediatrics*, *118*(2), 626-633.

Mixed-density convexity subdural hematoma and interhemispheric subdural hematoma suggest nonaccidental head injury. The purpose of this retrospective observational study is to investigate subdural hematoma on noncontrast computed tomography in infants with nonaccidental head injury and to compare these findings in infants with accidental head trauma for whom the date of injury was known. Two blinded, independent observers retrospectively reviewed computed tomography scans with subdural hematoma performed on the day of presentation on 9 infant victims of nonaccidental head injury (mean age: 6.8 months; range: 1–25 months) and on 38 infants (mean age: 4.8 months; range: newborn to 34 months) with accidental head trauma (birth-related: 19; short fall: 17; motor vehicle accident: 2). Homogeneous hyperdense subdural hematoma was significantly more common in children with accidental head trauma (28 of 38 [74%]; nonaccidental head trauma: 3 of 9 [33%]), whereas mixed-density subdural hematoma was significantly more common in cases of nonaccidental head injury (6 of 9 [67%]; accidental head trauma: 7 of 38 [18%]). Twenty-two (79%) subdural hematomas were homogeneously hyperdense on noncontrast computed tomography performed within two days of accidental head trauma, one (4%) was homogeneous and isodense compared to brain tissue, one (4%) was homogeneous and hypodense, and four (14%) were mixed-density. There was no statistically significant difference in the proportion of interhemispheric subdural hematoma, epidural hematoma, calvarial fracture, brain contusion, or subarachnoid hemorrhage. Homogeneous hyperdense subdural hematoma is more frequent in cases of accidental head trauma; mixed-density subdural hematoma is more frequent in cases of nonaccidental head injury but may be observed within 48 hours of accidental head trauma. Interhemispheric subdural hematoma is not specific for inflicted head injury.

Biron, D., & Shelton, D. (2005). Perpetrator accounts in infant abusive head trauma brought about by a shaking event. *Child Abuse & Neglect*, *29*(12), 1347-1358.

The objective was to analyze perpetrator and medical evidence collected during investigations of infant abusive head trauma (IAHT), with a view to (a) identifying cases where injuries were induced by shaking in the absence of any impact and (b) documenting the response of infant

victims to a violent shaking event. A retrospective study was undertaken of IAHT cases investigated by the Queensland Police Service over a 10-year period. Cases of head trauma involving subdural and/or subarachnoid hematoma and retinal hemorrhages, in the absence of any evidence of impact, were defined as shaking-induced. Perpetrator statements were then examined for further evidence to support the shaking hypothesis and for descriptions of the victim's immediate response to a shaking event. From a total of 52 serious IAHT cases, 13 (25%) were found to have no medical or observer evidence of impact. In 5 of those 13 cases, there was a statement by the perpetrator to the effect that the victim was subjected to a shaking event. In several cases both with and without evidence of associated impact, perpetrator accounts described an immediate neurological response on the part of the victim. The study confirms that IAHT resulting in death or serious neurological impairment can be induced by shaking alone. In cases where the infant's medical condition was adequately described, the symptoms of head injury presented immediately.

Dias, M. S., Smith, K., Mazur, P., Li, V., & Shaffer, M. L. (2005). [Preventing abusive head trauma among infants and young children: A hospital-based, parent education program.](#) *Pediatrics*, *115*(4), e470-e477.

Abusive head injuries among infants (shaken infant or shaken impact syndrome) represent a devastating form of child abuse; an effective prevention program that reduces the incidence of abusive head injuries could save both lives and the costs of caring for victims. We wished to determine whether a comprehensive, regional, hospital-based, parent education program, administered at the time of the child's birth, could be successfully implemented and to examine its impact on the incidence of abusive head injuries among infants <36 months of age. All hospitals that provide maternity care in an 8-county region of western New York State participated in a comprehensive regional program of parent education about violent infant shaking. The program was administered to parents of all newborn infants before the infant's discharge from the hospital. The hospitals were asked to provide both parents (mothers and, whenever possible, fathers or father figures) with information describing the dangers of violent infant shaking and providing alternative responses to persistent infant crying and to have both parents sign voluntarily a commitment statement (CS) affirming their receipt and understanding of the materials. Program compliance was assessed by documenting the number of CSs signed by parents and returned by participating hospitals. Follow-up telephone interviews were conducted with a randomized 10% subset of parents, 7 months after the child's birth, to assess parents' recall of the information. Finally, the regional incidence of abusive head injuries among infants and children <36 months of age during the program (study group) was contrasted with the incidence during the 6 preceding years (historical control group) and with

statewide incidence rates for the Commonwealth of Pennsylvania during the control and study periods, using Poisson regression analyses with a type I error rate of 0.05. During the first 5.5 years of the program, 65 205 CSs were documented, representing 69% of the 94 409 live births in the region during that time; 96% of CSs were signed by mothers and 76% by fathers/father figures. Follow-up telephone surveys 7 months later suggested that >95% of parents remembered having received the information. The incidence of abusive head injuries decreased by 47%, from 41.5 cases per 100 000 live births during the 6-year control period to 22.2 cases per 100000 live births during the 5.5-year study period. No comparable decrease was seen in the Commonwealth of Pennsylvania during the years 1996–2002, which bracketed the control and study periods in western New York State. . A coordinated, hospital-based, parent education program, targeting parents of all newborn infants, can reduce significantly the incidence of abusive head injuries among infants and children <36 months of age

Bechtel, K., Stoessel, K., Leventhal, J. M., Ogle, E., Teague, B., Laviertes, S., ... & Duncan, C. (2004). Characteristics that distinguish accidental from abusive injury in hospitalized young children with head trauma. *Pediatrics*, *114*(1), 165-168.

The objective was to describe the clinical features that distinguish accidental from abusive head injury in hospitalized children <24 months of age.. Prospective study of children <24 months of age hospitalized for head injury between August 1, 2000, and October 31, 2002. During hospitalization, children had computed tomographic scans of the brain, serial neurologic examinations, dilated ophthalmoscopic eye examinations, evaluation by a social worker, and, in some cases, a child abuse specialist. The main outcome measure was the proportion of children in each group with retinal hemorrhages (RHs). Secondary outcome measures were the proportion of children in each group who had vitreous hemorrhage; abnormal mental status on presentation; seizures; scalp hematomas; need for anticonvulsants; and operative procedures such as subdural tap, craniotomy, ventriculostomy, tracheostomy, and gastrostomy. Eighty-seven children were prospectively enrolled. Fifteen children were classified as having abusive head injury, and 72 were classified as having accidental head injury. Five children, all in the accidental head injury group, were excluded from statistical analysis, because they did not have a dilated ophthalmoscopic examination during their hospitalization. Thus 82 children were included in the statistical analysis. There were no significant differences between the 2 groups with respect to mean age, gender, or ethnicity. RHs were more likely to be seen in children with abusive head injury (60% vs 10%) and were more likely to be bilateral (40% vs 1.5%). Pre-RHs were more likely to be seen in children with abusive head injury (30% vs 0%). Premacular RHs and RHs that extended to the periphery

of the retina were also more likely to be seen in children with abusive head injury (20% vs 0% and 27% vs 0%, respectively). Of the 7 children with accidental head injury who had RHs, 6 had unilateral RHs. Children with abusive head injury were more likely to have seizures (53% vs 6%) and an abnormal mental status on initial presentation (53% vs 1%). Children with accidental head injury were more likely to have scalp hematomas (6.7% vs 49%). RHs are seen more often in abusive head injury and often are bilateral and involve the preretinal layer. Children with abusive head injury were more likely to have RHs that cover the macula and extend to the periphery of the retina. Unilateral RHs can be seen in children with accidental head injury. Children with abusive head injury were more likely to present with abnormal mental status and seizures, whereas children with accidental head injury were more likely to have scalp hematomas. Such characteristics may be useful to distinguish accidental from abusive head trauma in children <24 months of age.

Ettaro, L., Berger, R. P., & Songer, T. (2004). Abusive head trauma in young children: Characteristics and medical charges in a hospitalized population. *Child Abuse & Neglect*, 28(10), 1099-1111.

To describe the presenting characteristics, hospital course, and hospital charges associated with hospital admissions for head trauma in young children at a regional pediatric trauma center, and to examine whether these factors differ among abused and non-abused subjects. Comparative case series study involving a retrospective medical record review of children less than 3 years of age admitted to Children's Hospital of Pittsburgh from January 1, 1995 to December 31, 1999. Subjects (n=377) were identified on the basis of ICD-9-CM codes for head injury. Subjects were classified as abused or non-abused based on standard criteria using information about the type of injuries, the history provided by the caretaker, and physical and radiographic findings. Eighty- nine (23.6%) subjects were classified as abused and 288 (76.4%) were classified as non-abused. Abused subjects were more likely than non-abused subjects to be <1 year of age (vs. >1 year of age) (OR: 9.8; 95% CI: 5.0, 19.2), covered by Medicaid (vs. commercial insurance) (OR: 2.8; 95% CI: 1.7, 4.8), and admitted to the ICU (OR: 3.5; 95% CI: 2.1, 5.8; p<.001). The caretakers of abused subjects were more likely to give a history of no trauma or minor trauma compared to the caretakers of non-abused subjects (97% vs. 54%, p<.001). Length of stay was significantly greater for abused subjects versus non-abused subjects (mean: 9.25 days vs. 3.03 days, p<.001). Hospital charges (1999 dollars) were significantly higher for abused (mean±SD: 40,082±58,004) versus non-abused

(mean±SD: 15,671±41,777) subjects. These results highlight the differences in the demographics, presenting characteristics and economic impact of abusive head injuries compared to non-abusive head injuries

Keenan, H. T., Runyan, D. K., Marshall, S. W., Nocera, M. A., & Merten, D. F. (2004). [A population-based comparison of clinical and outcome characteristics of young children with serious inflicted and noninflicted traumatic brain injury.](#) *Pediatrics*, *114*(3), 633-639.

Diagnosing inflicted traumatic brain injury (TBI) in young children is difficult in practice. Comparisons of children with inflicted and non-inflicted TBI may help to identify markers of inflicted TBI. The objective of this study was to compare inflicted and noninflicted TBI in terms of presenting complaints, clinical features, and hospital outcomes. The presenting complaint, clinical finding, hospital course, and outcome of all children who were aged 2 years or younger in North Carolina and were admitted to a pediatric intensive care unit or died with a TBI in 2000 and 2001 were reviewed. Clinical presentation and injury types were compared between children with inflicted and noninflicted TBI. Risk ratios were used to compare clinical and outcome characteristics between the 2 groups. Among survivors, multivariate binomial regression was used to examine the adjusted risk of a poor outcome dependent on injury type. A total of 80 (52.6%) children had inflicted and 72 (47.3%) children had noninflicted TBI. Children with noninflicted TBI (not in a motor vehicle crash) were more likely to present to the emergency department asymptomatic (44.8% vs 8.3%) and to have a specific history of trauma than children with inflicted TBI. Retinal hemorrhage, metaphyseal fracture, rib fracture, and subdural hemorrhage were more commonly found in children with inflicted compared with noninflicted TBI. Skeletal survey and ophthalmologic examination combined would have missed 8 (10.0%) inflicted TBI cases. Manner of presentation and injury types are helpful in distinguishing inflicted TBI. Clinicians should not rule out inflicted TBI on the basis of skeletal survey and ophthalmoscopy alone but should proceed to computed tomography and/or magnetic resonance imaging.

Laskey, A. L., Holsti, M., Runyan, D. K., & Socolar, R. R. (2004). Occult head trauma in young suspected victims of physical abuse. *The Journal of Pediatrics*, 144(6), 719-722.

The objective was to determine the frequency of neuroimaging and ophthalmology consults in children evaluated for physical abuse without neurologic symptoms and the diagnostic yield of these studies. Records of neurologically asymptomatic patients younger than 48 months evaluated with a skeletal survey at two academic medical centers were reviewed for frequency of CT or MRI and ophthalmology consults, the results of these tests, and factors associated with given evaluations. Factors associated with positive findings during evaluation were also analyzed. Fifty-one patients had a skeletal survey and no clinical signs of intracranial injury. Seventy-five percent of patients had CT or MRI; 69% had formal evaluation for retinal hemorrhages. Twenty-nine percent had evidence of intracranial injury without neurologic symptoms. Age less than 12 months was the only factor significantly associated with neuroimaging (90% vs 55%, $P = .004$). Sex, race, insurance, and having an unrelated male caretaker were not significantly associated with performance of neuroimaging or findings of intracranial injury. Age less than 1 year was the only significant factor associated with the diagnostic evaluation. Neither retinal hemorrhage nor historic factors were sensitive markers for abnormalities found by neuroimaging. Clinicians should have a low threshold for neuroimaging when physical abuse is suspected in a young child.

Altman, R. L., Brand, D. A., Forman, S., Kutscher, M. L., Lowenthal, D. B., Franke, K. A., & Mercado, V. V. (2003). [Abusive head injury as a cause of apparent life-threatening events in infancy](#). *Archives of Pediatrics & Adolescent Medicine*, 157(10), 1011-1015.

An *apparent life-threatening event* (ALTE) refers to the sudden occurrence of a breathing abnormality, color change, or alteration in muscle tone or mental status in an infant. Several patients with ALTEs admitted to our institution were found to have sustained abusive head injuries. To systematically examine the possible causes of ALTEs and their relative frequencies. Prospective consecutive case series of 243 infants younger than 12 months admitted to a tertiary care academic medical center for evaluation of an ALTE during a 32-month interval. Thirty-five different causes of ALTEs were identified. Six subjects (2.5%) were diagnosed as having abusive head injuries, or 1 admission every 5 months. Three patients died in the hospital, 2 of whom were diagnosed as having abusive head injuries. A wide spectrum of diseases and disorders can

precipitate an ALTE. Among them, abusive head injury, a recently recognized cause, occurs frequently enough to obligate its inclusion in the differential diagnosis. An ophthalmologic evaluation with dilated fundus examination and cranial imaging should therefore be considered early in the investigation unless another cause becomes apparent soon after admission.

Donohoe, M. (2003). [Evidence-based medicine and shaken baby syndrome: part I: Literature review, 1966–1998](#). *The American Journal of Forensic Medicine and Pathology*, 24(3), 239-242.

Ricci, L., Giantris, A., Merriam, P., Hodge, S., & Doyle, T. (2003). Abusive head trauma in Maine infants: Medical, child protective, and law enforcement analysis. *Child Abuse & Neglect*, 27(3), 271-283.

The objective was to collect and compare the results of medical, child protective, and law enforcement evaluation of a sample of Maine children who were victims of abusive head trauma (AHT) in order to describe the clinical and evaluative characteristics as they relate to victims, families and perpetrators of such trauma and to improve the professional response to AHT in Maine. Retrospective chart review of medical, child protective, and law enforcement records of all AHT victims admitted to two tertiary care hospitals in Maine or seen by the state medical examiner from 1991 to 1994. Nineteen children (age range 2 weeks to 17 months) were identified as victims of AHT (out of a total of 94 head trauma admissions) accounting for 20 hospitalizations during the study period. There was a history of prior injury in 30%, history of prior medical evaluations for possibly abuse related problems in 65%, while, on presentation, 75% had evidence or history of prior injury. The hospitals notified child protective services (CPS) in all 20 cases and correctly identified abuse in 18 (90%). Parental risk factors for abuse identified in CPS records included substance abuse (53%), domestic violence (42%), criminal history (32%), unrealistic expectations (42%), and attachment problems (32%). However, risk factors were inadequately assessed in 53% of homes. Law enforcement identified a likely perpetrator in 79% of cases and in the majority the identified suspect was the father. In the 15 cases where a perpetrator was identified by law enforcement, that person was alone with the child at symptom onset in 14 (93%). The medical response, at least at the inpatient level, was generally well done with regard to suspicion and

reporting. Cases are possibly being missed at the outpatient level. Child protective risk assessment was limited overall yet in a third of the homes where AHT occurred, few if any risk factors were present to aid in identification and prevention. Law enforcement results suggest that a primary suspect for AHT is the caretaker alone with the child at the time of symptom onset.

Hymel, K. P., Jenny, C., & Block, R. W. (2002). Intracranial hemorrhage and rebleeding in suspected victims of abusive head trauma: Addressing the forensic controversies. *Child Maltreatment*, 7(4), 329-348.

Does an expanded subarachnoid space predispose to subdural bleeding? What does heterogeneity in the appearance of a subdural collection on CT or MRI imaging indicate? Spontaneous rebleeding? Minor re-injury? Major reinjury? In some specific cases, answers to these questions have important forensic implications. To conclude objectively that an infant's intracranial hemorrhage or rebleeding resulted from inflicted injury or re-injury requires an in-depth understanding of the pathogenesis of posttraumatic subdural and subarachnoid collections. The authors present two cases of indoor, accidental, pediatric, closed-head trauma that resulted in intracranial rebleeding. Both accidental cranial impacts occurred in medical settings and were independently witnessed by medical personnel. In addition, the authors summarize the relevant medical literature regarding pediatric intracranial bleeding and rebleeding.

Case, M. E., Graham, M. A., Handy, T. C., Jentzen, J. M., Monteleone, J. A., & National Association of Medical Examiners Ad Hoc Committee on Shaken Baby Syndrome. (2001). [Position paper on fatal abusive head injuries in infants and young children](#). *The American Journal of Forensic Medicine and Pathology*, 22(2), 112-122.

This article represents the work of the National Association of Medical Examiners Ad Hoc Committee on shaken baby syndrome. Abusive head injuries include injuries caused by shaking as well as impact to the head, either by directly striking the head or by causing the head to strike another object or surface. Because of anatomic and developmental differences in the brain and skull of the young child, the mechanisms and types of injuries that affect the head differ from those that affect the older child or adult. The mechanism of injury produced by inflicted head injuries in these children is most often rotational movement of the brain within the cranial cavity. Rotational

movement of the brain damages the nervous system by creating shearing forces, which cause diffuse axonal injury with disruption of axons and tearing of bridging veins, which causes subdural and subarachnoid hemorrhages, and is very commonly associated with retinal schisis and hemorrhages. Recognition of this mechanism of injury may be helpful in severe acute rotational brain injuries because it facilitates understanding of such clinical features as the decrease in the level of consciousness and respiratory distress seen in these injured children. The pathologic findings of subdural hemorrhage, subarachnoid hemorrhage, and retinal hemorrhages are offered as “markers” to assist in the recognition of the presence of shearing brain injury in young children.

David, T. J. (1999). [Shaken baby \(shaken impact\) syndrome: non-accidental head injury in infancy.](#) *Journal of the Royal Society of Medicine*, 92(11), 556-561.

The shaken baby syndrome has been a source of medical controversy for many years, and has been in the public eye since the televised trial of Louise Woodward in Boston in 1997. This paper outlines the condition and discusses some of the more controversial aspects. Is shaking without other trauma sufficient to cause injury? Can injuries from shaking be dated? Can accidents at home or minor trauma cause the condition?

Jenny, C., Hymel, K. P., Ritzen, A., Reinert, S. E., & Hay, T. C. (1999). [Analysis of missed cases of abusive head trauma.](#) *Jama*, 281(7), 621-626.

Abusive head trauma (AHT) is a dangerous form of child abuse that can be difficult to diagnose in young children. The objective was to determine how frequently AHT was previously missed by physicians in a group of abused children with head injuries and to determine factors associated with the unrecognized diagnosis. Retrospective chart review of cases of head trauma presenting between January 1, 1990, and December 31, 1995. One hundred seventy-three children younger than 3 years with head injuries caused by abuse. Characteristics of head-injured children in whom diagnosis of AHT was unrecognized and the consequences of the missed diagnoses. Fifty-four (31.2%) of 173 abused children with head injuries had been seen by physicians after AHT and the diagnosis was not recognized. The mean time to correct diagnosis among these children was 7

days (range, 0-189 days). Abusive head trauma was more likely to be unrecognized in very young white children from intact families and in children without respiratory compromise or seizures. In 7 of the children with unrecognized AHT, misinterpretation of radiological studies contributed to the delay in diagnosis. Fifteen children (27.8%) were reinjured after the missed diagnosis. Twenty-two (40.7%) experienced medical complications related to the missed diagnosis. Four of 5 deaths in the group with unrecognized AHT might have been prevented by earlier recognition of abuse. Although diagnosing head trauma can be difficult in the absence of a history, it is important to consider inflicted head trauma in infants and young children presenting with nonspecific clinical signs.

Hymel, K. P., Abshire, T. C., Luckey, D. W., & Jenny, C. (1997). Coagulopathy in pediatric abusive head trauma. *Pediatrics*, 99(3), 371-375.

Coagulopathy is a potential complication of head trauma that may be attributable to parenchymal brain damage. The objectives of this study were to assess the frequency of coagulation defects in pediatric *abusive* head trauma and to analyze their relationship to parenchymal brain damage.

We reviewed the records of 265 pediatric patients hospitalized for head trauma. One hundred forty-seven patients met study inclusion criteria: (1) radiologic evidence of head trauma, (2) multidisciplinary validation that head trauma had been inflicted, and (3) coagulation screening performed within 2 days of presentation. Using nonparametric analysis, initial coagulation test results were compared between study patients *without* parenchymal brain damage and those *with* parenchymal brain damage. Mild prothrombin time (PT) prolongations (median 13.1) occurred in 54% of study patients *with* parenchymal brain damage and only 20% of study patients *without* parenchymal brain damage. Among pediatric abusive head trauma patients with parenchymal brain damage *who died*, 94% displayed PT prolongations (median 16.3) and 63% manifested evidence of activated coagulation. PT prolongation and activated coagulation are common complications of pediatric abusive head trauma. In the presence of parenchymal brain damage, it is highly unlikely that these coagulation abnormalities reflect a preexisting hemorrhagic diathesis. These conclusions have diagnostic, prognostic, and legal significance.

Starling, S. P., Holden, J. R., & Jenny, C. (1995). Abusive head trauma: The relationship of perpetrators to their victims. *Pediatrics*, 95(2), 259-262.

Abusive head trauma is the most common cause of morbidity and mortality in physically abused infants. Effective prevention requires the identification of potential perpetrators. No study has specifically addressed the relationship of the perpetrators of abusive head trauma ("shaken baby syndrome") to their victims. The objectives of this study were to identify the abusers and their relationship to victims in these cases. We reviewed the medical charts of 151 infants who suffered abusive head trauma to determine the perpetrator of the abuse. Caretakers were classified by level of certainty: confession to the crime, legal actions taken, or strong suspicion by the staff. The relationship of abusers to victims was analyzed. Male victims accounted for 60.3% of the cases. Twenty-three percent of the children died, although death rates for boys and girls did not vary significantly. Male perpetrators outnumbered females 2.2:1, with fathers, step-fathers, and mothers' boyfriends committing over 60% of the crimes. Fathers accounted for 37% of the abusers, followed by boyfriends at 20.5%. Female baby-sitters, at 17.3%, were a large, previously unrecognized group of perpetrators. Mothers were responsible for only 12.6% of our cases. All but one of the confessed abusers were with the child at the time of onset of symptoms. Our data suggest male caretakers are at greater risk to abuse infants. Baby-sitters are a concerning risk group, because they represent a significant proportion of abusers, and they more easily escape prosecution. In addition, no prevention efforts have been directed at baby-sitters. These statistics could help change the focus of efforts to prevent abusive head trauma.