

The Non-Accidental Trauma Evaluation: How to get it RIGHT

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Non-accidental trauma (NAT) is one of the most depressing issues in Emergency Medicine. But it is also a diagnosis that is, perhaps, best understood in the same context as other diagnoses that Emergency Physicians (EPs) commonly make in the Emergency Department. For example, EPs routinely diagnose acute coronary syndrome (ACS). It is on the differential for every chest pain patient that walks through the doors. Countless hours of continuing education and residency training are spent on identifying current of injury patterns on EKG and clinical features that make ACS more or less likely. The stakes, after all, of missing this life threatening disease are high. As a result, miss rates for ACS in the US have been estimated to be as low as 2%.^{1,2} By contrast, it is estimated that up to 30% of ED cases of non-accidental trauma are missed. Unfortunately the consequences of missing this diagnosis may be catastrophic as up to 10% of children with missed NAT diagnosis may go on to suffer lethal injuries.^{3,4}

NAT is tragically common. In 2010 there were 754,000 identified cases of abuse and neglect and 1,560 deaths in the U.S.⁵ Yet, children who are abused rarely present with a clear history. Often they present with either non-specific symptoms related to their inflicted injuries or with a routine pediatric illness but with evidence of inflicted injuries on exam. These subtle presentations make identification of children who have been victims of inflicted injury exceptionally challenging. In a review of 44 cases of pediatric deaths from abusive trauma, 19 % of these children were evaluated by a physician in the month preceding their deaths.⁶ The overwhelming majority of these evaluations occurred in an Emergency Department. Chief complaints at the time of the evaluations included facial bruising, fussiness, vomiting and poor feeding.⁶ At the times of their deaths, many of these children had evidence of old injuries, suggesting that they could have been diagnosed earlier and that we may have been able to save their lives. Given the high stakes it is imperative that EPs are not only fluent in the evaluation of children when abuse is suspected, but also that they are skillful in identifying subtle patterns that should raise clinical suspicion for abusive injuries. EPs often feel comfortable in the evaluation of obvious presentations of abusive injury such as the child with extensive bruising and intracranial injury, but may struggle with more subtle presentations. Consider the following case:

A 4-month-old child presents for vomiting and diarrhea. The family reports that the infant has taken no formula but has taken 12 ounces of an oral rehydration solution. He has had 4 wet diapers. On exam the infant is awake and drinking from a bottle. He is mildly tachycardic, but has good capillary refill and normal skin turgor. The abdomen is soft, non-tender and non-distended. A bruise is noticed on the back of the infant's left hand and right thigh. The family is unsure how the bruises got there.

What is the appropriate evaluation for this child? Do these bruises require evaluation? If so, what studies are warranted?

Part I: Patterns You Need to Recognize

Bruising

Just as the EP is trained to recognize patterns of cardiac ischemia on the EKG, the EP must also be facile in the recognition of physical exam findings or injury patterns that are suggestive of inflicted injury. Bruises are the most important finding to recognize. They are the most common sign of maltreatment and are often the first indication that maltreatment is occurring. Notably, bruising is missed as an indication of abuse in up to 44% of fatal or severe cases of child abuse.^{7,8} Bruising, however, is common in childhood and distinguishing bruising that is worrisome from bruising that is not worrisome can be challenging. Multiple studies examining bruising patterns in children are instructive to the EP and can help the EP determine which bruising patterns should incite a more substantial evaluation.

Sugar et al., conducted a prospective cross-sectional survey of children, under 36 months of age, presenting to their pediatrician's office for well child care.⁹ All children were evaluated for bruising; and presence and location of all bruises were recorded. A total of 973 children were included in the study. Only 203 children had any bruising. In children under 6 months of age, only 0.6% had bruising anywhere on their bodies. Further, only 2.2% of non-mobile children of any age had bruising. Once children began cruising and walking, bruising incidence increased substantially, however the majority of bruising was noted on the anterior shins, knees and forehead. There were no bruises noted to the hands or the feet, and bruising to the trunk was rare. This landmark study resulted in the clinical pearl "Those who don't cruise, rarely bruise."

A systematic review of 23 articles evaluating bruising patterns in children echoes this finding, reporting that less than 1% of non-independently mobile infants have any bruises. Further they identified the following bruising locations and patterns as concerning: bruising away from bony prominences, bruises to the face and neck, bruises to trunk and buttocks, patterned and clustered bruises.¹⁰

A recently derived, but not yet prospectively validated, decision rule to identify concerning bruises shows promise. The rule, called the TEN-4 rule had a sensitivity of 97% and a specificity of 84% in the derivation study. The TEN-4 rule works as follows: any bruising in a suspicious body region in a child under 4 years of age merits further investigation. Suspicious body regions are defined by the TEN part of the decision rule, where **T** stands for torso (includes chest, abdomen, back, buttocks, genitourinary region and hip), **E** stands for ears and **N** stands for neck. In addition, any bruising in any child under 4 months of age merits further investigation.⁸ Why age 4 months? This rule was derived from a

retrospective case-control study comparing bruising characteristics of children 0- 48 months of age admitted to the PICU with accidental injuries to those with inflicted injuries. Detailed analyses revealed these were the age and bruising characteristics that offered the best sensitivity and specificity.

Bruising should be documented clearly in the medical chart with location, size and pattern (if present) all described in detail. When possible, photo-documentation can be helpful. Photos should be taken with a ruler or measuring tape in the photograph, as these scale details may be forensically important. No attempt should be made to date bruises. Several studies have demonstrated physicians cannot accurately date bruises, including one study in which the dating accuracy of physicians was less than 50%.¹¹ Dating estimations impede the legal community's efforts to correctly identify and prosecute the perpetrator.

*Case 1 epilogue and conclusion: Skeletal survey and non-contrast head CT reveal small bilateral subdural hematomas and multiple rib fractures. **Bruising is an important sign of inflicted injury; and it is often the only external sign that abuse is ongoing. Any bruising in a non-mobile infant or bruising in unusual areas such as those identified by the TEN-4 rule, regardless of the reason for the child's visit to the ED, should be treated as suspicious and prompt further evaluation for inflicted injury.***

Another presentation that may challenge the EP is the child who arrives for evaluation of a fracture. Consider the following case:

Case 2: Mom and dad bring in their 8-month old for swelling to the right thigh and refusal to bear weight. Dad reports falling on the stairs earlier that day while holding the child. The exam is remarkable for a fussy infant with notable swelling to the right thigh. There are no bruises noted on the child's skin. Careful exam of the head and oropharynx including frenula is normal. The remainder of the infant's exam is normal. X-ray reveals a transverse fracture of the femur.

What is the appropriate evaluation for this child?

Fractures

Fractures are the most common presentation of child abuse after bruising. Abusive etiology is initially missed in approximately 20% of cases.¹² Importantly, when these injuries are missed the risk of subsequent ongoing abuse is 31-50%, with an estimated 10% risk of lethal injury.¹³ Though there are some fracture patterns that are virtually pathognomonic for abuse, most fractures require more thorough investigation. The EP must consider the following features: type of fracture, fracture location, history offered, presence of associated injuries, developmental stage of the child, and whether or not there has been any delay in seeking care. Unfortunately, with rare exceptions, no fracture can independently differentiate abusive from inflicted injury.¹⁴ However, there are some types of fractures and features that are more suggestive and suspicious for abusive etiology.

The majority of abusive fractures occur in children under 3 years of age, with most of these occurring in children less than 18 months of age.^{13 14} In general the younger the child, the more likely it is that the injury was inflicted. In addition, presence of more than one fracture, or presence of significant additional

injury or bruising in the absence of a compelling trauma history, should raise suspicion for an abusive etiology.¹⁴

Certain fractures are independently predictive of abusive etiology. The classic metaphyseal lesion, also known as a corner fracture or bucket handle fracture is virtually pathognomonic for abuse.¹⁵ These fractures occur at the juncture of the metaphysis and epiphysis of long bones. It is believed to occur as the result of forceful pulling, yanking or shaking of a child (Image 1).



Image 1: Classic Metaphyseal Lesion

In children under 1 year of age, rib fractures (Image 2) are also usually caused by inflicted trauma.¹⁶



Image 2: Multiple Rib Fractures

Fractures in general, in children under a year of age, should incite concern. Long bone fractures in this population are estimated to be abusive in 40-80% of cases.¹⁵ Femur fractures specifically have been found to be abusive injuries in 80% of non-ambulatory children and in up to 1/3rd of ambulatory children.¹³ Distinguishing inflicted injury from accidental injury in these populations can be difficult however and requires a thorough, detailed history and physical examination. This means that the history must include very specific questioning. For example in the case above it is critical to ask about the specific details surrounding the fall (e.g. What position did the child land in? How did the child fall? What

position did you find the child in?)¹⁷ In a study by Pierce et al, caretakers provided graphic and detailed information about accidental falls and in almost all cases could at least give a good description of the position in which the child was found or landed.¹⁸ In abusive cases, by contrast, the caretaker was more likely to provide detailed information about the stairs and physical environment with little information provided about the child and the fall. Type of fracture is important to the clinical evaluation, however it is important that the EP remember that transverse, spiral and comminuted fractures may occur accidentally. Similarly, buckle fractures may occur from inflicted trauma. The most critical information is in the details. Does the history offered match the child's developmental abilities? Is the history consistent – or does it keep changing? Does the mechanism described explain the fracture observed?

Distinguishing abusive from accidental injury also requires a thorough physical examination to look for other signs of injury such as bruising. In children with accidental falls there was rarely bruising in more than one region.¹⁸ Further, in stair falls it is highly unlikely for the child to have more than one significant injury.

*Case 2 epilogue and conclusions: A thorough history revealed that the fall occurred in a public venue that was witnessed by 5 other adults, including a police officer who called 911 after witnessing the fall. This was confirmed directly with the police officer. **Fractures are common pediatric injuries. It can be challenging for the EP to determine which fractures are concerning for abusive injury. Considering the following questions can help in this process: Is this an unusual or highly suspicious fracture such as a classic metaphyseal lesion or a rib fracture? Is the child less than a year of age and/or non-ambulatory? Is the history offered implausible or vague? Is there more than one fracture or other associated injuries? Are there concerning bruising patterns? Yes to any of these questions should prompt further investigation for abusive injury.***

Once the EP identifies injuries or patterns that are concerning for abuse, it is critical that the EP conduct a thorough and appropriate evaluation including evaluation for occult injury. Consider the following case:

Case 3: A 3 month-old is brought to an Emergency Department for evaluation after her twin sister has had multiple rib fractures identified concerning for abusive injury. The child looks clinically well, she is appropriately interactive and is meeting milestones. She is feeding well. Her exam is completely normal, there is no bruising or external signs of trauma. She looks marvelous.

What is the appropriate evaluation for this child?

Part II: Occult Injuries

Siblings

Bruising or fracture patterns, as already reviewed, often trigger evaluation for non-accidental trauma. Another important population that requires a full evaluation for inflicted injury is siblings of children with known inflicted injury.⁴ There is good evidence that if one child is being abused in a household that another child may also be being victimized. This evidence is even more compelling in the setting of

twins.¹⁹ Injuries may *not* be externally apparent. For this reason, in children under 2 years of age, this evaluation always requires diagnostic studies, including, at a minimum, a skeletal survey.¹⁹ Older children may only require a thorough history and physical examination.

*Case 3 Epilogue: The patient underwent non-contrast head CT and skeletal survey which demonstrated subacute on chronic subdural hematomas and multiple rib fractures (Image 3). **Conclusion: Always inquire about other children in the home and ensure their safety. Medical evaluation is recommended for all other children in the home. Occult injury in younger household members must be ruled out.***

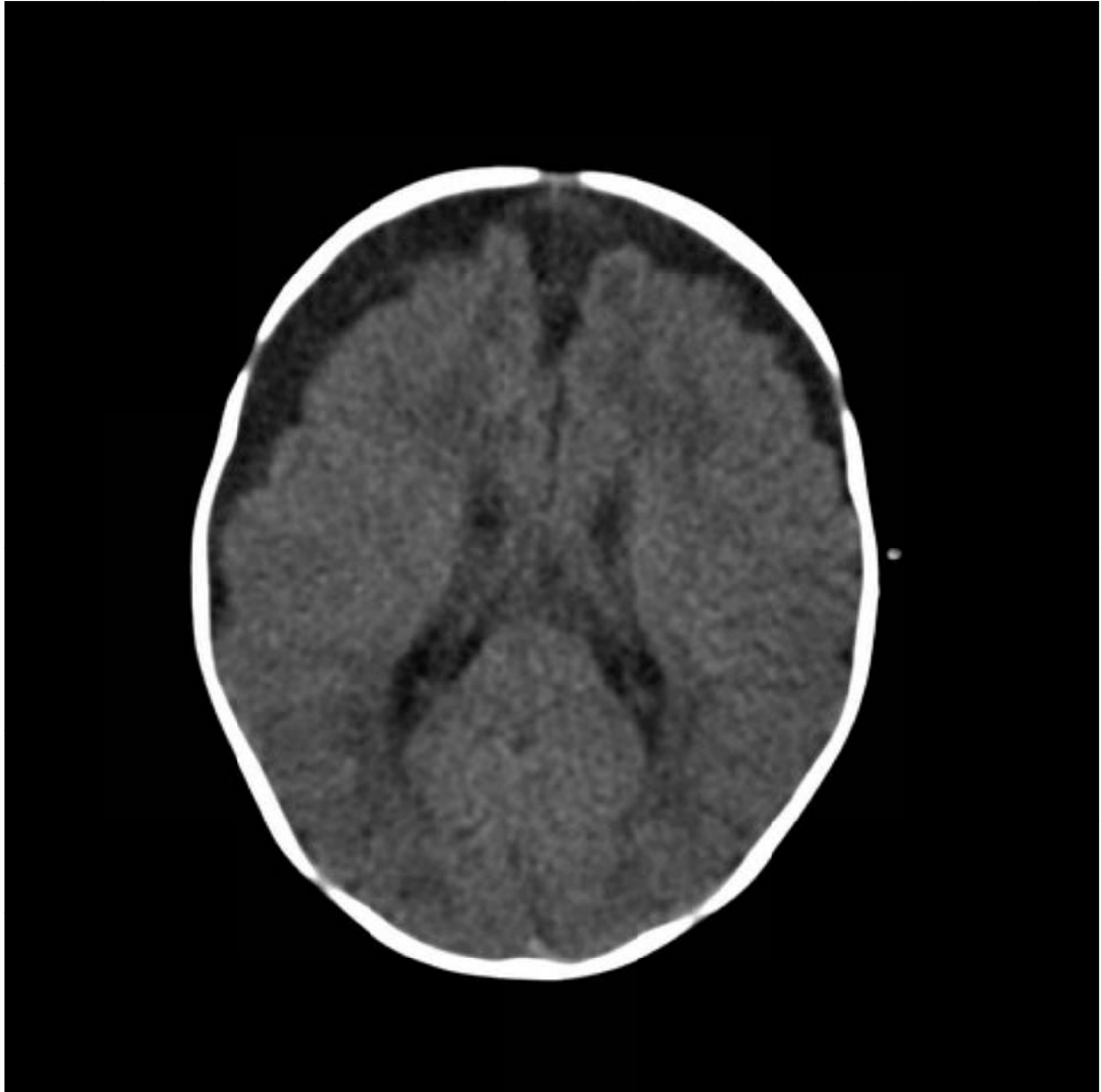


Image 3: Subacute on chronic subdural hematomas

Abusive Head Trauma

EPs must frequently weigh the risks and benefits of radiation exposure. This is especially true in children. Faced with a well appearing infant, the EP is often reticent to order CT imaging. However, in the child less than a year of age, with evaluation concerning for abuse, non-contrast Head CT imaging is imperative. Abusive head trauma (AHT) is the leading cause of death from inflicted injury in children. Though incidence is difficult to determine²⁰, it has been estimated to occur in approximately 1/3300 children under 12 months of age.²¹ Unfortunately many children have no external evidence of trauma. Furthermore, infants with significant intracranial injury are often asymptomatic or may present with non-specific complaints such as vomiting or increased fussiness. In a study looking at 173 cases of children with AHT, the diagnosis was initially missed for 31%. Mean time to correct diagnosis in these children was 7 days, but approximately 27% were reinjured between the initial evaluation and the correct diagnosis, and 40% had medical complications related to the diagnostic delay. Initial misdiagnosis included the following: acute gastroenteritis, rule-out sepsis, increasing head size, apnea, and bruising of unknown origin.³ Another study investigated the occurrence of occult head injury in children with other injuries suspicious for inflicted trauma.²² These were neurologically asymptomatic children without external signs of head injury who underwent non-contrast head CT as part of their evaluation for other injuries concerning for abuse. 29% of these children had evidence of abusive head trauma on CT. For these reasons - the dire consequences of missed head injury and the high incidence of occult injury in abused children - aggressive evaluation is warranted when physical abuse is strongly suspected. Evaluation should include non-contrast head CT in children less than 12 months of age with suspicious injuries or injury patterns.²³ In children 12 months and older, non-contrast head CT should be considered if there is any external evidence of injury about the head or neck or if there are clinical symptoms such as change in mental status, that are suggestive of intracranial injury.²³

Abusive Abdominal Trauma

In contrast to AHT, abusive abdominal trauma (AAT) occurs far less frequently. But like AHT, abusive abdominal trauma often presents with occult or non-specific complaints. Abusive abdominal trauma is the second leading cause of traumatic death from abusive injuries.²⁴ Its actual prevalence has been difficult to determine, however, estimates based on several studies put prevalence at 1-4%.^{25, 24} Coupled with this low frequency however, is a high mortality rate – as high as 50% in some studies.²⁴ Unfortunately, like AHT, children with AAT often have occult injuries or present with non-specific symptoms, such as vomiting or abdominal pain. Bruising, for example, may be absent in as many as 80% of cases.²⁶ In fact, in one study, over 40% of children with lethal injuries had no external abdominal wall contusions. Routine screening Abdominal CT is not recommended because AAT is, overall, a low frequency event. However, it is a high stakes injury. The current recommendations for evaluation for occult AAT in children presenting with other findings or complaints concerning for abuse is to obtain screening labs, inclusive of liver function tests.^{27,28} Many experts recommend that this screening should take place for all young children with findings that are concerning for abusive injury.^{23,25,27,28} Contrast Abdominal CT imaging is indicated for AST or ALT greater than 80 IU. In one study, this cut-off yielded a sensitivity of 77% and a specificity of 82%.²⁸ Abdominal CT imaging is also indicated if the clinical exam

is suspicious for intra-abdominal injury, such as bruising, regardless of the lab values. Screening with ultrasound is not recommended due to poor sensitivity overall.^{25,26}

Part 3: The Medicolegal Issues

All EPs strive to provide optimal care to their patients, and to identify and respond to potentially life threatening illnesses. This includes child abuse. Unfortunately the medicolegal risks associated with missing these diagnoses are real. Practitioners have been sued for missed diagnoses of child abuse. EPs must be equipped with the best information to care for evaluate these children.

Part 4: The Standard of Care When You Suspect Abuse

Just as aspirin is considered standard of care treatment for acute myocardial infarction and a full septic evaluation is considered standard of care for the febrile neonate, there IS a standard of care for the evaluation of the child with suspected abusive injuries. Consider the following case:

Case 4: A 4-month old infant presents to the emergency department with complaint of cough and fever. On exam, she is alert and interactive, sitting on mom's lap and drinking from a bottle. She has a fever to 101.7° F. She is mildly tachypneic and mildly tachycardic. HEENT exam is notable for mild rhinorrhea. Right sided crackles and tacyhpnea are noted on auscultation. Her respiratory exam is otherwise normal without use of accessory muscles, nasal flaring or grunting respirations. Her abdomen is soft, non-tender and non-distended. She is well hydrated with brisk capillary refill. Skin exam is notable for a 5mm bruise to the left lateral chest wall. The family has no explanation for the bruise.

What is the appropriate evaluation for this child?

The standards that have been developed for the evaluation of suspected non-accidental trauma exist because of the high incidence of significant occult injuries in generally well appearing children. In addition, even clinically insignificant injuries are forensically critical to ensuring the safety of children. Identifying such injuries may be the difference between sending a child back to an unsafe home environment and the introduction of family services and removal to safety. As with many pediatric illnesses and injuries, standard evaluation varies by patient age. Here is how it works:

- **Skeletal Surveys:** Any child under 2 years of age undergoing evaluation for suspected abuse requires a skeletal survey.^{17, 4} Skeletal surveys are rarely indicated or helpful in children older than 24 months of age. It is important to realize that a skeletal survey is a well-defined 20 view radiograph series.¹⁹ It is NOT a babygram. Anything less than this series is insufficient to detect the sometimes subtle, but always forensically important fracture.²⁹
- **Non-Contrast Head CT:** This imaging is strongly encouraged for children under 12 months of age when there is suspicion for abuse. Recall that many children in this age range may have significant intracranial injuries in the absence of any focal neurologic findings or external evidence of head or neck trauma. Children 13 months of age and older should have brain imaging as clinically indicated.^{22 23}

- Retinal Exam: A formal exam by ophthalmology is required in any infant or young child with identified intracranial injury.⁴ Note that some child abuse specialists may also request this exam in the setting of an infant with highly suspicious injuries regardless of findings on Head CT.
- IV Contrast Abdominal CT: An abdominal CT with IV contrast is indicated in children with external signs or clinical symptoms or exam suspicious for intra-abdominal injury.⁴ CT is also indicated for children undergoing laboratory screening evaluation for occult abdominal trauma if either the serum AST or the ALT are greater than 80 IU.²⁵
- Screening Liver Function Tests: This testing is recommended by many experts in the evaluation of children with suspected inflicted injuries.²⁵ Inclusion of other trauma labs, such as lipase, CBC and basic metabolic panel in this evaluation has been suggested, however, data is limited to support sensitivity and specificity of these studies.^{25 23}

Evaluation for suspected abuse can be time consuming and, in some instances, technically beyond the scope and resources of an institution. In these cases, it is quite reasonable for the EP to transfer the child to a tertiary center for further evaluation. In addition, in many states, consultation with a child abuse specialist may be available through the regional Children's Hospital. This resource can be instrumental to providing comprehensive care for at risk children.

Case 4 epilogue: The unusual bruising patterns in a non-ambulatory infant prompted further evaluation. Skeletal survey revealed multiple fractures including multiple bilateral rib fractures, skull fracture, right humeral shaft fracture, left both-bone forearm fracture, left tibial shaft fracture and bilateral tibial corner fractures. Chest x-ray revealed the rib fractures as noted and right basilar airspace disease. Non-contrast Head CT demonstrated the skull fracture but no intracranial injuries. Complete blood count and comprehensive metabolic panel demonstrated anemia with a hemoglobin of 9 g/dL and elevated transaminases with AST of 844 IU and ALT of 1177 IU. An abdominal CT with IV contrast demonstrated a grade III liver laceration. It further defined the right basilar airspace disease as a hemothorax.

Conclusion

Unfortunately, child abuse is common and it is commonly missed. Children will present to Emergency Departments with routine pediatric complaints, but may, on exam, have evidence of bruising or injury that should raise the EPs suspicion for inflicted injury. On other occasions children may present with traumatic injury that should incite concern for a non-accidental event. The EP must be as vigilant about identifying child maltreatment as he or she is in identifying ACS. The EP must consider these diagnoses and must be fluent in the appropriate evaluation and management. A child's life may depend on it.

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