

Radiology Missed an Intracranial Bleed in a Lethargic Infant.

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The Case

A 2-month-old full-term male infant was brought to the Pediatric Emergency Department (PED) for decreased responsiveness. He reportedly had a few days of cough, congestion and increased irritability, but he was more tired than usual on the evening of presentation. While falling asleep, he was noted to have eye-rolling and he did not respond to his name, shaking his hands, or placing ice on his chest. His feet were run under cold water, after which he briefly woke up, made some noises, and then went back to sleep. A parent called 911, and he was brought to the PED. Before the present illness, he was reportedly feeding, stooling and urinating normally. The patient's family denied fever, abnormal posturing, apnea or cyanosis. He had one non-bloody, non-bilious emesis the previous day. The social history was notable for living at home with parents, an older sibling and several extended family members; he had never attended day care or stayed in other homes.

On physical exam, the patient was asleep, arousing briefly with stimulation but then falling back to sleep. He did not cry at all with the examination. His anterior fontanelle was flat, his head was atraumatic, and pupils were equal and reactive bilaterally. His pulmonary, cardiac and abdominal examinations were unremarkable. He had normal muscle tone and movement of extremities. No bruising or abrasions were noted. He was able to tolerate an oral challenge despite his somnolence. Due to his persistently altered mental status, ultrafast magnetic resonance imaging (MRI) of the brain was obtained. Given limited overnight staffing, the MRI images were preliminarily read by a radiology resident. The patient was discharged with a parent after an "unremarkable" preliminary interpretation of the MRI.

However, the next morning, the final reading of the MRI by the attending physician noted a small (5mm) subdural hemorrhage overlying the left frontal convexity without mass effect or midline shift, but with trace left mastoid effusion. The family was called back to the PED for further evaluation and a parent disclosed that the child had fallen off a bouncy seat placed on the bed, onto the floor, 3 days prior to presentation. The patient underwent a non-accidental trauma evaluation including a comprehensive metabolic panel, lipase, complete blood count, urinalysis, and skeletal survey, followed by neurosurgery, pediatric surgery,

and ophthalmology consultations. His skeletal survey showed healing fractures of the left third and fourth lateral ribs; ophthalmology evaluation was negative for retinal hemorrhages. He was admitted for further evaluation and a Child Protective Services (CPS) case was initiated. A follow-up full brain MRI demonstrated mild prominence of the bilateral frontal spaces. After a period of observation and CPS assessment, he was discharged to the care of an extended family member, with close follow-up by county social services staff.

The Commentary

By Jihey Yuk, MD ,and Julia Magana, MD

In this case, a 2-month-old boy was brought to the PED with a non-specific clinical picture of decreased responsiveness in the setting of a viral upper respiratory illness (URI) and appeared somnolent on initial evaluation. At this point, the differential diagnosis was broad and superficially favored a viral illness, given the high frequency of such illnesses. However, the clinicians aptly recognized that the level of consciousness was more altered than is typically seen in a child with a respiratory virus. At this first entry point, many clinicians miss child abuse and incorrectly attribute symptoms to an alternative diagnosis. Recognizing non-accidental trauma (NAT) requires not only a thorough history and physical examination, but also experience with infants to know the expected level of alertness and responsiveness for an infant with a viral URI. In this case, the emergency medicine clinicians were clearly concerned about the possibility of abuse, based on their experience and training. It is critical that clinicians who see acutely ill and injured children understand how children with abusive head trauma (AHT) present and what evaluation is needed.

Background

Child maltreatment, including neglect, endangerment, and physical and or sexual abuse, is prevalent, with an estimated 600,000 affected children in 2021.¹ Child physical abuse evaluation starts with recognizing when there is an injury, and whether the injury matches with the reported injury mechanism (accident history). Thus, the diagnosis of non-accidental trauma, or child physical abuse, is made when a child sustains clear injury without a plausible trauma mechanism or an underlying medical condition that predisposes one to injury.

Children younger than 1 year of age are most vulnerable to NAT and comprise nearly half of child fatalities from abuse or neglect.¹ Abusive head trauma has the highest rate of mortality from NAT. AHT occurs from direct impact to the head, shaking, or a combination of both, and can lead to serious neurologic sequelae.

This case highlights some of the many pitfalls that clinicians encounter when they consider child abuse in the differential diagnosis. From initial triage to discharge, there are many opportunities to miss this crucial diagnosis, especially in smaller hospitals and rural settings that lack specialized expertise in pediatric trauma or child abuse. Hospitals and clinicians that may encounter injured children should commit to ongoing education and training on how to evaluate these injuries to rule out NAT. For this reason, several states (e.g., IA, MA, NY, PA) require physicians to obtain continuing medical education on identifying child abuse or neglect,² and several professional and advocacy organizations (e.g., [National Children's](#)

[Advocacy Center](#), [Children's Bureau Learning and Coordination Center \(CBLCC\)](#), [Prevent Child Abuse America](#), [The Child Abuse Prevention Center](#)) offer either online or in-person training programs for health professionals. Health care organizations that are unable to maintain expertise in recognizing NAT and other manifestations of child maltreatment should have systems in place to obtain telemedicine consultations from a specialty center, or to refer injured children immediately for further evaluation.

Abusive Head Trauma (AHT) is a Challenging Diagnosis

Abused infants can present with hard to identify signs such as bruises under clothing, torn frenula, subconjunctival hematomas, or no external findings of trauma at all. In fact, patients often present with non-specific symptoms such as vomiting, abnormal movements, changes in mental status, poor feeding, and decreased activity. These symptoms are often attributed to more common problems such as viral URI or acute gastroenteritis. In fact, abused patients often have a delayed presentation. The bedside parent may not give an accurate history or may not even know the accurate history. Without obvious external signs of trauma, recognizing NAT, including milder forms of AHT, can be especially challenging in infants. One retrospective study found that 31% of abusive head trauma cases were missed, and that 28% of those missed cases led to re-injury and 9% led to death.³ For this reason, infants younger than 90 days presenting with lethargy and other non-specific neurologic symptoms require careful evaluation, with a broad differential diagnosis including child physical abuse.

Approach to Improving Safety

Get a Head CT First for Evaluation of Possible AHT

In this case, an ultrafast brain MRI was ordered for "lethargy" and was preliminarily read as unremarkable by the radiology resident. The patient was discharged home to his caregivers once he showed mild clinical improvement. When a subsequent over-read by the attending radiologist showed a small subdural hemorrhage, the infant was called back to the hospital for a full child abuse evaluation. Further work-up identified healing fractures of the third and fourth lateral ribs, which in addition to the subdural hematoma, suggested child abuse.

A consensus statement supported by multiple international professional societies including the American Academy of Pediatrics, American Society of Pediatric Neuroradiology, and European Society of Neuroradiology recommends computed tomography (CT) without contrast as the initial imaging modality in an acutely ill child with any degree of neurologic impairment.⁴ Full multi-sequence MRI of the brain and at least the cervical spine should be performed for children with initial head CT findings consistent with intracranial injury.²

"Rapid MRI" or "ultrafast MRI" refers to acquiring fast T2-weighted sequences with a single-shot technique, which is fast enough that most children do not require sedation. Although this technique is increasingly available and promising in its ability to detect AHT in young infants, it has limitations. The sequences included in fast MRI vary depending on the technology and resources available to institutions. In addition, MRI has decreased sensitivity for subtle skull fractures and higher risk of motion artifacts without good immobilizing techniques.^{5,6} In children with neurologic findings, non-contrast head CT remains the preferred initial imaging modality due to its nearly universal, immediate availability and the ease with which

subdural hematomas and skull fractures can be detected even by less experienced readers.⁷ A strict CT protocol must be followed, with thin-section slices from skull to vertex and three-dimensional volume-rendered reconstructions.⁷

The single-phase CT head radiation dose for children 5 years old and younger is equivalent to 1.5-2.5 years of natural radiation exposure in our living environment;⁸ accordingly, head CT should be performed sparingly but not avoided in this population. Rapid brain MRI should be considered for first-line imaging only in asymptomatic children undergoing child abuse evaluation, such as the sibling of an index child suspected of having been abused.^{5,7} ED and pediatric providers should be trained in these standards of care for imaging of possible AHT. If rapid MRI is included in a hospital's [child abuse protocol](#), the correct indications for ordering rapid MRI should be clear to users. This is an area with evolving evidence as imaging technology as well as institutional experience and abilities improve.

Importance of Experienced Radiologists

When clinicians order imaging tests, the findings of abuse are often subtle and very specific to pediatrics, necessitating subspecialty expertise to consistently identify them. The initial head CT and skeletal survey provide critical information in screening and evaluating for NAT, to prevent children from returning to abusive homes. In a retrospective cohort of 467 children with suspected NAT, 51 children were sent home after a missed diagnosis of NAT – of these, 6 children later died and 10 survived with handicap.⁹ Evaluating skeletal surveys of younger children requires experienced and adequately trained radiologists, as this evaluation includes looking for subtle findings specific to abused infants such as classic metaphyseal lesions, differentiating normal variants from abusive injury, and understanding time frames for healing fractures and potential fracture mechanisms.¹⁰ Missing a case of NAT or inappropriately attributing normal findings to abusive injuries can be a life-changing error for children and families. Given the high stakes involved, some institutions perform independent double-reads of skeletal surveys for children undergoing NAT evaluation.

In addition, even though head CT has higher sensitivity for subdural hemorrhage and skull fracture than ultrafast brain MRI, suspicious findings can still be missed by less experienced readers. A study evaluating discrepancies in head CT readings between referring community radiologists and fellowship-trained neuroradiologists at a tertiary pediatric hospital showed a significantly higher discrepancy rate for children with AHT (19/46; 41%) than for children without AHT (32/138; 23%).¹¹ The most common findings resulting in a major discrepancy were a missed fracture and misdiagnosis of subdural hemorrhage, either through lack of detection or misinterpretation as benign enlargement of the subarachnoid spaces of infancy. A review of missed cases of AHT at a tertiary academic center found that 7 of 54 missed cases were attributed to radiographic misdiagnosis (6 on head CT and 1 on skeletal survey).³

These research findings highlight the importance of experienced clinicians providing a final read on images for NAT evaluation. When this evaluation occurs overnight, it may not be feasible for many institutions to have an attending radiologist immediately available. However, picture archiving and communication systems (PACS) have made it easier to consult an expert radiologist within an hour or two after a high-stakes imaging study. If an experienced radiologist is not available overnight, institutions should establish clear discharge criteria in their standardized protocols as well as action plans in case of errors in the

preliminary reading. Partnerships with referral centers may also be helpful to obtain needed subspecialty expertise.

Systems Improvement

Finally, it is important to acknowledge what “went right” in this case. In most referral centers, suspected NAT cases are evaluated by an interdisciplinary team of specialists that include physicians, nurses, hospital social workers and others.⁴ The goal of these teams is to diagnose and treat child abuse and neglect, assess alternative diagnoses, and assist in the efforts of the many agencies involved.⁴ As expected in a well-functioning system, the erroneous MRI interpretation was identified in a timely manner, the patient’s caregivers were contacted, appropriate follow-up testing was performed, all necessary consultations were obtained, the findings were appropriately reported to caregivers as well as external agencies, and measures were immediately implemented to protect the patient from further injury. Without these efforts, more serious consequences might have resulted.

Take-Home Points

- NAT, including neglect, endangerment, and physical or sexual abuse, is widespread and its recognition is crucial.
- Children under 1 year old are particularly vulnerable to NAT. Early recognition and appropriate diagnostic imaging are vital for timely intervention.
- Diagnosing AHT poses unique challenges due to non-specific symptoms, delayed presentations, and difficulty in obtaining accurate histories. Clinicians must consider subtle signs, such as bruises under clothing or torn frenula, which can be hard to identify. The frequent lack of external signs makes recognizing AHT, especially in infants presenting with non-specific symptoms, exceptionally challenging.
- Hospitals and clinicians should commit to ongoing education and training on how to evaluate acutely injured children.
- The standard initial imaging modality for acutely ill children with concern for AHT is a CT without contrast. Ultrafast MRI should generally be reserved for evaluation of asymptomatic children.
- Subtle findings specific to pediatric abuse require specialized expertise for detection. Skeletal surveys and head CTs, critical for screening and evaluating for NAT, should generally be interpreted by experienced radiologists, with rapid follow-up when errors are identified in preliminary readings.

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References

1. Children's Bureau. *Child Maltreatment 2021*. US Department of Health and Human Services. 2022. Accessed December 13, 2023. [[Free full text](#)]
2. Federation of State Medical Boards. *Continuing Medical Education. Board-by-Board Overview*. Accessed January 3, 2024. [[Free full text](#)]
3. Jenny C, Hymel K, Ritzen A, et al. Analysis of missed cases of abusive head trauma. *JAMA*. 1999;283(7): 621-626. [[Free full text](#)]
4. Choudhary AK, Servaes S, Slovis TL, et al. Consensus statement on abusive head trauma in infants and young children. *Pediatr Radiol*. 2018;48(8):1048-1065. [[Free full text](#)]
5. Ryan ME. Rapid magnetic resonance imaging screening for abusive head trauma. *Pediatr Radiol*. 2020;50(1):13-14. [[Free full text](#)]
6. Berger RP, Furtado AD, Flom LL, et al. Implementation of a brain injury screen MRI for infants at risk for abusive head trauma. *Pediatr Radiol*. 2020;50(1): 75-82. [[Available at](#)]
7. Paddock M, Choudhary A, Jeanes A, et al. Controversial aspects of imaging in child abuse: a second roundtable discussion from the ESPR child abuse taskforce. *Pediatr Radiol*. 2023; 53: 739-751. [[Free full text](#)]
8. World Health Organization. *Computed Tomography (CT) in Children What do we need to know?* Accessed December 15, 2023. [[Free full text](#)]
9. Carty H, Pierce A. Non-accidental injury: a retrospective analysis of a large cohort. *Eur Radiol*. 2002;12(12):2919-2925. [[Free full text](#)]
10. Offiah A, van Rijn RR, Perex-Rossello JM, et al. Skeletal imaging of child abuse (non-accidental injury). *Pediatr Radiol*. 2009;39:461–470. [[Free full text](#)]
11. Kralik SF, Finke W, Wu IC, et al. Radiologic head CT interpretation errors in pediatric abusive and non-abusive head trauma patients. *Pediatr Radiol*. 2017;47:942-951. [[Available at](#)]

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