Evaluation of Cervical Spine Clearance by Computed Tomographic Scan Alone in Intoxicated Patients With Blunt Trauma

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IMPORTANCE Current trauma guidelines dictate that the cervical spine should not be cleared in intoxicated patients, resulting in prolonged immobilization or additional imaging. Modern computed tomography (CT) technology may obviate this and allow for immediate clearance.

OBJECTIVE To analyze cervical spine clearance practices and the utility of CT scans of the cervical spine in intoxicated patients with blunt trauma.

DESIGN, SETTING, AND PARTICIPANTS We performed a prospective observational study of 1668 patients with blunt trauma aged 18 years and older who underwent cervical spine CT scans from March 2014 to March 2015 at an American College of Surgeons-verified Level I trauma center. Intoxication was determined by serum alcohol levels and urine drug screens. Physical examination and CT scan findings were evaluated for cervical spine injuries (CSI) and the incidence of missed injuries.

MAIN OUTCOMES AND MEASURES Clinically relevant CSIs requiring cervical stabilization.

RESULTS Of 1668 patients, 1103 (66.1%) were male, with a mean (SD) age of 49 (20) years and a mean (SD) Injury Severity Score of 10 (9). Vehicular (734 [44.0%]) and falls (579 [34.7%]) were the most common mechanisms for hospitalization. Intoxication was identified in 632 of 1429 of patients tested (44.2%; 425 [29.7%] by serum alcohol levels and 350 [24.5%] by urine drug screens). Half (316 [50.0%]) were admitted with cervical spine immobilization, and 38 (12%) of these were solely owing to the presence of intoxication. There were 65 abnormal CT scans (10.3%) in the intoxicated group. Among 567 normal CT scans, 4 (0.7%) had central cord syndrome found on initial physical examination, and 1 (0.2%) had a symptomatic unstable ligament injury that was misread as normal on CT scan but was abnormal on magnetic resonance imaging. The 316 patients kept in a cervical collar for intoxication had no missed CSIs but were kept immobilized for a mean (SD) of 12 (19) hours. Computed tomographic scans had an overall negative predictive value of 99.2% for patients with CSIs and a negative predictive value of 99.8% for ruling out CSIs that required immobilization or stabilization.

CONCLUSIONS AND RELEVANCE In this study, alcohol or drug intoxication was common and resulted in significant delays to cervical spine clearance. Computed tomographic scans were highly reliable for identifying all clinically significant CSIs. Spine clearance based on a normal CT scan among intoxicated patients with no gross motor deficits appears to be safe and avoids prolonged and unnecessary immobilization.
he initial evaluation of trauma involves rapidly identifying important or life-threatening injuries and preventing their exacerbation or the development of secondary injuries. One of the most widely accepted strategies to accomplish this involves cervical spine immobilization with a hard collar and proceeded as if every patient has a spine injury until proven otherwise. This is typically followed by a rigid and/or protocolized approach, with clearance based on clinical examination or radiographic imaging with computed tomography (CT). The rationale for this approach is to avoid creating an iatrogenic injury to the spinal cord or exacerbating an existing injury. In multiple series, cervical spine injuries (CSIs) have been associated with longer hospital and intensive care unit stays as well as increased morbidity and mortality.

Cervical spine injuries have a reported incidence of 2% to 15%, with 10% to 20% of these incidents including injury to the spinal cord. Two large prospective trials have established the reliability and safety of using clinical criteria or rules to clear the cervical spine without radiologic imaging. However, these criteria require the patient to be fully examinable and without any degree of intoxication. For those with an altered sensorium, distracting injuries, or intoxication, clearance based on clinical examination alone is not warranted, and spinal immobilization is continued. With intoxication identified in up to half of trauma patients, clearance of the cervical spine is a commonly encountered dilemma with both medical and medicolegal implications. The majority of guidelines or protocols dictate that the cervical spine should not be cleared in these patients, resulting in prolonged immobilization or additional imaging, even with a normal CT scan. Although CT scans provide highly detailed and accurate imaging that is superior to plain radiography, concerns about missed ligamentous injuries have led to widespread use of either prolonged immobilization or additional evaluation with magnetic resonance imaging (MRI). Although studies have challenged this dogma, they have mostly been retrospective and did not focus specifically on the intoxicated population. The purposes of this study were to prospectively examine cervical spine clearance practices for intoxicated trauma patients, examine the predictive utility and reliability of cervical spine CT scans for identifying clinically significant injuries, and identify and characterize any clinically significant injuries that were missed by CT scans.

Methods

This was a single-center prospective observational study conducted from March 2014 to March 2015 at an American College of Surgeons-verified Level I trauma center. Attending trauma surgeons were present for all trauma activations and either directly performed or supervised the initial evaluation. The study population included all adult (≥18 years) patients with blunt trauma who underwent evaluation of the cervical spine with a dedicated cervical CT scan. Exclusion criteria included patients presenting in a delayed manner after the index trauma, transfer patients without available CT images from the referring facility who did not undergo repeated CT scans at our facility, and patients with known recent cervical spine fractures or surgery. Intoxication was defined as a blood alcohol level greater than 80 mg/dL and/or a positive urine drug screen that was not attributable to field or emergency department medication administration. Patients were identified as intoxicated with any positive result and were then subcategorized as either alcohol intoxication or drug intoxication. The study protocol was reviewed and approved by the Legacy Emanuel Medical Center Institutional Review Board. Because this was an observation-only study with no intervention or effect on patient care, informed consent was waived.

All CT scans were performed using one of 2 dedicated emergency department imagers (Somatom Definition AS—128-slice configuration [Siemens Medical Solutions USA]). The CT protocol included continuous image acquisition from the skull base through the T1 vertebral body using 2-mm slice thickness. Axial images as well as coronal and sagittal reconstructions were immediately reviewed and interpreted by 1 of 8 board-certified radiologists, 2 of whom were neuroradiologists. No outside or “nighthawk” radiologist services were used during the study period.

All patients underwent a structured history and physical examination, with a focused examination of the cervical spine and full neurologic assessment. The findings of the cervical spine CT scans as well as any additional cervical spine imaging during the hospitalization were recorded. The status of the cervical spine at the time of admission was recorded, and in cases with continued cervical spine precautions, the primary reason was noted. The admitting surgeon was also asked specifically if the reason for immobilization was solely because of the presence of intoxication. Time to cervical spine clearance was defined as the time from hospital arrival until either removal of the cervical collar or entry of the spinal clearance order. All patients were followed up through the completion of their hospital stay and reevaluated at the time of discharge, including a recording of any interval diagnosis of cervical spine pathology, the discharge Glasgow Coma Scale score, and any focal neurologic deficits or concerns. We used a composite end point for identifying all CSIs and clinically significant injuries, which included MRI findings, operative findings, and clinical status at discharge.

Key Points

**Question** Can modern computed tomography reliably exclude clinically significant or unstable cervical spine injuries among intoxicated patients with blunt trauma?

**Findings** In this observational study of 1668 trauma patients (including 632 intoxicated patients), computed tomographic scans had a negative predictive value of 99.2% overall, 99.8% for clinically significant injuries, and 100% among intoxicated patients with no gross motor deficits on examination.

**Meaning** Computed tomographic scans are reliable for identifying clinically significant cervical spine injuries, and spine clearance based on a normal high-quality computed tomographic scan appears to be safe in intoxicated patients with no gross motor deficits.
A missed injury was defined as any bony, ligamentous, or spinal cord injury that was identified by any means during the index hospitalization that was not identified on the initial radiologist staff interpretation of the cervical spine CT scan. A clinically significant injury was any injury that required or benefited from cervical spine immobilization or alternatively was at risk of any adverse effect because of the removal of spine precautions. In this instance, CSI was defined as any unstable or potentially unstable injury that required surgical stabilization or prolonged immobilization.

Any additional events related to the cervical spine that occurred after discharge were identified from a review of outpatient clinic notes. All cases identified as a possible missed clinically significant injury were reviewed by the study authors and by an independent radiologist who was not a participant in the study. Any patient with a clinical or radiologic finding that was of unclear significance was reviewed with the attending spine surgeon, who made the final determination. Standard descriptive statistics for the entire cohort and select subgroups were performed. Continuous variables were compared with t test or Mann-Whitney U test and categorical variables with χ² or Fisher exact test. The sensitivity, specificity, and positive and negative predictive values for cervical spine CT scans were calculated for the identification of all CSIs and for the identification of clinically significant injuries only. Statistical significance was set at P < .05, and all analyses were performed using IBM SPSS Statistics version 22 (IBM Corporation).

Results

There were 1696 adult patients with blunt trauma who underwent cervical spine CT scan over the study period. A total of 1668 patients were included in the final data analysis after 28 patients were excluded. Of these, 1103 (66.1%) were male with a mean (SD; range) age of 49 (20; 18-101) years and a mean (SD; range) Injury Severity Score of 10 (9; 1-75). Forty-one percent of patients with a CSI had an Injury Severity Score greater than 15. Vehicular (734 [44.0%]) and falls (579 [34.7%]) were the most common mechanisms (Table 1). Intoxication was identified in 632 of 1429 patients (44.2%) with an alcohol or drug screen performed. A CSI was identified in 157 patients (9.4%) in the intoxicated group, and 84 patients (5%) underwent additional imaging, including MRI or flexion-extension radiography.

The incidence and types of CSIs in the sober vs intoxicated subgroups is shown in Figure 1. Cervical spine injuries occurred in 90 of 797 patients (11.3%) in the sober group, 23 of 232 (8.1%) in the alcohol-intoxicated group, and 17 of 142 (12.0%) in the drug-intoxicated group. The majority of injuries were vertebral body fractures and spinous/transverse process fractures, and the incidence of associated spinal cord injury ranged from 1% (sober) to 3.8% (drug-intoxicated). The incidence and types of CSI were similar between the sober and intoxicated groups (Table 2). The management of patients with identified CSI is shown in the eFigure in the Supplement. Most patients were managed either without intervention or with a continued hard collar. Among patients with an identified CSI, a surgical intervention was performed in 8 of 90 patients (8.9%) in the sober group and in 11 of 157 (7.0%) in the intoxicated group.

Table 3 shows the performance of CT scans for identifying all CSIs and for identifying clinically significant or unstable CSIs. The negative predictive values were 99.2% for all injuries and 99.8% for unstable injuries. When considering all identified CSIs, there were 5 false-negative CT scans, with 4 of these being central cord syndrome without an associated fracture. There was 1 false-negative CT scan for a potentially unstable injury identified in a drug-intoxicated patient who presented with clear quadriplegia on examination. Magnetic resonance imaging revealed findings of probable injury involving the anterior longitudinal ligament at C4-C5 and probable edema/contusion, and the patient underwent surgical stabilization. On independent review of the CT, there were felt to be missed signs of a CSI consistent with a misread, although the findings were subtle.

Half of the intoxicated patients (316 of 632 [50.0%]) were admitted with continued cervical spine immobilization ordered only based on the presence of intoxication. There were no missed CSIs identified, and all patients were discharged without evidence of an injury or neurologic deficit for a negative predictive value of 100% in this cohort. The mean (SD) duration of cervical spine immobilization in these patients was 15.1 (19.9) hours. Figure 2 shows the average time to cervical spine clearance among groups, with intoxicated patients remaining in precautions for significantly longer than the sober group (3.7 vs 15.1 hours; P < .01).

Table 1. Demographic Data for All 1668 Patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>No./Total No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>49 (20)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1103 (66.1)</td>
</tr>
<tr>
<td>Female</td>
<td>565 (33.9)</td>
</tr>
<tr>
<td>Mechanism</td>
<td></td>
</tr>
<tr>
<td>Motor vehicle crash</td>
<td>470 (28.2)</td>
</tr>
<tr>
<td>Ground-level fall</td>
<td>337 (20.2)</td>
</tr>
<tr>
<td>Other mechanism</td>
<td>263 (15.8)</td>
</tr>
<tr>
<td>Fall from height</td>
<td>242 (14.5)</td>
</tr>
<tr>
<td>Motorcycle crash</td>
<td>115 (6.9)</td>
</tr>
<tr>
<td>Automobile vs pedestrian</td>
<td>92 (5.5)</td>
</tr>
<tr>
<td>Assault</td>
<td>92 (5.5)</td>
</tr>
<tr>
<td>Bicycle vs automobile</td>
<td>57 (3.4)</td>
</tr>
<tr>
<td>Cervical spine injury</td>
<td>153 (9.2)</td>
</tr>
<tr>
<td>Arrival GCS score, mean (SD)</td>
<td>14 (4)</td>
</tr>
<tr>
<td>ISS, mean (SD)</td>
<td>10 (9)</td>
</tr>
<tr>
<td>GCS score, mean (SD)</td>
<td>10 (9)</td>
</tr>
<tr>
<td>Additional imaging</td>
<td>84 (5.0)</td>
</tr>
<tr>
<td>Positive for alcohol</td>
<td>425/1429 (29.7)</td>
</tr>
<tr>
<td>Positive for drugs</td>
<td>350/1429 (24.5)</td>
</tr>
</tbody>
</table>

Abbreviations: GCS, Glasgow Coma Scale; ISS, Injury Severity Score.
This prospective observational study examined cervical spine clearance practices and the utility of CT scans for identifying CSIs among patients with either alcohol or drug intoxication. The overall incidence of CSI is reported as 2% to 15% of all adult patients with blunt trauma, with missed injuries reported in as many as 5% of patients.\(^5\,6,9,18,19\) Patient intoxication is an extremely common problem that all busy trauma centers will...
frequently encounter, as highlighted by our patient intoxication rate of 44.2%. It is also an area of major importance because there are a number of potential adverse consequences and medicolegal implications of both inappropriately discontinuing spinal precautions and maintaining prolonged immobilization when it is not warranted. There is currently a lack of focus in the literature on this specific topic, with most available data being retrospective reviews or expert opinion.15,20-22

Although there are explicit and evidence-based criteria to safely clear the cervical spine based on history and physical examination alone (National Emergency X-Radiography Utilization Study and Canadian C-Spine10 rules), these apply to very select patients who are entirely alert and examinable and have no other factors that may compromise the physical examination.23 A primary disqualifier in all of these validated rules is the presence of intoxication because of concerns about the effect on the reliability of the examination and self-reported pain. As a result, cervical spine clearance practices in this population vary widely and often include routine radiologic imaging with CT scan. However, even in the presence of a normal CT scan, intoxicated patients are most commonly left in cervical spine precautions until they are sober and examinable and can then be cleared or have additional imaging performed if they have cervical spine tenderness or other concerning findings. This practice has primarily been based on concerns about the inability of CT scans to adequately visualize ligamentous injuries that may cause cervical spine instability. This has traditionally been the practice and policy at our trauma center, and as evidenced in this series, it results in a large number of patients being admitted for observation and with continued cervical spine precautions based primarily on the presence of intoxication, even with a normal CT scan.

One major limitation in interpreting the available evidence is the heterogeneity of the patient populations that are included. Most of the literature uses the catchall phrases obtunded or unexaminnable, which can include underlying conditions ranging from mild intoxication to a severe brain injury and vegetative state. In addition to the differences in underlying etiology, the ability to participate in an examination and the likely duration of altered sensorium must be factored into the decision-making process and the ultimate safety of spine clearance. Although older studies of CT demonstrated an inability to adequately identify certain unstable injuries, there is now a growing body of evidence that argues in favor of cervical spine clearance based on normal high-quality CT scans alone. There seems to be consensus that a patient with demonstrated extremity neurologic deficits and a normal CT scan requires an MRI to rule out injury.26 However, there are mixed recommendations regarding all other obtunded or unexaminnable patients. Panczykowski et al17 concluded that CT was more than 99.9% sensitive and specific for identifying unstable CSIs and that a cervical collar may be removed from an obtunded or intubated patient with a normal CT scan. Raza et al27 reported a negative predictive value of cervical spine CT of 99.7% and a positive predictive value of 93.7% in patients with blunt trauma with altered sensorium. Our results found a similarly high negative predictive value for cervical spine CT of 99.2% for all injuries and 99.8% for unstable injuries among a more homogeneous population of intoxicated patients.

In 2015, the Eastern Association for the Surgery of Trauma published a new practice management guideline on cervical spine evaluation in obtunded patients. Their review of 11 studies, including 1718 total patients, found that although the overall incidence of missed injury with CT was 9%, these misses were largely insignificant and would not result in any adverse effects from the removal of cervical spine precautions.24 Most importantly, they found the negative predictive value for identifying unstable CSIs to be 100% and thus have made a conditional recommendation for cervical collar removal based on a normal high-quality CT scan. However, they also noted the general weakness of the available data as well as the striking variability in the criteria used to define a patient as obtunded.24 We feel that our study makes several important contributions to the literature on this topic and also addresses several of the noted weaknesses. This includes the prospective collection of all data and the use of a structured evaluation and clinical examination, the focus on a more homogeneous subgroup of the obtunded population with alcohol or drug intoxication, and the identification of the primary reason of the admitting physician for continuing spinal precautions. We feel that our results provide additional support and validation for the findings and recommendations made by the Eastern Association for the Surgery of Trauma new practice management guidelines for cervical spine clearance.

In interpreting these and other study results, it is important to recognize that the primary motivation behind spinal precautions is not to immobilize all patients with a spine injury but to protect the patient with an unstable injury from developing or worsening a spinal cord injury. Although this has certainly been well described in the literature, it may now be of historical interest only because of the accuracy and reliability of modern CT scanning technology. Among all studies included in the new practice management guidelines,
was not a single case of a missed unstable injury or a patient who had adverse neurologic sequelae from the removal of spine precautions following a normal CT scan. In our study, we identified 1 potential missed injury in an intoxicated patient, but the patient had clear neurologic signs of a spinal cord injury at presentation and would have remained in spine precautions regardless of the CT findings. In addition, the review of the images in this case identified this as a misread and not a true false-negative scan. This case also highlights our contention that most intoxicated patients are not truly unexamined and that clinically relevant examination findings can typically be elicited.

Finally, there are some who continue to advocate for the use of additional imaging with MRI in the obtunded patient. While MRI does provide more detailed imaging of the cervical spine, there is no high-quality evidence of any additional benefit to patients or of improved outcomes. In fact, the well-recognized weakness of MRI in this setting is that it may be too sensitive and result in false-positive findings, particularly in the setting of acute injury. There are also recognized risks to both MRI scanning and to unnecessary prolongation of cervical collar immobilization, including increased intracranial pressure, pressure sores, adverse events during patient transport and prolonged imaging, and the effect of prolonged immobilization. An interesting analysis of the literature on this topic found that the risks of both prolonged cervical collar use and of MRI scanning were significantly higher than any risk of inadvertent spinal injury after a normal high-quality CT scan. Our data add to this literature in highlighting the significant effect that the presence of intoxication can have in terms of prolonged immobilization and cervical collar wear.

This study had several limitations. Although it was a prospective study, all decisions were at the discretion of the attending trauma surgeon and were not protocolized. We did not examine morbidity or complications associated with prolonged immobilization. We used a composite end point for identifying all CSIs and clinically significant injuries, which included MRI findings, operative findings, and clinical status at discharge. Therefore, it is possible that there were additional missed injuries that were not identified, but none of these appeared to have any clinical significance or effect. Although we focused on the intoxicated patient population, there is significant heterogeneity within this cohort by both the source of intoxication and the degree of intoxication. Finally, these results were obtained using a 128-slide modern CT scanner at a busy Level I trauma center with highly experienced trauma radiologists and may not be applicable to less advanced CT scanners or with less experienced radiologic interpretation.

Conclusions

To our knowledge, this is the first prospective study of cervical spine clearance practices and CT scan utility among intoxicated patients with blunt trauma. We found a high incidence of intoxication, with nearly half of patients meeting criteria for alcohol and/or drug intoxication. High-quality CT scans of the cervical spine that were interpreted by experienced radiologists were accurate and reliable for identifying most injuries, particularly clinically significant or unstable injuries. Clearing the cervical spine based on normal CT scans in intoxicated patients with no gross motor deficits or other signs of spinal cord injury is supported by these data and would have resulted in no missed injuries. Early CT-based clearance would also minimize unnecessary MRI scans, decrease the duration of immobilization, and minimize the risks of prolonged cervical collar wear.

REFERENCES

Cervical Spine Clearance in Intoxicated Patients by Computed Tomography

Invited Commentary

Does the Computed Tomographic Scan Tell the Whole Story for Cervical SpineClearance?

Olubode A. Olufajo, MD, MPH; Ali Salim, MD

Stabilization of the spine with rigid collars has been well established as a useful early intervention for preventing spinal cord injuries among trauma patients. Clinical examination and, in some cases, radiographic evidence showing the absence of clinically significant injuries are routinely required prior to making decisions regarding the removal of these collars, a process known as cervical spine clearance. Because thorough clinical examinations require intact sensorium and sobriety, there have been debates on the safety of cervical spine clearance among intoxicated patients. The study by Bush et al in this issue of JAMA Surgery is an impressive effort to prospectively evaluate the accuracy of using only computed tomographic (CT) scans as the basis for excluding potential spinal cord injuries among intoxicated trauma patients. Using a single institution’s data, this study showed that a normal CT finding alone could predict the absence of significant spinal injuries in more than 99% of cases. The results of this study suggest that it is unnecessary to delay cervical spine clearance until intoxicated patients are sober or until magnetic resonance imaging is performed. However, caution must be taken in making conclusions based on these data.

Although the authors conducted the study at an institution with high-quality CT technology and well-trained radiologists, they still recorded a false-negative CT report consistent with a misread. With the higher potential for this nature of error in lower-resourced settings, it becomes important to compare the costs and benefits of early removal of cervical collars. Bush et al showed that the average cervical spine clearance times were 6 to 12 hours longer among intoxicated patients compared with sober patients, presumably equivalent to the time required to become sober. The increased risk of pressure ulcers, which is the most commonly reported adverse effect associated with prolonged collar use, has been demonstrated only in patients who remain in cervical collars on the basis of a normal multidetector CT scan—a meta-analysis and cohort study. Injuries: 2013;44(11):1589-1595.

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JAMA Surgery September 2016 Volume 151, Number 9 813

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