Pediatric Trauma Case Presentations

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No Disclosures

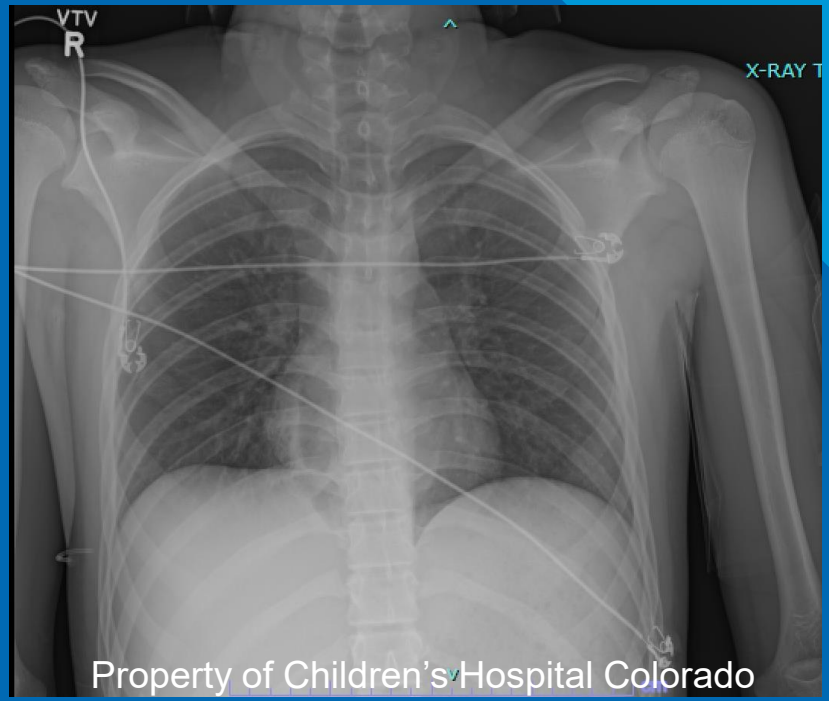
Planners, faculty and others in control of content (either individually or as a group) for this activity have no relevant financial relationships with ineligible companies.

Overview

1. Identify indications for CT imaging in blunt abdominal trauma
2. Describe approach to management of blunt solid organ injury
3. Recognize signs of child physical abuse
4. Outline the standard evaluation of suspected child physical abuse

Case 1

- 14 y/o m backseat passenger high speed MVC, unclear if he was restrained, no LOC, found crawling outside the vehicle, GCS 14
- En route
  - HR 130s
  - BP as low as 50s/30s
  - No right sided breath sounds so EMS performed needle decompression
  - No meds or fluids given
- On arrival
  - Protecting airway
  - Bilateral breath sounds clear
  - HR 110s; BP 110s/70s after crystalloid bolus
  - GCS 15
  - Abdomen soft, distended, diffusely tender without guarding



How should we evaluate his abdomen?

Is the Child Hemodynamically stable?

- If yes – you have time and can think about CT scan vs observation
- If No – Use FAST
- FAST – Focused Abdominal Sonography for Trauma
  - Sensitivity – 51% (95% CI 31-73%)
  - Specificity – 96% (95% CI 93-98%)
  - Positive predictive value – 48% (95% CI 28-69%)
  - Negative predictive value – 97% (95% CI 94-98%)
- Positive FAST suggests hemoperitoneum
- Negative FAST aids little in decision making

> Acad Emerg Med. 2011 May;18(5):477–82. doi: 10.1111/j.1553-2712.2011.01071.x.

Test characteristics of focused assessment of sonography for trauma for clinically significant abdominal free fluid in pediatric blunt abdominal trauma

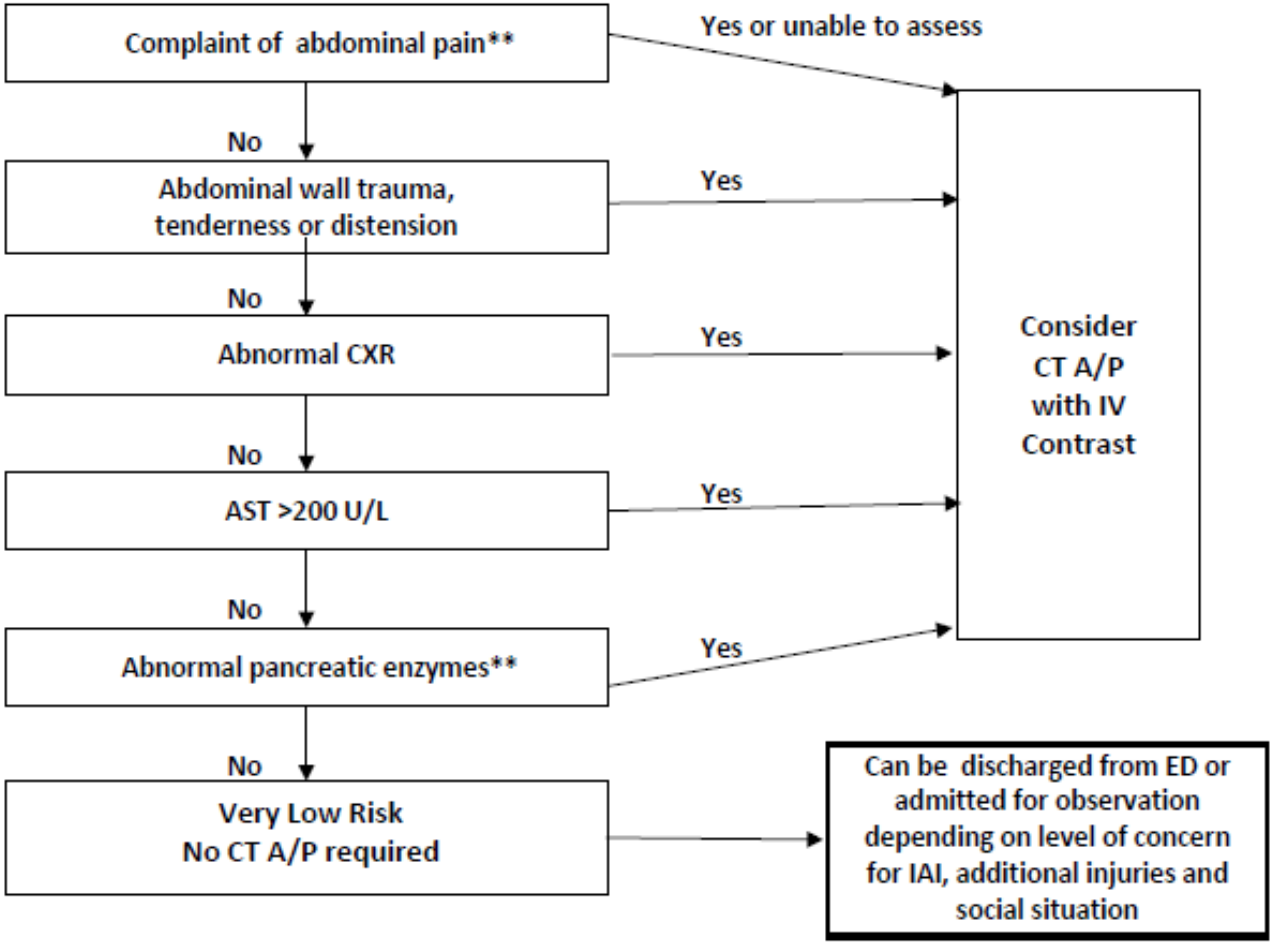
J Christian Fox [1], Megan Boysen, Laleh Gharahbaghian, Seric Cusick, Suleman S Ahmed, Craig L Anderson, Michael Lekawa, Mark I Langdorf

> Surgery. 2010 Oct;148(4):695-700; discussion 700-1. doi: 10.1016/j.surg.2010.07.032. Epub 2010 Aug 30.

FAST scan: is it worth doing in hemodynamically stable blunt trauma patients?

Bala Natarajan [1], Prateek K Gupta, Samuel Cemaj, Megan Sorensen, Georgios I Hatzoudis, Robert Armour Forse

- Adult Retrospective Study
- 2,105 patients; 118 false negative FASTs, 37% required surgery
- Conclusions:
  - Negative FAST without confirmatory CT will lead to missed injuries
  - Positive FAST requires CT confirmation to characterize injuries and decide on operative vs non-operative management

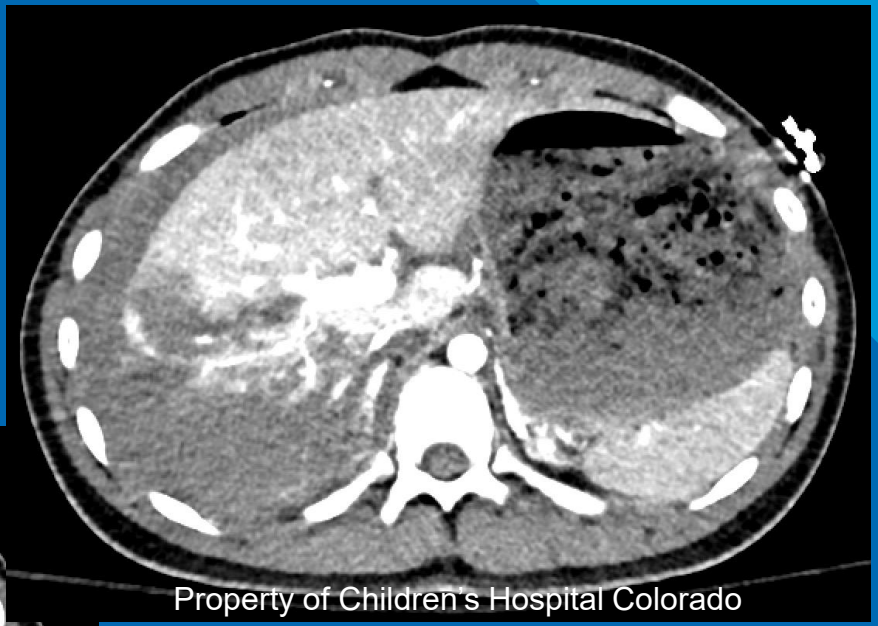


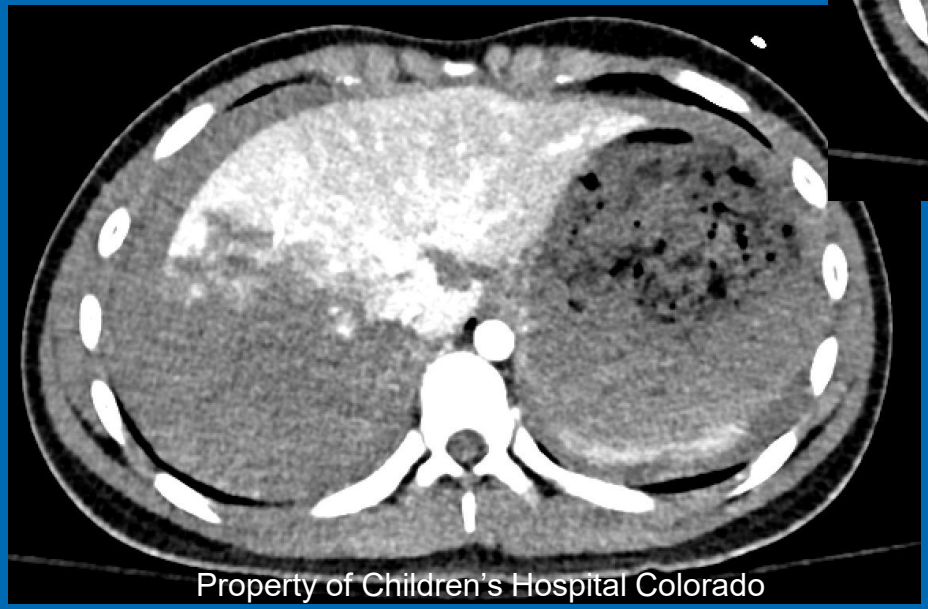
**If only abnormal risk factor present is complaint of abdominal pain or abnormal pancreatic enzymes, consider observation with serial abdominal exams over CT A/P

Algorithm courtesy of Christian Streck MD

Case continued

- ALT 725
- AST 1035
- Lipase 1134
- HR and BP stable after fluid bolus
- Protecting airway
- CT Abdomen/pelvis with IV contrast





- Grade 5 liver injury
- Grade 2 right renal injury
- Grade 2 splenic injury
- Grade 2 right adrenal injury
- Diffuse hypoenhancement of the pancreas
- Right 6th rib fracture

First 24 hours (first 4 hours) – worry about bleeding

Liver and Spleen injury

- Non operative management now standard
- 8% failure rate
  - Only 4.4% fail for bleeding
  - Others fail for other associated intra-abdominal injuries
  - Failure for isolated blunt solid organ injury
    - 0% for splenic injury
    - 3.9% for liver injury
- Risk factors for failure
  - High grade injury
  - Pancreatic injury
  - Multiple injured organs
- Fail median 3 hrs after injury

Holmes, et al. J Trauma 2005

Historical perspective – APSA Guidelines

	CT Grade			
	I	II	III	IV
ICU stay (d)	none	none	none	1
Hospital stay (d)	2	3	4	5
Predischarge imaging	none	none	none	none
Postdischarge imaging	none	none	none	none
Activity restriction (wk)*	3	4	5	6

*Return to full-contact, competitive sports (ie, football, wrestling, hockey, lacrosse, mountain climbing) should be at the discretion of the individual pediatric trauma surgeon. The proposed guidelines for return to unrestricted activity include "normal" age-appropriate activities.

Stylianos et al, J Pediatr Surg, 2000

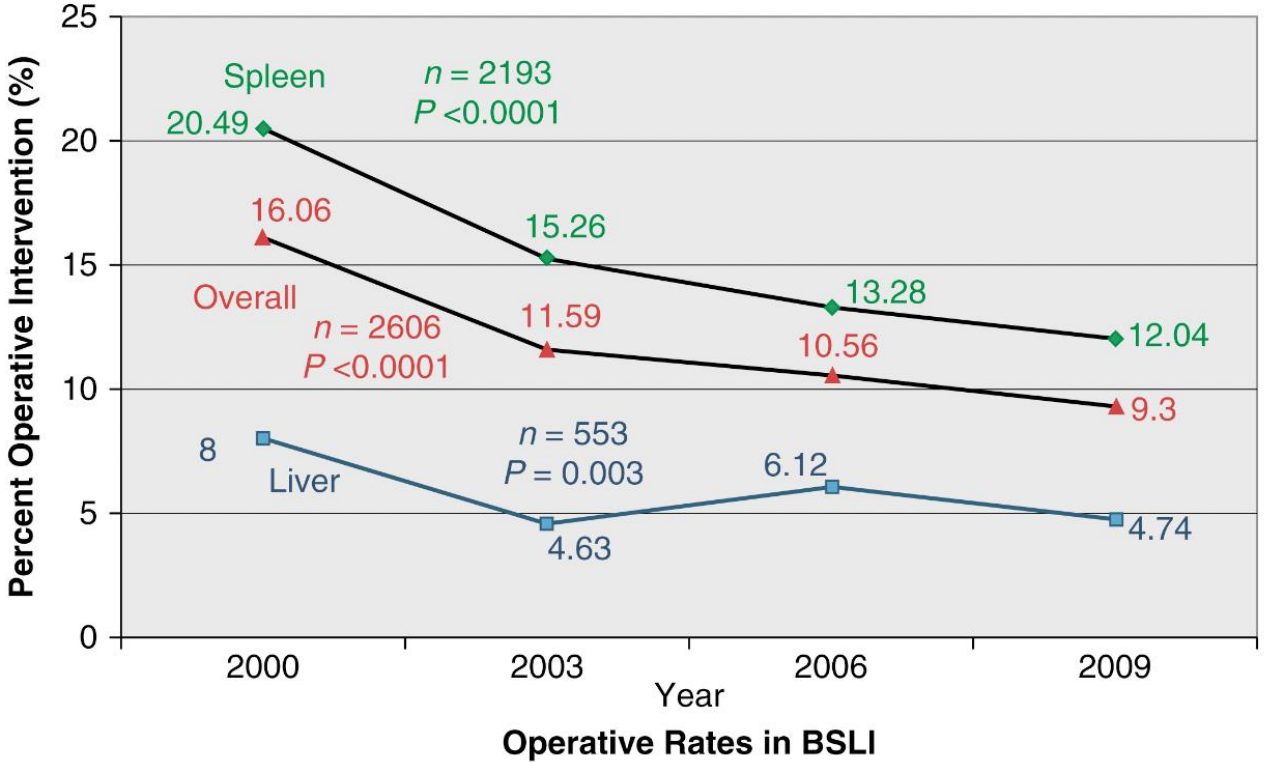


Fig. 16.5

This graph shows a decrease in the operatiive rates for splenic injury from 20.5% in 2000 to 12% in 2009. Similarly, there has been a 40% decline in operative management of liver injuries between 2000 and 2009.

From Dodgion CM, Gosain A, Rogers A, et al. National trends in pediatric blunt spleen and liver injury management and potential benefits of the abbreviated bed rest protocol. J Pediatr Surg 2014;49:1004–1008. Reprinted with permission.

Updated APSA Guidelines for the Management of Blunt Liver and Spleen Injuries

Regan F. Williams [a,*], Harsh Grewal [b], Ramin Jamshidi [c], Bindi Naik-Mathuria [d], Mitchell Price [e], Robert T. Russell [f], Adam Vogel [g], David M. Notrica [c], Steven Stylianos [h], John Petty [i]

Liver and Spleen injury - Admission

2.1.1. Recommendation

ICU Admission is indicated irrespective of CT grade if initial volume resuscitation does not normalize vital signs (hemodynamics) or response was only transient. Patients with normal vital signs regardless of grade of injury should be admitted to the hospital ward for observation though recent data may support discharge from the emergency department for low grade injuries.

Liver and Spleen injury

- Single center retrospective review of 133 ICU admissions for isolated blunt liver, spleen, or renal injury
- Aim to determine true need for ICU level intervention
- 19/133 (14%) required ICU intervention
- 18/19 who required intervention had elevated SIPA or hematocrit <30% on presentation
  - Sensitivity – 95%
  - NPV – 99%

Arbuthnot M, et al. J Pediatr Surg 2017

WTA 2015 Plenary Paper

Lack of utility of repeat monitoring of hemoglobin and hematocrit following blunt solid organ injury in children

Shannon N. Acker, MD, Branden Petrun, David A. Partrick, MD, Genie E. Roosevelt, MD, *and* **Denis D. Bensard, MD,** *Denver, Colorado*

- 245 children with liver or spleen injury; 45 required intervention (18%)
- 6 – went to OR due to hypotension median of 4 hrs after injury
- 18 – PRBCs due to hypotension median 2 hrs after injury
- 14 – PRBCs due to falling Hct, 3 with tachycardia; median 23 hrs after injury
- Conclusion: Need for emergent intervention occurs within the first 24hrs after injury

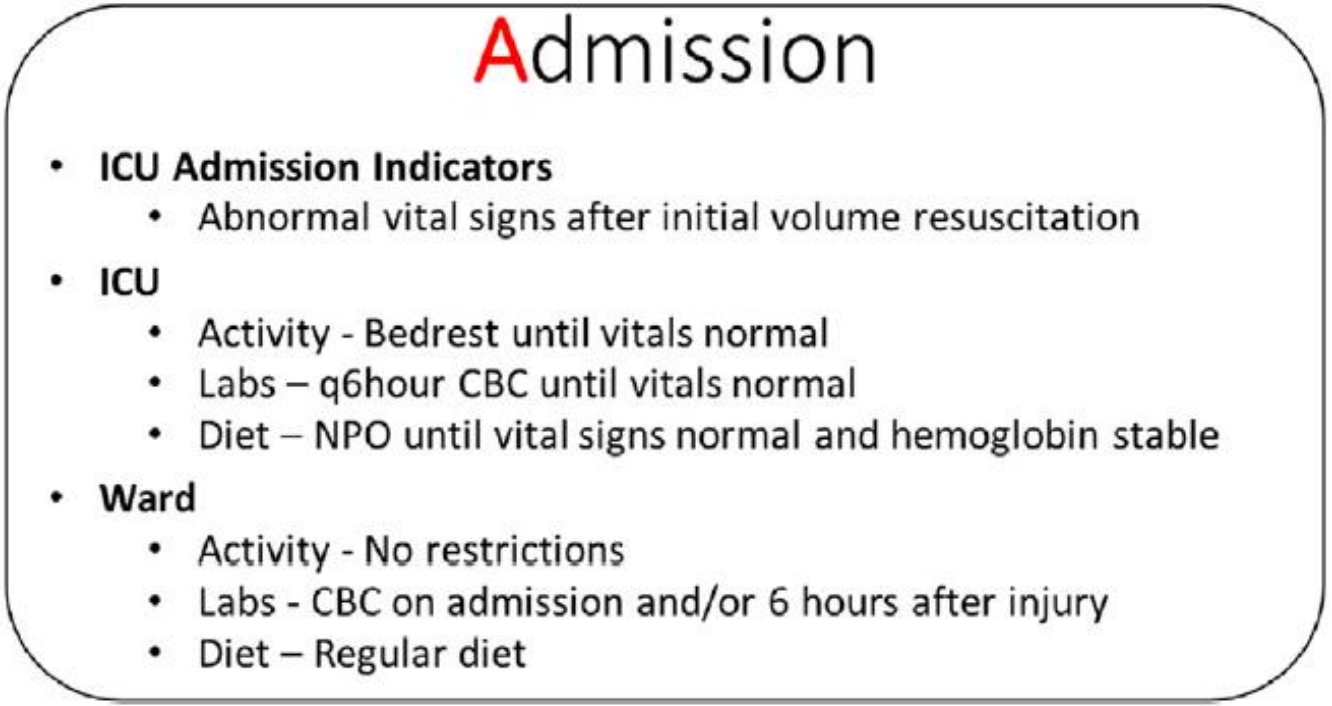


Fig. 2. Admission

Williams et al. J Pediatr Surg 2023

Procedures

- **Transfusion**
  - Unstable vitals after 20 cc/kg bolus of isotonic IVF
  - Hemoglobin < 7
  - Signs of ongoing or recent bleeding
- **Angioembolization or Operative Exploration**
  - Signs of ongoing bleeding despite pRBC transfusion
  - Angioembolization is not indicated for contrast blush on admission CT without unstable vitals
  - Operative exploration may be indicated when additional procedures or information needed

Fig. 3. Procedures

Williams et al. J Pediatr Surg 2023

Fig. 4. SET free

Williams et al. J Pediatr Surg 2023

Aftercare

Activity Restriction

- Restricting activity to grade plus 2 weeks is safe
- Shorter restrictions may be safe but there is inadequate data to support decreasing these recommendations

Follow up Imaging

- Risk of delayed complications following spleen and liver injuries is low
- Consider imaging for ***symptomatic*** patients with prior high grade injuries

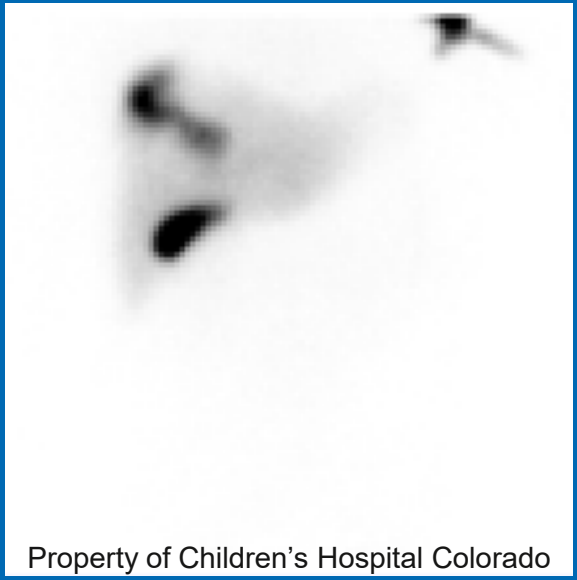
Fig. 5. Aftercare

Williams et al. J Pediatr Surg 2023

Hospital course

- Remained hemodynamically stable
- Transferred to floor on post injury day 1
- Rising total bilirubin
  - 0.7 → 10.7
- Worsening abdominal pain and distention
- HIDA with bile leak

- HD8 – diagnostic laparoscopy, drainage for 4.6L frank bile, drain placement
  - Right liver adherent to abdominal wall, well perfused
  - Drain placed in biloma
- HD9 – ERCP with stent and sphincterotomy



Case Continued

- Ongoing pain/fever
- IR for new drain placement and chest tube to drain effusion
- Discharged home with drain in place
- Presented to ED with blood from drain

Other Sequelae

Pseudoaneurysm

Clinical presentation:
Sentinel Bleed

Treat: IR embolization

or

Formal resection

Bile leak

Clinical Presentation:
Fever, abdominal pain, hyperbilirubinemia

Treat: ERCP with sphincterotomy, drain in biloma

Hemoperitoneum

Blood is irritating

Can wash it out if persistent pain/not tolerating diet

No data to guide decision

Case Conclusion

- Pseudoaneurysm too small to coil
- OR for formal right hepatectomy
  - One month after initial injury
- Post op course relatively uncomplicated
- Doing well 8 months out
- Requiring physical therapy and mental health services for him and his family

Follow up resources

- Acute Stress Disorder screening
  - Collaboration with Clinical Social Work and Behavioral health team to identify patients at risk of post traumatic stress and connect them with mental health resources

- Adolescent medicine and teen health
  - Can offer primary care services to trauma patients following injury
  - Collaborate with clinical social work – At Risk Intervention and Monitoring (AIM) Program

Summary

- Blunt solid organ injury common after MVC, sports related injuries
- Majority of cases managed with observation alone
- Complications are rare but related to higher severity of injury and presence of associated injuries
- Screening for acute stress disorder critical for injured children

Case 2

- 37-day old former term m presents for evaluation of one episode of blood in spit up
- History notable for intrauterine MMJ exposure
- Subconjunctival hemorrhage since birth, getting bigger
- Lives with parents and siblings
- 4.1kg (15^{th} percentile)
- Exam notable for Epstein pearls on palate with erythematous non-ulcerative lesion on posterior palate
- Trauma felt to be unlikely given historical features and physical exam findings
- Discharge home, PCP follow up in one week

Case continued

- 55-day old m brought in via EMS with bilateral eye bruising, bleeding from nose
- Patient with FOC through day, videochatted MOC at work and reported he thought he was having an allergic reaction because skin around the eyes “looked weird”
- MOC returned home 12 hrs later, noted bilateral eye bruising, blood in nares and mouth
- Report of infant sleeping on his face as cause of bleeding
- On arrival to ED, concern for seizure, received antiepileptic medication
- Exam – irritable but consolable infant
  - Fontanelle flat but mildly firm
  - Dried blood in bilateral nares
  - Torn lingual frenulum and mild tear of upper labial frenulum, dried blood on lips, petechiae of maxillary alveolus mucosa
  - Periorbital and lid edema

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 with signs or symptoms that were suggestive of abuse (in retrospect)
  - Missed cases
    - More often in white children than minorities
    - More often in families where both parents lived in the house
  - Unclear how many were in adult vs pediatric EDs

What can we do?

- 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

- Most common injury from child physical abuse
- Most common injury to be overlooked or misdiagnosed as non-abusive before an abuse-related fatality or near-fatality in a young child
- Often precedes abusive head trauma

- Failure to recognize bruising is a **missed opportunity** and an error in medical decision-making that contributes directly to poor patient outcomes

- There are differences 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

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

Concerning for accidental trauma	Concerning for nonaccidental trauma
Spill or flowing water injury	Immersion
Hot beverages (less often tap water)	Isolated scald to buttocks or perineum
Irregular margins	Clear upper limits
Varying burn depths	Uniform depth
Involvement of lower limbs, head, neck, trunk, face, upper body	Symmetric involvement of lower extremities; stocking/glove
Asymmetric	Skin fold sparing
	Hot tap water

NAT EVAL

Red flags:

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

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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

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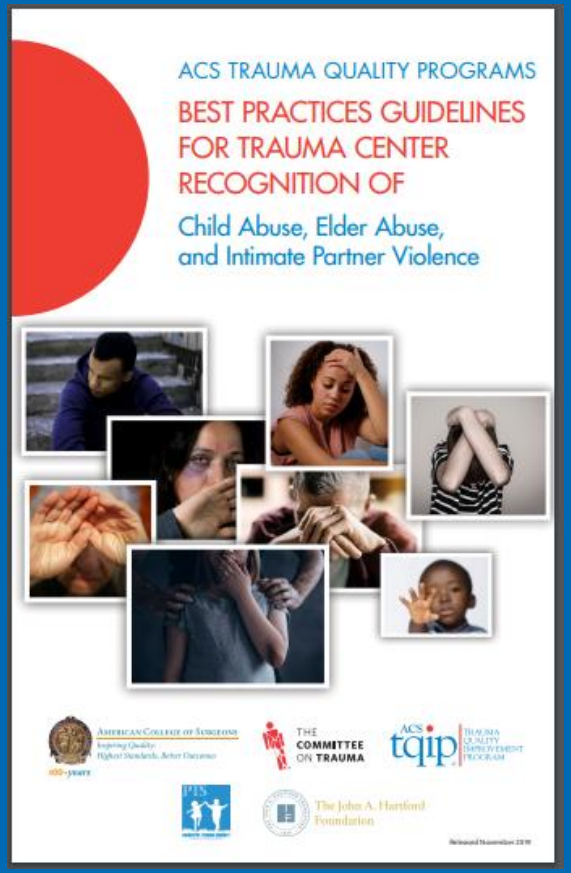
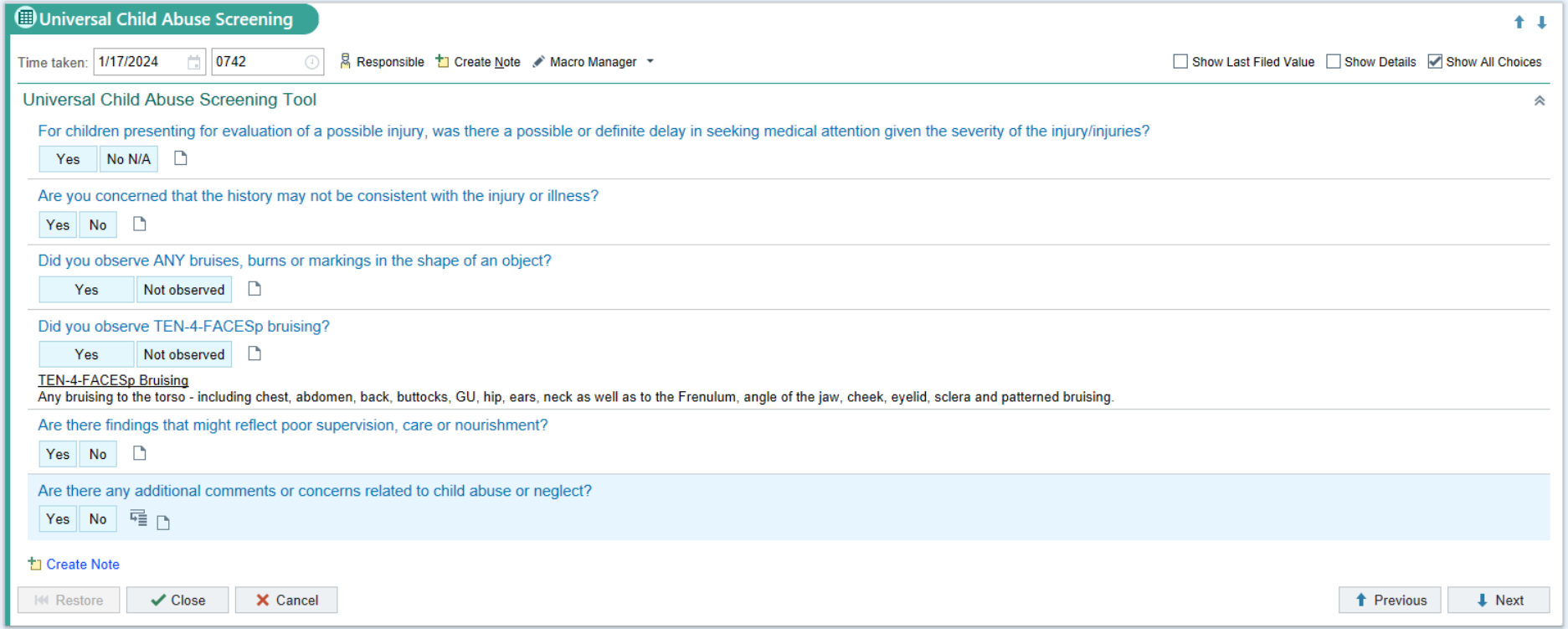
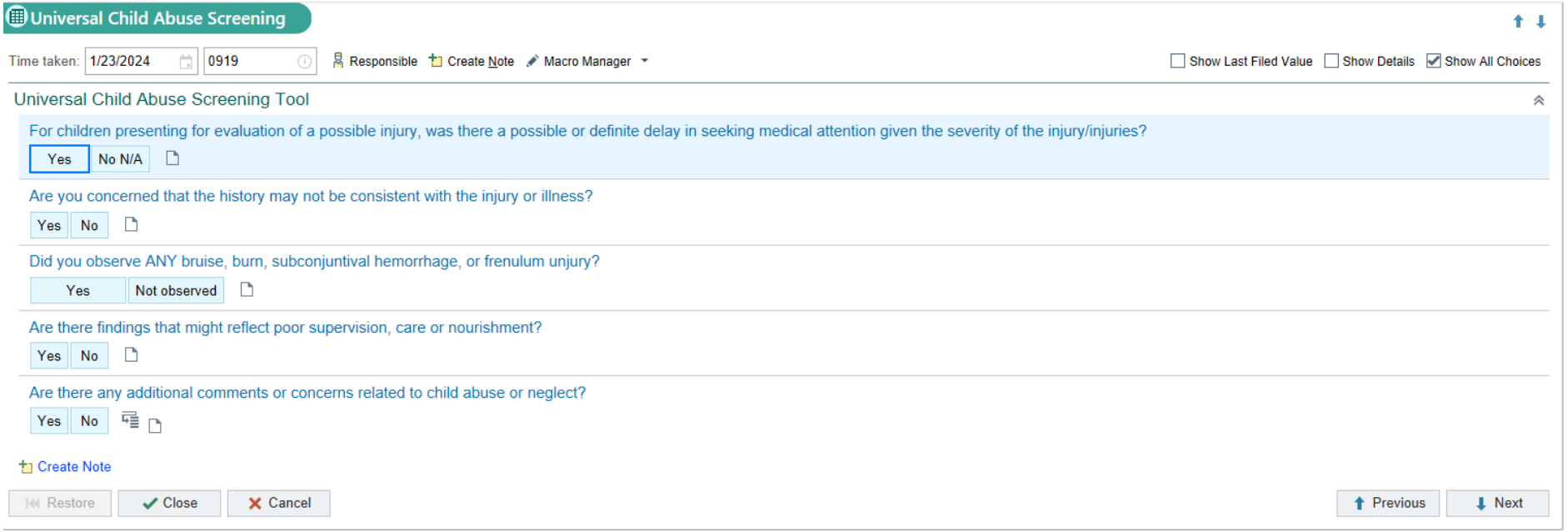


- Implement a standardized tool to screen for child physical abuse at all designated trauma centers and trauma hospitals.

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



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



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

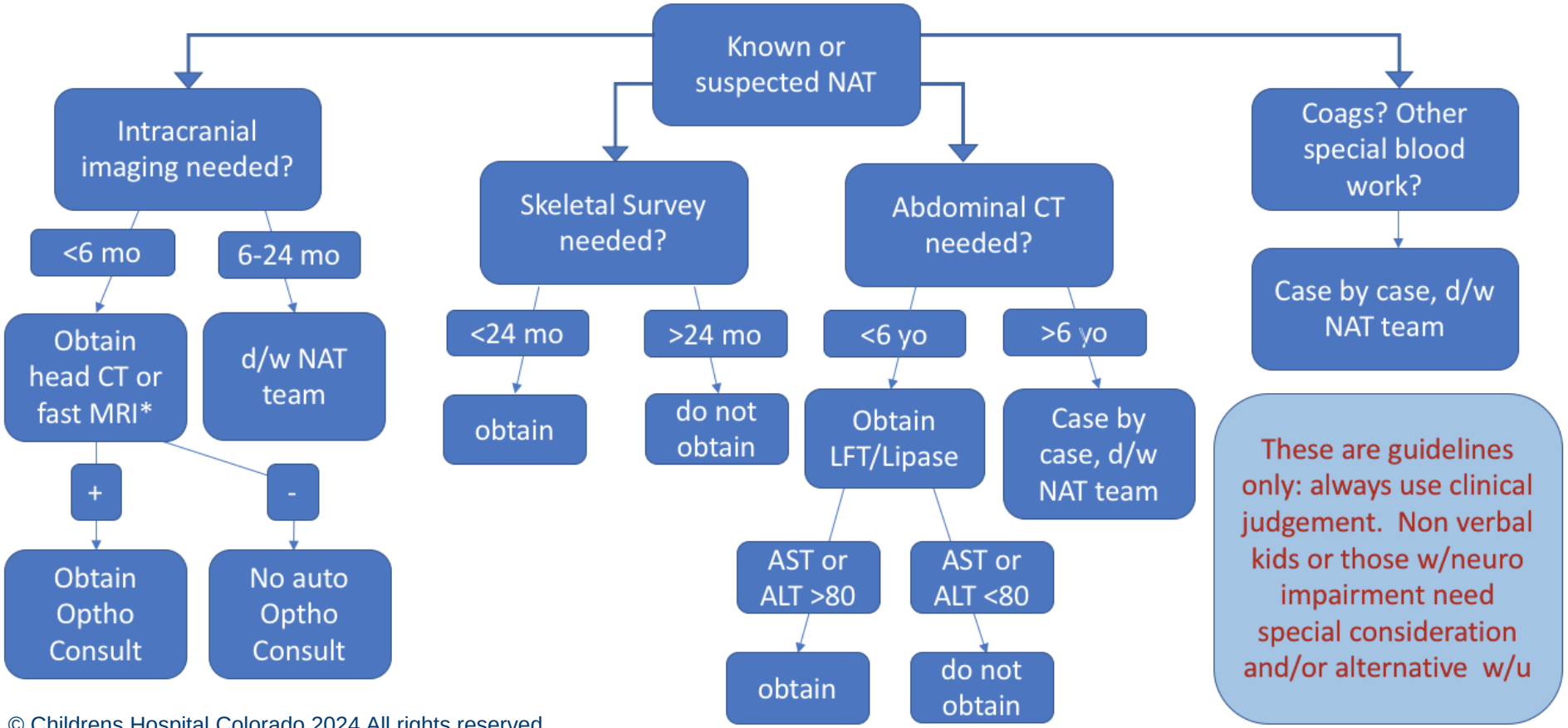
Variable	Points
Abnormality on dermatologic examination	2
Age $\geq$ 3 months	1
Head circumference >85th percentile	1
Hemoglobin < 11.2g/dL	1

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

Berger et al. Pediatrics 2016

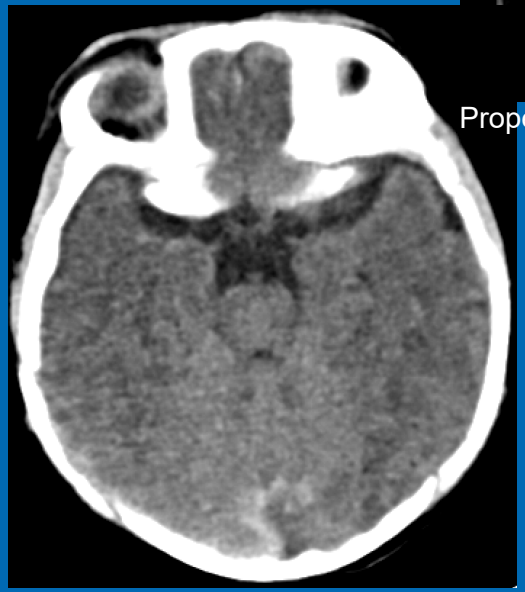
How to evaluate patients who screen positive or in whom abuse is suspected

NAT Workup Guidelines



Case Continued

- CT head - R parietal bone fracture, multifocal bilateral extra-axial hemorrhage
- CT C spine - neg
- Skeletal Survey- metaphyseal corner fractures R & L femur, R & L tibia, biparietal skull fractures
- AST 178 ALT 92
- CT A/P – neg
- Optho consult –
  - right intraretinal hemorrhages, too numerous to count



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 children

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

Fractures in non-ambulatory infants	History does not explain resultant fracture
Multiple fractures	Fractures of different ages
Rib fractures	Delay in seeking care
Mid shaft humerus or femur fractures	Inconsistent history
Unusual fractures – scapula, classic metaphyseal lesions of long bones, vertebrae or sternum unless clear history of severe trauma	Fractures in children with other concerning injuries or bruising

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 to be 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

Case continued

- Admitted to ICU for EEG monitoring
  - Multiple subclinical seizures treated with antiepileptics
  - Neuroprotective measures – elevate head of bed, Na >140, normothermia, normal O2 and PCO2, normoglycemia
- MRI head and c spine with venography after 48 hours
  - Right posterior quadrant cerebral ischemia
  - Bilateral subdural hemorrhage
  - No dural venous sinus thrombosis
  - C spine negative
- Speech evaluation – poor oral coordination, swallow study with aspiration
- Discharged to foster care with NG tube feeds
- Gastrostomy tube placement 6 weeks later

Case follow up - Medical

- Patient now 3 years, 9 months
- Medical diagnoses – TBI, blindness, epilepsy, ASD, global developmental delay, speech apraxia
- Cannot use speech functionally to communicate medical essential needs
- Undergoing evaluation for speech generating device
- Clonidine to regulate sleep
- Continues with PT, OT, ST, vision, and feeding therapy
- Happy and functioning well in current environment

Case follow up – Social/Legal

- Parent pled guilty to multiple felony counts of child abuse
  - Sentence included significant jail time
  - One year after initial presentation
- Patient and sibling adopted by foster mother

Consequence of Child Maltreatment

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

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

Summary

- Universal screening and use of TEN-4-FACES-P pneumonic can help identify suspected child abuse
- If suspected, follow a standard work up including head imaging, skeletal survey, and laboratory studies
- If injuries are identified, transfer to regional pediatric trauma center
- Our team is available 24/7 for consultation

Happy to help with any trauma questions

Urgent consults/transfers to Children's Hospital Colorado:

OneCall: 720-777-3999

Trauma Program/Policy Questions:

Shannon Acker
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