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Original Contributions

IMPLEMENTATION OF THE CANADIAN C-SPINE RULE REDUCES CERVICAL SPINE X-RAY RATE FOR ALERT PATIENTS WITH POTENTIAL NECK INJURY

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□ **Abstract—The objectives of this before-and-after study of alert, stable adult patients presenting to the Emergency Department of Western Hospital with potential neck injuries who were immobilized in hard cervical collars were to determine the impact of implementation of the Canadian C-spine rule on x-ray ordering rates and whether implementation of the rule reduced time in hard collars for patients with potential neck injury. Data collected included demographics, mechanism of injury, x-ray rate, and time in hard collar. Data analysis was by chi-square test for proportions and Mann-Whitney U test for continuous variables. There were 211 patients studied. The x-ray ordering rate decreased from 67% to 50% (25% relative reduction, $p = 0.0187$). Time in hard collar was also reduced from a median of 128 min to a median of 103 min (effect size 25.5 min), but this did not reach statistical significance. Implementation of the Canadian C-spine rule reduced x-ray ordering by 25%.** © 2005 Elsevier Inc.

□ **Keywords—x-ray; cervical spine; trauma; decision rules**

INTRODUCTION

The evaluation of the cervical spine (c-spine) with x-rays is a controversial area of trauma management (1,2). C-spine assessment continues to be driven by the fear of the consequences associated with "missed" significant injury (1–4). This has led to high c-spine x-ray ordering rates, despite the low incidence of clinically significant c-spine injuries (2,5,6). However, for patients this means unnecessary exposure to ionizing radiation, monetary expense, and lengthier immobilization in hard collars (7).

Recent efforts to address this have focused on the development and validation of clinical decision rules to reduce the need for x-rays in the assessment of the c-spine. Two such rules have been developed, the NEXUS guidelines and the Canadian C-spine Rule (CCR) (1,8–11). These studies report an expected reduction in c-spine x-ray ordering rates of 12.6% and 15.5%, respectively, but this has not been evaluated in a site not involved in the deriving studies (9,10).

This study aims to evaluate the impact of implementation of the CCR in an Emergency Department (ED) setting with respect to c-spine x-ray ordering rates and time spent by patients in hard collars.

METHODS

This before-and-after study was conducted in the ED of a community, teaching hospital in Melbourne, Australia, with an annual census of approximately 34,000 adult patients. All patients are treated in the pre-hospital setting by a single ambulance service (Metropolitan Ambulance Service, Victoria) and criteria for application of hard collars to patients having sustained trauma is governed by a clinical practice guideline. The ED is staffed

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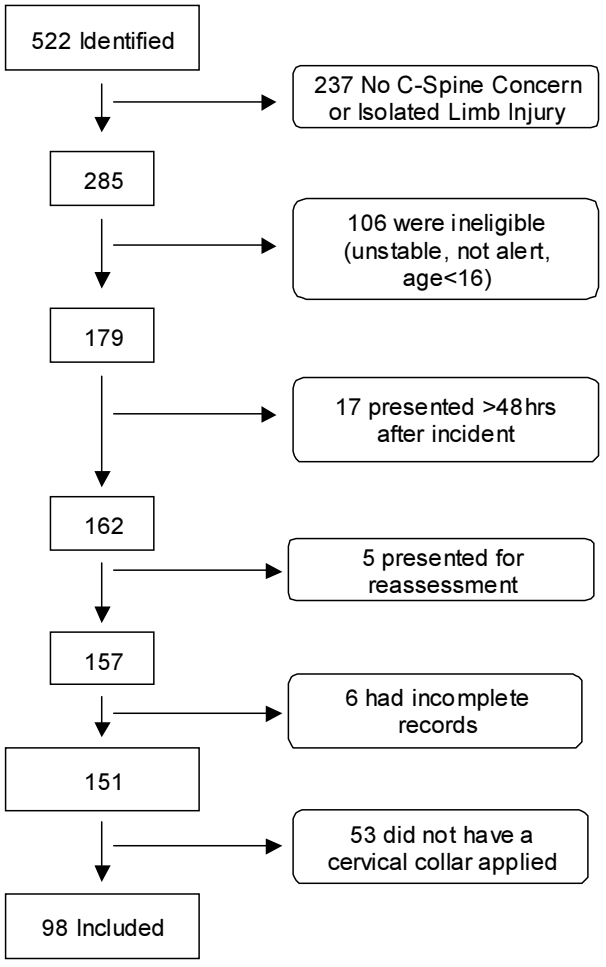

Figure 1. Derivation of before sample.

by a mixture of PGY1–3, training registrars in Emergency Medicine, and specialist emergency physicians. The study was approved by the institutional research and ethics committee.

The before component of the study was conducted by retrospective, explicit medical record and ambulance case note review for eligible patients who presented in the period 1 March to 31 May, 2002. Eligible patients were identified from the ED computer information system, using indicators of injury cause and ED discharge diagnosis suggesting head and neck injury and indicators of potential trauma. These were intentionally broad to minimize the risk of missed cases. Patients were excluded if there was no evidence of trauma in their record, there was an isolated limb injury, where the record made it clear that a c-spine injury was not of clinical concern, or the patient did not meet the criteria for application of the CCR (1). Patients were also excluded if they had minor trauma and a hard collar was not applied, on the assumption that this indicated that a significant c-spine injury was not of concern. Data collected included demographic information, date and time of presentation to ED, mode of transport to ED, injury cause, CCR eligibility criteria, whether or not a hard collar was applied and by whom as well as total duration of application in the ED, whether an x-ray was ordered and the result. A significant injury was defined as a fracture, dislocation, or ligamentous instability of the cervical spine identified by x-ray or computed tomography (CT) scan. Duration of neck immobilization by hard collar was calculated as the difference between the recorded time of application and time of removal of hard collar, both routinely documented by paramedics in the pre-hospital setting and nursing staff in the ED. Ten percent of the records were independently reviewed by a second researcher to assess inter-observer reliability of data collection.

Over a 2-month period, staff were educated in groups and individually about the CCR and its application. In addition, staff were provided with a reminder card containing the CCR and exclusion criteria, which attached to their identification badge. The CCR was formally adopted as ED policy for the assessment of potential neck injuries on 1 November, 2002.

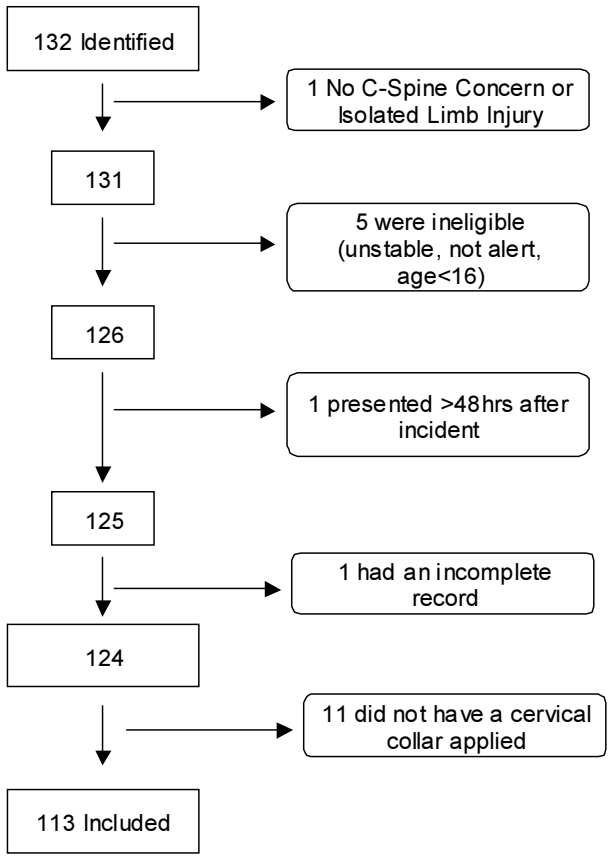

Figure 2. Derivation of after sample.

Table 1. Comparison of Demographics, Mode of Arrival, Injury Cause, Application of Cervical Collar, and Prevalence of Clinically Important Injury Between Cohorts

	Before (n = 98)	After (n = 113)	*p* Value	Odds Ratio (n, 95% CI)
Age: median (range)	33 (16 to 83)	38 (16 to 87)	0.2271	1.182 (0.678 to 2.062)
Gender (male): n (%)	62 (64.3)	67 (59.3)	0.6540	
Injury Cause: n (%)			0.1299	
MCA	50 (51)	62 (54.9)		
Collision/struck-by object and/or person	21 (21.4)	10 (8.8)		
Fall	13 (13.3)	17 (15.0)		
MBA	8 (8.2)	10 (8.8)		
Pedal cyclist	4 (4.1)	7 (6.2)		
Pedestrian	2 (2.0)	7 (6.2)		
Arrived by ambulance: n (%)	83 (84.7)	104 (92)	0.1450	0.479 (0.200 to 1.149)
Hard collar fitted pre-hospital: n (%)	79 (80.6)	103 (91.2)	0.0434	0.404 (0.178 to 0.916)
Clinically significant C-spine injuries: n (%)	3 (3.1)	1 (0.9)	0.5183	3.537 (0.362 to 34.566)

MCA = Motor Car Accident; MBA = Motor Bike Accident.

Before the evaluation phase, medical staff, particularly at registrar and specialist levels, were generally aware of the NEXUS guidelines and the CCR (1,8–10). There was considerable variability in practice, with more junior staff routinely x-raying all patients in hard collars and more senior staff being more selective, based on clinical assessment rather than one of the above guidelines. There was no standard protocol in place to guide practice.

The evaluation phase (after phase) commenced 1 month after the education period had been completed, to allow staff to gain experience in using the rule. It covered the period 29 November, 2002 to 7 March, 2003. Eligible patients were identified by nursing and medical staff and included patients with a suspicious mechanism of injury (motor vehicle accident, motor bike accident, fall, pedal cyclist, pedestrian, collision with person or object) where there was clinical concern about a potential cervical spine injury. The following information was collected on a data form: demographics, CCR eligibility and exclusions, application of the CCR items, whether x-ray was ordered and additional comments, in particular if the rule had been overridden and why. Medical records of enrolled patients were reviewed for additional information including eligibility, time in hard cervical collar, whether an x-ray was performed and the result.

The outcomes of interest were comparison of the proportion of patients investigated using c-spine x-rays and comparison of time in a hard collar between the cohorts.

To calculate sample size, we estimated before the study that x-ray ordering was 85%. We hypothesized that application of the CCR would reduce x-ray ordering by 15%. Using a power/sample statistical package calculator (http://www.univie.ac.at/medstat/) for a two-tailed test, with power of 0.8 and a p value <0.05, it was determined that a sample of 118 patients for each phase would be needed.

Data were analyzed using the Analyse-IT™ statistical package, an expansion for Microsoft Excel, using descriptive statistics, chi-square and odds ratio for comparison of proportions, and Mann-Whitney U test for comparison of continuous variables. Inter-rater reliability was assessed using weighted kappa statistics.

RESULTS

For the before phase, 522 eligible patients were screened; 424 were excluded, leaving a sample of 98 patients (Figure 1). Inter-observer reliability with respect to inclusion was assessed for 56 (10.7%) patients with good agreement (weighted kappa 0.65). For the after phase, 132 patients were enrolled; 17 were excluded, leaving a sample of 113 patients (Figure 2).

The before and after groups are compared for demographics, injury cause, application of hard collars, and prevalence of clinically significant injuries in Table 1. More patients in the after phase had collars applied in the pre-hospital setting ($p = 0.0434$). There were three clinically significant c-spine injuries in the before phase and one in the after phase, which was correctly detected by the CCR. This study was not designed to identify missed fractures.

The x-ray ordering rate in the after phase was reduced from 67% to 50%, a 25% relative reduction (Table 2). Patients in the after phase were in hard collars for less time, but this difference did not reach statistical significance (128.5 vs. 103 min, $p = 0.3475$).

Medical staff followed the directive of the CCR on 78% of occasions (76/113). Of the occasions where the rule was overridden and an x-ray ordered, no patient was found to have a clinically significant c-spine injury.

Table 2. Comparison of X-ray Ordering Rates and Time in Hard Collar Between Cohorts

Outcome	Before (n = 98)	After (n = 113)	Difference (95% CI)	*p* Value	OR (95% CI)
Time in collars (min) median (range)	128.5 (13 to 690)	103 (5 to 613)		0.3475	
X-ray ordering: n (%)	66 (67.3)	57 (50.4)	10 (−10 to 34)	0.0187	2.026 (1.157 to 3.549)

DISCUSSION

Extensive research has described high c-spine x-ray ordering rates for a comparatively low number (<2%) of significant injuries (5,9,12,13). In Canada, the ordering rate has been shown to vary between 58% and 68.9%, with clinically significant injuries of 0.9% to 1.7% (1,5). This high x-ray rate consumes resources, exposes some patients to unnecessary radiation, and may contribute to ED overcrowding as patients await x-rays and review. Waiting for an x-ray and its interpretation by a clinician before hard collar removal also increases time in uncomfortable hard collars for patients.

The development of clinical decision rules is one approach to rationalizing the use of resources by utilizing evidence to improve health care management and clinical diagnostic accuracy (14,15). These clinical decision rules undergo rigorous development and validation processes, but that does not guarantee their acceptance into practice.

Our study found a significant decrease (25% relative reduction) in c-spine x-ray ordering. This amount of reduction is both statistically and clinically significant and is larger than the reduction predicted by the rule's authors (10). Implementation of the rule by clinicians demonstrated a reduction in time for patients in neck immobilization with hard collars, although this did not reach statistical significance.

Attitudes towards clinical decision rules have been found to be positive but implementation into practice has been quite variable, so it was pleasing that the CCR was widely accepted and used by the treating clinicians (16,17). This is probably due to a number of factors, including leadership by senior clinicians, the robustness of the CCR's derivation and validation processes, and the use of a reminder card that made application of the rule at the bedside easy. The less vigorous medico-legal climate in Australia may also have enhanced acceptance. Nonetheless, questions remain relating to the sustainability of CCR utilization. Key issues are the number of rotating junior medical staff requiring education, limited educational resources, and the relative complexity of the CCR when compared with the NEXUS guidelines.

Future research might address whether the CCR can be accurately applied by nurses and ambulance paramedics. This would allow fewer hard collars to be applied (with a significant resource saving) and further reduce the time patients might be required to remain with a hard collar in situ.

The study had several limitations that should be taken into account when considering the results. The study was constrained by the time frame within which it could be conducted. This limited sample size. Patient identification, particularly in the before phase, was difficult. It relied on computerized data so miscoding may have resulted in missed cases. Data from the before phase are also subject to the limitations inherent in retrospective record review, especially missing data. Outcome beyond ED discharge was not performed on patients who did not have an x-ray. It is possible that these patients had a clinically significant c-spine injury that was detected after hospital discharge. The study was conducted at a single site, so generalizability to other settings cannot be assumed.

CONCLUSION

This study has demonstrated that the application of the CCR in a clinical setting can significantly reduce x-ray ordering rates for stable and alert adult patients with potential c-spine injury who have a hard collar applied. Additionally, acceptance and application of the CCR was high.

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