Clearing the Cervical Spine in Unconscious Head Injured Patients - The Evidence

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ABSTRACT

Cervical spine injury occurs in 5-10% of patients with traumatic brain injury (TBI) and the consequences of missing significant cervical injuries in unconscious blunt trauma patients are potentially devastating. An adequate cervical spine clearance protocol for unconscious patients must avoid missed injuries, but must also avoid unnecessary cervical immobilisation and the associated morbidity. Existing protocols include various combinations of plain X-rays, helical CT, dynamic flexion-extension X-rays and MRI. Some clinicians also maintain immobilisation until clinical clearance is eventually enabled by the return of an adequate conscious state.

Plain X-rays alone are inadequate and miss 12-16% of cervical injuries. Swimmer's views and/or oblique views identify more injuries, but are frequently inadequate. Helical CT is sensitive to fractures and subluxation/dislocation injuries but may be insufficient to exclude unstable ligamentous injuries. Dynamic flexion-extension fluoroscopy may better identify unstable ligamentous injuries, but at The Alfred Hospital Trauma Centre in Melbourne, this modality was insensitive in the routine protocol and repeatedly missed significant cervical instability. Furthermore at The Alfred Hospital, when routine dynamic flexion/ extension fluoroscopy and helical CT reconstructions were directly compared, flexion/extension identified no new injuries that had not already been diagnosed by early helical CT reconstructions.

Cervical MRI is intuitively appealing as it detects ligament, disc interspace, and cord injury more efficiently than other imaging modalities, but MRI also increases cervical clearance times, increases the risks associated with complex transports and is not an ideal acute screening tool. Nevertheless, recently at The Alfred Hospital, extremely high-risk TBI patients have had unstable cervical injuries detected solely by MRI. Current generation multi-slice CT with reconstructions may obviate the need for MRI even in these patients.

The current Alfred Hospital cervical clearance protocol for unconscious patients, and the evolutionary steps in its development, will be discussed. (**Critical Care and Resuscitation 2005; 7: 181-184**)

Key words: Cervical spine injury, cervical clearance, coma, review

An optimal protocol for clearing the cervical spine in unconscious trauma patients is controversial, in part because cervical instability from occult ligamentous injury is difficult to diagnose but is potentially catastrophic when missed. Injuries to the cervical spine occur in 5-10% of unconscious blunt trauma patients,[1,2] diagnosis is missed or delayed in nearly 5%,[3] and delayed diagnosis may have substantial physical, economic and social ramifications. Accordingly, the objective of an ideal routine cervical spine clearance protocol for unconscious patients is to clear the neck rapidly and to avoid significant missed injuries. Unfortunately, a conservative approach may cause unnecessary prolongation of cervical immobilisation and associated increased morbidity. Prolonged cervical collar use causes decubitus ulceration in 31% of unconscious trauma patients, with the median length of stay in this group increasing to 23 days from a median

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of 10 days for patients who do not develop ulcers ($p < 0.01$).[4] Therefore, cervical spine clearance protocols must balance the small risk of a missed injury against the substantial potential for increased morbidity from prolonged spinal immobilisation. Randomised controlled trials have not been conducted, and are inappropriate in these patients, hence observational studies and the experience of high volume trauma centres has guided protocol development.

Current debate particularly concerns the role of dynamic flexion/extension fluoroscopy, the best utilisation of magnetic resonance imaging (MRI) and the implications of recent improvements in computed tomography (CT) imaging for the cervical spine.

Cervical clearance protocols utilising plain X-rays alone are inadequate and miss 12-16% of injuries to the cervical spine.[5,6] Swimmer's views, to improve visualisation of the cervicothoracic junction, are also frequently inadequate. Helical 3mm CT scanning identifies many injuries, including 97% of skeletal fractures, 97% of locked facet injuries and 86% of subluxation/dislocation injuries, but also missed 75% of ligamentous injuries and 100% of spinal cord injuries in a prospective study of 688 blunt trauma patients.[7] In unconscious patients, clinical assessment is impossible, and many centres utilise dynamic flexion/extension fluoroscopy to evaluate stability after plain X-rays, CT or MRI. A prospective study at The Alfred Hospital in Melbourne found that dynamic flexion-extension X-rays (either bedside or in the radiology department) were safe and identified a small number of unstable injuries that were not found by other modalities.[6] Bedside flexion-extension X-rays, however, were frequently inadequate, and The Alfred then moved to conducting all of these procedures in the radiology department where the current and voltage of the image intensifier could be controlled by a consultant radiologist, and imaging quality could be optimised. The American "Eastern Association for the Surgery of Trauma" (EAST) currently recommends the inclusion of lateral flexion/extension cervical spine fluoroscopy in routine cervical spine clearance protocols.[8]

Next, investigators at The Alfred studied 123 unconscious trauma patients receiving a protocol which included plain X-rays and passive flexion/extension fluoroscopy and unexpectedly found that the procedure was falsely negative in four cases.[9] These four patients complained of neck pain after regaining consciousness, and cervical instability was then detected on CT. Two of these patients required internal surgical fixation and two were treated in cervical collars. This study concluded that passive flexion/extension fluoroscopy was not sensitive to the detection of cervical instability and did not reveal any significant injuries which had not already been identified using other imaging modalities. Recent studies by others[10,11] have also concluded that flexion/extension fluoroscopy is inadequate, and should be deleted from current protocols. However flexion/extension fluoroscopy for cervical spine clearance had not been directly compared with fine cut 3mm CT. Therefore, in 276 traumatically brain injury patients who all had received a protocol including plain 3 view X-rays, CT / 3D reconstructions and dynamic flexion/extension fluoroscopy, Padayachee et al[12] reported that the incidence of new cervical fractures or instability identified on flexion/extension fluoroscopy was zero. Initially, this protocol included CT reconstructions from 3mm cuts (C0-T2), but one missed type II odontoid fracture was identified, leading to the inclusion of 1mm cuts from C0-C3 in a protocol modification. Thereafter, there were zero missed injuries (95%CI, 99.95 to 100%). Dynamic flexion/extension X-rays with fluoroscopy were then deleted from the routine clearance protocol for unconscious patients at The Alfred.

MRI is a valuable tool in the assessment of potential cervical discoligamentous instability. This modality enables sagittal reconstructed images of the osseous spine, spinal cord and related soft tissue without the potential risk of neurologic injury associated with dynamic flexion/extension techniques. MRI also enables the patient with potential unstable cervical injury to remain immobilised until clearance or diagnosis, and early use of spinal MRI in trauma patients may enable more expedient cessation of spinal position restrictions. Limited MRI is highly sensitive for the detection of injuries to cervical ligaments, disc interspace and spinal cord which are often not apparent on plain films or CT,[7] and MRI does not have the disadvantage of involving ionising radiation. There may, therefore, be clinical advantage to including MRI in routine cervical clearance protocols for obtunded patients, whose clinical evaluation is not possible.[13,14,15]

The inclusion of MRI in routine protocols, however, is problematic for many reasons. Ferrous components are incompatible with the magnet (eg. intraorbital metallic foreign bodies, cochlear implants, cardiac pacemakers, cerebral aneurysm clips, traction equipment, pelvic fixateurs, intensive monitoring equipment etc), precluding many traumatically brain injured patients from undergoing MRI. The risks of transporting unstable critically injured patients away from an ICU environment for screening procedures are concerning,[14] and increased resources are required for transportation and observation in the (usually distant) MRI department. Limited availability of MRI time is another issue, with patients likely to be subjected to position restrictions for longer periods of time whilst

waiting for MRI, predisposing them to many complications. Furthermore, the very high sensitivity of MRI for both minor and major injury has the potential to lead to inappropriate treatment plans for injuries which may not be clinically significant.[16]

MRI is expensive and adds additional cost to cervical screening, and this must be weighed against the potential cost of increased morbidity from prolonged cervical immobilisation, and the cost of a potentially devastating missed injury. However, MRI may be superfluous as adequate and well interpreted plain films and high resolution thin cut CT images have a reported false negative rate of only 0.1% for cervical spinal injuries.[17] Despite this, significant unstable cervical injuries have been diagnosed solely on MRI at The Alfred Hospital recently in several very high risk patients. These unconscious trauma patients in intensive care underwent the routine Alfred cervical screening protocol which included: AP and lateral plain X-Rays and CT with 3D reconstructions (1mm cuts C0-C3 and 3mm cuts C2-T4/5) all of which were normal. MRI was done additionally in these patients solely as a result of one clinician's high index of suspicion after severe mechanisms of injury particularly suggestive of potential cervical spine injury. MRI was positive for unstable injuries in 3 patients, two of whom received halothoracic braces with one treated conservatively in a cervical collar for 6 weeks. These cases lead to another (temporary) change to the cervical screening protocol for unconscious patients at The Alfred to include MRI in cases of very high risk mechanisms of injury (eg. high speed motorcycle versus stationary object). Unfortunately, the protocol change was inefficient and significant delays in spinal clearance resulted immediately and lead to considerable increases in patient length of stay.[4]

Recent introduction of multi-slice CT (MSCT) has enabled significant decrease in artefact and enhanced clarity of reformatted images, such that detection of some soft tissue injuries is now possible.[18] The installation of a new generation MSCT scanner at The Alfred has provided substantially improved and rapidly available imaging and a new endpoint for cervical spine clearance. MRI has now been relegated to a selective role involving clarification of injuries detected or suggested on other radiographic modalities. In order to validate MSCT as a definitive tool in this process, and to ascertain the ability of MSCT to detect or suggest the presence of discoligamentous injuries, further studies are required.

Optimal clearance of the cervical spine in unconscious trauma patients continues to be controversial. These patients are often at very high risk of cervical injury. Cervical spine clearance protocols must prevent missed injuries and be balanced against the potential for increased morbidity associated with prolonged time to spinal clearance or diagnosis of injury. The risk of significant occult discoligamentous injury, while relatively small, has potential for enormous physical, economic and medicolegal ramifications. The most effective protocol for detecting these injuries is debated, but a clear role exists for plain films and CT. The upper spine requires more sensitive assessment, and the inclusion of 1mm CT cuts from C0-C3 is optimal. Dynamic flexion/extension X-rays have poor sensitivity for cervical instability, high rates of image inadequacy and are not cost effective. MRI is superior to CT in the detection of injuries to the cervical spine ligaments, disc interspace and spinal cord, but including routine MRI in cervical imaging protocols results in prolonged cervical immobilisation and increased morbidity. Multi-slice CT reconstructions appear to obviate the need for routine MRI in these patients, but there are no prospective studies comparing modern multi-slice CT and MRI for evaluation of occult cervical spine injuries in unconscious patients.

In June 2005, The Alfred cervical clearance protocol for unconscious head injury patients included immediate plain X-rays and helical CT, with MSCT and reconstructions for selected trauma patients having one of a defined list of extremely high risk mechanisms of injury. MRI was only used for further evaluation of patients with clinical signs or cervical injuries identified on other modalities. Dynamic flexion-extension fluoroscopy was no longer part of the protocol.

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REFERENCES

1. Holly LT, Kelly DF, Counelis GJ et al. Cervical spine trauma associated with moderate and severe head injury: Incidence, risk factors, and injury characteristics. J Neurosurg:Spine 2002;96:285-291.
2. Demetriades D, Charalambides BS, Chahwan S, et al. Non-skeletal cervical spine injuries: Epidemiology and diagnostic pitfalls. J Trauma 2000;48:724-727.
3. Davis JW, Phreaner DL, Hoyt DB, et al. The aetiology of missed cervical spine injuries. J Trauma 1993;34:342-346.
4. Ackland HM. Report on Cervical Spine Clearance. 2005. The Alfred Hospital, Melbourne.
5. Widder S, Doig C, Burrowes P, et al. Prospective evaluation of computed tomographic scanning for the spinal clearance of obtunded trauma patients: Preliminary results. J. Trauma 2004;56:6,1179-1184.
6. Ajani AE, Cooper DJ, Scheinkestrel CD, Laidlaw J, Tuxen DV. Optimal assessment of cervical spine trauma in critical ill patients: A prospective evaluation. Anaesth Intensive Care 1998;26: 487-491.

7. Holmes JF, Mirvis SE, Panacek EA, et al. Variability in computed tomography and magnetic resonance imaging in patients with cervical spine injuries. J Trauma 2002;53:524-530.
8. Marion D, Domeier R, Dunham CM, et al. Determination of cervical spine instability in trauma patients: Update of the 1997 EAST Cervical Spine Clearance Document. 2000. Available at: http:/www.east.org. Accessed April 6, 2005.
9. Freedman I, van Gelderen D, Cooper DJ, et al. Cervical spine assessment in the unconscious trauma patient. J Trauma (In press) 2005.
10. Bolinger B, Shartz M, Marion D. Bedside fluoroscopic flexion and extension cervical spine radiographs for clearance of the cervical spine in comatose trauma patients. J Trauma 2004;56:132-136.
11. Griffiths HJ, Wagner J, Anglen J et al. The use of forced flexion/extension views in the obtunded trauma patient. Skeletal Radiol 2002;31:587-591.
12. Padayachee L, Cooper DJ, Irons S, Ackland HM, et al. Cervical spine clearance in unconscious traumatic brain injured patients: Dynamic flexion-extension fluoroscopy vs CT with 3D reconstruction. 2005. (Submitted).
13. D'Alise MD, Benzel EC, Hart BL. Magnetic resonance imaging evaluation of the cervical spine in the comatose or obtunded trauma patient. J Neurosurg:Spine 1999;91:54-59.
14. Ghanta MK, Smith LM, Polin RS, et al. An analysis of Eastern Association for the Surgery of Trauma practice guidelines for cervical spine evaluation in a series of patients with multiple imaging techniques. Am Surg 2002;68:563-568.
15. Albrecht RM, Kingsley D, Schermer CR, et al. Evaluation of cervical spine in intensive care patients following blunt trauma. World J Surg 2001;25:1089-1096.
16. Horn EM, Lekovic GP, Feiz-Erfan I et al. Cervical magnetic resonance imaging abnormalities not predictive of cervical spine instability in traumatically injured patients. J Neurosurg:Spine 2004;1:39-42.
17. Marion D, Domeier R, Dunham CM, et al. Practice Management Guidelines for Identifying Cervical Spine Injuries Following Trauma. 1998.Available at: http:/www.east.org. Accessed April 6, 2005.
18. Crim JR , Tripp D. Multidetector CT of the spine. Semin Ultrasound CT MR 2004;25:55-66.