IMAGING IN PEDIATRIC TRAUMA

Summary of Grand Rounds January 2020

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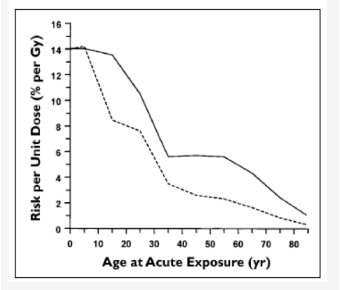
WHY ARE KIDS DIFFERENT

1. Anatomy
    a. Differs based on age
    b. Different patterns of injury
2. Anesthesia
    a. Balance the risks of anesthesia with the need for imaging
3. Radiation
    a. Relatively small cross-sectional area
    b. Increased radio-sensitivity of developing organs
    c. Longer life expectancy results in increased cumulative risk of malignancy



Brenner 2001

Imaging	Dose (mSv)	Equivalent # of CXRs	Equivalent period of exposure to natural radiation
CXR	0.02	-	3 days
C-Spine XR	0.08 (per view)	4	2 weeks
CT Head	2	100	10 months
CT C-Spine	2 (Max 6)	100 (300)	10 months (2.5 years)
CT Chest	3 (Max 6)	150 (300)	1.2 years (2.5 years)
CT Abdomen	3.7 (Max 12)	185 (600)	1.5 years (5 years)

There is clinical significance to radiation exposure!

- Miglioretti 2013:
    - 4670 cancers could be induced from 1 year of imaging with current US practice patterns

Lifetime % risk of cancer / CT scan in a child <5 years old		
	Girls	Boys
Head CT	0.18	0.07
Spine CT	0.38	0.05
Chest CT	0.28	0.08
Abdo / Pelvis CT	0.34	0.15

C-SPINE

- C-spine injuries are rare in the pediatric population (~1% in blunt trauma)
- Patterns of C-spine injury
    - More elastic soft tissues / ligaments / discs → less likely to sustain SCI
    - Large occiputs → more likely to have high CSI if it occurs
    - Transverse orientation of facet joints
    - Overall: More likely to sustain atlanto-occipital dissociation, atlanto-axial subluxation, vertebral end plate #s high CSI

GUIDELINES FOR CLEARANCE OF THE PEDIATRIC C-SPINE

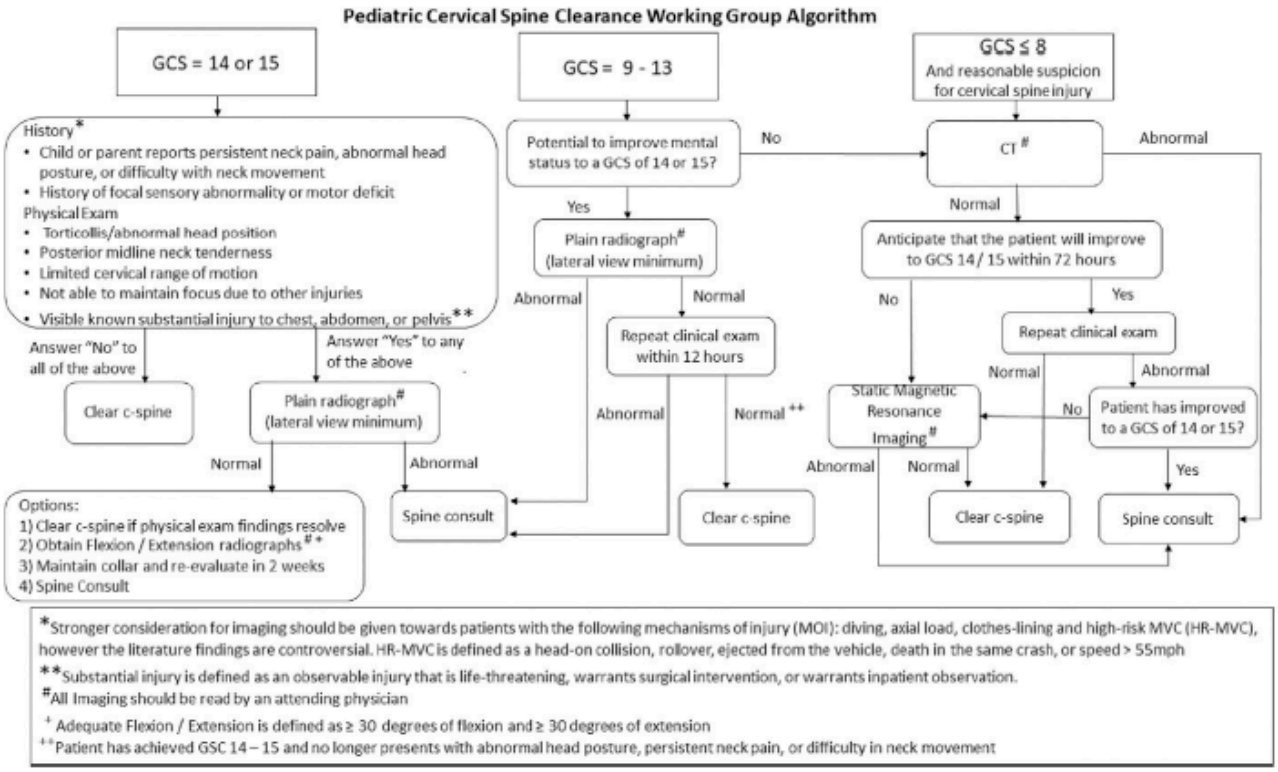


Fig. 1
The PCSCWG algorithm. C-spine = cervical spine.

Herman et al. 2019. Pediatric Cervical Spine Clearance: a consensus statement and algorithm from the Pediatric Cervical Spine Clearance Working Group. The Journal of Bone and Joint Surgery 101: e1(1-9)

GCS 14 – 15
May attempt to clear the C-spine without imaging based on risk factors for CSI
These risk factors are based on NEXUS and PECARN decision rules

NEXUS (Viccellio 2001)

- Validated in pediatrics
- Sensitivity and NPV 100%
- BUT the study captured very few children <age 9 (none <age 2)
    - Only apply to children > age 8

PECARN (Leonard 2011, 2019)

- Evaluated children that had received C-spine imaging at 17 PECARN centers
- Used multivariate regression analysis to identify independent predictors of CSI
- 9 Factors associated with CSI
    - Altered mental status
    - Focal neurologic findings
    - Neck pain
    - Torticollis / Inability to move the neck on history
    - Limited ROM on exam
    - Substantial torso injury
    - Conditions pre-disposing to CSI
    - Diving
    - High risk MVC
- Test characteristics
    - Derivation study: sensitivity 98%
        - Would reduce C-spine imaging 25%
    - Validation study: sensitivity 90.5%, NPV 99.6%

PCSCWG consolidated these decision rules and suggested the criteria listed in the box in the algorithm → a simplified list of these criteria

1. Altered mental status
2. Neck pain / torticollis or unable to assess
3. Abnormal neurologic exam
4. Substantial other injury

Note: substantial other injury is defined as "an observable injury that is life-threatening, warrants surgical intervention, or warrants inpatient observation"
Also, the mechanism of injury on its own is not enough to get imaging, but high-risk MOI may lower your threshold for obtaining imaging

Note: Younger children
Hale 2015

- Retrospective case review of children <5 yo with CSI
- Very rare in this population
- These patients are more likely to die from their injuries
- All of the patients with CSI presented with signs of CSI (abnormal neurologic exam, torticollis, neck pain)
- Conclusion: the risk of missing a CSI in an asymptomatic child younger than 5yo is very low
- If the child is alert, stable, and fighting the collar they are probably clearing themselves
    - Acceptable to remove the collar and observe them for normal ROM

Types of Imaging
First line = XR

- PCSCWG suggests a lateral view at the minimum

VIEWS

LATERAL	Alignment Vertebral body #s SP #s *Dens # Joint space widening (ligamentous injuries) Soft tissue swelling (occult injuries)
AP	TP #s Atlanto-axial rotary subluxation / dislocation
ODONTOID	C1 burst # *Dens #

Summary of Imaging Modalities

IMAGING MODALITY	SENSITIVITY FOR CSI	Pros / Cons
XR – 3 Views	~75- 90%	Odontoid film difficult to acquire – especially in younger age group
XR – 2 Views	~75 - 90%	AP film increases rate of false positives
XR – Lateral view	~75%	Highest yield radiographic view
CT	~98*	25 - 100x radiation
MRI	Best for ligamentous injury	Poor specificity – high rate of false positives

GCS 9 – 13 or GCS <8

- Follow the algorithm

CHEST

Holscher 2013

- Retrospective analysis of trauma registry data to compare CT vs. CXR
- CT finds more injuries
- BUT the injuries that it finds do NOT affect management
    - Contusions → less clinically significant in children
    - Pneumothoraces → occult PTX usually do not require a chest tube
    - Rib #s → can be managed clinically without imaging confirmation
- Conclusion: the substantial greater amount of radiation from CT is likely unnecessary given that CT does not change management

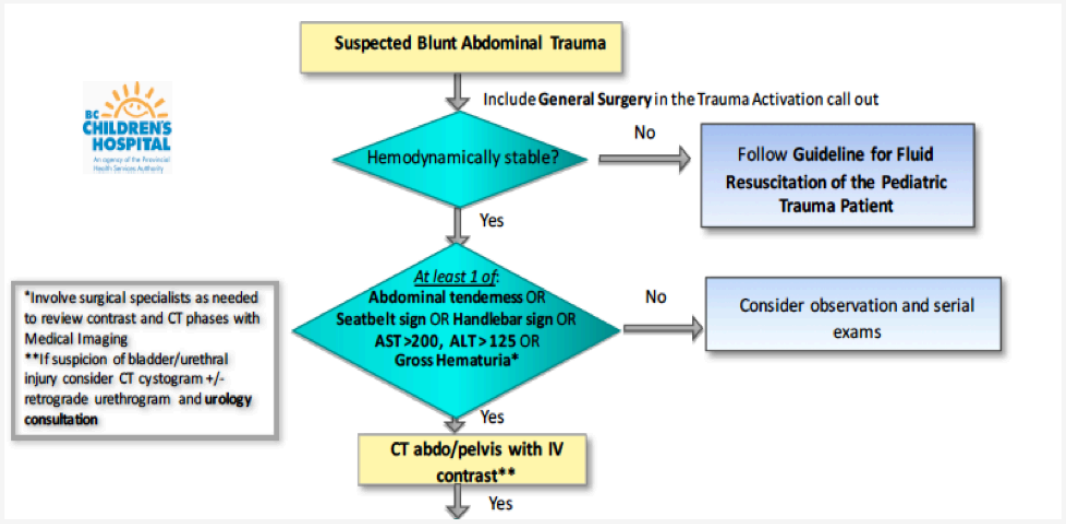
Aortic injuries

- Rare in children and if they occur the patient usually dies at the scene
- CXR are very sensitive for aortic injuries in children (sensitivity >9%)
- A normal CXR is usually adequate to rule out a thoracic aortic injury
- If the CXR is suggestive of aortic injury, get a CT chest

Conclusion: usually just a CXR is required!

ABDOMEN

BCCH Blunt Abdominal Trauma Algorithm



Risk factors based on the work of Dr. James Holmes and the PECARN Group (Holmes 2002 and 2013)

Holmes 2002

VARIABLES	ADJUSTED OR
CLINICAL FINDINGS	
Low SBP	4.1
Abdominal tenderness	5.8
Femur fracture	1.3
LAB FINDINGS	
AST >200 or ALT >125	17.4
Urinalysis – RBC >5 / hpf	4.8
Initial hematocrit <30%	2.6

Sensitivity 98%, NPV 99.6%

Holmes 2013

Independent Predictors of IAI Requiring Intervention

1. No evidence of abdominal wall trauma or seatbelt sign
2. GCS >13
3. No abdominal wall tenderness
4. No evidence of thoracic wall trauma
5. No complaints of abdominal pain
6. No decreased breath sounds
7. No vomiting

Sensitivity 97%, NPV 99.9%, Neg LR 0.07

Role of FAST

Holmes 2017

- FAST does not change outcomes
- In children that received FAST vs. those that did not
    - No significant difference in rate of CT scans, missed intra-abdominal injury, LOS

FAST should not be used on its own to decide on need for CT abdo; however, it may be a piece of clinical information to consider. It is likely more useful in hemodynamically unstable children to try to find the source of bleeding. Also, the above study did not assess eFAST – there may be greater utility in using FAST on the chest.

PAN SCANNING

There is a role for pan-scanning in the unstable poly-injured child. The advantages are timing and positioning. A pan-scan will get the necessary images faster and does not require re-orientation of the child in the scanner which comes with the risk of dislodging an ETT in a child with very small anatomy.