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

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BACKGROUND: With the use of the framework advocated by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group, our aims were to perform a systematic review and to develop evidence-based recommendations that may be used to answer the following PICO [Population, Intervention, Comparator, Outcomes] question:
In the obtunded adult blunt trauma patient, should cervical collar removal be performed after a negative high-quality cervical spine (C-spine) computed tomography (CT) result alone or after a negative high-quality C-spine CT result combined with adjunct imaging, to reduce peri-clearance events, such as new neurologic change, unstable C-spine injury, stable C-spine injury, need for post-clearance imaging, false-negative CT imaging result on re-review, pressure ulcers, and time to cervical collar clearance?

METHODS: Our protocol was registered with the PROSPERO international prospective register of systematic reviews on August 23, 2013 (Registration Number: CRD42013005461). Eligibility criteria consisted of adult blunt trauma patients 16 years or older, who underwent C-spine CT with axial thickness of less than 3 mm and who were obtunded using any definition.
Quantitative synthesis via meta-analysis was not possible because of pre-post, partial-cohort, quasi-experimental study design limitations and the consequential incomplete diagnostic accuracy data.

RESULTS: Of five articles with a total follow-up of 1,017 included subjects, none reported new neurologic changes (paraplegia or quadriplegia) after cervical collar removal. There is a worst-case 9% (161 of 1,718 subjects in 11 studies) cumulative literature incidence of stable injuries and a 91% negative predictive value of no injury, after coupling a negative high-quality C-spine CT result with 1.5-T magnetic resonance imaging, upright x-rays, flexion-extension CT, and/or clinical follow-up. Similarly, there is a best-case 0% (0 of 1,718 subjects in 11 studies) cumulative literature incidence of unstable injuries after negative initial imaging result with a high-quality C-spine CT.

CONCLUSION: In obtunded adult blunt trauma patients, we conditionally recommend cervical collar removal after a negative high-quality C-spine CT scan result alone. (*J Trauma Acute Care Surg*. 2015;78: 430–441.

LEVEL OF EVIDENCE: Systematic review, level III.
KEYWORDS: Cervical spine; cervical collar; obtunded; blunt trauma; clearance.

Cervical spine (C-spine) collar clearance or removal is well established for the alert patient with or without symptoms;[1,2] however, for the obtunded adult blunt trauma patient, it is unclear whether primary screening with computed tomography (CT) is sufficient or whether a second diagnostic adjunct is required.[3] The imprecise and possible overly broad interpretation

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of the word *obtunded* along with continual advances in imaging technology confound the decision to remove the cervical collar after blunt traumatic injury. Despite the multispecialty impact that a guideline directing efficient cervical collar clearance in the obtunded adult blunt trauma patient would have, there is no consensus recommendation available.

With the use of the framework advocated by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group,[4–6] our aims were to perform a systematic review and to develop evidence-based recommendations that might be used to direct decision making in the removal of a cervical collar from the adult obtunded blunt trauma patient.

OBJECTIVE

Our PICO [Population, Intervention, Comparator, and Outcomes] questions were structured as follows:

Population

In the obtunded adult blunt trauma patient

Intervention

Should cervical collar removal be performed after a negative high-quality C-spine CT result combined with adjunct imaging?

Comparator

Should cervical collar removal be performed after a negative high-quality C-spine CT result alone?

Outcome

To reduce peri-clearance events, such as new neurologic change (paraplegia, quadriplegia), unstable C-spine injury (subcategories, treated with operation or treated with orthotic), stable C-spine injury (subcategories treated with operation or treated with orthotic), post-clearance imaging, false-negative CT imaging result on re-review, pressure ulcers, and time to cervical collar clearance.

PATIENTS AND METHODS

Study Eligibility

Our PICO question and protocol were registered with the PROSPERO international prospective register of systematic reviews[7,8] on August 23, 2013 (Registration Number: CRD42013005461) and last revised on June 18, 2014. Inclusion criteria consisted of adult blunt trauma patients 16 years or older, who underwent C-spine CT with axial thickness of less than 3 mm and who were obtunded with any author-specified definition of this term (Glasgow Coma Scale [GCS] score < 15, unconscious, intubated, altered mental status, unreliable examination, distracting injury, intoxication, or not meeting NEXUS guidelines).

Exclusion criteria consisted of those studies that did not specify axial CT slice thickness and those with axial slice thickness of 3 mm or greater, so as to eliminate outdated CT technique and/or equipment. We also excluded case reports, newspaper articles, letters, comments, practice guidelines, news, editorials, legal cases, reviews, or congresses that contained no original data. However, to ensure our search strategy did not exclude any appropriate articles, we manually searched the references of all included and excluded publications, and we did not restrict by publication date or language.

Interventions and Comparators

Given the lack of randomized clinical trial data and near absence of complete cohort study designs, we anticipated and allowed partial cohort and pre-post study designs. Thus, each patient underwent a C-spine CT that was read as normal and was then retested with the comparator adjunct imaging and/or physical examination. Study design issues among intervention and comparators precluded a quantitative synthesis (estimate of treatment effect, heterogeneity assessment, meta-analysis, or full quality assessment).

Types of Critical Outcomes

As per GRADE methodology, outcomes were chosen by the team and rated in importance from 1 to 9 (Fig. 1), with scores of 7 to 9 representing critical outcomes. The critical outcomes were new neurologic change resulting in paraplegia or quadriplegia after cervical collar removal and identification of an unstable injury. The latter outcome measure was subcategorized into whether it was treated with an operation or an orthotic (e.g., cervical collar).

Types of Secondary Outcomes

The secondary outcomes, in order of decreasing importance, were stable C-spine injury (subcategories, treated with operation or treated with an orthotic), post-clearance imaging, false-negative CT imaging result on re-review, pressure ulcers, and time to cervical collar removal.

Information Sources

We conducted a systematic search using the PubMed, EMBASE, and the Cochrane Central Register of Controlled Trials (CENTRAL) databases with no restriction on study date. This search was last run on August 15, 2013, and our search terms are listed (Supplemental Digital Content, at http://links.lww.com/TA/A510). Given the time elapsed between the initial search and the data extraction stage, as of May 14, 2014, eight additional recent articles were provided for additional full-text review.

Selection of Studies

After completing the electronic literature search, two independent reviewers screened titles and abstracts, applying inclusion criteria. Any reviewer discordance was conservatively resolved by inclusion into the full-text phase. The resulting studies then underwent full-text review, again by two independent reviewers, to determine appropriateness for inclusion in the quantitative synthesis phase. Any disagreement at this stage was resolved by consensus between the two reviewers and, if necessary, the addition of a third reviewer.

Data Extraction and Management

At each stage of the systematic review, all forms used by each reviewer were entered into Web-based DistillerSR (2014 Systematic Review and Literature Review Software from Evidence Partners) and exported into Microsoft Excel for table creation.

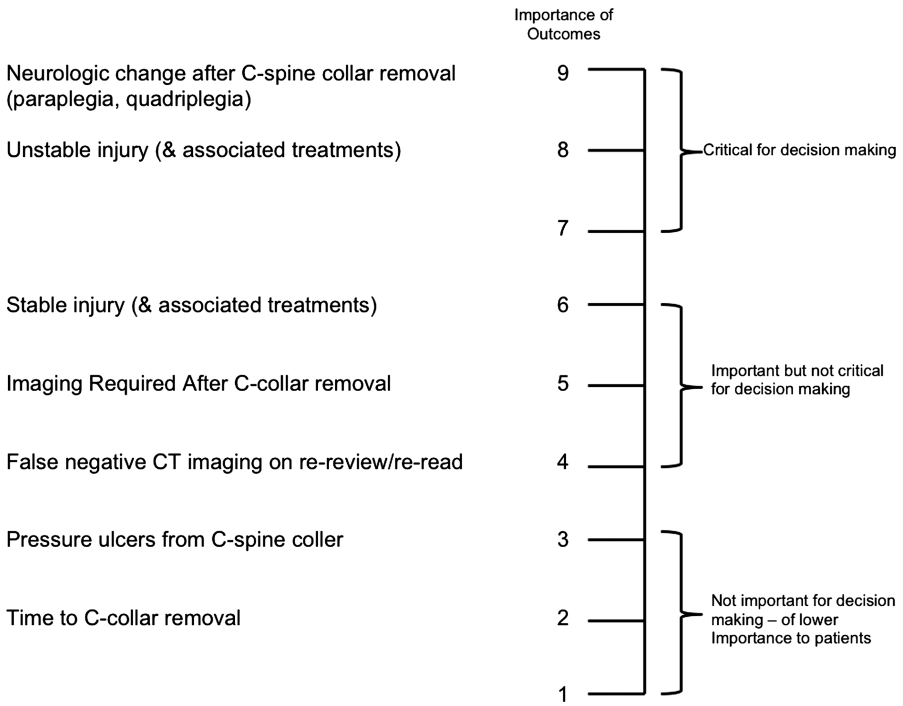

Figure 1. Hierarchy of outcomes for assessing C-spine collar removal in the obtunded adult blunt trauma patient after a negative C-spine CT result.

We extracted the following data: study author, study dates (as opposed to publication dates), population demographics (age, Injury Severity Score [ISS], GCS score, and definition of *obtunded*), adjunct method following C-spine CT, type of C-spine injury (bone, ligament, spinal cord, or intervertebral disc), stability of C-spine, and treatment provided for identified injury (if any). We did not capture sex or blunt injury mechanism subtype because of the literature deficits in plausibly linking these variables to any of our defined outcome measures. Given the overlap between patient factors and secular trends (e.g., institutional protocols, slice number, machine types), both associated with optimal spatial and contrast resolution for imaging of the C-spine, we limited our imaging data collection to axial thickness (in millimeters) for CT and Tesla strength for magnetic resonance imaging (MRI). We also aimed to capture any recognized false-negative C-spine CT radiographic interpretations on either clinical or research reassessment, cervical collar complication (e.g., pressure ulcer), and time to cervical collar clearance. The term *obtunded* required an operationalized definition using the terms *Glasgow Coma Scale*, *altered*, *intoxicated*, *intubated*, *unconscious*, and/or u*nreliable exam*.

Unstable injuries were identified primarily using the system delineated by White and Punjabi and the three-column model of Denis.[9–11] C-spine instability required either a fracture or fractures involving contiguous columns or levels, bone misalignment (subluxations, listhesis, interspinous widening, or splaying), or single-level ligamentous injury involving all three columns. A priori, our committee consensus of clinical judgment was that a 3 of 1,000 rate (0.3%) was an upper acceptable limit for a missed unstable C-spine injury. Spinal cord injuries included spinal epidural hematomas, subdural hematomas, cord edema, or cord contusions. Nonligamentous soft tissue injury was captured, when specified. If discrepancies existed among reviewed text and figures/tables, the former was prioritized.

Risk of Bias

Given that the most consistent outcome measures reported were those of diagnostic accuracy (identification of stable or unstable injury), we chose the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool to assess the quality of our included studies. The QUADAS-2 tool assesses four domains as follows: patient selection, index test, reference standard, and patient flow.[12,13] Each domain was assessed in terms of risk of bias, and the first three domains were also assessed for applicability.

RESULTS

Qualitative Synthesis

At the qualitative synthesis level, 40 of 52 studies were excluded because of the following reasons: 2 were systematic reviews,[14,15] 1 used survey data,[16] 11 did not use C-spine CT as a distinct primary imaging modality,[17–27] 13 failed to define or had 3 mm or greater axial CT thickness,[28–40] 11 had an undefined or mixed obtunded and nonobtunded population,[26,41–50] and 2 were case reports.[51,52] As outlined in our PRISMA [Preferred Reporting Items for Systematic Reviews and Meta-Analyses][53] diagram (Fig. 2), 12 studies were included in the qualitative synthesis and data extraction.[54–65] Quantitative synthesis via meta-analysis was not possible because of the previously mentioned partial-cohort study design

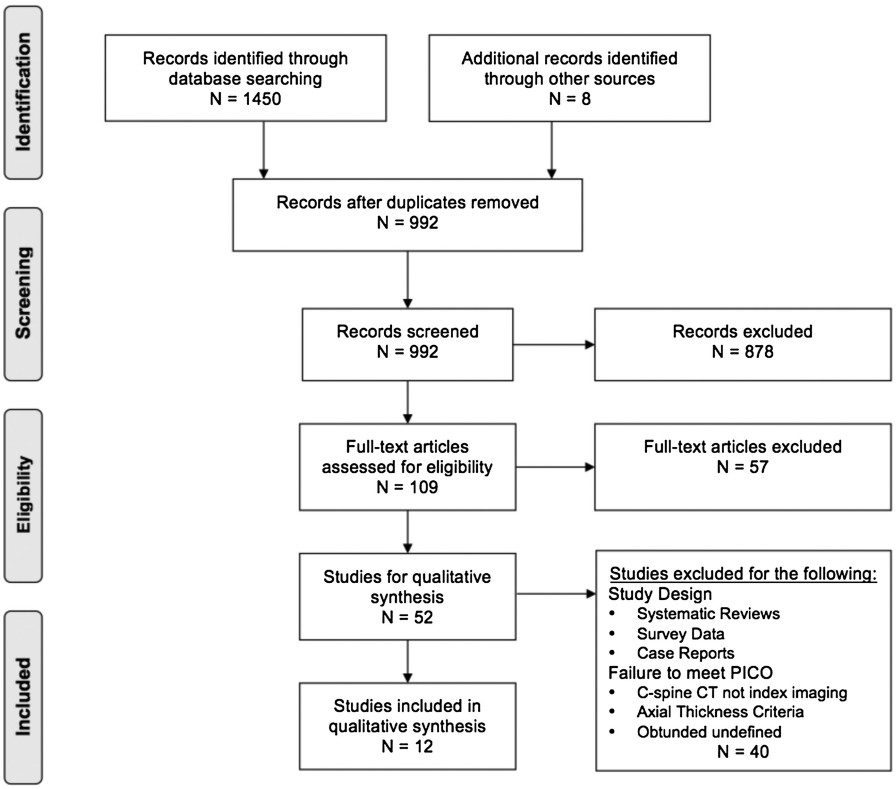

Figure 2. PRISMA flow diagram for systematic review phases of cervical collar clearance in the obtunded adult blunt trauma patient.

limitations and the consequential incomplete diagnostic accuracy data.

All were pre-post imaging studies and partial cohorts without attention to the positive C-spine CT result, except for one complete cohort study.[55] Four studies were prospective, and the remaining eight were retrospective. The most common adjunct imaging method was MRI at 1.5 T. Alternative adjunct methods included upright C-spine films, flexion-extension CT scans, and in-hospital clinical follow-up. General population demographics demonstrated some variability in age and injury severity (Table 1).

In particular, the study definition of an obtunded patient involved a nonnormal GCS score and/or inconsistent inclusion of at least one of the following terms: *altered*, *intubated*, *unconscious*, *unreliable* exam. Two studies required obtunded patients to have movement of all extremities (Table 2).

Of five articles with a total follow-up of 1,017 included subjects, none reported new neurologic change (paraplegia or quadriplegia) after cervical collar removal. Of 11 studies with a total of 1,718 subjects, no study reported an unstable C-spine fracture; one of the studies did not clearly report this outcome. There is a 9% incidence of stable injuries (161 of 1,718 in 11 studies) after coupling a negative high-quality C-spine CT result with 1.5-T MRI, upright x-ray series, flexion-extension CT, and/or clinical follow-up. Thus, the negative predictive value for C-spine CT was 100% for an unstable C-spine injury and 91% for any stable injury of the C-spine (Table 3).

Ligamentous injury was most commonly identified using adjunct testing. Strategies most commonly performed after adjunctive testing were either the continued use of a cervical collar or removal of the cervical collar, as opposed to operation. The relationship among C-spine injury subtypes, multiplicity of injury subtypes for a single subject, C-spine stability, and treatment was not clearly reported in most articles. False-negative clinical reread results were not reported in these studies, and rarely were pressure ulcers or time to collar clearance reported (Table 4).

Overall, bias assessment indicated high bias across patient selection, index test (C-spine CT), reference standard, and patient flow domains. Specifically, 10 of the 12 studies had high bias across all four domains. The two remaining studies still had high bias across three of four domains, but one had low bias in the interpretation of the index test because of independent radiographic study-related readings,[60] and the other had low bias regarding patient flow.[57]

RESULTS

Grading the Evidence

Following the GRADE methodology,[4–6] inconsistency of results, imprecision, and publication bias were difficult to assess because of the study design limitations of pre-post partial cohorts, resulting in an inability to perform a meta-analysis across any outcome measure. The quality of the evidence was further reduced because of indirectness of evidence relative to our wide definition of *obtunded* (population), noncomparable institutional imaging protocols (intervention and comparator), and inconsistently reported and often unavailable

TABLE 1. Study Designs, Demographics, and Adjuncts to C-spine CT for Cervical Collar Clearance in the Obtunded Adult Blunt Trauma Patient

Reference Number	Author	Article Year	Data Dates	Mean Age	Age Range	Mean ISS	Study Time	CT Axial Thickness, mm	Adjunct	MRI Strength, T
54	Anekstein et al.	2008	July 1, 2004, to January 31, 2005	36			Partial prospective cohort	1.3	Flexion-extension CT	N/A
55	Brohi et al.	2005	February 2002 to January 2004	34 (25–50)*			Prospective cohort	2.0	MRI** or clinical follow-up	N/R
56	Chew et al.	2013	January 2004 to June 2011	47†	13–97†		Partial retrospective cohort	1.0–2.0	MRI	1.5
57	Como et al.	2011	October 2006 to September 2008	47.3	4–99	23.2	Partial prospective cohort	0.9–1.0	Clinical follow-up	N/A
58	Harris et al.	2008	January 1, 2003, to December 31, 2004	40.2		24.5	Partial retrospective cohort	2.5	Upright C-spine	N/A
59	Kaiser et al.	2012	January 1, 2005, to August 1, 2008; September 20, 2008, to June 30, 2009	39	1–99	26	Partial retrospective cohort	1.0	MRI	1.5
60	Khanna et al.	2012	January 2004 to June 2008	36	1–89		Partial retrospective cohort	1.25	MRI	1.5
61	Menaker et al.	2010	July 2006 to July 2007	44.2		26	Partial retrospective cohort	1.0	MRI	1.5
62	Menaker et al.	2008	August 2004 to December 2005	42.3		29.1	Partial retrospective cohort	2.0	MRI	1.5
63	Schuster et al.	2005	January 1, 1999, to December 31, 2003	49.1		11.4	Partial prospective cohort	2.0	MRI	1.5
64	Steigelman et al.	2008	January 2002 to December 2006	33	0–91	24	Partial retrospective cohort	1.0–2.0	MRI	1.5 or 3.0
65	Tomycz et al.	2008	January 2003 to December 2006	43.7	15–93		Partial retrospective cohort	1.25	MRI	1.5

*Median (interquartile range).
**Twenty-four patients with MRI, remainder clinical follow-up.
†Age data were not separated for obtunded and nonobtunded populations.
N/A, Not Applicable.
NR, Not clearly Reported.

outcomes. Publication bias was present, as there is at least one case report[51] noting neurologic change after collar clearance with a negative C-spine CT result. Moreover, across multiple institutions, we have encountered at least one case of neurologic change. Thus, the quality of evidence across all outcomes is very low.

For one of our critical outcome measures, we rated up the quality of evidence from low quality to moderate quality for magnitude of effect, given the consistently high negative predictive value (100%) of a normal C-spine CT result for the finding of an unstable C-spine injury. Despite this, the overall quality of evidence across all outcomes remains very low because of the very low-quality evidence available for our most critical outcome, neurologic change after cervical collar removal (Table 5).

RECOMMENDATION

In obtunded adult blunt trauma patients, we conditionally recommend cervical collar removal after a negative high-quality C-spine CT scan result alone (Fig. 3). This conditional recommendation is based on very low-quality evidence but places a strong emphasis on the high negative predictive value of high-quality CT imaging in excluding the critically important unstable C-spine injury. Our recommendation is further supported by the high costs of MRI or other additional imaging. Adjunctive imaging after a high-quality CT scan increases the number of low-value diagnoses, places patients at risk for unnecessary treatment plans, puts patients with multiple injuries at risk by moving them out of the intensive care unit to the resource-limited MRI suite, and at best, results in the same clinical action of collar removal. However, the use of this approach may result in a nonzero rate of neurologic deterioration.

DISCUSSION

The multispecialty authors of this guideline conclude that in obtunded adult blunt trauma patients, cervical collars should be removed after a negative high-quality C-spine CT result alone. This recommendation is based on the finding that there is a worst-case 9% cumulative literature incidence of stable injuries and a 91% negative predictive value of no injury, after coupling a negative high-quality C-spine CT result with 1.5-T MRI, upright x-ray series, flexion-extension CT, and/or clinical follow-up. Similarly, there is a best-case 0% cumulative literature incidence of unstable C-spine injuries after negative initial imaging result with a high-quality C-spine CT.

The strengths of this work included the transparent multilevel systematic dual-review of the literature, an a priori publically available protocol and PICO question, as well as the multispecialty nature of the group. The authors were affiliated with 12 institutions, the GRADE working group, as well as the Eastern Association for the Surgery of Trauma and its Guidelines Committee and represent the fields of anesthesiology, emergency medicine, general surgery, orthopedics, public health, neurocritical care, neuroradiology, neurosurgery, rehabilitation, spine surgery, surgical critical care, as well as trauma and acute care surgery.

TABLE 2. Obtunded Definition for Cervical Collar Clearance in the Obtunded Adult Blunt Trauma Patient

Reference Number	Author	Mean GCS Score	GCS Score Range	Altered	Intubated	Unconscious	Unreliable Exam	Other
54	Anekstein et al.		≤13		Y			
55	Brohi et al.		≤11 T**		Y	Y		
56	Chew et al.		≤8					
57	Como et al.	6.7 (8.2*)					Y	Moving all 4 extremities
58	Harris et al.	5.9	≤13					Head Abbreviated Injury Scale (AIS) score ≥ 3
59	Kaiser et al.	8	≤14	Y				
60	Khanna et al.		≤8					
61	Menaker et al.	9.5	≤14				Y	
62	Menaker et al.	9.7	≤14					
63	Schuster et al.		≤8					Moving all 4 extremities
64	Steigelman et al.		≤14					
65	Tomycz et al.		≤13					

*GCS score on cervical collar clearance.
**Not author specified, but 11 T or less is operational definition of unconscious and intubated.
Y, Yes.

We acknowledge the weakness in data quality related to imprecision, publication bias, and indirectness of evidence as well as included study design limitations (see Results under the section on Grading the Evidence). It is possible that there is a Type II error in this systematic review because of the available literature that may be populated by underpowered studies. Moreover, the majority of the studies fail to report on those subjects with a positive C-spine CT result, so complete diagnostic accuracy[66] of C-spine CT remains unclear (e.g., prevalence, positive predictive value), as does the basis of other reported meta-analyses. In addition, we did not address pediatric patients.[67–69] Although we did look for the less important patient-centric outcomes of time to cervical collar clearance and pressure ulcers, we did not capture time to imaging adjunct because there is no evidence that the timing of adjunct imaging (i.e. MRI greater or less than 48 hours) influences imaging quality or interpretation.[70] Lastly, applying basic biomechanical theory behind C-spine stability,[9–11] the decision making surrounding the treatment of subtle stable injuries remains uninterpretable using available literature; nonetheless, there were only three documented operations among 1,814 subjects.

Strikingly, we found the term *obtunded* to have widely differing interpretations. There were no clear definitions applicable to clinicians, and there were no measures of validity or interrater reliability. This led to population contamination in many of the excluded studies[26,41–50] as well as a

TABLE 3. Critical Outcomes for Cervical Collar Clearance in the Obtunded Adult Blunt Trauma Patient

Reference number	Author	No. Negative CT C-spine Result	No. Positive Adjunct	NPV of CT C-spine for Any Injury	No. Unstable Injuries	NPV of CT C-spine for an Unstable Injury	No. Stable Injuries	NPV of CT C-Spine for Stable Injury	Neuro Change After Cervical Collar Removal
54	Anekstein et al.	31	0	100.0%	0	100.0%	0	100.0%	0
55	Brohi et al.	326	1	99.7%	0	100.0%	1	99.7%	0
56	Chew et al.	132	21	84.1%	0	100.0%	21	84.1%	NR
57	Como et al.	197	1	99.5%	0	100.0%	1	99.5%	0*
58	Harris et al.	367	1	99.7%	0	100.0%	1	99.7%	0**
59	Kaiser et al.	114	23	79.8%	0	100.0%	23	79.8%	NR
60	Khanna et al.	150	74	50.7%	0	100.0%	74	50.7%	NR
61	Menaker et al.	96	15	84.4%	NR	N/A	7 + NR	N/A	NR
62	Menaker et al.	203	18	91.1%	0	100.0%	18	91.1%	0†
63	Schuster et al.	12	0	100.0%	0	100.0%	0	100.0%	NR
64	Steigelman et al.	120	7	94.2%	0	100.0%	7	94.2%	0
65	Tomycz et al.	180	38	78.9%	0	100.0%	38	78.9%	NR
	Total average	**1,814**	**176**	**88.5 %**	**0**	**100.0%‡**		**90.6%**	**0**

*Of 197, 22 lost to follow-up and 25 died.
**Denominator is 328.
†Denominator is 182.
‡Numerator and denominator are 1,718.
NR, Not clearly Reported.
No., Number of.
NPV, Negative Predictive Value.

TABLE 4. Additional Outcomes for Cervical Collar Clearance in the Obtunded Adult Blunt Trauma Patient

					Treatment With			Injury Substrata						
Reference Number	Author	No. Negative CT C-spine Result	No. Positive Adjunct	No. Stable Injuries	Cervical Collar	Operation	Removal of Cervical Collar	Ligament	Cord	Bone	Disc	Soft Tissue	Pressure Ulcer From Cervical Collar	Mean Day of Cervical Collar Removal
54	Anekstein et al.	31	0	0	0	0	31	0	0	0	0	0	NR	NR
55	Brohi et al.	326	1	1	NR	NR	NR	0	0	1	0	0	NR	1*
56	Chew et al.	132	21	21	21	0	0	21	0	0	0	0	NR	NR
57	Como et al.	197	1	1	0	0	1	1	0	0	0	0	1	3.3
58	Harris et al.	367	1	1	1	0	0	1	1	0	0	0	NR	2.6**
59	Kaiser et al.	114	23	23	7	0	16	15	8	1	0	NR	NR	NR
60	Khanna et al.	150	74	74	NR	0	NR	60	5	0	9	NR†	NR	NR
61	Menaker et al.	96	15	7 + NR	7	1	7	7	7	1	0	0	NR	NR
62	Menaker et al.	203	18	18	14	2	2	13	5	0	0	1	NR	NR
63	Schuster et al.	12	0	0	NR	0	NR	0	0	0	0	0	NR	NR
64	Steigelman et al.	120	7	7	2	0	5	3	1	0	1	2	NR	NR
65	Tomycz et al.	180	38	38	38	0	0	16	6	1	4	12	NR	NR

*90.5% of cervical collars removed in 24 hours.
**Of known data on 328 subjects (89%).
†Combined with ligament injury.
NR, Not Clearly Reported.

number of previously published systematic reviews.[14,15,71] The argument that the obtunded population is most at risk for an unrecognized and devastating C-spine injury is often theoretically quoted as being based on higher concomitant multisystem injury and more severe physiologic insult, combined with the inability to perform a thorough neurologic examination. However, in this supersaturated high-risk population, given a high-quality C-spine CT, the negative predictive value of finding an unstable injury seems to be or is very close to 100%.

If the prevalence of C-spine injury is lowered and approaches zero because the population is increasingly composed of nonobtunded subjects, then the negative predictive value of a C-spine CT should approach 100%—this is the undeniable Bayesian statistical relationship between predicted value and disease prevalence using a test with high sensitivity and specificity.[72,73] Therefore, if collars are to be removed in a high-risk obtunded population, then why even use a C-spine clearance protocol[16,74–76] for the low-risk neurologically normal who have negative C-spine CT data? With a high-quality C-spine CT, cervical collar removal can be logically argued for any population, obtunded or not.

It should be acknowledged that cervical collar removal can result in neurologic change and even paralysis, although this may be underreported in the literature.[52,77,78] However, we cannot continue indiscriminate two-stage sequential screening for C-spine injuries if the injury rate is near 0% for the first test and the second adjunctive test results in false positives and inconsistent treatment plans. The essence of a diagnostic screening test is reduction of ambiguity surrounding a patient problem, not elimination. The medical community and legal community have interestingly and unsuccessfully tried to vanquish missed C-spine injuries with C-spine imaging and re-imaging, but our goal should be to achieve the greatest good for the greatest number of patients at reasonable risk, without significant overtriaging and undertriaging, to efficiently use finite resources, and to eliminate low-value, low-impact services (http://www.choosingwisely.org/).[79] Otherwise, all patients would be receiving Western blots for all negative enzyme-linked immunosorbent assay results for fear of missing a human immunodeficiency virus diagnosis, [80,81] all patients would be undergoing both cardiac catheterizations in addition to electrocardiographies when presenting with new chest pain for fear of undiagnosed myocardial infarction,[82] and we would indiscriminately admit every injured patient presenting to a Level 1 trauma center.[83]

There are many systematic reviews, meta-analyses, and guidelines[14,16,17,70,71,76,84–87] focusing on this topic; however, our eligibility criteria were strict, especially with our population (adult, obtunded) and intervention characteristics (C-spine CT axial thickness), resulting in exclusion of some previously included studies in favor of maintaining a rigorous review. CT axial thickness of less than 3 mm was chosen a priori as the parameter corresponding to the current era of CT scanners, as opposed to often not reported slice number, three-dimensional reconstruction, and other institutional and/or scanner-specific cross-sectional metrics. Furthermore, we felt that CT axial thickness would be a less restrictive marker than an arbitrary publication date range, by which we did not restrict. In addition, our PICO question reflects that among Level I trauma

TABLE 5. Grading the Evidence for Cervical Collar Clearance in the Obtunded Adult Blunt Trauma Patient

Quality Assessment						Summary of Findings					
							Study Event Rates, %			Anticipated Absolute Effects	
Participants (Studies)	Study Limitations	Consistency	Directness	Precision	Publication Bias	Overall Quality of Evidence	With Adjunct to CT C-spine	With No Adjunct to CT C-spine	Relative Effect	Risk With Adjunct to CT C-spine	Risk With No Adjunct to CT C-spine
Neurologic change (paraplegia or quadriplegia) after cervical collar removal without adjunct imaging [CRITICAL OUTCOME]											
1,017 (5 studies)	Serious limitations*	Unable to assess**	N/A	Unable to assess**	Likely†	+, very low	0/1,017 (0%)**	0/1,017 (0%)**	N/A	N/A	N/A
Unstable injury (and associated treatments) [CRITICAL OUTCOME]											
1,718 (11 studies)	Serious limitations*	Unable to assess**	Indirect‡	Unable to assess**	Unable to assess**	+++, moderate§	0/1,718 (0%)**	0/1,718 (0%)**	N/A**	N/A**	N/A**
Stable injury (and associated treatments) [IMPORTANT OUTCOME]											
1,718 (11 studies)	Serious limitations*	Unable to assess**	Indirect‡	Unable to assess**	Unable to assess**	+, very low	161/1,718 (9.3%)**	0/1,718 (0%)**	N/A**	N/A**	N/A**
Imaging required after cervical collar removal [IMPORTANT OUTCOME]											
0 (0 studies)	Serious limitations*	Unable to assess**	Indirect‡	Unable to assess**	Unable to assess**	+, very low	N/A	N/A	N/A	N/A	N/A
False-negative CT imaging result on re-review/reread [IMPORTANT OUTCOME]											
0 (0 studies)	Serious limitations*	Unable to assess**	Indirect‡	Unable to assess**	Unable to assess**	+, very low	N/A	N/A	N/A	N/A	N/A
Pressure ulcers from cervical collar [NOT IMPORTANT OUTCOME]											
1 (1 study)	Serious limitations*	Unable to assess**	Indirect‡	Unable to assess**	Likely†	+, very low	N/A	1/197 (0.5%)	N/A	N/A	N/A
Time to cervical removal [NOT IMPORTANT OUTCOME]											
890 (3 studies)	Serious limitations*	Unable to assess**	N/A	Unable to assess**	Unable to assess**	+, very low	N/A¶	N/A¶	N/A	N/A**	N/A**

*Study design limitations of pre-post partial-cohorts are serious; each patient was subject to the intervention of a C-spine CT and then retested with the comparator adjunct imaging and/or examination, as no control arms were used.
**Pre-post partial-cohort study design among intervention and comparators precluded a quantitative synthesis (estimate of treatment effect, heterogeneity assessment, meta-analysis, full quality assessment).
†Publication bias is present, as there are case reports reporting neurologic change after C-spine collar removal with a negative C-spine CT result, case series reporting cervical collar–related pressure ulcers, and the authors of this article, across multiple institutions, have encountered at least one case of each event, which are all unpublished.
‡Indirectness of evidence relative to the wide definition of obtunded (population), noncomparable institutional imaging protocols (intervention and comparator), and inconsistently reported and often unavailable outcomes.
§Upgraded quality of evidence from low to moderate quality given the consistent large magnitude of negative predictive value (100%) of finding an unstable C-spine injury using CT.
¶Studies report mean time to collar removal (in days), and lost to follow-up exists.
N/A, Not Applicable.

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

Conditional recommendation: Based on very low quality of evidence, but large magnitude of effect given 100% negative predictive value of finding an unstable cervical spine injury

Figure 3. Practice management guideline.

centers, C-spine CT is the dominant initial imaging modality for those not amenable to clinical clearance and numerous adjunct methods of cervical collar removal or clearance are used in 2014, not just MRI.[16] Again, many reviews have provided comprehensive test characteristics and estimation of risk with meta-analytic techniques. This guideline points to the difficulties of providing quantification secondary to the pervasive reporting of nonindependent, pre-post, partial-cohort, and quasi-experimental nature of the literature, which has the recognized limitations of nonrandomization, regression to the mean,[88–90] and temporal confounding.

The management of stable injuries identified after a negative C-spine CT result, particularly those found on MRI alone, remains ill-defined. Many of the studies did not clearly link neurologic examination, stable injuries, and their classification with the subsequent treatment plan. The management of these stable injuries was often nonoperative, with or without collar, and for variable periods and follow-up. Some may argue for continued cervical collar use given these injuries, which may represent the spectrum of "whiplash" types, but there is increased demonstration of early mobilization and therapy benefits over continued immobilization.[91,92] Continued use of the cervical collar carries the risk of pressure ulcers, decreased cerebral venous return, increased intracranial pressure, secondary brain injury, and difficulties with airway and central line management.[86,93–98] These complications are poorly reported in the literature in a systematic fashion and hence poorly documented in our review. Confounding conditions that influence treatment decisions include preexisting C-spine disease/surgery, ankylosing spondylitis, osteoporosis, degenerative joint disease, diffuse idiopathic skeletal hyperostosis, or an alteration in motor/sensory examination.[50]

The development of multispecialty, institution-specific protocols is an important step for the management of potential C-spine trauma. These protocols should consider imaging quality, presence or absence of spine pathology confounders, level of detail for neurologic examination, process for spine specialist consultation, and distinct reasons for using imaging adjuncts such as MRI, so that future process/quality improvement initiatives can grow. Indiscriminate reliance on cervical immobilization, confirmatory tests, and/or interventions without justification will drive up direct and indirect costs without demonstrable improvement in patient outcomes.[26,38,93,99,100] Future directions in management of C-spine trauma will require large multidisciplinary, protocol-driven, prospective cohort studies and clinical trials.

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AUTHORSHIP

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