



Evolving forensic controversies in child abuse imaging

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Abstract

Child abuse is a common cause of morbidity and mortality in the pediatric population. Despite well-defined evidence establishing bona fide clinical and imaging indicators of child abuse, denialists have emerged on behalf of defendants utilizing unaccepted scientific positions based on literature that they have often authored themselves. This manuscript describes many of the trends in recent legal proceedings while highlighting the importance of consensus statements and professional ethics as they pertain to child abuse imaging. Knowledge of these cases and legal defense strategies is valuable to potential expert witnesses in relevant proceedings.

Keywords Abusive head trauma · Child abuse · Children · Classic metaphyseal lesion · Forensic testimony · Imaging · Radiography

Introduction

Child abuse is an ongoing problem in the United States. In 2018, data from the National Child Abuse and Neglect Data System (NCANDS) revealed that 1,770 children died of causes related to abuse and neglect, accounting for a rate of 2.4 per 100,000 in the United States [1].

The contribution of radiology to the investigation of a potentially abused child has faced multiple challenges in recent years. Although the scientific basis for the radiologic appearance of non-accidental trauma has been established with widespread support from pediatricians and pediatric radiologists, efforts to cast doubt on this science have grown. Several opponents of accepted theories describing traditional imaging correlates of non-accidental trauma have authored manuscripts, participated in mainstream media interviews, and testified in trials of accused abusers. This has resulted in conflict over the established science both in the courtroom and in the court of public opinion.

In this manuscript, I discuss common theories offered as alternative explanations of radiographic findings in the abused

child while referencing legal cases in which these theories have been produced. I also discuss the evidence offered by child abuse denialists and the media attention given to well-publicized child abuse trials.

Vitamin D deficiency as a cause for the classic metaphyseal lesion

The most commonly observed fractures detected in abused children are rib fractures and classic metaphyseal lesions. The classic metaphyseal lesion was first described in association with child abuse by Silverman [2] and Caffey [3]. The classic metaphyseal lesion has two appearances that depend on the radiographic projection of the abnormality. The fracture fragment extends from the edge of the subperiosteal bone collar into the metaphysis, creating either a corner fracture appearance or that of a bucket handle. The lesion can occur if there is a twisting force placed on a limb or through a whiplash-like mechanism during shaking. Pathological correlation to classic metaphyseal lesions has been described [4]. Studies examining cohorts with Vitamin D deficiency have shown fractures to be rare, and rickets has been shown to be rare in infants with fatal abusive head trauma and classic metaphyseal lesions [5, 6].

Despite the evidence in support of the classic metaphyseal lesion as a strong correlate with non-accidental trauma, prevailing theories denying the association have largely centered

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on reviews published by David Ayoub and Marvin Miller and colleagues [7, 8]. The 2014 manuscript by Ayoub et al. [7] that suggests that the classic metaphyseal lesion has a metabolic, rather than traumatic, origin has been a top Google search result for “classic metaphyseal lesion” since 2017 despite its conclusions being strongly refuted by the Society for Pediatric Radiology (SPR) Child Abuse Imaging Committee [9]. The SPR Child Abuse Imaging Committee published an additional strong response [10] refuting statements made in a similar 2019 article [8].

Ayoub and Miller testified on behalf of James Duncan, who requested a new trial after being imprisoned for 23 years following his 1993 conviction for abusing his infant son [11, 12]. Duncan’s son Kody was found to have 13 fractures including a skull fracture, and the 2014 paper written by Ayoub and Miller [7] was a central component of Duncan’s request for a new trial. In 2018, Duncan’s request for a new trial was denied [11, 12]. In his opinion, Judge Michael Andrews referred to Ayoub and Miller’s assertion that the child had suffered from rickets rather than child abuse to be a “fringe opinion,” and Andrews questioned the credibility and objectivity of Ayoub and Miller [12, 13]. The judge also commented on the large number of cases in which Ayoub and Miller had testified without concluding that fractures were the result of abuse. Ayoub has testified in or provided consultation in hundreds of cases throughout North America, Europe and Australia, with approximately 80 trial testimonies in the United States as of 2018 [12, 14]. In a separate case in the United Kingdom, Judge Peter Jackson criticized Ayoub’s testimony, stating that “He entertained no doubts about the correctness of his opinion, a dangerous mindset for any expert witness” [15].

Ayoub has drawn skepticism from prosecuting attorneys in connection to his anti-vaccine stance, and it should be noted that he did not hold a subspecialty certificate in pediatric radiology as of May 2020. His area of expertise is in vascular and interventional radiology, with his subspecialty certificate in vascular and interventional radiology showing as having expired in 2005 (as of May 2020). Nonetheless, his testimony has been valuable to defendants. In a recent Massachusetts case, for instance, the jury sided with the Ayoub and the defense despite testimony provided by Paul Kleinman on behalf of the prosecution [14]. Kleinman is a renowned expert in child abuse imaging and served as the editor for *Diagnostic Imaging of Child Abuse* [16], a leading textbook on the topic. The judge in this case denied questioning related to Ayoub’s anti-vaccine views [14].

To strengthen the position of the Society for Pediatric Radiology, the group issued a consensus statement addressing the Vitamin D hypothesis in 2016 [17]. Among the conclusions of the authors are that classic metaphyseal lesions are not controversial in their high specificity with respect to child

abuse and that classic metaphyseal lesions are not sequelae of rickets.

Genetic syndromes as mimics of child abuse

Some genetic disorders are known to result in radiographic findings that can be similar to those seen in the abused child. Osteogenesis imperfecta, for example, is a heterogeneous group of disorders related to errors in collagen formation that can predispose children to multiple fractures. Likewise, Caffey disease is an inflammatory bone disease associated with a collagen defect. Hyper-IgE syndrome is a genetic disorder that affects cytokine pathways and can result in recurrent fractures. Disorders related to liver function and Vitamin K metabolism have been associated with intracranial hemorrhages. Glutaric aciduria Type 1 and Menkes syndrome are rare causes of cerebral volume deficiency that can mimic the post-traumatic findings commonly seen in abused children. The advent of molecular genetic techniques to aid in the diagnosis of these and other genetic diseases should help to decrease confusion over many of these conditions [18].

A disorder that has come to the forefront in defense of accused abusers is hypermobile Ehlers–Danlos syndrome, one of the least severe types of this disease family. In hypermobile Ehlers–Danlos syndrome, joints are lax, and affected patients bruise easily. The utility of this diagnosis in child abuse cases is that the mutation for this disease is unknown [19], which allows defense experts to offer the diagnosis without corroborating genetic testing.

A leading proponent of hypermobile Ehlers–Danlos syndrome is Michael Holick. Holick is trained as an internal medicine physician and endocrinologist, and he has testified or consulted in more than 300 cases of accused child abuse throughout the world, many of these without personally examining the child in question [20]. In 2017, he published a case series of 72 infants suspected to be abused who had been referred to his practice; he found that 93% had clinical evidence of Ehlers–Danlos or a family history of the disorder [21]. In many cases, Ehlers–Danlos was diagnosed in a parent for the first time after the referral of the child [21]. Holick was noted as an associate editor of this journal [20] that had not produced a new article since 2018 (as of June 2020).

Like Dr. Ayoub, Dr. Holick is known to attribute fractures to causes exclusive of child abuse, citing metabolic causes such as Vitamin D deficiency as the source in those instances in which he does not diagnose hypermobile Ehlers–Danlos syndrome. Unlike Ayoub, however, Holick does have a lengthy career as an academic physician, though he was cited with a practice restriction by one hospital in 2019 [22].

It must be reiterated that the role of the skeletal survey in diagnosing non-accidental trauma is multi-factorial. While the skeletal survey is useful in uncovering occult or healing

fractures, which might suggest child abuse, it is also used to evaluate for the possibility of underlying metabolic or genetic conditions that can contribute to fractures. Denialists who ignore the fact that experts trained in the interpretation of skeletal surveys and supporting clinical information have considered metabolic or genetic disease in the affected child fail to understand the spectrum of skeletal survey value.

Controversies related to abusive head trauma

Abusive head trauma has undergone much scrutiny in recent years, both in the courtroom and in the news media. Part of the manufacturing of confusion over abusive head trauma stems from attacks that denialists have levied at the varied nomenclature that has been applied to abusive head trauma over several decades. The terms “battered child syndrome,” “parent–infant traumatic stress syndrome” and “shaken baby syndrome” have all been used, but “abusive head trauma” emerged in 2009 as the preferred term [23]. Some of this evolution has emerged from developing science and improvements in technology. For instance, increased access to and utilization of MRI have allowed radiologists to better understand the magnetic properties of extra-axial hematomas [24] and potential admixture of cerebrospinal fluid. The increased utilization of MRI among neonates has demonstrated that birth-related subdural hematomas are relatively common within the first month after birth [25]. Improved imaging resolution has allowed clearer delineation of expanded subarachnoid spaces. What has traditionally been referred to as a subdural collection might be better described as an intradural collection because of the separation of a dural cell layer [26], a fact that attorneys can use to promulgate confusion at trial. Nonetheless, pediatricians and pediatric specialists have not wavered in support of the evidence basis for imaging findings associated with abusive head trauma.

A documentary attempting to spur controversy over abusive head trauma, *The Syndrome*, released in 2014, referred to the diagnosis of shaken baby syndrome as a “pop culture phenomenon” [27]. The information contained within the film is not peer-reviewed science, but it presents the denialists’ position on abusive head trauma and details the perspectives of several families affected by child abuse prosecutions. In this documentary, a small number of physicians including radiologist Patrick Barnes, neurosurgeon Ronald Uscinski, and the late pathologist John Plunkett are presented as pioneers in denying the science accepted by the pediatric medical community. The prosecution’s facts of each case are not detailed, but the documentary is nonetheless notable for its sensational appeal to personal emotion. A list of alternative causes of findings related to abusive head trauma is provided in the documentary; however, the notion that many of these alternatives can be medically excluded is not addressed. The

argument of occult postnatal Vitamin D deficiency, later cured by formula supplementation, is cited by one of the defendants. *NBC News* and the *Houston Chronicle* collaborated on a similarly one-sided article series dedicated to the alleged overdiagnosis of child abuse in 2019 [28].

In 2016, the Swedish Agency for Health Technology Assessment and Assessment of Social Services released a report denying the association between traumatic shaking and the triad of subdural hematomas, retinal hemorrhages and encephalopathy [29]. This report has been refuted as limited in its scope of review and for its reliance on the assumption that child abuse is commonly charged on the basis of the triad elements alone [30]. The SPR Child Abuse Imaging Committee and the European Society of Paediatric Radiology Child Abuse Task Force issued a formal statement opposing this report in 2017 [30].

With the continued onslaught on the science of abusive head trauma, a consensus statement supporting the evidence basis for findings related to abusive head trauma was released by the SPR in 2018 [23]. The power of this consensus statement was demonstrated in *United States v. Duran* [31]. The official opinion rendered in this case specifically cited this consensus statement as an authoritative scientific position in refutation of testimony offered by the defendant’s proposed expert witness. The use of physician witnesses as experts in support of findings related to abusive head trauma was affirmed in the unanimous decision rendered in *Wolfe v. Texas* [32].

Reasonable medical certainty and the burden of proof

Physicians sometimes struggle with legal concepts as they pertain to obligations as well as their role in the courtroom. While medical ethics holds that the physician maintains the need to act on the behalf of the patient, the physician who provides legal testimony is called to act on behalf of the court to assist in the execution of justice. While these concepts need not be mutually exclusive, the role of the expert witness can provoke anxiety among physicians unfamiliar with legal terminology.

Some description of the legal lexicon might thus be in order for some physicians. In the context of the crime of child abuse, the prosecutor is typically the state, and the defendant has the right to his or her own expert witness, even if that witness exhibits an opinion in staunch opposition to well-established science. Proof of criminal guilt typically holds demonstration of a criminal act beyond a reasonable doubt.

In civil proceedings, the standard of proof is instead a preponderance of the evidence rather than beyond a reasonable doubt. Financial damages are often sought in the adjudication of these torts, and monetary recompense for expert testimony

might be more commonplace. An example of the difference between these types of trials is the comparison between *People of the State of California v. Orenthal James Simpson*, in which O.J. Simpson was acquitted of murder, and the subsequent civil lawsuit in which he was found liable for his ex-wife's death. A level of greater than 50% certainty has been described as a threshold for preponderance of the evidence in civil trials, whereas 90–95% certainty is commonly applied to the “beyond a reasonable doubt” standard in criminal trials [33], though no official percentages are typically memorialized as legal standards.

In legal proceedings, physicians serving as expert witnesses are asked to testify according to a standard of “reasonable medical certainty” in which a numerical probability of certainty is not defined. This is important because a given physician might be willing to provide evidence of reasonable medical certainty in the case of a civil trial but not in a criminal trial if his or her level of reasonable medical certainty is somewhere on the spectrum between civil and criminal standards of proof [33]. To cloud the issue further, a survey of pediatric experts likely to testify in child abuse cases showed that responses were clustered about both of the greater than 50% and the greater than 90–95% certainty standards when asked about the definition of reasonable medical certainty [33].

In a criminal case, it is the state's burden to prove the guilt of the defendant, not the expert witness's. In the case of the pediatric radiologist, findings of possible abuse are often the first clue that a crime has been committed; however, that radiologist might not have additional clinical information that would affect that physician's stance. For example, an experienced radiologist might conclude that the radiologic evidence apparent at the time of presentation is associated with child abuse at a rate of greater than 50% of all similar cases that radiologist has reviewed in the past, but additional analysis from other experts might confound this degree of certainty. Nonetheless, any physician who encounters possible child abuse is compelled to report that possibility [34]. Mainstream media might emphasize a single isolated opinion as evidence of perceived injustice, which highlights a logical fallacy offered in many trials. This might explain why many of the opinions of those experts who have testified almost exclusively for the defense and in opposition to the accepted science of child abuse pediatrics have been discounted by judges. Ultimately, this emphasizes the importance of consensus statements endorsed by established professional societies such as those referenced here [17, 23].

In any trial, witnesses should only assert an expert opinion over that content in which he or she has expertise. An expert witness should provide an impartial and objective opinion and be prepared to explain the scientific basis for that opinion while also considering sources of bias. These elements are endorsed by the American College of Radiology as necessary components of accepted professional practice [35]. Expert

witnesses are encouraged to cite peer-reviewed literature that is embraced by general scientific consensus because these fundamentals are considered by judges, who are compelled to serve as gatekeepers of expert witness testimony under *Daubert v. Merrell Dow Pharmaceuticals Inc.* [36].

Conclusion

Imaging findings associated with child abuse have come under scrutiny in recent years. Described here are several examples of challenges to accepted theories that are commonly used in legal proceedings. Knowledge of these cases and awareness of the evidence basis utilized by defense experts can be valuable to experts and litigators testifying in suspected cases of child abuse moving forward. Child abuse is unfortunately common. Armed with the evidence basis for child abuse forensics including consensus statements, we can best serve the interests of the court, the medical community, and most important, our children.

Compliance with ethical standards

Conflicts of interest None

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