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

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Author Disclosures

WTA C-Spine Study Group members - Martin Schreiber: grants, Arsenel Medical and Deciduo Health. Martin Zielinski: grants, National Center for Advancing Translational Research. Steve E. Wolf: salary, Elsevier; royalties, Up-to-Date/Wolters Kluwer; honorarium, Merck; grants, TATRC. The other bylined authors and study group members have nothing to disclose.

Reviewer Disclosures

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BACKGROUND: For blunt trauma patients who have failed the NEXUS (National Emergency X-Radiography Utilization Study) low-risk criteria, the adequacy of computed tomography (CT) as the definitive imaging modality for clearance remains controversial. The purpose of this study was to prospectively evaluate the accuracy of CT for the detection of clinically significant cervical spine (C-spine) injury.

METHODS: This was a prospective multicenter observational study (September 2013 to March 2015) at 18 North American trauma centers. All adult (≥18 years old) blunt trauma patients underwent a structured clinical examination. NEXUS failures underwent a CT of the C-spine with clinical follow-up to discharge. The primary outcome measure was sensitivity and specificity of CT for clinically significant injuries requiring surgical stabilization, halo, or cervical-thoracic orthotic placement using the criterion standard of final diagnosis at the time of discharge, incorporating all imaging and operative findings.

RESULTS: Ten thousand seven hundred sixty-five patients met inclusion criteria, 489 (4.5%) were excluded (previous spinal instrumentation or outside hospital transfer); 10,276 patients (4,660 [45.3%] unevaluable/distracting injuries, 5,040 [49.0%] midline C-spine tenderness, 576 [5.6%] neurologic symptoms) were prospectively enrolled: mean age, 48.1 years (range, 18–110 years); systolic blood pressure 138 (SD, 26) mm Hg; median, Glasgow Coma Scale score, 15 (IQR, 14–15); Injury Severity Score, 9 (IQR, 4–16). Overall, 198 (1.9%) had a clinically significant C-spine injury requiring surgery (153 [1.5%]) or halo (25 [0.2%]) or cervical-thoracic orthotic placement (20 [0.2%]). The sensitivity and specificity for clinically significant injury were 98.5% and 91.0% with a negative predictive value of 99.97%. There were three (0.03%) false-negative CT scans that missed a clinically significant injury, all had a focal neurologic abnormality on their index clinical examination consistent with central cord syndrome, and two of three scans showed severe degenerative disease.

CONCLUSIONS: For patients requiring acute imaging for their C-spine after blunt trauma, CT was effective for ruling out clinically significant injury with a sensitivity of 98.5%. For patients with an abnormal neurologic examination as the trigger for imaging, there is a small but clinically significant incidence of a missed injury, and further imaging with magnetic resonance imaging is warranted. (*J Trauma Acute Care Surg.* 2016;81: 1122–1130. Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Diagnostic tests, level II.
KEY WORDS: Blunt trauma; cervical collar; cervical spine; clearance.

After all immediately life-threatening injuries have been addressed, clearance of the cervical spine (C-spine) remains one of the most critical subsequent steps in the systematic evaluation of the multisystem blunt trauma patient. While all trauma patients are at risk of injury, the actual incidence is only 1% to 3%,[1] with the number that are unstable requiring intervention being even smaller. However, because missing a clinically significant injury in a patient who arrives neurologically intact can lead to a subsequent injury, delineating the optimal mechanism for clearance remains an important research goal. Because of time and cost constraints, as well as the radiation burden, screening imaging cannot be performed in all patients. Therefore, to develop a safe and accurate process for clearance of the C-spine, two questions must be addressed: (1) Which patients require screening? And (2) what is the optimal diagnostic modality for this screening?

For the first question, in patients who are awake, alert, and evaluable with no distracting injuries and neurologically normal with no midline C-spine tenderness, the collar can be cleared clinically using the National Emergency X-Radiography Utilization Study (NEXUS) decision-making rule.[2] For those who fail to meet this standard, however, imaging is required, and computed tomography (CT) is utilized as the next step in radiographic clearance. The sensitivity of CT is superior to that of plain films, rendering the latter of minimal benefit in the acute diagnostic evaluation of the blunt trauma patient at risk of injury.[3–5] For those who have a CT that is both adequate and negative, the added value of obtaining a magnetic resonance imaging (MRI) remains poorly defined and is the crux of the second question. The contemporary evidence base is weak because of the small patient numbers and primarily retrospective design of many of the studies that are currently being used to drive practice.[6–14] In 2015, the Eastern Association for the Surgery of Trauma published a comprehensive systematic review[7,11,12,14–22] and practice management guidelines specifically for the obtunded adult blunt trauma patient.[23] In summarizing five studies with a total of 1,017 patients meeting their entry criteria, the summary conclusion was that they would “conditionally recommend cervical collar removal after a negative high-quality C-spine CT scan result alone.” This was based on the high

Submitted: February 16, 2016, Revised: May 17, 2016, Accepted: May 19, 2016, Published online: July 20, 2016.
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This study was presented at the 46th annual meeting of the Western Trauma Association, February 28–March 4, 2016, in Lake Tahoe, California.
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DOI: 10.1097/TA.0000000000001194

negative predictive value (NPV) of CT for excluding unstable fractures, as well as the high cost and real risk associated with transport to MRI, with the potential for unnecessary treatments being rendered for questionable findings. For patients who require imaging because of persistent midline tenderness or neurologic deficits and have a negative CT, few data are available. In a recent prospective, single-center observational study, 830 patients with tenderness or focal neurologic deficit were evaluated with CT, which was found to have a sensitivity and specificity of 100% for clinically significant injuries.[24]

Although the data to date are consistent, the absence of a large-scale multicenter data set examining this clinical issue has made the development of a universally acceptable protocol for C-spine clearance a challenge. To this end, a prospective multicenter trial was designed and conducted through the Multi-Institutional Trials group of the Western Trauma Association. The purpose of this study was to prospectively evaluate the sensitivity and specificity of CT scan for the detection of clinically significant C-spine injury.

METHODS

This is a prospective multicenter observational trial performed at 18 Level I and II trauma centers in North America through the Western Trauma Association Multi-institutional Trials group. The study was designed to evaluate the diagnostic sensitivity, specificity, NPV, and positive predictive value (PPV) of CT scan for the detection of clinically significant C-spine injury after blunt trauma. After independent institutional review board approval at each of the study sites, a convenience sample of blunt trauma patients (September 2013 to March 2015), 18 years or older, was prospectively screened for enrollment at the time of their initial trauma evaluation. Patients were screened utilizing a standardized clinical examination. Those patients failing the NEXUS[2] low-risk criteria underwent a CT scan of the C-spine and were prospectively followed to discharge. Any patients who were transferred from an outside facility, had a history of spinal instrumentation, or who did not undergo diagnostic imaging with CT scan of their C-spine were

TABLE 1. Characteristics of Blunt Trauma CS Patients (n = 10,276)

Variables	Total n = 10,276	CS Injuries (Sx or Halo or CTO) n = 198	No CS injury n = 10,078	*p*
Age, mean (range), y	48.1 (18–110)	51.1 (18–92)	48.1 (18–110)	0.138
Male sex, n (%)	6,858 (66.7)	146 (73.7)	6,712 (66.6)	0.036
Blunt Mechanism, n (%)				0.005
MVC	3,085 (30.0)	67 (33.8)	3,018 (29.9)	0.280
GLF	2,149 (20.9)	41 (20.7)	2,108 (20.9)	0.998
Fall from height	1,221 (11.9)	32 (16.2)	1,189 (11.8)	0.080
Other	1,052 (10.2)	27 (13.6)	1,025 (10.2)	0.144
AVP	925 (9.0)	11 (5.6)	914 (9.1)	0.111
Assault	718 (7.0)	2 (1.0)	716 (7.1)	0.001
MCC	713 (6.9)	13 (6.6)	700 (6.9)	0.939
BVA	387 (3.8)	5 (2.5)	382 (3.8)	0.457
ISS, median (IQR)	9 (4–16)	17 (10–25)	9 (4–16)	<0.0001
Admission Glasgow Coma Scale score, median (IQR)	15 (14–15)	15 (14–15)	15 (14–15)	0.426
Admission SBP, mean ± SD	138 ± 26	133 ± 31	138 ± 25	0.006
Admission HR, mean ± SD	90 ± 20	84 ± 23	90 ± 20	<0.001
Neurologic exam, n (%)				
Unevaluable	4,660 (45.3)	71.0 (35.9)	4,589 (45.5)	0.008
TBI	375 (3.6)	6.0 (3.0)	369 (3.7)	0.781
Distracting injury	438 (4.3)	5.0 (2.5)	433 (4.3)	0.296
Intoxicated/intubated	1,171 (11.4)	17.0 (8.6)	1,154 (11.5)	0.253
Combination	2,676 (26.0)	43.0 (21.7)	2,633 (26.1)	0.187
Evaluable	5,616 (54.7)	127 (64.1)	5,489 (54.5)	0.001
Evaluable + no deficit	5,040 (49.0)	60 (30.3)	4,980 (49.4)	<0.0001
Evaluable + motor deficit	243 (2.4)	18 (9.1)	225 (2.2)	<0.0001
Evaluable + sensory deficit	182 (1.8)	17 (8.6)	165 (1.6)	<0.0001
Evaluable + motor/sensory deficit	151 (1.5)	32 (16.2)	119 (1.2)	<0.0001
Type of imaging, n (%)				
CT	10,276 (100.0)	198 (100.0)	10,078 (100.0)	1.000
MRI	950 (9.2)	126 (63.6)	824 (8.2)	<0.0001
Plain x-ray	144 (1.4)	28 (14.1)	116 (1.2)	<0.0001
Flex-Ex CS x-ray	43 (0.4)	2 (1.0)	41 (0.4)	0.474

AVP, automobile versus pedestrian; BVA, bicycle versus automobile; CS, C-spine; Sx, surgery; MVC, motor vehicle collision; GLF, ground-level fall; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; HR, heart rate; MCC, motorcycle collision; SBP, systolic blood pressure; TBI, traumatic brain injury.

TABLE 2. Interventions and Outcomes of Blunt Trauma CS Patients (n = 10,276)

Variables	Total n = 10,276	CS Injuries (Sx, Halo, or CTO) n = 198	No CS injury n = 10,078	p
Final neurologic diagnosis, n (%)				
CS injury (all)	1,096 (10.7)	198 (100.0)	898 (8.9)	NA
CS injury (CTO, Halo, or Sx)	198 (1.9)	198 (100.0)	0 (0.0)	NA
CS injury (Halo or Sx)	178 (1.7)	178 (89.9)	0 (0.0)	NA
Treatment, n (%)				
None	7,774 (75.7)	0 (0.0)	7,774 (77.1)	NA
Soft collar	193 (1.9)	0 (0.0)	193 (1.9)	NA
Hard collar	2,063 (20.1)	0 (0.0)	2,063 (20.5)	NA
CTO	20 (0.2)	20 (10.1)	0 (0.0)	NA
Halo	25 (0.2)	25 (12.6)	0 (0.0)	NA
Sx	153 (1.5)	153 (77.3)	0 (0.0)	NA
Other	48 (0.5)	0 (0.0)	48 (0.5)	NA
Discharge GCS, median (IQR)	15 (15–15)	15 (15–15)	15 (15–15)	<0.0001
Discharge disposition, n (%)				
Home	7,258 (72.0)	70 (36.3)	7,188 (72.7)	<0.0001
Skilled nursing facility	928 (9.2)	25 (13.0)	903 (9.1)	0.139
Rehabilitation	777 (7.7)	67 (34.7)	710 (7.2)	<0.0001
Other	409 (4.1)	9 (4.7)	400 (4.0)	0.860
Outside hospital	361 (3.6)	13 (6.7)	348 (3.5)	0.029
Died	311 (3.1)	9 (4.7)	302 (3.1)	0.284
Jail	39 (0.4)	0 (0.0)	39 (0.4)	0.773
Hospital LOS, median (IQR)	2 (1–6)	8 (4.4–18.0)	2 (1.0–6.0)	<0.0001
ICU LOS, median (IQR)	0 (0–1.4)	3 (1.0–8.0)	0 (0–1.1)	<0.0001
In-hospital mortality, n (%)	311 (3.1)	9 (4.7)	302 (3.1)	0.284

CS, C-spine; GCS, Glasgow Coma Scale; ICU, intensive care unit; LOS, length of stay; Sx, surgery.

excluded from the final analysis. All patients underwent multi–detector-row helical CT (≥64 channels) at the 18 participating centers. Patients with C-spine imaging from outside hospitals were excluded. This was a convenience sampling. The patients who were not included in this study made up a small percentage of the total; however, further information on these patients was not obtained.

This was a pragmatic observational study, and all patient care decisions were made by the treating surgical team without reference to the study protocol. Likewise, any additional imaging including the use of MRI was at the discretion of the treating clinician based on individual provider preference and local institutional protocols. The history and physical examination were performed by a senior resident or faculty member using a structured form and included injury demographics, associated injuries, all imaging performed for the C-spine, and treatments rendered. All imaging was interpreted by an attending radiologist blinded to the study case report form contents, and the final attending radiologist reading was utilized for the analysis. The physical examination consisted of the NEXUS criteria including the patient's ability to cooperate with the assessment (awake and alert, not intoxicated, no painful distracting injuries), as well as for those who were evaluable, the presence or absence of midline C-spine tenderness and the results of the neurologic examination.

The primary outcome measure assessed in this study was the presence of a clinically significant C-spine fracture. For a fracture to be clinically significant, an abnormal or equivocal finding observed on either CT or MRI consistent with acute traumatic injury was necessary, along with one of three active interventions: surgical stabilization, Halo orthotic placement, or use of a cervical-thoracic orthotic (CTO).

TABLE 3. Characteristics of Patients With Clinically Significant Missed Injuries

Patient	Age, y	Gender	Mechanism	Treatment	CT	MRI	Final Diagnosis
1	79	Male	Auto vs. pedestrian	C5–6 ACDF	Degenerative disease	C6 cord contusion	Central cord syndrome
2	58	Male	Ground-level fall	C4–5 ACDF	Degenerative disease	C4–5 disk herniation	Central cord syndrome
3	36	Male	Fall from height	Anterior cervical microdiskectomy C4–5 arthrodesis	Normal	C4/5 cord contusion	Central cord syndrome

ACDF, anterior cervical diskectomy and fusion.

TABLE 4. Clinically Significant Injury Distribution by Location

					Fisher Exact Test *p*		
Level	All	Surgery	Halo	CTO	Sx vs. Halo	Halo vs. CTO	Sx vs. CTO
C1	27 (13.6%)	16 (10.5%)	9 (36%)	2 (10%)	0.0024	0.0791	1.0000
C2	66 (33.3%)	40 (26.1%)	22 (88%)	4 (20%)	0.0001	0.0001	0.7853
C3	18 (9.1%)	12 (7.8%)	3 (12%)	3 (15%)	0.4466	1.0000	0.3874
C4	51 (25.8%)	47 (30.7%)	3 (12%)	1 (5%)	0.0578	0.6174	0.0154
C5	59 (29.8%)	54 (35.3%)	4 (16%)	1 (5%)	0.0667	0.3624	0.0045
C6	94 (47.5%)	83 (54.2%)	3 (12%)	8 (40%)	0.0001	0.0409	0.2449
C7	64 (32.3%)	53 (34.6%)	2 (8%)	9 (45%)	0.0088	0.0059	0.4577

Surgery, 153 patients; Halo, 25 patients; CTO, 20 patients.

A power analysis was performed assuming a conservative estimated incidence of clinically significant C-spine injury of 2% derived from the largest prospective study cohort to date.[24] The sample size needed to achieve statistical significance at the 5% level, 2-tailed, with β value of 0.20 was 5,350 to detect 107 patients with a clinically significant injury. Categorical values were compared using the Fisher exact test or Pearson χ^2 test, as appropriate. Continuous variables were compared using an unpaired, 2-tailed *t* test. All analyses were performed using SPSS Mac version 23.0 (IBM Corp., Armonk, New York). Descriptive statistics were used to characterize the study population. Mean with SD or range and median with IQR were used to characterize age, Injury Severity Score, systolic blood pressure, heart rate, and Glasgow Coma Scale score. Using a criterion standard of the final diagnosis at the time of discharge, which included the results of all imaging and operative findings as the criterion standard, sensitivity, specificity, NPV, and PPV for CT scan in the diagnosis of clinically significant C-spine injury were calculated.

RESULTS

During the study period, 35,538 blunt trauma patients 18 years or older presented to the 18 study sites, with 10,765 screened patients meeting the entry criteria. Of these, 489 (4.5%) were excluded (previous spinal surgery [n = 470], outside hospital transfer [n = 17], both [n = 2]), resulting in 10,276 patients enrolled in the study protocol. Of the remaining 10,276 patients, 4,660 (45.3%) were unevaluable or with distracting injuries precluding evaluation, 5,040 (49%) had midline C-spine tenderness, and 576 (5.6%) had neurologic symptoms as their primary reason for inability to clear the C-spine clinically. The study population was predominantly male (66.7%) with a mean age of 48.1 years (range, 18–110 years) and median

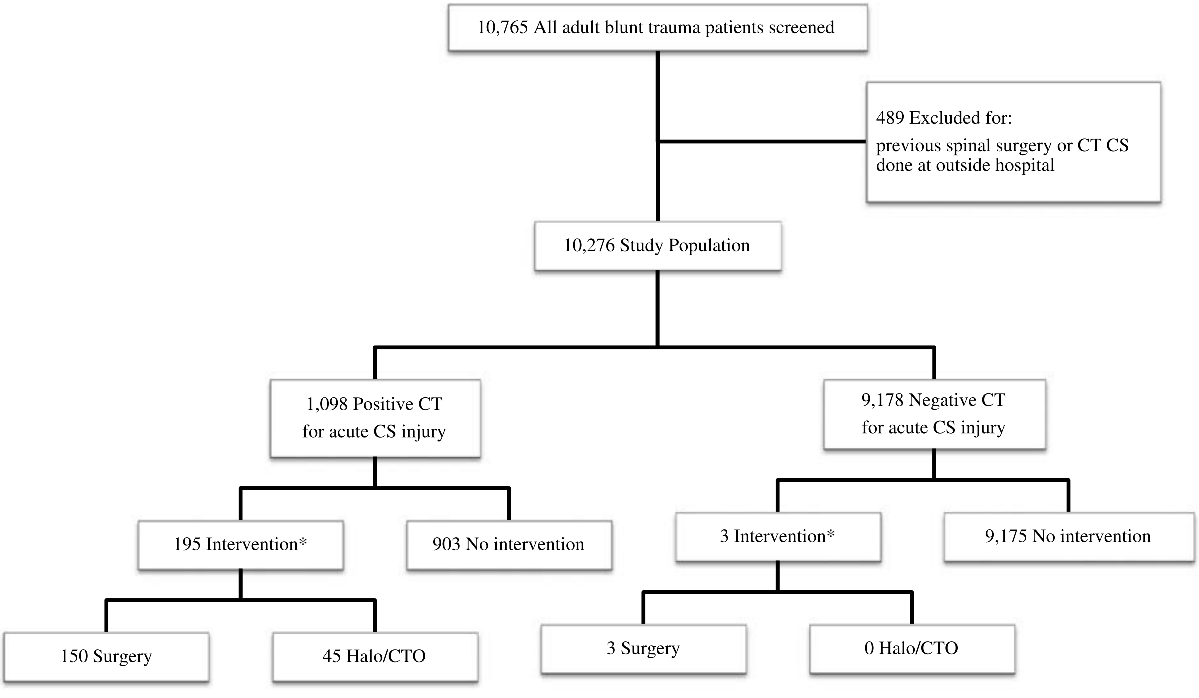

Figure 1. Enrolled adult, blunt trauma patients between September 2013 and March 2015. *Intervention was defined as surgery, Halo, or CTO. CS, C-spine; CTO, cervical thoracic orthotic.

Injury Severity Score of 9 (range, 4–16). The most common mechanism of injury was a motor vehicle collision (30.0%) followed by ground-level fall (20.9%) and fall from height (11.9%) (Table 1). Overall, 950 patients (9.2%) had MRI, and the median length of stay was 2 days (range, 1–6 days). The in-hospital mortality was 3.1%, none directly attributable to the C-spine injury (Table 2).

Of the 10,276 patients who failed the NEXUS low-risk criteria and required CT scan clearance, 1,096 (10.7%) received a diagnosis of an injury. Of these, 198 (1.9%) met the definition of clinically significant requiring intervention. Surgery was required for 153 (1.5%), a Halo orthotic was placed in 25 (0.2%), and a CTO was required for 20 (0.2%) (Table 2). All but three (1.5%) of these injuries were diagnosed on the initial CT scan, the remainder were diagnosed on MRI. These three patients with a nondiagnostic CT all had an index neurologic examination on presentation consistent with central cord syndrome. In addition, two had cervical degenerative disease on CT. All three underwent surgical stabilization (Table 3).

Injuries requiring surgery included fractures (83.3%), subluxation or dislocation (18.7%), stenosis (13.1%), ligamentous injury (13.1%), disk injury (4.0%), and epidural hematoma (4.0%). Surgical interventions included fusion, fixation or arthrodesis (88.4%), and decompression, laminectomy, or corpectomy (19.4%). The level of injury for those requiring operative intervention in decreasing frequency were C6 (54.2%), C5 (35.3%), C7 (34.6%), C4 (30.7%), C2 (26.1%), C1 (10.5%), and C3 (7.8%). Injuries requiring Halo orthotic placement involved C2 (88%), C1 (36%), C5 (16%), C6 (12%), C3 (12%), C4 (12%), and C7 (8%). Injuries requiring CTO were at C7 (45%), C6 (40%), C2 (20%), C3 (15%), C1 (10%), C4 (5%), and C5 (5%) (Table 4).

Overall, 2,063 patients (20.1%) were treated with a "hard" collar (Table 2). The discharge instructions ranged from wearing the collar for comfort to wearing the collar at all times. Of these, 1,438 (69.7%) had normal imaging and did not have a C-spine diagnosis at the time of discharge. For the remaining 625 patients with a finding on CT or MRI, 31 had a negative CT with a positive MRI. The MRI findings for 29 (93.5%) of these patients consisted of equivocal findings or edema, "sprains" or "strains." Two patients had a finding other than those described previously. One patient was a 55-year-old man who was a restrained rear-seat motor vehicle collision passenger who presented with C-spine and lower back tenderness and decreased right anterior thigh sensation. He had a normal CT of the C-spine with a concurrent distraction fracture involving the anterior cortical margin of the T9 vertebral body without subluxation and degenerative changes visible in the L-spine. On the MRI, there was widening of the anterior disk space at the C6–7 level and edema consistent with a possible injury to the anterior ligaments. He was treated with a semirigid collar, which was successfully removed at 6 weeks with no residual neurologic issues. The second patient was a 48-year-old woman who presented after a motor vehicle collision with C-spine tenderness and a normal neurologic examination. The CT was negative; however, the MRI was equivocal for injury, demonstrating a possible nondisplaced fracture involving the left inferior articular facet of C5. A semirigid collar was prescribed for when the patient was out of bed. Both

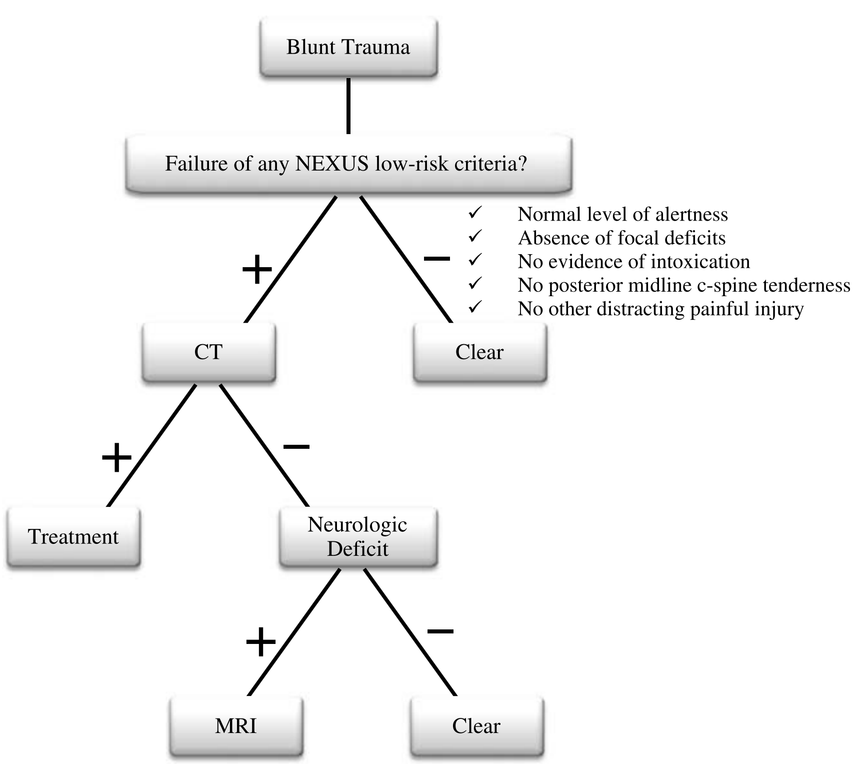

Figure 2. Clinical decision rule for C-spine evaluation after blunt trauma. NEXUS criteria defined by Hoffman et al.[2]

injuries were considered to be stable injuries by the neurosurgery service caring for the patient.

Comparison of CT with the criterion standard of final diagnosis at the time of discharge demonstrated a sensitivity of 98.5% and specificity of 91.0% for clinically significant injuries. The PPV was 17.8%, and NPV was 99.97%. In all patients with a clinically significant C-spine diagnosis, either the CT was positive for injury, or there was an abnormal motor examination. No clinically significant injury was missed when CT was combined with the motor examination. Comparison of CT and motor examination with the criterion standard of final diagnosis at time of discharge demonstrated a 100% sensitivity with an NPV of 100% for detecting all clinically significant C-spine injuries (Fig. 1).

DISCUSSION

Clearance of the C-spine remains a critical step in the management of the multisystem blunt trauma patient. There are severe consequences if a clinically significant injury is missed, especially in the patient who arrives neurologically intact, with an occult unstable injury. Clinical examination has been demonstrated to be effective at determining who requires imaging, with both the NEXUS low-risk criteria and Canadian C-spine Rules[2,25,26] documenting high sensitivities and acceptable specificities for the detection of clinically significant injuries. Patients who cannot be cleared by these clinical decision rules require screening imaging. While CT has been accepted as the standard first-line diagnostic modality, the adequacy of a normal CT alone has been questioned.

Unfortunately, the literature providing the foundation for our current clinical practice remains less than ideal, with small, predominately retrospective and single-center–based case series attempting to evaluate the adequacy of CT for clearance. With a retrospective study design, accurate capture of the presenting clinical examination in particular remains a challenge. In 2015, the Eastern Association for the Surgery of Trauma confronted this issue by performing a systematic review of the existing literature.[23] They targeted a specific population, those who could not be cleared by the NEXUS low-risk criteria because of being obtunded. Their practice management guidelines highlighted the paucity of patients enrolled in the five studies that met their inclusion criteria. Despite this limitation, they did conclude that a high-quality negative CT could effectively exclude an unstable fracture. They noted that this was due to both the discriminating ability of the CT and the downstream effects of additional imaging such as MRI detecting clinically irrelevant injuries that go on to be treated. There is also a real risk to the travel required to obtain this additional imaging. The group emphasized the need for large, protocol-driven, prospective corroborating data sets to support their conclusions. In addition to the obtunded patient, a subset of the evaluable patient cohort may also require screening imaging. These are patients with either residual midline C-spine tenderness or neurologic deficits. Unfortunately, there are even fewer data supporting the accuracy of CT screening in this patient population. In a contemporary prospective observational study of 830 patients, for those with tenderness or a neurologic deficit, the sensitivity was again found to be 100% for clinically significant injuries.[24]

This is the first large-scale prospective multicenter study to address the adequacy of CT as a screening modality, and the findings were consistent with those of the studies previously discussed. For all clinically significant fractures, CT has a high sensitivity with acceptable specificity and is therefore an effective screening modality. For the three patients who had injuries that were missed by CT, all had a neurologic motor deficit consistent with central cord syndrome. If all patients with a negative CT who had a neurologic deficit underwent MRI, the sensitivity for detecting clinically significant injuries would be increased to 100%.

In this study cohort, approximately a fifth of patients were treated with a hard collar. This was expressly omitted as a clinically significant outcome measure because of the difficulty in adjudicating the clinical relevance of the diagnoses leading to these collars being prescribed. Highlighting this fact was the wide variability in the instructions given to the patient at discharge ranging from wear for comfort, to when out of bed, to at all times. Perhaps even more important was that fact that more than two thirds of patients who were prescribed one of these collars had no C-spine injury diagnosis at the time of discharge. Despite the pitfalls of using this as an outcome measure, because of the potential that there may have been a clinically significant injury within this group of patients, all patients with a negative CT but positive MRI resulting in collar prescription were reviewed in detail. This amounted to approximately 1.5% of the study population. The vast majority of these had equivocal findings or a strain or sprain. The two patients who had an MRI with something other than a strain or sprain both had MRI findings that were equivocal, and even if there truly was an injury, they would have been stable and would not have benefited from prolonged immobilization or surgery. While it was not possible to confirm the clinical relevance of the “strains” and “sprains” diagnosed on MRI and treated with a hard collar, the possibility remains that some of these were clinically relevant. This remains a limitation of the study. Practically, the prescription of a collar for outpatient use in these patients with midline C-spine tenderness for comfort without a defined injury may be warranted at the discretion of the treating physician.

In summary, the primary objective of this study was to evaluate the ability of CT to clear the C-spine. In this large multicenter study, CT was found to be highly sensitive for clinically significant injuries. Based on these results, we would propose the following decision-making algorithm (Fig. 2). For the patient who arrives into the resuscitation bay after blunt trauma with an uncleared C-spine, the NEXUS low-risk criteria should be applied. If negative, the collar should be removed. All other patients should proceed to CT as the initial screening modality. If the CT is adequate and negative, the collar may be removed with a low risk of clinically significant injury. The only exception to this is the patient who arrives with motor or sensory neurologic deficits or without witnessed movement of all extremities. Even if the CT is adequate and negative, MRI may detect a small percentage of patients who have clinically significant injuries.

AUTHORSHIP

All authors contributed actively to the drafting and critical revision of the manuscript, and each approved the final version being submitted. In addition, the authors contributed to the following: K.I.: concept; literature search; study design; data collection, analysis and interpretation. S.B.: literature search; study design; data collection, analysis and interpretation. L.D.B.: data collection and analysis. M.J.M.: data collection, analysis and interpretation. D.M.: data collection and interpretation. K.A.P.: data collection and interpretation. G.B.: data collection and interpretation. M.J. B.: data collection and interpretation. J.P.H.: data collection and interpretation. R.C.: data collection and interpretation. J A.J.C.: data collection and interpretation. C.V.R.B.: data collection and interpretation. C.G.B.: data collection and interpretation. J.R.C.-B.: data collection and interpretation. C.C.B.: data collection and interpretation. B.J.: data collection and interpretation. J.D.: data collection and interpretation. C.T.M.: data collection and interpretation. M.M.C.: data collection and interpretation. G.M.B.: data collection and interpretation. D.D.: study design; data collection, analysis and interpretation.

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DISCLOSURE

The authors declare no conflicts of interest.

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EDITORIAL CRITIQUE

Although relatively infrequent, undetected traumatic cervical spine injuries can result in subsequent patient neurological injury, potentially with catastrophic results. Current literature supports the concept that cervical spine clearance can be achieved utilizing the NEXUS decision-making rule. Furthermore, when imaging is required in the adult patient, computed tomography is superior to plain film radiography. Current consensus gaps in knowledge are found in the potential use of computed tomography (CT) as the sole imaging modality in obtunded patients and symptomatic patients. The possibility of clinical reliance on CT is attractive as imaging with magnetic resonance imaging and cervical collar prophylaxis carry additional costs and the potential for significant risks.

The Western Trauma Association trial is a large prospective multicenter observational study aimed at determining the sensitivity and specificity of CT for clinically significant cervical spine injury, defined in this trial as injury requiring surgical stabilization, halo, or CTO. The observational structure of the study provides a "real world" evaluation of the role of CT, but sacrifices some generalizability due to the practice heterogeneity regarding the use of cervical collars. Additionally, the use of condition at discharge as the gold-standard diagnostic criterion would miss the rare delayed presentation of an unrecognized injury. Regardless, the large data set and the authors' realistic appraisal of the strengths and limitations of the study design and results allows the reader to appropriately frame the new data within the current body of literature.

In the adult trauma patient, absent a history of prior spinal surgery, who fails a NEXUS low-risk criteria, an appropriately protocolled and technically adequate CT exam may be adequate for cervical spine clearance in the absence of neurological deficit. However, the heterogeneity in the use of cervical collars and use of MRI among study participants, speaks to the importance of clinical discretion when decision making is applied to individual cases. Furthermore, the three cases with neurologic deficits and normal CT exams, argues against generalization of study results to obtunded patients.

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