Implementation of the Modified Canadian C-Spine Rule by Paramedics

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Study objective: The Canadian C-spine rule was modified and validated for use by the paramedics in a multicenter study where patients were assessed with the Canadian C-spine rule yet all transported with immobilization. This study evaluated the clinical impact of the modified Canadian C-spine rule when implemented by paramedics.

Methods: This single-center prospective cohort implementation study took place in Ottawa, Canada (from 2011 to 2015). Advanced and primary care paramedics were trained to use the modified Canadian C-spine rule, collect data on a standardized study form, and selectively transport eligible patients without immobilization. We evaluated all consecutive low-risk adult patients (Glasgow Coma Scale [GCS] 15, stable vital signs) at risk for a neck injury. We followed all patients without initial radiologic evaluation for 30 days. Analyses included descriptive statistics with 95% confidence intervals (CI), sensitivity, specificity, and kappa coefficients.

Results: The 4,034 enrolled patients had a mean age of 43 (range 16 to 99), and 53.4% were female. Motor vehicle collisions were the most common mechanism of injury (55.1%), followed by falls (23.9%). There were 11 clinically important injuries. The paramedics classified these injuries with a sensitivity of 90.9% (95% CI, 58.7 to 99.8) and specificity of 66.5% (95% CI, 65.1 to 68.0). There was no adverse event or resulting spinal cord injury. The kappa agreement between paramedics and investigators was 0.94. A total of 2,583 (64.0%) immobilizations were avoided using the modified Canadian C-spine rule.

Conclusion: Paramedics could accurately apply the modified Canadian C-spine rule to low-risk trauma patients and significantly reduce the need for spinal immobilization during transport. This resulted in no adverse event or any spinal cord injury. [Ann Emerg Med. 2023;81:187-196.]

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0196-0644/$-see front matter

https://doi.org/10.1016/j.annemergmed.2022.08.441

INTRODUCTION

Background

The Ontario Emergency Medical Services annually respond to 1.4 million calls, one million of which result in transport to a receiving hospital for a variety of reasons.[1] Many of these calls are for motor vehicle collisions or falls where the patient may have injured their neck (cervical spine). Less than 1% of all such patients have a C-spine fracture, and even less (0.5%) have a spinal cord injury.[2,3] The injury had typically already occurred before the arrival of an ambulance and paramedic crew. Nonetheless, basic life support protocols in many emergency medical services dictate that patients with a potential neck injury be fully immobilized for transport using a combination of a cervical collar, backboard, and head immobilizers. The patient remains immobilized during transport, and until physician assessment or diagnostic imaging is complete to rule out an injury. In times of crowding, a patient can stay immobilized for several hours. This prolonged immobilization is often unnecessary given the very low rate of cervical spine fracture or spinal cord injury and is uncomfortable for the patient. It also delays paramedic crews who may be required to remain with the immobilized patient and adds to the burden of crowded emergency departments (EDs).

Importance

The Canadian C-spine rule is a clinical decision rule consisting of 3 high-risk criteria, 5 low-risk criteria, and the ability of patients to rotate their necks. It was derived, validated, and implemented for use by emergency physicians to quickly and safely remove the immobilization equipment applied by paramedics without the use of diagnostic imaging in low-risk trauma patients (normal alertness and vital signs).[3-5] The Canadian C-spine rule was

Editor's Capsule Summary

What is already known on this topic

The Canadian C-spine rule can assist emergency physicians in identifying injured patients who do not require cervical spine imaging.

What questions this study addressed

Can paramedics use a modified Canadian C-spine rule identify low-risk trauma patients who can be safely transported without spinal immobilization?

What this study adds to our knowledge

In 2,669 of the 4,034 (66%) patients, the modified Canadian C-spine Rule recommended "no immobilization." When the rule guidance was to immobilize, 31 of 1352 (2.3%) of those patients were not immobilized. The rule failed to identify 1 of 11 patients with clinically important injuries; there was no adverse outcome.

How this is relevant to clinical practice

EMS personnel can safely identify and transport selected patients without formal immobilization using this validated tool.

also successfully validated and implemented by ED triage nurses, allowing them to do the same.[6,7] However, it would be ideal not to have the immobilization equipment applied in the first place in selected cases where it is appropriate to do so. For this reason, the Canadian C-spine rule was slightly modified to be used by paramedics. Two of its original low-risk criteria, "sitting position in the emergency department" and "delayed onset of neck pain," were removed and modified, given their inapplicability in the field. The modified Canadian C-spine rule was validated in a multicenter study involving 1,949 patients in 7 regions across Canada, during which paramedics evaluated each patient with the modified Canadian C-spine rule but continued to transport them all using spinal immobilization as per their existing protocols.[8] Although the modified Canadian C-spine rule successfully identified all 12 observed significant injuries, a study to evaluate its implementation in the out-of-hospital setting (where selected patients could be transported without immobilization) was needed.

Goal of This Investigation

The goal of this study was to prospectively assess the safety, clinical impact, and performance of the modified Canadian C-spine rule when implemented by paramedics in the out-of-hospital setting, allowing them to selectively transport eligible low-risk trauma patients requiring transport to a hospital without immobilization.

MATERIALS AND METHODS

Study Design

We conducted a single-center prospective cohort implementation study to evaluate the safety and accuracy of the modified Canadian C-spine rule (Figure 1) when used by advanced and primary care paramedics to evaluate consecutive low-risk trauma patients. Additional methodological details are published in the study protocol.[9] The study was registered on clinicaltrials.gov NCT01188447. The study received funding from the Canadian Institutes of Health Research Grant FRN#102597.

Setting

This study took place from 2010 to 2015 in the city of Ottawa, Ontario, Canada, with a single paramedic service. The Ottawa Paramedic Service employs primary and advanced care paramedics to provide emergency medical services to an area encompassing 2,796 km^2 and a population of 994,837 (2021). Medical oversight for the Ottawa Paramedic Service is provided by the Regional Paramedic Program for Eastern Ontario.

Study Population

We enrolled all consecutive, eligible patients evaluated by the paramedics after sustaining acute blunt trauma with a potential for a neck injury. This included patients with neck pain and/or visible injury above the clavicles and/or a mechanism of injury that could result in a neck injury in the opinion of the treating paramedic (purposefully not specifically defined, allowing for paramedic clinical judgment). These patients would require spinal immobilization as per the standard protocols in place for the Ontario Paramedics at the time. Trained investigators screened for eligible cases using a piloted and inclusive electronic filter designed to capture cases with a presenting complaint that was likely to require C-spine evaluation (for those cases which may have been transported without immobilization) and reviewed all cases where a cervical collar was applied for eligibility criteria. The application of a cervical collar must be documented and coded in the paramedic care report.

We included low-risk trauma patients who were alert and stable with an acute injury. Alert was defined as a GCS score of 15, indicating that the patient is able to converse, is

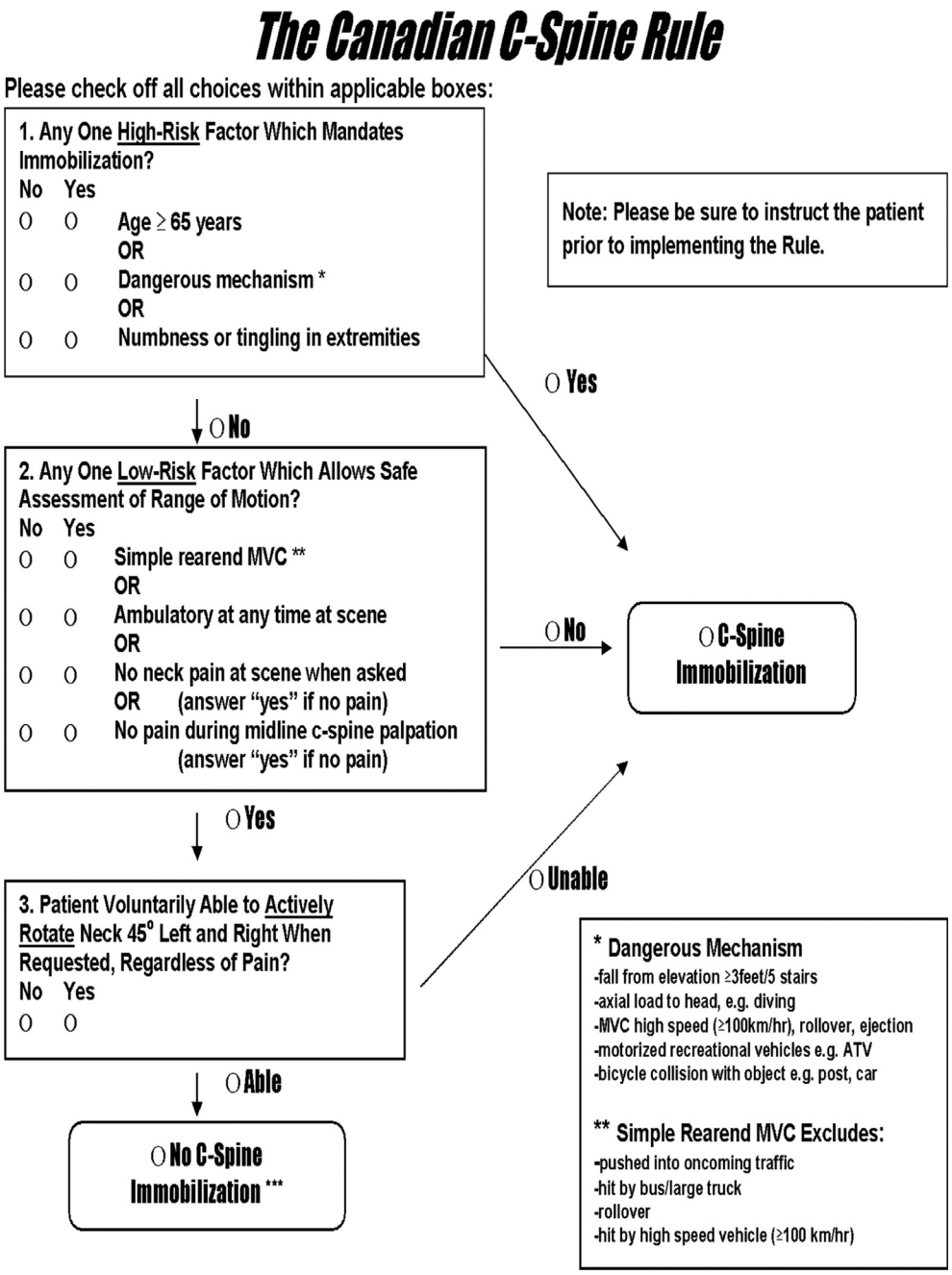

Figure 1. The modified Canadian C-spine rule as validated for use by paramedics The Canadian C-spine rule for alert (Glasgow Coma Scale score 15) and stable trauma patients with a potential for cervical spine injury. *MVC,* motor vehicle collision; *ATV,* all-terrain vehicle.

fully oriented and follows commands.[10] Stable refers to systolic blood pressure of ≥90 mmHg and a respiratory rate between 10 and 24 breaths/min, defined as normal vital signs by the Revised Trauma Score.[11] To be considered acute, the injury had to have occurred within 4 hours before the paramedic assessment. We excluded patients if they did not satisfy the inclusion criteria of alert, stable, and acute or if they were under the age of 16, had sustained penetrating trauma from a stabbing or gunshot wound, were experiencing acute paralysis (paraplegia or quadriplegia), had a known vertebral disease (ankylosing spondylitis, rheumatoid arthritis, spinal stenosis, previous cervical spine surgery) or were referred from another hospital and only required inter-facility transport.

This study was reviewed and approved by the Ottawa Health Sciences Network Research Ethics Board under waiver of patient informed consent.

Intervention and Training

The paramedics received one hour of online training, followed by a one-hour smaller group presentation delivered by trained study staff using common case scenarios demonstrating the application of the modified Canadian C-spine rule. This was followed by an online quiz to assess learning. Refresher training and reminders were provided regularly throughout the study period in small group sessions and through newsletter distribution. Local experts, or "study champions", were identified as a local resource for answering questions, relaying key study messages, and providing feedback. Once all active paramedics had completed the standardized training, a medical directive was put in place, authorizing paramedics to use the modified Canadian C-spine rule to determine the need for spinal immobilization.

Method of Measurement

The paramedics were required to complete a standardized-piloted study form for each patient they assessed for a potential neck injury. If the patient was eligible, the rule portion of the form was completed. If the patient did not meet the eligibility criteria, the paramedic indicated the reason the patient was ineligible and did not apply the modified Canadian C-spine rule. The paramedic study form also included an assessment of comfort in using the modified Canadian C-spine rule using a 5-point scale from "very comfortable" to "very uncomfortable."

Outcome Measures

The prespecified outcome measures were divided into 3 categories: measures of safety, clinical impact, and modified Canadian C-spine rule performance. Measures of safety (primary study outcome) include the number of missed acute cervical spine injuries and the number of serious adverse outcomes. An acute cervical spine injury was defined as any fracture, dislocation, or ligamentous instability demonstrated on radiographic imaging. After *a priori* consultation with a spinal neurosurgeon, all injuries were considered clinically important unless radiography demonstrated one of the following clinically unimportant injuries: avulsion fracture of osteophyte, fracture of the transverse process not involving facet joint, fracture of the spinous process not involving lamina or simple compression fracture less than 25% of vertebral body height.[12] Trained investigators used a piloted-standardized data collection tool to ascertain clinical outcomes using all available hospital records until a patient was either released from the emergency department or discharged after hospital admission. This was done at all 4 adult Ottawa area receiving hospitals, including the regional neurosurgical center, to obtain outcome data. This single neurosurgical care center is the only such referral center for a large catchment area, including communities beyond that of the city of Ottawa. Patients were followed for a period of 30 days after their injury to capture any ED visits for those patients refusing transport or return visits for those who did not undergo radiography during their index visit, and to capture any subsequent abnormal diagnostic imaging or referral to our neurosurgical care center, occurring in the 30 days after the initial injury and paramedic assessment. This approach was adopted to ensure there were no missed cases and followed the same health record review method. A serious adverse outcome was defined as the development of neurological deficit after C-spine clearance by paramedics and transport to a receiving hospital without spinal immobilization. This was also determined through a review of hospital medical records.

We measured the clinical impact as the proportion of patients transported without spinal immobilization. This outcome was obtained through a review of the paramedic study form and the paramedic patient care record.

Modified Canadian C-spine rule performance secondary outcomes included accuracy of the rule for identifying clinically important cervical spine injuries, paramedic accuracy in the overall interpretation of the modified Canadian C-spine rule, and comfort with and use of the modified Canadian C-spine rule using a 5-point scale from "very comfortable" to "very uncomfortable." These outcomes were obtained through a review of the paramedic study form and the accompanying paramedic patient care record. Paramedics documented elements of the rule together with their overall interpretation (immobilize vs not) on a standardized data collection form while the investigators (blinded to patient outcomes) used all available out-of-hospital data sources, including paramedics' narrative comments, to complete the modified Canadian C-spine rule independently.

An independent, external Data Safety Monitoring Board was formed to review study progress and data on the primary outcomes of interest twice yearly throughout the data collection period. The board had the authority to recommend terminating the study if patient safety became a concern at any point.

Data Analysis

We describe the patient and system characteristics using descriptive statistics. For measures of safety, we report the number and details of cervical spine injuries and adverse outcomes. Any missed injuries are reported as simple counts.

The measure of the clinical impact defined as patients transported without immobilization is reported as an overall proportion.

The performance of the modified Canadian C-spine rule, including the accuracy of the rule, is reported with 95% confidence intervals (CI) for sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio. The paramedic accuracy was calculated as the simple agreement between responses on the paramedic data collection form to the investigator's interpretation of the rule using Cohen's Kappa statistic and 95% CIs. Paramedic comfort with and using the rule was tabulated in a simple descriptive format. All analyses were performed with SAS statistical software, version 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

Characteristics of the Study Subjects

The paramedics received training on the modified Canadian C-spine rule from September to December 2010. They assessed 4,794 patients for eligibility from January 2011 to August 2015 (Figure 2). Seven hundred and sixty of these patients were ineligible to be evaluated with the modified Canadian C-spine rule; most of them (54.1%) because of a GCS l<15.

Characteristics of the 4,034 eligible patients are presented in Table 1. The mean age of the patients evaluated by the modified Canadian C-spine rule was 42.9 years with a range of 16–99. Female patients made up 53.4% of the cohort. The most common presenting mechanism of injury was motor vehicle collision (55.1%), followed by falls (23.9%). Nine hundred fifty-two patients (23.6%) underwent diagnostic imaging (including plain radiography, oblique views, flexion-extension views, computed tomography [CT], and magnetic resonance imaging [MRI]). Abnormal imaging was seen in 31 cases (0.8%). Using our predetermined classification criteria, 21 of these abnormalities were adjudicated not to be clinically important, and 10 were considered clinically important. An additional case of spinal cord injury without radiological abnormality was observed and judged to be clinically important, for a total of 11 important injuries (0.3%). We did not find any additional injury over our 30-day follow-up period.

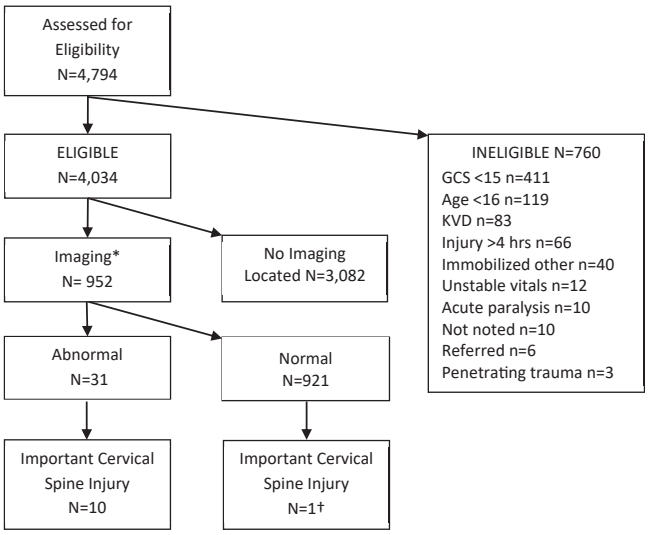

Figure 2. The flow of patients evaluated by the modified Canadian C-spine rule. *Includes diagnostic imaging performed any time within 30 days of injury. †Spinal cord injury without obvious radiological abnormality (SCIWORA). *GCS,* Glasgow Coma Scale; *KVD,* known vertebral disease; *h,* hours.

Measures of Safety

Key characteristics of the 11 important injuries are reported in Table 2. A fall was the mechanism of injury involved in 63.6% of these injuries, and a Canadian C-spine rule high-risk criteria were present in 81.8% of cases. The modified Canadian C-spine rule identified 10 of the 11 important injuries, and all 10 patients were transported to the receiving ED with full spinal immobilization. The modified Canadian C-spine rule missed one injury, as noted in Table 2, only the second injury missed by the Canadian C-spine rule after more than 40,079 patients evaluated in various reported studies, including this one.[3-8] This patient, a middle-aged (<65 years old) man, was assaulted and fell to the ground, striking his head on an object. There were no high-risk criteria present, 2 low-risk criteria were noted to be present by the treating paramedic (ambulatory at scene, absence of midline cervical spine tenderness), and the patient was voluntarily able to rotate his neck when asked. The patient was transported to the hospital without spinal immobilization and was found to have sustained a Hangman's Fracture of C2. Of note, the treating emergency physician also did not suspect this important cervical injury which was only discovered when a computed tomography of the head was completed to assess the patient for his reported head injury. The patient was observed by a neurosurgery team and discharged home without any procedures with a rigid collar. There were no serious adverse outcomes reported in any patients that were assessed using the modified Canadian C-spine rule and transported without immobilization.

Table 1. Characteristics of included study patients.

Characteristics	Total N = 4,034
Mean age, y [range]	42.9 [16-99]
Female sex, No. (%)	2,153 (53.4)
Mechanism of injury, No. (%)*	
Motor vehicle collision	2,221 (55.1)
City speed (<60 km/h; <37 mph)	1,021 (46.0)
Highway speed (60–100 km/h; 37–62 mph)	553 (24.9)
High speed (>100 km/h; >62 mph)	51 (2.3)
Stopped	299 (13.5)
Unknown speed	297 (13.4)
Ejection from vehicle	4 (0.2)
Rollover	125 (5.6)
Seatbelt use	2,053 (92.4)
Head-on collision	122 (5.5)
Simple rear-end motor vehicle collision	600 (27.0)
Motorcycle	62 (1.5)
Other motorized vehicle	24 (0.6)
Fall from sitting	41 (1.0)
Fall from standing	592 (14.7)
Fall from elevation < 3 feet/5 stairs	124 (3.1)
Fall from elevation 3-10 feet/5 to 15 stairs	163 (4.0)
Fall from elevation >10 feet/15 stairs	45 (1.1)
Assault fist or feet	148 (3.7)
Assault blunt object	37 (0.9)
Pedestrian struck	105 (2.6)
Pedestrian struck and thrown	29 (0.7)
Hit head on an object	224 (5.6)
Head struck by other object	30 (0.7)
Fall onto head (axial load)	10 (0.2)
Heavy object onto head (axial load)	8 (0.2)
Other bicycle	84 (2.1)
Bicycle struck	47 (1.2)
Bicycle collision	36 (0.9)
Other sports	60 (1.5)
Contact sports (axial load)	2 (0.0)
Diving	2 (0.0)
Other	185 (4.6)
Cervical spine imaging performed, No. (%)†	952 (23.6)
Acute cervical spine injury, No. (%)	32 (0.8)
Fracture	27 (0.7)
Dislocation	2 (0.0)
Ligamentous instability	5 (0.1)
Clinically important cervical spine injury, No. (%)	11 (0.3)
Stabilizing treatments, No. (%)	19 (0.5)
Rigid collar	13 (0.3)
Brace	0 (0.0)
Internal fixation	5 (0.1)
Halo	1 (0.0)
Admitted to hospital, No. (%)	282 (7.0)

Notes: *km/h*, kilometers per hour; *mph*, miles per hour
Admitted to the hospital includes eligible patients who were transferred from another receiving hospital that were subsequently admitted.
*Mechanism of injury may have been classified in more than one category.
†Includes any imaging completed within 30 days of injury.

Measures of Clinical Impact

Among the 4,034 eligible patients, the modified Canadian C-spine rule indicated that no immobilization was required for transport in 66.2% of cases (Table 3). In fact, immobilization was not applied in 2,664 (66.0%) of the eligible patients assessed by paramedics, including 833 patients who refused transport to a receiving hospital and 50 patients (3.7%) who did require spinal immobilization as per the modified Canadian C-spine rule but were not immobilized for transport by paramedics. Among these 50 patients, no reason was provided by the paramedics to justify their decision not to follow the modified Canadian C-spine rule's recommendation in 17 (34.0%) cases, the rule was felt to be overly conservative by paramedics in 10 (20.0%) cases, and 4 (8.0%) cases were classified as indeterminate because they were not asked to attempt rotating their neck as required by the modified Canadian C-spine rule. All these cases were reviewed by the investigator, and feedback was provided to the treating paramedic by the study champion. The remaining 19 (38.0%) cases had documentation that the patient refused immobilization equipment despite being indicated. Eighty-five (3.2%) patients who did not require spinal immobilization as per the modified Canadian C-spine rule were nonetheless immobilized by paramedics as per their preference, which was not discouraged.

Performance of the Canadian C-Spine Rule

The performance of the modified Canadian C-spine rule as applied and interpreted by paramedics and of the rule itself as interpreted by the study investigators is shown in Table 4. The sensitivity of the rule was 90.9% (95% CI, 58.7 to 99.8), regardless of whether the evaluation was performed by paramedics or study investigators. The specificity of the modified Canadian C-spine rule was 66.5% (95% CI, 65.1 to 68.0) when assessed by paramedics, compared with 68.2% (95% CI, 66.7 to 69.7) when applied by the investigators. The positive likelihood ratio of the modified Canadian C-spine rule was 2.7 (95% CI, 2.2 to 3.4) when assessed by paramedics, compared with 2.9 (95% CI, 2.4 to 3.5)

Table 2. Classification of 11 clinically important C-spine injuries.

Subject #	Injury	Stabilizing Treatment	Mechanism of Injury	Modified Canadian C-spine rule Criterion Leading to Immobilization
0171	Fracture	Halo	Motor vehicle collision	Had none of the low-risk criteria
0513	Fracture	Internal fixation	Fall from elevation 3–10 feet / 5–15 stairs	High-risk criteria (age >65, M)
0685	Fracture	Internal fixation	Hit head on an object	High-risk criteria (age >65)
1143	Fracture, dislocation, ligamentous instability	Internal fixation	Fall from elevation >10 feet / 15 stairs	High-risk criteria (M, N/T)
1364	Fracture, dislocation, ligamentous instability	Internal fixation	Fall from elevation >10 feet / 15 stairs	High-risk criteria (age >65, M)
1944	Fracture	Rigid collar	Fall from elevation >10 feet / 15 stairs	High-risk criteria (M)
2102	Fracture	Rigid collar	Fall from standing	High-risk criteria (age >65)
2606	Ligamentous instability	Internal fixation	Fall from elevation < 3 feet / 5 stairs	High-risk criteria (age >65)
3208	SCIWORA	Rigid collar	In other sports, hitting the head on an object	High-risk criteria (N/T)
3411	Fracture	Rigid collar	Assault fist or feet, hit head on an object	Canadian C-spine rule recommended no immobilization
3552	Fracture	Rigid collar	Fall from elevation 3-10 feet / 5-15 stairs	High-risk criteria (M)

Notes: *Canadian C-spine rule,* Modified Canadian C-spine rule; *M,* dangerous mechanism; *N/T,* numbness and/or tingling in extremities; *SCIWORA,* spinal cord injury without radiological abnormality

when applied by the investigators, and their negative likelihood ratio was identical at 0.1 (95% CI, 0.0 to 0.9).

The Cohen's Kappa agreement between the paramedics' and investigators' application of the modified Canadian C-spine rule (immobilization required versus not) was 0.94 (95% CI, 0.93 to 0.95).

We included a question on the paramedic study data form to measure overall comfort in using the modified Canadian C-spine rule using a 5-point Likert Scale with options ranging from "Very Comfortable" to "Very Uncomfortable." Among the 3,936 responses received, paramedics, indicated they were "Very Comfortable" (68.6%), "Comfortable" (21.2%), "Neutral" (5.6%), "Uncomfortable" (2.0%) or "Very Uncomfortable" (2.6%) using the modified Canadian C-spine rule.

LIMITATIONS

First, although our cohort contains a large number of patients, it only included 11 clinically important cervical injuries. This resulted in a wide CI around the modified Canadian C-spine rule's sensitivity or ability to safely identify all clinically important injuries. That said, the rule is meant to be applied to low-risk trauma patients who are alert and stable. We would expect a higher number of clinically important cervical injuries among patients more severely injured who were not eligible to be evaluated by the modified Canadian C-spine rule. Second, the modified Canadian C-spine rule missed one injury judged to be clinically important when applied by paramedics and investigators. This is only the second missed injury after evaluating more than 40,079 patients with the Canadian C-spine rule in various reported studies, including this one.[3-8] This patient did not suffer any adverse outcomes and was discharged home with a rigid collar. Third, our study included several patients who refused transport to a hospital. This group may have included patients whose only indication for transport to the hospital was a potential

Table 3. Clinical impact of the modified Canadian C-spine rule on immobilization for transport.

Modified Canadian C-spine Rule Recommendation (Paramedic Application N=4,034)	Actual Immobilization Status	N (%)
No immobilization required	Immobilized for transport	85 (3.2)
N=2,669 (66.2%)	Not immobilized for transport	1,779 (66.7)
	Refused transport	805 (30.2)
Immobilization required	Immobilized for transport	1,274 (94.2)
N=1,352 (33.5%)	Not immobilized for transport	50 (3.7)
	Refused transport	28 (2.1)
No interpretation	Immobilized for transport	11 (84.6)
N=13 (0.3%)	Not immobilized for transport	2 (15.4)

Notes: All patients refusing transport were included in the 30-day hospital review to ensure there was no missed injury.

Table 4. Performance of the modified Canadian C-spine rule for a clinically important cervical spine injury, as applied and interpreted by the paramedics and of the rule itself as interpreted by study investigators.

	Paramedics' Interpretation		Investigators' Interpretation	
Result of Application	**Injury**	**No Injury**	**Injury**	**No Injury**
Immobilization required (N)	10	1,342	10	1,219
Immobilization not required (N)	1	2,668	1	2,612
Sensitivity, % (95% CI)	90.9 (58.7–99.8)		90.9 (58.7 to 99.8)	
Specificity, % (95% CI)	66.5 (65.1–68.0)		68.2 (66.7 to 69.7)	
Positive likelihood ratio, (95% CI)	2.7 (2.2–3.4)		2.9 (2.4 to 3.5)	
Negative likelihood ratio (95% CI)	0.1 (0.0–0.9)		0.1 (0.0–0.9)	

N, number; *CI*, confidence interval.
In 13 cases, Canadian C-spine rule determination was left blank on the paramedic study form; these cases were omitted from the analysis. In 192 cases, the investigators could not independently assess the rule according to the documentation provided by paramedics, including 148 cases where neck rotation was not attempted as required by the Canadian C-spine rule. These cases were classified as indeterminate and were not included in the analysis.

neck injury. No injury, clinically important or otherwise, was observed in any such patient refusing transport during our 30-day follow-up. Telephone follow-up could only reach 70% of patients in our previous validation study.[8] In this current study, we used a much more reliable strategy which included reviewing all diagnostic imaging performed in our large catchment area in the 30 days after the initial paramedic assessment and reviewing all referrals and admissions to the only spinal trauma referral center in our region. Lastly, our study did not measure patient-oriented outcomes such as pain, discomfort, or immobilization-related adverse events. It would be important to include such measures in future studies.

DISCUSSION

The Canadian C-spine rule was extensively studied in prior derivation, validation, and implementation studies involving emergency physicians and triage nurses. It was slightly modified and further validated for use by paramedics. This was the first opportunity to study the modified Canadian C-spine rule's result when implemented for use by paramedics in the field. In this large single-center prospective cohort implementation study, the paramedics were able to accurately assess low-risk trauma patients and transport a large proportion to a hospital without spinal immobilization. This was achieved without any observed adverse event.

Previous Studies

We believe our findings are impactful and reassuring compared with that of other out-of-hospital selective spinal immobilization strategies. A study of 974 patients by Hoffman et al revealed that no single or paired combination of clinical findings could identify all 27 spinal injuries observed.[13] Domeier et al[14] published a large cohort study evaluating 8,975 patients where 15 of 295 patients with a C-spine injury were transported without spinal immobilization. In a subsequent larger cohort study of 13,357 patients, 33 of 415 spinal injuries were missed.[15] Stroh et al [16] also published a study where five of 504 C-spine injuries were missed and transported without immobilization, 2 of which were considered unstable, and 1 was associated with residual quadriparesis. Many of these studies used another validated tool, the NEXUS tool, which was found to be less accurate than the Canadian C-spine rule both in a head-to-head prospective comparison, and in an independent systematic review.[3,17]

Our findings contribute to a growing body of knowledge suggesting that immobilization is often unnecessary. Immobilization may also contribute to pain, discomfort, and adverse events of its own.[18,19] Pressure points from backboards, pulmonary restriction from chest straps, cervical hyperextension from lack of head support, neck vein compression, and increased intracranial pressure from cervical collars, and risk of aspiration have all been reported in studies involving real patients and healthy volunteers.[20-24] A review published by Abram and Bulstrode [25] suggests there is a growing body of evidence documenting the "risks and complications of routine spinal immobilization" and that there is a "possibility that immobilization could be contributing to mortality and morbidity in some patients." Another review by Sundstrom et al [26] concludes there is limited evidence supporting current C-spine immobilization practices and that large definitive randomized trials are lacking. It further suggests the benefit of C-spine immobilization on neurological injury and spinal stability is uncertain and that there is a growing body of opinions against the use of C-spine collars. In

2015, the American Heart Association and Red Cross first aid guidelines even went as far as recommending against the routine application of cervical collars by first aid providers for adults and children with suspected blunt traumatic C-spine injury.[27] In 2018, the American College of Surgeons Committee on Trauma, the American College of Emergency Physicians, and the National Association of EMS Physicians published a joint position statement proposing that, although backboards have historically been used to provide spinal immobilization, spinal motion restriction can also be achieved using an ambulance mattress alone.[28]

Clinical Implications

We believe a strategy allowing properly trained paramedics to use the modified Canadian C-spine rule and transport selective low-risk trauma patients to the receiving hospitals without immobilization may have significant patient-oriented and healthcare benefits. A large proportion of patients could be transported with less pain, more comfortably, and with a lesser need for subsequent analgesia and diagnostic imaging. There are significant costs involved with the use of disposable and reusable spinal immobilization equipment, which could be avoided. When immobilization is not recommended by the modified Canadian C-spine rule, a significant amount of time could also possibly be saved by the paramedics. Moreover, it is possible that some patients could decide their neck injury did not require further physician assessment and transport to the hospital after an assessment with the modified Canadian C-spine rule. This has a potential cost and resource savings for both busy emergency medical services and crowded EDs. It is possible the effect of paramedics using the modified Canadian C-spine rule may be further enhanced in patients of a certain age or sex or for those with longer transport times.

In summary, we have successfully demonstrated that properly trained paramedics could accurately apply the modified Canadian C-spine rule to low-risk trauma patients and significantly reduce the need for spinal immobilization during their transport to the receiving hospitals. The modified Canadian C-spine rule should be widely adopted by paramedic services to further evaluate its safety.

Acknowledgments: The authors thank for the support and efforts of several key individuals, including Janice Woods, Jennifer Kortko, and Suzanne Noel, our paramedic Study Champions; Jane Marchand at the Regional Paramedic Program for Eastern Ontario; the members of the Ontario Base Hospital Medical Advisory Group; the members of our Data Safety Monitoring Board: Jan Jensen, Alison Armstrong, Dr. Alix Carter, MD, Andre Turbide and Dr. Krista Ritchie, MD; and most importantly the paramedics of the Ottawa Paramedic Service and its leadership. It is also with great sadness and sorrow that we mourn the loss of one of our co-authors. Justin Maloney, MD, is described as a "giant" of paramedicine in our community. His many contributions to our field will forever last, and our thoughts will always be with him and his family.

Supervising editor: Theodore R. Delbridge, MD, MPH. Specific detailed information about the possible conflict of interest for individual editors is available at https://www.annemergmed.com/editors.

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Author contributions: CV, IGS, and GAW conceived the idea, designed the study, and obtained research funding. CV, JM, RD, and PK supervised the conduct of the trial and data collection. CV, RD, MC, and JS designed and executed the training program. MC and JS managed data collection, including quality control. GAW provided statistical advice on study design, and MJN completed the analyses. RD chaired the Medical Oversight Committee, and PK chaired the Paramedic Research Review Committee. MC drafted the manuscript, all authors contributed substantially to its revision, and all are meeting ICMJE requirements. CV takes responsibility for the paper as a whole.

All authors attest to meeting the four ICMJE.org authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors report no such relationships. The study received funding from the Canadian Institutes of Health Research Grant FRN#102597.

Publication dates: Received for publication February 2, 2022. Revisions received July 14, 2022; July 26, 2022. Accepted for publication August 11, 2022.

Trial Registration Number: NCT01188447

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