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The Use of the Canadian C-Spine Rule to Reduce the Rate of Unnecessary Radiography in Alert Stable Patients With Trauma

Abstract

Background: Despite a small percentage of true cervical spine injuries, a high number of the five million patients presenting to emergency departments with suspected cervical spine injuries undergo x-ray or computed tomography to rule out injury. High volume radiographic imaging can lead to higher medical costs as well as the potential for increased risk of cancer in overly exposed patients. The Canadian C-Spine Rule (CCR) is a clinical decision or prediction rule developed in Canada that is used to detect acute cervical spine injury. The objective of this systematic review is to determine if the use of the CCR, results in decreased radiographic imaging of the cervical spine versus unstructured physician judgment.

Methods: An extensive search of the literature was conducted using MEDLINE, CINAHL, and Pubmed. Four studies were selected that met the inclusion and exclusion criteria.

Results: All of the studies reviewed concluded that the CCR was better than unstructured physician judgment at reducing unnecessary radiographic imaging, and the CCR was more sensitive and specific than unstructured physician judgment at detecting cervical spine injury.

Conclusion: The CCR is superior to unstructured physician judgment in the reduction of unnecessary radiographic imaging in stable, alert adults with cervical-spine injury. It is also considered a more sensitive and specific tool than relying on individual physician judgment alone.

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The Use of the Canadian C-Spine Rule to Reduce the Rate of
Unnecessary Radiography in Alert Stable Patients With Trauma

Shannon Goddard



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ABSTRACT

Background: Despite a small percentage of true cervical spine injuries, a high number of the five million patients presenting to emergency departments with suspected cervical spine injuries undergo x-ray or computed tomography to rule out injury. High volume radiographic imaging can lead to higher medical costs as well as the potential for increased risk of cancer in overly exposed patients. The Canadian C-Spine Rule (CCR) is a clinical decision or prediction rule developed in Canada that is used to detect acute cervical spine injury. The objective of this systematic review is to determine if the use of the CCR, results in decreased radiographic imaging of the cervical spine versus unstructured physician judgment.

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Keywords: cervical-spine trauma, Canadian C-Spine Rule, radiography

TABLE OF CONTENTS

INTRODUCTION.....	5
Background.....	5
Purpose of the Study	8
METHODS	9
RESULTS.....	9
DISCUSSION.....	13
CONCLUSION.....	18
REFERENCES.....	20
APPENDIX	22
A. Table 1: GRADE.....	22

INTRODUCTION

Background

It is estimated that over five million people present to emergency departments annually with potential neck injury (Niska, Bhuiya, & Xu, 2010). However, only a small percentage of those people are found to have unstable cervical spine injury as a result of blunt trauma when examined with radiography. (Goldberg et al., 2001). The use of radiography as a screening tool has several counter arguments, which include cost and potential unnecessary exposure to radiation.

Although radiography of the cervical spine is viewed as a low-cost item particularly in plain films, in large volume it has the potential to become high-cost. Furthermore, although computerized tomography (CT) is more sensitive than x-ray at detecting injury, more costs are incurred with its use. According to the US Government Accountability Office, annual spending on CT imaging more than doubled from 2000 to 2007 from \$975 million to \$2171 million. During the same period, spending for standard imaging (plain radiographs and ultrasounds) increased by 65% (2008).

In addition to needless expense, there is evidence from epidemiologic studies that the adult organ doses of radiation associated with a common CT study (two or three scans, totaling an estimated dose range of 30 to 90 mSv) carries an increased risk of cancer. (Brenner & Hall, 2007).

The Canadian C-Spine Rule (CCR) is a clinical prediction rule, the role of which is to reduce the uncertainty in determining if a patient requires radiographic imaging of the cervical spine. It uses the findings based on physical exam to make that prediction. "Clinical prediction rules are derived from systematic clinical observations. They can

help physicians quickly identify patients who require diagnostic tests, treatment, or hospitalization” (Wasson, Sox, Neff, & Goldman, 1985, 793).

The CCR is a clinical decision or prediction rule developed in Canada that is highly sensitive for detecting acute cervical spine injuries in patients that have a Glasgow coma score of 15 and that have stable vital signs (Stiell et al., 2001). In a study published in 2001 involving 8,924 patients, the CCR was found to be 100% sensitive and 42.5% specific. (Stiell et al., 2001).

The CCR was developed, not only to guide providers in identifying patients at risk for neck injury, but also to potentially decrease practice variation and inefficiency in emergency department radiography. The CCR is not applicable for: “non-trauma cases, Glasgow coma score less than 15, unstable vital signs, age less than 16 years, acute paralysis, known vertebral disease, or previous surgery of the cervical spine” (Stiell et al., 2009, 2).

The rule is based on three clinical questions:

1. Is there any high risk factor that requires radiography? This includes any one of the following three statements: age greater than or equal to 65 years, dangerous mechanism of injury, or extremity paresthesia. The authors define dangerous mechanism as: “fall from elevation greater than or equal to 0.9 meters (3 feet/5 stairs), axial load to the head- for example, diving, motor vehicle collision high speed (greater than 100 km/hour), rollover or ejection motor vehicle accidents, motorized recreational vehicles, or bicycles struck or collision” (Stiell et al., 2009,2). If the answer is yes, radiography is recommended.

2. Are there low risk factors that allow for safe assessment of range of motion? These factors include any of the following:

- Simple rear end motor vehicle collision
- Sitting position in emergency department
- Walking at any time
- Delayed onset of neck pain
- Absent midline cervical spine tenderness (Stiell et al., 2009, 2).

If any of these are not present, (for example, if the patient had midline cervical spine tenderness or acute onset of neck pain) radiography is recommended. If present, then the provider may continue to question three.

3. Is the patient able to actively rotate the neck 45 degrees left and right? If able, radiography is not indicated. If not, radiography is again recommended.

The CCR is not the only tool used by providers to determine cervical injury. The National Emergency X-Ray Radiography Utilization Study (NEXUS) Low-Risk Criteria (NLC) were introduced in 1992 after a study that included 1,000 patients was conducted in the US that concluded that cervical spine radiography does not need to be performed on selected blunt trauma patients who are 1) awake, 2) alert, 3) nonintoxicated, 4) do not complain of midline neck pain, and 5) have no tenderness over the bony cervical spine (Hoffman, Schriger, Mower, Luo, & Zucker, 1992).

A validation study for the NLC method was conducted later in the US that examined the performance of the criteria in a study involving 34,069 patients, and it was determined that the NLC was 99.0% sensitive but only 12.9% specific (Hoffman, Mower, Wolfson, Todd, & Zucker, 2001). The CCR was more specific than the NLC (42.5% versus 12.9%). This is significant, as a lower specificity may result in a higher rate of patients being unnecessarily imaged. A cohort study published by Stiell et al. (2003)

conducted in Canada determined that the CCR was more sensitive than the NLC (99.4% versus 90.7%) and more specific (45.1% versus 36.8%). The study also found a bigger reduction in radiography rates for the CCR (55.9% versus 66.6%).

The CCR has been scrutinized for its complexity, particularly in reference to the evaluation of cervical range of motion. The authors of the 2003 study admitted that in some cases on the range of motion step was ignored and some participants could not be included in the study's primary analysis as a result of this omission (Stiell et al., 2003). There is also concern regarding the medical/legal climate in the US, particularly that is more litigious than other countries. It is felt that this climate may contribute to the higher incidence of radiography in the US.

Purpose of the Study

The purpose of this study is to perform a systematic review of the literature that compares the CCR and unstructured physician judgment in assessment of alert, stable patients with suspected cervical injury, and determine which is more proficient in reduction of unnecessary radiography. In this review, the Grading recommendations (Guyatt et al., 2008) will be applied to assess the quality of the evidence.

METHODS

An extensive search of the literature was conducted using MEDLINE, CINAHL, and Pubmed. The following keywords were searched individually and in combination: Canadian C-Spine Rule and trauma. Studies were selected for analysis based on the

following criteria: published in the English language, human subjects, and since the year 2000. This resulted in 64 articles of which duplicates, narrative reviews, editorials and letters to the editor were excluded. Four articles met the criteria to be included in the analysis.

RESULTS

A randomized trial by Stiell et al. (2009) was conducted in 12 university and community emergency departments in Canada. The design was a matched pair cluster randomized trial that evaluated the diagnostic imaging rate of the cervical spine during two 12 month before and after periods, comparing the use of the CCR versus unstructured physician judgment. The examiners enrolled in the study, 11,824 alert and stable patients that presented with blunt trauma to the head and neck with neck pain; or if neck pain was absent but had obvious injury above the clavicles, had not walked, and the mechanism of injury was evaluated as dangerous. Additionally, patients were required to have a Glasgow coma score of 15, stable vital signs, and be within 48 hours of their injury. Exclusion criteria included: under age 16, penetrating trauma, acute paralysis, known vertebral disease, or if patient was returning for reassessment of injury. Of the 12 hospital emergency departments involved, six were control sites and six were intervention sites. The intervention sites received training on the CCR that included a teaching session as well as literature, and a real time reminder of the CCR when imaging was requested. Conversely, the control sites had no intervention introduced to them and relied strictly on physician discernment. Each site was assessed for 12 months with these variables in place, and immediately after for an additional 12 months, when the variables (CCR literature, real time reminder, teaching

session) were removed. During the second 12 month period none of the sites were aware that data was being collected. The intervention sites at the end of data collection showed a decrease in cervical spine imaging while the control sites showed an increase. There was an overall reduction in the proportion of patients referred for cervical spine imaging of 12.8% ($p=0.01$) and a relative increase of 12.5% ($p=0.03$) at the control hospitals (Stiell et al., 2009). These changes, when compared represented a greater than 25% relative difference between study groups ($p<0.001$). The authors concluded that implementation of the CCR for use in patients with cervical spine injury would reduce the incidence of nonessential imaging.

Bandiera et al. (2003) conducted a prospective multicenter cohort study in 10 Canadian urban academic emergency departments. The authors stated that this was a substudy of the Canadian C-Spine and CT Head Study, although that study is not referenced directly in that explanation. The study lasted 18 months and included 6,265 patients with presentation equal to that described in the Stiell et al. (2009) study. Exclusion criteria were identical as well. In this study, physicians approximated the probability of cervical spine injury using clinical judgment alone, utilizing a data form that instructed them to circle a percentage value from 0-100%. The CCR was not used in the approximation of probability. The unstructured physician judgment was then compared to CCR by using the areas under the respective receiver operating characteristic (ROC) curve with 95% confidence intervals (Bandiera et al, 2003). The areas under the ROC curve for predicting cervical spine injury were 0.85 and 0.91 ($p<0.05$) for physician judgment and the CCR, respectively. The sensitivity of the CCR at 100% demonstrated a higher predictive value than that of physician judgment at 92%,

and the specificities were again higher for the CCR versus physician judgment, 55.3% and 44.0%, respectively. Furthermore, the authors state that the CCR would have accurately predicted that 17.5% of the patients who were imaged would not have required imaging had the CCR been applied (Bandiera et al., 2003). The authors concluded that CCR use in suspected cervical spine injury would decrease nonessential imaging.

Rethnam et al. (2008) conducted a retrospective analysis study in two district hospitals in Canada. The study included 114 alert and stable adult patients who had cervical spine radiographs. Excluded from the study were children, non-trauma related cases, presentation after 48 hours, and unstable vitals. The radiology database and patient records identified patients and who were placed in low or high risk categories based on the CCR (Rethnam et al., 2008). Radiograph reports were evaluated for presence or absence of significant cervical spine injury. Significant cervical spine injury was defined as any fracture, dislocation, or ligamentous instability demonstrated by diagnostic imaging (Rethnam et al., 2008). Of the 114 patients who had the imaging, the authors stated that 86 of them were placed in the low risk category, and the remaining 24 in the high risk category. The authors claimed that if the CCR had been applied, there would have been a 75.4% reduction in radiography as the patients were correctly identified as low risk (Rethnam et al., 2008). The authors concluded that CCR use leads to reduction in unnecessary radiographs in patients with suspected cervical injury.

Kerr et al. (2005) presented a “before and after” cohort study that examined the rate of radiography as well as time in a hard collar in alert, stable adult patients with

potential neck injuries before the CCR was implemented and after. It was conducted in the emergency department of a teaching hospital in Melbourne, Australia. The study included 98 subjects before the implementation, and 113 after. The before portion of the study identified eligible patients based on medical records for a three month period, and patients were excluded if: no evidence of injury, isolated limb injury, no clinical concern of c-spine injury, or patient did not meet CCR criteria. After the three month period, staff were trained in the application of the CCR, and it was adopted as a policy in the emergency department. For the next four months, providers used the CCR and patients were identified by staff for study eligibility again based on medical records. The x-ray ordering rate in the after phase was reduced from 67% to 50%, a 25% ($p=0.0187$) relative reduction (Kerr et al, 2005). The authors concluded that use of the CCR would reduce x-ray ordering rates. The calculation of time in hard collar that compared before and after phases (128.5 minutes versus 103 min, $p = 0.3475$) was not statistically significant.

DISCUSSION

The intention of this systematic review was to analyze the current literature to determine if the CCR reduced rates of unnecessary radiography in stable, alert patients with trauma. All four studies reviewed, concluded that, use of the CCR versus unstructured physician judgment resulted in decreased imaging. Furthermore, all four studies surmised the CCR was more sensitive and specific than unstructured physician judgment in detecting cervical-spine injury. The combination of decreased radiography rates as well as higher sensitivity and specificity led the researchers to draw the

conclusion that the CCR, when used correctly, was capable of reducing rates of unnecessary radiography, and statistically does so without missing significant injury.

Bandiera et al. (2003), Kerr et al. (2005), Stiell et al. (2009), and Rethnam et al. (2008) agree that applying the CCR will reduce the use of cervical-spine radiography. This is an important factor to consider given the high rates of imaging that occur across the nation (Government Accountability Office, 2008). Implementation of a clinical decision rule such as the CCR has the ability to allow for more selective ordering of imaging, faster ruling out of negative injury, and decreased overall spending. It also allows for less exposure to radiography over time, and the protection of patients from cancer risks due to repeated exposure to CT scans or x-ray.

The authors of all four studies found the CCR to be more sensitive and specific than unstructured physician judgment in determining cervical spine injury. Because it has lower sensitivity, unstructured physician judgment is more likely to miss important cervical-spine injuries, or those requiring radiography. Conversely, because the CCR is more specific than unstructured physician judgment, it has a more positive effect on reducing nonessential radiography.

Stiell et al. stated no funding support was received and declared no competing interests (2009). Bandiera et al. (2003) reported funding support as well the affiliation of one of the researchers with the Canadian Institutes of Health Research. Rethnam et al. (2008) identified no funding was obtained for the study but did not declare any areas of competing interest. Kerr et al. (2005) did not acknowledge either funding or competing interests.

Although there are clinically important positive outcomes in each of the studies analyzed, it is important to present the limitations of each study.

In Stiell et al. (2009), the intervention group was unable to be blinded to the use of the CCR. Because the providers in this group knew they were performing the intervention, this may have influenced performance. Also of note is the fact that of the twelve sites utilized in this study, seven had already been introduced to the CCR in previous studies (Stiell et al., 2009). This may account for the low final imaging rates (53.3%) at the end of the study, as compared to the beginning (61.7%) for the intervention group (Stiell et al., 2009). The authors also concluded that the real time reminder that was supposed to be given to providers when imaging was ordered in the form of a verbal notification supplied by radiology technicians may not have occurred because the technicians were not comfortable with that role. This may have affected the overall imaging rates. Finally, misinterpretation of the rule may have influenced unnecessary imaging.

In the Bandiera et al. (2003) study, the authors state that the performance of the CCR was compared to performance of unstructured physician judgment. However, it is not clear when the CCR was applied or by whom, which limits the findings of this study. The authors identify the details of that study as a substudy of the “CCC study” (Rethnam et al., 2008) however the details of that study were not reported. If it had been, the reader may have been able to extrapolate the identity of those individuals responsible for performing the CCR.

Rethnam et al. (2008) had a small sample size of 114 subjects. The rate of reduction (75%) was much higher than that of other studies. The retrospective aspect

of the study required the authors to examine medical records of the subjects who had all undergone radiographic imaging of the cervical-spine. The CCR was applied to the data contained in the medical records, therefore requiring the authors to assume who was at a high risk versus low risk using the CCR. The authors postulated that the patients in the low risk category were able to rotate their head 45 degrees to either side, even if that information was not available from medical records. If the patients had truly had cervical range of motion assessed, a portion of them may have required radiography if they were unable to demonstrate adequate range of motion, which could then lead to a smaller reduction amount than the 75% result given in the study. Missing data is another limitation of this study.

In the study published by Kerr et al. (2005), the short time frame of two months for the before portion of the study and three months after limits the study. Like the Rethnam et al. (2008) study, missing data is limitation of this study also, as it requires examiners to apply the CCR retrospectively to patients' chart information.

In this systematic review, the following three outcomes were examined using the GRADE classification system: rate of radiographic imaging, sensitivity, and specificity. All four of the studies contributed to the grading of these outcomes. The criteria established by the GRADE Working Group in assessing the quality of the evidence is as follows:

High quality— Further research is very unlikely to change our confidence in the estimate of effect

Moderate quality— Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate

Low quality— Further research is very likely to have an important impact

on our confidence in the estimate of effect and is likely to change the estimate

Very low quality— Any estimate of effect is very uncertain (Guyatt et al., 2008, 926).

The GRADE table for this paper illustrates the comparison of the CCR versus unstructured physician judgment for the outcomes discussed above (Appendix, Table 1). Based on the study design of the four studies (one randomized control trial and three observational studies), each of the findings (the result of the outcome examined) was given a starting grade and then examined to determine if that starting grade could be upgraded or downgraded. The starting grade is high for a randomized control trial and low for an observational study (Guyatt et al., 2008). Randomized controlled trials can be downgraded based on any of the following:

- Study Limitations
- Consistency
- Directness
- Precision
- Publication Bias (Guyatt et al., 2008).

Conversely, observational studies can be upgraded based on any of the following:

- Large Magnitude
- Dose-Response
- Confounders (Guyatt et al., 2008).

The first outcome examined was the rate of radiographic imaging. The findings, fewer images were obtained using CCR than unstructured physician judgment, were consistent across all four studies reviewed. The randomized controlled trial was given a high starting grade, but reduced to moderate grade because of the study quality, as the intervention group was not blinded in the first stage of the trial. The three observational

studies were given a low starting grade, and upgraded in respect to the authors' reliably accounting for confounders. The combined grade for rate of radiographic imaging was moderate.

The remaining two outcomes (sensitivity and specificity) were examined in the same fashion and found to have a moderate grade of evidence as well.

The overall grade of the evidence given was determined to be moderate. In essence, this means "further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate" (Guyatt et al., 2008, 926). The moderate grade given in this systematic review limits confidence in the CCR, so providers must independently compare the upsides and drawbacks of using the CCR.

From a clinical perspective these four studies clearly indicate that use of the CCR is better than unstructured physician judgment for reducing unnecessary radiographic imaging. The technique is also more sensitive and specific than unstructured physician judgment.

In conclusion, utilization of the CCR in assessing the need for x-ray may result in a decrease in cervical spine x-ray rates. Although a cervical-spine series is a relatively low cost procedure, overutilization results in higher overall cost. Furthermore, the use of CCR may prevent patients from nonessential radiation exposure. The CCR has proven to be a highly sensitive and moderately specific tool when performed correctly, and it is clear that providers need training on the CCR prior to its use. Adoption of a clinical prediction rule such as the CCR should be considered by institutions in the US, as healthcare costs continue to rise. It follows that providers who use the rule are

trained adequately and given retesting at predetermined intervals to maintain consistency. More studies that compare the CCR head to head with tools such as the LRC may demonstrate its superiority despite proposed increased complexity of performance. Given the high number of patients who present annually to emergency departments with suspected cervical injury, the CCR may reduce the time spent in high acuity beds for patients who have minor injuries, as it is designed to be a relatively quick screening tool.

Conclusion

The CCR is superior to unstructured physician judgment in the reduction of unnecessary radiographic imaging in stable, alert adults with cervical-spine injury. It is also considered a more sensitive and specific tool than relying on individual physician judgment.

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APPENDIX A
Table 1: GRADE Table

Comparison	Outcome	Quantity and type	Findings	Statin	Decrease GRADE							Increase GRADE	Grade of Evidence	Overall GRADE of Evidence
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Comparison	Outcome	Quantity and type	Findings	Statin	Decrease GRADE							Increase GRADE	Grade of Evidence	Overall GRADE of Evidence	
					Study Quality	Consistency	Directness	Precision	Publication Bias	Large Magnitude	Dose-Response				Confounders
CCR versus unstructured physician judgment	Rate of radiographic imaging	1 RCT	Decreased rate of imaging	High	-1	0	0	0	0	0	0	0	0	Moderate	Moderate
		3 Obs		Low	0	0	0	0	0	0	0	0	+1	Moderate	
	Specificity	1 RCT	CCR more specific	High	-1	0	0	0	0	0	0	0	0	Moderate	
		3 Obs		Low	0	0	0	0		0	0	+1	Moderate		
	Sensitivity	1 RCT	CCR more sensitive	High	-1	0	0	0	0	0	0	0	0	Moderate	
		3 Obs		Low	0	0	0	0	0	0	0	+1	Moderate		

