JUNE 2024

Identifying Non Accidental Trauma

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Trauma Medical Director
Children's Hospital Colorado

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No disclosures

Overview

1. Background and epidemiology
2. Case examples
3. Screening tools
4. How to work up a patient with suspicion of NAT
5. What injuries are suspicious for NAT

Child Maltreatment

- FY 2015, Child Protective Services agencies received an estimated 4M referrals involving approximately 7.2M children
  - 58.2 percent of referrals were screened in

- Children may suffer multiple forms of maltreatment
  - 75.3% of victims are neglected
  - 17.2% of victims are physically abused
  - 8.4% of victims are sexually abused
  - 6.9% of victims are psychologically maltreated

*http://www.acf.hhs.gov/programs/cb/research-data-technology/statistics-research/child-maltreatment

U.S. Epidemiology

Deaths

1,770 children died from abuse and neglect in 2018
2.39/100,000 children
57% male, 43% female

Over 80% of perpetrators are family members
All ethnicities represented

Before 2020, NAT was most common cause of trauma-related death at CHCO

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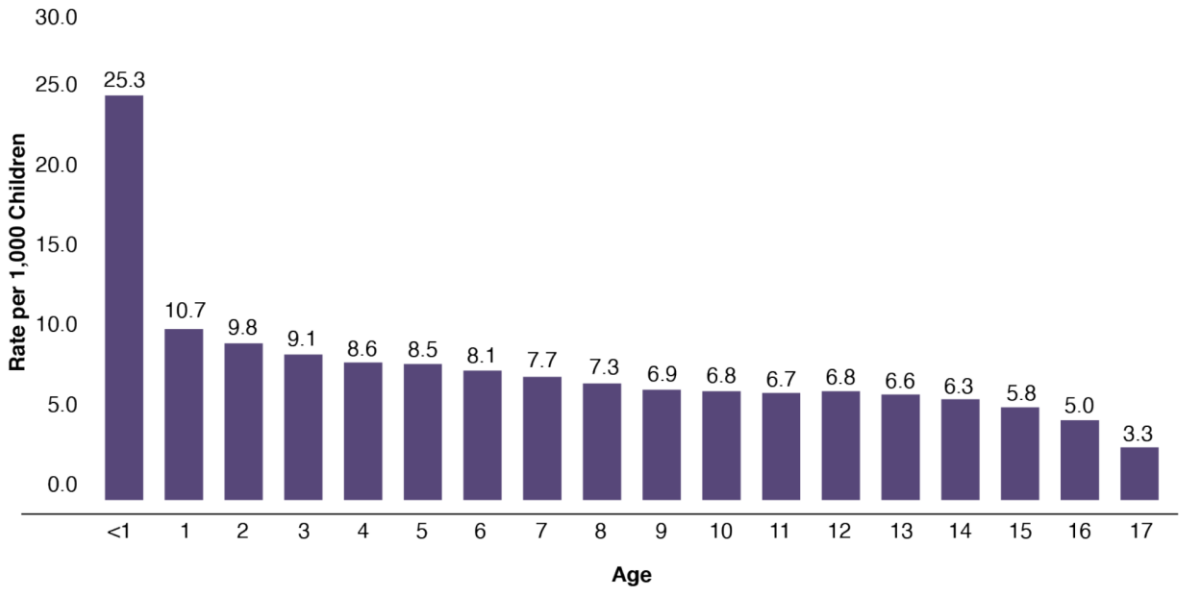
U.S Dept of Health and Human Services, Admin for Children and Families, Children's Bureau
https://www.acf.hhs.gov/sites/default/files/documents/cb/cm2018.pdf

U.S. Epidemiology- Child Abuse

Exhibit 3–D Victims by Age, 2021

The youngest children are the most vulnerable to maltreatment



Based on data from 51 states. See table 3–5.

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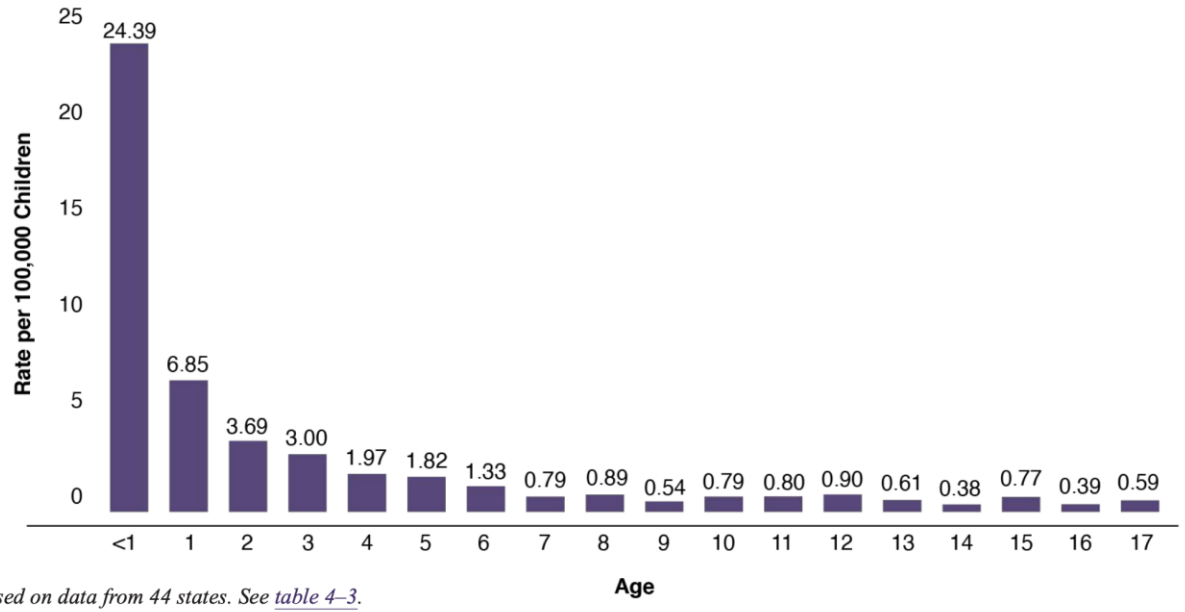
U.S Dept of Health and Human Services, Admin for Children and Families, Children's Bureau
https://www.acf.hhs.gov/sites/default/files/documents/cb/cm2021.pdf

U.S. Epidemiology Child Abuse Deaths

Exhibit 4–B Child Fatalities by Age, 2021

Children <1 year old died from abuse and neglect at more than three times the rate of children who were 1 year old.



Based on data from 44 states. See table 4–3.

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https://www.acf.hhs.gov/sites/default/files/documents/cb/cm2018.pdf

Consequence of Child Maltreatment

- More likely to experience teen pregnancy[1]
- More likely to engage in sexual risk taking, putting them at greater risk for STDs[1]
- 30% of abused/neglected children will later abuse their own children[2]
- Financial cost of child abuse/neglect in US is estimated at $585 billion[3]

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[1]Snyder, Howard, N. 2000.

[2]U.S. Department of Health and Human Services, 2013

[3]Fang, X., et al. Child Abuse & Neglect 2012

Financial Cost of Abusive Head Trauma

- The estimated 4,824 incidents of AHT cases in 2010 had an estimated lifetime cost of
  - $13.5 billion
    - $257 million for medical care
    - $552 million for special education
    - $322 million for child protective services/criminal justice
    - $2.0 billion for lost work
    - $10.3 billion for lost quality of life
- Discounted lifetime cost of abusive head trauma 5.7 million for a death, 2.6 million for survivor.

  - Lifetime Cost of Abusive Head Trauma at Ages 0-4, USA
    - Miller et al. Prevention Science 2017

Legal outcomes

J Pediatr Surg. 2015 Apr;50(4):604-7. doi: 10.1016/j.jpedsurg.2014.05.030. Epub 2014 Jul 11.

Beyond morbidity and mortality: the social and legal outcomes of non-accidental trauma

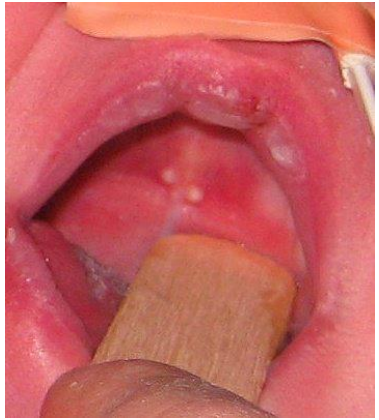
Shannon N Acker [1], Jonathan P Roach [2], David A Partrick [2], Frederick M Karrer [2], Denis D Bensard [3], Andrew P Sirotnak [4]

- Abusive head trauma led to fatality in 1 in 5 cases
- Perpetrators identified and found guilty in 29% of cases

Case 1

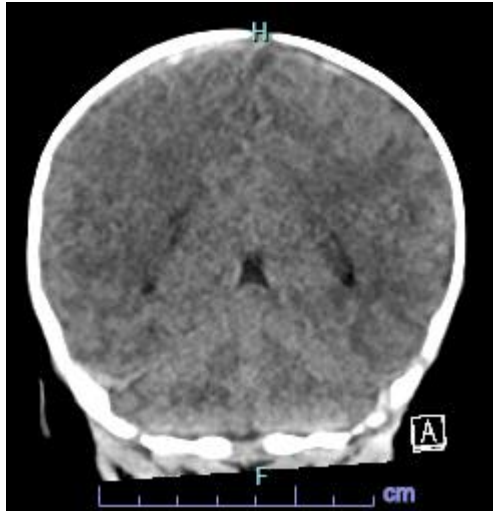
- 31 day old m with 1 episode of bright red spit up
- **Subconjunctival hemorrhage** since birth by history
- Erythematous non-ulcerative **lesion on the palate**
- Thought to be ruptured Ebstein's Pearl
  - Ebstein's pearls are small cysts that can be seen on the palate in the newborn period

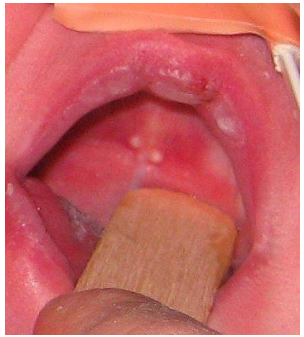
Normal Ebstein's Pearl



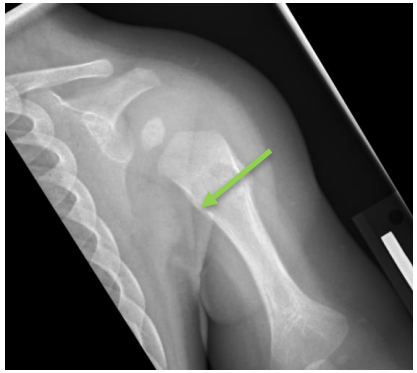
Case 1

- 19 days later
- 55 day old via EMS for bilateral eye bruising, bleeding from nose
- Patient was with FOC through the day and when MOC got him back he was more tired and fussy
- CT head R parietal bone fracture, multifocal bilateral extra-axial hemorrhage
- Skeletal Survey- metaphyseal corner fractures R & L femur, R & L tibia, biparietal skull fractures





Case 2

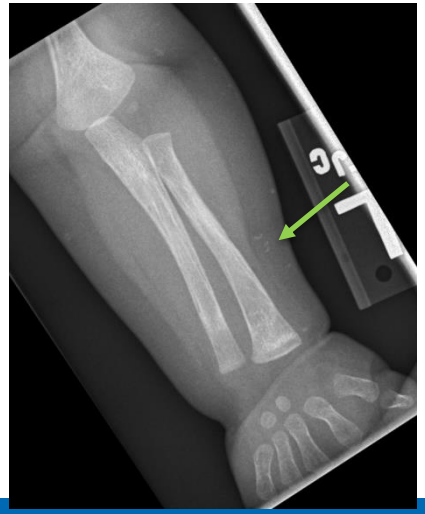


First presentation

- 5 month old male with thrush being treated with Nystatin presented for evaluation of bleeding mouth lesion
- Seen by APP, PEM and pediatric ENT
- Discussion of but overall very low concern for NAT
- Had follow up with PCP on 3 and 7 days later

One week later

- At PCP follow up found to have concerning bruising and sent to ED for further eval
- Eval showed normal head CT, L proximal humerus fracture, healing distal R radius fracture, L tibia healing fracture, L 3rd rib fracture

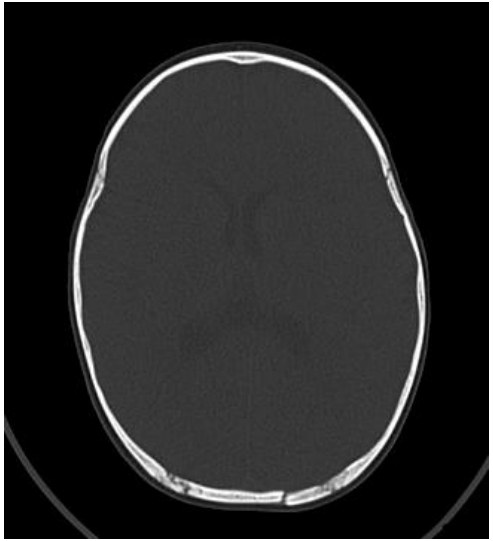


Case Study 3

- 17 mos old M, call from OSH
- H/O reflux. Witnessed choking on an orange, now vomits immediately with oral intake
- D/W GI fellow - patient to go to AMC for EGD, through ED
- In ED 3 hours. IV placed and went to Amb Surg for Procedure
- Same day to OR with normal EGD, still not tolerating PO's
- Admit to inpatient unit
- Inpatient note on 11/16, sleepier through the day, looking at other causes

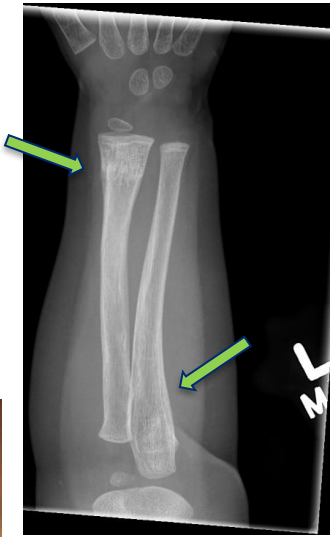
Case Study 3

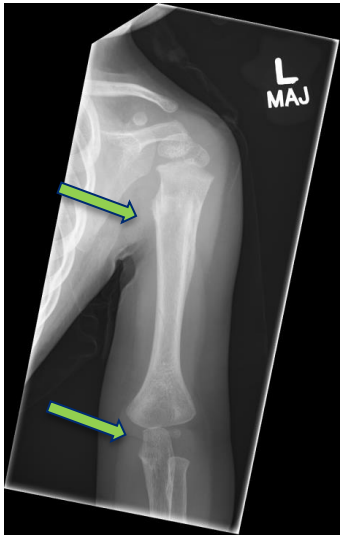
- CT Head- L occipital skull fx. Sagittal Sinus thrombosis. Also, mandibular f
- Many bruises
- 11/17 CPT and ophtho consults, skeletal survey



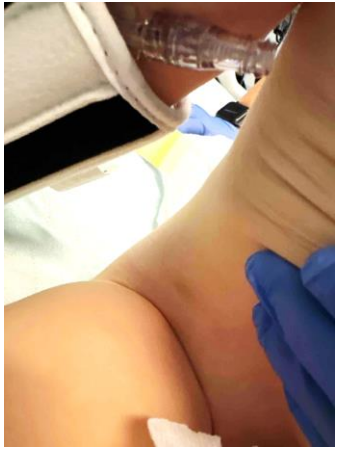
Case Study 3

- Skeletal Survey- Multiple fractures and suspected fractures at various stages of healing, including at the bilateral upper extremities, right proximal tibia/fibula, and again involving the intra-articular right mandibular condyle and the left occipital bone, as detailed above. Given the various stages of healing, nonaccidental trauma is highly suspected.
- CPT consult- **Skin:** pink, warm, well perfused, posterior right thigh with circular bruise noted, right lateral buttocks with faint circular bruise, posterior torso with multiple scattered contusions, right hip with contusion noted.





Right Thigh



Understanding 'Missed Opportunities'

- Abusive head trauma (AHT) is the leading cause of death from child abuse and causes lifelong consequences in survivors

- A number of studies have shown that a significant proportion of children with AHT have had a prior visit to a healthcare provider with a missed opportunity to recognize abuse

Missed Opportunities- AHT

- Jenny et al. JAMA 1999. Analysis of Missed cases of Abusive head Trauma
  - 173 children with abusive head trauma
  - 54 cases (31.2%) had a prior 'miss' opportunity where they were seen by a medical provider and with signs or symptoms that were suggestive of abuse (in retrospect)
  - Of the missed cases more often in white children than minorities
  - Of the missed cases more often in families where both parents lived in the house
  - Unclear how many were in adult vs pediatric EDs

Can anything be done?

- Is there a way to recognize the patients at that previous visit?
- Are there less severe injuries that point to abuse that could be used to find these patients early?

Concerning findings in the history

- Lack of or vague explanation for significant injury
- Lack of reported trauma in child with obvious injury
- Discrepant histories overtime or between persons
- Explanation that is not consistent with injury pattern or severity
- Explanation that is not consistent with child's developmental capability
- Delay in seeking care
- History of multiple injuries/emergency department visits/hospitalizations

Bruising Clinical Decision Rules

"**Bruising** is the most common injury from child physical abuse and the most common injury to be overlooked or misdiagnosed as non-abusive before an abuse-related fatality or near-fatality in a young child."

"Several studies identified bruises as the preceding injury to abusive head trauma."

"Failure to recognize bruising caused by physical child abuse is a **missed opportunity** and an error in medical decision-making that contributes directly to poor patient outcomes."

"Published evidence confirms that measurable differences exist between bruising from non-abusive and abusive injury in infants and young children."

JAMA Network Open. 2021;4(4):e215832. doi:10.1001/jamanetworkopen.2021.5832

Bruising Clinical Decision Rules

- Update of the bruising clinical decision rule 2021
- TEN-4 is now the TEN-4-FACESp
  - Bruising to the Torso, Ears, Neck in a child less than 4 years old
  - Any bruise in a child less than 4.99 months
  - Injury to the Frenulum, Angle of the Jaw, Cheek, Ears, Sclera
  - Patterned bruises

Better Sensitivity and Acceptable specificity compared to the TEN-4, derived from much more robust data

JAMA Network Open. 2021;4(4):e215832. doi:10.1001/jamanetworkopen.2021.5832

What is the TEN-4 FACES Model for Recognizing Concerning Bruising or injury?

Ear Bruising

Neck Bruise

A pneumonic for identifying bruising and injury concerning for physical abuse

- Bruising to the Torso, Ears, or Neck in a ≤ 4-year-old child
- Any bruise in a child <4 months old
- Bruising or or injury to the:
  - Frenulum
  - Angle of the jaw
  - Cheeks
  - Eyelids
  - Sclera
- Patterned bruising or injury

Burns – common manifestation of NAT

- 1-35% of children admitted to burn center
- Skin is thinner, more susceptible to burns
  - Liquids over 130 degrees F
- Less common than bruises but more painful with more sequelae
- Scald and immersion burns most common in NAT
- Immersion burns spare skin folds and have abrupt line of demarcation

Scald burn characteristics [55]

concerning for accidental trauma	concerning for nonaccidental trauma
spill or flowing water injury hot beverages, less often hot tap water irregular margins varying burn depth asymmetric involvement of lower limbs head, neck, trunk, face and upper body	immersion hot tap water clear upper limits uniform depth symmetrical involvement of lower limbs especially with skin fold sparing ("zebra striping") or central sparing of buttocks ("doughnut pattern") or soles of the feet isolated scald to buttocks/perineum glove and stocking appearance

Source: American Pediatric Surgical Association Not a Textbook

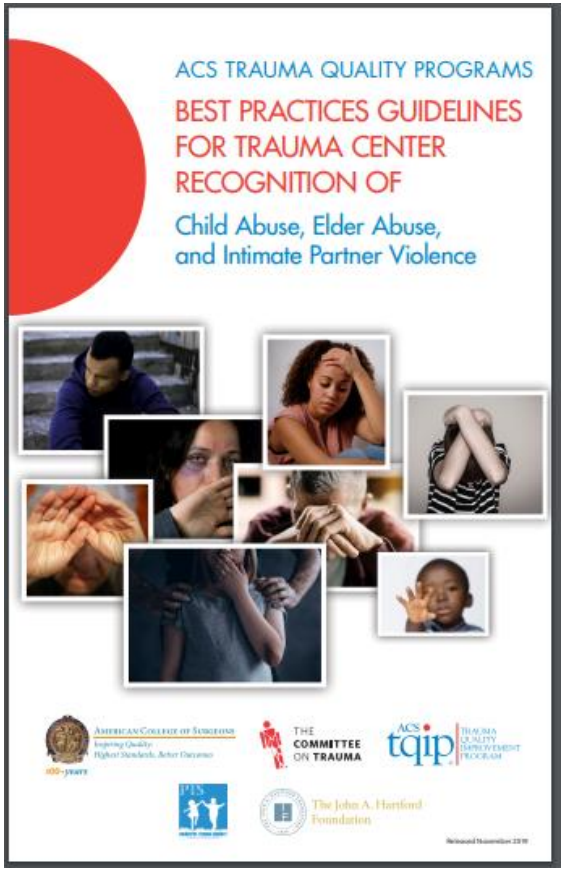
NAT EVAL

Red flags:

- Delays in seeking treatment
- Inconsistent story
- Caregiver with inappropriate affect
- Injury pattern not matching story
- History of previous injuries

Concerning injuries:

- Torn frenulum
- Bruising in uncommonly injured areas (ears, face, head, neck)
- Burns (circumferential, immersion, cigarette, lighter)
- Bite marks
- Multiple fracture/injuries in various stages of healing
- Evidence of poor care or FTT
- Blunt instrument marks



- Implement a standardized tool to screen for child physical abuse at all designated trauma centers and trauma hospitals.

NAT Screening Tool, age >6 months; RN/EMT view

Universal Child Abuse Screening

Time taken: 1/17/2024 0742 Responsible Create Note Macro Manager Show Last Filed Value Show Details Show All Choices

Universal Child Abuse Screening Tool

For children presenting for evaluation of a possible injury, was there a possible or definite delay in seeking medical attention given the severity of the injury/injuries?

Yes No N/A

Are you concerned that the history may not be consistent with the injury or illness?

Yes No

Did you observe ANY bruises, burns or markings in the shape of an object?

Yes Not observed

Did you observe TEN-4-FACESp bruising?

Yes Not observed

TEN-4-FACESp Bruising
Any bruising to the torso - including chest, abdomen, back, buttocks, GU, hip, ears, neck as well as to the Frenulum, angle of the jaw, cheek, eyelid, sclera and patterned bruising.

Are there findings that might reflect poor supervision, care or nourishment?

Yes No

Are there any additional comments or concerns related to child abuse or neglect?

Yes No

Create Note

Restore Close Cancel Previous Next

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NAT Screening Tool, age less than 6 months; RN/EMT view

Universal Child Abuse Screening

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Universal Child Abuse Screening Tool

For children presenting for evaluation of a possible injury, was there a possible or definite delay in seeking medical attention given the severity of the injury/injuries?

Yes | No N/A

Are you concerned that the history may not be consistent with the injury or illness?

Yes | No

Did you observe ANY bruise, burn, subconjuntival hemorrhage, or frenulum unjury?

Yes | Not observed

Are there findings that might reflect poor supervision, care or nourishment?

Yes | No

Are there any additional comments or concerns related to child abuse or neglect?

Yes | No

Create Note

Restore | Close | Cancel | Previous | Next

Screening Questions – Over 6 months

1. For children presenting for evaluation of a possible injury, was there a possible or definite delay in seeking medical attention given the severity of injury/injuries?
2. Are you concerned that the history may not be consistent with the injury or illness?
3. Did you observe ANY bruising or marking in the shape of an object?
4. Did you observe TEN-4-FACESp bruising?
5. Are there findings that might reflect poor supervision, care or nourishment?
6. Are there any additional comments or concerns related to child abuse or neglect?

Screening Questions – Under 6 months

1. For children presenting for evaluation of a possible injury, was there a possible or definite delay in seeking medical attention given the severity of injury/injuries?
2. Are you concerned that the history may not be consistent with the injury or illness?
3. Did you observe ANY bruise, burn, subconjunctival hemorrhage, or frenulum injury?
4. Are there findings that might reflect poor supervision, care or nourishment?
5. Are there any additional comments or concerns related to child abuse or neglect?

Screening for abusive head trauma

- Multiple different clinical prediction rules
- Pittsburgh Infant Brain Injury Score
  - Which well appearing but high-risk infants need a CT to evaluate for AHT
  - High risk: afebrile with no history of trauma but apparent life-threatening event, apnea, vomiting, seizures, soft tissue swelling of scalp, bruising or other nonspecific neurologic symptoms

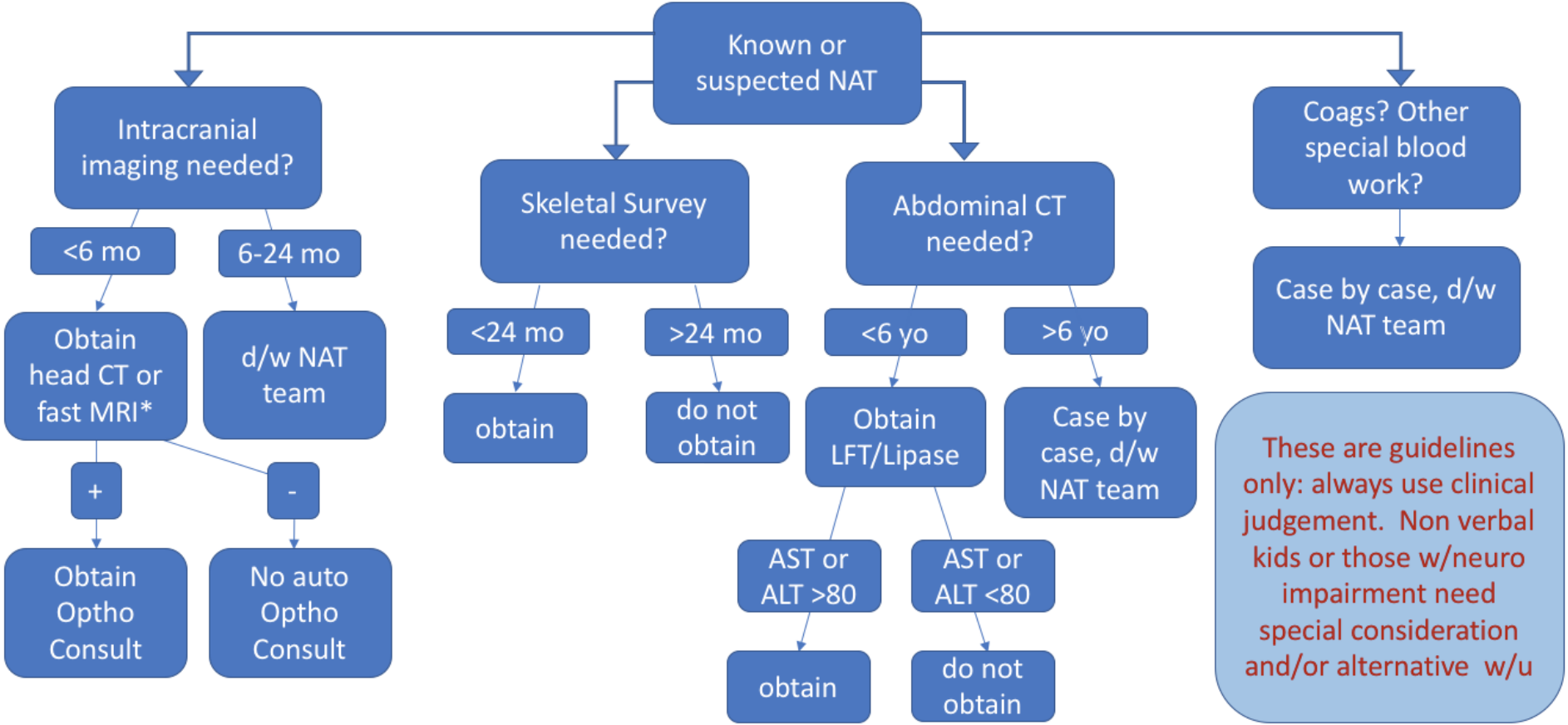
Abnormality on dermatologic examination	2
Age ≥3.0 mo	1
Head circumference >85th percentile	1
Hemoglobin <11.2 g/dL	1

- Score of 2 yielded sensitivity of 93%, specificity of 53%, PPV 39%

Berger et al. *Pediatrics* 2016

How to evaluate patients who screen positive or in whom abuse is suspected

NAT Workup Guidelines



Standardized Physical Abuse Guideline

<6 Months of Age	6–12 Months of Age	>12–36 Months of Age
• Social work consult • Skeletal survey • Head CT • AST, ALT, lipase • Abdominal CT if AST or ALT ≥80 • Troponin I for infants ≥3 months of age if AST or ALT ≥80, signs of chest trauma, or ill appearance • CBC, PT test, and PTT test if bruising or ICH present	• Social work consult • Skeletal survey • AST, ALT, lipase • Abdominal CT if AST or ALT ≥80 • Troponin I if AST or ALT ≥80, signs of chest trauma, or ill appearance • Head CT for facial bruising, abnormal neurological examination, or other clinical concern • CBC, PT test, and PTT test if bruising or ICH present	• Social work consult • Skeletal survey for <24 months • *Strongly consider* skeletal survey for 24–36 months if severely injured • *Strongly consider* ALT, AST, lipase • Abdominal CT if AST or ALT ≥80 • Troponin I if AST or ALT ≥80, signs of chest trauma, or ill appearance • Head CT for abnormal neurological examination or other clinical concern • CBC, PT test, and PTT test if bruising or ICH present

Cincinnati Children's
changing the outcome together

Lauren C. Riney et al. Pediatrics 2018;141:e20171994

PEDIATRICS®

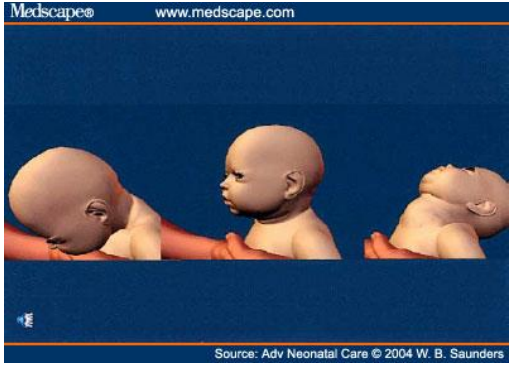
Injuries that raise suspicion of NAT

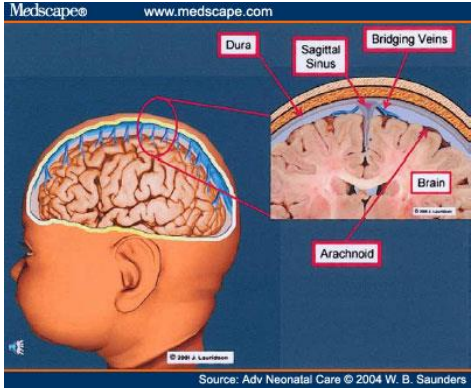
> Pediatr Surg Int. 2014 Nov;30(11):1103-6. doi: 10.1007/s00383-014-3598-3. Epub 2014 Sep 25.

Head injury pattern in children can help differentiate accidental from non-accidental trauma

Jonathan P Roach [1], Shannon N Acker, Denis D Bensard, Andrew P Sirotnak, Frederick M Karrer, David A Partrick

- Subdural hemorrhage
  - 76% of patients with NAT
  - 23% of children with accidental injury
- Diffuse axonal injury
  - 14% of abused children
  - 8% of non abused childre





Fractures

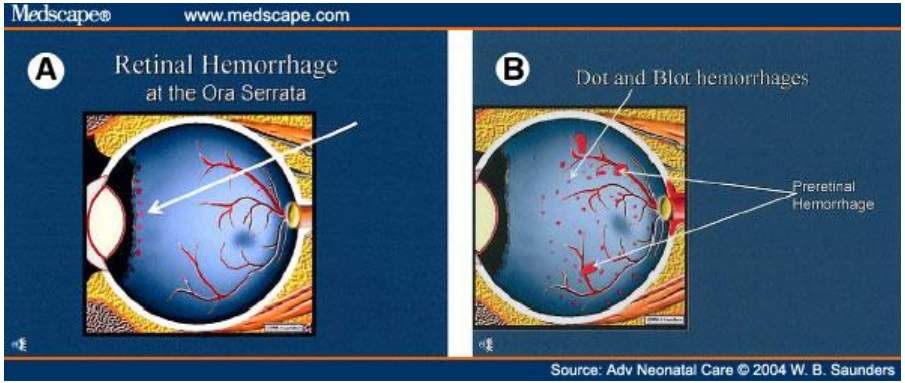
- Fractures due to abuse present the same as accidental fractures
- Need to look at patterns and overall clinical picture
- Consider child's gross motor ability
  - Roll over, crawl, cruise, walk
- Fractures due to abuse
  - Typically present in infants and toddlers
  - Fractures less than 6 mths (excluding skull fractures) more likely to be abuse than accidental
    - Caveat – clavicular fractures are common in childbirth

Fractures – when to suspect NAT

- fracture(s) in nonambulatory infants - especially in those without a clear history of trauma or a known medical condition that predisposes to bone fragility
- children with multiple fractures
- infants and children with rib fractures
- infants and toddlers with midshaft humerus or femur fractures
- infants and children with unusual fractures, including those of the scapula, classic metaphyseal lesions (CMLs) of the long bones, vertebrae, and sternum, unless explained by a known history of severe trauma or underlying bone disorder
- the history of trauma does not explain the resultant fracture
- fractures of different ages
- children with other injuries suspicious for physical abuse
- inconsistent histories
- delay in seeking care for an injury

Retinal Hemorrhage

- Seen in up to 78% of AHT
- Other injuries – retinoschisis, perimacular retinal folds, retinal and vitreous detachment
- Hemorrhagic lesions in the back of the eyes
  - Thought due to rapid increases in ICP and/or venous pressure, shearing of retinal vessels
  - Uncommon in other types of closed head injury
  - Characteristics concerning for abuse:
    - Bilateral
    - Large number in each eye
    - All layers of retina involved
    - Extends into periphery



Apparent life threatening event (ALTE)

- Abuse presenting as ALTE – about 5%
- Retinal involvement helpful
  - If patients presents with ALTE and no evidence of retinal hemorrhage, unlikely to be abused

Abusive Abdominal Trauma

- 0.5-11% of NAT
- Associated with mortality rates 9-45%
- **Second** most common fatal form of Child Abuse after Abusive Head Trauma

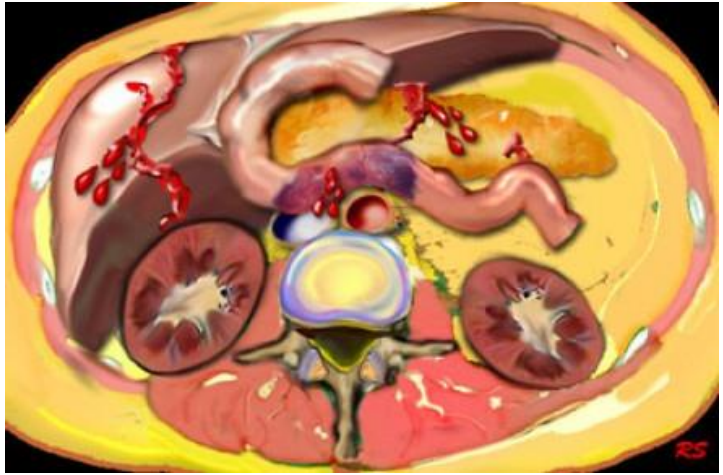
Lane. Child Abuse Neglect 2012
Roaten. Am J Surg 2005

Abusive Abdominal Trauma

- In ages 0-4 yrs, 15 % of blunt abdominal injuries are associated with abuse
- In <1 yr, ¼ hospitalizations for abdominal trauma are secondary to abuse
- Nearly 50% abused children with abdominal trauma require emergent surgery compared 5% without abdominal injury

Lane. Child Abuse Neglect 2012
Roaten. Am J Surg 2005

Visceral Injury



Due to direct blow to the abdomen

Usually younger than 3 years, but range weeks to teen

Average age of fatal injury around 2 years

Delay in seeking care, modest predictor abuse

Kidney and spleen injuries are less common than in accidental trauma

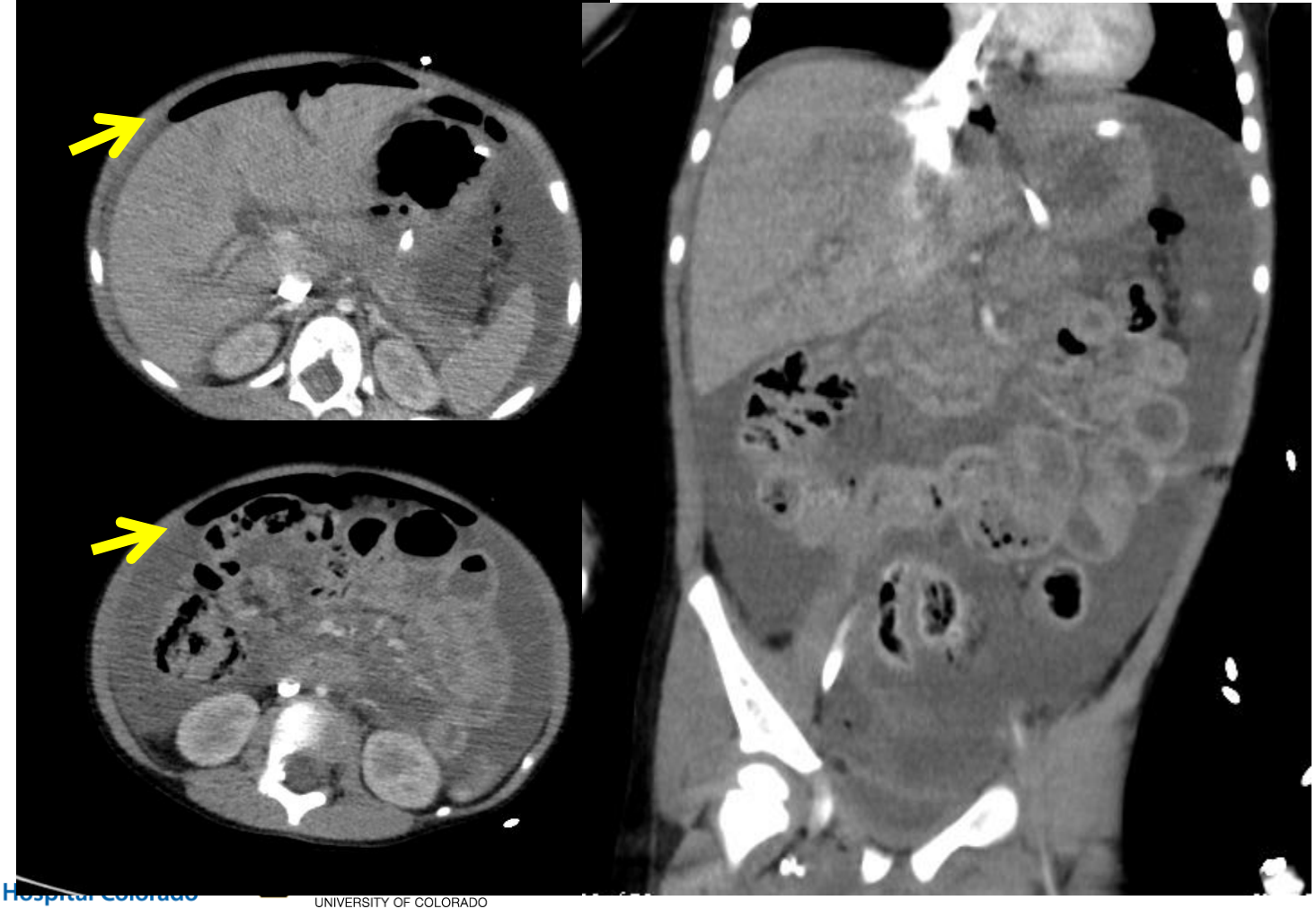
High concurrence with head and thoracic injuries (rib fx, SDH, pulm cont)

How to Evaluate

- Since the rate of visceral injury involved all NAT cases is low – 0.5-11%, We cannot screen with CT
- **Transaminase levels are recommended under age 6** when NAT suspected
- If AST/ALT >80 IU/L, consider CT (S/S 77/82%)
  - Quickly normalize
- To decrease excessive radiation exposure, perform CT correctly the first time
  - IV contrast
- **No utility in Non contrast exam**

Lindberg. Pediatrics 2009

- 3 year old
- Fall from standing
- Vomiting at daycare
- Seen in ER, given Zofran
- Returned next day with lethargy, black vomit
- ALT/AST 617/280



Abusive Abdominal Trauma

- Retrospective review 312 cases small bowel perforation due to blunt trauma and 677 falls down stairs
- No overlap
- Rate of bowel injury 3x higher in NAT than AT
- Hollow viscus plus solid organ injuries exclusive to NAT

Huntimer. Pediatrics 2000
Trokel. Ped Emer Care 2006

Abusive Abdominal Trauma

- **Solid organ injuries (liver) most common**
- **Hollow viscous injuries/pancreatic injuries have strongest association with abuse and more often require surgery**
- **Clinical presentation is similar to that seen with accidental trauma-distension, pain, vomiting**
- **Bruising often absent, up to ¼ with intraabdominal injury have no bruising**
- **Up to 35% of abused children with visceral injury have no clinical or radiographic evidence of trauma**

Barnes. Lancet 2005

NAT: Hollow Viscous Injury

- **Perforation-usually near ligament of Treitz:**
  ***jejunum* >duodenum > ileum**
- **Gastric perforation rare**
- **Free air seen in only *one third* of pts**
- **Up to 35% of abused children with injury have no clinical or radiographic evidence trauma**
- **Most frequent CT findings with bowel rupture is unexplained free fluid**

Happy to help with any trauma questions!

Urgent consults/transfers to Children's Hospital Colorado:

OneCall: 720-777-3999

Trauma Program/Policy Questions:

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