



HEALTH
UNIVERSITY OF UTAH

PEDIATRIC CERVICAL SPINE

KATIE RUSSELL, MD

NORTHWEST STATES TRAUMA CONFERENCE

JANUARY 26, 2024



“Never event.”

-Douglas Brockmeyer, MD

WHAT ARE THE NUMBERS?

Effect of age on cervical spine injury in pediatric population: a National Trauma Data Bank review

Shahin Mohseni, Peep Talving*, Bernardino Castelo Branco, Linda S. Chan, Thomas Lustenberger, Kenji Inaba, Margarita Bass, Demetrios Demetriades

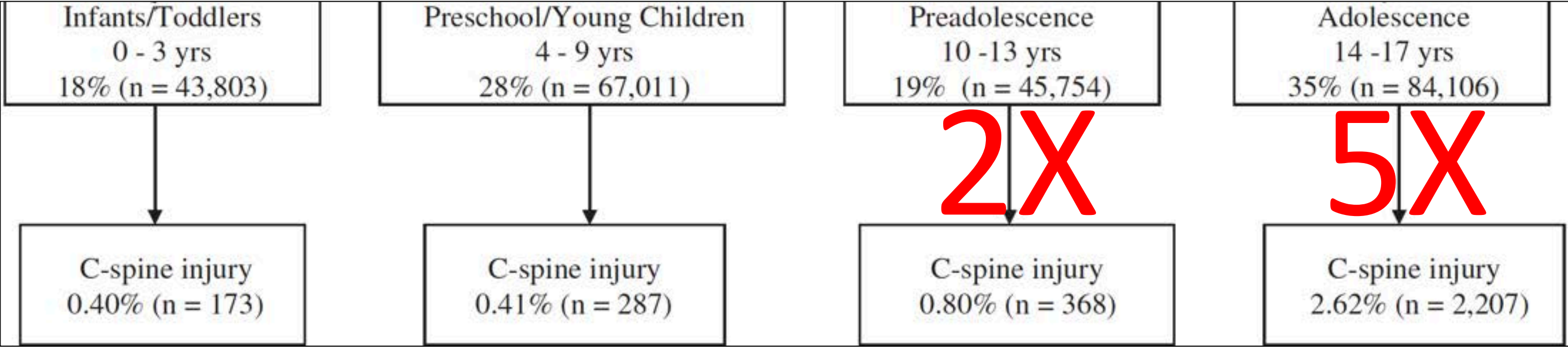
Division of Acute Care Surgery (Trauma, Emergency Surgery and Surgical Critical Care), Department of Surgery, Keck School of Medicine, University of Southern California, Los Angeles, CA 90033-4525, USA

240,647 pediatric blunt trauma patients

Overall incidence CSI

1.3%

Effect of age on cervical spine injury in pediatric population: a National Trauma Data Bank review



ISS ≥ 16 OR 4.1 GCS ≤ 8 OR 1.6 MVC OR 1.3 Hypotensive OR 1.4. Female OR 1.2

Children ≥ 9 have injuries more similar to adults

Effect of age on cervical spine injury in pediatric population: a National Trauma Data Bank review

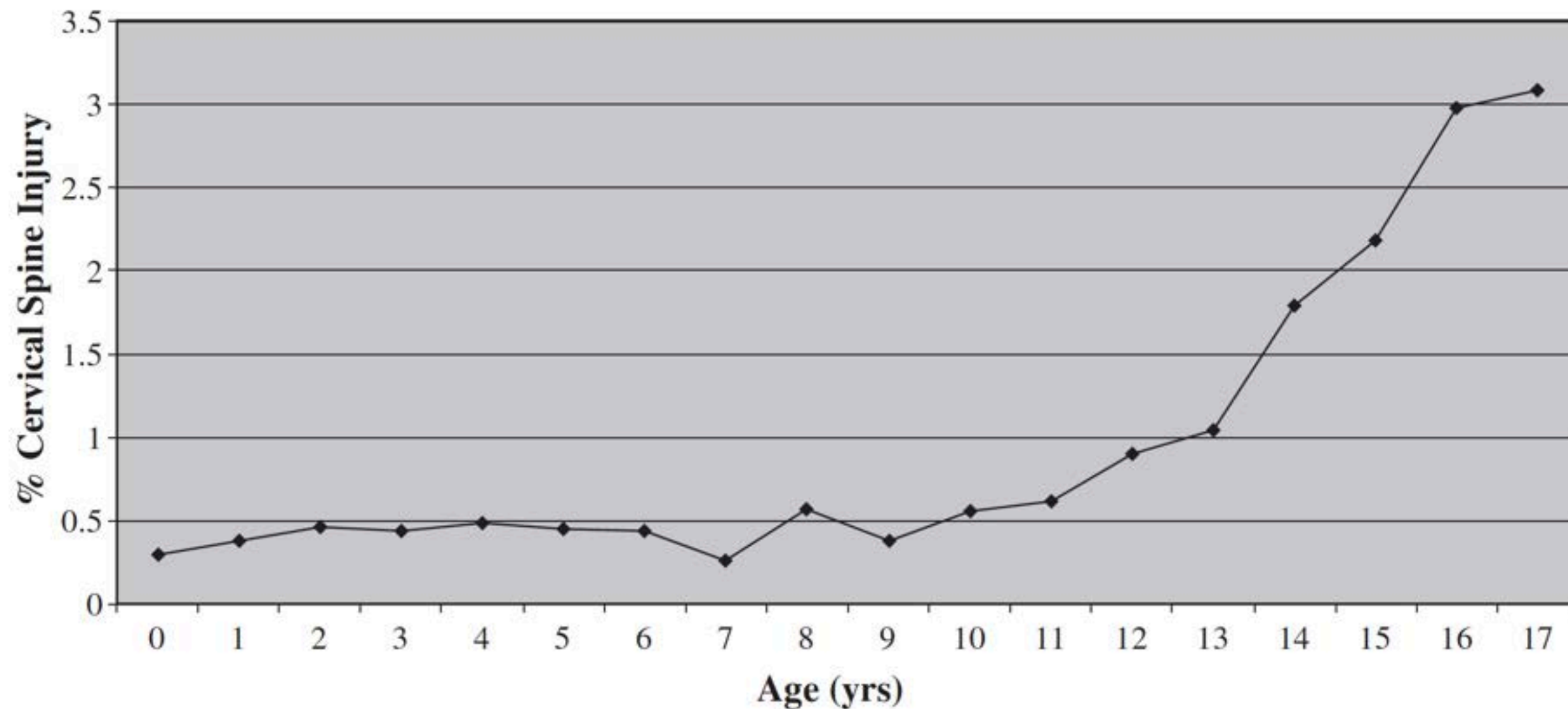


Fig. 1 Cervical spine injury incidence by age.



UPPER CSI YOUNG KIDS

Large head

Weak neck muscles

Elastic ligaments

Incomplete ossification

At 9 the vertebrae start to ossify

Upper CSI are less common

DOES C-SPINE
IMMOBILIZATION EVEN
HELP?

SURGICAL DOGMA

■ PRELIMINARY REPORTS

Out-of-hospital Spinal Immobilization: Its Effect on Neurologic Injury

Mark Hauswald, MD, Gracie Ong, MBBS, Dan Tandberg, MD, Zaliha Omar, MBBS

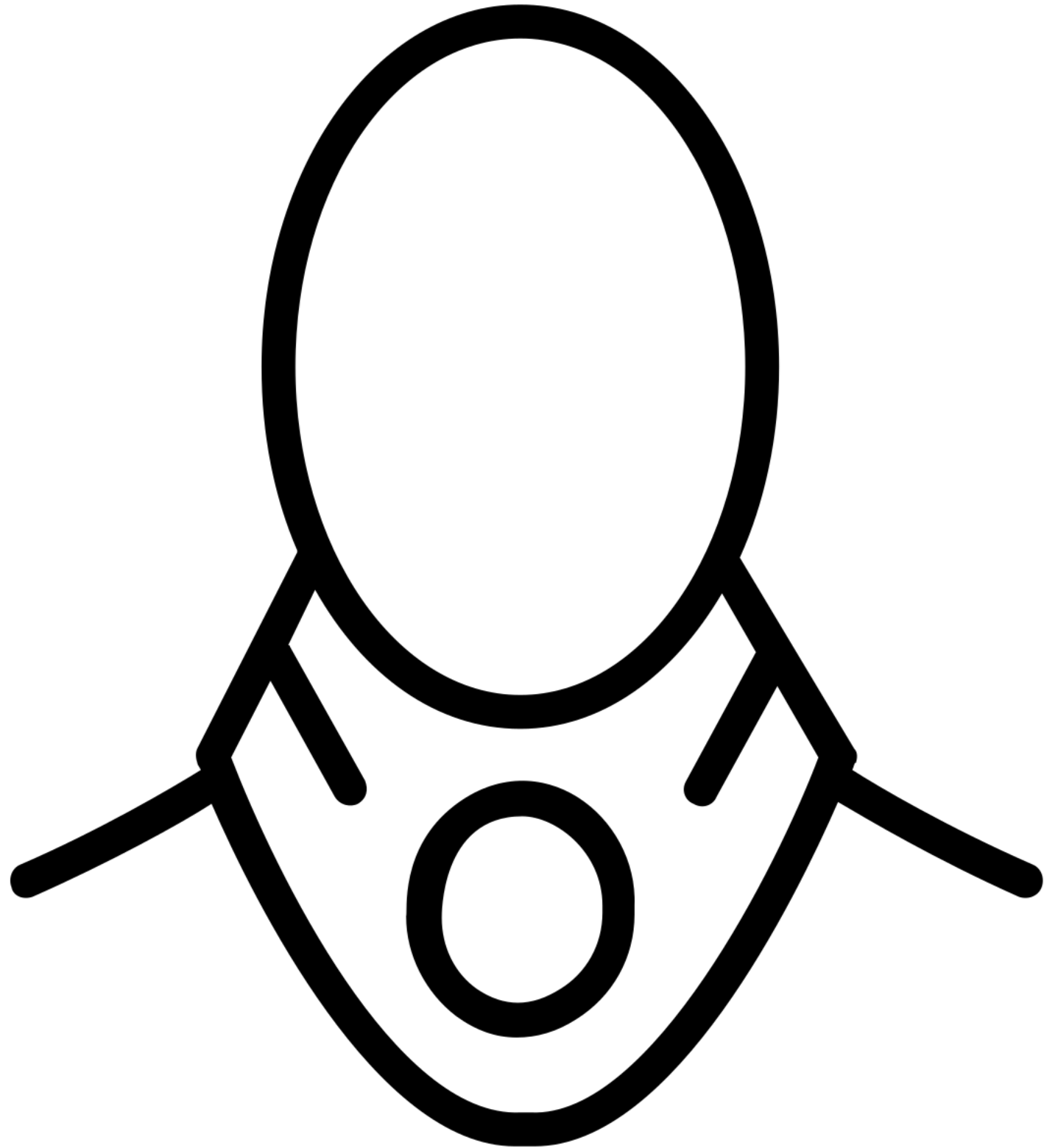
Disability OR 2.03 for immobilized patients

98% probability that immobilization is harmful or of no value

CERVICAL COLLARS ARE INSUFFICIENT FOR IMMOBILIZING AN UNSTABLE CERVICAL SPINE INJURY

MaryBeth Horodyski, EDD,* Christian P. DiPaola, MD,† Bryan P. Conrad, PHD,* and Glenn R. Rechtine, II, MD†

5 cadavers lightly embalmed
Created unstable c-spine injuries
Motion analysis device
C-collar did nothing

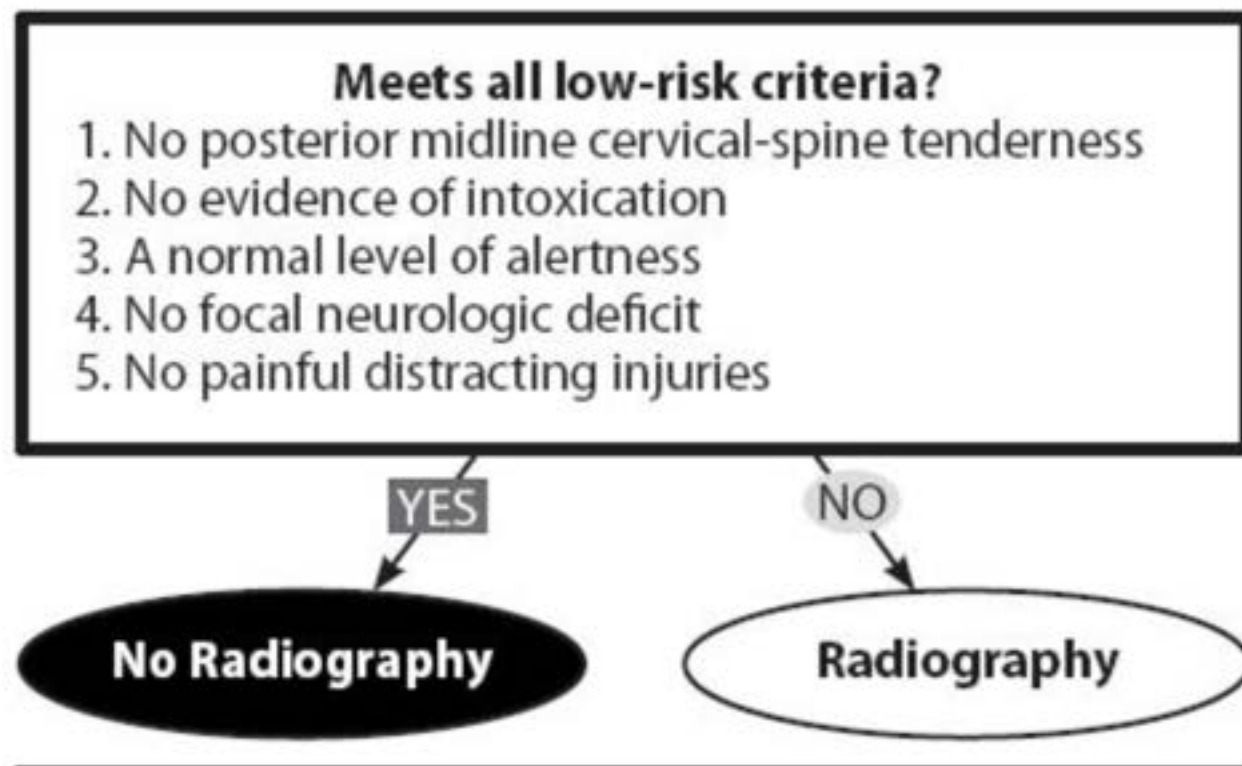


SCREENING & CLEARING

A Prospective Multicenter Study of Cervical Spine Injury in Children

Peter Viccellio, MD*; Harold Simon, MD†; Barry D. Pressman, MD§; Manish N. Shah, MD||; William R. Mower, MD, PhD¶; and Jerome R. Hoffman, MA, MD¶, for the NEXUS Group

Figure 11. National Emergency X-Radiography Utilization Study (NEXUS) Criteria



34,069 trauma patients
21 national ERs
99% sensitive for CSI
GREAT SCREENING TEST IN ADULTS

A Prospective Multicenter Study of Cervical Spine Injury in Children

Peter Viccellio, MD*; Harold Simon, MD†; Barry D. Pressman, MD§; Manish N. Shah, MD||;
William R. Mower, MD, PhD¶; and Jerome R. Hoffman, MA, MD¶, for the NEXUS Group

3065 pediatric traumas

30 CSI

0.98%

Rule did not miss any CSI

Limitations

No CSI < 2 YO

Only 905 <8 YO

Only 4 CSI <8 YO

Factors Associated With Cervical Spine Injury in Children After Blunt Trauma

Julie C. Leonard, MD, MPH, Nathan Kuppermann, MD, MPH, Cody Olsen, MS, Lynn Babcock-Cimpello, MD, MPH, Kathleen Brown, MD, Prashant Mahajan, MD, MPH, Kathleen M. Adalgais, MD, Jennifer Anders, MD, Dominic Borgialli, DO, MPH, Aaron Donoghue, MD, MSCE, John D. Hoyle, Jr, MD, Emily Kim, MPH, Jeffrey R. Leonard, MD, Kathleen A. Lillis, MD, Lise E. Nigrovic, MD, MPH, Elizabeth C. Powell, MD, MPH, Greg Rebella, MD, MS, Scott D. Reeves, MD, Alexander J. Rogers, MD, Curt Stankovic, MD, Getachew Teshome, MD, MPH, and David M. Jaffe, MD, for the Pediatric Emergency Care Applied Research Network*

Retrospectively identified 8 factors highly associated with CSI in children 0-16 years.

- Altered mental status
- Focal neurologic deficits
- Complaints of neck pain
- Torticollis
- Substantial injury to the torso
- Predisposing condition for c-spine injury
- High risk MVC
- Diving

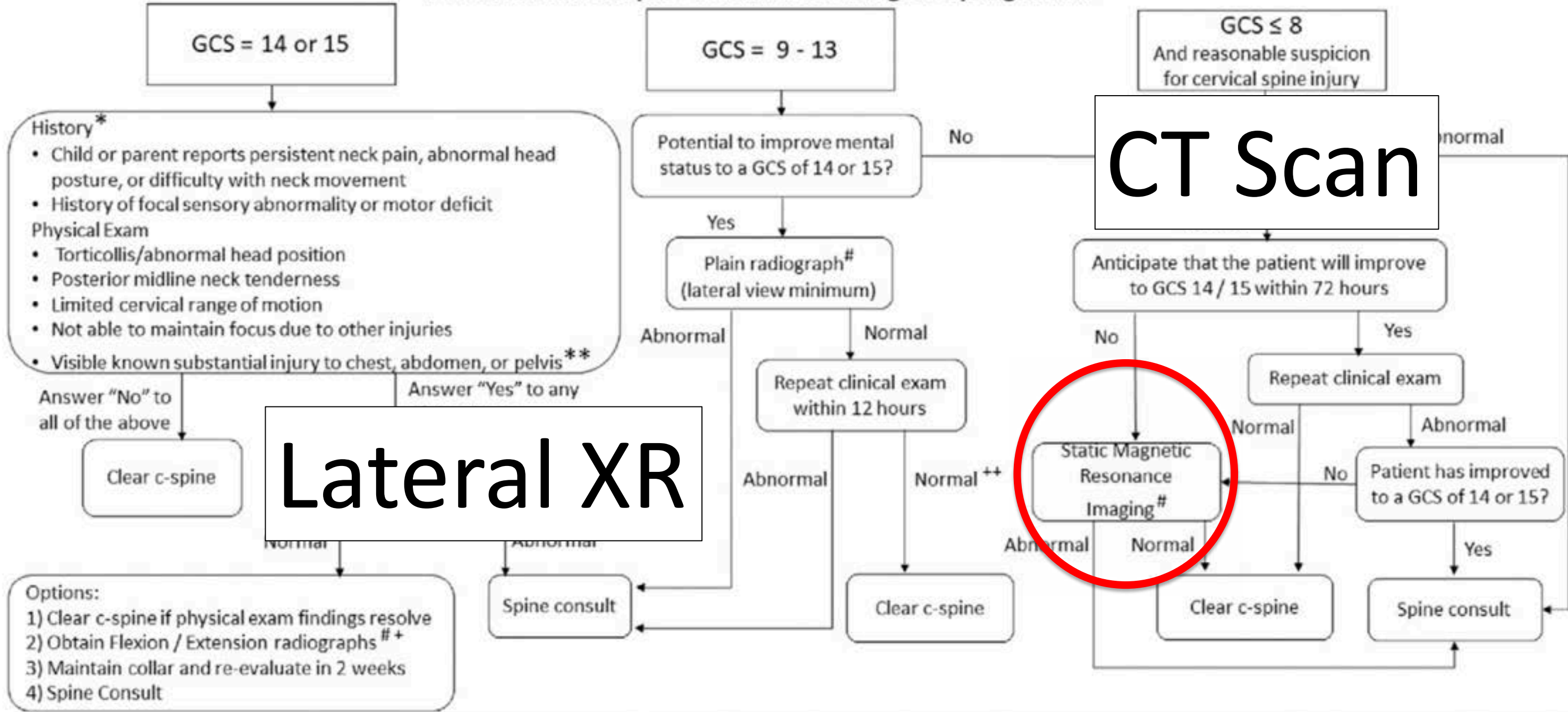
THE ORTHOPAEDIC FORUM

Pediatric Cervical Spine Clearance

A Consensus Statement and Algorithm from the Pediatric Cervical Spine Clearance
Working Group

Martin J. Herman, MD, Kristin O. Brown, MS, Paul D. Sponseller, MD, Jonathan H. Phillips, MD, Philip M. Petrucelli, MD, Darshan J. Parikh, BS, Kush S. Mody, BS, Julie C. Leonard, MD, MPH, Matthew Moront, MD, Douglas L. Brockmeyer, MD, Richard C.E. Anderson, MD, Adam C. Alder, MD, John T. Anderson, MD, Robert M. Bernstein, MD, Timothy N. Booth, MD, Bruno P. Braga, MD, Patrick J. Cahill, MD, Jeanne M. Joglar, MD, Jeffrey E. Martus, MD, MS, Jo-Ann O. Nesiama, MD, Joshua M. Pahys, MD, Karl E. Rathjen, MD, Anthony I. Riccio, MD, Jacob F. Schulz, MD, Anthony A. Stans, MD, Manish I. Shah, MD, MS, William C. Warner Jr., MD, and Burt Yaszay, MD

Pediatric Cervical Spine Clearance Working Group Algorithm



IMAGING

The 64-Slice CT Scan Is Revolutionizing Imaging

JUNE 02, 2007

Rebekah McCallister

Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study

Mark S Pearce, Jane A Salotti, Mark P Little, Kieran McHugh, Choonsik Lee, Kwang Pyo Kim, Nicola L Howe, Cecile M Ronckers, Preetha Rajaraman, Sir Alan W Craft, Louise Parker, Amy Berrington de González

50 mGy might triple the risk of leukemia
60 mGy might triple the risk of brain tumor
1/10,000 head CTs

CT CS 10 milligray
Lat XR 0.47 milligray

A 3-year review of MRI safety incidents within a UK independent sector provider of diagnostic services

¹DARREN HUDSON, BSc(hons), MHSc, PgCert and ²ANDREW P JONES, BSc, MSc, CSci, FIPEM, FBIR

¹InHealth Group, Buckinghamshire, UK

²Christie Medical Physics and Engineering, The Christie NHS Trust, Manchester, UK

The New York Times

M.R.I.'s Strong Magnets Cited in Accidents

By Donald G. McNeil Jr.

Aug. 19, 2005



Nurse Injured in MRI Accident at Swedish Hospital

Metal in weighted vest believed to have caused extensive injuries that landed nurse in intensive care

Man dies after being sucked into MRI scanner at Indian hospital

Man was carrying oxygen cylinder which was pulled by machine's magnetic force and then thought to have punctured

MRI accidents raise safety concerns

7th January 2020 483

Boy, 6, Killed in Freak MRI Accident

By ABC News

January 7, 2006, 8:21 AM • 4 min read



Several reports emerged last year concerning issues with MRI safety.



RISKS OF MRI

- Nursing time
- Difficult transport
- Potential to lose tubes etc.
- Potential decompensation
- Sedation requirement
- Metal may be issue
- Cost
- Delay of clearance

Cost-effectiveness of Magnetic Resonance Imaging in Cervical Clearance of Obtunded Blunt Trauma After a Normal Computed Tomographic Finding

Xiao Wu, BS; Ajay Malhotra, MD, MMM; Bertie Geng, BS; Vivek B. Kalra, MD; Khalid Abbed, MD;
Howard P. Forman, MD, MBA; Pina Sanelli, MD, MPH

\$14,185

“MRI may have a lower health benefit and higher cost after a negative CT for blunt trauma”

The utility of magnetic resonance imaging in pediatric trauma patients suspected of having cervical spine injuries

S. Christopher Derderian, MD, Krista Greenan, MD, David M. Mirsky, MD, Nicholas V. Stence, MD, Sarah Graber, CCRP, Todd C. Hankinson, MD, Noah Hubbell, BA, Allyson Alexander, MD, PhD, Brent R. O'Neill, MD, C. Corbett Wilkinson, MD, and Michael H. Handler, MD, *Aurora, Colorado*

An analysis of cervical spine magnetic resonance imaging findings after normal computed tomographic imaging findings in pediatric trauma patients: Ten-year experience of a Level I pediatric trauma center

Jessie Gargas, MD, Burt Yaszay, MD, Peter Kruk, MD, Tracey Bastrom, MA, David Shellington, MD, and Sandeep Khanna, MD, *San Diego, California*

PTS 2014 PLENARY PAPER

Utility of magnetic resonance imaging in diagnosing cervical spine injury in children with severe traumatic brain injury

David Qualls, BS, Jeffrey R. Leonard, MD, Martin Keller, MD, Jose Pineda, MD, and Julie C. Leonard, MD, MPH, *Columbus, Ohio*

CT is very good for detecting clinically significant injuries

OBTUNDED CHILD





Eastern Association for the Surgery of Trauma

Advancing Science, Fostering Relationships, and Building Careers

Cervical spine collar clearance in the obtunded adult blunt trauma patient: A systematic review and practice management guideline from the Eastern Association for the Surgery of Trauma

Mayur B. Patel, MD, MPH, Stephen S. Humble, Daniel C. Cullinane, MD, Matthew A. Day, MD, Randeep S. Jawa, MD, Clinton J. Devin, MD, Margaret S. Delozier, Lou M. Smith, MD, Miya A. Smith, Jeannette M. Capella, MD, MEd, Andrea M. Long, MD, Joseph S. Cheng, MD, MS, Taylor C. Leath, BS, MPH, Yngve Falck-Ytter, MD, Elliott R. Haut, MD, PhD, and John J. Como, MD, MPH, Nashville, Tennessee

Cervical spine collar clearance in the obtunded adult blunt trauma patient: A systematic review and practice management guideline from the Eastern Association for the Surgery of Trauma

Rigorous process using GRADE method
12 studies identified
Neg CT scan NPV 91% stable injury
Neg CT scan NPV 100% unstable injury
Evidence is weak to moderate

Cervical spine collar clearance in the obtunded adult blunt trauma patient: A systematic review and practice management guideline from the Eastern Association for the Surgery of Trauma

In obtunded adult trauma patients, we conditionally recommend cervical collar removal after a negative high-quality C-spine CT scan alone

“Children over the age of 8 years have anatomy similar to adults, and thus the most common injury location in these children is in the lower cervical spine.”

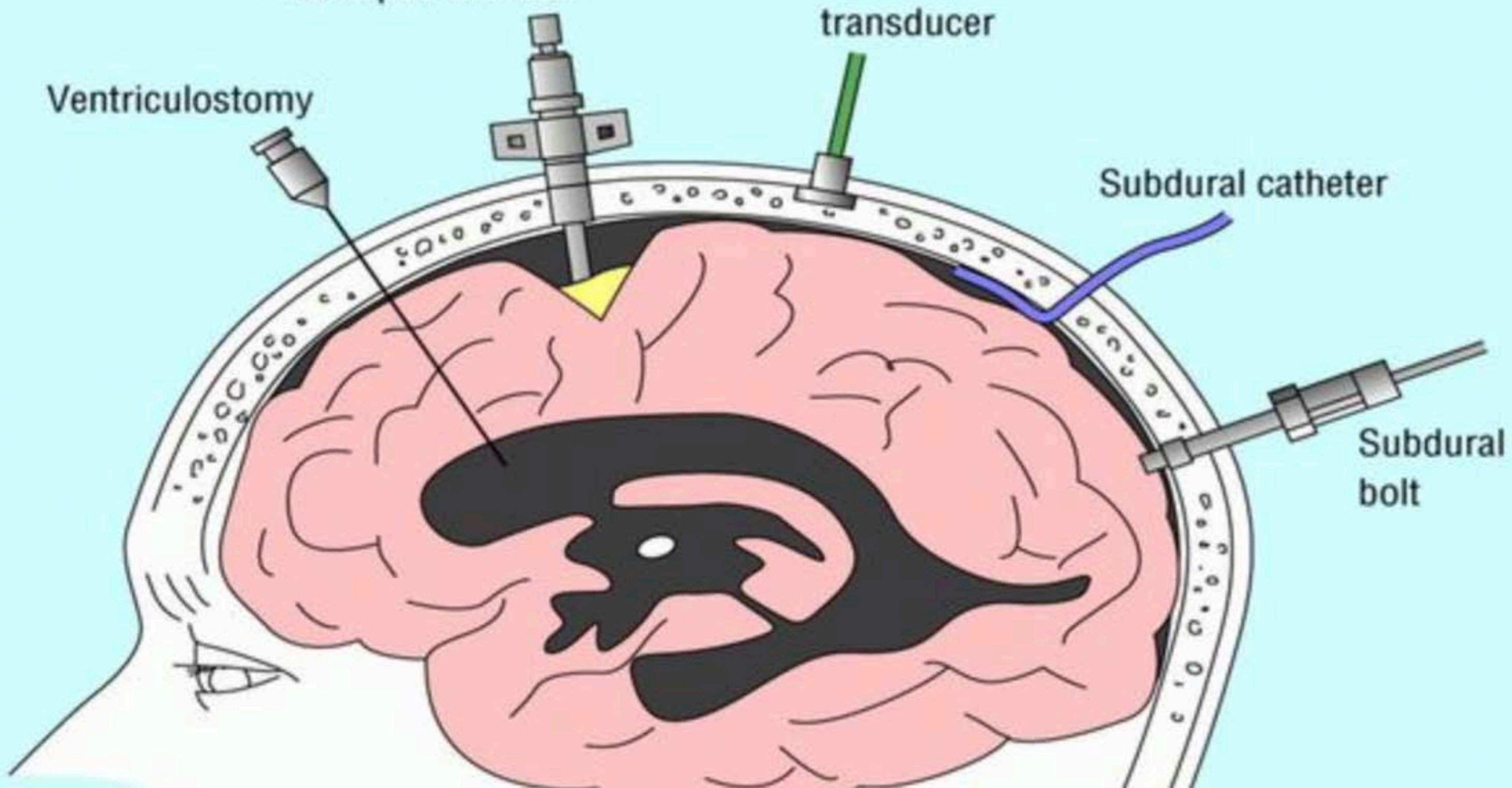
Intraparenchymal
fibreoptic catheter

Epidural
transducer

Ventriculostomy

Subdural catheter

Subdural
bolt



ORIGINAL ARTICLE

Cervical spine injuries and collar complications in severely injured paediatric trauma patients

M Chan¹, W Al-Buali², T Charyk Stewart³, RN Singh^{4,5}, A Kornecki^{4,5}, JA Seabrook^{4,5} and DD Fraser^{4,5,6,7,8}

10%

Older
TBI
Lower GCS
Longer ICU LOS
Longer time to CS clearance
p<0.05



Contents lists available at [ScienceDirect](#)

Journal of Pediatric Surgery

journal homepage: www.sciencedirect.com/journal/journal-of-pediatric-surgery



WPTC PAPERS

Cervical Collar-Associated Pressure Injury in Pediatric Trauma Patients: A Western Pediatric Surgery Research Consortium Study[☆]



Caroline Melhado ^a, Katie W. Russell ^b, Shannon N. Acker ^c, Benjamin E. Padilla ^d,
Katrine Lofberg ^e, Ryan G. Spurrier ^f, Bryce Robinson ^g, Stephanie Chao ^h,
Romeo C. Ignacio ⁱ, Mark Ryan ^j, Aaron R. Jensen ^{a,*}, on behalf of
the Western Pediatric Surgery Research Consortium Cervical Spine Injury Study Group¹

Cervical Collar-Associated Pressure Injury in Pediatric Trauma Patients: A Western Pediatric Surgery Research Consortium Study[☆]



Retrospective
5 years
10 hospitals
49,218 patients



32 pressure ulcers
Median age 5
78% ICU
Median 11 days to HAPI
78% had injuries

ONLY 4 PROPHYLACTIC COLLARS

CONCLUSIONS

- Pediatric cervical spine injuries are rare
- Kids >8 YO are similar to our adults
- CT scans have improved and are very unlikely to miss an unstable injury
- Going to MRI is a BIG deal
- C-collars can cause injury
- We do need better pediatric literature

PUSH FOR EARLY C-SPINE
CLEARANCE WITH A HIGH
QUALITY NEGATIVE CT



MRI MAY BE OVERKILL UNLESS
THERE IS LEGITIMATE CLINICAL
SUSPICION FOR INJURY...
BUT THIS IS MOSTLY BASED OFF
OF ADULT DATA





Cervical spinal clearance: A prospective Western Trauma Association Multi-institutional Trial

Kenji Inaba, MD, Saskya Byerly, MD, Lisa D. Bush, MPAS, Matthew J. Martin, MD, David T. Martin, MD, Kimberly A. Peck, MD, Galinos Barmparas, MD, Matthew J. Bradley, MD, Joshua P. Hazelton, DO, Raul Coimbra, MD, PhD, Asad J. Choudhry, MBBS, Carlos V.R. Brown, MD, Chad G. Ball, MD, MSC, Jill R. Cherry-Bukowiec, MD, MS, Clay Cothren Burlew, MD, Bellal Joseph, MD, Julie Dunn, MD, MS, Christian T. Minshall, MD, PhD, Matthew M. Carrick, MD, Gina M. Berg, PhD, MBA, Demetrios Demetriades, MD, PhD, and the WTA C-Spine Study Group, Los Angeles, California

Evaluate the accuracy of CT for the detection of clinically significant cervical spine injury

ALL 3 MISSES HAD
NEUROLOGIC FINDINGS

10,765 All adult blunt trauma patients screened

489 Excluded for:
previous spinal surgery or CT CS
done at outside hospital

10,276 Study Population

1,098 Positive CT
for acute CS injury

9,178 Negative CT
for acute CS injury

195 Intervention*

903 No intervention

3 Intervention*

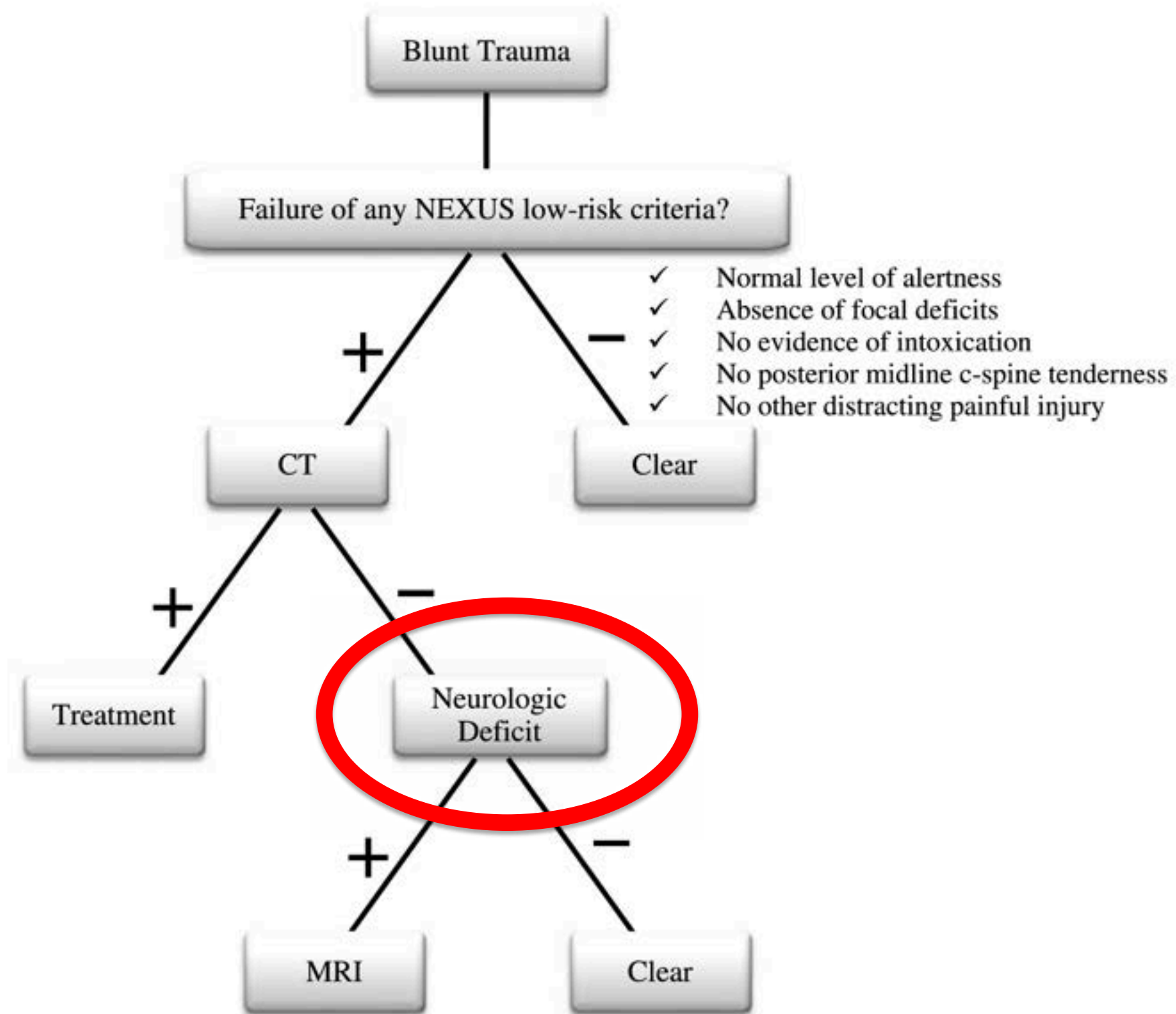
9,175 No intervention

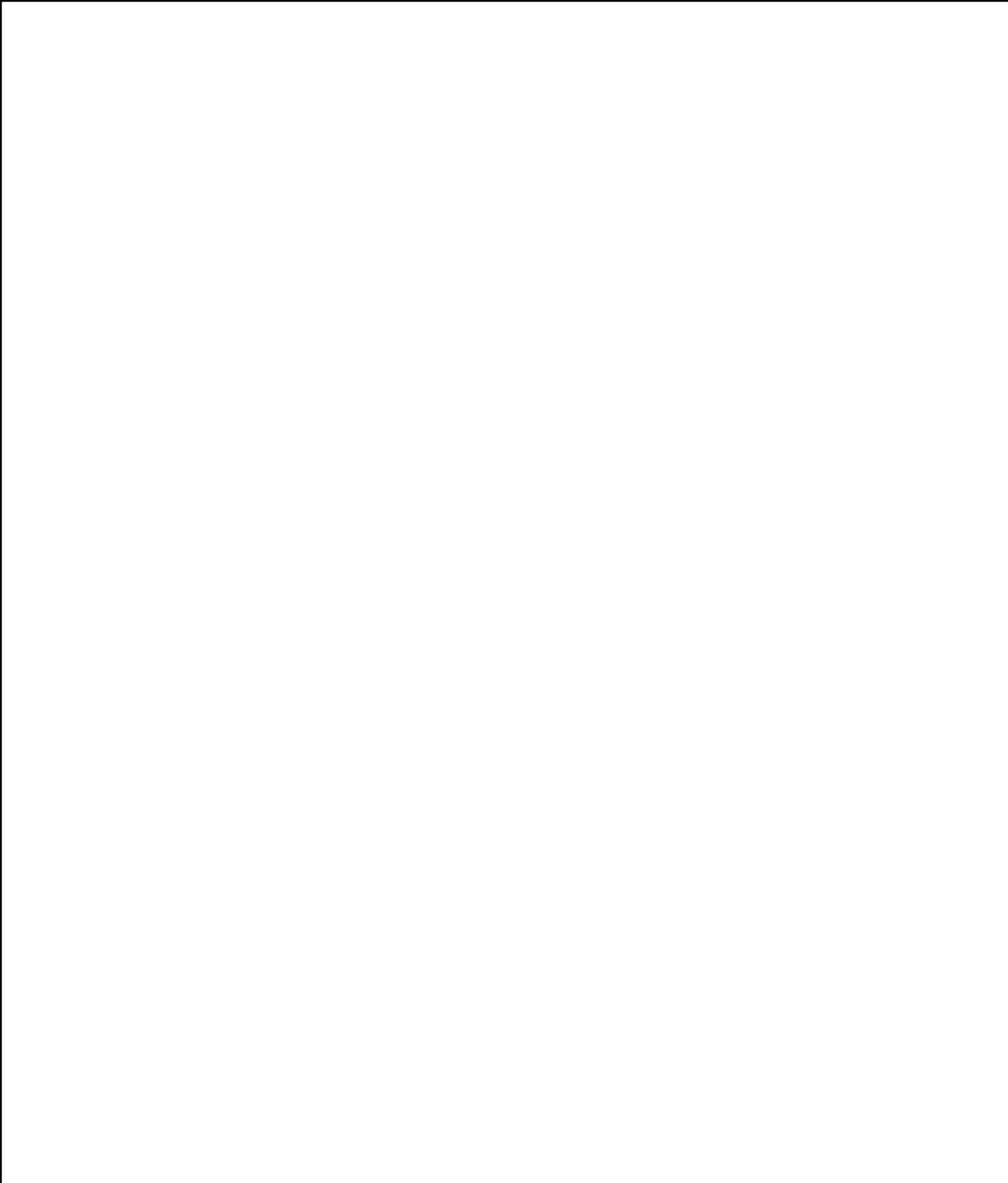
150 Surgery

45 Halo/CTO

3 Surgery

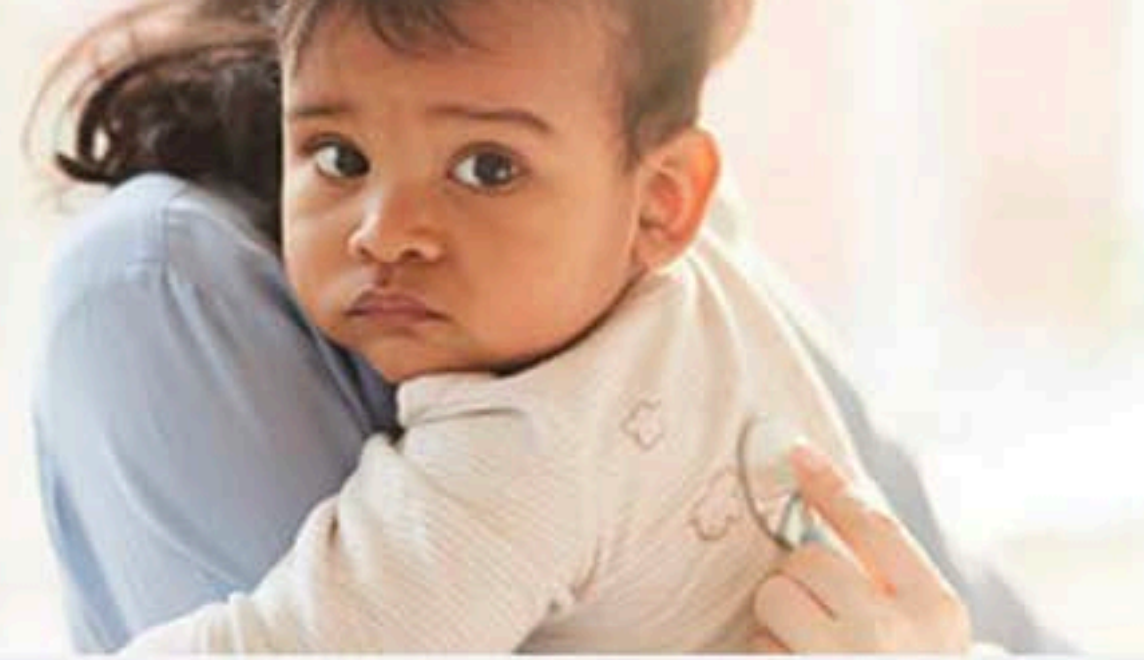
0 Halo/CTO





INTRAMURAL FUNDING PROGRAM

\$50k



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[Departmental Intramural Funding](#)

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Career Development Research Grant - Primary Children's Hospital Foundation (PCHF):

The PCHF Early Career Development Research Grant helps launch pediatric junior investigators or careers in child health and human development. Applicants must have a faculty appointment with a junior rank (Instructor or Assistant Professor), or be a pediatric post-doctoral fellow. Awards are based upon the project's scientific merit and relevance to current program goals, i.e. basic-, clinical-, translational-, and health services research projects. The program supports pilot research that evidences a clear relationship to pediatrics and /or child health and that will lead to extramural funding. Applicants must demonstrate ongoing research mentorship. Applicants can apply for up to \$25,000 in direct costs each year for up to two years during two funding cycles. Preliminary applications must be invited to submit a full proposal.

HYPOTHESIS

CT is highly sensitive for identifying cervical spine injuries in children, especially in the adolescent population

AIM

Determine the sensitivity of CT and XR for identifying clinically significant cervical spine injury in children



Retro C-Spine-CTSI5298 PID 11050

Record Status Dashboard (all records)

Displayed below is a table listing all existing records/responses and their status for every data collection instrument (and if longitudinal, for every event). You may click any of the colored buttons in the table to open a new tab/window in your browser to view that record on that particular data collection instrument. Please note that if your form-level user privileges are restricted for certain data collection instruments, you will only be able to view those instruments, and if you belong to a Data Access Group, you will only be able to view records that belong to your group.

Legend for status icons:

- Incomplete Incomplete (no data saved) ?
- Unverified
- Complete

Dashboard displayed: [Default dashboard]

[Create custom dashboard](#)

Displaying record Page 5 of 5: "4079" through "4562" of **4,478** records

1000 records per page

[+ Add new record](#)

Displaying: [Instrument status only](#) | [Lock status only](#) | [All status types](#)

[Table not displaying properly ?](#)

Record ID	Demographics	Admission	Imaging Results
4079	●	●	●
4080	●	●	●
4081	●	●	●
4082	●	●	●
4083	●	●	●

Project Home and Design

- [Project Home](#) · [Project Setup](#)
- [Designer](#) · [Dictionary](#) · [Codebook](#)
- Project status: **Production**

Data Collection

- [Record Status Dashboard](#)
- [Add / Edit Records](#)
- Show data collection instruments

Applications

- [Project Dashboards](#)
- [Alerts & Notifications](#)
- [Multi-Language Management](#)
- [Calendar](#)
- [Data Exports, Reports, and Stats](#)
- [Data Import Tool](#)
- [Data Comparison Tool](#)
- [Logging and Email Logging](#)
- [Field Comment Log](#)
- [File Repository](#)
- [User Rights and DAGs](#)

Reports

[Search](#) [Organize](#) [Edit](#)

- 1) Injury DC hard collar
- 2) All Injury
- 3) iniurv and surgerv



Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.sciencedirect.com/journal/journal-of-pediatric-surgery



Hanging and Strangulation Injuries: An Institutional Review From a Level 1 Pediatric Trauma Center



Robert A. Swendiman ^{a,*}, Jack H. Scaife ^b, Kacey L. Barnes ^a, Teresa M. Bell ^a,
Christopher M. Roach ^c, Rajiv R. Iyer ^d, Douglas L. Brockmeyer ^d, Katie W. Russell ^a

^a Division of Pediatric Surgery, University of Utah, Salt Lake City, UT, USA

^b University of Utah School of Medicine, Salt Lake City, UT, USA

^c Department of Radiology, University of Utah, Salt Lake City, UT, USA

^d Department of Neurosurgery, University of Utah, Salt Lake City, UT, USA

No cervical spine injuries or BCVIs

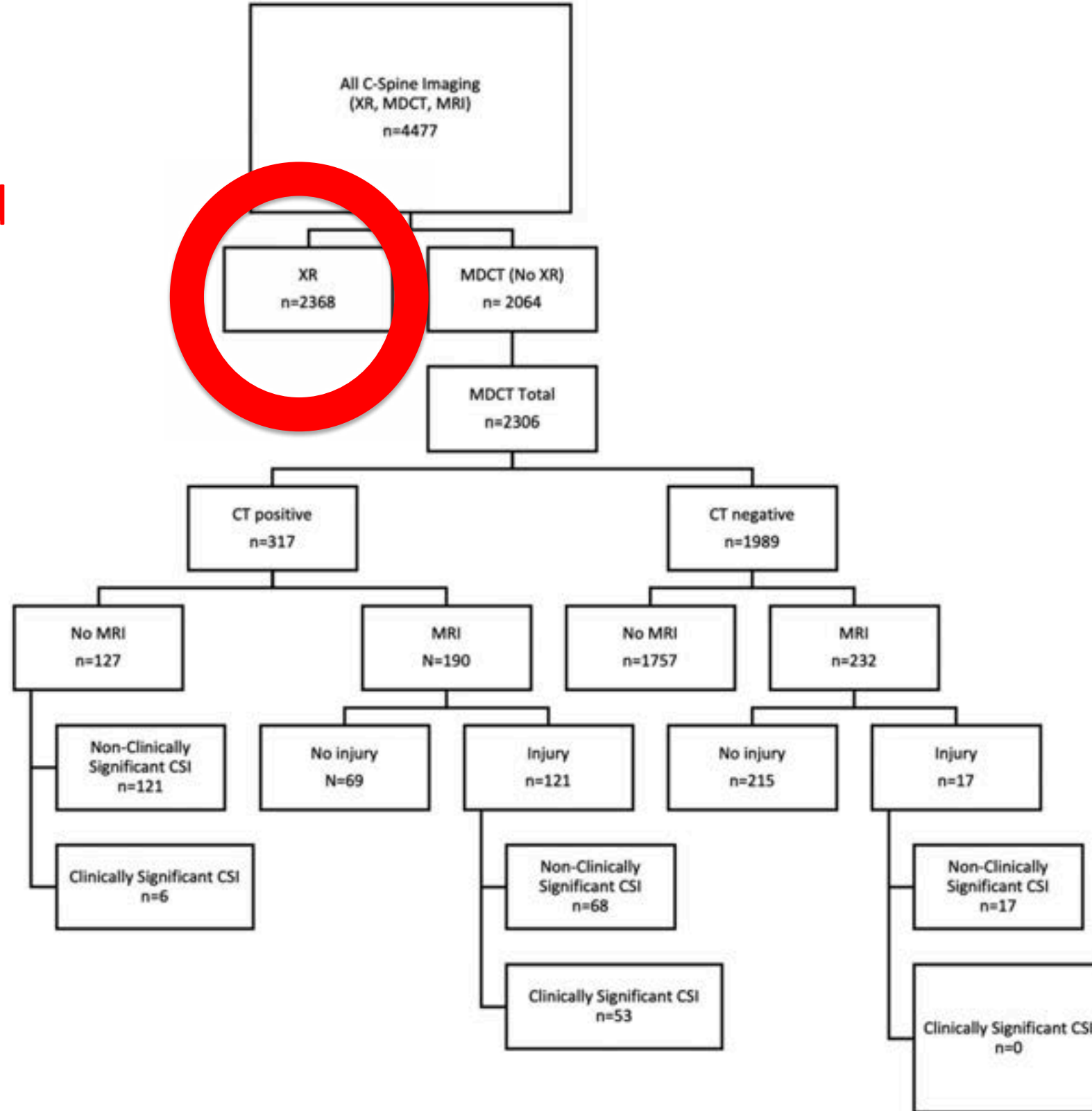
Pediatric cervical spine clearance: A 10-year evaluation
of multidetector computed tomography at level 1
pediatric trauma center

Article of
the month
JTACS

Katie W. Russell, MD, Stephanie E. Iantorno, MD, Rajiv R. Iyer, MD, Douglas J. ... MD,
Karch M. Smith, MD, Natalya E. Polukoff, MD, Kezlen E. Larsen, BS, Kacey L. B ... MSN, ... M. Bell, PhD,
Stephen J. Fenton, MD, Kenji Inaba, MD, and Robert A. Swendiman, MD, M ... MSCE, Salt Lake City, Utah

4,500 patients
60 injuries, all diagnosed on CT or XR
17 +MRIs deemed stable by Brockmeyer/Raj
Sensitivity CT 100%

We should still be screening kids with XRs



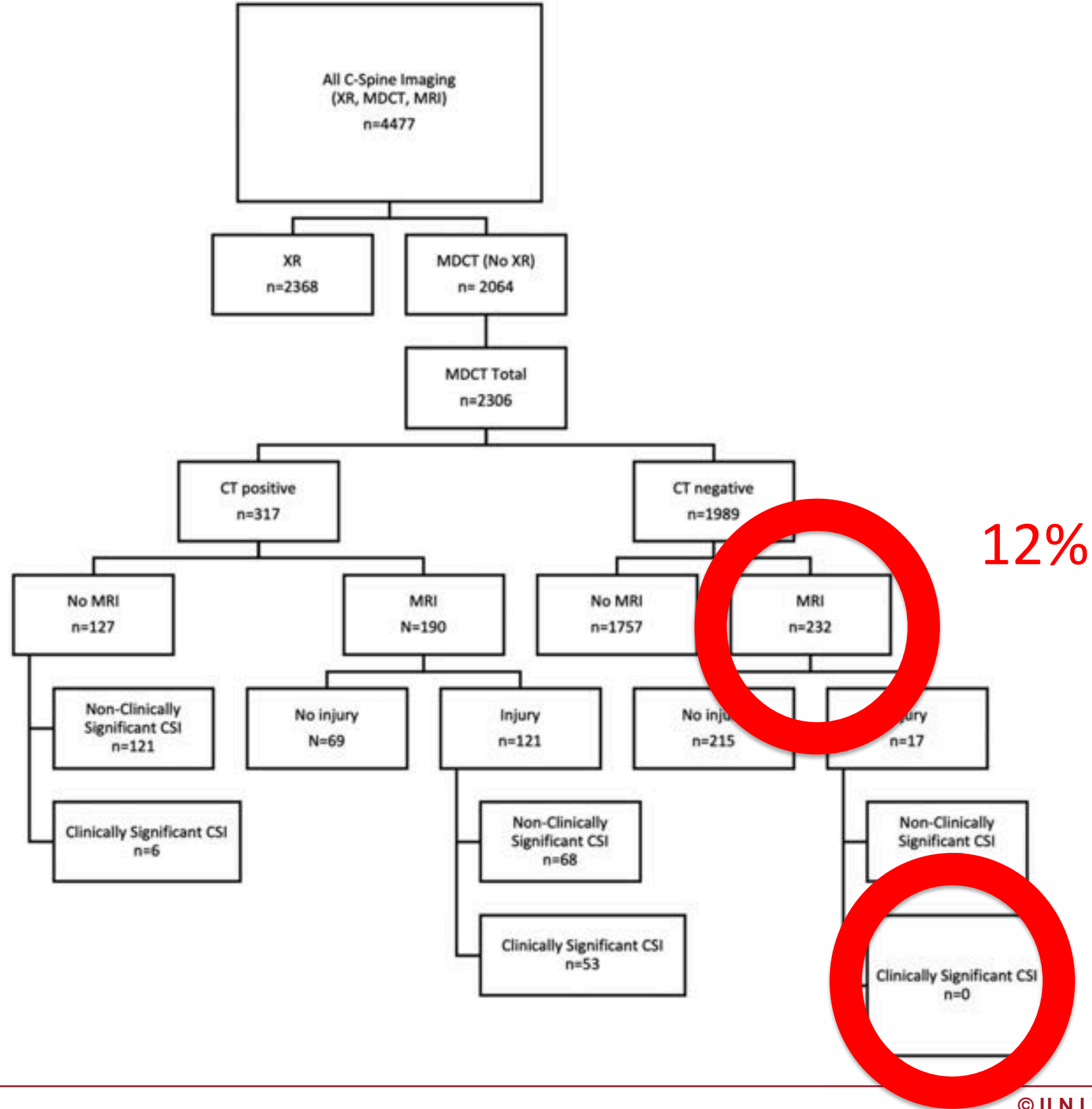
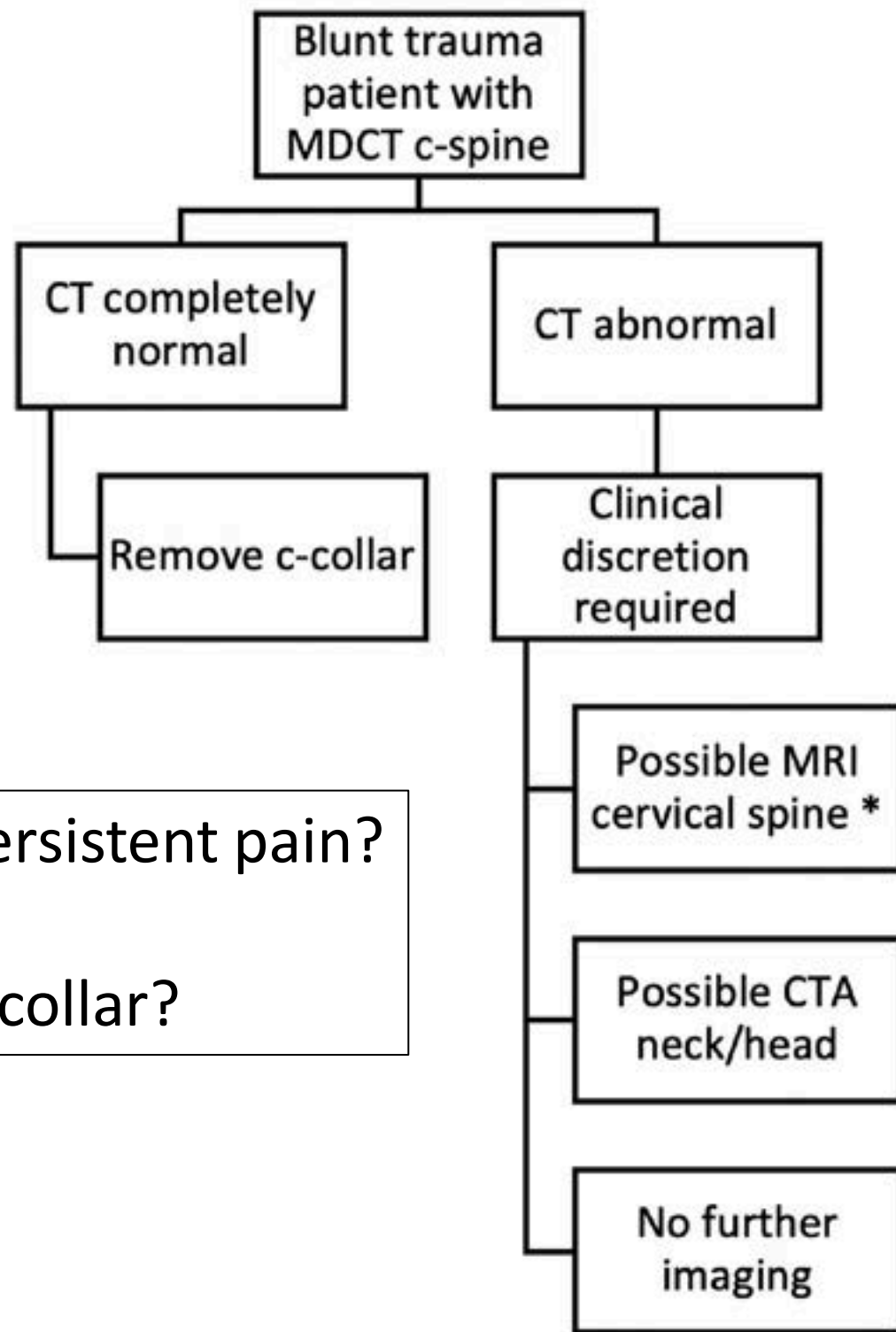


TABLE 2. Seventeen Patients With Normal CTs That Had Abnormal MRIs

Number	Age	Sex	Initial GCS	Mechanism	MRI Injury	Treatment	Clearance	Stable
1	5.6	M	8	Fall	Probable microtrabecular compression fracture C7-T4	Discharged hard collar 2 d	Flex-ex	Y
2	10.3	M	15	MVC	Suspected injury to the apical and alar ligaments, retroclival hematoma	Discharged hard collar 2 wk	Flex-ex	Y
3	7.9	M	9	MVC	C4-5 interspinous ligament and ligamentum flavum	Discharged hard collar 2 wk	Left the state	Y
4	12.5	F	15	ATV	Suspected ligamentous strain interspinous ligaments	None	None	Y
5	16.4	F	15	Sports	Edema involving the C5 through C8 right nerve roots	Discharged hard collar 2 wk	Lost to follow-up	Y
6	4.2	F	3	MVC	Minimal edema within the cervical interspinous and supraspinous ligaments	Discharged hard collar 5 wk	Lost to follow-up, MRI 3 mo and cleared	Y
7	0.8	M	6	NAT	Interspinous ligament stretching injury	Discharged hard collar 4 wk	Flex-ex	Y
8	15.4	M	3	Horse kick	Edema C1-C2 spinous ligamentous complex	Hard collar 2 wk, still inpatient	None	Y
9	15.2	F	4	MVC	Mild edema posterior interspinous ligament	Hard collar 1 wk, still inpatient	Flex-ex in hospital	Y
10	12.8	M	3	ATV	Edema C3-C5 interspinous ligament	Discharged hard collar 2 wk	Flex-ex	Y
11	1.5	M	6	NAT	Edema interspinous and nuchal ligaments upper cervical region	None	None	Y
12	6.1	M	3	Fall	Edema interspinous and nuchal ligaments upper cervical region	None	None	Y
13	10.9	F	3	Horse kick	Minimal compression C7	None	None	Y
14	17	M	14	MVC	Bone bruise C2 with possible fx on CT review, chord contusion C4-C5	Discharged hard collar 6 wk	Left state	Y
15	14.6	M	8	MVC	Edema interspinous ligaments C1-C2, suspected atlantoaxial membrane avulsion	Discharged hard collar 6 wk	Flex-ex	Y
16	8.6	M	4	MVC	Edema posterior interspinous ligaments upper c-spine	Discharged hard collar 2 wk	Flex-ex	Y
17	16.5	M	3	MVC	Edema interspinous ligaments C1-C2, C5-C7	Hard collar 2 wk, still inpatient	Flex-ex	Y

ATV, all-terrain vehicle; F, female; Flex-ex, flexion-extension radiographs; NAT, non-accidental trauma; M, male; MVC, motor vehicle crash; Y, yes.

If I had taken the collars off, or sent them home in hard collars, I would not have hurt anyone



Proposed algorithm, but more data needed

What if persistent pain?
 -MRI?
 -Home in collar?

Figure 2. Proposed algorithm for clearance of the pediatric c-spine.

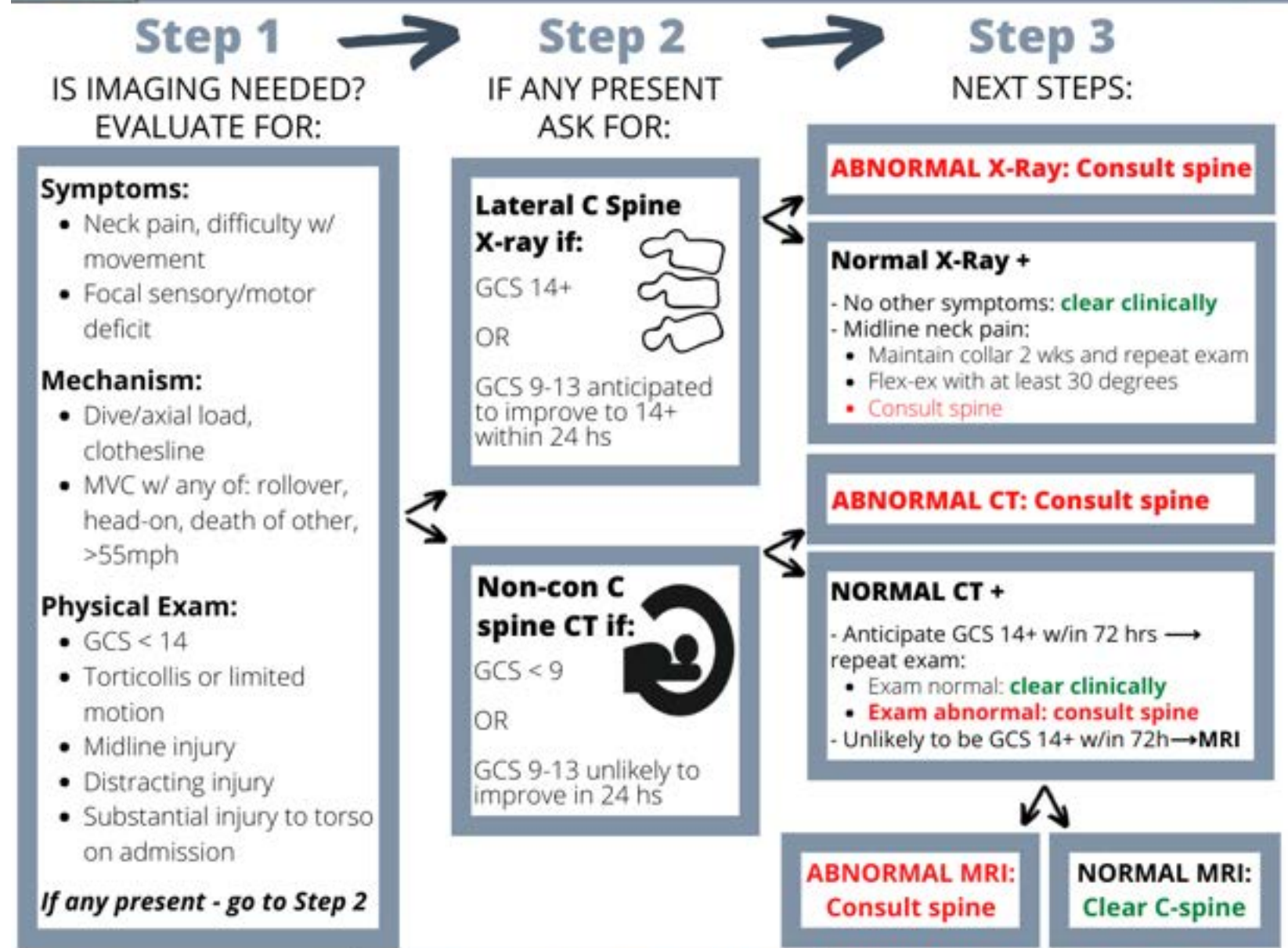
ADDITIONAL PAPERS

- Infants <1 YO (PTS, Iantorno/Eldredge)
- Sensitivity of XR (PTS, Starr/Iantorno)
- Injury Patterns (WPTC, Smith)
- Pressure Ulcers (McNamara/Iantorno)
- IHC System (AAST 2024, Russell/Morris)
- WPSRC Quick Scan MRI (PTS Tepas Award, JTACS)
- WPSRC Sensitivity (AAP, JAMA Surg)

PTS Guideline Cervical Spine Clearance

New PECARN
paper coming

Pediatric Cervical Spine Clearance Recommendations



@StayCurrentMD
Created by Cecilia Gigena, MD @gigenace

Adapted from: **Herman, Martin J. MD**
Orthopedic Center for Children, St. Christopher's Hospital for Children, Philadelphia, Pennsylvania
doi: 10.2106/JBJS.18.00217

@PediTraumaSoc @APSASurgeons

PEDIATRIC TRAUMA SOCIETY
A Voice for the Injured Child
pediatrictraumasociety.org

APSA
American Pediatric Surgical Association
Saving Lives



Western Pediatric
CERVICAL SPINE STUDY

HYPOTHESIS

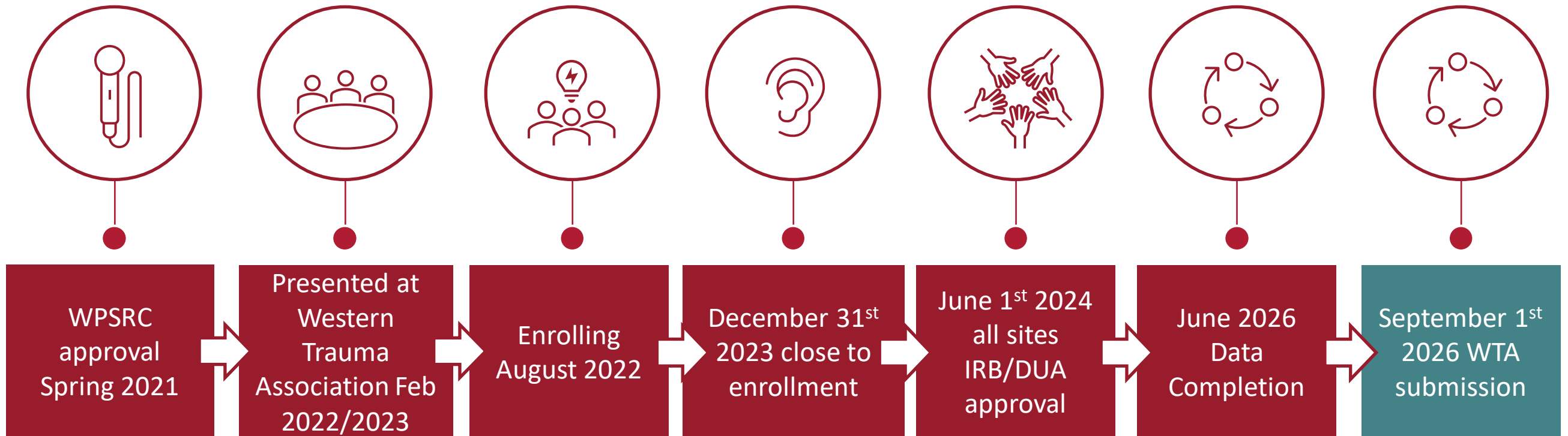
CT is highly sensitive for identifying cervical spine injuries in children, especially in the adolescent population

AIM

Determine the sensitivity of CT and XR for identifying clinically significant cervical spine injury in children



C-spine Anticipated timeline



DIVISION/DEPT | TITLE | DATE



Sites Recruited

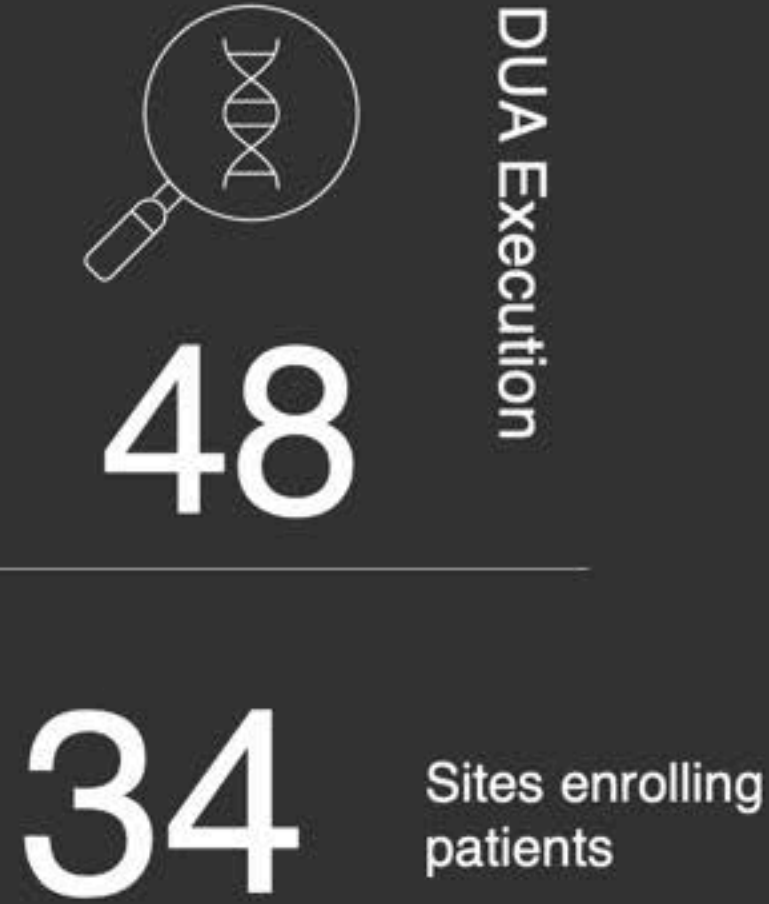




Figure 1: Geographic distribution of participating centers

NEXT STEPS

- Keep pushing prospective study
- Identify funding opportunities
- Institutional review BCVI (WPTC, Alexander)
- Radiation risk (APSA, Alexander)

