

# Overview and Comparison of NEXUS and Canadian C-Spine Rules

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## Abstract

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Each year, over 13 million patients are evaluated in U.S. emergency departments for possible cervical spine injuries. While only a small fraction of these patients (approximately 0.3%) turn out to have significant C-spine injuries, an overwhelming amount of cervical imaging, costing well over \$180 million dollars annually, is performed. In addition to the financial burden, patients requiring radiography are often subjected to uncomfortable waits and take up scarce resources in emergency departments. In order to address these concerns, there has been an effort in recent years to develop clinical decision rules that can safely and reliably “rule-out” C-spine injury. The NEXUS Low-Risk Criteria and the Canadian Cervical Spine Rule have emerged as two of the most promising decision rules for evaluating which patients warrant cervical spine imaging. This paper reviews these rules, their sensitivities, specificities, and limitations in clinical application. While the Canadian Cervical Spine Rule has proven to be both more sensitive and specific than the NEXUS criteria, practitioners appear reluctant to fully implement any decision rule given the high morbidity and mortality associated with any missed cervical spine injury.

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## Introduction

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It is estimated that emergency departments in the United States annually treat over 13 million patients with possible neck injuries. Only 0.3%, which equates to approximately 40,000, of these patients will have actually sustained a cervical spine (C-spine) or spinal cord injury.<sup>1</sup> Despite the small incidence of significant cervical spine injury, an overwhelming amount of cervical spine radiography is performed each year. While each individual cervical spine series is relatively inexpensive, it is estimated that well over \$180 million dollars is spent each year on this single diagnostic test.<sup>2</sup> Furthermore, once the radiography process is initiated, it must continue until suitable images are obtained. Often in the face of inadequate plain films, this will require CAT scans and/or MRI's. While this high rate of cervical spine imaging comes at a large financial cost to patients, it also comes with a significant physical and psychological cost to those patients who must remain immobilized until the tests are completed. Furthermore, precious emergency department space is occupied, and arguably wasted, while the imaging is completed and interpreted.<sup>3</sup> Given the various problems associated with such a high rate of cervical spine imaging, in conjunction

with the low incidence of significant findings, there has been an effort in recent years to develop a set of reliable and simple clinical criteria that can safely rule-out injuries to the cervical spine. The National Emergency X-Radiography Utilization Study (NEXUS) Low-Risk Criteria and the Canadian Cervical-Spine Rule (CCR) have emerged as the two most prominent sets of criteria. To varying degrees, each set has shown its ability to reliably and safely rule-out patients for cervical spine injuries, thus significantly reducing the amount of unnecessary cervical imaging.<sup>4</sup>

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## National Emergency X-Radiography Utilization Study

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The work that ultimately became the National Emergency X-Radiography Utilization Study (NEXUS) Low-Risk Criteria was first introduced in 1992 when research indicated that cervical spine radiography may not be necessary to rule-out C-spine injury in patients who displayed no cervical spine tenderness, signs of intoxication, altered mental status, or significant and painful distracting injuries.<sup>5</sup> A fifth element (absence of focal neurological deficits) was subsequently added to produce what stands as the current NEXUS Low-Risk Criteria.<sup>2</sup> In a study of 34,069 patients, the NEXUS researchers found the criteria to have a sensitivity of 99.6% and a specificity of 12.9% for significant cervical spine injuries.<sup>4,9</sup> While it has been argued that the NEXUS criteria are vague and poorly reproducible, the original NEXUS participants were provided with further explanations and guidelines for each criterion.<sup>2,4</sup> For the purposes of the original study, a patient was deemed to have altered mental status if he/she or they exhibited any one or more altered mental status criteria including a rating of 14 or less on the Glasgow Coma Scale, disorientation to person, time, or place, delayed or inappropriate response to external stimuli, any focal neurological deficits, or an inability to remember three objects after five minutes. Similarly, a patient was defined as intoxicated if they had a history of recent intoxication or ingestion, signs and symptoms consistent with intoxication, or a blood alcohol level of .08mg/dl. Physicians were allowed to use their judgment as to what constituted a distracting injury but were instructed that any long bone fracture, visceral injury requiring a surgical consultation, crush or degloving injury, significant laceration or burn would constitute such an injury.<sup>2</sup>

Many clinicians and researchers, however, have found it

difficult to determine exactly what type of injuries could interfere with a thorough physical exam or distract a patient from other injuries.<sup>3,4,10</sup> In an effort to address this concern and potentially improve the NEXUS criteria, Heffernan et al. (2005) investigated how an injury's location affected an accurate assessment of the cervical spine. The results of the 406 patient study indicated that serious injuries to the upper torso, defined as any region above the lumbar spine, could, in fact, distract patients from pain in their cervical spine, thus interfering with a dependable C-spine assessment. Injuries located solely in the lower torso, however, did not appear to interfere with an accurate assessment for C-spine tenderness.<sup>10</sup>

Although the original NEXUS research reported nearly 100% sensitivity for significant cervical spine injuries, subsequent studies have demonstrated slightly less sensitivity for the Low-Risk Criteria.<sup>4,6</sup>

While the primary NEXUS study focused on adult patients, Viccellio et al investigated how accurate the NEXUS criteria were when applied to pediatric patients presenting with blunt trauma.<sup>7</sup> Of the 3,065 pediatric patients (18 and younger) enrolled in the study, 30 (0.98%) were found to have significant cervical spine injuries.<sup>7</sup> The NEXUS criteria were found to be 100% sensitive in the pediatric population and would have successfully "ruled-out" 603 patients as low risk, thus potentially reducing cervical spine imaging by approximately 20%.<sup>7</sup> Given that pediatric patients can prove to be quite difficult to examine, especially when physical and emotional stressors are involved, a fast, yet reliable, clinical decision rule for cervical spine injuries would prove quite useful.

Ngo et al (2000) also found the NEXUS criteria to be effective with elderly patients.<sup>11</sup> Of the 1,070 elderly patients, defined as 80 years or older, involved in the original NEXUS research, 50 (6.11%) were found to have significant cervical spine injuries. The NEXUS criteria were found to be 100% sensitive in this population and effectively deemed 132 patients to be at low risk (ruled-out) for cervical spine injury.<sup>11</sup> In addition to being at a higher risk of cervical spine injuries,<sup>11</sup> elderly patients also appear to experience a higher level of discomfort from devices used to immobilize the cervical spine. With this in mind, a safe and effective way to limit immobilization times for elderly patients at low risk for cervical spine injury would be quite beneficial.

**Figure 1: The NEXUS Low-Risk Criteria\***

**C-spine imaging is recommended for patients with trauma unless they meet all of the following criteria:**

- **Absence of posterior midline cervical-spine tenderness,#**
- **No evidence of intoxication,\***
- **A normal level of alertness and consciousness (baseline mental status),◆**
- **Absence of focal neurological deficit,\***
- **Absence of any distracting injuries.○**

# Midline posterior bony cervical-spine tenderness is present if the patient reports pain on palpation of the posterior midline neck from the nuchal ridge to the prominence of the first thoracic vertebra, or if the patient expresses pain with direct palpation of any cervical spinous process.

\* Patients should be considered intoxicated if they have a recent history provided by the patient or an observer of intoxicating ingestion or evidence of intoxication on physical exam such as an odor of alcohol, slurred speech, ataxia, or any behavior indicative of intoxication. Patients may also be considered to be intoxicated if laboratory tests are positive for alcohol or drugs that affect the level of alertness.

◆ An altered level of alertness can include any of the following: a GCS score of 14 or less; disorientation to person, place, time, or events; inability to recall three objects at five minutes; a delayed or inappropriate response to external stimuli; or alternative findings consistent with altered mental status.

\* A focal neurological deficit is any focal neurological finding on motor or sensory examination.

○ A distracting injury is any condition that, in the examiner's judgment could be producing enough pain so as to distract the patient from another, particularly cervical, injury. Such injuries may include a long-bone fracture; a visceral injury; a significant laceration, degloving injury, or crush injury; large burns; or any other injury causing acute functional impairment.

Adapted from Hoffman and colleagues, as presented by Stiell et al.,<sup>4,9</sup>

Just as physicians must decide whether they can clinically "clear" a patient's cervical spine, pre-hospital medical providers must decide whether cervical spine immobilization is indicated in the first place. In an attempt to limit unnecessary immobilization, the State of Maine has incorporated a conservative version of the NEXUS criteria into their 2002 Protocols.<sup>8</sup> The Maine Pre-hospital Protocols differ from the original NEXUS criteria in two significant ways. First, they combine the intoxication and altered mental status criteria into a single, more comprehensive, mental status criterion. This simplifies the rule and emphasizes the importance of the patient's mental status. The second major change is that instead of limiting the criteria to cervical spine tenderness, the Maine protocols state that pre-hospital providers will immobilize any patient complaining of neck pain or tenderness anywhere along the posterior spine. This change works to increase the sensitivity of the rule as well as to decrease disagreement between providers.

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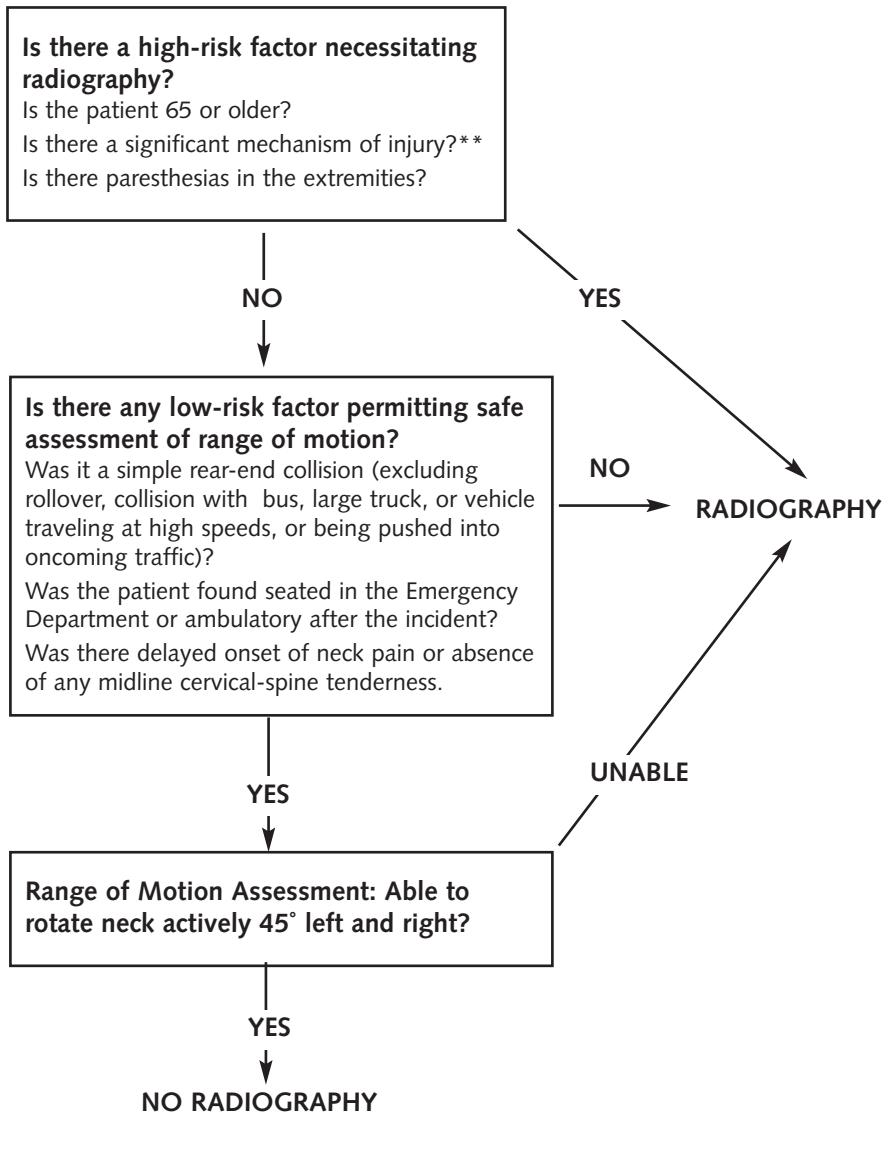
**Canadian Cervical Spine Rule**

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As with the NEXUS researchers, the Canadian Cervical

**Figure 2: The Canadian Cervical-Spine Rule\***

To be used on alert (GCS of 15) and stable trauma patients with potential C-spine injury.



\*Adapted from Stiell et al. 3,4

\*\* A Dangerous Mechanism includes: a fall from an elevation ≥3 feet

or 5 stairs; an axial load to the head (e.g. diving); a motor vehicle collision at high speed (>100 km/hr) or with rollover or ejection; a collision involving a motorized recreational vehicle; or a bike collision.

Spine Rule (CCR) investigators were attempting to develop a set of clinical criteria for evaluating the need for C-spine radiography in stable trauma patients.<sup>3</sup> First published in 2001, the CCR assessed patients for a high-risk factor, a low-risk factor, and the ability to actively rotate their necks.<sup>3,4</sup> Patients were only eligible for CCR evaluation if they were 16 years old or older, were alert and oriented (defined as scoring 15 on the Glasgow Coma Scale), had sta-

ble vital signs, and had sustained some trauma which placed them at risk for C-spine injury. Additionally, patients were not eligible if they had any of a few confounding factors such as paralysis, history of vertebral injury or disease, or pregnancy.

The CCR first evaluates suitable patients for any of three high risk criteria. The first of the three is an age-factor, deeming any patient who is 65 years old to be at high risk. The second factor looks for any dangerous mechanism, including a fall from a height greater than 3 feet, a high-speed motor vehicle collision (greater than 100km/hr, with or without rollover or ejection), an accident involving a bike or motorized recreational vehicle, or a direct axial load that would place the patient at high risk for a C-spine injury. The third high-risk factor is paresthesias in any or all extremities. If any of the three high-risk factors applies to the patient, the CCR mandates radiography.

If the patient lacks any high-risk factor, the CCR then evaluates the patient for the presence of any low-risk factor that will eventually allow for safe assessment of cervical range of motion. The published low-risk factors are simple rear-end motor vehicle collisions, a patient found sitting in the Emergency Department or ambulatory after the accident, delayed onset of neck pain or absence of any midline cervical pain. If none of these low-risk factors applies to the patient, the CCR mandates radiography.

If, however, the patient has no high-risk factor and does have at least one low-risk factor, the CCR then assesses the patient's ability to actively rotate their neck, both left and right, at a 45° angle, with or without pain. If the patient is physically unable to perform this exercise, radiography is indicated. If the

patient can perform this manipulation, however, the CCR recommends that no radiography is necessary to rule-out significant cervical spine injury.

The CCR was evaluated in a large study involving 10 separate Canadian Emergency Departments.<sup>3</sup> Across the 8,924 patients enrolled, the incidence of significant C-spine injury was 1.7%. The CCR was found to be 100% sensitive and 42.5% specific for these "significant" injuries. Using the

CCR, the radiography rates in the study population would have been reduced by 15.5%.

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### Comparison

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In order to directly compare the CCR and the NEXUS Low-Risk Criteria, Stiell et al. performed a comparison study in affiliation with nine Canadian Emergency Departments.<sup>4</sup> Of the 8,283 trauma patients enrolled in the study, 169 (2%) were found to have significant C-spine injuries. The CCR was found to be 99.4% sensitive and 45.1% specific while the NEXUS criteria were determined to have a sensitivity of 90.7% and a specificity of 36.8%. The CCR would have reduced the radiography rate to 55.9% of the actual rate while a 66.6% rate would have been observed using the NEXUS criteria.

Interestingly, however, the study noted that physicians were both less comfortable and less accurate when applying the CCR as compared to the NEXUS criteria. In fact, physicians failed to perform the required range of motion assessment for 845 patients (10.2% of the enrolled population). Although these patients were sent for imaging at a higher rate than the average patient in the study (98.8%), they did not have a higher incidence of injuries (0.8%). Had these patients been included in the data analysis as high risk cases, the CCR's sensitivity would have remained at 99.4% while the specificity would have dropped to 40.4%. While this reluctance to evaluate range of motion is understandable given the emphasis on complete spinal immobilization for patients with potential cervical trauma, one must question how useful the tool will be if physicians are reluctant to fully employ it.

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### Conclusions

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While the literature has consistently demonstrated the CCR to be both more sensitive and specific than the NEXUS Low-Risk Criteria for detecting cervical spine injuries, one must question how good the instruments must be before they are widely accepted by practitioners.<sup>3,4,6,9</sup> Some physicians, for example, would be willing to risk missing a small percentage of those patients with fractures while most would not accept any misses of clinically significant fractures and thus would continue to radiograph all trauma patients at risk for C-spine injury. Despite the fact that research has found the CCR to be better than unstructured physician judgement,<sup>1</sup> there still seems to be a general reluctance for the implementation of clinical judgment rules for ruling-out cervical spine injuries. C-spine injuries, while relatively rare, can result in devastating outcomes, thus encouraging physicians to remain conservative and cautious.

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### References

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1. Bandiera G, Stiell, IG, Wells GA et al. The Canadian C-Spine Rule performs better than unstructured physician judgment. *Annals of Emergency Medicine* 2003; 42, 395-402.
2. Hoffman JR, Wolfson AB, Todd K, Mower WR. Selective cervical spine radiography in blunt trauma: methodology of the National Emergency X-Radiography Utilization Study (NEXUS). *Annals of Emergency Medicine* 1998; 32, 461-9.
3. Stiell IG, Wells GA, Vandeheem K, et al. The Canadian C-Spine rule study for alert and stable trauma patients. *JAMA* 2001; 286: 1841-8.
4. Stiell IG, Clement CM, McKnight RD, et al. The Canadian C-Spine rule versus the NEXUS low risk criteria in patients with trauma. *New England Journal of Medicine* 2003; 349: 2510-8.
5. Hoffman JR, Schriger DL, Mower WR, et al. Low-risk criteria for cervical-spine radiography in blunt trauma: a prospective study. *Annals of Emergency Medicine* 1992; 21:1454-1460.
6. Dickinson G, Stiell IG, Schull M, et al. Retrospective application of the NEXUS low-risk criteria for cervical-spine radiography in Canadian emergency departments. *Annals of Emergency Medicine* 2004;43: 507-514.
7. Viccellio P, Simon H, Pressman BD, et al. A prospective multicenter study of cervical spine injury in children. *Pediatrics* 2001;108: e20.
8. State of Maine Spinal Assessment Protocol. *Maine EMS* 2002.
9. Hoffman JR, Mower WR, Wolfson AB, et al. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. *New England Journal of Medicine* 2000; 343: 94-99.
10. Heffernan, DS, Schermer, CR, Lu, SW. What defines a distracting injury in cervical spine assessment. *Journal of Trauma Injury, Infection, and Critical Care* 2005; 59: 1396-1399.
11. Ngo, B, Hoffman, JR, Mower, WR. Cervical spine injury in the very elderly. *American Society of Emergency Radiology* 2000; 7:287-291.