Variation in emergency department use of cervical spine radiography for alert, stable trauma patients

Evidence

Études

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Abstract

Objective: To assess the emergency department use of cervical spine radiography for alert, stable adult trauma patients in terms of utilization, yield for injury and variation in practices among hospitals and physicians.

Design: Retrospective survey of health records.

Setting: Emergency departments of 6 teaching and 2 community hospitals in Ontario and British Columbia.

Patients: Consecutive alert, stable adult trauma patients seen with potential cervical spine injury between July 1, 1994, and June 30, 1995.

Main outcome measures: Total number of eligible patients, referral for cervical spine radiography (overall, by hospital and by physician), presence of cervical spine injury, patient characteristics and hospitals associated with use of radiography.

Results: Of 6855 eligible patients, cervical spine radiography was ordered for 3979 (58.0%). Only 60 (0.9%) patients were found to have an acute cervical spine injury (fracture, dislocation or ligamentous instability); 98.5% of the radiographic films were negative for any significant abnormality. The demographic and clinical characteristics of the patients were similar across the 8 hospitals, and no cervical spine injuries were missed. Significant variation was found among the 8 hospitals in the rate of ordering radiography ($p < 0.0001$), from a low of 37.0% to a high of 72.5%. After possible differences in case severity and patient characteristics at each hospital were controlled for, logistic regression analysis revealed that 6 of the hospitals were significantly associated with the use of radiography. At 7 hospitals, there was significant variation in the rate of ordering radiography among the attending emergency physicians ($p < 0.05$), from a low of 15.6% to a high of 91.5%.

Conclusions: Despite considerable variation among institutions and individual physicians in the ordering of cervical spine radiography for alert, stable trauma patients with similar characteristics, no cervical spine injuries were missed. The number of radiographic films showing signs of abnormality was extremely low at all hospitals. The findings suggest that cervical spine radiography could be used more efficiently, possibly with the help of a clinical decision rule.

Résumé

Objectif : Évaluer l'utilisation, dans les services d'urgence, de la radiographie de la colonne cervicale chez des patients traumatisés adultes stables et éveillés pour ce qui est de l'utilisation, des résultats anormaux découverts et de la variation des pratiques entre hôpitaux et entre médecins.

Conception : Étude rétrospective des dossiers.

Contexte : Services d'urgence de 6 hôpitaux d'enseignement et de 2 hôpitaux communautaires de l'Ontario et de la Colombie-Britannique.

Patients : Patients traumatisés adultes stables éveillés consécutifs, possiblement atteints d'un traumatisme à la colonne cervicale, accueillis entre le 1er juillet 1994 et le 30 juin 1995.

Principales mesures des résultats : Nombre total des patients admissibles, présentation pour une radiographie de la colonne cervicale (au total, par hôpital et par médecin), présence d'un traumatisme à la colonne cervicale, caractéristiques des patients et hôpitaux associés à l'utilisation des radiographies.

Résultats : On a prescrit une radiographie de la colonne cervicale chez 3979 (58,0 %) des 6855 patients admissibles. On a constaté un traumatisme aigu de la colonne cervicale (fracture, luxation ou instabilité ligamentaire) chez 60 (0,9 %) seulement des patients; 98,5 % des films n'ont révélé aucune anomalie significative. Les caractéristiques démographiques et cliniques des patients étaient semblables entre les 8 hôpitaux et l'on n'a raté aucun traumatisme cervical. On a constaté une variation significative entre les 8 hôpitaux quant au taux de prescription de radiographies ($p < 0,0001$), la fourchette variant d'un minimum de 37,0 % à un maximum de 72,5 %. Une analyse de régression logistique, ou l'on a contrôlé à chaque hôpital les différences possibles sur les plans de la gravité du cas et des caractéristiques des patients, a révélé un lien important entre 6 des hôpitaux et l'utilisation de la radiographie. Dans 7 hôpitaux, on a constaté une variation significative du taux de prescription d'une radiographie entre les médecins traitants de l'urgence ($p < 0,05$), la fourchette variant d'un minimum de 15,6 % à un maximum de 91,5 %.

Conclusions : Même si l'on a constaté une variation importante entre les établissements et entre les médecins dans la façon de prescrire une radiographie de la colonne cervicale de patients traumatisés stables et éveillés qui avaient des caractéristiques similaires, on n'a raté aucun traumatisme à la colonne cervicale. Le nombre de films radiographiques indiquant des anomalies a été extrêmement faible dans tous les hôpitaux. Les résultats indiquent que l'on pourrait utiliser la radiographie de la colonne cervicale de façon plus efficiente, peut-être si l'on disposait d'une règle de décision clinique.

Neck injuries are common among blunt trauma victims seen in emergency departments across Canada and other Western nations. Unfortunately, there are no accurate Canadian data available for the number of trauma patients seen in emergency departments or for the use and yield of cervical spine radiography. We do know, however, that although most of the more than 1 million cases of neck injury seen annually in US emergency departments[1,2] represent soft-tissue injuries, 30 000 of these patients have cervical spine fractures or dislocations and about 10 000 suffer spinal cord injury.[3,4] Because of the potential for spinal cord injury, emergency care workers go to great lengths to protect the cervical spine of trauma patients. The American College of Surgeons has recommended cervical spine radiography for all trauma patients with injury above the clavicle.[5] Indeed, a recent survey found that 97% of 125 US trauma centres routinely order it as part of a protocol for trauma patients.[6] Radiography of the cervical spine is the most commonly performed musculoskeletal examination in emergency departments.[7–9]

Universal cervical spine radiography is, however, very controversial among Canadian and US physicians and has been deemed inefficient by many who note that the numbers of fractures and dislocations found are very low.[10–16] In most case series of trauma patients, the proportion of cervical spine radiographic series positive for fracture or dislocation has been less than 3%.[10–13,17–25] The huge number of negative cervical spine radiographs adds to health care costs[26,27] and to the burden of time and effort of emergency physicians, nurses, orderlies and radiology technicians.

Although we have no reliable Canadian figures, we can estimate the national cost of cervical spine radiography in US emergency departments to be as much as US$1 billion. The cumulative cost of inexpensive but high-volume procedures such as cervical spine radiography is considerable and may contribute more to rising health care costs than more expensive "high-technology" tests.[28,29] Guidelines that could realize even a modest reduction in the proportion of trauma patients undergoing cervical spine radiography would lead to large savings in health care expenditures.

There are no widely accepted guidelines for the use of cervical spine radiography such as the clinical decision rules for using radiography in cases of acute ankle and knee injuries, which our research group previously developed,[30,31] validated[32,33] and implemented.[34,35] We had previously demonstrated both the inefficiency and the potential for improving the use of radiography for ankle and knee injuries seen in emergency departments[36,37] but were uncertain about the potential for standardizing the use of radiography for suspected cervical spine injuries.

The objective of this study was to obtain reliable Canadian data regarding the emergency department use of plain cervical spine radiography in alert, stable trauma patients at risk for cervical spine injury. We did not include unconscious or unstable patients because we believe that they represent a small minority of cases with potential cervical spine injury and that such patients are not suitable for selective radiography guidelines. In particular, we wished to assess cervical spine radiography with regards to frequency of utilization, yield for significant abnormality, incidence of missed injury, and variations in use among institutions and among physicians. This information, in turn, would suggest the potential for improved efficiency and standardization of trauma patient care through guidelines or a clinical decision rule.

Methods

Setting

This health records survey was conducted at 8 hospitals in British Columbia and Ontario. These institutions were chosen because they represent typical, busy teaching (6) and community (2) hospital emergency departments (35 000 to 65 000 visits annually) in a variety of Canadian cities. All of the departments are staffed by full-time, certified emergency physicians, and in most of the departments some patients are seen by residents under the supervision of emergency physicians. Our review was designed to include all eligible adult patients seen at the study hospital emergency departments between July 1, 1994, and June 30, 1995. The study was approved by the research ethics committee at each institution.

Patients

Patients were eligible for our study if they had suffered acute blunt trauma to the head or neck and could be considered alert and stable. "Trauma to the head or neck" was defined as either (a) neck pain after any type of injury, or (b) no neck pain but any injury above the clavicles associated with a high-risk mechanism of injury (motor vehicle collisions, motorcycle accidents, pedestrians struck by motor vehicles, falls from heights of 1 m or more or down 5 or more stairs, diving accidents or contact sports). "Acute" was defined as injury within the past 48 hours. "Alert" was defined as a Glasgow Coma Scale score of 15 out of 15 (patient able to converse, fully oriented and able to follow commands). "Stable" was defined as normal vital signs according to the Revised Trauma Score (systolic blood pressure 90 mm Hg or greater and respiratory rate between 10 and 24 breaths per minute).

We excluded patients if they were less than 16 years old, had penetrating trauma, were quadriplegic, had chronic vertebral disease, were referred from elsewhere with cervical spine radiographs or were returning for reassessment of the same injury.

Data collection

Data collection was performed at each hospital by registered nurses or health record analysts, all trained to select cases and abstract data in a standardized fashion according to the study manual. Potential cases were identified through a review of computer-generated lists of patient diagnoses, patient visit logs and radiology lists. Clinical and demographic data were abstracted onto case record forms and were obtained from hospital charts that included emergency department records of treatment, nursing notes, ambulance call reports and radiology reports. The eligibility of all patients and the accuracy of the data abstraction was reviewed independently by 2 of us (I.G.S. and K.V.), and any disagreements were resolved by consensus.

Statistical analysis

Descriptive statistics detailing clinical and demographic characteristics and use of radiography were compiled in a simple tabular format for all hospitals combined and for individual hospitals. Variation among institutions for use of cervical spine radiography and for yield of radiography was determined by Cochran's Q test for homogeneity.[38] The univariate association of various patient characteristics with use of radiography was determined for nominal data with the use of the χ^2 test without continuity correction and for continuous data with the use of the unpaired 2-tailed *t*-test, using pooled or separate variance estimates as appropriate. To control for possible differences in patient population and case severity at each hospital and to assess the impact of individual hospitals, logistic regression analysis with forward stepwise selection was performed to identify significant factors associated with (but not necessarily predictive of) the use of cervical spine radiography. In addition to each individual hospital, the following markers of case severity

were considered in the analyses: age, high-risk mechanism of injury, time from injury, arrival by ambulance, transfer from another hospital, neck pain, concussion, acute cervical spine injury (fracture, dislocation or ligamentous instability) and admission to hospital. Finally, variation in use of radiography among attending staff physicians who had seen at least 10 eligible cases in each institution was determined by Cochran's Q test for homogeneity. Almost all of these physicians had certification in emergency medicine from the Royal College of Physicians and Surgeons of Canada or the College of Family Physicians of Canada.

Results

During the 12-month study period, 6855 patients with potential cervical spine injury were seen at the 8 hospitals (Table 1). Overall, 60 (0.9%) were found to have an acute cervical spine injury (fracture, dislocation or ligamentous instability). The demographic and clinical characteristics of the patients were generally similar among the 8 hospitals. The following differences between institutions may be considered to be of clinical importance: the Eagle Ridge Hospital had lower rates of arrival by ambulance, transfer from another hospital, concussion and admission and a higher rate of neck pain; the Kingston General Hospital had higher rates of cervical spine injury and admission; the Royal Columbian Hospital had a lower rate of transfer; and the Sunnybrook Health Science Centre had higher rates of transfer and admission.

Overall, plain cervical spine radiography was ordered for 3979 (58.0%) of the patients (Table 2); this included

Table 1: Characteristics of all 6855 patients with potential cervical spine injury seen at 8 Canadian emergency departments* during the 12-month study period

	Hospital; % (and no.) of patients†								
Characteristic	Total *n* = 6855	ERH *n* = 630	KGH *n* = 356	OCH *n* = 892	OGH *n* = 647	RCH *n* = 1348	SHSC *n* = 582	VGH *n* = 1595	VH *n* = 805
Age, yr									
Mean (and SD‡)	34.9 (15.5)	32.8	35.0	36.9	36.1	32.7	40.6	33.8	35.0
Range	16–96								
Sex									
Male	3862 (56.3)	50.2	57.0	52.9	51.3	59.1	53.6	59.6	59.5
Mechanism of injury									
High risk	5684 (82.9)	84.4	77.5	76.7	86.4	87.4	84.0	83.6	78.6
Motor vehicle collision	4739 (69.1)								
Motorcycle collision	78 (1.1)								
Motor vehicle–pedestrian collision	194 (2.8)								
Fall from ≥ 1 m or down ≥ 5 stairs	431 (6.3)								
Diving	5 (0.1)								
Contact sport	237 (3.5)								
Other	1171 (17.1)	15.6	22.5	23.3	13.6	12.6	16.0	16.4	21.4
Bicycle accident	329 (4.8)								
Assault	367 (5.4)								
Fall from < 1 m	332 (4.8)								
Other	143 (2.1)								
Mean time from injury (and SD), h	3.3 (4.6)	2.7	1.8	3.2	3.8	2.4	3.6	3.5	3.1
Arrival by ambulance	3247 (47.4)	25.2	49.2	44.8	54.9	49.7	56.7	46.4	51.9
Transfer from other hospital§	169 (2.5)	0	4.8	1.7	5.1	0.2	8.4	0.9	4.6
Neck pain	5323 (77.7)	90.2	62.1	74.9	70.9	83.8	69.8	84.7	64.7
Concussion	912 (13.3)	4.1	24.7	13.1	16.4	8.8	18.4	12.3	19.0
Acute cervical spine injury	60 (0.9)	0.2	3.7	0.3	0.3	0.8	1.6	0.9	0.8
Fracture	48 (0.7)								
Dislocation	3 (0.04)								
Ligamentous instability	9 (0.1)								
Disposition									
Discharged	6280 (91.6)	98.9	81.7	94.5	90.3	94.0	77.0	93.9	90.2
Admitted	575 (8.4)	1.1	18.3	5.5	9.7	6.0	23.0	6.1	9.8
Ward	418 (6.1)								
Critical care unit	88 (1.3)								
Operating room¶	69 (1.0)								
Died	0								

*ERH = Eagle Ridge Hospital (community), Port Moody, BC; KGH = Kingston General Hospital, Kingston, Ont.; OCH = Ottawa Civic Hospital, Ottawa; OGH = Ottawa General Hospital, Ottawa; RCH = Royal Columbian Hospital (community), New Westminster, BC; SHSC = Sunnybrook Health Science Centre, North York, Ont.; VGH = Vancouver General Hospital, Vancouver; VH = Victoria Hospital, London, Ont.
†Unless otherwise stated.
‡SD = standard deviation.
§Patients transferred with cervical spine radiographs excluded.
¶Includes patients undergoing orthopedic, abdominal or other surgery.

3409 (64.0%) of those with neck pain. Radiographs were negative for significant cervical spine abnormality in 3919 (98.5%) of the 3979 patients who underwent radiography. Significant variation was found among the 8 hospitals in the rate of ordering radiography, from 37.0% to 72.5% ($p < 0.0001$). There was also significant variation in the yield of radiography, from 90.8% to 99.6% of the radiographs being negative ($p < 0.001$).

Patients with negative radiographs spent on average 82 minutes longer in the emergency department before discharge than did those who had no cervical spine radiography (183.9 v. 101.8 minutes). None of the patients discharged without radiography were later identified as having an acute cervical spine injury (although these patients were not specifically followed other than having return visits monitored). Six patients, however, who did have radiography were later found to have a cervical spine injury that was not identified at the initial visit (4 had fractures, 1 a dislocation and 1 ligamentous instability).

Displayed in Table 3 are the univariate associations of various clinical and demographic characteristics with the ordering of cervical spine radiography. Those characteristics most strongly correlated with radiography use may be considered potential markers of case severity. These patient characteristics and the individual hospitals were further assessed by logistic regression analysis. Independent factors associated with the likelihood of having cervical spine radiography were transfer from another hospital, acute cervical spine injury, arrival by ambulance, neck pain and admission to hospital (Table 4). After controlling for these differences among patients, the logistic regression model also revealed that 6 of the hospitals were significantly associated with use of radiography (3 with odds ratios less than 1, and 3 with odds ratios greater than 1).

At 7 of the institutions, there was significant variation ($p < 0.05$) in the ordering of radiography among the attending staff physicians who had seen at least 10 eligible patients (Fig. 1). There was considerable variation at each hospital between physicians with the lowest and highest rates of ordering radiography. As the extremes, 1 physician ordered radiography for only 15.6% of 32 patients seen, and another ordered films for 91.5% of 130 patients seen.

Table 2: Use and yield of cervical spine radiography, by hospital

Hospital	Total no. of patients	No. (and %) referred for radiography*	No. (and %) with negative radiographs†
ERH	630	233 (37.0)	232 (99.6)
KGH	356	142 (39.9)	129 (90.8)
OCH	892	471 (52.8)	468 (99.4)
OGH	647	368 (56.9)	366 (99.5)
RCH	1348	682 (50.6)	671 (98.4)
SHSC	582	393 (67.5)	384 (97.7)
VGH	1595	1157 (72.5)	1142 (98.7)
VH	805	533 (66.2)	527 (98.9)
All	6855	3979 (58.0)	3919 (98.5)

*$p < 0.0001$, by Cochran's Q test for homogeneity between individual hospitals.
†$p < 0.001$.

Table 3: Clinical and demographic characteristics associated with use of cervical spine radiography, as determined by univariate analysis

Patient characteristic	Radiography ordered; no. (and %) of patients* Yes $n = 3979$	No $n = 2876$	p value
Mean age (and SD), yr	35.6 (15.8)	33.9 (14.9)	< 0.01
Male sex	2271 (57.1)	1591 (55.3)	NS
High-risk mechanism of injury	3339 (83.9)	2345 (81.5)	< 0.05
Mean time from injury (and SD), h	3.1 (4.4)	3.7 (4.8)	< 0.01
Arrival by ambulance	2391 (60.1)	856 (29.8)	< 0.001
Transfer from other hospital	126 (3.2)	43 (1.5)	< 0.001
Neck pain	3409 (85.7)	1914 (66.6)	< 0.001
Concussion	646 (16.2)	266 (9.2)	< 0.001
Acute cervical spine injury	60 (1.5)	0‡	< 0.001
Admission to hospital	509 (12.8)	66 (2.3)	< 0.001

*Unless otherwise stated.

Discussion

Our study revealed that the prevalence of cervical spine injury is very low, at only 0.9% of trauma cases commonly seen in Canadian emergency departments. Although most alert, stable trauma patients undergo cervical spine radiography, the yield of these films is very low, with more

Table 4: Patient characteristics and hospitals independently associated with use of cervical spine radiography, as determined by logistic regression analysis

Characteristic	Coefficient	Odds ratio (and 95% CI*)
Intercept	–2.389	–
Patient characteristic		
Transfer from other hospital	–0.519	0.6 (0.4–0.9)
Acute cervical spine injury	1.087	3.0 (1.2–7.5)
Arrival by ambulance	1.570	4.8 (4.2–5.4)
Neck pain	2.278	9.8 (8.2–11.5)
Admission to hospital	2.467	11.8 (8.5–16.4)
Hospital		
KGH	–0.786	0.5 (0.3–0.6)
ERH	–0.718	0.5 (0.4–0.6)
RCH	–0.412	0.7 (0.6–0.8)
SHSC	0.367	1.4 (1.1–1.8)
VGH	0.788	2.2 (1.9–2.6)
VH	0.834	2.3 (1.9–2.8)

*CI = confidence interval.

than 98% being negative for fracture or dislocation. There is significant variation in the rate of ordering cervical spine radiography among the study hospitals. This variation could not be accounted for by differences in patient characteristics or case severity. In our analysis we carefully controlled for all measurable markers of severity and still found large differences (more than 4-fold) at each institution in the likelihood that radiography would be ordered. Our study also demonstrated a large variation in radiography ordering practices among emergency physicians within institutions, with an extraordinary range of radiography rates. This variation occurred despite the fact that almost all of the physicians were certified career emergency physicians.

Variations between regions have been previously demonstrated in the use of health care services, including hospital admission, surgery and diagnostic procedures.[39–41] Researchers must determine whether apparent variations can be attributed to such issues as inaccuracy in coding diagnoses and procedures, differences in the demographic and clinical characteristics of patients, instability of utilization rates because of small volumes of procedures or random fluctuation.[42] Wennberg[39] believes that true variations are strongly affected by individual physician practice and by a lack of agreement on the optimal management for many medical problems. Kassirer[43] has suggested that variations in patterns of care should lead to the development of clinical practice guidelines.

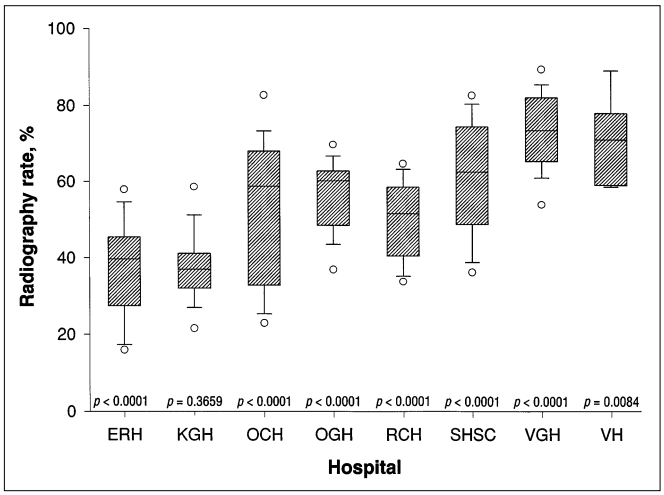

Fig. 1: Inter-physician variation in referral rates for cervical spine radiography at 8 Canadian emergency departments. Boxes represent interquartile range (25th to 75th percentiles) and horizontal lines dividing boxes represent median (50th percentile). Whiskers emerging from boxes extend to adjacent values (three-halves the interquartile range); observed points more extreme than this are individually plotted. *P* values represent variation among attending staff physicians within each institution, as determined by Cochran's Q test for homogeneity. See footnote in Table 1 for names of hospitals.

We believe that the large variations among hospitals and physicians in our study may be explained by the lack of consensus in the literature regarding cervical spine radiography for alert, stable trauma patients. Current guidelines are contradictory and ambiguous. Without reliable guidelines, many physicians are likely to order radiography for most trauma patients seen in North American emergency departments. This approach, previously described for patients with ankle and knee injuries, is also fostered by the nature of emergency department practice: high case volumes, brief physician–patient contact, uncertain follow-up and fear of medicolegal repercussions.[36,44,45] Physicians would be expected to be especially conservative in the management of neck injuries, given the rare but potentially catastrophic occurrence of spinal injury and paralysis. Nevertheless, many of the physicians in the Canadian emergency departments in our study appeared to be already very selective in their use of cervical spine radiography; in fact, the hospital with the highest rate of cervical spine injury also had the lowest rate of negative radiographic films. This selective approach has no apparent deleterious effect on patient care in that none of the patients discharged without radiography was later found to have a cervical spine injury.

Considerable controversy exists in the literature regarding selective use of cervical spine radiography. Some authors have recommended that all trauma patients undergo this type of radiography.[3,5,24,46–48] Others agree that a selective approach is ideal but do not give clear recommendations.[6,11,17,25,49–53] Still others suggest a very cautious approach that radiography may not be required in alert patients without pain or tenderness of the neck.[10,12,14–16,19–21,54–62] Only a few are willing to suggest that radiography be withheld in alert patients with neck pain if there is no midline bone tenderness.[13,18,22] Regardless of the controversy, the greatest consensus among physicians is that more research is required before guidelines can be confidently offered.[6,12,15,17–19,21–23,50,53,55–57,61]

The findings of our study may be limited by several factors. We cannot necessarily generalize our findings to other Canadian hospitals. A recent survey of members of the Canadian Association of Emergency Physicians and discussions with colleagues across the country suggest considerable variation.[63] Retrospective chart studies may suffer from problems with unclear or missing data or with inconsistencies in data abstraction. We believe that these problems were minimized by our use of a study manual and standardized data forms and the careful, independent review of all cases by 2 of us at the coordinating centre. Finally, we cannot be absolutely certain that no missed injuries occurred in patients who may have been followed up at a different hospital. We believe that this is unlikely because the study hospitals represented the main trauma

and neurosurgical centres for their communities.

We believe that our study results strongly support the need for a clinical decision rule for the use of cervical spine radiography. Current practice is inefficient, with more than 98% of radiographic films being negative for any important abnormality. Also, there is significant variation in the rates of ordering this type of radiography: almost 2-fold among similar large hospitals and almost 6-fold among experienced and certified staff emergency physicians. Our results show that hospitals and physicians with low ordering rates are no more likely to miss a cervical spine injury than those with high ordering rates. The survey of Canadian emergency physicians showed that only 22% agreed with guidelines recommending universal cervical spine radiography and that 98% of these physicians would strongly support the development of an accurate decision rule for this clinical problem.[63]

We have previously derived, validated and successfully implemented decision rules for ankle radiography (the Ottawa ankle rules)[30,32,34,35,64] and knee radiography (the Ottawa knee rule).[31,33,65] A reliable and highly sensitive decision rule for cervical spine radiography would permit physicians to provide more standardized and efficient care for trauma patients. Such a decision rule should, therefore, lead to improved patient care and considerable savings for North American health care systems.[66] Our collaborative Canadian research group has recently started a multicentre 2-phase study to derive and validate a clinical decision rule for cervical spine radiography.

Conclusion

Our study demonstrated considerable variation among institutions and individual physicians in the ordering of cervical spine radiography for alert, stable trauma patients with similar characteristics. None of the institutions with low ordering rates missed any patients with cervical spine injury. The yield of radiography for significant abnormality was extremely low at all hospitals. These findings suggest great potential for more efficient use of cervical spine radiography, possibly through the use of a clinical decision rule.

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