Retrospective Application of the NEXUS Low-Risk Criteria for Cervical Spine Radiography in Canadian Emergency Departments

Study objective: We evaluate the accuracy, reliability, and potential impact of the National Emergency X-Radiography Utilization Study (NEXUS) low-risk criteria for cervical spine radiography, when applied in Canadian emergency departments (EDs).

Methods: The Canadian C-Spine Rule derivation study was a prospective cohort study conducted in 10 Canadian EDs that recruited alert and stable adult trauma patients. Physicians completed a 20-item data form for each patient and performed interobserver assessments when feasible. The prospective assessments included the 5 individual NEXUS criteria but not an explicit interpretation of the overall need for radiography according to the criteria. Patients underwent plain radiography, flexion-extension views, and computed tomography at the discretion of the treating physician. Patients who did not have radiography were followed up with a structured outcome assessment by telephone to determine clinically important cervical spine injury, a previously validated outcome measurement. Analyses included sensitivity and specificity with 95% confidence interval (CI), κ coefficient, and potential radiography rates.

Results: Among 8,924 patients, 151 (1.7%) patients had an important cervical spine injury. The combined NEXUS criteria identified important cervical spine injury with a sensitivity of 92.7% (95% CI 87% to 96%) and a specificity of 37.8% (95% CI 37% to 39%). Application of the NEXUS criteria would have potentially reduced cervical spine radiography rates by 6.1% from the actual rate of 68.9% to 62.8%. Of 11 patients with important injuries not identified, 2 were treated with internal fixation and 3 with a halo.

Conclusion: This retrospective validation found the NEXUS low-risk criteria to be less sensitive than previously reported. The NEXUS low-risk criteria should be further explicitly and prospectively evaluated for accuracy and reliability before widespread clinical use outside of the United States.

RETROSPECTIVE APPLICATION OF THE NEXUS LOW-RISK CRITERIA

Capsule Summary

What is already known on this topic
Two different decision rules (the Canadian C-Spine Rule and the National Emergency X-Radiography Utilization Study [NEXUS] rule) have been developed in the past 5 years, each of which, if used as recommended, can decrease the number of unnecessary radiographic studies in patients with cervical spine injuries.

What question this study addressed
The Canadian C-Spine Rule group conducted a retrospective study using the original Canadian C-Spine Rule database to evaluate the accuracy, reliability, and potential impact of the NEXUS low-risk criteria for cervical radiography in 10 Canadian emergency departments.

What this study adds to our knowledge
In the 10 Canadian emergency departments, the NEXUS criteria were less sensitive (93%) than previously reported in the original NEXUS study (99%). However, the Canadian C-Spine Rule investigators used surrogates or approximations of the NEXUS criteria in their study design rather than the exact NEXUS criteria. This, along with the retrospective nature of the study, the differences in hospital populations studied, and practice differences in the two countries, does not allow us to determine whether the reported decrease in sensitivity is real or a result of differences in study methodology.

How this might change clinical practice
Both clinical decision rules appear to reduce the unnecessary ordering of cervical spine radiographs in blunt trauma patients. At this time, it is unclear whether one decision rule is more efficient and effective than the other.

INTRODUCTION

Blunt trauma with potential cervical spine injury is common, with more than 1 million patients treated annually in US emergency departments (EDs).1-2 Although the majority of these cases represent soft tissue injuries, 30,000 patients experience cervical spine fractures or dislocations, and approximately 10,000 patients experience spinal cord injury.3,4 The catastrophic sequelae of cervical spinal cord injury has led to a low threshold for ordering cervical spine radiographs in trauma patients. A survey of 125 US trauma centers found that 97% routinely order cervical spine radiographs for all trauma patients, yet more than 98% of cervical spine radiograph results are negative for fracture.5-11

This inefficient use of cervical spine radiography wastes health care dollars, prolongs uncomfortable immobilization with hard collars and back boards, results in unnecessary exposure to ionizing radiation, and delays ED discharge.12

A widely accepted clinical decision rule for cervical spine radiography that is safe and efficient could reduce the large number of normal radiographic studies, save time and expense, and benefit patient comfort and care. Recently, 2 sets of independently developed decision criteria to guide cervical spine radiography have been reported: the National Emergency X-Radiography Utilization Study (NEXUS) low-risk criteria for cervical spine radiography, developed and tested in the United States, and the Canadian C-Spine Rule, derived and presently being validated in Canada.13-15 The purpose of this study was to evaluate the accuracy and reliability of the NEXUS low-risk criteria for cervical spine radiography in a large cohort of alert blunt trauma patients in Canadian EDs.

MATERIALS AND METHODS

The derivation study for the Canadian C-Spine Rule was a prospective cohort study conducted in 10 large Canadian community and university hospital EDs between October 1996 and April 1999. Consecutive adult patients at risk of cervical spine injury after acute blunt trauma to the head or neck were considered for enrollment. Obtaining radiography was at the discretion of the treating physician and not a factor in eligibility for enrollment. Inclusion and exclusion criteria are summarized in the Figure. Detailed descriptions of these criteria and the methodology have been previously published.15-17

Physicians completed a 20-item data form of standardized clinical findings from the history and physical examinations before radiography on each patient. The prospective assessments included the elements of the 5 NEXUS criteria. The NEXUS criterion “posterior midline cervical tenderness” was specifically defined and captured in the Canadian C-Spine Rule database. The NEXUS criterion “focal neurologic deficit” was captured in the Canadian C-Spine Rule as 2 elements, “motor deficit” and “sensory deficit.” If either was positive, it was considered to be a focal neurologic deficit. A normal level of alertness was an inclusion criterion for the Canadian C-Spine Rule so that interobserver assessments of this element were not obtained. The NEXUS criterion “no evidence of intoxication” was captured in the Canadian C-Spine Rule database as “unreliable findings due to drugs or ethanol.” The presence of “distracting painful injuries” was a specific data element in the Canadian C-Spine Rule questionnaire. Physician assessors were all staff emergency physicians or supervised emergency medicine residents who had received a 1-hour training session on data form completion. When-
ever feasible, patients were assessed independently by a second emergency physician to judge interobserver agreement.

The primary outcome measure was the presence or absence of a clinically important cervical spine injury, including fractures, dislocations, or ligamentous instability demonstrated by diagnostic imaging. Injuries deemed clinically important were standardized and predefined.18

In Canadian emergency practice, a proportion of alert patients with acute blunt trauma are “clinically cleared” and do not undergo cervical spine radiography. All enrolled patients who did not have radiography were assessed with a structured telephone questionnaire administered 14 days after their ED visit by a trained registered nurse blinded to the results of the initially collected predictor variables. This tool classified patients as having no clinically important cervical spine injury if they met all 4 of the following explicit criteria: (1) neck pain rated as none or mild; (2) restriction of neck movement rated as none or mild; (3) use of a cervical collar not required; and (4) return to usual occupational activities not prevented by neck injury. Patients not fulfilling all criteria were recalled for clinical assessment and radiography. Patients who could not be contacted were excluded from the final study analysis. This follow-up tool had been shown to identify all cervical spine injuries in a sample of 389 patients, including 66 with clinically important cervical spine injury, all of whom had undergone radiography.19

By using these Canadian C-Spine Rule data elements as close approximations of the NEXUS criteria, the classification performance of the NEXUS decision instrument for identifying clinically significant cervical spine injury was assessed by calculating sensitivity and specificity, with 95% confidence intervals (CIs). Likelihood ratios for each of the NEXUS criteria were used to determine the strength of association with cervical spine injury. Interobserver agreement for each of the NEXUS variables was measured by calculating the $\kappa$ coefficient, the proportion of potential agreement beyond chance, along with 95% CIs.20 Data collection forms and case histories of all cases of cervical spine injury not identified by the NEXUS low-risk criteria were independently reviewed by 2 of the authors (IGS and GD), and any discrepancies were resolved by consensus.

**RESULTS**

Of the 8,924 potential cervical spine injury patients, 151 patients had a clinically important cervical spine injury, and some patients had more than 1 injury. There were 143 fractures, 23 dislocations, and 9 cases of ligamentous instability in this group. An additional 28 patients had a clinically unimportant cervical spine injury (Table 1).

The number of patients who had cervical spine radiography performed was 6,143 (68.9%). Applying the NEXUS criteria approximations to this population would have resulted in a 6.1% absolute reduction in the rate of radiography to 62.8% (5,601 patients).

The association between the individual NEXUS criteria variables and clinically important cervical spine injury is shown in Table 2. The presence of a focal neurologic deficit had the strongest statistical association with significant cervical spine injury. $\kappa$ Values (with 95% CI) for the individual NEXUS criteria approximations were (1) posterior midline cervical spine tenderness 0.78 (95% CI 0.67 to 0.89); (2) focal neurologic deficit: motor deficit 0.93 (95% CI 0.79 to 1.0), sensory deficit 0.60 (95% CI 0.28 to 0.92); (3) altered level of alertness (not applicable, inclusion criterion for

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**Figure.**

**Inclusion and exclusion criteria.** GCS, Glasgow Coma Scale.

**Canadian C-Spine Rule**
1. **Inclusion Criteria**
   A. Risk of cervical spine injury includes either
      1. neck pain from any injury or
      2. no neck pain but all of the following:
         a. visible injury above clavicles
         b. had not been ambulatory
         c. dangerous mechanism of injury
   B. Alert (GCS score 15)
   C. Stable (systolic blood pressure >90 mm Hg and respiratory rate 10-24 breaths/min)
2. **Exclusion Criteria**
   A. age <16 y
   B. minor injuries
   C. GCS score <15
   D. abnormal vital signs
   E. injury >48 h previously
   F. penetrating trauma
   G. acute paralysis
   H. known vertebral disease
   I. reassessment of same injury
   J. pregnant

**NEXUS**
1. **Inclusion Criteria**
   A. blunt trauma
   B. cervical spine radiography
2. **Exclusion Criteria**
   A. penetrating trauma
   B. cervical spine imaging unrelated to trauma
   C. no radiography
C2 fracture, 2 mandibular fractures, and 3 lacerations to his scalp, he denied any pain or tenderness, clearly an atypical individual.

Patient 2 was involved in a highway-speed motor vehicle rollover and sustained a C7 fracture. The only additional injuries were a scalp laceration and shoulder contusion. Patient 3 fell down 12 stairs the day before initial assessment. His plain radiographs were interpreted as normal, and flexion-extension views were of poor quality. The patient refused further assessment and left against medical advice. After radiologist review of the radiographs, the patient was recalled and had a computed tomography scan 4 days after the original injury, which demonstrated a minimally displaced oblique coronal fracture of the right superior facet of C6. He refused halo treatment and left the hospital with a hard collar.

Clinical variables: $\kappa$ values and likelihood ratios for clinically important cervical spine injury.

<table>
<thead>
<tr>
<th>Clinical Variables</th>
<th>Cervical Spine Injury, % (N=151)</th>
<th>No Cervical Spine Injury, % (N=8,773)</th>
<th>Likelihood Ratio Positive*</th>
<th>Likelihood Ratio Negative*</th>
<th>$\kappa$ (N=150)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior midline neck tenderness</td>
<td>86.1</td>
<td>57.3</td>
<td>1.5</td>
<td>0.3</td>
<td>0.78</td>
</tr>
<tr>
<td>Focal neurologic deficit</td>
<td>Motor deficit</td>
<td>4.6</td>
<td>1.2</td>
<td>3.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Sensory deficit</td>
<td>6.0</td>
<td>1.9</td>
<td>3.1</td>
<td>0.9</td>
<td>0.60</td>
</tr>
<tr>
<td>Intoxication</td>
<td>8.0</td>
<td>4.1</td>
<td>1.9</td>
<td>0.9</td>
<td>0.22</td>
</tr>
<tr>
<td>Distracting painful injuries</td>
<td>15.2</td>
<td>7.7</td>
<td>2.0</td>
<td>0.9</td>
<td>0.41</td>
</tr>
</tbody>
</table>

*Guide to likelihood ratios and the expected changes from pretest to posttest probability: >10 or <0.1 large/conclusive; 5-10 or 0.1-0.2 moderate; 2-5 or 0.5-0.2 small; 1-2 or 0.5-1.0 unimportant.

Classification performance of NEXUS criteria approximations for 151 clinically important cervical spine injury cases.*

<table>
<thead>
<tr>
<th>Cervical Spine Injury</th>
<th>NEXUS Positive</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>140</td>
<td>5,461</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>11</td>
<td>3,312</td>
<td></td>
</tr>
</tbody>
</table>

* Sensitivity 92.7% (95% CI 87% to 96%); specificity 37.8% (95% CI 37% to 39%).
Patients 4 and 5 fell from a standing position to sustain their injuries. Patient 4 had a C2 fracture and a fractured nose. The initial treating physician did not notice her cervical spine fracture, and the patient was discharged home. She was recalled the next day after review of the films by a radiologist, admitted to the hospital, and discharged home.

Table 4. Patients with cervical spine injury with negative NEXUS criteria for radiography.

### A. Clinically significant cervical spine injury.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, y</th>
<th>Sex</th>
<th>Mechanism of Injury</th>
<th>Cervical Spine Injury</th>
<th>Transfer With Cervical Spine Injury</th>
<th>Other Imaging</th>
<th>Cervical Spine Treatment</th>
<th>Other Injuries</th>
<th>Other Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46</td>
<td>M</td>
<td>Trampled on head and face by horses</td>
<td>C2 anterior vertebral body ~10%</td>
<td>Yes</td>
<td>CT, MRI, flex-ext</td>
<td>Ward</td>
<td>Halo</td>
<td>Fractured mandible (X2); facial and scalp lacerations (X3)</td>
</tr>
<tr>
<td>2</td>
<td>49</td>
<td>F</td>
<td>MVC rollover at high-speed</td>
<td>C7 through left lamina and lateral mass</td>
<td>Yes</td>
<td>CT</td>
<td>Ward</td>
<td>Halo</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>44</td>
<td>M</td>
<td>Fell down 12 stairs</td>
<td>Oblique coronal fracture of superior facet of C6</td>
<td>Yes</td>
<td>CT</td>
<td>Left</td>
<td>Halo</td>
<td>Hard collar; halo recommended, but patient refused</td>
</tr>
<tr>
<td>4</td>
<td>78</td>
<td>F</td>
<td>Tripped and fell to ground, hitting face</td>
<td>C2 anterior inferior vertebral body</td>
<td>No</td>
<td>CT, flex-ext</td>
<td>ICU</td>
<td>Halo</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>88</td>
<td>F</td>
<td>Fell in bathroom</td>
<td>C1 (posterior arch) and C2 (type II odontoid)</td>
<td>Yes</td>
<td>CT</td>
<td>ICU</td>
<td>Internal fixation</td>
<td>Left forehead laceration, distal radius fracture</td>
</tr>
<tr>
<td>6</td>
<td>69</td>
<td>M</td>
<td>Fell down flight of stairs</td>
<td>C1 to right lateral mass and posterior arch</td>
<td>Yes</td>
<td>CT</td>
<td>Ward</td>
<td>Halo</td>
<td>Hard collar</td>
</tr>
<tr>
<td>7</td>
<td>87</td>
<td>M</td>
<td>Fell down 14 stairs</td>
<td>C1, both lamina of posterior arch</td>
<td>No</td>
<td>CT</td>
<td>Ward</td>
<td>Halo</td>
<td>Hard collar</td>
</tr>
<tr>
<td>8</td>
<td>90</td>
<td>F</td>
<td>Fell down flight of stairs</td>
<td>Type 3 odontoid fracture</td>
<td>No</td>
<td>CT</td>
<td>Ward</td>
<td>Halo</td>
<td>Hard collar</td>
</tr>
<tr>
<td>9</td>
<td>73</td>
<td>M</td>
<td>MVC rollover (X6) at highway speed</td>
<td>Bilateral fractures</td>
<td>No</td>
<td>CT, flex-ext, CT, MRI</td>
<td>ICU</td>
<td>Internal fixation</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>34</td>
<td>M</td>
<td>Fell skiing; hit head and twisted neck; transient right arm paresthesiae; injury occurred 1 day earlier</td>
<td>Fracture anterior articular facet, widening C5/6 facet joint, small bony fragment narrowing neural foramen on right</td>
<td>No</td>
<td>CT, flex-ext</td>
<td>Home</td>
<td>Hard collar</td>
<td>No</td>
</tr>
<tr>
<td>11</td>
<td>43</td>
<td>M</td>
<td>Fell from a ladder; transient right arm paresthesiae</td>
<td>C6 pedicle</td>
<td>Yes</td>
<td>CT, flex-ext</td>
<td>Home</td>
<td>Hard collar</td>
<td>No</td>
</tr>
</tbody>
</table>

### B. Clinically unimportant cervical spine injury.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, y</th>
<th>Sex</th>
<th>Mechanism of Injury</th>
<th>Cervical Spine Injury</th>
<th>Transfer With Cervical Spine Injury</th>
<th>Other Imaging</th>
<th>Cervical Spine Treatment</th>
<th>Other Injuries</th>
<th>Other Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>18</td>
<td>F</td>
<td>200-lb man fell back on her head</td>
<td>Undisplaced fractures bodies of C4 and C5</td>
<td>No</td>
<td>CT, flex-ext</td>
<td>Ward</td>
<td>Hard collar</td>
<td>No</td>
</tr>
<tr>
<td>13</td>
<td>53</td>
<td>M</td>
<td>Fell down 13 steps</td>
<td>Fracture anterior inferior corners of C2 and C3</td>
<td>No</td>
<td>CT, flex-ext</td>
<td>Home</td>
<td>Soft collar</td>
<td>Left shoulder contusion</td>
</tr>
<tr>
<td>14</td>
<td>63</td>
<td>M</td>
<td>MVC broadsided</td>
<td>Small teardrop avulsion fracture anterior-inferior body of C3</td>
<td>No</td>
<td>CT, flex-ext</td>
<td>Home</td>
<td>Hard collar</td>
<td>Scalp laceration, facial abrasion</td>
</tr>
</tbody>
</table>

MVC, Motor vehicle crash; CT, computed tomography; MRI, magnetic resonance imaging; AMA, against medical advice; flex-ext, flexion-extension.
and treated with a hard collar. Patient 5 had C1 and C2 fractures and was treated with internal fixation. In addition, she had a forehead laceration and a distal radius fracture treated with a cast. The wrist fracture was not recognized on initial assessment but was subsequently treated with a forearm cast during hospitalization.

Patients 6 to 9 had a variety of contusions, abrasions, and lacerations, which were all considered minor, in addition to their significant cervical spine fractures. Patient 6 had consumed “5 beers” before falling backwards down a flight of stairs. He was assessed in tertiary care center 17 hours after his injury, by which time intoxication was not considered to be a significant factor in his assessment. Patient 8, a 90-year-old woman, had fallen down a flight of stairs and had an odontoid fracture. She was known to have a degree of dementia; however, the treating physician indicated that at initial assessment, the patient was alert and answered all questions appropriately.

Patient 10 was a 34-year-old man who fell while skiing, directly hitting his head and twisting his neck. At the time of injury, he had paresthesia in his right arm that resolved after 20 minutes. He continued skiing after his fall and flew home the next day, presenting to his local hospital the day after the original injury. He had a C5 fracture with widening of the C5/6 facet joint and a small bony fragment narrowing the neural foramen on the right. He was treated with internal fixation.

Patient 11 was a 54-year-old man who fell from a ladder 1 day before presentation and had transient right arm paresthesia that lasted for a few minutes. He walked to his local hospital and was transferred to tertiary care facility with a fracture of the left C6 pedicle. He was discharged home with a hard collar after normal flexion-extension radiography and neurosurgical consultation.

Of the 28 clinically unimportant cervical spine injuries, application of the NEXUS criteria approximations identified 25 (Tables 4 and 5).

Limitations
The major limitation of this study was the use of approximations of the NEXUS criteria. Although the approximations were similar to the defined NEXUS criteria, they were not identical. Thus, the results of this study apply to the surrogates used for the NEXUS criteria and may not be applicable to the original NEXUS variables. Assessing the need for radiography according to the approximations of the NEXUS criteria was determined retrospectively from the data collection forms for the Canadian C-Spine Rule derivation study. This study was conducted by the Canadian C-Spine Rule study group, which has proposed an alternative to the NEXUS criteria for assessing the need for cervical spine radiography. This alternative might be perceived as a potential conflict of interest and could conceivably have led to an unconscious bias in the results.

Discussion
The NEXUS decision instrument and the Canadian C-Spine Rule share common goals: reducing the rate of unnecessary cervical spine radiography and safely identifying patients who do not require radiography. The NEXUS low-risk criteria for cervical spine radiography did not perform as well as in the original US study when applied to the Canadian cases in the Canadian C-Spine Rule derivation data set. In the NEXUS study, the sensitivity for identification of a clinically significant injury was 99.6%. When applied to the Canadian C-Spine Rule data set, the sensitivity of the NEXUS criteria approximations was 92.7%, with 11 of 151 patients with clinically significant injuries not identified.

The NEXUS and Canadian C-Spine Rule studies had identical rates (1.7%) of clinically significant cervical spine injury, which suggests that both studies enrolled populations of similar injury severity. For physicians outside of the United States, knowing when to apply the NEXUS criteria is problematic because one of the basic study inclusion criteria is the need for cervical spine radiography, as determined by a US emergency physician (Figure). Application of the NEXUS criteria in the United States would allow a reduction in cervical spine radiology rate to 87.4% and increase the rate of positive radiography from 1.7% to 1.9%. However, the baseline rate of radiography in the Canadian C-Spine Rule

Table 5.
Classification performance of NEXUS criteria approximations for 28 clinically unimportant cervical spine injury cases.

<table>
<thead>
<tr>
<th>NEXUS Positive</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>25</td>
<td>5,436</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>3,309</td>
</tr>
</tbody>
</table>

*Sensitivity 89.3% (95% CI 71% to 95%); specificity 37.8% (95% CI 37% to 39%).
The Canadian C-Spine Rule definition of distracting painful injury is more subjective: “other injuries, such as fractures, which are so severely painful that neck examination is unreliable.” With this definition, interobserver agreement between Canadian emergency physicians is poor ($\kappa = 0.41$), and the presence of a distracting painful injury is not incorporated into the Canadian C-Spine Rule decision process. Patient 1, with a mandibular fracture, would likely be considered as having a distracting painful injury by strict NEXUS criteria despite the patient’s denial of any pain. Patient 5, with a fractured radius, could also have been considered to have a distracting painful injury by NEXUS criteria, although because this injury was not observed on initial assessment, it is unlikely to have been painful enough to distract from cervical spine assessment.

The criterion “no focal neurologic deficit” was described in the original NEXUS article as “the absence of a focal neurologic deficit.” In early articles on NEXUS methodology, this criterion is specifically defined as “any focal deficit on motor or sensory exam.” With this definition, 2 cases (patients 10 and 11) of transient paresthesia were missed by the NEXUS criteria. However, in a more recent publication from the NEXUS group, it appears that this criterion has been revised and now is defined as “any focal neurological complaint (by history) or finding (on motor or sensory examination).” With this revised definition, both cases would be captured by the NEXUS application.

Application of close approximations of the NEXUS criteria in Canada to a population with similar injury severity produced different results, with nearly 3 times the specificity and only 92.7% sensitivity in identifying patients with significant cervical spine injury as requiring radiography.

There seems to be a significant variation in the interpretation and application of the NEXUS low-risk criteria between emergency physicians in Canada and the United States. The NEXUS low-risk criteria should be further explicitly and prospectively evaluated for accuracy and reliability before widespread clinical use outside the United States.

In Retrospect

This study would have been improved if the specific NEXUS criteria had been applied by Canadian emergency physicians, rather than the approximations. However, these data were collected before publication of the NEXUS trial. All subsequent studies from our group have used the specifically defined NEXUS criteria. 

The application of clinical judgment is influenced by local standards of care and varies considerably among experienced emergency physicians. Before the development of any cervical spine decision rules, the rate of obtaining cervical spine radiography for alert, stable trauma patients varied by a factor of 2 among Canadian EDs (37.0% to 72.5%) and by a factor of 6 among experienced Canadian emergency physicians (15.6% to 91.5%). The specificity in the NEXUS study was experienced Canadian emergency physicians (15.6% to 37.0% to 72.5%), and by a factor of 2 among Canadian EDs (37.0% to 72.5%) and by a factor of 6 among experienced Canadian emergency physicians (15.6% to 91.5%).

The criterion concerning intoxication is most divergent between the NEXUS definition “no evidence of intoxication” and the Canadian C-Spine Rule definition of “unreliable findings due to drugs or alcohol.” The NEXUS definition is clearly defined and more inclusive, including a recent history of an intoxicating ingestion, an odor of alcohol, or a positive blood alcohol test. An assessment of intrarater reliability of the NEXUS criterion for intoxication in 118 patients found excellent agreement between physicians ($\kappa = 0.86$). Although this study was biased toward agreement by always having 1 of 5 investigators perform the second assessment, the explicit definitions would predict strong agreement. In contrast, with the Canadian C-Spine Rule definition of “unreliable findings due to drugs or ethanol,” agreement between Canadian emergency physicians is poor ($\kappa = 0.22$), and intoxication is not incorporated into the Canadian C-Spine Rule decision process. In the series of 11 patients with significant cervical spine injury, missed by NEXUS, patient 6, who had been drinking beer 17 hours before assessment, may have been considered to have “evidence of intoxication” by NEXUS definitions.

Deciding whether other injuries are “distracting” and obscure the assessment of cervical spine injury is based on bedside clinical judgment. The NEXUS definition of distracting painful injury specifically includes long-bone fractures, visceral injuries, large lacerations, degloving or crush injuries, and large burns. Any other injury that produces “acute functional impairment” is also included. Using these definitions, the NEXUS group reported good intrarater reliability ($\kappa = 0.77$). The Canadian C-Spine Rule definition of distracting painful injury is more subjective: “other injuries, such as fractures, which are so severely painful that neck examination is unreliable.” With this definition, interobserver agreement between Canadian emergency physicians is poor ($\kappa = 0.41$), and the presence of a distracting painful injury is not incorporated into the Canadian C-Spine Rule decision process. Patient 1, with a mandibular fracture, would likely be considered as having a distracting painful injury by strict NEXUS criteria despite the patient’s denial of any pain. Patient 5, with a fractured radius, could also have been considered to have a distracting painful injury by NEXUS criteria, although because this injury was not observed on initial assessment, it is unlikely to have been painful enough to distract from cervical spine assessment.
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Author contributions: IGS and GAW conceived the study, designed the trial, and obtained research funding. IGS, CMC, and KLV supervised the conduct of the trial and data collection. IGS, MS, RB, CMC, KLV, DC, DM, GG, JRW, MR, LM, MAE, and JD undertook recruitment of participants and centers and managed the data, including quality control. IGS and GAW provided statistical advice on study design and analyzed the data. IGS chaired the data oversight committee. GD drafted the manuscript, and all authors contributed substantially to its revision. IGS takes responsibility for the paper as a whole.

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