Cervical Spine Clearance: A Review and Understanding of the Concepts

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ABSTRACT

Cervical spine injury is relatively rare, occurring in only 2% to 3% of patients with blunt trauma who undergo imaging studies. However, timely and accurate recognition of cervical spine injury is essential for the optimal management of patients with blunt trauma as subsequent morbidity includes prolonged immobilization. Evaluation of cervical spine injuries should begin in the emergency department and involves a combination of pediatric, trauma, orthopedic, and neurosurgeons for definitive management. Knowing which patients are at highest risk for injuries will undoubtedly influence decisions on how aggressively to pursue a potential cervical spine injury and can be achieved by establishing a multidisciplinary team approach that provides cervical spine immobilization, assessment, and clearance. Implementation of such guidelines will decrease time for cervical spine clearance and incidence of missed injuries. In this article different aspects of cervical spine injuries and cervical spine clearance protocols are reviewed.

Key words: *cervical, injury, trauma, spine, vertebrae*

INTRODUCTION

Historically imaging the cervical spine in blunt trauma has been controversial. The debate has been dominated by the problem of ruling out a spinal injury in the unconscious trauma patient. There have been several reports of spinal instability despite normal radiographs, but maintaining immobilization on the intensive care unit 'just in case' has been associated with significant morbidity. New imaging techniques have become available, but did not solve the problem, adding their own 'baggage', such as cost, availability, logistic difficulties, radiation dosage, lack of specificity and evidence of effectiveness or safety.[1] Timely and accurate recognition of cervical spine injury is essential to the optimal management of patients with blunt trauma as subsequent morbidity may cause prolonged immobilization.[2]

Epidemiology

Cervical spine injury is relatively rare, occurring in only 2% to 3% of patients with blunt trauma who undergo imaging studies.[3,4] Existing epidemiologic studies of patients with cervical spine injury typically focus on admitted patients or populations seen at referral centers. The spectrum of cases seen in such studies may not represent the patterns of patients or injuries seen in most emergency departments.[5-7]

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Clinical assessment

Evaluation of cervical spine injuries begins in the emergency department and involves a combination of pediatric, trauma, orthopedic, and neurosurgeons for definitive management.[8-10]

Different guidelines

Knowing which patients are at highest risk for injuries will undoubtedly influence decisions on how aggressively to pursue a potential cervical spine injury, however no published studies have yet identified the relative risks of injury to the cervical spine in different patient groups. Analysis of the TARN database shows that the relative risk of cervical spine fracture, or cord injury, is greatly increased by the presence of a depressed level of consciousness, severe injuries to other body systems, head injury and chest injury.[11]

NEXUS study

The National Emergency X-Radiography Utilization Study validated the use of a 5-point decision-making instrument for identifying trauma patients in whom cervical spine radiography is required.[12]

The points identified were

- Altered level of alertness
- Intoxication
- Posterior midline cervical spine tenderness
- Distracting painful injury
- Focal neurological deficit

Absence of all 5 of these had a negative predictive value of 99.9% (95% confidence interval 99.8-100%).[13]

The Canadian C-Spine Rule[14]

The Canadian C-Spine Rule[14] has recently been developed to reduce radiography of cervical spine injuries. In alert, stable patients, X-rays are deemed to be unnecessary if the patient is less than 65 years of age and does not have a dangerous mechanism of injury and does not have paraesthaesia in the extremities and was involved in a simple rear end shunt or is in a sitting position in the Emergency Department or has been ambulatory at any time since injury or has delayed onset of neck pain or has absence of midline cervical spine tenderness and is able to rotate the head by 45^{o} to both sides.

A dangerous mechanism of injury is defined as-

- Fall >1 m or 5 stairs
- Axial load to the head
- RTA >100 km/h, rollover or ejection
- Motorized recreational vehicles
- Bicycle collision

This rule was derived solely in a cohort of adult patients, and has not been validated in children and therefore, the rule is not applicable in pediatric practice.[14]

Vandemark: criteria for high-risk patients[15]

1. High velocity blunt trauma
2. Multiple fractures
3. Evidence of direct cervical injury (cervical pain, spasm, obvious deformity)
4. Altered mental status (loss of consciousness, alcohol and/or drug abuse)
5. Drowning of diving accident
6. Fall of >10 ft
7. Significant head or facial injury
8. Thoracic or lumbar fracture
9. Rigid vertebral disease (AS, DISH)
10. Paresthesias or burning in extremities

University of Washington criteria

Mechanism parameters

- High-speed (>35 mph) MVA
- Crash with death at scene
- Fall from height >10 ft

Clinical parameters

- Closed head injury
- Neurological symptoms or signs
- Referred to the cervical spine
- Pelvic or multiple extremity fractures

Hanson validated high risk cervical spine[16]

Mechanism

- Speed >35 mph;
- Fall >10 ft;
- Death at scene

Clinical

- Cervical spine pain, spasm, deformity or neurology
- Significant closed head injury;
- Pelvic or multiple extremity fractures

Role of imaging

Imaging plays an important part in the diagnosis of spinal injuries. In view of the potentially disastrous consequences of a missed spinal injury, imaging is employed to diagnose or, more frequently, to rule out a spinal injury. Over the last decade there has been a rapid change in clinical and imaging practice for the diagnosis of potential injuries of the cervical spine. This is driven by the standardization of health care, with definition of clinical protocols aided by the rapid advances in imaging

technology.[17] Controversies include the use of the trans-oral or odontoid views, flexion-extension films, CT scans, and MRIs, all of which have been shown to miss injuries in adults.[18-21] One should remember that no imaging modality is accurate 100% of the time, and the combination of accurate history taking, physical examination, and appropriate spinal imaging is required to minimize missed CSI.[1]

Plain radiography

Despite the availability of newer technologies, there is still an important role for plain films and all staff needs a basic understanding of the principles. They are ubiquitous, cheaper than CT and the radiation dose is much less for the full spine. Standard radiographic evaluation of the cervical spine in such patients typically consists of cross-table lateral, anteroposterior, and open-mouth odontoid views, supplemented at some centers with oblique imaging.[2] Some authors have stated that the odointoid peg view is unhelpful in young children (notwithstanding the practical difficulties that may be encountered).[18] Little information can be gleaned from static views regarding the stability of the cervical spine. Static flexion-extension radiographs have been advocated in adults to determine the stability of the cervical spine.[22]

Do X-ray

- Patient has altered conscious state
- Adequate assessment of neck symptoms not possible due to distracting injury
- Intoxication/sedation
- Neck tenderness or pain
- Abnormal neurological signs

Do not X-ray

- Patient is alert and has normal conscious state
- No distracting injury, intoxication or sedation, etc.
- No neck pain or tenderness
- Normal neurological examination

Adequacy of the films

There is often a difference in quality between portable films and those taken on a fixed departmental machine, although new portable digital units are a great improvement. Good radiographic technique is essential if subtle signs are to be revealed. To be adequate, the films should show the full extent of the cervical spine, from the occiput to the upper border of T1, and should not be rotated (Figure 1). The penetration should be sufficient to show bone architecture without losing soft tissue detail. The films must be evaluated by a competent practitioner who maintains sufficient activity to maintain skills.

Computed tomography

Role of CT scan has not been compared with plain radiography, other than in small case series (Figure 2). CT scans may, however, miss important injuries-transverse slices, may not detect the presence of a Salter Harris I fracture through the odointoid synchondrosis, and as seen below, significant soft tissue lesions may be detected on MR scan that have been missed by CT. Dynamic CT has been used to confirm the presence, or absence, of atlanto-axial rotatory fixation in a child presenting with torticollis, following injury to the neck.[23]**Magnetic resonance imaging**

Utility of MR for imaging the patient with an acute spinal injury is widely accepted, despite a relative paucity of technology assessment studies addressing accuracy of MR findings. MR imaging is used to evaluate two different aspects of spinal injury. One is the extent of injury to neural tissues. Extent of spinal cord and root injury and the likelihood of improvement are the neurologic questions, which need to be answered. Neurological function can be correlated to the imaging appearance of the spinal cord. Assessment of biomechanical integrity of the ligamentous-osseous skeleton is the second aspect of MR evaluation. Identification of injury to specific soft tissues of the spine and their distribution (pattern) reflect mechanisms and extent of injury, and guide treatment planning. Addressing both aspects is necessary in most patients.[24]

Limitations of imaging

The evidence from a large prospective study strongly suggests that adequate screening radiographs identify the large majority of patients with bony cervical spine injuries and that the overwhelming majority of patients with blunt trauma with an adequate screening series that shows no injury are indeed without bony injury. Nevertheless, in a small number of patients with blunt trauma, important cervical spine injury can be missed, even on adequate screening plain films. Furthermore, in many patients with blunt trauma, plain films are not adequate, and adjunctive studies are required before cervical spine injury can be excluded. Any strategy designed to improve the identification of such injuries must attempt to achieve a balance between detecting a small number of additional injuries and exposing large numbers of patients with trauma to the costs and radiation associated with additional imaging.[25]

Pediatric perspective

Due to the higher frequency of adult trauma, clinicians are exposed on a regular basis to adults with potential cervical spine injury, but have relatively little exposure to, and experience in, the management of children with

a potential for these injuries.[26] The incidence of cervical spine injury (CSI) in children is low (1% to 2%) and failure to recognize a CSI can produce catastrophic neurologic disability.[27,28]

Figure-1.X-ray cervical spine showing all cervical vertebrae

Figure-2.CT scan cervical spine showing fracture of C-5 vertebral body

Anatomical considerations

There are several features peculiar to the paediatric cervical spine, when compared to that of adults.[29,30]

- A relatively large head leading to a fulcrum of flexion at C2/3 rather than at C5/6, as in adults
- Horizontally aligned facet joints, compared to oblique orientation in adults. This is most noticeable in upper cervical vertebrae
- Underdeveloped uncinate processes of C3-C7, leading to flatter articular surfaces
- Anterior ''wedging'' of the vertebral bodies
- Synchondrosis at the junction of the odontoid peg and C2 vertebral body, allowing physeal injuries to occur
- Less rigid ligamentous support and weaker supportive muscles, allowing greater displacement for a given force

These anatomical differences can be expected to lead to different patterns of injuries in children. Horizontal facet joints, increased ligamentous laxity and weaker musculature make the child's bony cervical spine more mobile, with a lower expectation of bony injury. The higher fulcrum of flexion would be expected to lead to injuries occurring at a higher level than those seen in adults. Although there is inevitably some individual variation, the cervical spine is believed to take on a more adult structure and behaviour at around the age of 8-9 years.[31,32]

Clinical evaluation

Evaluation of the stability of the cervical spine in pediatric patients has been inconsistent and controversial. Pediatric surgeons as well as emergency room physicians and trauma, orthopedic, and neurologic surgeons often are asked to rule out cervical spine injuries.[1] Subsequent variability in the diagnostic approach and management of CSI in children includes issues such as who to perform cervical spine radiographs on, which radiographs to obtain, duration of immobilization, when to contact subspecialists, when to obtain computed tomography (CT) and magnetic resonance imaging (MRI) scans, and how to show the absence of a ligamentous injury in comatose patients.[1] The solution often is the overuse of cervical spine radiographs. However, guidelines as to which patients require imaging as well as what constitutes "routine screening" are variable and still evolving.[9,33] Pediatric patients with the following risk factors for cervical spine injury undergo cervical immobilization and radiographic evaluation:[1]

- Unconscious patient or patient with abnormal neurologic examination findings
- Mechanism of injury potentially associated with CSI

(high-speed motor vehicle collisions, falls greater than body height, bicycle or diving accidents, forced hyperextension injuries, acceleration-deceleration injuries involving the head)

- Neck pain
- Focal neck tenderness or inability to assess secondary to distracting injury
- Abnormal neurologic examination findings (complete testing of motor, sensory, and reflex functions of all extremities is required)
- History of transient neurologic symptoms suggestive of SCIWORA (weakness, paresthesias, or lightning/ burning sensation down the spine/ extremity or related to neck movement)
- Physical signs of neck trauma (ecchymosis, abrasion, deformity, swelling, or tenderness)
- Unreliable examination secondary to substance abuse
- Significant trauma to the head or face
- Inconsolable children.

Clearing the c-spine

Clearing the c-spine of injury is an area that requires strict rules and guidelines. Within this framework it can be broken into who and how to clear the c-spine.[1-4,14-16]

Who

If the patient is to be discharged from the emergency department, the Registrar from the following units may clear the c-spine after discussion with the emergency department-

- Emergency
- Intensive care
- Orthopaedic
- Neurosurgery
- General surgery

If the patient is an inpatient the c-spine can only be cleared after consultation with the

Neurosurgical or Orthopedic consultant, or the Emergency consultant if the patient is still in the emergency department.

How

Several questions need to be asked when attempting to clear the c-spine. These are questions that need to be asked of adult and paediatric patients. These are:

- Can pain and tenderness be assessed?
- Are there other distracting (painful) injuries?
- Is there neck pain?
- Is there tenderness over the cervical spine?
- Are there any motor or sensory abnormalities?
- Is there limitation of active neck movement?
- Is there limitation to head control?

Who to immobilize

In identifying who to immobilize patients can be devided into two groups' i.e. conscious and unconscious patients. The unconscious patient is by far the most difficult to assess but for obvious reasons easier to immobilize. Patients with an alteration in their level of consciousness are at increased risk for cervical spine fracture hence 'the unconscious patient with a history of possible trauma must be immobilized'.[34,35] It is important to note here that for cooperative patients who arrive with a hard collar in situ and who do not have a mechanism of injury warranting continued immobilization, the collar should be removed whilst a senior staff member maintains the head alignment. The neck is palpated for tenderness, and if none elicited, assessed for pain on active movement. If these are all absent the collar may be removed.[36-38]

How to immobilize

Immobilization of the patients with cervical spine is a very difficult and at times controversial task. Method for immobilizing these patients was put together with (at best) general agreement from all teams.[34,35,38] There is little literature available that documents the methods used for immobilizing young children. It has been shown that small children can be immobilize flat on a spine board in a semi rigid one piece cervical collar and a head immobilizer, and for children less than two year of age use of towels and staff or parents holding the head. Sedation is not used, but if the patient is head injured and uncooperative anesthesia, paralysis and intubation are used to aid assessment and imaging.[39]

C-spines and spine boards

Patients with suspected cervical spine injury should be placed in supine position, flat on their backs, in such a way as to avoid potential airway compromise. In children simple interventions like placing a diaper or towel roll under the shoulders can better position the head and airway.[40-42]

Collars

In addition to spine boards and the ever-popular towels and tape, cervical collars are an integral part of spinal immobilization in adults.[43,44] The problem is finding a collar that not only optimizes cervical motion limitation but also properly fits the patient in order to avoid improper spinal position and skin breakdown.[43-46] Unfortunately, many pediatric cervical collars simply do not fit children.

An apparently normal magnetic resonance image can conclusively exclude cervical spine injury and is established as a gold standard for clearing the cervical spine in a clinically suspicious or unevaluatable blunt trauma patient.[47] MRI may be unnecessary if the CT scan is negative.[48,49] Spinal cord injury treatment with intrathecal autologous bone marrow stromal cell transplantation: the first clinical trial case report.[50]

CONCLUSION

Clearing the cervical spine is a vital part of the treatment of trauma patients and if undetected an injury to the cervical spine can result in paralysis and even death. Establishing a multidisciplinary team provides standards for cervical spine immobilization, assessment, and clearance. Implementation of such guidelines will decrease time for cervical spine clearance, and ongoing analysis of sensitivity is encouraging. Team members consisted of pediatric surgeons, orthopedic surgeons, neurosurgeons, emergency room physicians, and trauma nurse practitioners. Cervical spine injuries in children are uncommon, but present many potential pitfalls in management.

REFERENCES

1. Lee SL, Sena M, Greenholz SK, Sacramento MF. A Multidisciplinary Approach to the Development of a Cervical Spine Clearance Protocol: Process, Rationale, and Initial Results. J Pediatr Surg 38:358-62.
2. American College of Radiology. Appropriateness Criteria for Imaging and Treatment Decisions. Reston, VA: American College of Radiology; 1995.
3. Spinal Cord Injury Statistics. Birmingham, AL: National Spinal Cord Injury Association Resource Center; 1999.
4. Hoffman JR, Schriger DL, Mower WR, et al. Low-risk criteria for cervical spine radiography in blunt trauma: a prospective study. Ann Emerg Med 1992;12:1454-1460.
5. O'Malley KF, Ross SE. The incidence of injury to the cervical spine in patients with craniocerebral injury. J Trauma 1988;28:1476-8.
6. Cooper C, Atkinson EJ, O'Fallon WM, et al. Incidence of clinically diagnosed vertebral fractures: a population-based study in Rochester, Minnesota, 1985-1989. J Bone Miner Res 1992;7:221-7.
7. Hu R, Mustard CA, Burns C. Epidemiology of incident spinal fracture in a complete population. Spine 1996;21:492-9.
8. Pasquale M, Fabian TC: Practice management guidelines for trauma from the Eastern Association for the Surgery of Trauma. J Trauma 1998;44:941-57.
9. Viccellio P, Simon H, Pressman BD, et al: A prospective multicenter study of cervical spine injury in children. Pediatr 2001;108:E20.
10. Brown RL, Brunn MA, Garcia VF: Cervical spine injuries in children: A review of 103 patients treated consecutively at a level 1 pediatric trauma center. J Pediatr Surg 2001;36:1107-14.
11. Baker SP, O'Neill B, Haddon Jr W, Long WB. The injury severity score: a method for describing patients multiple injuries and evaluating emergency care. J Trauma 1974;14(3):187-96.
12. Hoffman JR, Mower WR, Wolfson AB, et al. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. N Engl J Med 2000;343(2):94-9.
13. Goldberg W, Mueller C, Panacek E, Tigges S, Hoffman JR, Mover WR. NEXUS Group. Distribution and patterns of blunt traumatic cervical spine injury. Ann Emerg Med 2001;38(1):17-21.
14. Steill IJ, Wells GA, Vandemheen KL, Clement CM, Lesiuk H, DeMaio VJ, et al. The Canadian C-spine rule for radiography in alert and stable trauma patients. JAMA 2001;286(5):1841-8.
15. Vandemark RM. Radiology of the cervical spine in trauma patients: practice pitfalls and recommendations for improving efficiency and communication. AJR 1990; 155:465-72.
16. Hanson JA, Blackmore CC, Mann FA, Wilson AJ. Cervical spine injury: a clinical decision rule to identify high-risk patients for helical CT screening. AJR 2000;174:713-8.
17. Tins BJ, V.N. Cassar-Pullicino. Imaging of acute cervical spine injuries: review and outlook. Clinical Radiology 2004;59:865-80.
18. Buhs C, Cullen M, Klein M, Farmer D. The pediatric trauma c-spine: is the 'odointoid' view necessary? J Pediatr Surg 2000;35(6):994-7.
19. Ralston ME, Chung K, Barnes P, et al. Role of flexion-extension radiographs in blunt pediatric cervical spine injury. Acad Emerg Med 2001;8:237-45.
20. Chee SG. Review of the role of magnetic resonance imaging in acute cervical spine injuries. Ann Acad Med 1993;22:757-61.
21. Davis JW, Parks SN, Detlefs CL, et al. Clearing the cervical spine in obtunded patients: The use of dynamic fluoroscopy. J Trauma 1995;39:435-8.
22. Woods WA, Brady WJ, Pollock G, et al. Flexion-extension cervical spine radiography in pediatric blunt trauma. Emerg Radiol 1998;5:381-4.
23. Phillips WA, Hensinger RN. The management of rotatory atlanto-axial subluxation in children. J Bone Joint Surg Am 1989;71(5):664-8.
24. Cohen WA, Giauque AP, Hallam DK, Linnau KF, Mann FA. Evidence-based approach to use of MR imaging in acute spinal trauma. European Journal of Radiology 2003;48):49-60

25. Mower WR, Hoffman JR, Pollack CV Jr, Zucker MI, Browne BJ, Wolfson AB, for the NEXUS Group. Ann Emerg Med. 2001; 38:1-7.

26. ONS. Mortality statistics: childhood, infant and perinatal. London: Office for National Statistics; 2002. Series DH3 no. 33.

27. Kokoska ER, Keller MS, Rallo MC, et al: Characteristics of pediatric cervical spine injuries. J Pediatr Surg 2001;36:100-5.

28. Patel JC, Tepas III JJ, Mollitt DL, et al. Pediatric cervical spine injuries: Defining the disease. J Pediatr Surg 2001;36:373-6.

29. Bonadio WA. Cervical spine trauma in children. Part I. General concepts, normal anatomy, radiographic evaluation. Am J Emerg Med 1993;11(2):158-65.

30. Roche C, Carty H. Spinal trauma in children. Pediatr Radiol 2001;31:677-700.

31. Dickman CA, Rekate HL, Sonntag VKH, Zabramski JM. Pediatric spinal trauma: vertebral column and spinal cord injuries in children. Pediatr Neurosci 1989;15(5):237-56.

32. Hill S, Miller C, Kosnick E. Pediatric neck injuries: a clinical study. J Neurosurg 1984;60(4):700.

33. Jaffe DM, Binns H, Radkowski MA, et al. Developing a clinical algorithm for early management of cervical spine injury in child trauma victims. Ann Emerg Med 1987;16:270-6.

34. Chandler DR, Nemejc C, Adkins RH, Waters RL. Emergency cervical-spine immobilization. Ann Emerg Med 1992;21:1185-8.

35. Richter D, Latta LL, Milne EL, Varkarakis GM, Biedermann L, Ekkernkamp A, Ostermann PA: The stabilizing effects of different orthoses in the intact and unstable upper cervical spine: a cadaver study. J Trauma 2001;50:848-54.

36. Kanter AS, Wang MY, Mummaneni PV. A treatment algorithm for the management of cervical spine fractures and deformity in patients with ankylosing spondylitis. Neurosurg Focus 2008;24(1):E11.

37. Golob JF Jr, Claridge JA, Yowler CJ, Como JJ, Peerless JR. Isolated cervical spine fractures in the elderly: a deadly injury. J Trauma. 2008;64(2):311-5.

38. Rethnam U, Cordell-Smith J, Sinha A. Specialisation of spinal services: consequences for cervical trauma management in the district hospital. J Trauma Manag Outcomes. 2007 30;1(1):6.

39. Kim PD, Jennings JS, Fisher M, Siddiqui AH. Risk of cervical spine injury and other complications seen with skull fractures in the setting of mild closed head injury in young children: a retrospective study. Pediatr Neurosurg 2008;44(2):124-7.

40. Bledsoe BE, Porter RS, Cherry RA. Pediatrics. In: Paramedic care: principles and practice. Vol 4. Upper Saddle River (NJ): Prentice-Hall; 2001. p. 38-135.

41. Emergency Nurses Association. Pediatric trauma. In: Emergency nursing pediatric course. 2nd ed. Park Ridge (IL): ENA; 2000. p. 131-76.

42. Dieckmann R, editor. Trauma. In: Pediatric education for prehospital professionals. Sudbury (MA): Jones & Bartlett; 2000. p. 129-55.

43. Hazinski M, editor. Trauma resuscitation and spinal immobilization. In: PALS provider manual. Dallas: American Heart Association; 2002. p. 253-358.

44. Simon J, Goldberg A, editors. Pediatric trauma. In: Prehospital pediatric life support. St. Louis: Mosby; 1989. p. 70-81.

45. Kadish H. Cervical spine evaluation in the pediatric trauma patient. Clin Pediatr Emerg Med 2001;2:41-7.

46. Askins V. Efficacy of five cervical orthoses in restricting cervical motion: a comparison study. Spine 1997;22:1193-8.

47. Muchow RD, Resnick DK, Abdel MP, Munoz A, Anderson PA. Magnetic resonance imaging (MRI) in the clearance of the cervical spine in blunt trauma: a meta-analysis. J Trauma 2008;64(1):179-89.

48. Saito F, Nakatani T, Iwase M, Maeda Y, Hirakawa A, Murao Y, Suzuki Y, Onodera R, Fukushima M, Ide C. Spinal cord injury treatment with intrathecal autologous bone marrow stromal cell transplantation: the first clinical trial case report. J Trauma. 2008;64(1):53-9.

49. Derwinis T, Bialoszewski D. General principles governing radiological examinations in cervical spine injuries. Ortop Traumatol Rehabil 2000;2(1):91-4.

50. Como JJ, Thompson MA, Anderson JS, Shah RR, Claridge JA, Yowler CJ, Malangoni MA. Is magnetic resonance imaging essential in clearing the cervical spine in obtunded patients with blunt trauma? J Trauma. 2007;63(3):544-9.