Canadian C-spine Rule and the National Emergency X-Radiography Utilization Low-Risk Criteria for C-spine radiography in young trauma patients

Peter F. Ehrlich⁎, Christopher Wee, Robert Drongowski, Ankur R. Rana

Section of Pediatric Surgery, Department of Surgery, The University of Michigan Medical School and The C.S. Mott Children's Hospital, Ann Arbor, MI 48109, USA

Received 11 January 2009; accepted 15 January 2009

Key words: Clinical decision rule pediatric; Trauma; Cervical spine

Abstract

Purpose: The Canadian C-spine (cervical spine) Rule (CCR) and the National Emergency X-Radiography Utilization Low-Risk Criteria (NLC) are criteria designed to guide C-spine radiography in trauma patients. It is unclear how these 2 rules compare with young children.

Methods: This study retrospectively examined case-matched trauma patients 10 years or younger. Two cohorts were identified—cohort A where C-spine imaging was performed and cohort B where no imaging was conducted. The CCR and NLC criteria were then applied retrospectively to each cohort.

Results: Cohort A contained 125 cases and cohort B with 250 cases. Seven patients (3%) had significant C-spine injuries. In cohort A, NLC criteria could be applied in 108 (86.4%) of 125 and CCR in 109 (87.2%) of 125. National Emergency X-Radiography Utilization Low-Risk Criteria suggested that 70 (58.3%) cases required C-spine imaging compared to 93 (76.2%) by CCR. National Emergency X-Radiography Utilization Low-Risk Criteria missed 3 C-spine injuries, and CCR missed one. In cohort B, NLC criteria could be applied in 132 (88%) of 150 and CCR in 131 (87.3%) of 150. The NLC criteria identified 8 cases and CCR identified 13 cases that would need C-spine radiographs. Fisher’s 2-sided Exact test demonstrated that CCR and NLC predictions were significantly different (P = .002) in both cohorts. The sensitivity of CCR was 86% and specificity was 94%, and the NLC had a sensitivity of 43% and a specificity of 96%.

Conclusions: Although CCR and NLC criteria may reduce the need for C-spine imaging in children 10 years and younger; they are not sensitive or specific enough to be used as currently designed.

© 2009 Elsevier Inc. All rights reserved.

Cervical spine injuries (CSIs) remain one of the most devastating consequences from trauma. An injury can result in lifelong morbidity. Therefore, a thorough evaluation is mandated when a spinal cord injury is suggested or suspected. Alternatively, CSIs are rare events, especially in pediatric trauma (1%-2%), and often many children undergo cervical spine imaging who may not need it [1-5]. This is further complicated by concerns regarding the routine use of
Clinical decision rules (CDRs) are developed to reduce the uncertainty of medical decision making by standardizing the collection and interpretation of clinical data [6-8]. A decision rule is derived from original research and may be defined as a decision-making tool that incorporates 3 or more variables from the history, physical examination, or simple tests [6-8].

The Canadian C-spine (cervical spine) Rule (CCR) and the National Emergency X-Radiography Utilization Low-Risk Criteria (NLC) are decision rules designed to guide C-spine radiography in trauma patients [9-11]. National Emergency X-Radiography Utilization Low-risk criteria was first described in 1992 [11]. A validation study involving 34,069 patients reported a sensitivity of 99.6% and a specificity of 12.9% for CSI [9]. In this validation study, however, only 2.5% of the participants were children younger than 10 years, and only 0.08% had a CSI [9,12]. The CCR studied 8924 patients and reported a sensitivity of 100% (95% confidence interval, 98%-100%) and 42.5% specificity (95% confidence interval, 40%-44%) for identifying 151 clinically important CSIs [10]. No children younger than 16 were included in this study. Both the NLC and the CCR studies concluded that their rules had the potential to significantly reduce practice variation and inefficiency in emergency department use of C-spine radiography.

The evaluation of the cervical spine in a young (<10) trauma patient is challenging. Young children may not be able to communicate crucial symptoms; the physical examination can be compromised in an anxious crying or uncooperative child. There are also recognized anatomical differences between pediatric and adult cervical spines [13-15]. Therefore, the presentation of a CSI in an adult is not necessarily the same as a child. Thus, clinical decisions rules for cervical spine imaging derived from adult studies may not be as sensitive or specific in a young pediatric population.

In 2003, a study compared the NLC and CCR decisions rules and suggested that CCR may be superior to NLC in reducing the rates of unnecessary C-spine imaging because of a higher sensitivity and specificity for detecting clinical significant spine injuries [16]. It is unclear how the 2 decision rules compare with young children. The purpose of this case-matched study was to examine the performance of the decision rules in a pediatric trauma population younger than 10 years. Our working hypothesis is that NLC and the CCR are effective decision rules in determining the necessity of cervical spine imaging for pediatric trauma patients 10 years and younger.

1. Methods

This study was approved by the University of Michigan’s Institutional Review Board (Ann Arbor, Mich). It is a retrospective case-matched design with trauma patients 10 years or younger. The University of Michigan CS Mott Children’s Hospital is an American College of Surgeons-verified level I pediatric trauma center. The pediatric trauma registry from 2005 to 2007 was used to identify the patients. The pediatric trauma registry records all hospital trauma patients younger than 18 years.

1.1. Cervical spine imaging

Our institutional guidelines suggest an initial physical examination of the C-spine for all trauma patients. There were no protocols or other CDR being used for cervical spine examination. Patients with reliable examinations and who were fully awake without motor/sensory deficits, neck pain, evidence of intoxicating agents, and distracting injuries were clinically cleared in the trauma center by an Advanced Trauma Life Support-certified physician. No further evaluation of the cervical spine was performed after the stabilization collar was removed.

If the patient complained of neck tenderness, had neurologic deficits, had an abnormal Glasgow Coma Scale (GCS) (because of head injury, drugs, alcohol), or distracting pain from another injury, the patient underwent cervical spine imaging. Plain C-spine radiographs, CT scan, or both were used, and the decision for investigation was made by the designated leader of the trauma team. If the radiographic imaging was negative for CSI, the initial stabilization collar was changed to a padded collar until a reliable examination could be performed. Flexion and extension views were performed in patients with continued cervical tenderness or if they required prolonged intubation. If pain persisted, patients were discharged home with a cervical spine collar and followed by the neurosurgery team for clearance.

The ultimate decision to image the cervical spine was at the discretion of the trauma team leader. Trauma team leaders could be one of the following: a pediatric surgeon or fellow, an emergency department faculty or fellow, or the senior resident (level 4) in general surgery.

1.2. Clinical decision criteria

The CCR criteria and NLC criteria are shown in Table 1. A positive answer to any of the 3 CCR criteria or 1 of the 5 NLC criteria mandated cervical spine imaging.

1.3. Study cohorts

The study population of interest was the pediatric trauma patient 10 years or younger. Two study cohorts were identified. Cohort A included all the trauma patients 10 years or younger who underwent C-spine imaging as part of their initial workup in the emergency department. Cohort B included trauma patients 10 years or younger who...
did not undergo C-spine imaging as part of their initial workup in the emergency department. This cohort was randomly identified by the trauma registry. After this, the CCR and NLC criteria were then applied to each cohort based on the initial history and physical examination using 2 blinded and trained research assistants (RAs).

### 1.4. Research assistants

Research assistants (RAs) were undergraduate science and/or medical students at the University of Michigan. Research assistants were trained by the study principal investigator to review charts and identify the CCR and NLC criteria from the medical record. A $\beta$ sample of 20 patients per RA was then reviewed by the principal investigator to ensure reliability and validity of the RA interpretation. The patients were then reentered into each cohort. Study patients were reviewed twice (once by each RA) in a blinded fashion. If there was discrepancy between the 2 RA interpretations or if there was a question about a particular study patient, the principle investigator reviewed the case and made a final determination.

### 1.5. Research outcomes

Research outcomes included missed injuries, the ability to apply the CCR or NLC criteria, and reduction or increased requirements for decision rules per cohort. In addition, age, sex, Injury Severity Score, GCS, intubation status, and treatment plan were analyzed. A *clinically important spine injury* was defined as any fracture, dislocation, or ligamentous instability demonstrated by imaging. Clinically unimportant findings included osteophyte avulsion, a transverse process not involving the facet joint, a spinous process not involving the lamina, or a simple vertebral compression of less than 25% of body height. This definition has been used and standardized in previous studies [17].

### 2. Results

Between 2005 and 2007, 1307 pediatric trauma patients were identified for review. For 318 patients (24.3%), radiographic imaging was performed to rule out a possible CSI. Of these, 125 were 10 years or younger and comprised cohort A. Nine hundred eighty-nine patients did not undergo cervical spine imaging of which 150 children 10 years or younger were randomly identified from the trauma registry. This comprised cohort B. Injury characteristics are shown in Table 2. Seven patients (3%) had clinically significant CSIs all of whom underwent C-spine imaging (cohort A) as determined by the trauma team leader.

Cohort A (imaged) contained 72 males and 53 females with an average age of $4.3 \pm 3.1$ years. Cohort B (nonimaged) contained 88 males and 62 females with an average age of $5 \pm 2.6$ years. As expected, the Injury Severity Score and GCS were significantly different between the 2 cohorts. Posterior midline tenderness (NLC1) and ability to rotate the neck (CCR3) were the most frequent criteria that could not be evaluated.

In cohort A, NLC criteria could be applied in 108 (86.4%) of 125 patients, whereas CCR criteria could be applied in 109 (87.2%) of 125. National Emergency X-Radiography Utilization Low-Risk Criteria suggested that only 70 (58.3%) cases required C-spine imaging compared to 93 (76.2%) by CCR. A 2-sided Fisher’s Exact test demonstrated that the CCR and NLC predictions were significantly different ($P = .002$). If applied, NLC would have missed 3 CSIs (fractures of C3, C5, and C7), whereas CCR would have missed one (spinous fracture of C5). The sensitivity and specificity of CCR were 86% and 94%, respectively, whereas the NLC had a sensitivity of 43% and a specificity of 96%.

In cohort B, the NLC criteria could be applied to 132 (88%) of 150 patients, and the CCR criteria could be applied to 131 (87.3%) of 150 patients. If applied, NLC and CCR criteria identified 8 and 13 cases, respectively, that would have needed C-spine radiographs. Only 4 cases were common to both groups. A 2-sided Fisher’s Exact test showed that NLC and CCR were different ($P = .003$). There were no missed injuries.

### Table 2

Comparison of patient demographics between cohort A and B

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cohort A (imaged)</th>
<th>Cohort B (not imaged)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>$4.3 \pm 3.1$</td>
<td>$5 \pm 2.6$</td>
</tr>
<tr>
<td>GCS</td>
<td>$13.1 \pm 4.2$</td>
<td>$14.9 \pm 0.2$</td>
</tr>
<tr>
<td>ISS</td>
<td>$13.3 \pm 11.1$</td>
<td>$6.9 \pm 6.0$</td>
</tr>
<tr>
<td>Sex</td>
<td>Male = 72</td>
<td>Male = 88</td>
</tr>
<tr>
<td></td>
<td>Female = 53</td>
<td>Female = 62</td>
</tr>
<tr>
<td>Missed injuries</td>
<td>NLC = 3</td>
<td>NLC = 0</td>
</tr>
<tr>
<td></td>
<td>CCR = 1</td>
<td>CCR = 0</td>
</tr>
</tbody>
</table>

ISS indicates Injury Severity Score.
3. Discussion

Clinical decision rules help clinicians make diagnostic and therapeutic decisions at the bedside. They are derived from original research and incorporate 3 or more variables from the history, examination, or simple tests [6-8]. Clinical decision rules have been developed for ankle injuries, deep vein thrombosis, and for patients who have pneumonia [6,7,18-21]. There are 3 stages in developing a CDR. The first stage is to create/derive the rule; the second stage involves validation of the rule to assess the rule’s accuracy, reliability, and potential impact; and the third stage is to assess the rule’s impact on patient care and outcomes.

Cervical spine injuries after pediatric trauma are rare (1%) [1,2]. The NLC and CCR are 2 CDRs developed to assist with cervical spine imaging after a trauma. Their goals are 2-fold—identify patients at risk for a CSI and reduce unnecessary imaging. Cervical spine imaging after a trauma is important because missing an injury is potentially devastating. However, unnecessary imaging increases costs and, with the increased use of CT for CSIs, may expose patients to excess radiation [22]. This is particularly important for children [23,24].

The NLC criteria were developed and then validated in a mixed population of adults and children; however, only 9% of the patients were considered pediatric. Furthermore, intoxication is not a relevant issue in young children, and no special considerations were used for nonverbal children. A secondary analysis of the pediatric cases was performed, and although the NLC criteria were performed well, there were several concerns raised by the authors [12]. Although no CSI were missed and the sensitivity of the decision rule was 100%, the confidence intervals were wide, ranging from 87.8% to 100%. Furthermore, there were only 30 children with CSIs in this series, and all injuries were located between C5 through C7. This does not reflect true injury patterns. A recent publication from Garton et al [25] had a similar finding in their study in which the NLC had a sensitivity of 75%. Although the CCR performed better than NLC in this study because of the inherent rarity of CSI, a single injury would have dramatically affected sensitivity of each CDR.

An important aspect of a CDR to consider is whether one can apply the criteria to a specific patient population. When the NLC was compared to the CCR, 10% of patients were excluded because all criteria could not be fully evaluated [16]. In this study, a similar observation was noted. The respective criteria of each CDR could not be applied in every case (NLC, 86.4%; CCR, 87.2%). Posterior midline tenderness (NLC1) and the ability to rotate the neck (CCR3) were the most frequent criteria that could not be evaluated. This may be because physicians may not be comfortable assessing the range of motion (CCR3) and midline tenderness (NLC1) in children wearing a collar. Alternatively, this study was a retrospective, and although in some cases where the CDR criteria could not be applied was because examination was not performed, it could also have been performed but simply not documented.

The cases in cohort A that the CCR and NLC determined did not require imaging were not the same. In cohort B, the CCR determined that 13 patients required imaging, whereas the NLC found 8. Only 4 cases were common to both. This observation that both the CCR and NLC performed differently should not be surprising because the CDRs only share one clinical component.

The limitations of this study are inherent in its design. This is a retrospective study based on chart reviews. A prospective study where the criteria are assessed at the same time as the physician determines the need for cervical spine imaging may produce different results. Although the RAs were trained to apply CDR criteria, they were not medical doctors [27].

In summary, neither CDR performed at a high enough level to be used with confidence. Intuitively, this is not surprising because neither CDR was designed to account for pediatric issues. Both CDRs were more sensitive and specific...
with the adolescent population and may be a useful tool in this group as they account for a significant proportion of pediatric trauma patients. Furthermore, it is a compelling argument to use CDR to improve the efficiency of cervical spine imaging. Both of these CDR have criteria that are relevant, but age adjustments need to be evaluated to ensure a higher sensitivity and specificity for younger children. Future research should focus on identifying the most robust criteria as well as developing new criteria designed specifically for younger children.

References