ORIGINAL CONTRIBUTION
spine, cervical, radiographs

Rational Ordering of Cervical Spine Radiographs Following Trauma

A retrospective review of 312 hospitalized patients with cervical spine injuries was conducted to identify presenting signs, symptoms, and coexisting conditions, and to determine if any injuries were not diagnosed in the emergency department. Of the 257 (82%) patients who were alert on ED evaluation, 215 (84%) complained of neck pain or tenderness. Of the remaining 42 alert patients without neck pain, 34 had sensory or motor symptoms or signs suggestive of cervical spine injury, and eight had significantly painful other injuries. Of the 284 patients presenting within the first 48 hours after injury, 23 were not diagnosed initially, 21 because radiographs were initially read as negative and two because no radiographs were taken. A significant number of patients had more than one fracture of the spinal column. A stepwise approach to rational ordering of cervical spine radiographs in blunt trauma is proposed. [Ringenberg BJ, Fisher AK, Urdaneta LF, Midthun MA: Rational ordering of cervical spine radiographs following trauma. Ann Emerg Med August 1988;17:792-796.]

Beverly J Ringenberg, MD, FACEP
Anne K Fisher
Luis F Urdaneta, MD, FACS
Mark A Midthun, MA
Iowa City, Iowa

From the University of Iowa Hospitals & Clinics, Iowa City, Iowa.

Received for publication November 4, 1987. Revision received February 12, 1988. Accepted for publication March 1, 1988.

Presented at the Scientific Assembly of the American College of Emergency Physicians in San Francisco, November 1987.

Address for reprints: Beverly J Ringenberg, MD, FACEP, University of Iowa Hospitals & Clinics, Iowa City, Iowa 52242.

INTRODUCTION

In 1979 Bohlman[1] published a retrospective review of 300 patients with cervical spine injuries. One-third of the patients with injuries were not diagnosed initially in the emergency department. This study clearly demonstrated a need for emergency physicians to heighten their index of suspicion and make cervical radiography a routine part of the evaluation of trauma patients, especially those with an altered level of consciousness due to head injury, intoxication, or multiple injuries. Other authors have reported "occult" injuries,[2,3] "personal experience" with painless cervical spine fractures,[4] and cervical spine injuries in patients with "minimal or no symptoms."[5]

Undoubtedly the safest approach to the problem of missed neck injuries, as promoted by the American College of Surgeons in their advanced trauma life support guidelines,[6] is to make cervical spine radiography a routine part of the evaluation of every trauma patient. However, the high percentage of negative studies[7,8] and an increased awareness of the need to consider cost containment have encouraged recent investigators to propose guidelines for cervical radiographic evaluation of trauma patients[7,9] and to develop high-yield criteria for cervical radiography.[8,10-12]

Fischer reported that in 333 fully alert head injury patients, all five patients with cervical spine injuries had symptoms or signs referable to the cervical spine.[13] Similarly, Bachulis found that all 65 alert trauma patients with positive cervical radiograph findings had symptoms of neck injury.[7] The remaining 29 patients with cervical spine injuries had a decreased level of consciousness secondary to brain injury, alcohol, shock, or mental handicap. These reports lend credence to Gatrell's suggestion that "the asymptomatic cervical injury may be a myth."[14]

Our retrospective review of hospitalized patients was conducted to address the question of the asymptomatic cervical spine injury. Guidelines for rational ordering of cervical spine radiographs were developed based on our findings as well as suggestions of earlier authors.

METHODS

The University of Iowa Hospitals and Clinics is a 1,020-bed tertiary care

facility that serves as the major referral center for the state of Iowa. Using the main frame hospital computer and the ICD-9 coding system, a list of all patients discharged from the University Hospitals with a diagnosis of cervical spine injury between January 1979 and April 1985 was obtained.

Detailed analyses of the ED records, consultants' statements, radiographic reports, discharge summaries, and transfer records, if available, were completed. Age, sex, time of presentation, mechanism of injury, type and location of all spinal injuries, evidence of alcohol or other drug intoxication, and concurrent injuries were recorded. Documentation of the presence or absence of neck pain or tenderness as well as subjective or objective sensory or motor findings were noted. If any of these signs or symptoms were mentioned by any examiner they were to be positive findings. Any delays in diagnosis of the cervical spine injury and circumstances surrounding these delays were analyzed.

RESULTS

Three hundred twelve cases were studied retrospectively after the deletion of duplicate records (three); cases without clear evidence of trauma, those with the diagnosis of cervical strain, old fracture, or congenital abnormality (109); and those unavailable for review (52).

Two hundred forty-nine (77%) of these 312 patients were men, with a mean age of 31 ± 16.4 years. The mean age of the 72 women was 36.5 ± 23.4 years. Mechanisms of injury are shown (Table 1). There were no patients with penetrating trauma in this series. The distribution of cervical spine injuries is shown (Table 2). Concomitant spinal injuries included 4% of patients with one or more thoracic spine fractures, 4% with one or more lumbar spine fractures, and 1% with fractures of the cervical, thoracic, and lumbar spines.

Two hundred fifty-seven patients (82%) were conscious and alert at the time of initial evaluation; the remaining 55 (18%) had evidence of decreased mentation. This included 37 patients impaired by head trauma who were either comatose or disoriented and uncooperative, 13 with anoxic brain injury due to high cord transection, two comatose patients after cardiac arrest, one patient under the influence of general anesthesia following splenectomy at a referring facility, one mentally retarded child, and one patient with organic brain syndrome. None of these 55 patients had decreased mentation due to alcohol or drugs alone.

TABLE 1. *Mechanisms of injury*

Mechanism	%
Motor vehicle accident	50.0
Fall	25.2
Diving	8.6
Motorcycle accident	8.4
Altercation	3.1
Bicycle	1.9
Motor vehicle-pedestrian accident	1.9
Wrestling	0.9

TABLE 2. *Distribution of cervical spine injuries by vertebral level*

Level of Fracture	%*
C-1	8
C-2	27
C-3	7
C-4	9
C-5	24
C-6	23
C-7	14
Subluxation or dislocation without fracture	13

*Total is more than 100% because some patients sustained more than one fracture.

Of the 257 alert patients, 215 (84%) complained of neck pain or tenderness on initial ED evaluation. The remaining 42 (16%) alert patients had no neck pain or tenderness documented. Of these 42 patients, 25 had both subjective symptoms and sensory or motor signs, four had subjective complaints only, four had objective findings only, and one had isolated radicular pain. Of the remaining eight patients without documented neck pain or tenderness, all had significantly painful other injuries. Six of these patients were involved in automobile accidents, two were involved in motorcycle accidents, and two appeared intoxicated. The other painful injuries are listed (Figure 1). Although the charts reflected that 54 (21%) of these patients appeared intoxicated, all of them were capable of cooperating sufficiently to obtain historical or physical information suggestive of cervical spine injury.

Two hundred eighty-four of the 312 patients presented for evaluation within 48 hours of injury. Of these, 261 (92%) had cervical spine injuries diagnosed on initial ED evaluation. In the remaining 23 (8%), diagnosis was delayed. In 21 of these 23 patients, radiographs were taken but were read initially by the emergency physician, specialty consultant, and/or radiologist as negative. Initial radiographs were taken at another hospital and thus were unavailable for review in ten cases. In four of these cases from another hospital, the diagnosis was made the next day after review of the films by a radiologist. Three cases were diagnosed when the patient returned complaining of persistent pain or paresthesias and additional studies were performed; and three cases were diagnosed only after referral to our institution.

In 11 patients seen initially at our institution, fractures were not recognized at the time of initial presentation by the emergency physician, specialty consultant, or on-duty radiologist. Nine patients had complete cervical spine radiographs (ie, anterior-posterior, lateral, odontoid, supine obliques). In five of these cases, the diagnosis was suspected on review by the staff radiologist and confirmed with polytomography. One was diagnosed by the staff radiologist on the plain films alone, and three were not diagnosed until the patients returned and were reevaluated because of persistent symptoms (68-year-old man with a unilateral C6-7 facet dislocation, 83-year-old woman with C-6 body fracture, and 24-year-old woman with C-4 and C-5 facet fractures).

Two patients did not have adequate studies. One had a complete series, but only the superior end plate of the seventh vertebra was visualized (diagnosed as a superior facet fracture of C-7 20 days later when the patient returned complaining of persistent pain). The other had a poor-quality series because of patient motion and lack of cooperation. The diagnosis was suspected by the staff radiologist on re-

Significantly Painful Other Injuries		
Patient Age (yr)	Sex	Injuries
37	F	Liver laceration, pelvis and femur fractures, noted to be intoxicated
32	M	Pubic ramus and fibular fracture, noted to be intoxicated
23	F	Liver laceration, hypotension
42	F	Open tibia/fibula fracture, mandible fracture, talus fracture
35	M	Skull fracture, fracture of lateral and inferior orbital wall, lateral maxillary sinus
21	M	Open femur fracture, forearm fracture
31	M	Extensive scrotal lacerations
60	M	Multiple facial fractures, skull fracture, multiple extremity fractures

1

FIGURE 1. *Eight alert patients with cervical spine fractures did not have signs or symptoms referable to the cervical spine but had other more painful injuries.*

TABLE 3. *Distribution of fractures missed on initial radiograph interpretation*

Level	No.*
C-1	1
C-2	8
C-3	2
C-4	2
C-5	3
C-6	1
C-7	3
Subluxation or dislocation without fracture	3

*Twenty-three abnormalities missed on 21 patients.

view of films the next day and confirmed as stable fracture of the right articular facet C-4 by polytomography. The distribution of fractures missed on initial review of the radiograph is shown (Table 3).

The remaining two patients with delayed diagnoses had no cervical spine radiographs taken as part of their ED evaluation. One of these patients was a 55-year-old man who apparently sustained a cervical spine fracture when he fell from a standing position at the time of a cardiac arrest. Despite motor and sensory deficits at the time of transfer to this facility, a neck fracture was not suspected until the next day. The second patient was an 83-year-old woman with organic brain syndrome who was found lying next to her bed. In this case, the diagnosis was made three days after admission when she complained of neck pain.

Fourteen of the 21 patients who were not diagnosed at the time of initial ED presentation required halo traction (12) and/or surgery (two), while the other seven were treated with neck collars only.

Twenty-eight of the 312 patients (9%) presented for initial evaluation more than 48 hours after injury. Forty-four percent of these patients presented between 48 hours and one week, 37% between one and four weeks, and 19% between one and ten months. It was not possible to determine the incidence of missed diagnoses in this group because the majority of these patients did not present to our facility initially, and a careful review of the available records did not fully explain the circumstances leading to delay in presentation or details of initial radiographic evaluation.

DISCUSSION

The age/sex distribution and mechanisms of injury in our study were similar to those seen in other studies.[7,13,15] The predominance of injuries at the C-2, C-5, and C-6 levels was also consistent with previous reports.[16-18]

Because patients with cervical spine injuries may not present with dramatic signs and symptoms, a high index of suspicion is required to prevent a missed diagnosis and possible cord injury. However, our study demonstrated that in our series of 312 patients, no conscious, alert patient had a cervical spine injury without signs or symptoms consistent with neck injury or other significantly painful injuries that may have distracted the attention of the patient and/or examining physician. These findings concur with those of other authors who recently questioned the existence of truly "asymptomatic" cervical spine injuries in alert trauma patients.[7,13,14]

The limitations of a retrospective study such as ours must be considered. Because our review was based on discharge diagnoses of hospitalized patients at a single institution, any patient who was not admitted or who may have decided to go to another facility following initial evaluation in our ED would have been missed. In addition, although every effort was made to locate all charts, and it is unlikely that the inability to locate "lost charts" would have biased the data base, this limitation must be considered.

Understanding the limitations of a retrospective study, it is clear that any recommendations made from our review for rational ordering of cervical spine radiographs should be validated in a large prospective multicenter study. An algorithm for rational ordering of cervical spine radiographs would start with the decision to obtain films on any patient who has sustained blunt trauma and is incapable of giving a good history or cooperating with a physical examination. This would include all cases in which the clinician judges the patient's mental status impaired for any reason, including head injury, anoxia, organic brain syndrome, or mental retardation. In the absence of decreased mentation, the next step would be to ascertain whether neck pain or tenderness is present. Alert patients with neck pain would be radiographed, as would alert patients without neck pain or tenderness if complete history and physical examination demonstrated any subjective or objective findings consistent with cervical spine injury.

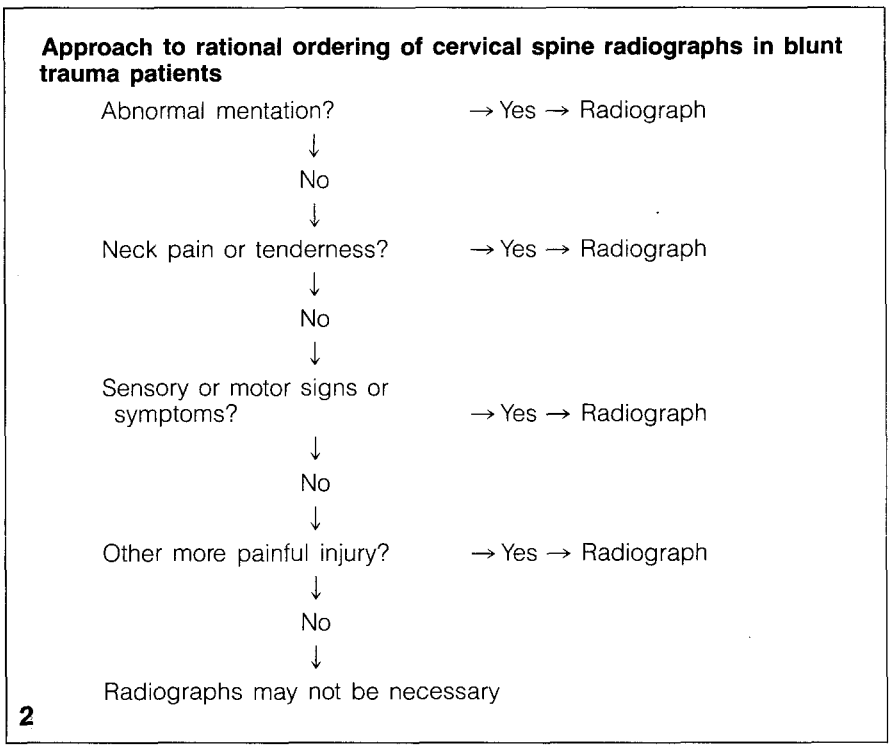

FIGURE 2. *Proposed algorithm for rational ordering of cervical spine radiographs.*

Finally, any blunt trauma patient with other significantly painful injuries should receive radiographic evaluation of the cervical spine. Blunt trauma patients without an altered level of consciousness, neck pain or tenderness, numbness, weakness or radicular pain, or other more painful injuries probably do not need radiographs. Our recommendations are outlined (Figure 2).

Head or facial trauma or preceding loss of consciousness without impaired mentation at the time of ED evaluation is not part of the decision tree described (Figure 2). Some authors consider these factors alone to be criteria for radiographic evaluation of the cervical spine.[3,4,9,11,19,20] Other investigators have questioned the usefulness of these criteria.[8,11,13,15,16,21] No attempt was made to evaluate these correlations in our study.

The observation that a significant number of patients with cervical spine injuries will have more than one fracture of the cervical spine or have unsuspected fractures involving the thoracic or lumbar spine has been made by other authors as well.[17,18,22,23] Documentation of fracture at one spinal level should prompt a radiographic investigation of the entire spine in any patient with pain or the inability to complain of pain in the thoracic or lumbar areas. While severe deficit from injury at the cervical level may seem to make treatment of lower spinal fractures less urgent, the possibility of recovery of function with rapid treatment of the cervical spine injury requires the recognition of other unstable spinal injuries.

Seven percent of the patients in our series had cervical spine radiographs initially read as negative by the radiologist and/or emergency physician. Although 11 of 21 (52%) of these were diagnosed or suspected on review of films by the staff radiologist, it is imperative that the clinician maintain a high index of suspicion and that there be a timely mechanism for review of films that initially appear to be negative. As shown clearly by the 14 of 21 patients in our series who required neurosurgical stabilization, difficulty in diagnosing a fracture or dislocation may not mean the injury is insignificant or stable.

CONCLUSION

In our retrospective study of 312 patients with cervical spine fracture or dislocation, there were no conscious and alert patients without neck pain or tenderness, signs or symptoms of cervical spine pathology, or other more painful injuries. In 7% of patients the diagnosis of cervical spine injury was missed on ED evaluation because initial radiographs were read as negative. Half of these patients were suspected or diagnosed after further review of the plain films, although most required additional studies to confirm the diagnosis. Associated fractures of the thoracic and lumbar spine are not uncommon in patients with cervical spine injuries.

The following recommendations thus can be made but must be substantiated by a prospective study before accepted as valid. All blunt trauma patients with neck pain, tenderness, signs or symptoms of cervical spine injury, decreased mentation, or other painful injuries secondary to blunt trauma should receive radiographic evaluation of their cervical spine. Patients with none of these findings after thorough history and physical examination may not require radiographic evaluation of the cervical spine.

All radiographs should be reviewed as soon as possible by a staff radiologist, and patients with persistent complaints should be carefully reevaluated. A full series of spinal radiographs should be completed on all patients with documented cervical spine fracture who complain of pain in other areas of the spine or who have altered mentation or neurologic impairment.

REFERENCES

1. Bohlman HH: Acute fractures and dislocations of the cervical spine. *J Bone Joint Surg* 1979;61A:1119-1142.

2. Haines JD: Occult cervical spine fractures. *Postgrad Med* 1986;80:73-77.

3. Bresler MJ, Rich GH: Occult cervical spine fracture in an ambulatory patient. *Ann Emerg Med* 1982;11:440-442.

4. Maull KI, Sachatello CR: Avoiding a pitfall in resuscitation: The painless cervical fracture. *South Med J* 1977;70:477-478.

5. Thambyrajah K: Fractures of the cervical spine with minimal or no symptoms. *Med J Malaysia* 1972;26:244-249.

6. Collicott PE, Aprahamian C, Carrico CJ, et al: *Advanced Trauma Life Support Course for Physicians.* Chicago, American College of Surgeons, 1984, p 256.

7. Bachulis BL, Long WB, Hynes GD, et al: Clinical indications for cervical spine radiographs in the traumatized patient. *Am J Surg* 1987;153:473-477.

8. Jacobs LM, Schwartz R: Prospective analysis of acute cervical spine injury: A methodology to predict injury. *Ann Emerg Med* 1986;15:85-90.

9. Ross SE, O'Malley KF, Delong WG, et al: Clinical predictors of cervical spine injury (CSI) in blunt high-energy transfer injuries (BHETI) (abstract). *Ann Emerg Med* 1987;16:498-499.

10. Rattner R, Faller R, Tintinalli JE, et al: Selective use of cervical spine radiography in blunt trauma (abstract). *Ann Emerg Med* 1987; 16:498.

11. Cadoux CG: High-yield roentgenographic criteria for cervical spine injuries. *Ann Emerg Med* 1987;16:738-742.

12. Wales LR, Knopp RK, Morishima MS: Recommendations for evaluation of the acutely injured cervical spine: A clinical radiologic algorithm. *Ann Emerg Med* 1980;9:422-428.

13. Fischer RP: Cervical radiographic evaluation of alert patients following blunt trauma. *Ann Emerg Med* 1984;13:905-907.

14. Gatrell CG: "Asymptomatic" cervical injuries: A myth? *Am J Emerg Med* 1985;3:263-264.

15. Walter J, Doris PE, Shaffer MA: Clinical presentation of patients with acute cervical spine injury. *Ann Emerg Med* 1984;13:512-515.

16. McCabe JB, Angelos MG: Injury to the head and face in patients with cervical spine injury. *Am J Emerg Med* 1984;2:333-335.

17. Miller MD, Gehweiler JA, Martinez S, et al: Significant new observations on cervical spine trauma. *AJR* 1978;130:659-663.

18. Ragozzino MW, Deluca SA: Upper cervical spine trauma. *Am Fam Physician* 1985;32: 113-119.

19. Scher AT: A plea for routine radiographic examination of the cervical spine after head injury. *S Afr Med J* 1977;51:885-886.

20. Bertolami CN, Kaban LB: Chin trauma: A clue to associated mandibular and cervical spine injury. *Oral Surg* 1982;53:122-126.

21. Gbaanador GB, Fruin AH, Taylon C: Role of routine emergency cervical radiography in head trauma. *Am J Surg* 1986;152:643-648.

22. Scher AT: Double fractures of the spine — an indication for routine radiographic examination of the entire spine after injury. *S Afr Med J* 1978;53:411-413.

23. Calenoff L, Chessare JW, Rogers LF, et al: Multiple level spinal injuries: Importance of early recognition. *AJR* 1978;130:665-669.