



Eastern Association for the Surgery of Trauma

27th Annual Scientific Assembly

Sunrise Session 08

To Scan or Not To Scan- That is the Question

January 16, 2014

Waldorf Astoria Naples

Naples, Florida

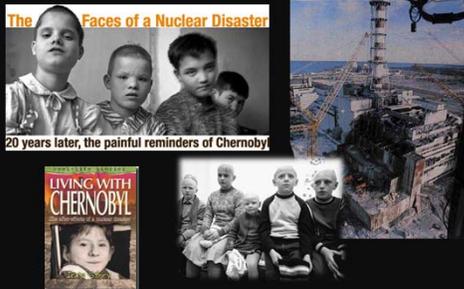
To Scan or Not to Scan: That is the Question



Robert W. Letton, Jr., MD
Pediatric Trauma Medical Director
The Level 1 Pediatric Trauma Center
Oklahoma University Medical Center
Oklahoma City, Oklahoma



A trip to the CT might not be





Radiation Reduction

- Modifying CT scan parameters
 - Not looking for sub-centimeter metastatic disease in pediatric trauma patients
 - Limit multiple sequences
- Do it right the first time
 - Insure images can be uploaded
- Judicious use of CT




The BIG three

Chest X-ray	0.02mSv
Lateral C-spine	0.02mSv
Pelvic film	0.03mSv

PAN SCAN

Head CT	2mSv
Cervical Spine Ct	2mSv
Chest CT	8mSv
Abd/pelvic CT	10mSv

Next morning

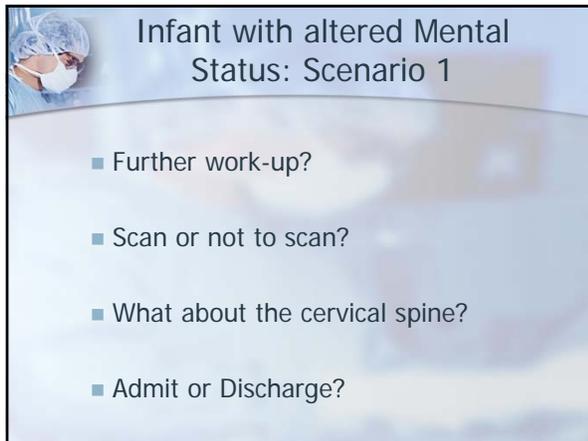
Repeat CT - head	2mSv
T&L spine films	0.1mSv
Chest Xray	0.02mSv

Total (first 18 hours) 24.2mSv



Infant with altered Mental Status: Scenario 1

- 1 year with witnessed fall out of shopping cart at grocery store
 - Brief loss of consciousness but crying when EMS arrives
 - Placed in cervical collar on backboard and taken to hospital where GCS is 15
 - PERRL, EOMI, TM's clear, small contusion/hematoma over right eye
 - Acting appropriate when mother is present



Infant with altered Mental Status: Scenario 1

- Further work-up?
- Scan or not to scan?
- What about the cervical spine?
- Admit or Discharge?

 **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 Alatabaki, Richard Holubkov, Frances M Neidel, David Monroe, Rachel M Starley, Dominik A Buegler, Mohamed F Badawy, Jeff E Schunk, Kimberly S Ouyale, Prashant Mahajan, Richard Lichtenstein, Kathleen A Lillis, Michael G Tanik, 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 Girardi, Craig A Melville, J Paul Muizelaar, David H Wisner, Sally Jo Zuppan, J Michael Dean, Sandra L Wootton-Gorges, for the Pediatric Emergency Care Applied Research Network (PECARN)*

Findings We enrolled and analysed 42 412 children (derivation and validation populations: 8502 and 2216 younger than 2 years, and 25 283 and 6411 aged 2 years and older). We obtained CT scans on 14 969 (35.3%); cITBIs occurred in 376 (0.9%), and 60 (0.1%) underwent neurosurgery. In the validation population, the prediction rule for children younger than 2 years (normal mental status, no scalp haematoma except frontal, no loss of consciousness or loss of consciousness for less than 5 s, non-severe injury mechanism, no palpable skull fracture, and acting normally according to the parents) had a negative predictive value for cITBI of 1176/1176 (100.0%, 95% CI 99.7–100.0) and sensitivity of 25/25 (100%, 86.3–100.0). 167 (24.1%) of 694 CT-imaged patients younger than 2 years were in this low-risk group. The prediction rule for children aged 2 years and older (normal mental status, no loss of consciousness, no vomiting, non-severe injury mechanism, no signs of basilar skull fracture, and no severe headache) had a negative predictive value of 3798/3800 (99.95%, 99.81–99.99) and sensitivity of 61/63 (96.8%, 89.0–99.6). 446 (20.1%) of 2223 CT-imaged patients aged 2 years and older were in this low-risk group. Neither rule missed neurosurgery in validation populations.

Interpretation These validated prediction rules identified children at very low risk of cITBIs for whom CT can routinely be obviated.

Lancet 2009; 374: 1160–70

Head CT is not generally indicated in children less than 2 years of age that meet the following criteria:

- Normal mental status
- No scalp hematoma other than frontal
- No loss of consciousness greater than 5 seconds
- Non severe injury mechanism
- No palpable skull fracture
- Acting normally according to family

Head CT is not generally indicated in children 2 years and older that meet the following criteria:

- Normal mental status
- No loss of consciousness
- No vomiting
- Non severe injury mechanism
- No signs of basilar skull fracture
- No severe headache

What about the Cervical Spine?



Trauma Association of Canada Pediatric Subcommittee National Pediatric Cervical Spine Evaluation Pathway: Consensus Guidelines

Seen Chung, MD, FRCPC, Angelo Mikrotanakis, MD, FRCPC, Paul W. Wales, MD, Peter Dirks, MD, PhD, Manohar Shroff, MD, DRMD, Ash Singhal, MD, Vincent Grant, MD, FRCPC, B. J. Hancock, MD, FRCSC, FACS, David Creery, MD, MSc, FRCPC, Jeff Atkinson, MD, Dickens St-Vil, MD, Louis Crevier, MD, MSc, FRCSC, Natalie Yancher, MD, MSc, FRCSC, Allen Hayashi, MD, Vivek Mehta, BA, MD, MSc, FRCSC, FACS, Timothy Carey, MD, Sunny Dhanani, BSc(Pharm), MD, FRCPC, Ron Siemens, MD, FRCP, FAAP, Sheila Singh, MD, PhD, FRSCS, and Dave Price, MD, FRCSC(C)

Background: The Institute of Medicine calls for the use of clinical guidelines and practice parameters to promote "best practices" and improve patient outcomes. In 2006, **The Trauma Association of Canada Pediatric Committee set out to create an evidence-based, national pediatric cervical spine (c-spine) clearance guideline based on the literature, existing algorithms from each pediatric trauma center and from expert opinion from across Canada.**

Methods: A review of the literature took place in September 2006 using the PubMed database. Search criteria were "cervical spine," "c-spine," "clearance," and "trauma." Limits that were applied were "Language: English," "Humans," "Type of Article: Meta-Analysis, Practice Guidelines, Randomized Control Trial, Review," and "Age: all child 0-18 years." These search criteria were repeated in December 2007, April 2009, and October 2009. **A total of 248 articles were identified. Existing guidelines were identified and their practices examined as models of care.** Two draft guidelines were created for discussion: one for the pediatric patient with a reliable clinical examination and the other for the pediatric patient with an unreliable clinical examination. Via

email, telephone, and two national videoconferences, the content of the guidelines was reviewed, discussed, and amended. The final article was prepared and circulated for author input until consensus was reached.

Results: **A consensus was reached on two pathways to evaluate the pediatric cervical spine: a patient with a reliable clinical examination and a patient with an unreliable examination.**

Conclusions: Presented herein are the consensus Trauma Association of Canada, National Pediatric Cervical Spine Evaluation Pathways for the patient with a reliable clinical examination, and the patient with an unreliable clinical examination.

Key Words: Pediatric, Trauma, Cervical spine injury.
(J Trauma. 2011;70: 873-884)



Canadian Pediatric C-Spine

- It is possible to clinically clear the pediatric cervical spine
- Using a combination of NEXUS and the CCR
- Pediatric patients should be managed with the lowest possible radiation exposure



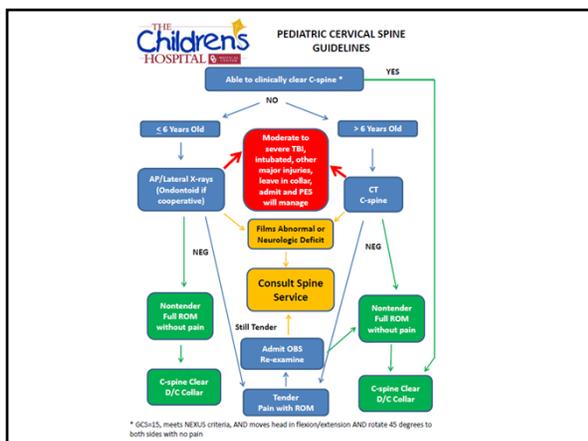
Canadian Pediatric C-Spine

- The odontoid view may be beneficial in cooperative patients
- Flexion-Extension may be indicated for the neurologically intact patient with persistent tenderness
- Plain radiographs should still be the assessment tool of choice
 - CT reserved for cases where more diagnostic certainty is required
 - Upper c-spine C1-C3



Canadian Pediatric C-Spine

- MRI is recommended for all patients with an abnormal neurologic exam
 - And patients requiring investigation of soft tissues and spinal cord
- Pediatric patients with an unreliable clinical exam should be managed conservatively and cautiously
 - CT scan should be considered at any time
 - MRI if not alert and cooperative after 24 to 72 hours



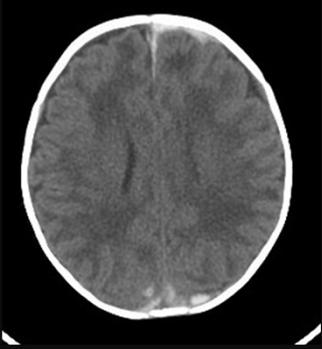
 **Infant with altered Mental Status: Scenario 2**

- 1 year old found unresponsive in crib by mother's boyfriend while she was at work
- EMS responds to find crying inconsolably, opens eyes to loud noise, localizes pain: GCS=11
- Transported to hospital in collar and on board with a PIV

 **Infant with altered Mental Status: Scenario 2**

- How does this work-up vary from Scenario 1
- What other parts of PE are pertinent?
- Scan or Not?
- What about cervical spine?

Multiple SDH on Head CT





Non-Accidental Trauma

- Contact DHS/CPS
- Complete Physical Exam
- Ophthalmology Consult to look for retinal hemorrhage
- Skeletal Survey
- MRI of brain/cervical spine
- Bone scan or Chest CT to look for occult rib fractures



Toddler with Vomiting, Abdominal Distension and Bruising

- 3 year old reportedly pushed by younger brother down a flight of stairs
- 6 hours later family called EMS because of vomiting and pain
- EMS finds child lying perfectly still, holding abdomen, saying "tummy hurts"

Toddler with Vomiting, Abdominal Distension and Bruising



Toddler with Vomiting, Abdominal Distension and Bruising

- Patent airway, bilateral breath sounds, 100% SaO2 on RA, hemodynamically stable, GCS 15
- Distended, tender, with rebound and guarding
- Foley placed with concentrated urine, and NG has bilious output
- Scan or not?

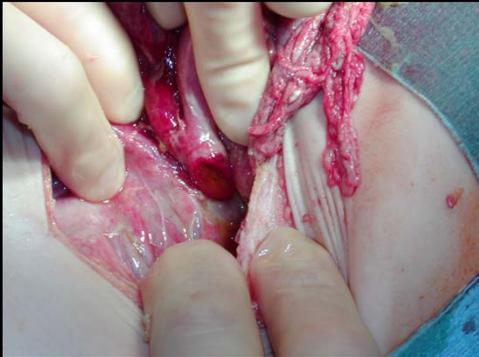
Plain Films



Ultrasound??



Retinal Scan





Child in Motor Vehicle Collision Age appropriate restraint

- 7 year old, rear seat passenger, age appropriate restraint, in MVC
- No LOC, no amnesia, GCS 15, hemodynamically stable
- No chest or abdominal bruising
- No obvious fractures
- Minimal complaints that "belly hurts"
- No tenderness to palpation, rebound or guarding



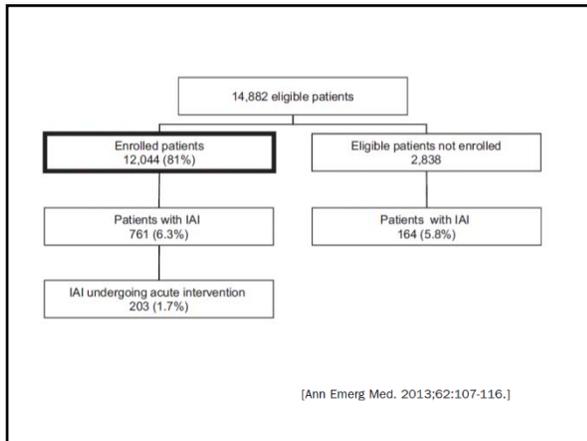
Child in Motor Vehicle Collision Age appropriate restraint

- Further workup?
- Ultrasound?
- Scan or not?
- Admit or discharge?

Identifying Children at Very Low Risk of Clinically Important Blunt Abdominal Injuries

James F. Holmes, MD, MPH; Kathleen Lillis, MD; David Monroe, MD; Dominic Gorgianni, DO, MPH; Benjamin T. Kerrey, MD; Prashant Mahajan, MD, MPH; Kathleen Adalgais, MD, MPH; Angela M. Ellison, MD, MS; Kenneth Yen, MD, MS; Shireen Atabaki, MD, MPH; Jay Menaker, MD; Bema Bonsu, MD; Kimberly S. Quayle, MD; Madelyn Garcia, MD; Alexander Rogers, MD; Stephen Blumberg, MD; Lois Lee, MD, MPH; Michael Tunik, MD; Joshua Kooistra, DO; Maria Kacik, MD; Lawrence J. Cook, PhD; J. Michael Dean, MD, MSc; Peter E. Sokolow, MD; David H. Wiener, MD; Peter Ehrlich, MD; Arthur Cooper, MD, MS; Peter S. Dayan, MD, MS; Sandra Wootton-Gorges, MD; Nathan Kuppermann, MD, MPH; for the Pediatric Emergency Care Applied Research Network (PECARN)*

Conclusion: A prediction rule consisting of 7 patient history and physical examination findings, and without laboratory or ultrasonographic information, identifies children with blunt torso trauma who are at very low risk for intra-abdominal injury undergoing acute intervention. These findings require external validation before implementation. [Ann Emerg Med. 2013;62:107-116.]





7 Findings in Descending Order

- No evidence of abdominal wall trauma
- GCS greater than 13
- No abdominal tenderness
- No evidence of chest wall trauma
- No complaints of abdominal pain
- No decreased breath sounds
- No vomiting



Ultrasound Score (USS)

- 5 spaces are scanned with US: Morrison's, perisplenic, right and left subphrenic and the pelvis
- Depth of the deepest pocket of fluid in cm, plus the number or additional spaces where fluid is noted
- If fluid was present in three areas and the deepest pocket measured 4 cm, the USS would be $4 + 2 = 6$



If we don't scan
the child what are
we missing???



Child in Motor Vehicle Collision Seat Belt Stripe

- 7 year old rear seat passenger, restrained with lap belt, in MVC
- Positive LOC and GCS 14
- Pulse 100, BP stable, and complains of abdominal pain
- No obvious extremity fractures
- Tender to palpation, even away from stripe, but no rebound or guarding



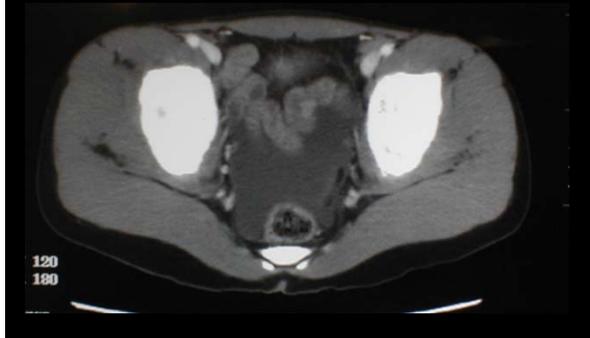
 **Child in Motor Vehicle Collision
Seat Belt Stripe**

- Further workup?
- Role of Ultrasound
- Role of CT?
- What about the Chest?
- Emergent operative intervention?

What if FAST positive??

A FAST (Focused Assessment with Sonography in Trauma) ultrasound image. The image shows a cross-section of the abdomen. There is a dark, anechoic area in the right upper quadrant, which is indicative of free fluid (blood) in the peritoneal cavity. The liver is visible in the upper left, and the right kidney is visible in the lower right. The overall image is in grayscale.

Abdominal CT



Rush to the OR????



Blunt bowel and mesenteric injuries in children: Do nonspecific computed tomography findings reliably identify these injuries?

Eric Peters, MD; Barry LoSasso, MD; Jennifer Foley, RN, BSN; Alexander Rodarte, MD; Susan Duthie, MD; Melvin O. Senac Jr, MD

Pediatr Crit Care Med 2006 Vol. 7, No. 6

Delay in diagnosis and treatment of blunt intestinal injury does not adversely affect prognosis in the pediatric trauma patient

Robert W. Letton*, Veronica Worrell
the APSA Committee on Trauma Blunt Intestinal Injury Study Group¹

Journal of Pediatric Surgery (2010) 45, 161-166

Role of Computed Tomography and Clinical Findings in Pediatric Blunt Intestinal Injury

A Multicenter Study

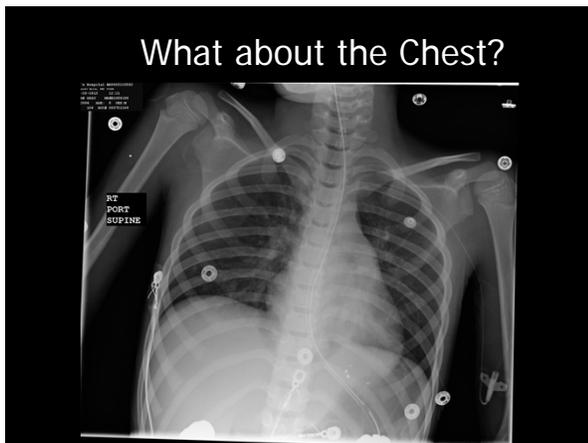
Kaveer Chatoorgoon, MD, Rebecca L. Brown, MD, Victor F. Garcia, MD,
and Richard A. Falcone, Jr, MD, MPH

(Pediatr Emer Care 2012;28: 1338-1342)



Common conclusions

- Free fluid on CT scan without peritonitis does not always require operative intervention
- The decision to operate better based on serial physical exam
- Children tolerate the delay to intervention better than adults



Should Helical CT Scanning of the Thoracic Cavity Replace the Conventional Chest X-ray as a Primary Assessment Tool in Pediatric Trauma? An Efficacy and Cost Analysis

By J. Renton, S. Kincaid, and P.F. Ehrlich
Morgantown, West Virginia

Background/Purpose: Findings from studies in the trauma literature suggest that thoracic computed tomography (TCT) scanning should replace conventional radiographs as an initial imaging modality. Limited data exist on the clinical utility and cost of TCT scans in pediatric trauma. Our current practice is to obtain TCT scans in those children at risk for thoracic injuries. The purpose of this study is to examine what additional information TCT provides, how frequently it results in a change in clinical management, and a cost/benefit analysis.

Methods: Children 18 years old and younger that had both a Chest x-ray (CXR) and TCT scan in their initial workup were included. Indications for TCT scan were (1) any sign of thoracic injury on CXR, (2) pathologic findings on physical examination of the chest, and (3) high impact force to chest wall. A child may have had one or more indications for a TCT scan.

Results: Between 1996 and 2000, 45 of 1,638 trauma patients met study criteria. Indications for TCT included thoracic injury on CXR (n = 27), findings on physical examination (n = 8) and high-impact force (n = 33). In 18 of the 45 (40%), injuries were detected with TCT imaging but not on CXR.

These included contusions (n = 12), hemothorax (n = 6), pneumothorax (n = 5), widened mediastinum (n = 4), rib fractures (n = 2), diaphragmatic rupture (n = 1), and aortic injury (n = 1). In 9 patients (17.7%), TCT imaging resulted in a change in clinical management. These included insertion of a chest tube (n = 5) aortography (n = 2) and operation (n = 1). Age, sex, injury severity score, mechanism, and indication for TCT could not predict differences between TCT and CXR (P > .05). In our institution, the cost of a TCT is \$200, and the patient charge is \$906 (\$34 per CXR). Based on our study data 200 TCTs would need to be done for each clinically significant change, increasing patient (\$180,000) and hospital (\$39,600) costs.

Conclusions: Helical TCT is a highly sensitive imaging modality for the thoracic cavity; however, routine CXR still provides clinically valuable information for the initial trauma evaluation at minimal cost. TCT should be reserved for selected cases and not as a primary imaging tool.

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INDEX WORDS: Thoracic trauma, helical thoracic computerized tomography.

Risk factors for blunt thoracic aortic injury in children

Seth R. Heckman, Stanley Z. Trooskin, Randall S. Burd*

Division of Pediatric Surgery, Department of Surgery, Robert Wood Johnson Medical School, PO Box 19, New Brunswick, NJ 08903, USA

Index words:
Thoracic aortic injury;
Wounds, nonpenetrating;
Child

Abstract

Background/Purpose: Because blunt thoracic aortic injury is rare in children, a high index of suspicion is needed to identify this injury. The purpose of this study was to use a large national trauma database to define the risk factors for blunt thoracic aortic injury in children.

Methods: Using the National Trauma Database, the authors compared patient demographics, mechanism of injury, and associated injuries between children sustaining blunt trauma with and without a thoracic aortic injury. Factors independently associated with this injury were identified using multivariate methods.

Results: Among 26,940 children with a blunt mechanism of injury, 34 (0.1%) children sustained a thoracic aortic injury, 14 (41%) of whom died. Thoracic aortic injuries were independently associated with age, injury sustained as an occupant in a motor vehicle crash, and severe injuries (Abbreviated Injury Scale value of ≥ 3) involving the head, thorax (other than aorta), abdomen, and lower extremities.

Conclusions: Older children involved in a motor vehicle crash with severe head, torso, and lower extremity injuries are a group at high risk for injury to the thoracic aorta. These easily identifiable risk factors may facilitate more rapid identification of this rare and potentially fatal injury.
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Journal of Pediatric Surgery (2005) 40, 98–102

Risk factors for blunt thoracic aortic injury in children

Seth R. Heckman, Stanley Z. Trooskin, Randall S. Burd*

Division of Pediatric Surgery, Department of Surgery, Robert Wood Johnson Medical School, PO Box 19, New Brunswick, NJ 08903, USA

Table 2 Univariate analysis of potential variables associated with BAI

Parameter	No BAI, n = 26940 (%)	BAI, n = 34 (%)	Rate per 1000 blunt trauma discharges	Relative risk (95% CI)
Age (y)				
0-9	11,839 (43.9)	2 (5.9)	0.2	Reference
10-14	4864 (18.1)	2 (5.9)	0.4	2.4 (0.3-17.3)
>14	10,237 (38.0)	30 (88.2)	2.9	17.3 (4.1-72.3)
Sex				
Female	9878 (36.7)	11 (32.4)	1.1	Reference
Male	17,038 (63.3)	23 (67.6)	1.3	1.2 (0.6-2.5)

Journal of Pediatric Surgery (2005) 40, 98–102

The significance of first rib fractures in children

Nicholas A. Hamilton, Brian T. Bucher, Martin S. Keller*

Division of Pediatric Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, MO, USA

Purpose: The purpose of the study was to determine if first rib fractures are associated with an increased incidence of thoracic vascular injury in pediatric patients.

Methods: The medical records of all children diagnosed with a first rib fracture or a central vascular injury after blunt trauma treated at a state-designated level 1 pediatric trauma center from 2000 to 2009 were reviewed.

Results: Thirty-three children (0.27% of patients; mean age, 10.9 ± 0.9 years) were identified with either a first rib fracture or thoracic vascular injury owing to blunt trauma. Thirty-two children had a first rib fracture, and only 1 child (3%) had significant thoracic vascular injury. Mediastinal abnormalities (indistinct aortic knob) were identified in 3 children, 2 with first rib fracture on initial chest radiograph.

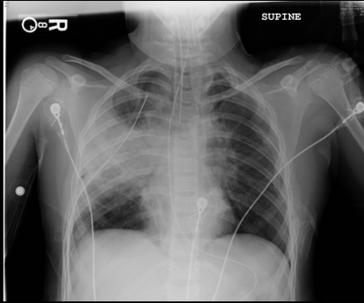
Despite a normal cardiovascular examination result, 25 (74%) children with a normal mediastinum on screening chest radiograph underwent computed tomography. No child with a normal mediastinum on initial chest radiograph was found to have associated intrathoracic injuries requiring further intervention.

In children with first rib fractures and a normal mediastinum by screening chest x-ray, the negative predictive value for thoracic vascular injury was 100%.

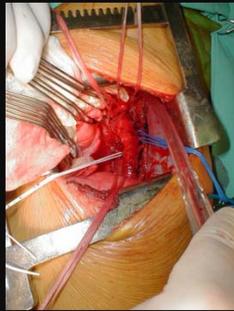
Conclusions: Children with first rib fractures without mediastinal abnormality on chest radiograph require no further workup for thoracic vascular injury.

Journal of Pediatric Surgery (2011) 46, 169–172

Bad CXR



Chest CT



Management of pediatric occult pneumothorax in blunt trauma: a subgroup analysis of the American Association for the Surgery of Trauma multicenter prospective observational study²³

David M. Notrica^{a,*}, Pamela Garcia-Filion^b, Forrest O. Moore^b, Pamela W. Goslar^b, Raul Coimbra^a, George Velmahos^c, Lily R. Stevens^d, Scott R. Petersen^e, Carlos V.R. Brown^f, Kelli H. Faulkrod^g, Thomas B. Coopwood Jr.^h, Lawrence Lottenbergⁱ, Herb A. Phelan^j, Brandon Bruns^k, John P. Sherck^l, Scott H. Norwood^m, Stephen L. Barnesⁿ, Marc R. Matthews^o, William S. Hoff^o, Marc A. deMoya^o, Vishal Bansal^o, Charles K.C. Hu^o, Riyad C. Karmy-Jones^o, Fausto Vinces^o, Jenessa Hill^o, Karl Pembaur^o, James M. Haan^o

Background: Occult pneumothorax (OPTX) represents air within the pleural space not visible on conventional chest radiographs. Increased use of computed tomography has led to a rise in the detection of OPTX. Optimal management remains undefined.

Methods: A pediatric subgroup analysis (age <18 years) from a multicenter, observational study evaluating OPTX management. Data analyzed were pneumothorax size, management outcome, and associated risk factors to characterize those that may be safely observed.

Results: Fifty-two OPTX (7.3 ± 6.2 mm) in 51 patients were identified. None were greater than 27 mm; all those under 16.5 mm (n = 48) were successfully managed without intervention. Two patients underwent initial tube thoracostomy (one [21 mm] and the other with bilateral OPTX [24 mm, 27 mm]). Among patients under observation (n = 49), OPTX size progressed in 2; one (6.4mm) required no treatment, while one (16.5 mm) received elective intervention. Respiratory distress occurred in one patient (10.7 mm) who did not require tube thoracostomy. Nine received positive pressure ventilation; 8 did not have a tube thoracostomy. Twenty-four patients (51%) had one or more rib fractures; 3 required tube thoracostomy.

Conclusion: No pediatric OPTX initially observed developed a tension pneumothorax or adverse event related to observation. Pediatric patients with OPTX less than 16 mm may be safely observed. Neither the presence of rib fractures nor need for PPV alone necessitates intervention.

Journal of Pediatric Surgery (2012) 47, 467–472

Isolated computed tomography diagnosis of pulmonary contusion does not correlate with increased morbidity

Albert Kwon^a, Donald L. Sorrells Jr.^a, Arlet G. Kurkchubasche^b,
John A. Cassese^b, Thomas F. Tracy Jr.^a, Francois I. Luks^{a,*}

^aDivision of Pediatric Surgery, Brown Medical School, Providence, RI 02905, USA

^bDivision of Pediatric Diagnostic Imaging, Brown Medical School, Providence, RI 02905, USA

Background: Increased utilization of computed tomography (CT) has led to a rise in the diagnosis of pulmonary contusion. Its clinical significance, in the absence of findings on chest radiograph (CXR), has not been defined. This study examines the clinical course of patients with CT-only diagnosis of pulmonary contusion and compares it with that of patients with CXR-proven pulmonary contusion.

Methods: The trauma database identified all children undergoing chest CT for blunt thoracic trauma during a 3-year period. Records were reviewed for age, mechanism of injury, Injury Severity Score (ISS), length of hospital stay (LOS), need for intensive care unit admission, and need for endotracheal intubation. A pediatric radiologist reviewed all films in a blinded fashion. Statistical analysis was performed using analysis of variance and Fisher's Exact test for 2 × 3 tables.

Results: Eighty-two patients were identified. There were no CXR-positive, CT-negative cases. A CT diagnosis of pulmonary contusion was made in 46 patients. Of these, 31 had a contusion on CXR as well (CXR+ group) and 15 had a normal CXR (CT+ only group). Mean ISS score did not differ significantly between the two groups (27 ± 12.3 and 22 ± 10.3, respectively). Thirty-six patients had a normal CT (control). Mean LOS was significantly longer in the CXR+ group (13 ± 12.0 days) than in the CT+ only and control groups (5 ± 3.6 and 9 ± 9.5 days, respectively; $P < .01$). The percentages of children requiring intensive care unit admission and intubation were also significantly higher in the CXR+ group.

Conclusion: The finding of pulmonary contusion by CT alone does not increase patient morbidity and appears to be of limited clinical significance.

Journal of Pediatric Surgery (2006) 41, 78–82