Emergency Assessment of Neuro Nightmares

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"**Every child comes with the message that God is not yet discouraged of man**"
Rabindranath Tagore

"**See that you do not despise one of these little ones, for I say to you that their angels in Heaven always look upon the face of my Heavenly father**"
Matthew 18:10

"**We find delight in the beauty and happiness of children**"
Ralph Waldo Emerson

To my child...

Just for this morning, I am going to smile when I see your face and laugh when I feel like crying.

Just for this morning, I will let you choose what you want to wear, & smile & say how perfect it is.

Just for this morning, I am going to step over the laundry, & pick you up and take you to the park to play.

Just for this morning, I will leave the dishes in the sink, and let you teach me how to put that puzzle of yours together.

Just for this afternoon, I will unplug the telephone & keep the computer off, & sit with you in the backyard & blow bubbles.

Just for this afternoon, I will not yell once, not even a tiny grumble when you scream and whine for the ice cream truck, & will buy you one if he comes by.

Just for this afternoon, I won't worry about what you are going to be when you grow up, or second guess every decision I have made where you are concerned.

Just for this afternoon, I will let you help me bake cookies, & I won't stand over you trying to fix them.

Just for this afternoon, I will take us to McDonald's and buy us both a Happy Meal so you can have both toys.

Just for this evening, I will hold you in my arms and tell you a story about how you were born & how much I love you.

Just for this evening, I will let you splash in the tub & not get angry.

Just for this evening, I will let you stay up late while we sit on the porch and count all the stars.

Just for this evening, I will snuggle beside you for hours, and miss my favorite TV shows.

Just for this evening when I run my finger through your hair as you pray, I will simply be grateful that God has given me the greatest gift ever given. I will think about the mothers and fathers who are searching for their missing children, the mothers and fathers who are visiting their children's graves instead of their bedrooms, and mothers and fathers who are in hospital rooms watching their children suffer senselessly, and screaming inside they can't handle it anymore.

And when I kiss you goodnight, I will hold you a little tighter, a little longer. It is then, that I will thank God for you, and ask him for nothing, except one more day...

Requests From The Mother Of A Catastrophically Injured Child

- My child had a full active life prior to this injury - please ask them about it.

- Keep our family informed

- Answer questions to the best of your ability

- Whenever possible, provide information about possible outcomes

- Be ready for my child when he arrives on your unit / at your hospital

- I need some attention too - I am frightened & feel so alone

- Let me know how to get in touch with you if I need you

- Allow me to stay with my child whenever possible

- Help my child to not be in pain, please!

- Arrange it so he/she can get some sleep - even in the ICU

- Try not to ask repeated questions for which there are answers in my child's chart

- Respect my child's need for privacy and modesty - remember he's only a child

- Introduce yourself, write down your role - better yet, give me your business card

- Document carefully so I don't have to clarify things

- Speak directly to my child

- Don't stand at the foot of his/her bed - go the side, bend down he/she can see you

- My child is a bright child. Please don't talk down to him/her

- Notice non-clinical things (a new postcard, a photo of pet, etc)

- Help me to construct letters to my insurance company

- Allow my child to maintain a sense of self-esteem & some control over what is happening by giving my child some choices

- This may be the 100'th child you have cared for with this type of injury - it's our first!

Good care is important - True caring is a gift!

Assessment of Neuro Nightmares I
Pediatric Head Injuries

"... there have been no major breakthroughs in pediatric traumatic brain injuries in the past 20 years..."

Pediatric differences

A. 80% of pediatric patients with severe closed head injury (CHI) have cerebral edema & increased intracranial pressure (ICP) versus 50% of adults

B. Open fontanelles & larger head surface area results in the ability to swell more

C. Big head & little body syndrome

II. Incredibly "exciting", but necessary quick review of neuro anatomy

A. Skull & the "big hole in the back of the head"

B. Fontanelles, aka. holes, aka. soft spots, aka. baby pop-off valves

C. Cerebrum

1. Frontal lobe

2. Parietal lobe

3. Temporal lobe

4. Occipital lobe

D. Cerebellum

E. Medulla ("brain stem")

F. Meninges ("PAD")

1. Pia

2. Arachnoid

3. Dura

G. Your brain only wants three things to be a "happy" brain

1. Blood

2. Oxygen

3. Glucose

III. Mechanisms of injury

A. Blunt trauma

B. Penetrating trauma

C. Forces... “Something will keep moving...”

3 collisions in every car accident/motor vehicle crash

- Car vs. tree, other car, etc.

- Head and/or chest vs. dash or windshield

- Internal organs vs. the rest of the body

IV. Waddell’s triad (little pedestrians vs. moving cars)

- Femur fracture

- Belly or chest injuries

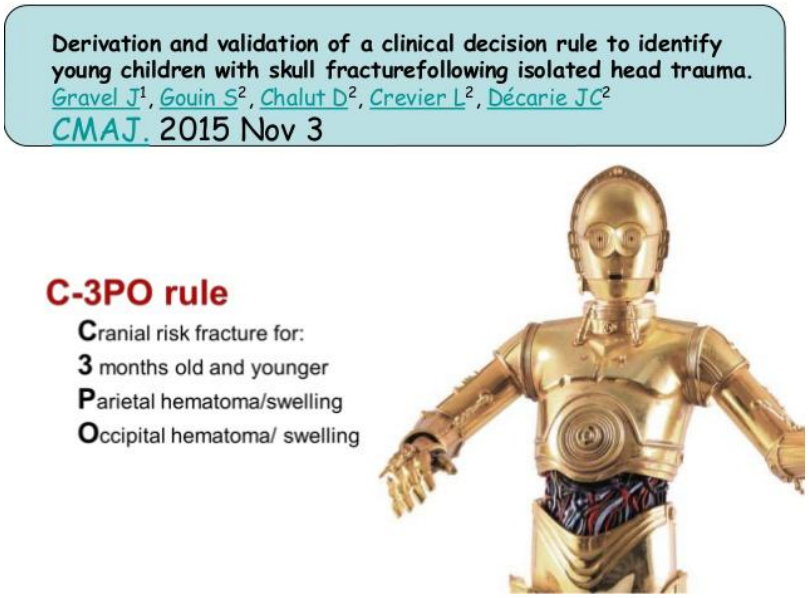
- Head injuries

A. Other level of consciousness influencing factors

"*Remember what makes a brain happy*"

V. Different results of traumatic injuries

BREAKS



A. Skull fractures

1. 400X chance of having a brain injury if skull fractured
2. Ultrasound finds 90% of skull fractures in kids < 2 years old
3. Linear skull fracture - Little line fracture on skull
4. Depressed skull fracture – self explanatory
5. Basilar skull fracture
    a. Raccoon eyes - bruising around the eyes
    b. Battle sign - bruising behind the ear
    c. Hemotympanum (blood behind the eardrum)
    d. Cerebral spinal fluid (CSF) leaks from ears, nose, or mouth

- Halo test? Test for glucose?

- No blindly inserted nasogastric or nasotracheal tubes

BONKS

Concussions

- "Rapid onset of short-lived impairment of neurologic function that resolves spontaneously", but more commonly defined by loss of consciousness (only 10% of cases)

- Headache & dizziness most common symptoms

- CT fine and most patients do fine

- Post-concussive syndrome (slow return to normal mental state)

- Second-impact syndrome

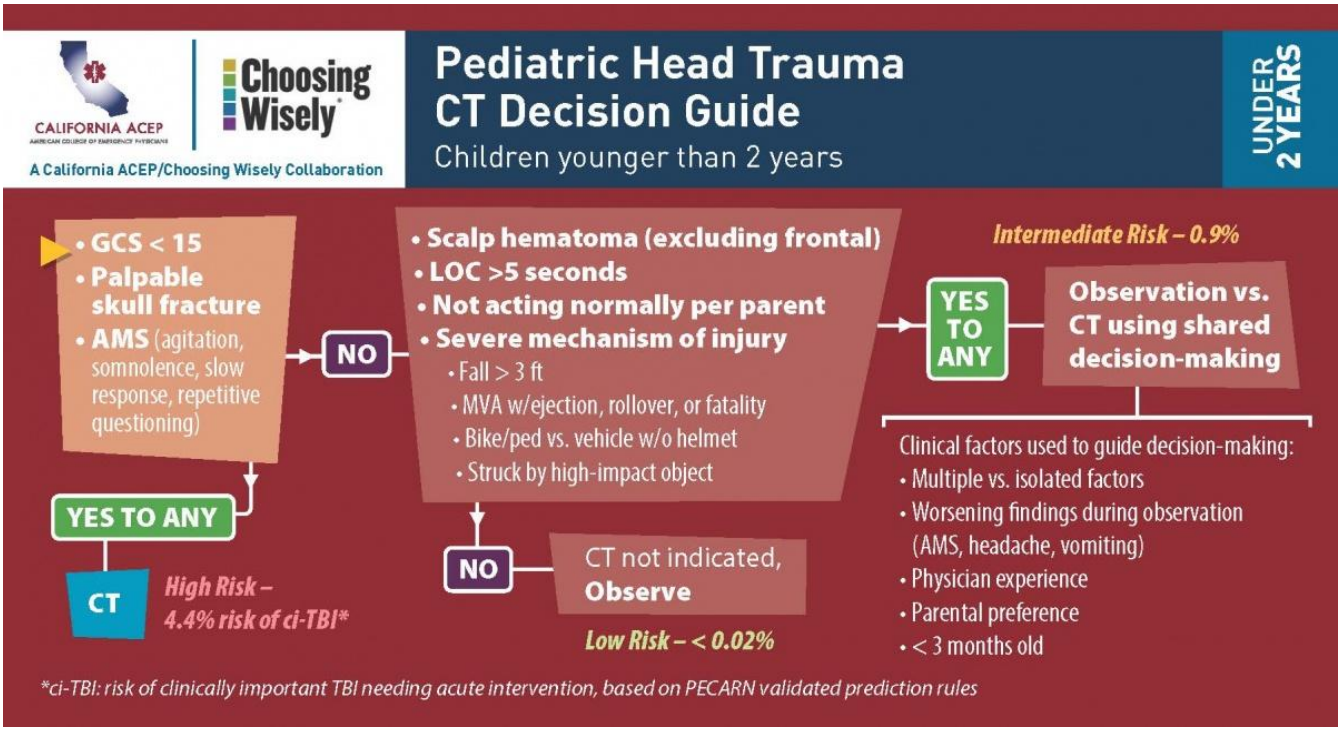
  - Football players get a concussion; look great and go back to play

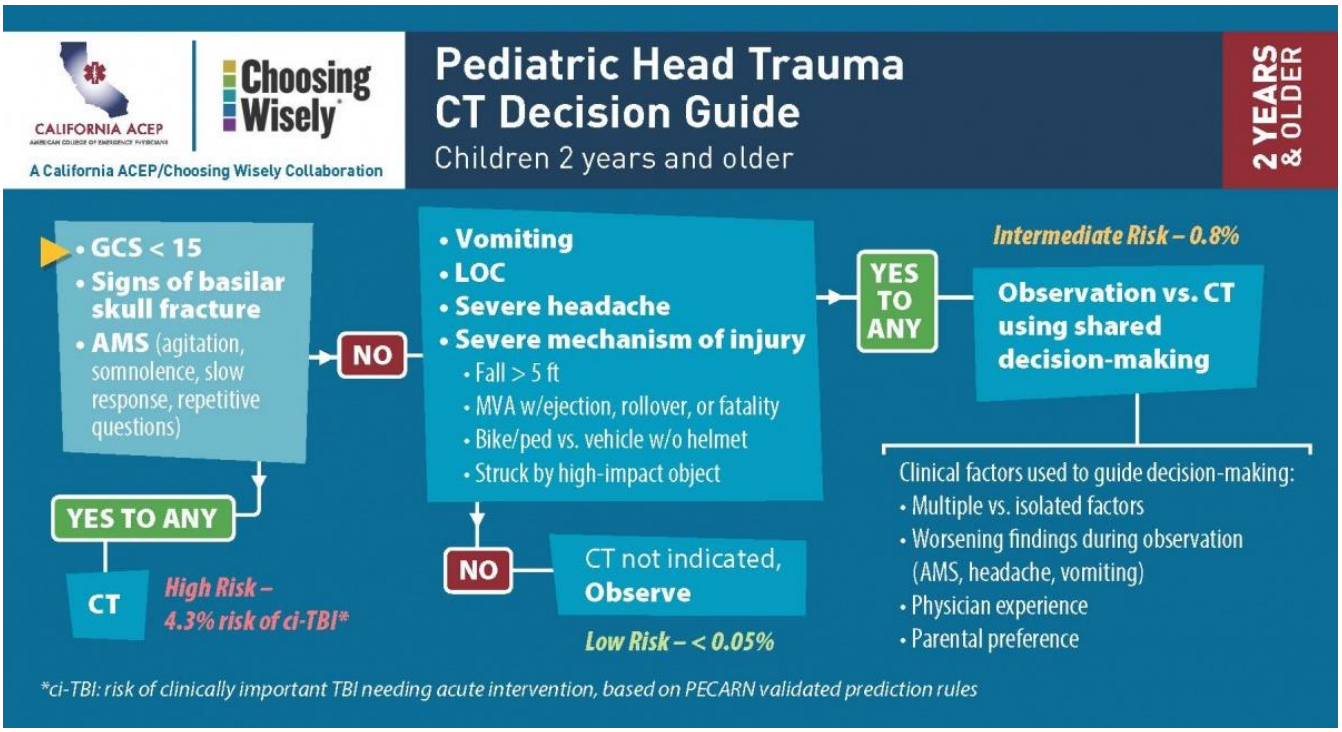
  - Get a second concussion, immediate massive cerebral edema, and death!

Contusions

- Aka brain bruise

- They look bad now, but worse tomorrow


CALIFORNIA ACEP
Choosing Wisely
A California ACEP/Choosing Wisely Collaboration
Pediatric Head Trauma
CT Decision Guide
Children younger than 2 years
UNDER 2 YEARS
• GCS < 15
• Palpable skull fracture
• AMS (agitation, somnolence, slow response, repetitive questioning)
NO
YES TO ANY
CT
High Risk – 4.4% risk of ci-TBI*
• Scalp hematoma (excluding frontal)
• LOC >5 seconds
• Not acting normally per parent
• Severe mechanism of injury
• Fall > 3 ft
• MVA w/ejection, rollover, or fatality
• Bike/ped vs. vehicle w/o helmet
• Struck by high-impact object
NO
CT not indicated, Observe
Low Risk – < 0.02%
Intermediate Risk – 0.9%
YES TO ANY
Observation vs. CT using shared decision-making
Clinical factors used to guide decision-making:
• Multiple vs. isolated factors
• Worsening findings during observation (AMS, headache, vomiting)
• Physician experience
• Parental preference
• < 3 months old
*ci-TBI: risk of clinically important TBI needing acute intervention, based on PECARN validated prediction rules


CALIFORNIA ACEP
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Pediatric Head Trauma
CT Decision Guide
Children 2 years and older
2 YEARS & OLDER
• GCS < 15
• Signs of basilar skull fracture
• AMS (agitation, somnolence, slow response, repetitive questions)
NO
YES TO ANY
CT
High Risk – 4.3% risk of ci-TBI*
• Vomiting
• LOC
• Severe headache
• Severe mechanism of injury
• Fall > 5 ft
• MVA w/ejection, rollover, or fatality
• Bike/ped vs. vehicle w/o helmet
• Struck by high-impact object
NO
CT not indicated, Observe
Low Risk – < 0.05%
Intermediate Risk – 0.8%
YES TO ANY
Observation vs. CT using shared decision-making
Clinical factors used to guide decision-making:
• Multiple vs. isolated factors
• Worsening findings during observation (AMS, headache, vomiting)
• Physician experience
• Parental preference
*ci-TBI: risk of clinically important TBI needing acute intervention, based on PECARN validated prediction rules

Paediatric Emergency Medicine

#FOAMEd CEM Curriculum Based

August 2013

Head Injuries In Children

NICE Guidelines

(very similar to CHALICE)

Are any of the following present?

- Witnessed loss of consciousness lasting > 5 minutes
- Amnesia (antegrade or retrograde) lasting > 5 minutes
- Abnormal drowsiness
- 3 or more discrete episodes of vomiting
- Clinical suspicion of non-accidental injury
- Post-traumatic seizure but no history of epilepsy
- Age > 1 year: GCS < 14 on assessment in the emergency department
- Age < 1 year: GCS (paediatric) < 15 on assessment in the emergency department
- Suspicion of open or depressed skull injury or tense fontanelle
- Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from ears or nose, Battle's sign)
- Focal neurological deficit
- Age < 1 year: presence of bruise, swelling or laceration > 5 cm on the head
- Dangerous mechanism of injury (high-speed road traffic accident either as pedestrian, cyclist or vehicle occupant, fall from > 3 m, high-speed injury from a projectile or an object)

Yes → Request CT scan immediately

No → No imaging required now

CATCH NPV 99.8%, sensitivity 100%

Minor Head Injury:
- Injury in the past 24hours AND
- Witness LOC
- Definite amnesia
- Witnessed disorientation
- Persistent vomiting (more than one episode)
- Persistent irritability in a child <2

AND:

High risk (need for neurological intervention)

1. Glasgow Coma Scale score < 15 at 2 h after injury
2. Suspected open or depressed skull fracture
3. History of worsening headache
4. Irritability on examination

Medium risk (brain injury on CT scan)

5. Any sign of basal skull fracture (eg, haemotympanum, 'raccoon' eyes, otorrhoea or rhinorrhoea of the CSF, Battle's sign)
6. Large, boggy haematoma of the scalp
7. Dangerous mechanism of injury (eg, motor vehicle crash, fall from elevation 3ft (91cm) or 5 stairs, fall from bicycle with no helmet)

PECARN Decides who NOT to CT

<2 NPV 100%, sensitivity 100%

AGE < 2 YRS

Any 1 of following?
- GCS 14
- AMS
- Palpable skull fx

YES (4.4% risk of ciTBI) → CT

NO ↓

1 or more of following?
- Non-frontal hematoma
- LOC ≥ 5 sec
- Severe injury mechanism*
- Not acting normal per parent

YES (0.9% risk of ciTBI) → OBS vs CT

Use clinical gestalt:
- MD experience
- Mult vs isolated finding
- Worsening sx after obs
- Age < 3 months
- Parental preference

NO (<0.02% risk of ciTBI) → NO CT

>2 NPV 99.95%, sensitivity 96.8%

AGE ≥ 2 YRS

Any 1 of following?
- GCS 14
- AMS
- Signs of basilar skull fx

YES (4.3% risk of ciTBI) → CT

NO ↓

1 or more of following?
- LOC
- h/o vomting
- Severe injury mechanism*
- Severe headache

YES (0.9% risk of ciTBI) → OBS vs CT

Use clinical gestalt:
- MD experience
- Mult vs isolated finding
- Worsening sx after obs
- Parental preference

NO (<0.05% risk of ciTBI) → NO CT

Radiation Risk

- 2-3 brain CTs triples the risk of tumour
- 5-10 brain CTs triples risk of leukaemia
- 10,000 patients a head CT might cause a brain tumour and a leukaemia in 1 person

	20 y		40 y		60 y	
	Female	Male	Female	Male	Female	Male
CT Head / Neck						
• Routine Head	4300	7300	8100	11080	12250	14680
• Routine Neck	2390	4020	4430	6050	6750	8030
• Suspected CVA	660	1120	1230	1682	1860	2230
CT Chest						
• Routine Chest, no contrast	360	1040	720	1398	1080	2080
• Routine Chest, with contrast	380	1020	720	1538	1370	2040
• Suspected Pulmonary Embolism	330	660	620	1333	930	1770
• Coronary Angiogram	150	340	270	680	420	790
CT Abdomen and Pelvis						
• Abdomen Pelvis, no contrast	400	680	630	1050	1400	1330
• Abdomen Pelvis, with contrast	470	820	870	942	1320	1250
• Multiphase Abdomen Pelvis	250	330	460	496	700	660
• Angio to rule Aneurysm Dissection	320	420	580	630	880	840

Comparing Accuracy of Clinical Decision Rule

Lyttle et al. Emerg Med J. Feb 2012

	Sensitivity	Specificity	NPV	PPV
Need for Neurological intervention				
CATCH	100%	70.2%	100%	2.1%
Clinically significant intracranial injury				
CHALICE	98.6%	86.9%	99.9%	8.6%
Clinically significant intracranial injury in patients with GCS 13-15				
CHALICE	97.6%	87.3%	99.9%	5.4%
Clinically important brain injury				
PECARN < 2yrs	98.6%	53.7%	99.9%	1.8%
PECARN ≥ 2yrs	96.7%	58.5%	99.9%	2.0%
CT Visible brain injury				
CATCH	98.1%	50.1%	99.8%	7.8%
CHALICE	98.6%	-	-	-
PECARN < 2yrs	Not possible to calculate – derivation group reported only ciTBI			
PECARN ≥ 2yrs				

BLEEDS

B. Epidural arterial bleeds ("Epi" means ...) - “Smile & die bleeds”

C. Subdural venous bleeds ("Sub" means ...)

1. Acute - “Head vs...”

2. Chronic

a. ETOH abuse

b. Anticoagulated

D. Subarachnoid arterial bleeds ("Worst headache of life")

E. Intracerebral just bad bleeds ("Intra" means ...)

F. Shaken baby syndrome

1. **Shaking causes linear & angular forces up to *9.3G***

a. Roller coaster produces *3-4G*

b. Fighter pilots experience *6G*

c. **If child struck against solid object, forces *increase 50-fold to 428G*!**

2. 22% of abused children have central nervous system (CNS) injuries
Typically present with non-specific symptoms

a. Vomiting

b. Failure to thrive

c. Changes in level of consciousness

d. Seizures

3. Retinal hemorrhages from shaking are...

a. Present in 75-90% of cases

b. Not due to minor or moderate trauma

c. Different than those from CPR, hemophilia, or spontaneous bleeds

4. Classic triad of shaken baby syndrome

a. Cerebral edema

b. Retinal hemorrhages

c. Subdural or subarachnoid hemorrhage

d. “Each finding alone or in combination are regarded as reinforcing, rather than necessary for diagnosis. It is not an “all or none phenomenon”

5. Early ophthalmology evaluation

a. Correct diagnosis

(1) Other things look like retinal hemorrhages

(2) Other things can cause retinal hemorrhages

b. Court

Some electronic medical records (EMRs) now automatically screen for possible abuse/non-accidental trauma - That's way cool

Labs

- "Common tests of blood coagulation include prothrombin time (PT/INR) and partial thromboplastin time (aPTT) which measure coagulation factor function, but rTEG (rapid thromboelastography) or ROTEM (rotational thromboelastometry) also can assess platelet function, clot strength, and fibrinolysis which these other tests cannot"

- Think of rTEG and ROTEM as "prescription transfusion" - i.e. the child really needs FFP vs. platelets vs. cryo vs. PRBC vs...

G. Why is cerebral edema & bleeding really a problem?

VI. Neuro assessment tools and techniques

A. AVPU scale

1. A(lert)

2. V(erbal)

3. P(ain)

4. U(nresponsive)

Glasgow coma scale (overview)

15 is good – 3 is bad - Anything between means something's not right

Motor, aka. engine (6)

Eyes (4)

Voice (5)

B. Pediatric Glasgow coma scale

1. Eye opening (4)		**>1 year**	**<1 year**
a.	4	Spontaneous	Spontaneous
b.	3	To command	To shout
c.	2	To pain	To pain
d.	1	None	None

2. Motor (6)		**>1 year**	**<1 year**
a.	6	Obeys command	Spontaneous
b.	5	Localizes pain	Localizes pain
c.	4	Withdraws pain	Withdraws pain
d.	3	Abnl flexion	Abnl flexion
e.	2	Abnl extension	Abnl extension
f.	1	None	None

3. Voice (5)

>5 years

a.	5	Oriented & converses
b.	4	Confused conversation
c.	3	Inappropriate words
d.	2	Incomprehensible sounds
e.	1	None

2-5 years

f.	5	Appropriate words & phrases
g.	4	Inappropriate words
h.	3	Persistent crying or screaming to pain
i.	2	Grunts or moans to pain
j.	1	None

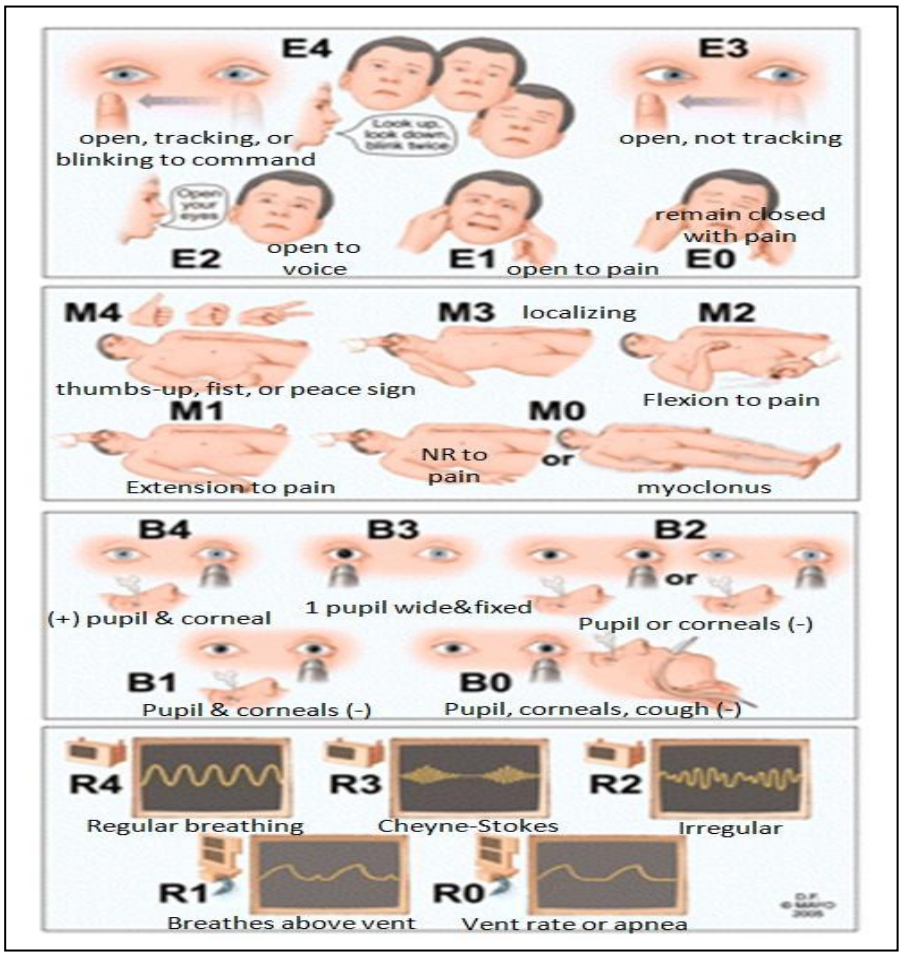
0-2 years

k.	5	Babbles or coos appropriately
l.	4	Cries, but is consolable
m.	3	Persistent crying or screaming to pain
n.	2	Grunts or moans to pain
o.	1	None

GCS	FOUR score

• Three major components
  • Eye—4 points
  • Motor—6 points
  • Verbal—5 points
• Limited utility in intubated patients and children with limited language development
• Key component of other ICU severity of illness scales such as acute physiology and chronic health evaluation II score (APACHE-2)
• Widely used and validated for more than 30 years
	• Four components (E_4, M_4, B_4, R_4) with maximum score of 4 points each
	  • Eye response
	  • Motor response
	  • Brainstem reflexes
	  • Respiratory pattern
	• Includes testing for intubated patients and brainstem reflexes
	• Useful in detecting patients with locked-in syndrome and VSs
	• Multicenter trials and validation are pending

Component Tested	Score
Eye response	
Eyelids open or opened, tracking or blinking to command	4
Eyelids open but not tracking	3
Eyelids closed, but open to loud voice	2
Eyelids closed, but open to pain	1
Eyelids remain closed to pain	0
Motor response	
Thumbs-up, fist or peace sign	4
Localizing to pain	3
Flexion response to pain	2
Extension response to pain	1
No response or generalised myoclonus status	0
Brain stem reflexes	
Pupil and corneal reflexes present	4
One pupil wide and fixed	3
Pupil or corneal reflexes absent	2
Pupil and corneal reflexes absent	1
Absent pupil, corneal and cough reflex	0
Respiration	
Not intubated, regular breathing pattern	4
Not intubated, cheyne stokes breathing pattern	3
Not intubated, irregular breathing	2
Breathes above ventilator rate	1
Breathes at ventilator rate or apnea	0



4. Things that "mess up" scoring the coma scales
    a. Intubation
    b. Swollen eyes
    c. Chemical or physical paralysis
    d. Sedatives &/or analgesics
    e. "Nap time"

C. Scott's pediatric coma scale
    1. Barney/Arthur
    2. SpongeBob
    3. Sports figures/video games
    4. Parental assessment

D. Fontanelles

E. Pupils
    1. Are they equal?
    2. Do they react?
    3. Size?

F. Extremities - "Can they move & feel everything?"

G. Posturing

- Decorticate (deCORDicate) – Abnormal flexion (bad)

- Decerebrate – Abnormal extension (worse)

H. Vital signs (why does the body do what it does?) - Cushing's Triad

- BP goes way up
- HR and RR go way down
- Reflex and compensation for squished brain and brain stem

Common Indications of Non-Accidental Trauma (Child Abuse)

Family Behaviors	Child Behaviors	Historical Findings	Physical Findings	Radiographic Findings
Inappropriate parent-child interactions	Extreme behaviors, i.e. withdrawn or acting out	Story inconsistent with physical findings (doesn't fit)	Multiple injuries in various stages of healing	Multiple fractures
Hostile or unconcerned interactions with hospital staff	Doesn't oppose painful procedures	Story inconsistent with developmental stage (kids can't do that)	Injury and location of injury don't fit developmental stage	Fractures in different stages of healing
Unrealistic expectations of the child	Inappropriate sexual behavior	Delay in seeking medical care	Characteristic patterns (belt or bite marks)	Skull fractures
Parents deny any knowledge as to how injury occurred	Somatic complaints (i.e. chronic headaches, sleep disorders, bedwetting)	Child verbalizes abuse	Signs of poor overall care	Intracranial hemorrhage
Siblings blamed for injury	Suicidal threats or attempts	Multiple visits to the ED	Genital bleeding or discharge in pre-teen age children	
Parents over or under reacting to child's condition	Alcohol or drug abuse			

Adapted from Salassi-Scotter, M., Jardine, J., and Lawson, L. (1994). Child maltreatment. In Henderson, D. and Brownstein, D. Editor. Pediatric Emergency Manual. Springer: New York. 293-322.

Assessment of Neuro Nightmares II
Pediatric Spinal Cord Injuries

I. Pediatric differences

A. Big head & little bodies

B. Types of cord injuries

1. < 8 years old have "higher" cord injuries (C1-C4)

2. 8-12 years old transitional stage

3. > 12 years old injuries are "like adults" (C4-C7)

C. Loose ligaments

II. Incredibly "exciting", but necessary quick review of neuro anatomy

A. Functions of spinal cord

B. Bones

C. Discs

D. Ligaments

E. Meninges

F. Gray/White matter

G. Tracts

1. Posterior

2. Spinothalamic

3. Corticospinal

H. Sympathetic nervous system (brain)

I. Parasympathetic nervous system (body)

J. Bone &/or cord injury

1. If you break the vertebrae, are you automatically paralyzed?

2. Do you have to break a single vertebrae to be paralyzed?

3. 10% of patients with a cervical spine injury have other spine fractures

III. Differentiation of cord injuries

A. Mechanism of injury

1. Hyperflexion

2. Hyperextension

3. Axial loading/Vertical compression

4. Penetrating injuries

IV. Diagnosis of spinal cord injuries

A. History & mechanism of injury

B. Plain film radiographs (never say "shooting")

1. Number of "needed" x-rays to "clear" the C-spine

a. Plain films "catch" 73-83% of fractures in children <8 years old

b. Plain films "catch" 93% of fractures in children >8 years old

c. Little kids & open mouth view probably ain't gonna happen - CT head to C2

d. CT "catches" 97-100%

e. If going to get plain films, at least 3 views are currently recommended “seeing all you want to see”

“In God we trust... All others get a spine board” (or do they?)
Rowley Cottingham

2. Does every trauma patient need C-spine x-rays?

   a. History of...

      (1) Direct neck trauma

      (2) Altered mental status (pre-existing)

      (3) Under 2-years old - automatically high risk

      (4) Children with Down Syndrome are higher risk due to atlantoaxial instability

   b. Physical findings

      (1) Neck pain or tenderness

      (2) Immobility

      (3) Altered mental status (new)

      (4) Altered motor/sensation findings

3. Normal pediatric C-spine radiology variants

   a. Facet joints of C1-C3 nearly horizontal

   b. **Fulcrum of cervical motion is at *C2-C3*, versus *C5-C6* in adults**

   c. Pseudosubluxation of C2-C3

   d. Absence of normal cervical lordosis

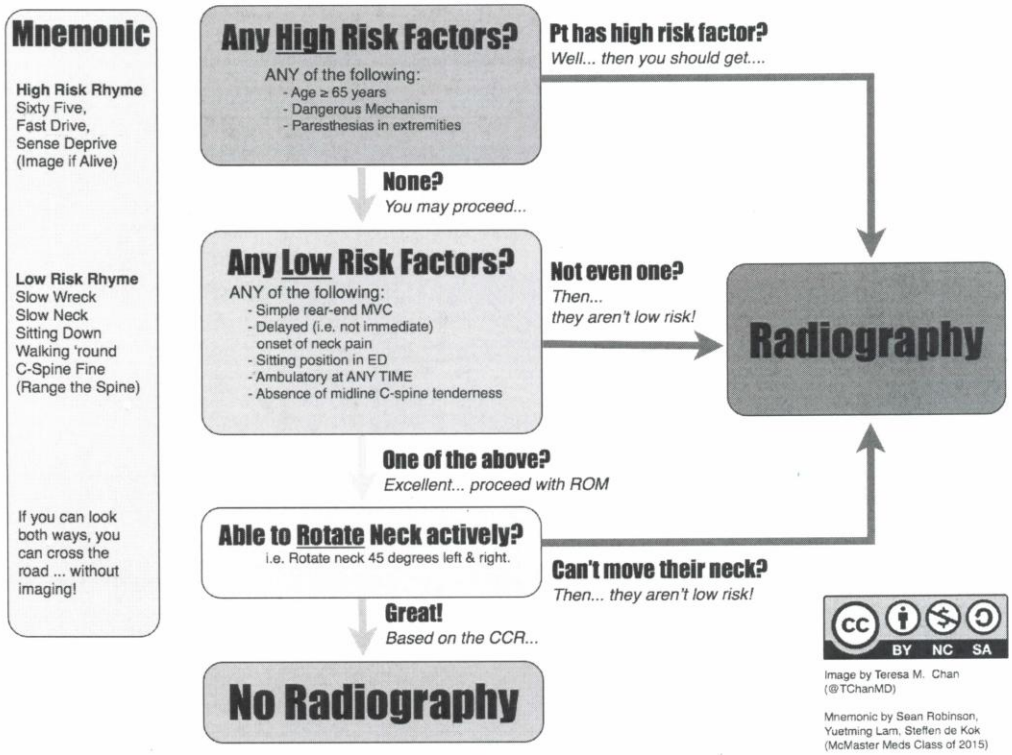
   e. Prevertebral soft tissue swelling

   f. Anterior wedging of the vertebral body, especially of C3

   g. Slightly longer atlas-dens interval

   h. **Loose ligaments**

C. MRI if obtunded with possible CSI or unable to clear within 3 days



- **Dangerous Mechanism**
  - Fall from elevation>=3 feet/ 5 stairs
  - Axial load to head (diving)
  - MVC high speed (>100km/hr), rollover, ejection
  - Motorized recreational vehicle
  - Bicycle collision

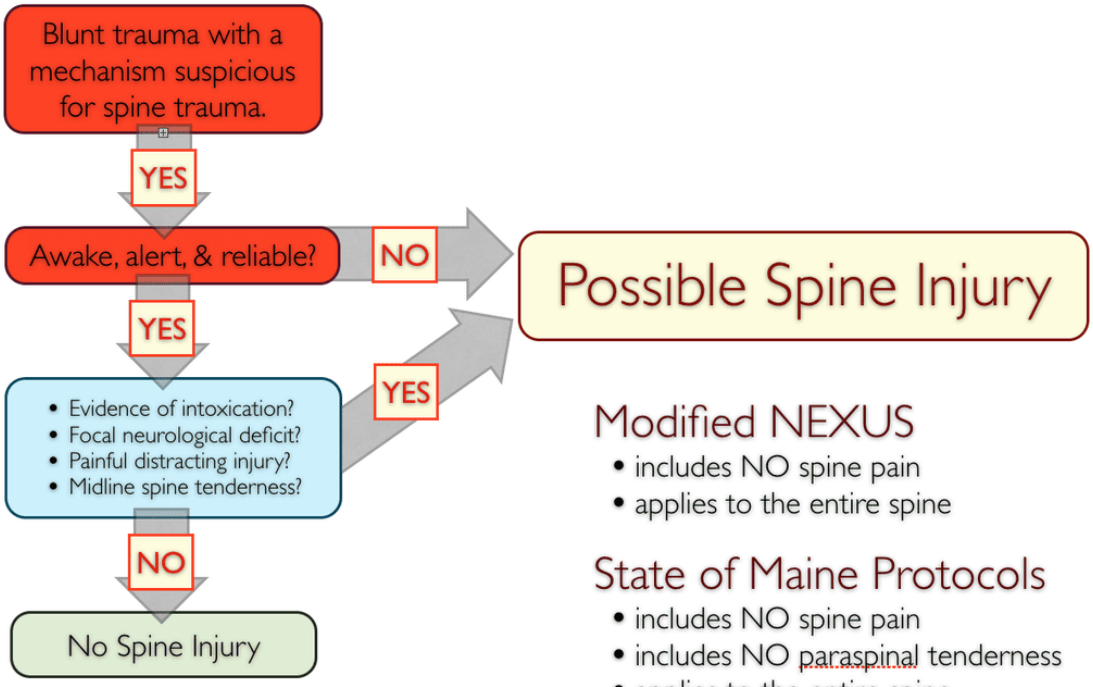
Clinical Question: Can emergency department triage nurses apply the Canadian C-Spine Rule to adult blunt trauma patients and safely clear the c-spine?

Reference: Stiell et al. A Multicenter Program to Implement the Canadian C-Spine Rule by Emergency Department Triage Nurses. Annals of EM Oct 2018

- **Population:** Alert adults presenting to the ED ambulatory or by EMS with acute blunt trauma occurring within the previous 48 hours with posterior neck pain and were in stable condition. Alert and stable was defined as a Glasgow Coma Scale (GSC) score of 15 with normal vital signs.
  - **Exclusions:** Age less than 16 years, penetrating trauma, acute paralysis, or known vertebral disease
- **Intervention:**
  - **Phase 1 (Certification):** All ED nurses who performed triage activities had didactic training and then had to demonstrate competence by accurately assessing ten patients before being certified.
  - **Phase 2 (Implementation):** All triage nurses who had become certified were empowered by a medical directive to "*clear*" the cervical spine of patients, allowing them to remove cervical spine

1.

NEXUS



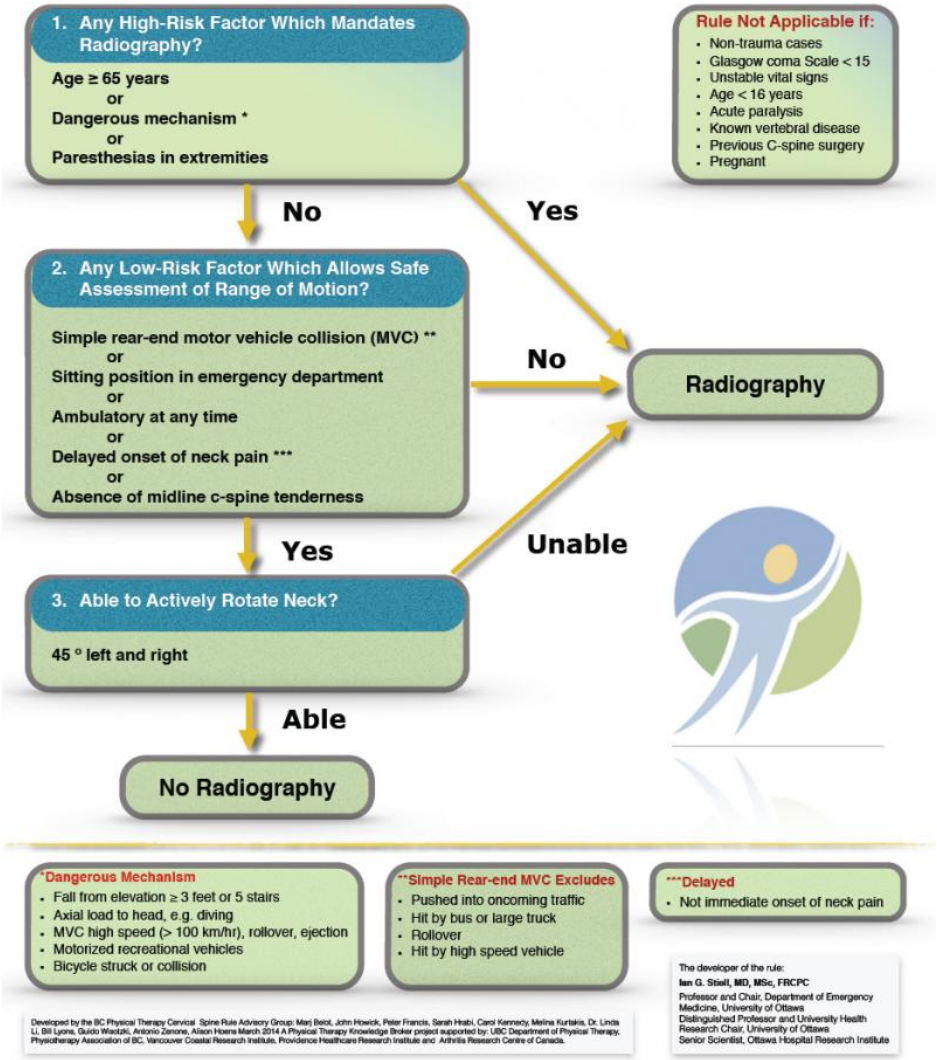
Modified NEXUS

- includes NO spine pain
- applies to the entire spine

State of Maine Protocols

- includes NO spine pain
- includes NO paraspinal tenderness
- applies to the entire spine

Canadian C-spine Rule



Canadian C-spine vs. NEXUS

	Canadian C-spine	NEXUS	
Sensitivity	99.4%	90.7%	P<0.001
Specificity	45.1%	36.8%	P<0.001
Radiography rates	55.9%	66.6%	P<0.001

- The Canadian C-spine Rule would have missed 1 patient and the NEXUS would have missed 16 patients with important injuries.
- But, both are not meant for pediatric population.

Peds C-Spine Clearance Guidelines

PECARN

Imaging indicated

One or more

Risk Factors
- -Altered mental status
- -Focal neuro deficit
- -Complaint neck pain
- -Torticollis
- -'Substantial' torso injury
- -Predisposing condition
- -High risk MVC
- -Diving

None

No imaging indicated

Guidelines for Cervical Spine imaging in the pediatric trauma patient when clinically indicated:

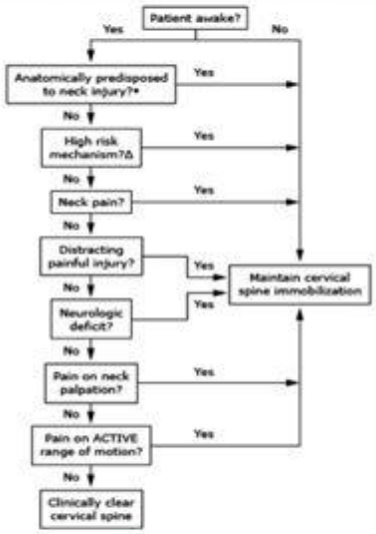
AGE	< 5 Years	5-13 Years	≥14 Years
Initial Imaging	Lateral and AP views (no odontoid views)	Lateral, frontal, and open mouth (+/- swimmer's view)	3 Views Radiograph or CT
If cannot be cleared radiographically or concern persists	CT of the level in question + one level above and below*	CT of the level in question + one level above and below*	CT of the level in question + one level above and below*
If concern for SCIWORA or ligamentous injury	MRI of entire cervical spine	MRI of entire cervical spine	MRI of entire cervical spine

* Note: CT of entire cervical spine in children 0-13 years old is inappropriate.

Figure 3: Hasbro Children's Hospital C-Spine Guidelines

To date, no national interdisciplinary agreement exists regarding a best practice cervical spine clearance protocol. Collaboration among pediatric subspecialty disciplines to determine best practice protocols for cervical spine clearance will be required to address this issue.

Cervical spine clinical clearance algorithm*



* This algorithm applies to children who are able to converse, can convey accurately the presence or absence of numbness, weakness, or other neurologic symptoms, and remember the event.
• Down syndrome, Klippel Feil syndrome, Morquio syndrome, Larsen syndrome, prior cervical spine injury, or cervical spine surgery.
Δ High speed motor vehicle collision, bicycle injury, diving or other activity with hyperextension or hyperflexion of neck, falls greater than body height, and other acceleration-deceleration injuries of the head.

UpToD

Guideline for clearing the cervical spine in the unreliable pediatric patient

Trauma Association of Canada (TAC) national pediatric c-spine evaluation pathway: Unreliable* clinical exam

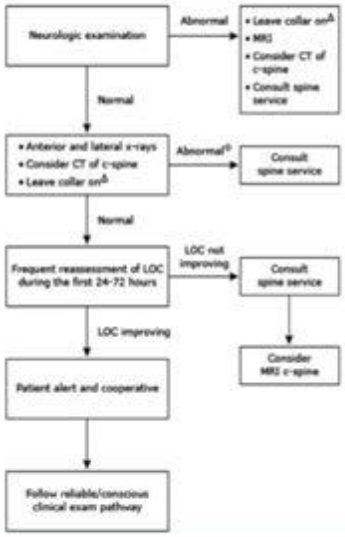


Figure 4: From Evaluation of Cervical Spine Injuries in Children and Adolescents. UptoDate.com

V. "Where you are injured = What you can or can't do"

- A. C3-C5
- B. C7-T1
- C. T12/L1
- D. S2-S4
- E. Glasgow Coma Scale & SCI’s
  1. Eye opening
  2. Motor
  3. Voice
- F. Motor
- G. Sensation

VI. Types of injuries

- A. Spinal cord concussion
- B. Spinal cord contusion

C. SCIWORA (**S**pinal **C**ord **I**njury **W**ithout **R**adiologic **A**bnormality) vs. SCIWNA (**S**pinal **C**ord **I**njury **W**ithout **N**euroimaging **A**bnormality) vs. SCIWORET (**S**pinal **C**ord **I**njury **W**ithout **R**adiographic **E**vidence of **T**rauma)

1. Up to 40% of pediatric and adult spinal cord injury patients

2. Pathophysiology

   a. Disruption of microvascular blood supply

   b. Hypermobility & ligamentous laxity allow bones to pop out and then back in like a rubber band, but trash the spinal cord in the process

   c. MRI is diagnostic modality of choice (70-100% diagnosis with MRI)

3. “Seemingly normal X-ray with a not neurologically normal kid”

D. Complete vs incomplete injuries

Complete injury - "Can’t move and can’t feel below the injury level

   a. Motor - lost below lesion

   b. Sensation - lost below lesion

   c. Paralysis status - yes, below lesion

   d. Essentially no recovery

Central cord syndrome - "Exactly the opposite of what you’d imagine with spinal cords"

   e. Motor - greater loss in arms

   f. Sensation - greater loss in arms

   g. Paralysis status - as above

   h. 75% chance of functional recovery

Brown-Sequard syndrome - "This is the only spinal cord syndrome which has a name cut in half with a hyphen (Brown-Sequard,) so it's when the cord is cut in half

i. Motor - lost on same side below lesion

j. Sensation - loss of pain & temperature on other side below lesion

k. Paralysis status - yes, below lesion on same side

l. 90% chance of functional recovery

VII. Pediatric air bag & car seat injuries - Put kids in the back seat (<13 years old per NHTSA)

A Cold Weather Miracle (x 2)

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