Clearing the spine in the unconscious trauma patient: an update 2C01

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Clearing the spine of the unconscious traumatised patient is a task that the intensive care clinician faces frequently. Technological advances in cross-sectional imaging are such that the cervical and thoraco-lumbar spine can now be cleared quickly and reliably in a single computerised tomography imaging session, which all trauma patients require, with no extra exposure to radiation. This results in less patient manipulation and should reduce the time to cessation of unnecessary spinal precautions which themselves can lead to patient harm. Such head-to-toe inclusive 'traumagrams' are the standard of care received by casualties presenting at western military medical facilities in Afghanistan.

Keywords: *trauma; cervical spine; thoracolumbar spine; clearing; radiological*

Introduction

Clearing the spine, and in particular the cervical spine, in the unconscious or obtunded patient remains a frequent clinical challenge, with cervical spinal injuries occurring in 2 to 4% of blunt trauma casualties[1] leading to between 600 and 700 injuries a year in the UK.[2] The clinician must balance the risks of a missed or delayed diagnosis (which increases the incidence of secondary neurological deficit by a factor of 10, occurring most frequently in obtunded patients)[3] with the significant increase in morbidity associated with spinal precautions maintained beyond 48 hours. Recommendations for what constitutes appropriate imaging change with advancing technology and have evolved from adequate three-view plain films (lateral, anteroposterior and open-mouth odontoid views) possibly combined with dynamic films, to computed tomography (CT) scanning, magnetic resonance imaging (MRI) and, infrequently, dynamic fluoroscopy (DF).

This article explores the advances in this field subsequent to its last review some seven years ago,[4] which resulted in the publication of clinical guidelines supported by the Intensive Care Society.[5] That review highlighted the risks associated with prolonged spinal immobilisation and concluded that the combination of adequate plain films and directed CT-scanning of the cervical spine reviewed by an appropriate radiologist, has sufficient specificity and sensitivity to allow cessation of spinal precautions and allow normal nursing in unconscious patients. It also recommended examination of the thoraco-lumbar spine (TLS) via antero-posterior and lateral plain film radiography in unconscious patients considered at risk. The review suggested that the spine should be declared 'clear' by these methods within 48-72 hours of spinal precautions being instigated. Ethical considerations mean that these and future conclusions must largely be reached in the absence of randomised controlled trials and based instead on retrospective observational work.

Figure 1 Three-dimensional reconstruction of the TLS in a patient suffering from penetrating trauma.

Methods

A literature search of the Pubmed and Cochrane databases was undertaken looking for editorials, meta-analyses, randomised controlled trials and reviews in English-language journals involving human subjects published since 2004. The search included any combination of the titles *spinal injury, cervical spine injury, computed tomography, magnetic resonance imaging, dynamic fluoroscopy and complications of spinal precautions and immobilisation.*

Which imaging modality?

The clinician currently has the choice of plain radiography, either single or multidetector computed tomography (MDCT) scanning, MRI or a combination of these. Dynamic fluoroscopy is a further option, though not widely practised.

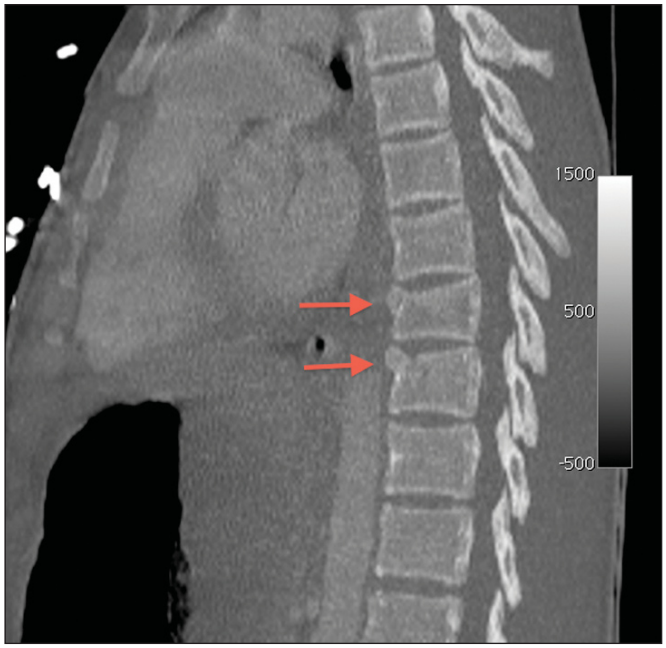


Figure 2 T8 and T9 fractures in patient suffering from an axial compression injury.

MDCT produces excellent images, especially when reconstructed in three dimensions (**Figure 1**) although two-dimensional views are used more routinely (**Figures 2** and **3**). MDCT scanning had a negative predictive value of 99% for ligamentous injury (LI) and 100% for unstable cervical spine injury in a large, well-constructed study in which no unstable injury was missed by MDCT alone.[6] This North American study directly compared plain film radiography with MDCT as the initial imaging method for investigating possible spine trauma (including the TLS) and found a sensitivity of 70% in the plain film group *vs* 100% in the CT group. The MDCT cohort also spent significantly less time undergoing radiological examination but were exposed to six times more radiation. This centre has adopted MDCT as its first-line investigation but recognises that the long-term consequences of the increased radiation exposure are currently unknown. At the time of writing, a cervical spine MDCT costs £104.89 compared to £21.02 for a single cervical spine plain film radiograph.[7] Respective radiation doses for the two imaging modalities are 2.0 millisieverts (mSv) compared to 0.1 mSv for a single radiograph.[8]

The concern remains that while MDCT is clearly superior to MRI for detecting bony injury,[9] isolated LI may be missed. Isolated LI is however rare[10] (0.6% in one large review in which all injuries were identified without MR imaging or DF)[11] and unstable injuries due solely to LI are very rare. The R Adams Cowley Shock Trauma Center (USA) formerly undertook MRI investigation in patients obtunded for greater than 72 hours in addition to MDCT scanning. Retrospective analysis of 366 patients undergoing both imaging modalities revealed a negative predictive value of 98.9% for LI and 100% for an unstable injury with MDCT scanning alone.[12]

Dynamic fluoroscopy uses an image intensifier, allowing real-time images of the cervical spine to be viewed as it is passively stressed in extension and flexion. Its value has recently been examined in a prospective study involving 276 patients undergoing DF routinely in addition to MDCT scanning.[13] In this study DF identified no new injuries, was inadequate in 3% and falsely positive in 2% of patients. The relative paucity of further work involving DF reflects its labour intensive nature and that it is potentially dangerous in obtunded patients who cannot appreciate or communicate pain. The availability of MDCT scanning means its use should be restricted to fully conscious patients with normal CT imaging and under expert supervision.

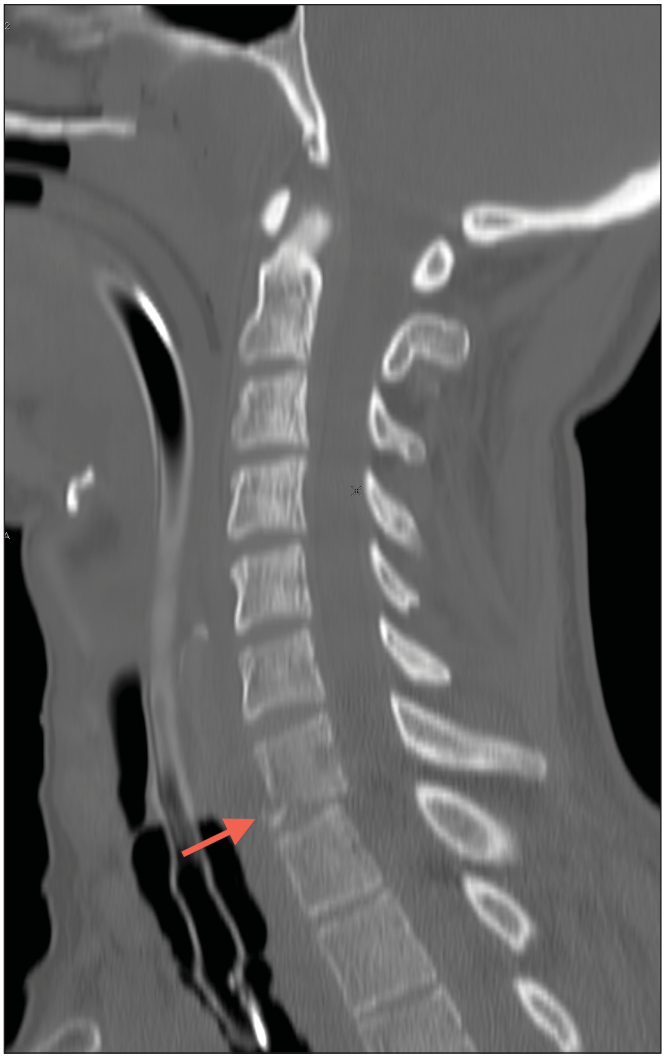


Figure 3 C7 teardrop avulsion fracture.

So what role remains for magnetic resonance imaging?

The risks and disadvantages of MRI in unstable ventilated patients are considerable, and include prolonged scanning times, limited availability, the possible requirement for radiological screening for foreign bodies (and subsequent determination of their composition), incompatibility with monitoring and infusion devices and relative isolation within the hospital. However, MRI has greater specificity and sensitivity than CT for detecting spinal cord injury, extra-axial lesions, and ligamentous injury, and can be used to assess the chronicity of a fracture by evaluating the degree of marrow

- Fall from height greater than 10 feet
- Struck pedestrians
- Road traffic accident (RTA) with or without ejection
- Motorised recreational activities
- Bicycle collision

Table 1 Dangerous mechanisms of injury according to EAST.

oedema.[14] It is the only imaging modality that can differentiate between cord haemorrhage and oedema, which is prognostically important.[15] Suggested indications therefore are to futher delineate injury revealed by MDCT scanning, especially in the context of unexplained abnormal neurology and to investigate suspected spinal cord injury, suspected disc herniation, and suspected extra-axial haematoma not fully elucidated by MDCT. Pre-operative assessment and planning is a further important indication.

Two groups of patients are at particular risk for spinal cord injury without obvious radiological abnormality (SCIWORA); those aged less than eight years old and older patients with pre-existing degenerative disease. However, in the NEXUS study, SCIWORA was uncommon and only seen in older adults.[16]

What are the risks of prolonged spinal immobilisation?

Spinal immobilisation may be associated with significant morbidity, the most common of which is collar-related decubitus ulceration. This can occur at the occiput, chin, mandible, ears, shoulders, laryngeal prominence and sternum and may ultimately require skin grafting.[17] Rigid collars complicate initial airway management and may contribute to airway obstruction.[18] A retrospective study of 299 trauma patients found that time to cervical spine clearance was the most important risk factor for the development of collar-related ulceration and that the risk increased by 66% for every one day increase in duration.[19] Of note however, the collars used in this trial were of the Philadelphia® type and not the Aspen® type, the introduction of which significantly reduced the incidence of ulceration.[20] Small studies in healthy volunteers currently suggest that the Miami J® collar is the most effective, while having the least potential for causing ulceration.[21,22] In addition, as discussed in the former review, rigid cervical collars predispose to the development of deep vein thromboses (DVT), raise intra-cranial pressure (particularly in the context of head injury), prevent central venous access via the jugular route, inhibit good mouth care and limit administration of physiotherapy. Supine positioning predisposes to aspiration of gastric contents and thus ventilator-associated pneumonia. This is associated with significant mortality in older patients.[23] Physical restriction by immobilisation complicates emergence from sedation and poorly fitting collars may even exacerbate spinal injury. These risks must be considered in the light of the fact that the best evidence to date suggests that the number needed to treat (NNT) with spinal immobilastion in order to prevent one secondary neurological injury lies between 625 and 3,333 trauma patients.[24]

- Spinous process fracture
- Wedge compression fracture with < 25% loss of body height no teardrop fracture)
- Isolated avulsion without ligamentous injury
- End-plate fracture
- Osteophyte fracture
- Transverse process fracture
- Injury to trabecular bone

Table 2 Examples of stable injuries.[37]

Thoraco-lumbar spine

Thoraco-lumbar spine fractures occur in approximately 4% of trauma victims,[25] 40% of whom may be asymptomatic.[26] A review of 183 patients with fractures found 110 patients had no neurological deficit and 34 (31%) had no pain or tenderness on examination.[27] Radiological examination in blunt trauma victims has attracted less interest and research than that of the cervical spine, and plain film radiography is the current accepted gold standard.[28] However, such films are difficult to obtain and interpret (especially in obese patients) and have a sensitivity and specificity of 60-70%.[29] MDCT scanning has a sensitivity and specificity of 98% and 97% respectively[30] and should now be considered the gold standard imaging modality.[31] Isolated LI involving the TLS is extremely rare and with greater relative bony contribution to overall stability compared to the cervical spine, such an injury is very unlikely to be unstable.[32]

In the trauma patient undergoing chest, abdomen and pelvic scans, the TLS can be imaged with no further radiation exposure and reduced delay. The emergence of the 'traumagram' in the UK has, in one of the author's institutions, been developed from experiences in military trauma. The traumagram consists of a non-contrast CT head scan followed by a dual phase arterial and portal venous phase scan from the Circle of Willis to the pelvis or feet. The traumagram therefore covers the entire spine, including the soft tissues, which can be evaluated in different planes. This represents the current standard of care delivered by western military medical services in Afghanistan. Although the increased radiation exposure (approximately doubled) resulting from a traumagram may not be justified in all UK civilian trauma patients, it should be strongly considered in anyone suffering an injury with sufficient energy transfer such that soft tissue injury is possible. In civilian practice it is worth considering that the older patient is less able to tolerate delayed management of occult haemorrhage while also being potentially less susceptible to the stochastic risks of radiation exposure (genetic damage and cancer etc).

What does the mechanism of injury tell us?

Head injury (excluding blunt assault) is the most important risk factor for cervical spine injury, the incidence but not severity of which is inversely related to the presenting Glasgow coma score.[32] **Table 1** lists the mechanisms of injury considered to be high risk according to the Eastern

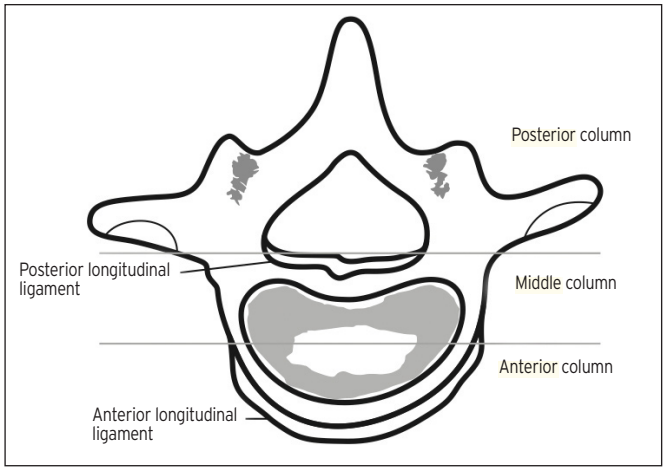


Figure 4 Schematic of a lumbar vertebra representing the Denis three-column classification.

Association for the Surgery of Trauma.[33]

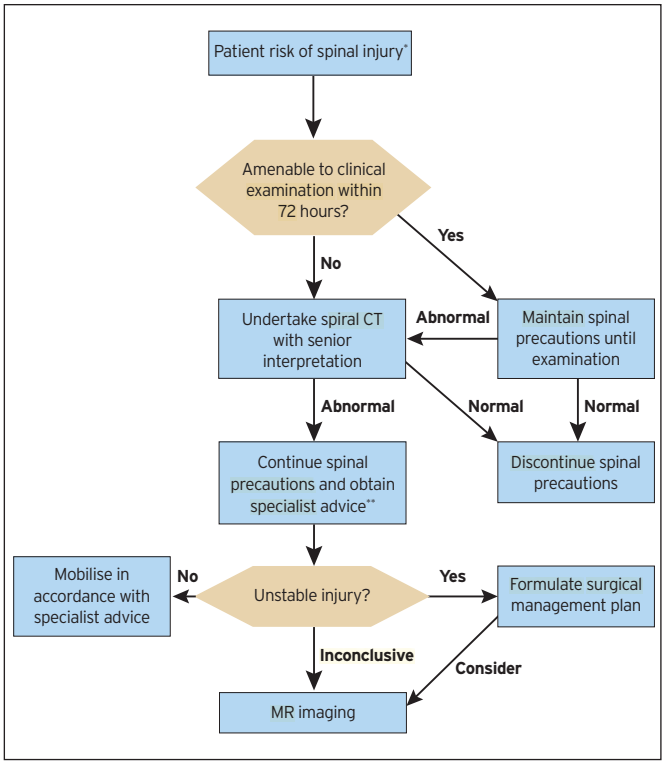
The well-described phenomenon of multi-level noncontiguous spinal fractures dictates that once a fracture is identified, the remainder of the spine should be screened. Penetrating injuries to the cervical spine resulting from gunshot or stab wounds tend to be rapidly fatal but survivors not demonstrating neurological impairment from the outset have stable spines and the application of a collar may impede the management of such injuries or conceal their seriousness.[34] While the mechanism of injury may have a positive predictive value, its negative predictive value is poor and injury cannot be excluded based on knowing the cause of injury. Patients with ankylosing spondylitis are particularly vulnerable to suffering significant injury resulting from seemingly minor trauma and must be considered as a high risk group in which the imaging modality of choice remains MDCT scanning.[35]

When is an injury unstable?

Stability is not a binary condition and instability exists as a spectrum ranging from bony injury severe enough such that the spinal cord is vulnerable, to lesser degrees of injury which jeopardise the long-term structural integrity of the spine. In specific patient sub-groups SCIWORA must be borne in mind. Assessment of stability remains a specialist skill though systematic approaches exist which are useful to the non-specialist clinician. An example is the Denis[36] three column classification which applies to the lower cervical (C3-C7) and TLS and describes three bony and ligamentous complexes responsible for structural integrity, with the middle column being the most important (**Figure 4**). To create an unstable injury, two adjacent columns must be compromised. **Table 2** provides some examples of injuries not involving the middle column that are regarded as being stable.

Conclusion

Patients at risk for spinal injury but with a level of consciousness that precludes clinical evaluation should undergo MDCT examination as soon as is safely possible. Identification of an injury should trigger similar examination of the remainder of the spine if not already done. Where MDCT scanning is available, there is no longer a role for plain film examination of the spine in the obtunded patient and the initial 'trauma series' should be reduced to a chest and a pelvic X-ray. The goal of removing unecessary collars within 48-72 hours remains valid and in all patients, stiff-neck extraction collars should be replaced by an Aspen type collar as soon as practicable. MRI has a role when MDCT scanning is inconclusive or when unexplained neurology exists. A MDCT scan can only be acted upon once reported by an appropriately senior radiologist. **Figure 5** outlines a management protocol for obtunded adult patients at risk of spinal injury.



*Risk factors	Clinically significant head injury
	Fall from height greater than 10 feet
	Struck pedestrian
	RTA with or without ejection
	Motorised recreational activities
	Bicycle collision
	Patients with ankylosing spondylitis
	Spinal injury identified (non-contiguous injury)
**Continued precautions	Remove from spinal extraction board as soon as possible.
	Replace extraction stiff collar with Aspen type collar.

Figure 5 Protocol for the management of unconscious adult patients at risk of spinal injury.

Conflicts of interest

None.

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