UCSF Benioff Children's Hospitals

ZUCKERBERG SAN FRANCISCO GENERAL Hospital and Trauma Center

Head and Neck Imaging in Pediatric Trauma

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Disclosures

None

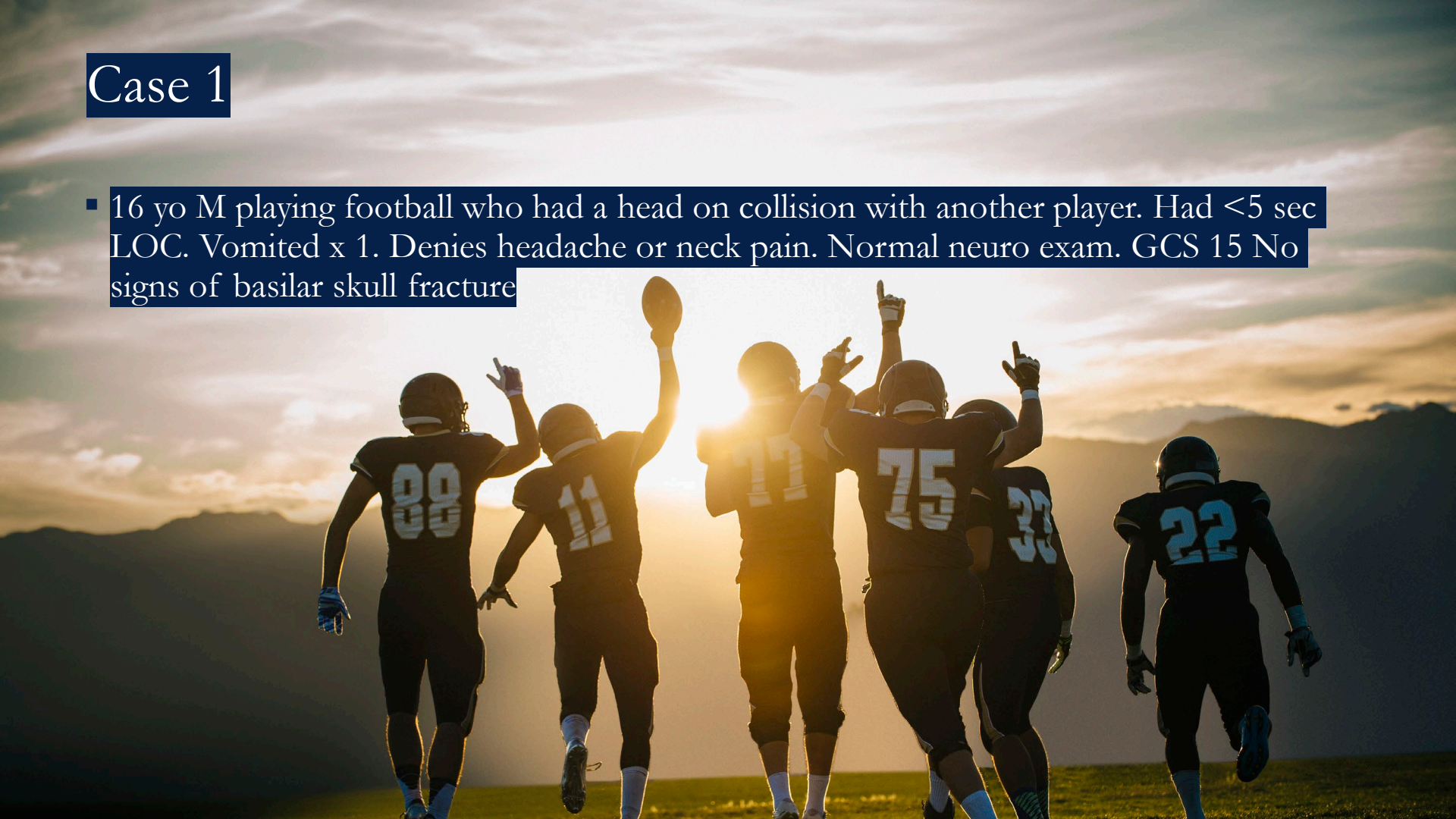
Learning Objectives

By the end of this lecture, learners will able to:

- Discuss radiation exposure and how it relates to head and neck imaging
- Describe evidence-based indications for imaging in:
  - Pediatric head trauma
  - Pediatric neck trauma

Case 1

- 16 yo M playing football who had a head on collision with another player. Had <5 sec LOC. Vomited x 1. Denies headache or neck pain. Normal neuro exam. GCS 15 No signs of basilar skull fracture



Case 2

- 2.5 mo old fell off a 3 foot tall changing table onto wooden floor. Cried immediately. Has a 3cm hematoma on the left parietal aspect of the head. No other focal findings, acting at baseline per family. GCS 15 no palpable skull fracture.

Average yearly background radiation

- ~3 mSV a year

- ~0.035 mSV per X-country flight

Radiation from CT

	Ave mSV	Equivalent background
CT Brain	1.6	7 months
CT Cspine	4-6	1.3-2 years

Source: Radiological Society of North America, Inc. `
https://epmonthly.com/article/plain-cervical-spine-x-ray-almost-dead/#:~:text=When%20it%20comes%20to%20radiation,and%20how%20they%20are%20performed.

ZSFG data

	Ave mSV	Equivalent background
CT Brain alone	1.1	130 days
CT Brain and Cspine	2.6	306 days

PECARN! (Not PECAN)

Multicenter Study > Acad Emerg Med. 2021 Oct;28(10):1124-1133. doi: 10.1111/acem.14308. Epub 2021 Jul 8.

PECARN algorithms for minor head trauma: Risk stratification estimates from a prospective PREDICT cohort study

aa Eapen [2 3], Natalie Phillips [4 5], Yuri Gilhotra [4], Amit Kochar [6], A Cheek [2 3 8 9], Jeremy Furyk [10 11 12], Jocelyn Neutze [13], ephen Hearps [2], Susan Donath [2 3], Ed Oakley [2 3 8], Stuart R Dalziel [15 16], Meredith L Borland [17 18], Franz E Babl [2 3 8]; Emergency Departments International Collaborative (PREDICT)

: 10.1111/acem.14308

> Eur J Pediatr. 2022 May;181(5):2147-2154. doi: 10.1007/s00431-022-04424-9. Epub 2022 Feb 22.

PECARN Rule in diagnostic process of pediatric patients with minor head trauma in emergency department

Alessandro Gambacorta [1], Marianna Moro [2], Antonie
Marcello Covino [3], Antonio Chiaretti [1], Antonio Gatto

Affiliations + expand

PMID: 35194653 PMCID: PMC9056473 DOI: 10.10(

Observational Study > Am J Emerg Med. 2020 Aug;38(8):1599-1603. doi: 10.1016/j.ajem.2019.158439. Epub 2019 Sep 10.

Validation of the PECARN head trauma prediction rules in Japan: A multicenter prospective study

unsuke Hayano [3], Yusuke Hagiwara [4], Kenichi Tetsuhara [5], iro Sekine [8], Masashi Mikami [9], Tohru Kobayashi [10]

n.2019.158439

PECARN prediction rules for CT imaging of children presenting to the emergency department with blunt abdominal or minor head trauma: a multicentre prospective validation study

James F Holmes, Kenneth Yen, Irma T Ugalde, Paul Ishimine, Pradip P Chaudhari, Nisa Atigapramoj, Mohamed Badawy, Kevan A McCarten-Gibbs, Donovan Nielsen, Allyson C Sage, Grant Tatro, Jeffrey S Upperman, P David Adelson, Daniel J Tancredi, Nathan Kuppermann

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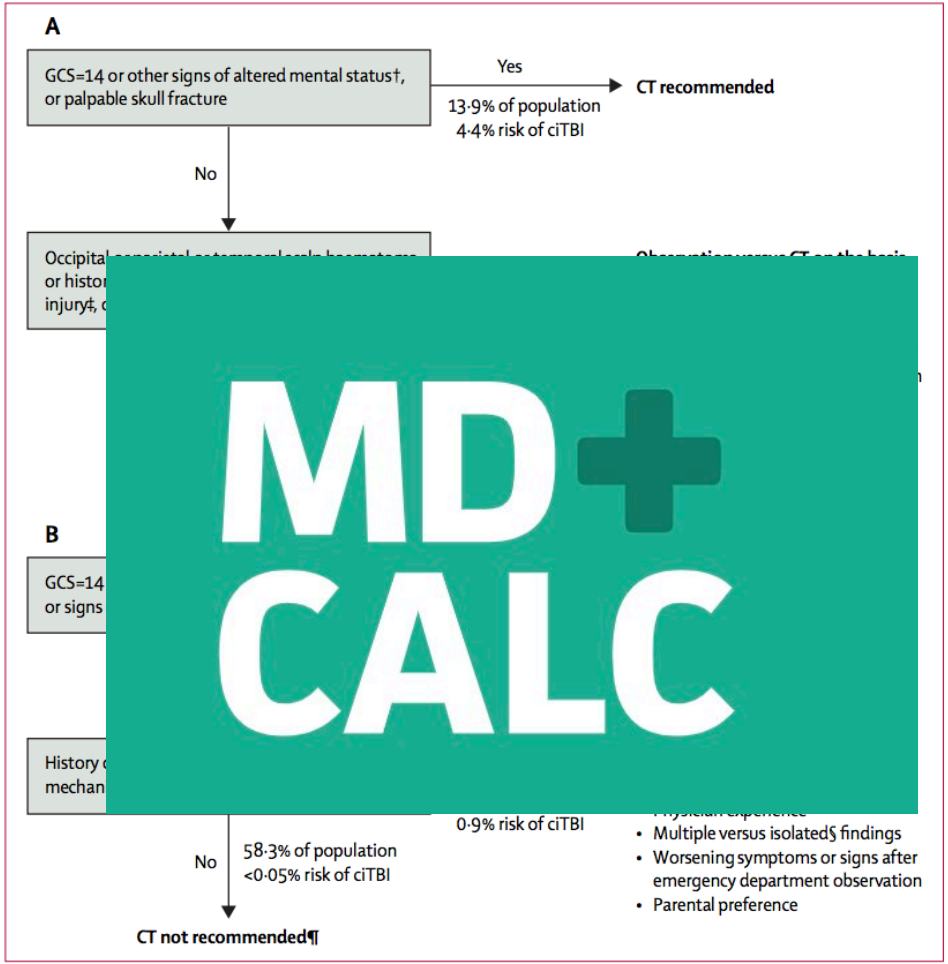
40,000 kids!!

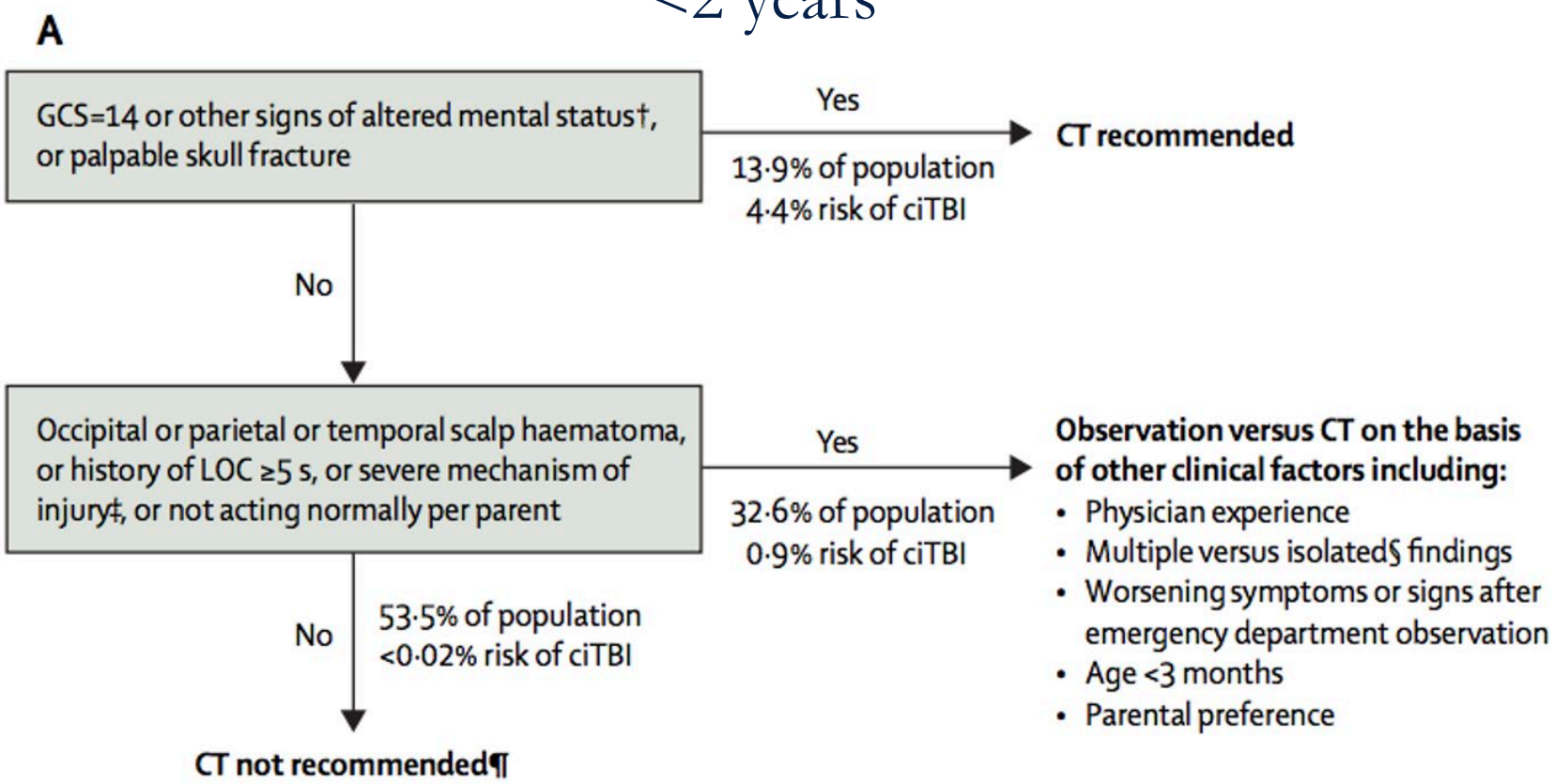
Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study

*Nathan Kuppermann, James F Holmes, Peter S Dayan, John D Hoyle, Jr, Shireen M Atabaki, Richard Holubkov, Frances M Nadel, David Monroe, Rachel M Stanley, Dominic A Borgialli, Mohamed K Badawy, Jeff E Schunk, Kimberly S Quayle, Prashant Mahajan, Richard Lichenstein, Kathleen A Lillis, Michael G Tunik, Elizabeth S Jacobs, James M Callahan, Marc H Gorelick, Todd F Glass, Lois K Lee, Michael C Bachman, Arthur Cooper, Elizabeth C Powell, Michael J Gerardi, Kraig A Melville, J Paul Muizelaar, David H Wisner, Sally Jo Zuspan, J Michael Dean, Sandra L Wootton-Gorges, for the Pediatric Emergency Care Applied Research Network (PECARN)**

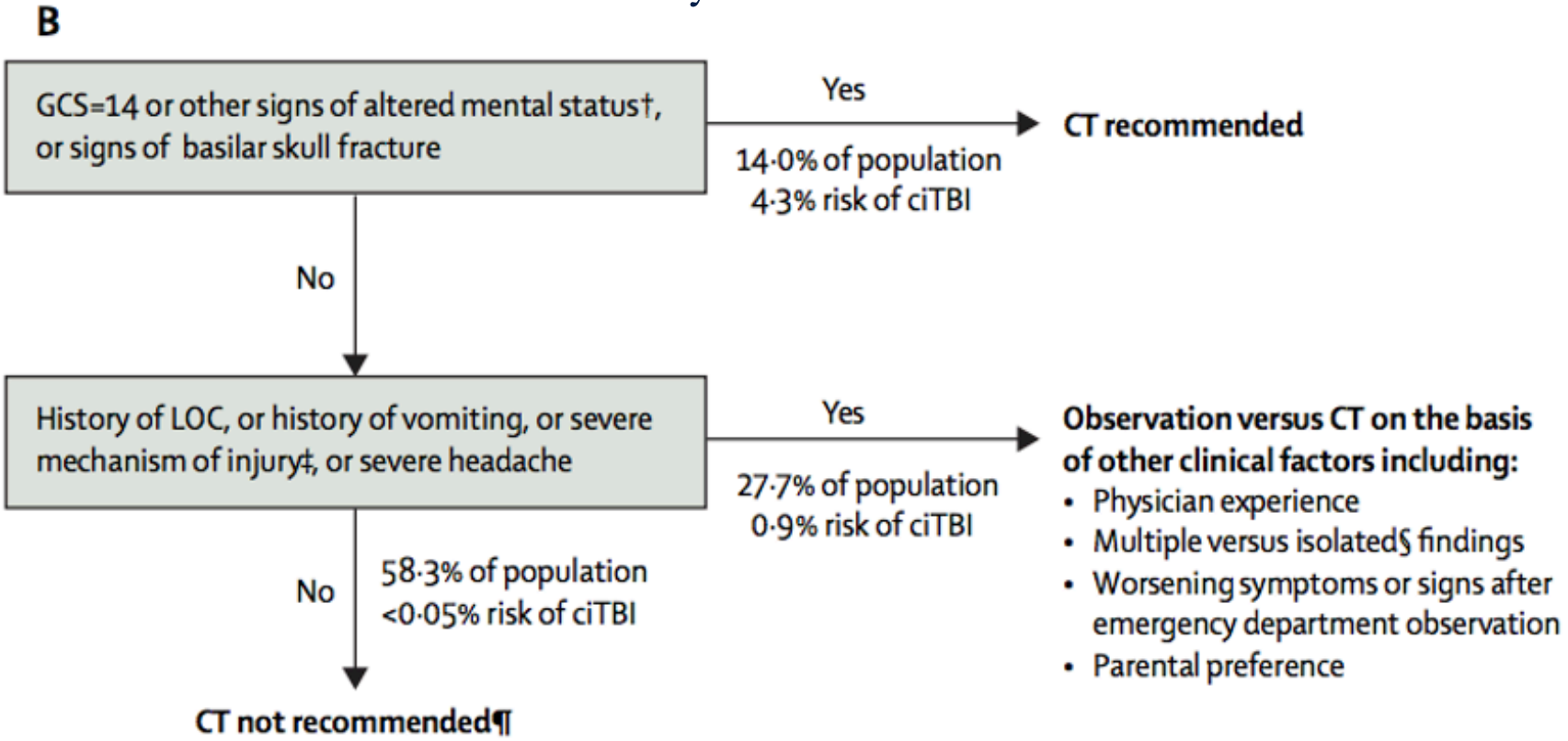


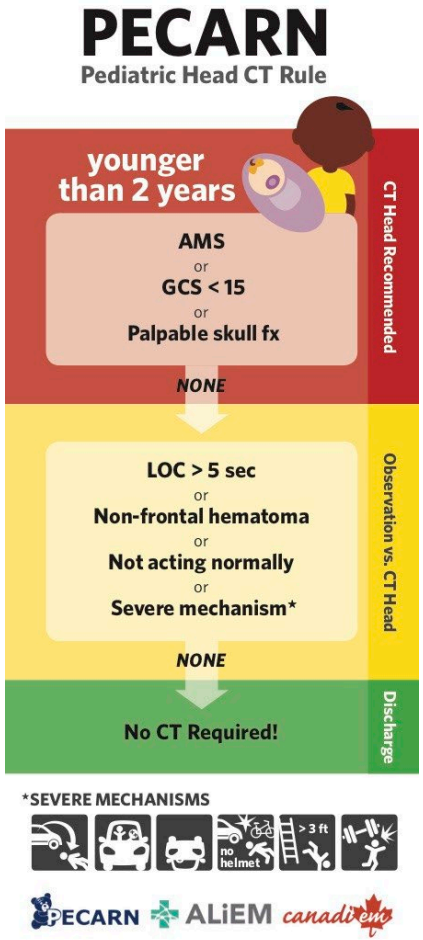
Source: Kuppermann et al 2009

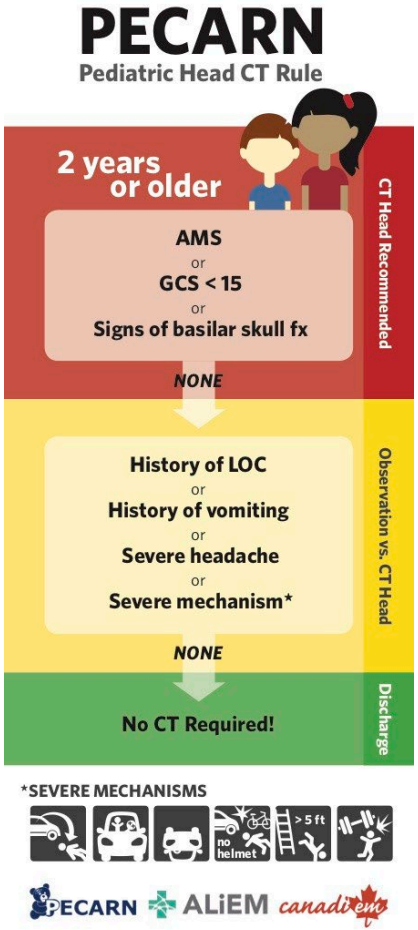
<2 years


A
GCS=14 or other signs of altered mental status†, or palpable skull fracture
Yes
13·9% of population
4·4% risk of ciTBI
CT recommended
No
Occipital or parietal or temporal scalp haematoma, or history of LOC ≥5 s, or severe mechanism of injury‡, or not acting normally per parent
Yes
32·6% of population
0·9% risk of ciTBI
Observation versus CT on the basis of other clinical factors including:
• Physician experience
• Multiple versus isolated§ findings
• Worsening symptoms or signs after emergency department observation
• Age <3 months
• Parental preference
No
53·5% of population
<0·02% risk of ciTBI
CT not recommended¶

2+ years


B
GCS=14 or other signs of altered mental status†, or signs of basilar skull fracture
Yes
14·0% of population
4·3% risk of ciTBI
CT recommended
No
History of LOC, or history of vomiting, or severe mechanism of injury‡, or severe headache
Yes
27·7% of population
0·9% risk of ciTBI
Observation versus CT on the basis of other clinical factors including:
• Physician experience
• Multiple versus isolated§ findings
• Worsening symptoms or signs after emergency department observation
• Parental preference
No
58·3% of population
<0·05% risk of ciTBI
CT not recommended¶





Source: https://www.aliem.com/2017/06/pecarn-pediatric-head-trauma-official-visual-decision-aid/

<2yr

2+yr

Source:
https://www.aliem.com/2017/06/pecarn-pediatric-head-trauma-official-visual-decision-aid/

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NONE

LOC > 5 sec
or
Non-frontal hematoma
or
Not acting normally
or
Severe mechanism*

Observation vs. CT Head

NONE

No CT Required!

Discharge

*SEVERE MECHANISMS

NONE

History of LOC
or
History of vomiting
or
Severe headache
or
Severe mechanism*

Observation vs. CT Head

NONE

No CT Required!

Discharge

*SEVERE MECHANISMS

Source:
https://www.aliem.com/2017/06/pecarn-pediatric-head-trauma-official-visual-decision-aid/

Bottom Line- # of Risk Factors

- 1 risk factor- super low risk ≤0.5% observe
- 3+ risk factor >4-5% risk- Likely image
- What about 2 risk factors?

Source: Dayan et al 2014, Lee et al 2014, Nigrovic et al 2012, Dayan et al 2015

Bottom Line- 2 risk factors

- Some risk factors are more risky
  - LOC
  - Mechanism
- When combined with another RF=4-5% risk

Source: Lee et al 2014, Nigrovic et al 2012

Scalp Hematoma

Daniel Paquet. https://creativecommons.org/licenses/by-sa/4.0/

Low threshold to image:

- <3mo* with hematomas
- 3-6mo if nonfrontal/large hematoma
- Hematoma + severe mechanism
- Infant Scalp Score

Scalp Score

Risk Points	Patient Age (months)	Hematoma Size	Hematoma Location
0	>12	None	Frontal
1	6–11	Small	Occipital
2	3–5	Medium	Temporal/Parietal
3	0–2	Large	

*lower threshold in general –Abid et al 2021

Source: Dayan et al 2014; Table Schutzman et al 2021

Beware younger patients!! Esp <3mo

Emergency Department Evaluation of Young Infants With Head Injury

Todd W. Lyons, MD, MPH,[a,c] Rebekah Mannix, MD, MPH,[a,c] Michael C. Monuteaux, ScD,[b,c] Sara A. Schutzman, MD[a,c]

- <3mo old get more imaging but also have higher risks of bad outcomes (TBI, ciTBI, death)

Pediatric Head Trauma Summary

- NOT low risk: GCS < 15, AMS, palpable skull fracture/basilar skull fracture→CT
- Other risk factors→ observation vs CT
  - <2 yr: severe mechanism, nonfrontal hematoma, LOC 5+sec, not acting normally per parent
  - 2+yr: severe mechanism, headache, vomiting, any LOC
  - 1 risk factor-> observe
  - 2 risk factors -severe mechanism and LOC- more risky
  - 3+-> likely image
- For <2yr with scalp hematoma, age, location, size and mechanism matter
  - Consider carefully <3mo age

Fast brain MRI?

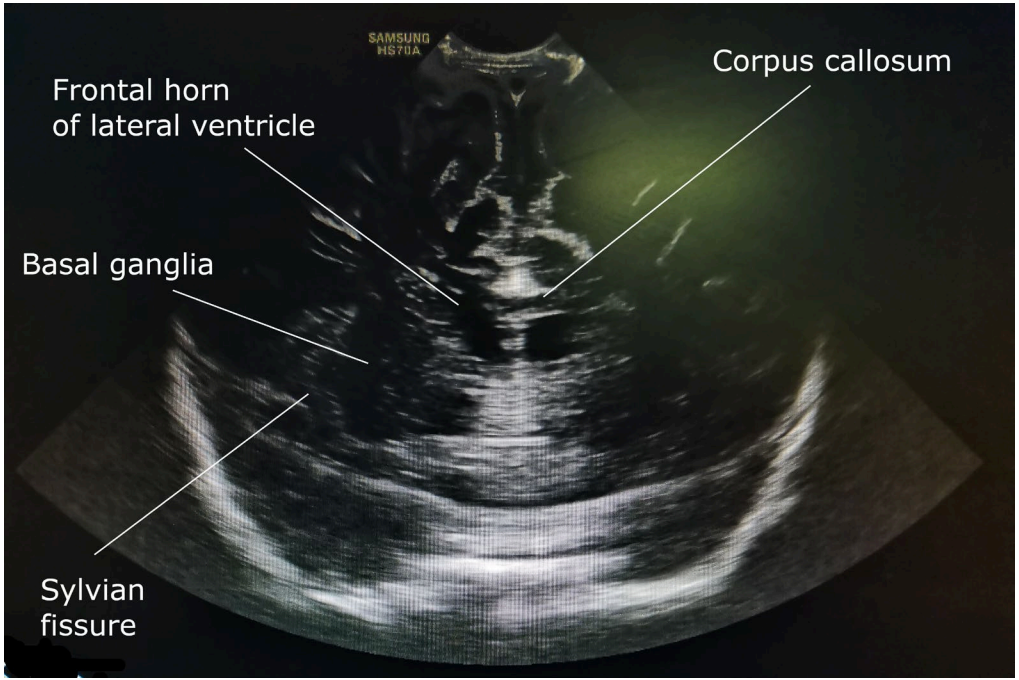
- Studies have looked at Fast Brain MRI in pediatric head trauma
  - Varying sensitivities but generally good for ciTBI
  - Not as good for SAH, skull fracture
  - Questions on effect on LOS

https://commons.wikimedia.org/wiki/File:MRI-Philips.JPG

Kabakus et al 2021, Burns et al 2024, Sheridan et al 2020, Lindberg et al. 2019

Head US?

- Limited studies but likely good for ciTBI- not good for skull fracture
- Not the gold standard



https://commons.wikimedia.org/wiki/File:Coronal_anterior_section_through_anterior_fontanelle_using_ultrasound.jpg

Peter et al 2023, Masaeli et al 2019

Case 1

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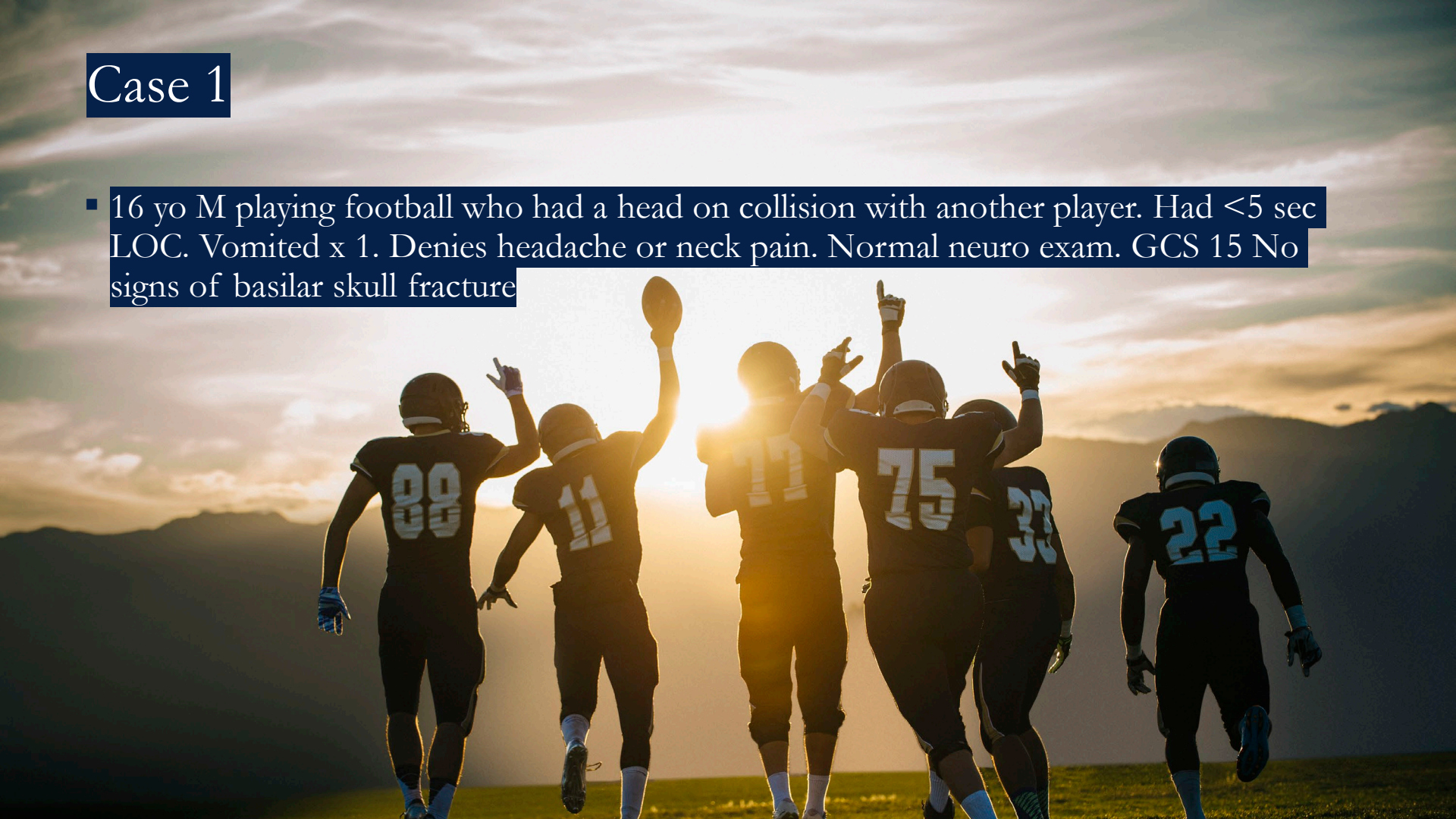
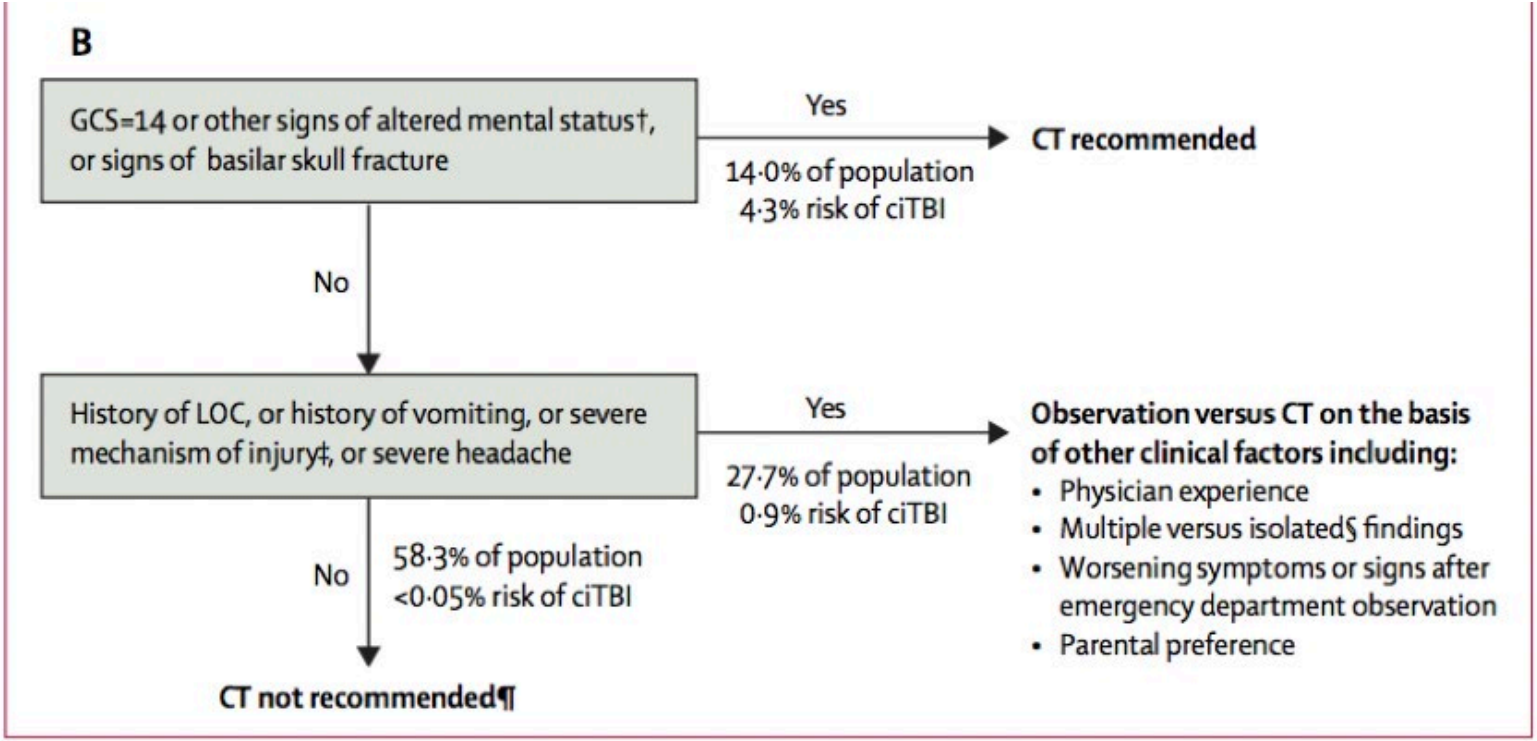


2+ yr

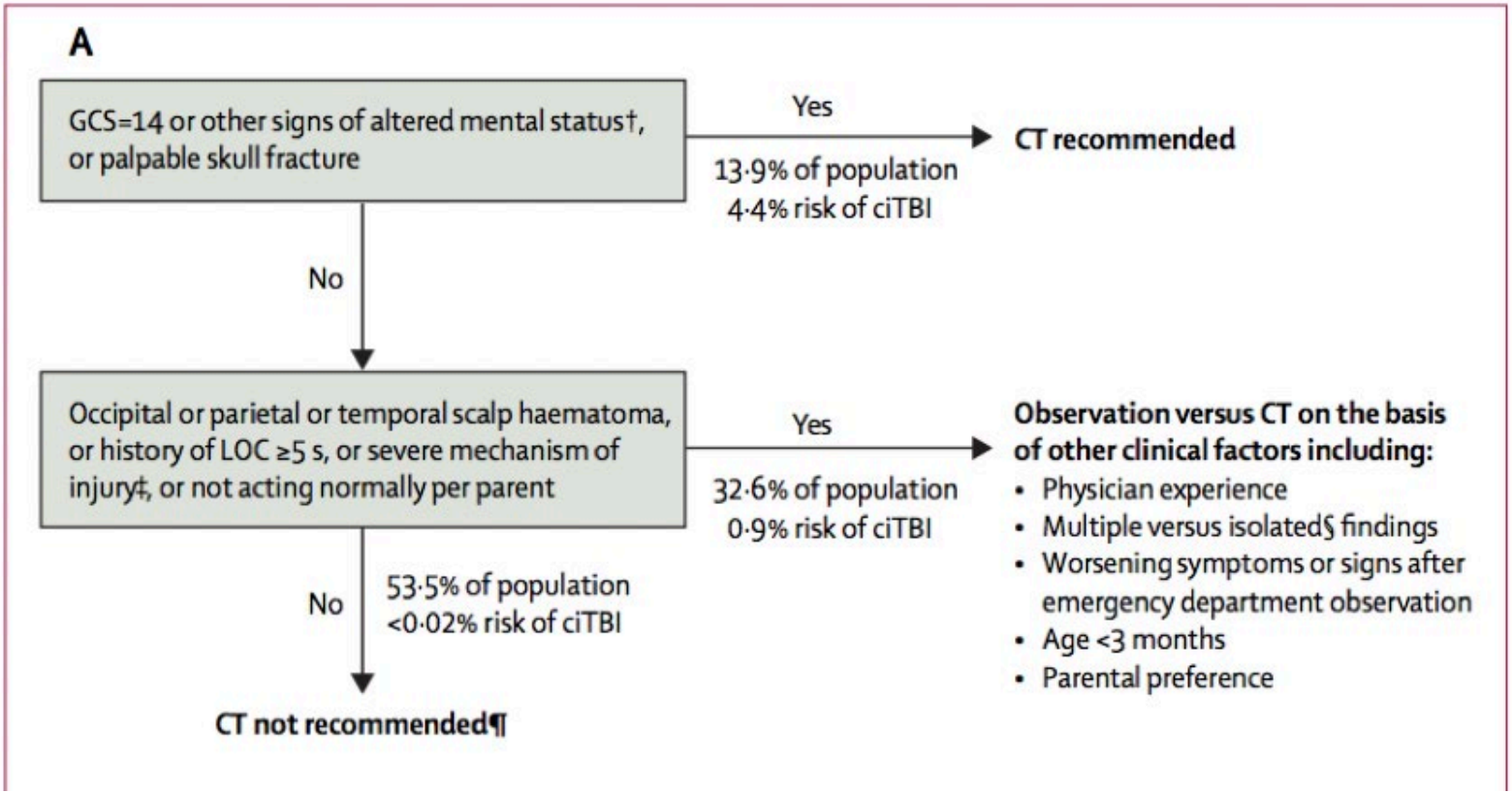


Source: Kuppermann et al 2009

Case 2

- 2.5 mo old fell off a 3 foot tall changing table onto wooden floor. Cried immediately. Has a 3 cm hematoma on the left parietal aspect of the head. No other focal findings, acting at baseline per family. GCS 15 no palpable skull fracture.

<2 yr



Source: Kuppermann et al 2009

What about the neck?

Case 3

- 15 yo F at cheerleading competition was thrown upwards doing a jump and landed on her head. Has some right sided neck pain. No numbness, weakness or tingling. No LOC, no vomiting, no headache. No other complaints. GCS 15, Non-focal neuro exam, no signs of basilar skull fracture.

Pediatric Neck Anatomy

- Head larger relative to body
  - Stress on neck as fulcrum
  - Ligaments are lax
  - In spine injury 60-80% involve the neck (versus adults 30-40%)

- Overall: Not common <1% of children presenting for trauma evaluation

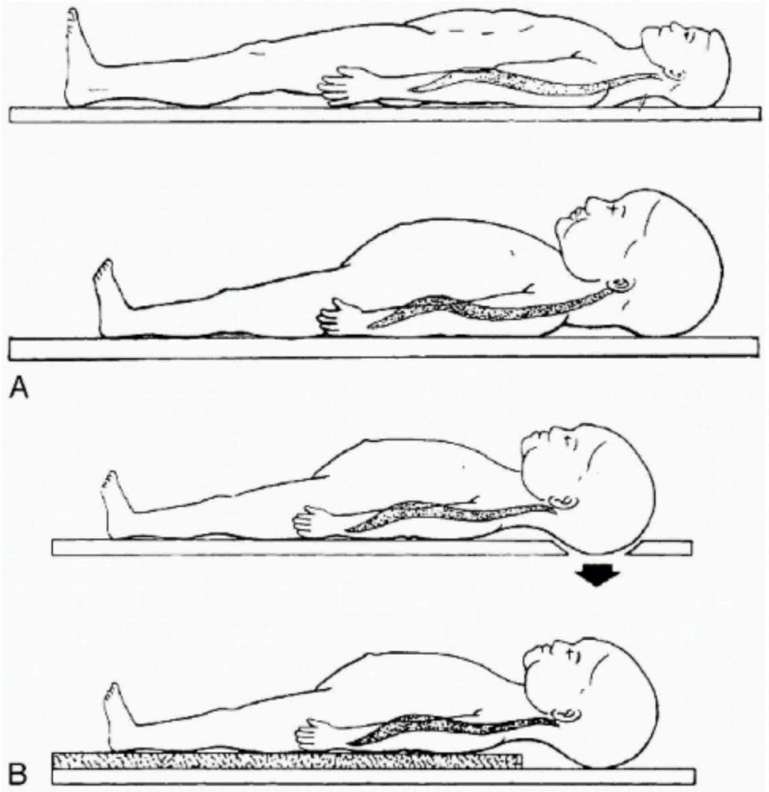


FIGURE 9-1 • Effects of backboard on cervical spine position. **A.** Adult and child immobilized on standard backboard. **B.** Backboards modified with occipital recess and mattress pad to allow neutral positioning of the cervical spine in a young child. (Reprinted with permission from Herzenberg J, Hensinger R, Dedrick D, et al. Emergency transport and positioning of young children who have an injury of the cervical spine: the standard backboard may be hazardous. *J Bone Joint Surg* 1989;71-A:15-21.)

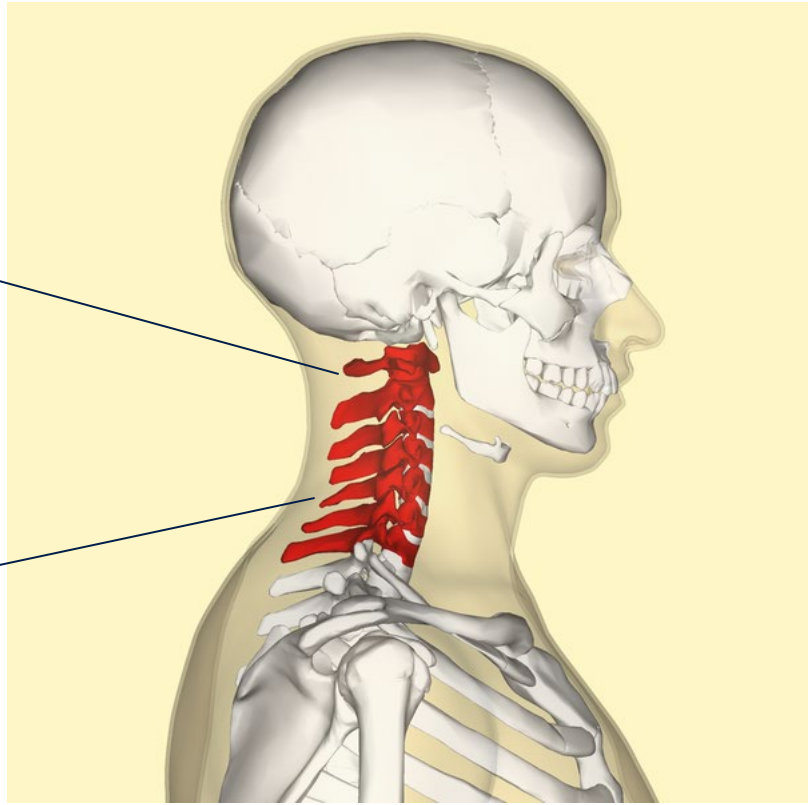
Cspine stabilization in children

Type of C-spine injury by Age

Younger kids (<8yr)

SCIWORA

Older kids



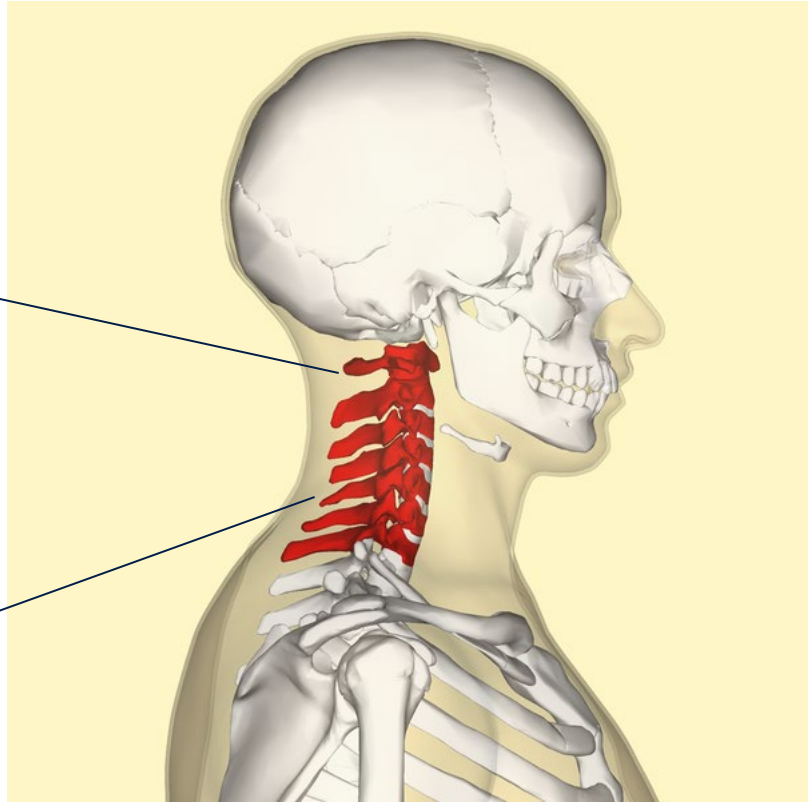
Source: Leonard et al 2015

Mechanism

MVCs, falls from elevation, pedestrian struck, blunt blows to head and neck

SCIWORA

Sports, diving, ATV/motorcycle



Source: Leonard et al 2015

SCIWORA

- Spinal Cord Injury without Radiographic Abnormality
  - Children with objective signs of acute traumatic myelopathy with negative plain films, flex-ex and/or CT
  - With MRI 2/3 now able to be imaged
  - NOT the same as stingers/burners which are peripheral brachial plexus injuries

Outcomes

- Worse morbidity/mortality: Younger patients and higher level of injury
- Special populations at higher risk
  - Down's syndrome
  - Mucopolysaccharidosis
  - SCIWORA history
  - Achondrodysplasia
  - Congenital anomalies of Cspine
    - os odontoideum

Source: Leonard et al 2015

Source: Leonard et al 2010, Leonard 2015
Leonard et al 2019

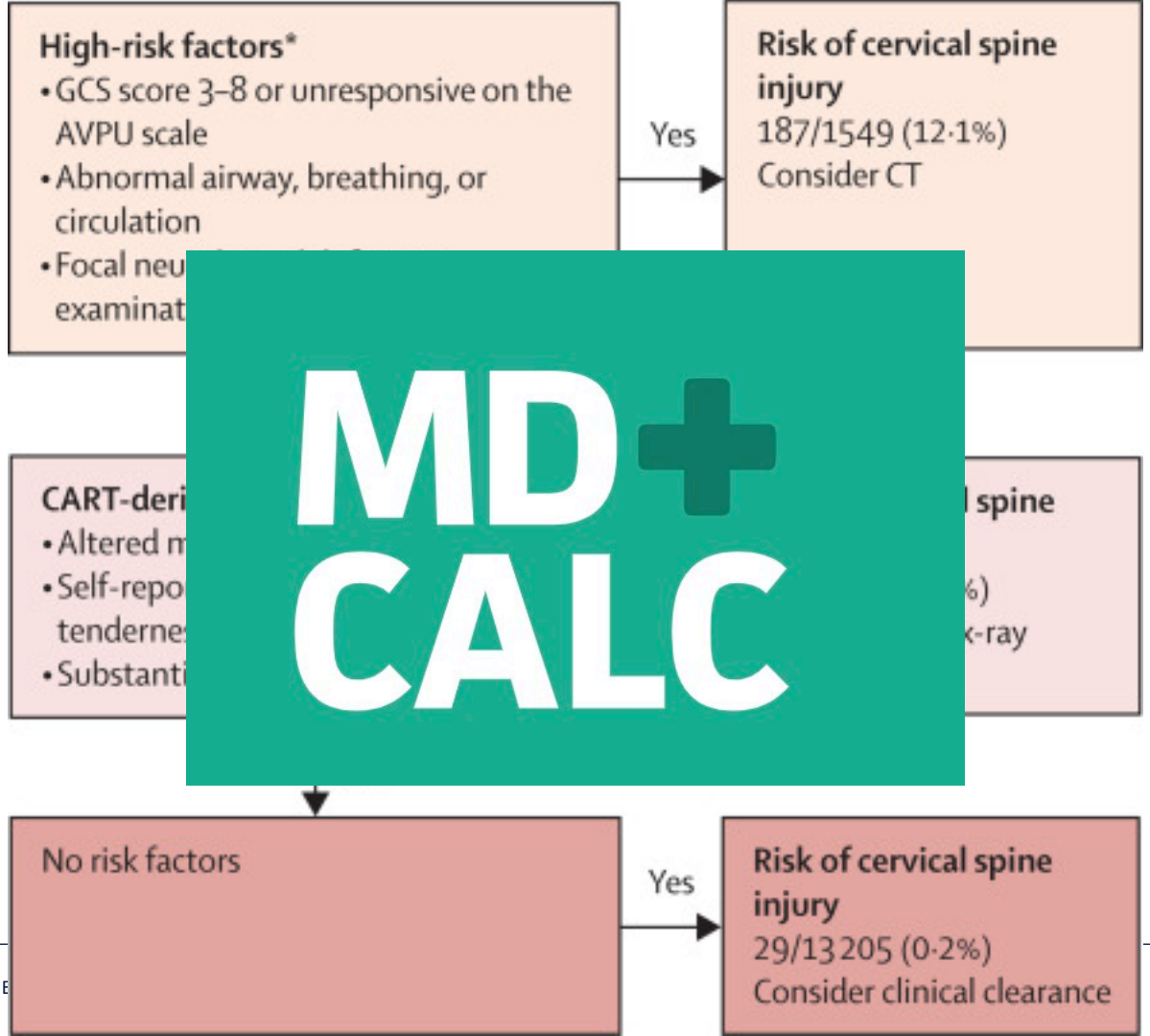
PECARN Cervical Spine Injury (CSI) risk factors

- Studies from 2010, 2015, 2019 (Leonard)
  - Risk Factors for CSI
  - Good sensitivity (98%) not great specificity (26%- 50% depending on study)

AMS	**Axial load biomechanics**
Respiratory Distress	**Diving**
Intubation	**Reported inability to move neck**
	Neck pain

PECARN prediction rule for cervical spine imaging of children presenting to the emergency department with blunt trauma: a multicentre prospective observational study

Julie C Leonard, Monica Harding, Lawrence J Cook, Jeffrey R Leonard, Kathleen M Adelgais, Fahd A Ahmad, Lorin R Browne, Rebecca K Burger, Pradip P Chaudhari, Daniel J Corwin, Nicolaus W Glomb, Lois K Lee, Sylvia Owusu-Ansah, Lauren C Riney, Alexander J Rogers, Daniel M Rubalcava, Robert E Sapien, Matthew A Szadkowski, Leah Tzimenatos, Caleb E Ward, Kenneth Yen, Nathan Kuppermann


High-risk factors*
• GCS score 3–8 or unresponsive on the AVPU scale
• Abnormal airway, breathing, or circulation
• Focal neu
examinat
Yes
Risk of cervical spine injury
187/1549 (12·1%)
Consider CT
CART-deri
• Altered m
• Self-repo
tenderne
• Substanti
spine
%)
x-ray
MD+CALC
No risk factors
Yes
Risk of cervical spine injury
29/13 205 (0·2%)
Consider clinical clearance

UCSF

Plain Films

- Retrospective review of 206 kids (subset of PECARN) with Cspine films
  - Sensitivity 90% (85-94), improved in older kids >8
  - Missed injuries which required surgical stabilization had focal neurologic findings.

Source: Nigrovic et al 2012

Adequate C spine?

Typically 3 view: C1-T1

- AP
- Lateral
- Odontoid

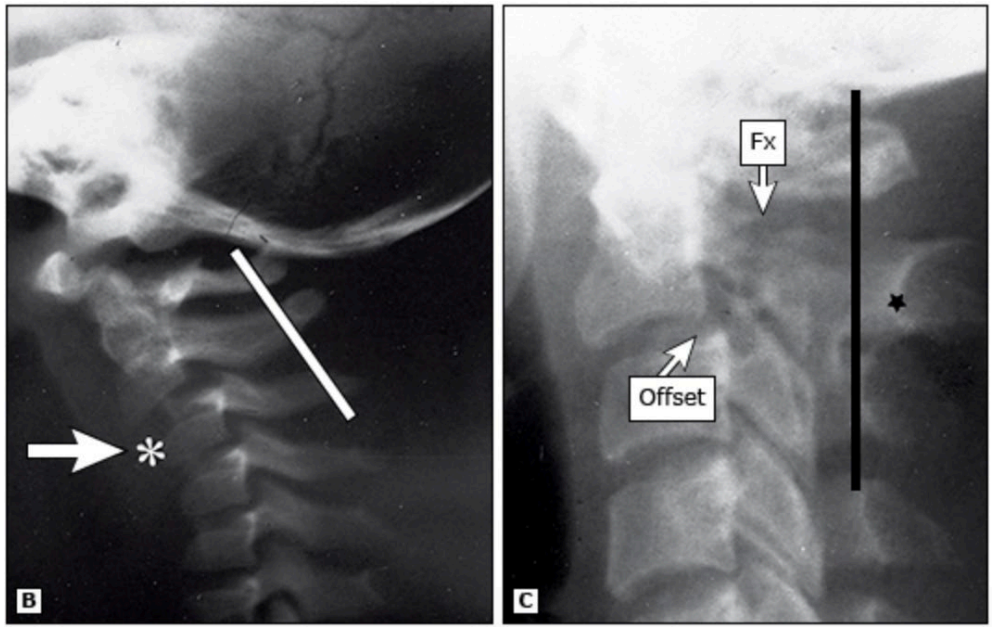
- In PECARN study: Required 2 views only, C1-T1 visualized and Radiologists felt was adequate (i.e. did not say was inadequate)

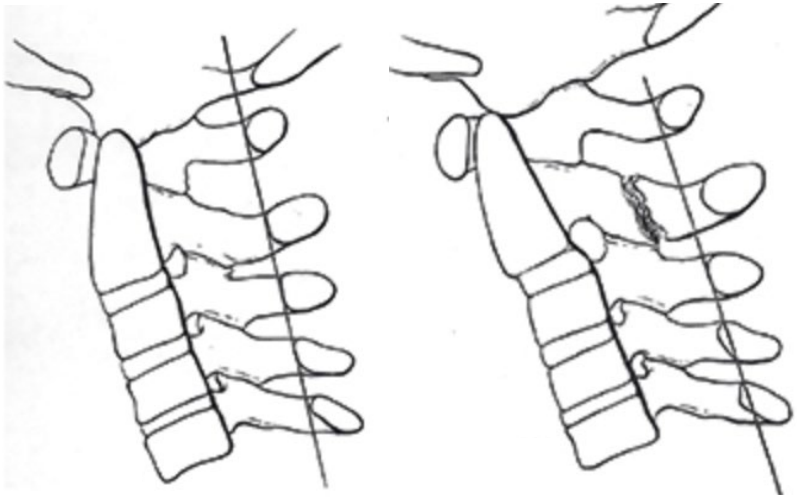
- Cross table alone about 80% sensitive

Pseudo subluxation

Seen in Children <7yr, Usually C2 on C3

Line of Swischuk (posterior cervical line- Spinolaminar C1-C3) <2mm





CT

Very Sensitive and Specific for Bony Injury- 98%

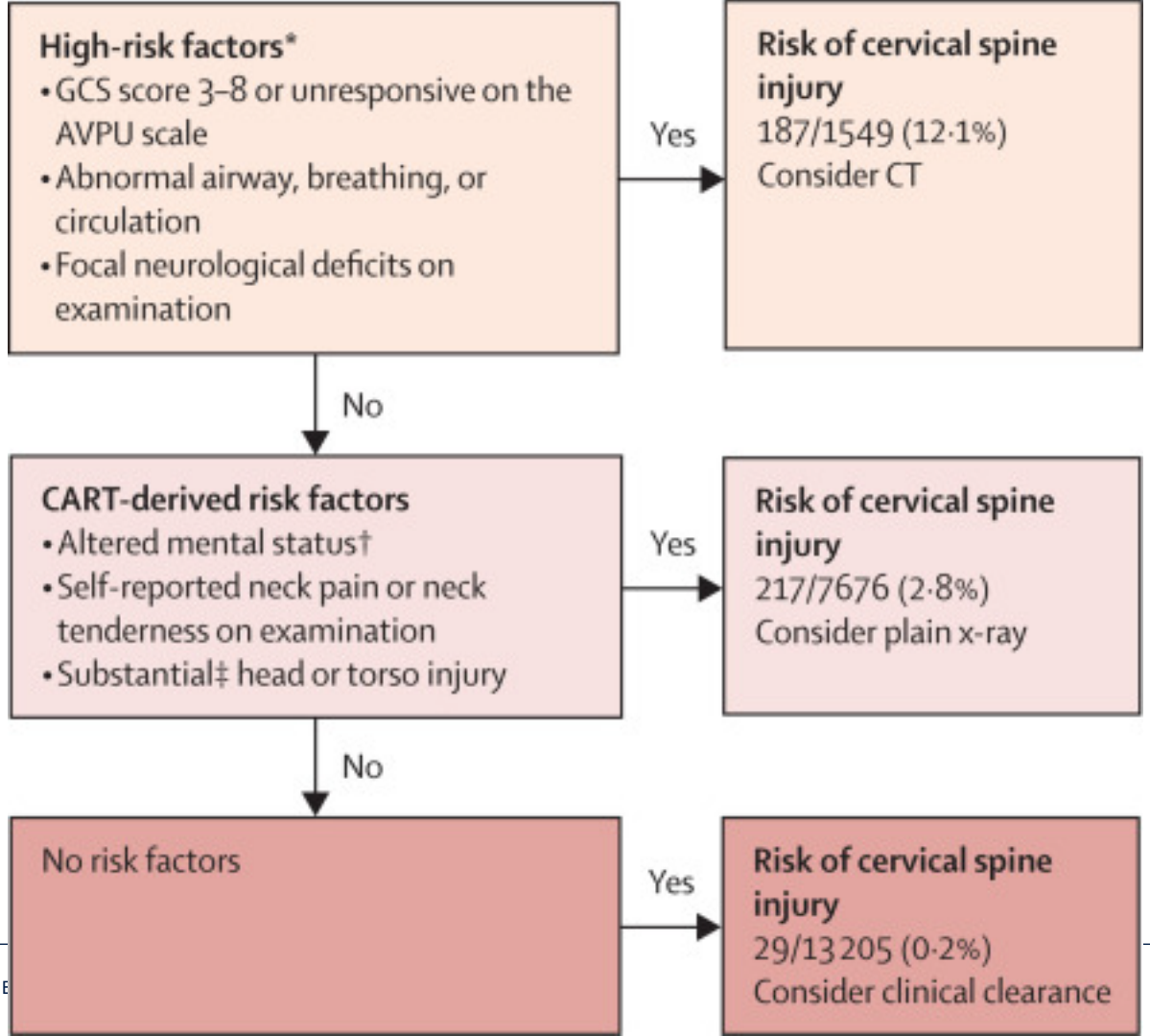
MRI

Should be obtained if neurologic symptoms with negative xray/CT

- MRI is superior to CT for
  - soft tissue injury
  - identifying intervertebral disk herniation
  - ligamentous injuries
  - spinal cord injury

Case 3

- 15 yo F at cheerleading competition was thrown upwards doing a jump and landed on her head. Has some right sided neck pain. No numbness, weakness or tingling. No LOC, no vomiting, no headache. No other complaints. GCS 15, Non-focal neuro exam, no signs of basilar skull fracture.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• GCS score 3–8 or unresponsive on the AVPU scale
• Abnormal airway, breathing, or circulation
• Focal neurological deficits on examination
Yes
Risk of cervical spine injury
187/1549 (12·1%)
Consider CT
No
CART-derived risk factors
• Altered mental status†
• Self-reported neck pain or neck tenderness on examination
• Substantial‡ head or torso injury
Yes
Risk of cervical spine injury
217/7676 (2·8%)
Consider plain x-ray
No
No risk factors
Yes
Risk of cervical spine injury
29/13 205 (0·2%)
Consider clinical clearance

Pediatric Cspine Injury Summary

- Rare finding but can have serious consequences
- Less strong data for cspine imaging versus head:
  - Risk Factors
    - high risk: AMS (GCS 3-8), focal neurologic, abnormal ABCs→CT
    - Still risk factor: AMS (GCS 9-14), neck pain or tenderness, substantial head/torso injury→Plain film
- Imaging: Plain films vs CT, MRI

Questions?

- Margaret.Lin-Martore@ucsf.edu

References

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