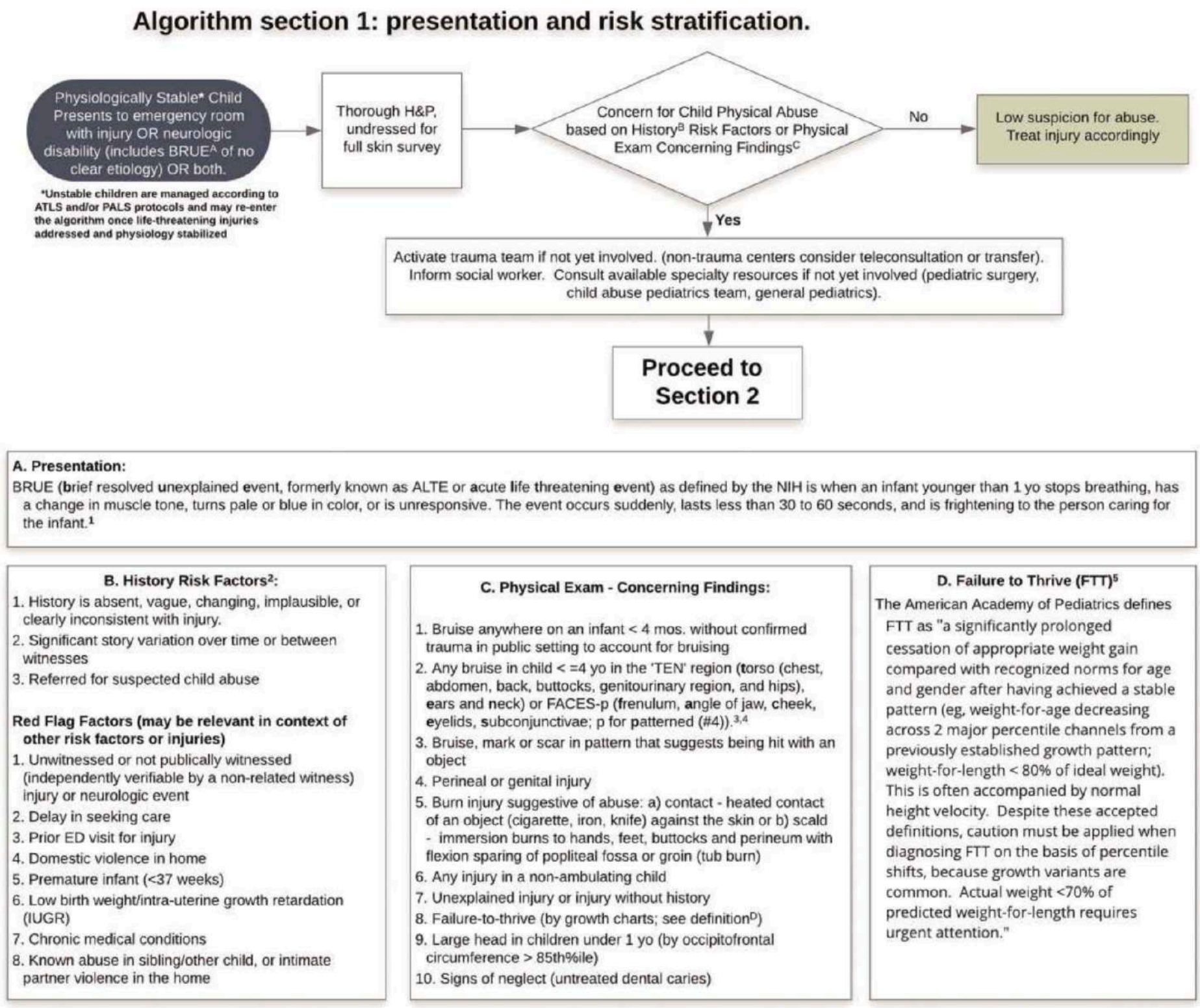

Figure 1. Algorithm section 1: presentation and risk stratification.

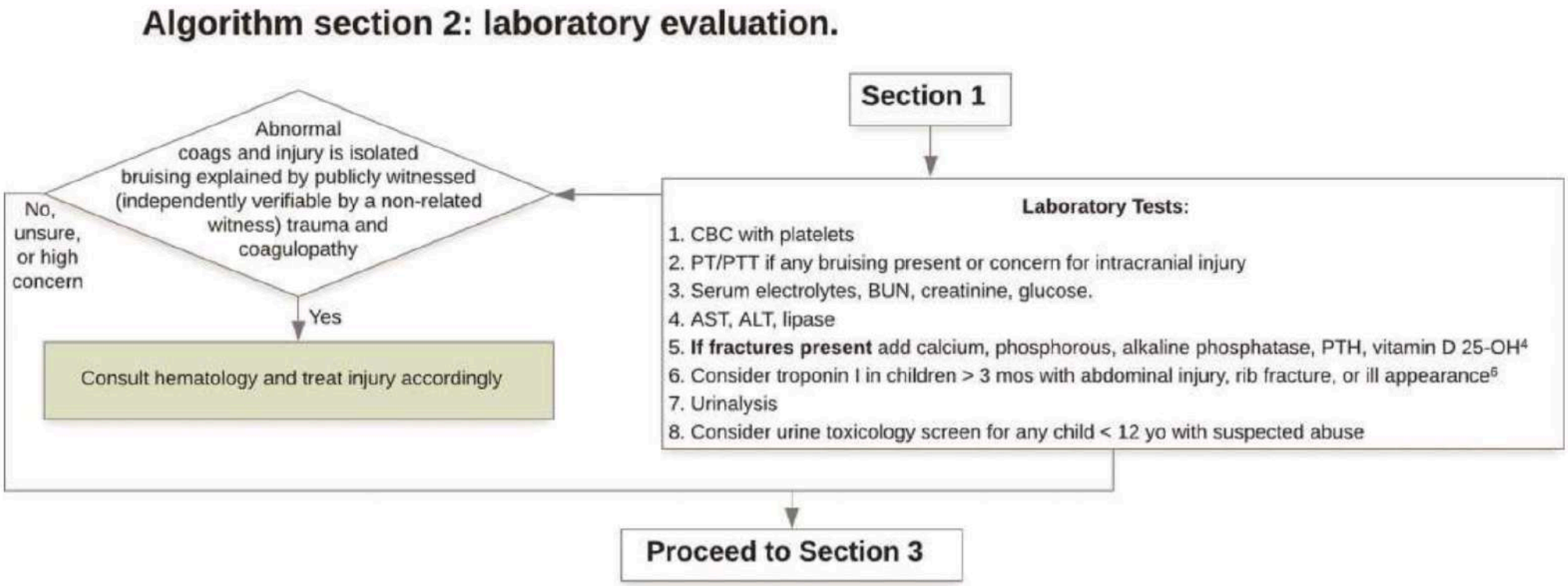

Figure 2. Algorithm section 2: laboratory evaluation.

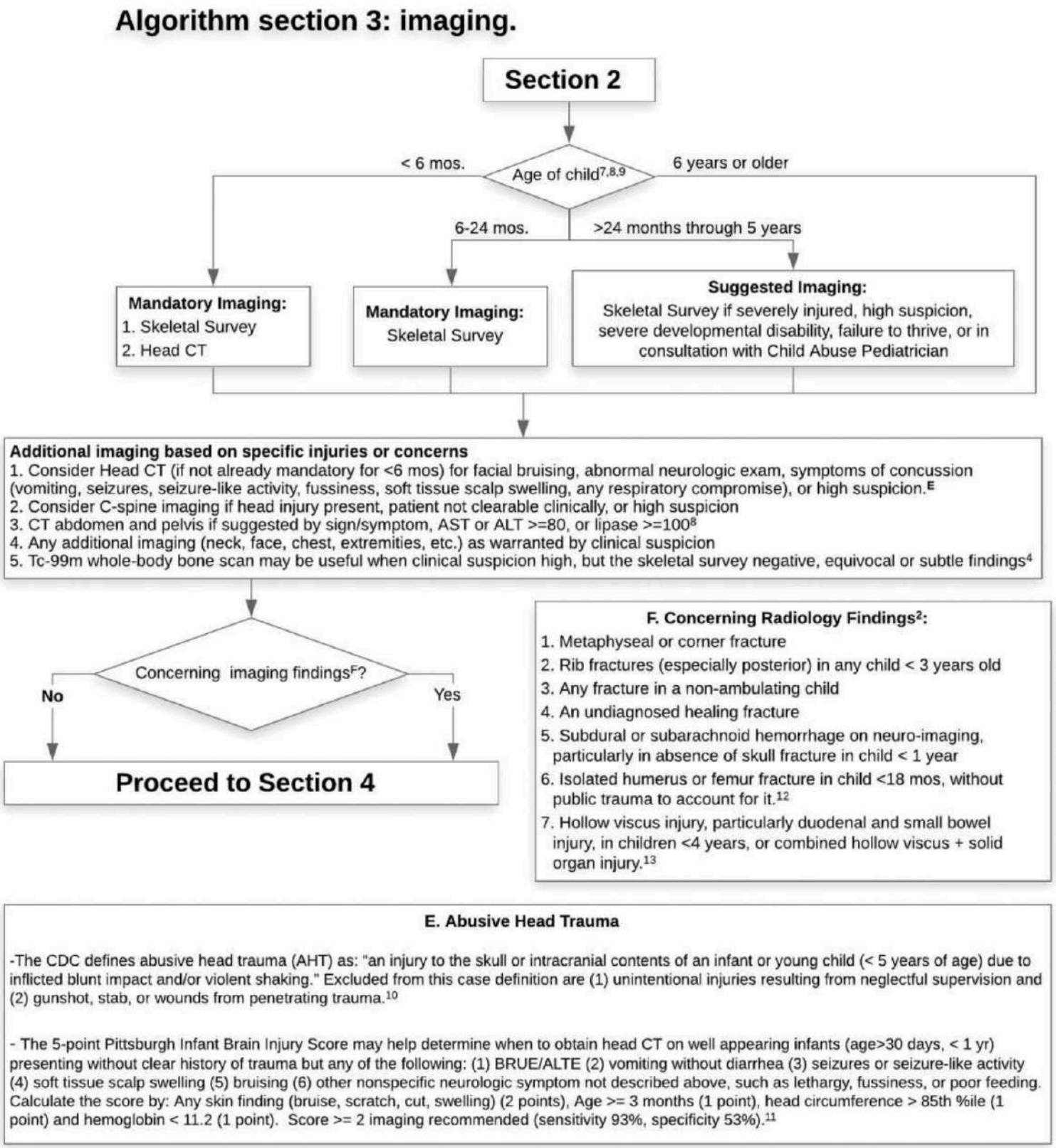

Figure 3. Algorithm section 3: imaging.

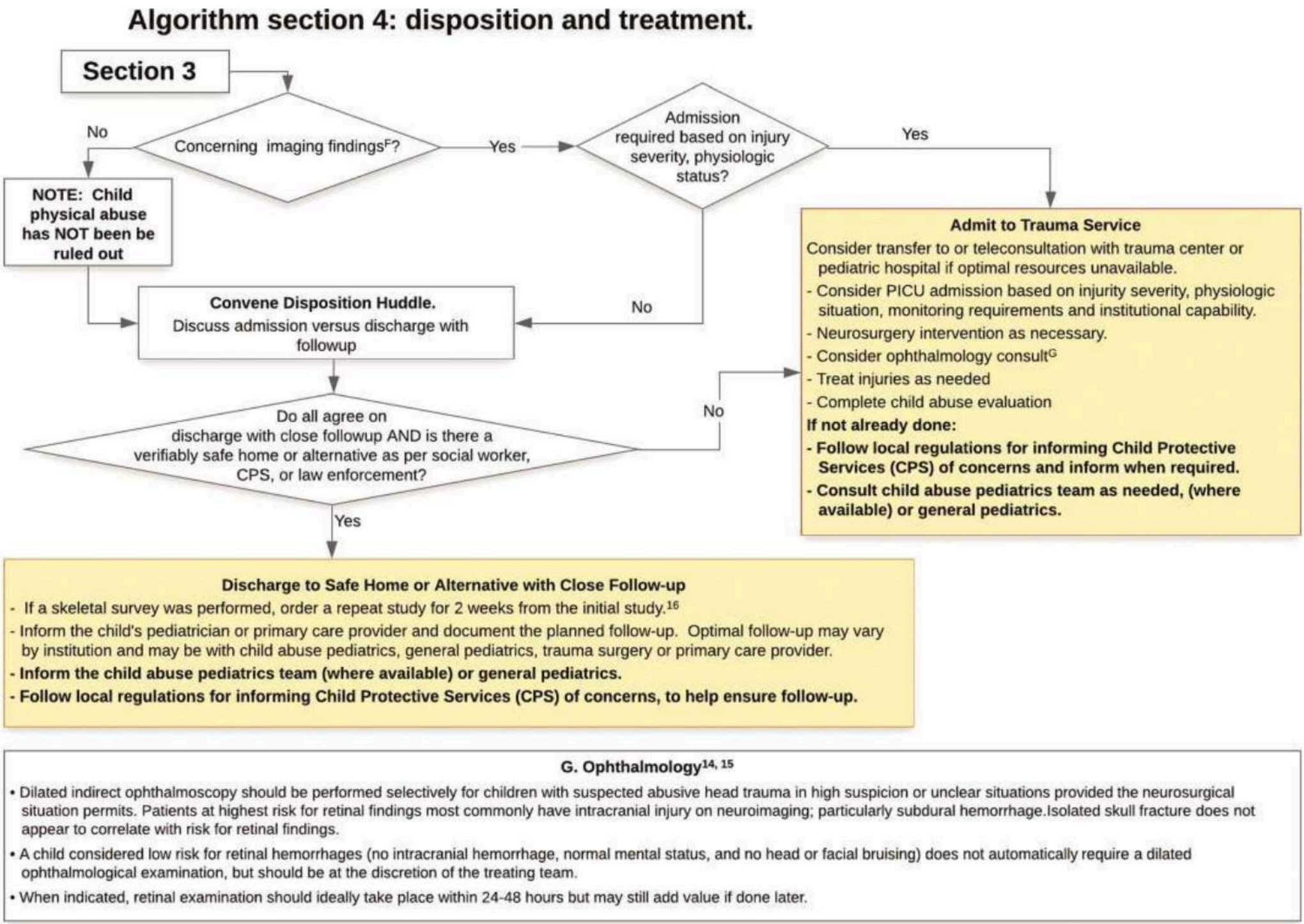

Figure 4. Algorithm section 4: disposition and treatment.

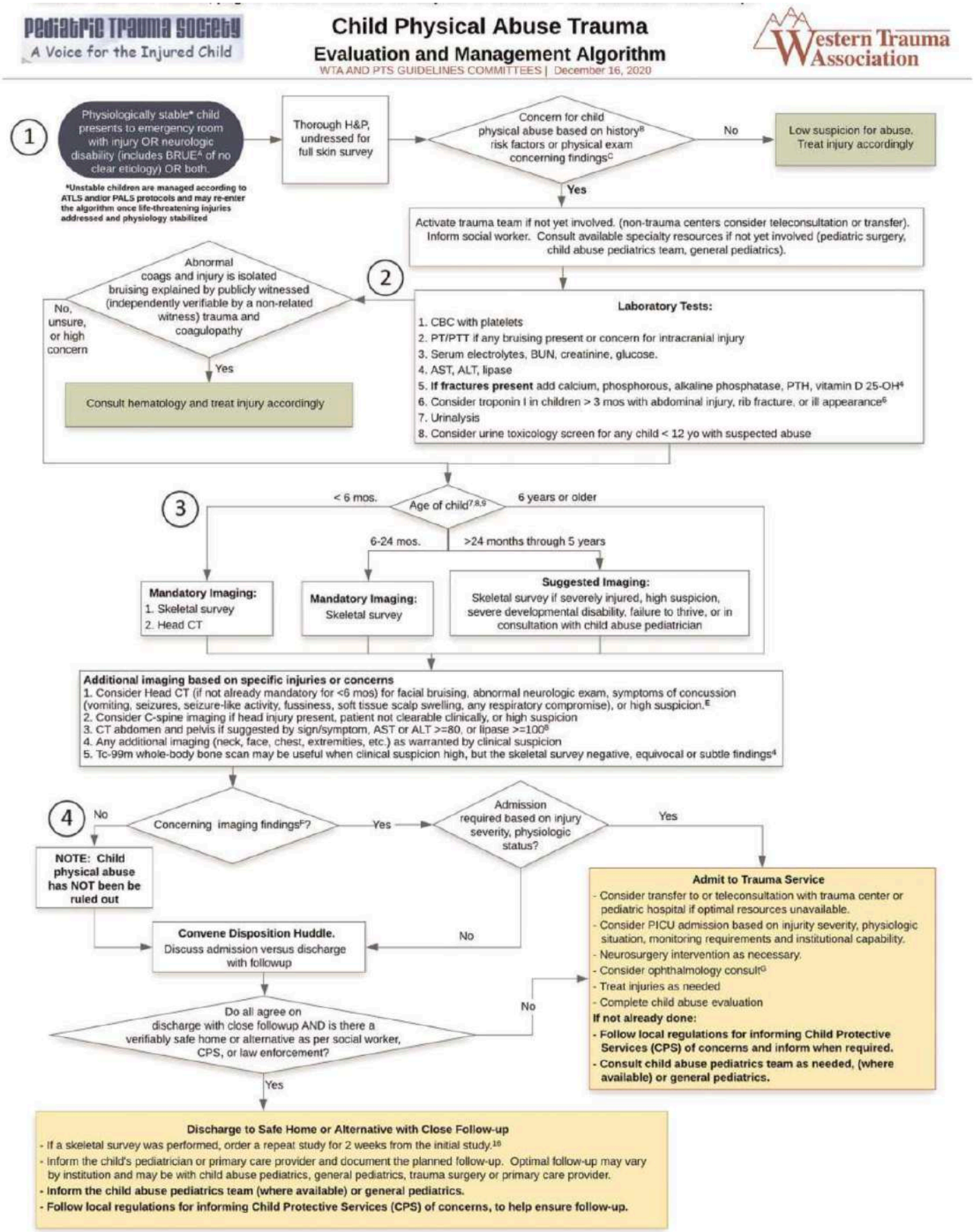

Figure 5. Western Trauma Association and PTS complete algorithm for the evaluation and management of children with CPA trauma, page 1. Circled numbers correspond with Figures 1–4 which show each section in greater detail.

Western Trauma Association and Pediatric Trauma Society CPA complete algorithm page 2 with detailed annotation corresponding with references to lettered blocks from page 1.

A. Presentation:

BRUE (brief resolved unexplained event, formerly known as ALTE or acute life threatening event) as defined by the NIH is when an infant younger than 1 yo stops breathing, has a change in muscle tone, turns pale or blue in color, or is unresponsive. The event occurs suddenly, lasts less than 30 to 60 seconds, and is frightening to the person caring for the infant.[1]

B. History Risk Factors[2]:

1. History is absent, vague, changing, implausible, or clearly inconsistent with injury.
2. Significant story variation over time or between witnesses
3. Referred for suspected child abuse

Red Flag Factors (may be relevant in context of other risk factors or injuries)

1. Unwitnessed or not publically witnessed (independently verifiable by a non-related witness) injury or neurologic event
2. Delay in seeking care
3. Prior ED visit for injury
4. Domestic violence in home
5. Premature infant (<37 weeks)
6. Low birth weight/intra-uterine growth retardation (IUGR)
7. Chronic medical conditions
8. Known abuse in sibling/other child, or intimate partner violence in the home

C. Physical Exam - Concerning Findings:

1. Bruise anywhere on an infant < 4 mos. without confirmed trauma in public setting to account for bruising
2. Any bruise in child < =4 yo in the 'TEN' region (torso (chest, abdomen, back, buttocks, genitourinary region, and hips), ears and neck) or FACES-p (frenulum, angle of jaw, cheek, eyelids, subconjunctivae; p for patterned (#4)).[3,4]
3. Bruise, mark or scar in pattern that suggests being hit with an object
4. Perineal or genital injury
5. Burn injury suggestive of abuse: a) contact - heated contact of an object (cigarette, iron, knife) against the skin or b) scald - immersion burns to hands, feet, buttocks and perineum with flexion sparing of popliteal fossa or groin (tub burn)
6. Any injury in a non-ambulating child
7. Unexplained injury or injury without history
8. Failure-to-thrive (by growth charts; see definition[D])
9. Large head in children under 1 yo (by occipitofrontal circumference > 85th%ile)
10. Signs of neglect (untreated dental caries)

D. Failure to Thrive (FTT)[5]

The American Academy of Pediatrics defines FTT as "a significantly prolonged cessation of appropriate weight gain compared with recognized norms for age and gender after having achieved a stable pattern (eg, weight-for-age decreasing across 2 major percentile channels from a previously established growth pattern; weight-for-length < 80% of ideal weight). This is often accompanied by normal height velocity. Despite these accepted definitions, caution must be applied when diagnosing FTT on the basis of percentile shifts, because growth variants are common. Actual weight <70% of predicted weight-for-length requires urgent attention."

E. Abusive Head Trauma

-The CDC defines abusive head trauma (AHT) as: "an injury to the skull or intracranial contents of an infant or young child (< 5 years of age) due to inflicted blunt impact and/or violent shaking." Excluded from this case definition are (1) unintentional injuries resulting from neglectful supervision and (2) gunshot, stab, or wounds from penetrating trauma.[10]

- The 5-point Pittsburgh Infant Brain Injury Score may help determine when to obtain head CT on well appearing infants (age>30 days, < 1 yr) presenting without clear history of trauma but any of the following: (1) BRUE/ALTE (2) vomiting without diarrhea (3) seizures or seizure-like activity (4) soft tissue scalp swelling (5) bruising (6) other nonspecific neurologic symptom not described above, such as lethargy, fussiness, or poor feeding. Calculate the score by: Any skin finding (bruise, scratch, cut, swelling) (2 points), Age >= 3 months (1 point), head circumference > 85th %ile (1 point) and hemoglobin < 11.2 (1 point). Score >= 2 imaging recommended (sensitivity 93%, specificity 53%).[11]

F. Concerning Radiology Findings[2]:

1. Metaphyseal or corner fracture
2. Rib fractures (especially posterior) in any child < 3 years old
3. Any fracture in a non-ambulating child
4. An undiagnosed healing fracture
5. Subdural or subarachnoid hemorrhage on neuro-imaging, particularly in absence of skull fracture in child < 1 year
6. Isolated humerus or femur fracture in child <18 mos, without public trauma to account for it.[12]
7. Hollow viscus injury, particularly duodenal and small bowel injury, in children <4 years, or combined hollow viscus + solid organ injury.[13]

G. Ophthalmology[14, 15]

- • Dilated indirect ophthalmoscopy should be performed selectively for children with suspected abusive head trauma in high suspicion or unclear situations provided the neurosurgical situation permits. Patients at highest risk for retinal findings most commonly have intracranial injury on neuroimaging; particularly subdural hemorrhage.Isolated skull fracture does not appear to correlate with risk for retinal findings.
- A child considered low risk for retinal hemorrhages (no intracranial hemorrhage, normal mental status, and no head or facial bruising) does not automatically require a dilated ophthalmological examination, but should be at the discretion of the treating team.
- When indicated, retinal examination should ideally take place within 24-48 hours but may still add value if done later.

SELECTED REFERENCES (Refer to manuscript for full references)

1. U.S. National Library of Medicine MedlinePlus. Brief resolved unexplained event - BRUE. https://medlineplus.gov/ency/article/007683.htm, Updated July 29, 2018. Accessed 12/2/2019.
2. Escobar MA, Pfugeisen BM, Duralde Y,Morris CJ, Haferbecker D, Amoroso PJ, Lemley H, Pohlson EC. Development of a systematic protocol to identify victims of non-accidental trauma, *Pediatr Surg Int* 2016;32:377–386.
3. Pierce MC, Kaczor K, Aldridge S, O'Flynn J, Lorenz DJ. Bruising characteristics discriminating physical child abuse from accidental trauma, *Pediatrics* 2010;125:64-71.
4. American College of Surgeons Trauma Quality Improvement Program. ACS trauma quality programs best practice guidelines for trauma center recognition of child abuse, elder abuse, and intimate partner violence. https://www.facs.org/-/media/files/quality-programs/trauma/tqip/abuse_guidelines.ashx, Released November 2019. Accessed May 15, 2020.
5. Block RW, Krebs NF, and the (AAP) Committees on Child Abuse and Neglect, and Nutrition. Failure to thrive as a manifestation of child neglect, *Pediatrics* 2005;116(5)1234-1237.
6. Bennett BL, Steele P, Dixon CA, Mahabee-Gittens EM, Peebles J, Hart KW, Lindsell CJ, Chua MS, Hirsh R. Serum cardiac troponin I in the evaluation of nonaccidental trauma, *J Pediatr* 2015 Sep;167(3):669-673.
7. Expert Panel on Pediatric Imaging: Wootton-Gorges SL, Soares BP, Alazraki AL, Anupindi SA, Blount JP, Booth TN, Dempsey ME, Falcone RA, Hayes LL, Kulkarni AV, et al.ACR appropriateness criteria® suspected physical abuse - child. *J Am Coll Radiol* 2017;14:S338-S349.
8. Riney LC, Frey TM, Fain ET, Duma EM, Bennett BL, Kurowski EM. Standardizing the evaluation of nonaccidental trauma in a large pediatric emergency Department, *Pediatrics* 2018;141(1):e20171994
9. Lindberg DM, Berger RP, Reynolds MS, Alwan RM, Harper NS, On behalf of the Examining Siblings to Recognize Abuse (ExSTRA) Investigators. Yield of skeletal survey by age in children referred to abuse specialists, *J Pediatr* 2014;164(6):1268-1273.
10. Parks SE, Annest JL, Hill HA, Karch DL, Pediatric abusive head trauma: recommended definitions for public health surveillance and research. Centers for Disease Control and PreventionNational Center for Injury Prevention and ControlDivision of Violence Prevention Atlanta, Georgia, 2012 April https://www.cdc.gov/violenceprevention/pdf/PedHeadTrauma-a.pdf, accessed 7/17/2020.
11. Berger RP, Fromkin J, Herman B, Pierce MC, Saladino RA, Flom L, Tyler-Kabara EC, McGinn T, Richichi R, Kochanek PM. Validation of the Pittsburgh infant brain injury score for abusive head trauma. *Pediatrics*. 2016;138(1): e20153756.
12. Mitchell IC, and Pediatric Trauma Society guidelines committee, personal communication, unpublished work.
13. Escobar MA, Flynn-O'Brien KT, Auerback M, Tiyyagura G, Borgman MA, Duffy SJ, Falcone KS, Burke RV, Cox JM, Maguire SA. The association of nonaccidental trauma with historical factors, examination findings, and diagnostic testing during the initial trauma evaluation, *J Trauma Acute Care Surg* 2017;82(6):1147-1157.
14. Christian CW, Levin AV, Council on Child Abuse and Neglect, Section on Ophthalmology, American Association of Certified Orthoptists, American Association for Pediatric Ophthalmology and Strabismus, American Academy of Ophthalmology. The eye examination in the evaluation of child abuse, *Pediatrics* 2018 Aug 2018;142(2):e20181411
15. Li S, Mitchell E, Fromkin J, Berger RP. Retinal hemorrhages in low-risk children evaluated for physical abuse, *Arch Pediatr Adolesc Med* 2011 Oct;265(10):913-917.
16. Bennett BL, Chua MS, Care M, Kachelmeyer A, Mahabee-Gittens M. Retrospective review to determine the utility of follow-up skeletal surveys in child abuse evaluations when the initial skeletal survey is normal. *BMC Res Notes*. 2011 Sep;4:354.

Figure 6. Western Trauma Association and PTS CPA complete algorithm page 2 with detailed annotation corresponding with references to lettered blocks from page 1.