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Original Contributions

THORACOLUMBAR EVALUATION IN THE LOW-RISK TRAUMA PATIENT: A PILOT STUDY TOWARDS DEVELOPMENT OF A CLINICAL DECISION RULE TO AVOID UNNECESSARY IMAGING IN THE EMERGENCY DEPARTMENT

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☐ **Abstract—Background: Thoracolumbar (TL) injury is a common finding in the severely injured multi-trauma patient. However, the incidence and pattern of TL injury in patients with milder trauma is unclear. Objective: The aim of this study was to collect and analyze evidence for the development of a clinical decision rule (CDR) to evaluate the TL spine in patients with non-severe blunt trauma and avoid dedicated imaging in low-risk cases. Methods: Adult patients with blunt trauma who presented to a major academic center (May 2016 to October 2017) and received dedicated imaging of the TL spine were included. Exclusion criteria consisted of any coexisting condition preventing the acquisition of history or examination. The primary endpoint is TL spine injury requiring orthopedic evaluation, bracing/orthosis, or surgery. Preliminary CDR derivation was performed with recursive partitioning. Results: Of 4612 patients screened, 1049 (22.7%) met inclusion criteria. Thirty-six (3.4%) patients were found to have TL spine injury, of which 88.9% received spinal bracing, orthosis, or surgery. Absence of midline tenderness conveyed the highest negative predictive value, followed by a non-severe mechanism of injury, lack of neurologic examination findings, and age < 65 years. No patients in this cohort with these four findings had a TL spine injury. Conclusions: In certain lower-risk blunt trauma patients < 65 years of age, focused examination combined with mechanism of injury may be highly sensitive (100%) to rule out TL injury without the need for dedicated imaging. However, validation is necessary, given multiple study limitations. Potential instrument to screen for TL injury in minor trauma: TL injury is unlikely if all four of the following are present: 1) no midline back tenderness or deformity, 2) no focal neurologic signs or symptoms or altered mentation, 3) age < 65 years; and 4) lack of severe mechanism of injury, for example, fall greater than standing, motor-vehicle collision with rollover/ejection/pedestrian or unenclosed vehicle, and assault with a weapon.**

☐ **Keywords—thoracolumbar; spine; trauma; blunt; imaging; rule**

INTRODUCTION

Thoracolumbar (TL) spine injury is not an uncommon finding in the multi-trauma patient. However, the incidence and pattern of TL injury in patients with milder trauma, typically seen in the average emergency department (ED) setting, remains unclear. Injury to the back is a common presentation in the ED after blunt trauma (eg, fall, motor-vehicle accident, and assault), accounting for more than 13 million ED visits in the United States alone in 2015 (1).

For the cervical spine, the NEXUS Criteria and Canadian C-Spine Rule provide validated and high-quality evidence-based clinical decision rules (CDRs) allowing for stratification of low-risk patients who do not require imaging (2,3). However, widely adopted

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clearance guidelines do not currently exist for the TL spine, and there is no validated CDR to rule out TL injury to date. Multiple studies have shown that physical examination alone is likely insufficient to rule out TL spine injury in patients with major blunt trauma (4–6). The most recent 2012 Eastern Association for the Surgery of Trauma (EAST) evidence-based practice management guidelines issue no level 1 recommendation on patients eligible to forgo radiologic imaging (7).

Overall, there remains a lack of evidence to determine the necessity of radiologic imaging in patients with mild to moderate trauma most frequently seen in the ED. The purpose of this study is to examine the incidence and pattern of TL injury in the ED for the future development of a CDR with high sensitivity for exclusion of all clinically relevant TL spine fractures in the setting of non-severe blunt trauma, without the need for further imaging. Ideally, the CDR would have at least moderate specificity and be of functional clinical utility.

PATIENTS AND METHODS

Study Population

We screened patients aged 18 years and older who presented to a major academic center with mild to moderate blunt traumatic injuries. Approval by the hospital's Institutional Review Board and Ethics Committee was obtained prior to the initiation of the study. Given that the hospital is the region's largest trauma level I referral center, a minority of high-risk patients underwent "trauma activation" due to prehospital suspicion for multiple injuries. This activation includes routine imaging of the entire chest and abdomen, encompassing the TL spine. We identified our study population as all adult blunt trauma presentations without prehospital activation of the surgical trauma team (Supplementary Table 1) to allow for independent and individual emergency physician assessment.

Additional exclusion criteria consisted of lack of dedicated imaging and interpretation of the thoracic, lumbosacral, or TL spine; previous treatment at an outside hospital for the same injury; any coexisting condition(s) preventing the acquisition of history or examination, including altered mentation from intoxication or otherwise; chronic focal neurologic deficit; injury chronicity of more than 7 days; or patients who left prior to complete evaluation.

Protocol

Patients who visited the ED between May 1, 2016 and October 31, 2017 were identified based on International Classification of Diseases, 10th revision (ICD-10) diagnoses and radiographic imaging obtained during their ED course. All clinical management decisions, including imaging modalities, were dictated by individual emergency physician preference and hospital protocols without investigator interference.

All patient encounter information was documented on a single electronic medical record system using preset "click-box" designations. History and physical examination were performed by a resident, nurse practitioner, or attending physician, and all radiologic images obtained were interpreted by an attending radiologist. Subjective neurologic findings had to conform to a spinal level or dermatome to qualify as focal neurologic symptoms, whereas complaints of associated diffuse numbness were not considered to be due to a potential spinal injury.

Abstraction of relevant findings was performed primarily by resident physicians. Abstractors remained blinded to the final hypothesis, as the rule formation was data driven and not performed until data extraction was complete. Ten percent of charts were reviewed by a second physician to assess for inter-rater agreement.

We categorized trauma both by type of mechanism, such as motor-vehicle collision (MVC) or fall, and severity (ie, mild, moderate, or severe). For example, ground-level falls were mild, falls above 10 feet were severe, and in between were moderate (Supplementary Figure 1). Certain types of mechanisms were deemed inherently severe (eg, motorcycle collisions, pedestrian MVCs) and not subcategorized. These classifications were used for the statistical analysis to derive the CDR.

Dedicated radiographic imaging was defined as any imaging with the primary purpose of evaluating the TL spine. Patients with radiographic imaging of the entire chest or abdomen were not considered dedicated imaging. Clinicians ordering these broader studies were assumed to have indications aside from or in addition to suspected TL spine injury.

Outcome

The primary outcome assessed was any acute radiographic injury of the TL spine, including any injury requiring orthopedic evaluation, TL spine bracing/orthosis or surgical stabilization.

Statistical Analysis

Based on a review of literature, we collected a set of variables consisting of multiple elements of history, mechanism, examination, and demographic findings as potential criteria for our model (Supplementary Figure 1). We tabulated their individual odds ratios, sensitivity, specificity, and negative predictive values (NPVs) for TL spine injury. Odds ratios were tested for strength of association. Fisher's exact and χ^2 testing was used for all categorical and continuous data, respectively.

To achieve the goal of a highly sensitive but clinically usable CDR, we adopted a tree-based classification for variable selection. We specifically utilized the method of recursive partitioning, which sequentially partitions the data to optimize accuracy sensitivity in identifying TL injuries (8). The number and type of partitions (or variables included) are limited through cross validation on subsets of our cohort. This approach is the ideal method for creating an instrument with near 100% sensitivity (9).

Final variables derived were also fitted into a logistic regression model to assess the individual strength of association in the presence of other predictors. This serves as an intuitive understanding of the variables' associations not provided by the decision tree.

All statistics and models were generated with R statistical software. Partitioning was performed using the RPART open source package (10). Source data storage and management were documented using RedCap (11,12).

RESULTS

Summary

From May 1, 2016 to October 31, 2017, we screened 117,266 ED encounters, yielding 4612 patients with ICD-10 diagnoses for blunt trauma (coded as V00–49, V70–99) who did not qualify for prehospital trauma team activation. Of those, 1049 (22.7%) met the inclusion criteria and 3563 were excluded (Figure 1). The most common reason for exclusion was not receiving dedicated imaging of the TL spine (3421 patients). This was followed by chronic injury without acute trauma, inability to obtain a history or physical examination, repeat presentation or transfer after having previously received care at another health care facility, misclassification of non-traumatic presentations, and patients who left prior to complete evaluation (142 patients total). The underlying prevalence of TL injury in this population was low. Thirty-six (3.4%) patients were found to have TL spine injury, of which 83.3% received spinal bracing or orthosis, and 5.6% of injuries required surgical intervention.

Due to the exclusion criteria, all included patients had a documented history, complete physical examination, and interpretation on at least one radiologic study. The most common pertinent neurologic findings documented were motor function, sensation, gait, and radiculopathy. The most common back examination findings were midline tenderness, paraspinal tenderness, and generalized tenderness.

The population age was varied (median age 46 years; range 18–100 years) and 53.4% were male. The mechanism was predominantly falls and MVCs (84.4%). Twenty-four percent of patients underwent computed tomography (CT) or magnetic resonance imaging and the remaining plain films only. These findings and selected other variables collected are outlined in Table 1.

Derivation

Nearly all included patients complained of back pain (96.2%). This finding was highly sensitive (94.4%) and but also highly non-specific (4.0% specificity) for TL spine injury. The underlying risk of TL injury in this population was low (3.4%).

Figure 1. Flow diagram. *Patients excluded due to pre-activation of the surgical trauma team, known previous imaging at an outside hospital for the same injury, or any coexisting condition preventing the acquisition of history or examination. TL = thoracolumbar.

Table 1. Baseline Characteristics

Characteristic	Data
Age, years, median (range)	46 (33–57)
Sex, male, % (n)	53.4 (561)
Mechanism of injury, % (n)	
Fall	44.1 (463)
Motor-vehicle collision	40.3 (423)
Pedestrian, bicycle, or motorcycle vs. motor-vehicle collision	6.2 (65)
Assault	5.6 (59)
Symptoms, % (n)	
Back pain	96.2 (1009)
Radiculopathy	3.7 (39)
Other neurologic complaints	1.8 (19)
Physical examination findings, % (n)	
Midline TL spine tenderness	28.6 (300)
General TL tenderness	32.7 (343)
Focal neurologic signs	0.3 (3)
Limited range of motion or ambulation	3.1 (33)
> 24 h to presentation, % (n)	18 (189)

TL = thoracolumbar.

Although most patients did complain of back pain, midline tenderness was the next most sensitive finding, followed by a concerning mechanism of injury (MoI) and any tenderness of the back. Midline tenderness conferred the highest NPV, followed by focal neurologic examination findings, concerning MoI, and then age. These findings are outlined in Table 2.

The model's optimal partitioning of the recursive partitioning model is shown as Figure 2. The final classification decision tree yielded midline tenderness, focal neurologic examination findings, high-risk mechanism, and then age. The algorithm was able to consistently capture all TL injuries using these four variables. The resulting performance of the derived potential clinical decision rule on our cohort yielded 100% sensitivity (95% confidence interval [CI] 91.2–100.0%), 53.1% specificity (95% CI 50.5–55.7%), and 100% NPV (95% CI 99.3–100.0%) for ruling out TL spine injury.

The optimal separation point of age was determined to be 65.4 years. This was rounded to 65 years and older. The optimal demarcation of concerning MoI was specified as any fall above ground level, high-risk MVC (eg, rollover, ejection, extreme speed), unenclosed MVC (included pedestrian and bicyclist hit by car), and assault with any weapon.

To assess the association of the selected variables with our primary outcome while in the presence of the other predictors, we fit all four variables into a single logistic regression model (Table 3). The model had excellent goodness of fit and low multicollinearity (variance inflation factor 1.14). All variables were strongly and significantly associated with TL spine injury, with the exception of age. However, the 95% CI of age was relatively wide and centered on an odds ratio of 1.72, suggesting the variable may be underpowered for this model (possibly due to the low pretest prevalence of TL injury).

Approximately 10% of all charts were subsequently abstracted by a second reviewer to assess for inter-rater reliability. Subjective measures were commonly agreed upon (κ statistics 0.9–1.0) with unanimous agreement in all cases with injury noted on radiography. These are outlined on Supplementary Table 2.

DISCUSSION

This is a large single-center retrospective pilot study toward the goal of developing a highly sensitive and at least moderately specific CDR to assist with clearance of the TL spine injury in patients with mild to moderate blunt trauma injury. While a high proportion of patients with severe traumatic presentations will undergo multidetector CT of the abdomen and torso with 3-dimensional construction of the TL spine, this is not true for all presentations (13).

Key Findings

An unexpected finding was the overall low prevalence of TL spine injury in our cohort, just 3.4%, which is much lower than the anticipated 7% based on prestudy power

Table 2. Odds Ratios and Key Statistics

Variable	Without Injuries, False Positive (n = 1013)	With Injuries, True Positive (n = 36)	Sensitivity (95% CI), %	Specificity (95% CI), %	NPV (95% CI), %	Odds Ratio
Back pain	973	34	94.4 (81–99)	4.0 (2.8–5.3)	95.2 (83–99)	0.70
Midline tenderness	276	24	70.6 (53–85)	72.8 (70–75)	98.4 (97–99)	5.36
Other tenderness	334	9	25 (12–42)	66.9 (64–69)	96.1 (95–97)	0.67
High-risk mechanism	182	14	38.9 (23–57)	81.3 (79–84)	97.2 (96–98)	2.71
Age ≥ 65 years	119	6	16.7 (6–33)	88.2 (86–90)	96.7 (96–97)	1.49
Focal neurologic signs or symptoms	52	4	11.1 (3–26)	94.5 (93–96)	97.4 (96–98)	2.31
>24 h since injury	182	6	16.7 (6.4–33)	81.9 (79–84)	96.5 (96–97)	0.91
Derived CDR	475	36	100.0 (91–100)	53.1 (51–56)	100.0 (99–100)	NA

CDR = clinical decision rule; CI = confidence interval; NA = not applicable; NPV = negative predictive value.

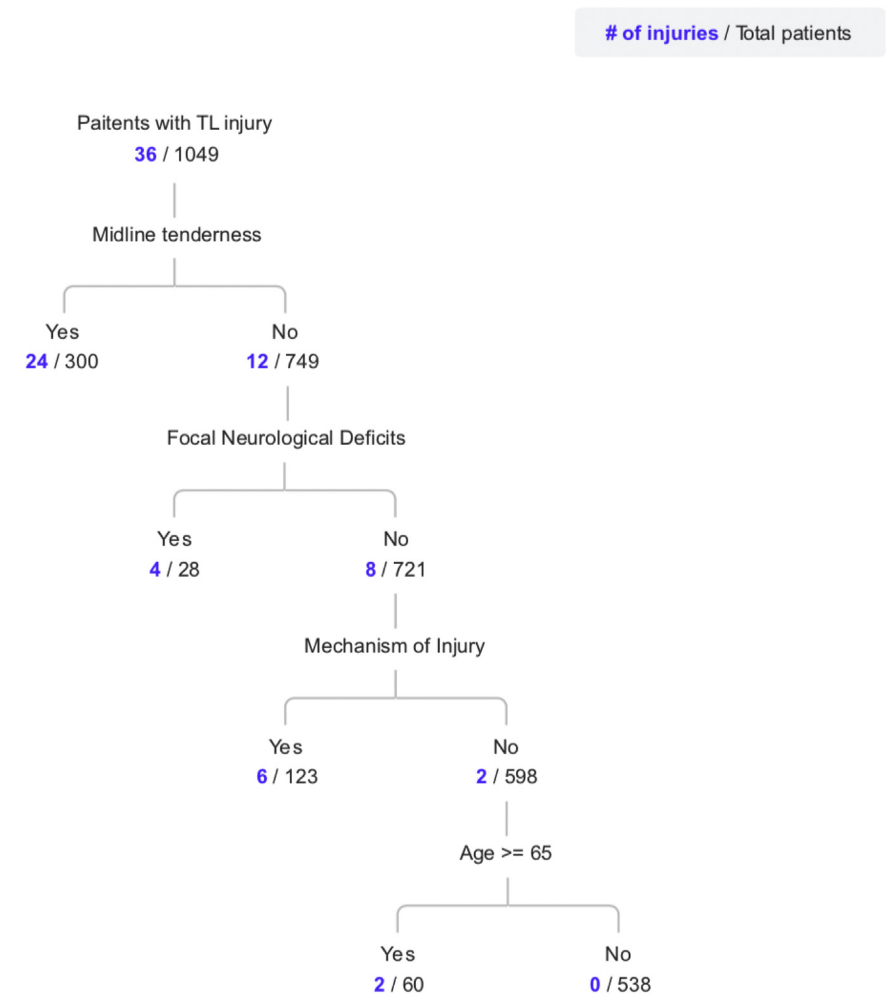


Figure 2. Recursive partitioning model. TL = thoracolumbar.

calculations (14). This is most likely due to the removal of the "surgical trauma activations." This relatively easy to identify (usually determined prehospital or by a triage nurse) subset of patients allows for an already low pretest probability for any candidate CDR.

The low prevalence of TL spine injury is remarkable, given the total number of patients who underwent radiographic examination. This further highlights the need for the future development of a validated CDR to avoid unnecessary irradiation and TL spine precautions.

Table 3. The Logistic Regression Model

Variable	Coefficient	OR (95% CI)
Intercept	−4.56	—
High-risk mechanism	0.93	2.53 (1.3–5.1)
Midline tenderness	1.72	5.65 (2.8–11.5)
Focal neurologic signs or symptoms	1.30	3.70 (1.2–11.5)
Age ≥ 65 years	0.41	1.72 (0.7–4.3)

CI = confidence interval; OR = odds ratio.

Our model recognizes four components, all of which must be absent for injury to effectively be ruled out (in this cohort) in non-severe traumatic presentations: midline TL spine tenderness, focal neurologic findings, age 65 years or older, or high-risk mechanism. High-risk mechanisms are unenclosed MVC (including bicyclist of pedestrian involvement), high-risk MVC (rollover, ejection, or extreme speed), fall from height above ground level, and assault with a weapon.

All patients in our cohort with TL spine injury requiring intervention or follow-up satisfied at least one of these criteria. This is notable not only for the high sensitivity and NPV, but also that the relatively common complaint of back pain was not required to be absent.

Comparable Research

Several studies in recent years have attempted to identify a group of risk factors to predict the absence of TL spine injury. The majority of the studies examining risk factors for TL spine injuries are small in size and have conflicting results, making any analysis of these results difficult and thus compromising the accuracy of these findings (15–19). A study of 152 patients with spine injuries found that lack of pain, tenderness, decreased level of consciousness, neurologic deficit, and distracting injuries were found to have an NPV of 100%, with a specificity of 3.9% (20).

One larger study, which has yet to undergo prospective validation, included 3065 patients with blunt trauma, demonstrating a sensitivity of 98.9% and specificity of 29.0% for clinically significant fractures using a combination of pain, mechanism of injury, age, and physical examination. The design included both high- and low-risk trauma presentations. These findings are similar to the pre-existing level 2 recommendation of the 2012 EAST guidelines that patients without complaints of TL pain; with normal mental status, neurologic, and physical examinations; and no suspicion of high-energy mechanism may be excluded from TL injury by clinical examination alone, without radiographic imaging (7,19). One key difference in our cohort is that absence of back pain was not a requirement of foregoing imaging.

Analogously, the NEXUS Chest Decision Instrument for Blunt Chest Trauma provides guidelines whereby chest imaging may be avoided, or at the very least x-ray study may be used instead of CT (21). The instrument has low specificity but much higher sensitivity. NEXUS Chest may have utility in identifying low-risk patients and avoiding unnecessary radiation when appropriate, demonstrating a similar goal to our pilot study and desired endpoint.

Strengths

The electronic health record utilized documented both positive and negative findings of the variables, allowing for standardization. Clinical findings obtained by treating physicians as well as imaging interpretation by radiologists were performed without knowledge of this study. Our derivation adhered to existing methodological standards and the mathematical techniques employed are open, reproducible, and evidence-based (9,10).

Within our cohort, this preliminary rule is sensitive with relatively high specificity. This bestows a high NPV, key for any tool to provide clearance for such a critical injury. The specificity may also aid in the efficiency of radiologic utilization, reduce exposure to radiation, and limit the use of backboards in the prehospital and hospital settings. Finally, while this study was designed to identify only clinically relevant fractures, in our cohort, the derivation was 100% sensitive for excluding all TL spine injuries identified on radiographic imaging.

Limitations

Due to this study's targeted population of traumatic presentations with low to moderate severity, this cohort's prevalence of TL spine injury is lower than for all blunt trauma presentations. Fewer TL injuries minimize the prospective validity, especially the finding of 100% sensitivity for TL injury. We emphasize the need for a validation study. Only with a larger cohort containing additional TL injuries, the low prevalence of injury may allow for a higher and more precise NPV value. This would be helpful in the derivation of the one-way, rule-out CDR.

Per the nature of the study's design, out-of-hospital follow-up was not performed. A large percentage of patients underwent plain film studies of the TL spine alone as their radiologic assessment. There is a possibility that a small percentage of TL injuries were missed. Additionally, not all trauma patients with blunt mechanism received imaging. Patients evaluated by clinical assessment alone or in combination with non-dedicated radiology of the TL spine were not included.

Despite the utilization of click-box documentation in the medical record system and standardized data collection forms, all abstracted data from an electronic heath record is inherently prone to a certain level of bias. The abstracted data had good inter-rater reliability (κ statistics 0.9–1.0, refer to Supplementary Table 2). As a retrospective study, it is not possible to assess important missing data, such as completion of comprehensive neurologic examinations. Undocumented or missing positive findings would reduce the reported specificity of our prospective pathway.

As a single-center study at a large urban academic center, these results have unproven external validity with suburban and rural community EDs. Additionally, there is some inter-regional variability of criteria for pre-activation of the surgical trauma team. Furthermore, not every clinical site will have the same low prevalence of TL spine injury of 3.4%.

Our inclusion of blunt traumatic presentation depended on the patient's ICD-10 coding. Inadequately coded encounters could be missed on ICD-10 code screening. It is unclear how this would bias or skew the population studied. However, multiple studies have shown excellent sensitivity, specificity, and inter-coder agreement of the utilization of ICD coding for identifying trauma and mechanism of injury (22,23).

CONCLUSIONS

In patients with mild to moderate blunt traumatic presentations, it may be possible to clinically determine the absence of TL spine injury without radiologic imaging. Our exploratory study has shown that the combination of age, mechanism of injury, physical examination, and neurologic complaints may be predictive. A large, multi-centered prospective validation study with follow-up is required.

REFERENCES

1. Centers for Disease Control and Prevention. Injury Center. Data and Statistics (WISQARS). 2018. Available at: https://www.cdc.gov/injury/wisqars/nonfatal.html. Accessed February 24, 2018.
2. Hoffman JR, Mower WR, Wolfson AB, Todd KH, Zucker MI. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. National Emergency X-Radiography Utilization Study Group. N Engl J Med 2000; 343:94–9.
3. Stiell IG, Wells GA, Vandemheen KL, et al. The Canadian C-Spine Rule for Radiography in Alert and Stable Trauma Patients. JAMA 2001;286:1841–8.
4. Inaba K, DuBose JJ, Barmparas G, et al. Clinical examination is insufficient to rule out thoracolumbar spine injuries. J Trauma 2011;70:174–9.
5. Sava J, Williams MD, Kennedy S, Wang D. Thoracolumbar fracture in blunt trauma: is clinical exam enough for awake patients? J Trauma 2006;61:168–71.
6. Gill DS, Mitra B, Reeves F, et al. Can initial clinical assessment exclude thoracolumbar vertebral injury? Emerg Med J 2013;30: 679–82.
7. Sixta S, Moore FO, Ditillo MF, et al. Screening for thoracolumbar spinal injuries in blunt trauma: an Eastern Association for the Surgery of Trauma practice management guideline. J Trauma Acute Care Surg 2012;75(suppl 4):S326–32.
8. Friedman JH. A recursive partitioning decision rule for nonparametric classification. J IEEE Trans Comput 1977;26:404–8.
9. Stiell IG, Wells GA. Methodologic standards for the development of clinical decision rules in emergency medicine. Ann Emerg Med 1999;33:437–47.
10. Therneau A, Atkinson B, Ripley B. rpart: Recursive Partitioning and Regression Trees. R package version 4.1-13. Vienna, Austria: R Foundation for Statistical Computing; 2018.
11. R Core Team. R. A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2017. Available at: http://www.R-project.org/. Accessed January 2018.
12. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap). J Biomed Inform 2009;42:377–81.
13. Long B, April MD, Summers S, Koyfam A. Whole body CT versus selective radiological imaging strategy in trauma: an evidence-based clinical review. Am J Emerg Med 2017;35:1356–62.
14. Katsuura Y, Osborn JM, Cason GW. The epidemiology of thoracolumbar trauma: a meta-analysi. J Orthop 2016;13:383–8.
15. Samuels LE, Kerstein MD. 'Routine' radiologic evaluation of the thoracolumbar spine in blunt trauma patients: a reappraisal. J Trauma 1993;34:85–9.
16. Durham RM, Luchtefeld WB, Wibbenmeyer L, Maxwell P, Shapiro MJ, Mazuski JE. Evaluation of the thoracic and lumbar spine after blunt trauma. Am J Surg 1995;170:681–4.
17. Stanislas MJ, Latham JM, Porter KM, Alpar EK, Stirling AJ. A high risk group for thoracolumbar fractures. Injury 1998;29:15–8.
18. Hsu JM, Joseph T, Ellis AM. Thoracolumbar fracture in blunt trauma patients: guidelines for diagnosis and imaging. Injury 2003;34:426–33.
19. Inaba K, Nosanov L, Menaker J, et al. Prospective derivation of a clinical decision rule for thoracolumbar spine evaluation after blunt trauma: an American Association for the Surgery of Trauma Multi-Institutional Trials Group Study. J Trauma Acute Care Surg 2015; 78:459–67.
20. Holmes JF, Panacek EA, Miller PQ, Lapidis AD, Mower WR. Prospective evaluation of criteria for obtaining thoracolumbar radiographs in trauma patients. J Emerg Med 2003;24:1–7.
21. Rodriguez RM, Langdorf MI, Nishijima D, et al. Derivation and validation of two decision instruments for selective chest CT in blunt trauma: a multicenter prospective observational study (NEXUS Chest CT). PLoS Med 2015;12(10):e1001883.
22. LeMier M, Cummings P, West TA. Accuracy of external cause of injury codes reported in Washington State hospital discharge records. Inj Prev 2011;7:334–8.
23. McKenzie K, Enraght-Moony EL, Waller G, Walker SM, Harrison JE, McClure RJ. Causes of injuries resulting in hospitalization in Australia: assessing coder agreement on external causes. Inj Prev 2009;15:188–96.

APPENDIX

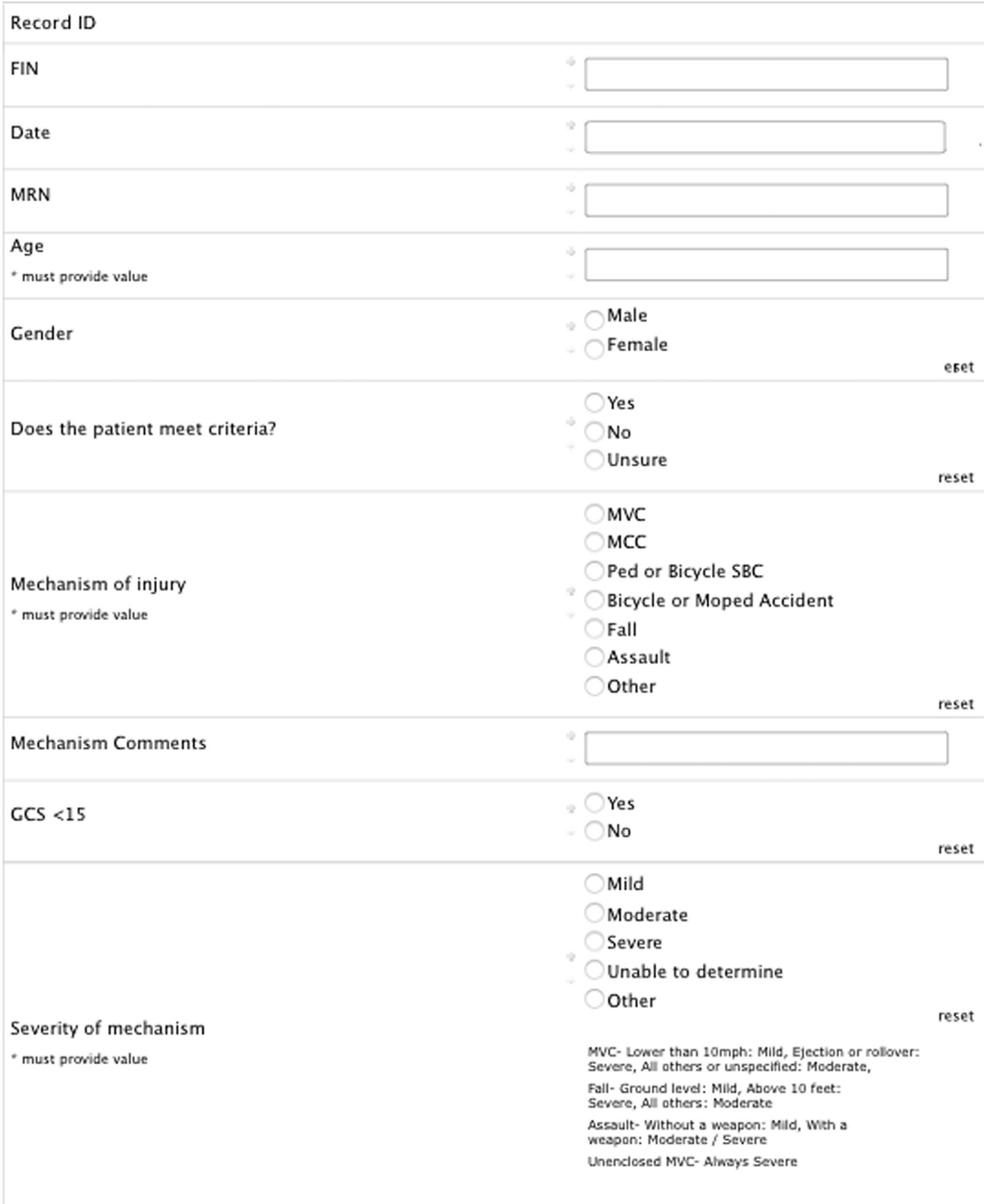
Supplementary Table 1. Prehospital Surgical Trauma Team Pre-Activation Criteria

Any One of	Or Any Two of
Loss of airway	Respiratory rate ≥ 30 breaths/min
GCS < 12 or BMR ≤ 4	BMR ≤ 5
Multiple long bone fractures	Age ≥ 55 years
No radial pulse and sustained HR > 120 beats/min, or SBP < 90 mm Hg	Sustained HR ≥ 120 beats/min
GCS < 15 with head injury on anticoagulation	Fall > 10 ft, ejection, or rollover MVC
	Long bone fracture from MVC or fall ≥ 10 ft
	Ejection, death of occupant, or steering wheel deformity

BMR = Best Motor Response; GCS = Glasgow Coma Scale; HR = heart rate; MVC = motor-vehicle collision; SBP = systolic blood pressure.

Supplementary Table 2. Inter-Rater Reliability of Select Abstracted Variables

Variable	Cohen's κ
Midline tenderness	0.935
Mechanism of injury	0.944
Focal neurologic deficit	1.00
Age	1.00



Record ID	
FIN	
Date	
MRN	
Age * must provide value	
Gender	Male Female eset
Does the patient meet criteria?	Yes No Unsure reset
Mechanism of injury * must provide value	MVC MCC Ped or Bicycle SBC Bicycle or Moped Accident Fall Assault Other reset
Mechanism Comments	
GCS <15	Yes No reset
Severity of mechanism * must provide value	Mild Moderate Severe Unable to determine Other reset MVC- Lower than 10mph: Mild, Ejection or rollover: Severe, All others or unspecified: Moderate, Fall- Ground level: Mild, Above 10 feet: Severe, All others: Moderate Assault- Without a weapon: Mild, With a weapon: Moderate / Severe Unenclosed MVC- Always Severe

Supplementary Figure 1. Standardized REDCap abstraction form.

Severity comments	[ ]
Symptoms * must provide value	[ ] Pain [ ] Radiculopathy [ ] Neurological complaints [ ] Incontinence [ ] Other [ ] None
Additional information on symptoms	[ ]
Physical exam * must provide value	[ ] Tenderness (midline) [ ] Tenderness (other) [ ] Bruising or contusion [ ] Limited ROM [ ] Limited ambulation [ ] Focal neurological decit [ ] Other [ ] No signicant ndings
Additional information on physical exam	[ ]
Past Hx * must provide value	[ ] Hx of back trauma [ ] Hx of back sur gery [ ] Hx of osteoporosis [ ] Hx of drug seeking behaviour [ ] Hx psychiatric disor ders [ ] Hx of back pain [ ] Other [ ] No signicant past history
Additional information on past history	[ ]
Incident mor e than 24 hours ago?	( ) Yes ( ) No reset
Additional information if the patient is into xicated (unable to obtain HPI or PE). Leave blank if not.	[ ]

Supplementary Figure 1. (*continued*).

ARTICLE SUMMARY

1. Why is this topic important?

Most emergency departments (EDs) face challenges such as high cost of medical care and declining reimbursements, overcrowding, increasing lengths of stay, and overutilization of resources. Preliminary steps toward the derivation of a highly sensitive clinical decision rule that reduces the need for imaging can address these components, while decreasing patient exposure to unnecessary radiation.

2. What does this study attempt to show?

Given the low incidence of thoracolumbar (TL) injury in patients with mild to moderate trauma presenting to the ED, the use of a clinical decision rule similar to NEXUS Criteria/Canadian C-Spine rule may be helpful in reducing the need for radiographic imaging in low-risk trauma patients.

3. What are the key findings?

In low-risk trauma patients, the absence of a high-risk mechanism, age older than 65 years, focal neurologic complaints/altered mentation, and midline tenderness to palpation may effectively rule out injury without the need for further imaging. Prospective validation studies, however, are required.

4. How is patient care impacted?

In low-risk trauma patients, the prevalence of TL spine injury is low. Using a validated CDR would avoid unnecessary radiation and reduce the need for TL spine precautions. This could improve patient satisfaction, decrease costs of medical care, and hasten ED throughput.