Radiological investigations in spinal injuries

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Abstract

Diagnosis and management of spinal injuries require a multidisciplinary approach. Imaging plays a fundamental role in demonstration of injury patterns and influences therapeutic planning. This review article discusses the common imaging modalities used in evaluation of spinal trauma. The strength and weakness of different imaging techniques is described in light of current knowledge and evidence. An imaging strategy based on review of the literature is suggested.

Keywords CT; imaging; MRI; radiology; spine; trauma

Introduction

The spine is a complex articulated system stabilized by ligaments and muscles. It forms a conduit to protect the neural axis, as well as balancing and supporting the head and trunk in posture and motion. Trauma to the spine and the neural axis is potentially devastating for the patient and is a challenge to the clinicians involved in patient care, requiring a multidisciplinary approach of several clinical specialities. Imaging plays a key role along with clinical examination in establishing diagnosis, delineating location and pattern of injury, assessing stability and effect of trauma on neurological structures, determining prognosis, as well as a baseline for further follow-up of spinal injury patients (Figure 1). With increasing availability of new imaging modalities and advancing technology, the recommended imaging in spine trauma is constantly changing. Imaging modalities are to be used in a cost-effective manner while keeping the radiation dose as low as reasonably possible.

The imaging approach and modality is dictated by the clinical scenario. Poly-trauma is usually imaged by whole body multi-detector CT[1]; while conscious patients with minor neck trauma would be assessed using the Canadian C-spine rule in order to establish the need for imaging.[2] Plain X-rays still remain the initial investigation in many instances of spinal injury. Increasing availability of and access to multi-detector CT permits fast and accurate assessment of osseous injuries and evaluation of their effect on mechanical stability. MRI is however the modality of choice in assessing injuries to the soft tissue components of the axial skeleton and their impact on producing a neurological injury.

Modality

Plain radiographs

Before the advent of cross-sectional imaging, plain radiography was the traditional way to assess the spine. This is readily available in most hospitals and is a low-cost imaging method to evaluate spinal deformity while it permits erect weight bearing projections. Plain films may be helpful in fracture screening but these are neither particularly sensitive nor specific.

In the trauma setting, it is often difficult to demonstrate the entire cervical spinal anatomy adequately with plain films.[3] The cervico-cranial junction, cervico-thoracic junction and the upper thoracic spine are difficult to image on plain films and difficult to interpret. Approximately, 10–20% of significant cervical spinal injuries are missed with radiographs.[4] Suboptimal radiographs, errors in interpretation, as well as difficult detection of hairline and non-displaced fractures account for the low sensitivity of this technique.

Two large studies in North America have provided level 2 evidence for low-risk criteria for clinical exclusion of cervical spinal injury in alert stable patients. The NEXUS and CCR suggest certain clinical criteria which seem to have a significant prediction in the exclusion of cervical spinal fracture; their use would result in reduced rates of radiography.

The National Emergency X-Radiography Utilization Study (NEXUS) comprising of five simple criteria was first described in 1992[5] and validated in a study involving 34 609 patients after blunt trauma in order for patients to be classified as having a low probability of injury.[6] The negative predictive value of this rule was 99.8% but the specificity is only 12%.[7]

The Canadian C-Spine Rule (CCR) was developed for use in the triage of cervical spinal trauma in alert (Glasgow Coma Scale score = 15) and stable cervical spinal injuries in a study involving 8924 patients.[2] The study showed a specificity of 42.5% and only 58.2% of alert stable patients were required to have C-Spine radiography.

The CCR rule was only validated for adult patients, while NEXUS included paediatric patients. The CCR rule also specifically excluded patients older than 65 years of age, and this age group is at a higher risk of cervical spine fractures in comparison to the young adult population. In the above 65 years age group, focal neurologic deficit, severe head injury, high energy and moderate energy mechanisms are clinical predictors for significantly increased risk of fracture.[8] However, 11% of elderly patients with cervical spinal fractures sustained injuries in the standing or sitting position and these fractures would have been potentially missed if the imaging was restricted to only high risk elderly patients.

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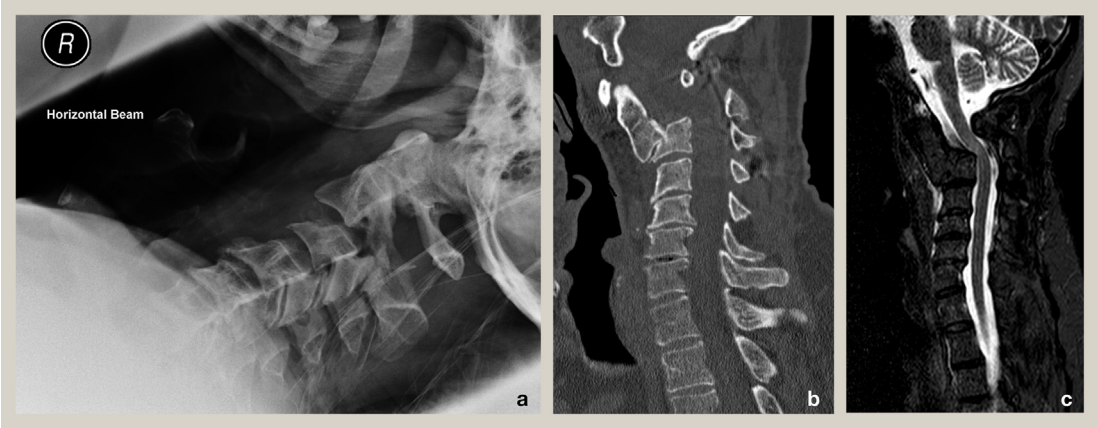

Figure 1 Hangman's fracture. (**a**) horizontal beam lateral radiograph shows the traumatic spondylolisthesis of the axis; (**b**) and (**c**) show late CT and MR appearances following conservative management with malunion. The cord is draped over the deformity with mild increased signal.

It is stated that CCR is superior to the NEXUS low-risk criteria (NLC) with respect to sensitivity and specificity for cervical spinal injury.[9] The accuracy of this conclusion is however controversial and in daily practice there is no clear advantage of one over the other. Both sets of criteria have been shown to be powerful predictors of cervical spinal injury and their consistent application should substantially reduce the rate of unnecessary imaging.

Trauma radiographic series of the cervical spine should consist of an antero-posterior, cross-table lateral and open-mouth odontoid peg views. There is no significant benefit in performing larger radiographic series[10] but it can increase the diagnostic confidence.

Flexion-extension radiographs have no role in clearance of the cervical spine in the alert patient during the acute phase due to pain and muscle spasm.[11] If there are persistent complaints at two weeks following an injury when the initial plain films were normal, delayed imaging with flexion-extension radiographs may be useful.[12] Use of flexion-extension radiographs in obtunded patients is controversial.

Clinically, stability is defined as the limitation of displacement of the spine under applied physiologic loads, which prevents spinal cord and nerve root damage.[13] Stability in the cervical spine, however cannot be assessed on static imaging, and can only be inferred from the alignment on the lateral radiographs (five parallel lines – anterior longitudinal line, posterior longitudinal line, articular pillars, spino-laminar line and spinous process line) and on the frontal radiograph (atlanto-dental distance, spinous process alignment and the lateral contour lines). A vertebral olisthesis is considered non-physiological if >2 mm of displacement occurs in the lateral flexion-extension radiographs. Evidence for cervical spinal instability on the static lateral radiograph are widened interspinous spaces >2 mm, widened facet joints >2 mm, anterior olisthesis >3.5 mm (indicating ligamentous disruption), narrowed/widened disc space, focal angulation of vertebral bodies >11°, and vertebral compression >25%.[13]

Fluoroscopic flexion-extension views of the cervical spine in the acute phase in obtunded patients may exclude significant local instability[14] but this is performed by expert clinicians in a dedicated setup. The American College of Radiology (ACR) Appropriateness Criteria (2013) for suspected C-Spine trauma however states that dynamic fluoroscopy should not be used to evaluate for ligamentous injury in obtunded patients.

With regards to the thoracic or lumbar spine, there are no defined clinical criteria for diagnosis or exclusion of spinal injuries. Spinal injuries can initially be asymptomatic in patients with history of high energy trauma.[15] Careful clinical examination and tailored imaging are necessary in evaluating thoracolumbar injuries and spinal stability.

Multi-detector CT (MDCT)

Advancements in CT imaging technology permit fast volumetric acquisition with thin sub-millimetre collimation; high quality isotropic and multi-planar two- and three-dimensional reconstructions allow improved interpretation. The new generation CT scanners can image the entire body in under a minute. Multidetector CT plays a critical role in the rapid assessment of the poly-traumatized patient[16] and spinal protocols can be easily included in the total body screening. If intra-vascular contrast is used concurrently with the CT examination, vertebral artery injuries in cervical spinal injuries can also be delineated (Figure 2). The presence of a normal CT is reliable in excluding clinically significant unstable ligamentous injuries.[17]

MDCT allows rapid and accurate radiological clearance of the cervical spine when compared to plain radiography. In acute spinal trauma, MDCT is more time efficient than radiography and well suited for use in the emergency setting.[18] In a meta-analysis, CT outperforms radiography in cervical spinal injury detection, with a pooled sensitivity of 98% for CT and 52% for radiography in patients at high risk for injury.[19] There is, however, insufficient evidence that CT should replace radiography in patients at low-risk for cervical injury. It has been suggested that cervical collars in obtunded and intubated trauma patients can be removed if a CT scan excludes any injury.[20] 50% of patients with delayed diagnosis of cervical spinal injuries had neurological deterioration,[21] most of which used conventional radiography as the initial screening modality. Although more expensive than radiography, once all institutional costs are taken into account, MDCT is more cost-effective.[22]