Interpretation of cervical spine radiographs

Introduction

Patients who present to emergency departments following neck trauma are frequently investigated with plain radiographs. The great majority of radiographs will be normal, but interpreting these films can be a daunting task for a junior doctor as the findings may be subtle and the consequences of missing an injury may be catastrophic. The process can be made simpler by understanding which patients require X-rays, developing a systematic approach to reading the films and being able to decide whether further investigation is required. A basic comprehension of the types of cervical spine trauma is useful as well as understanding the principles of stable and unstable injuries.

Anatomy

There are seven cervical vertebrae which support the skull and articulate with the thoracic spine. The normal cervical vertebral alignment is lordotic – which may straighten as a result of muscle spasm following a spinal injury. The inferior articular process of each vertebra forms a facet joint with the superior articular process of the vertebra below. The vertebral bodies are the load-bearing structures of the spine and are cushioned by the intervertebral discs. The pedicles and laminae form the protective neural canal surrounding the spinal cord. The cervical nerve roots, of which there are eight, pass through the intervertebral foraminae where they may be vulnerable to compression by an acute disc prolapse. The vertebral arteries pass cranially within the foramina transversaria to contribute to the posterior circulation of the brain.

The C1 (atlas) and C2 (axis) vertebrae are adapted to support the cranium as well as allowing stable rotational movement of the head. The vertebral body of C1 is fused with that of C2 below to form the odontoid peg. The peg articulates with the anterior arch of C1 at the median atlanto-axial joint and posterior movement towards the medulla is prevented by the strong transverse ligament. Sometimes the peg remains unfused with the body of C2 and forms a separate os odontoideum. The weight of the skull is borne by the lateral masses of C1 which form the atlanto-occipital joints with the occipital condyles above and the lateral atlantoaxial joints with C2 below.

The cervical spine is further stabilized by the anterior and posterior longitudinal ligaments, the interspinous ligaments and the ligamentum flavum.

Who needs imaging?

Cervical spine trauma is common but less than 2% attending an emergency department will have a clinically significant injury (Stiell et al, 2001) and most will only require conservative management. Avoiding indiscriminate radiographs will help to reduce the population exposure to medical ionizing radiation and may reduce costs.

A number of guidelines have been suggested to rationalize the use of cervical radiographs and have been validated in clinical trials. If certain criteria are fulfilled (*Table 1*) then clinical assessment of the cervical spine may be performed without resorting to radiographs (British Trauma Society, 2003). If there is no bruising, tenderness or deformity and there is a full range of pain-free neck movement then no further investigations are required.

In patients who do not satisfy these criteria lateral, anteroposterior (AP) and open-mouth radiographs are performed. However, between 10 and 20% of significant cervical spine injuries will be missed on plain radiographs (Tins and Cassar-Pullicino, 2004). The majority of these will be the result of poor radiographic technique or misinterpretation. If there is persisting clinical suspicion of a fracture, an abnormality is seen on plain radiographs or the patient is unconscious then computed tomgraphy (CT) may be performed. With multidetector CT increasingly available the whole cervical spine may be rapidly imaged at high resolution and multiplanar reformats produced. However, CT is not routinely used as a first-line investigation to 'clear' the cervical spine and should be interpreted in conjunction with the plain radiographs and clinical findings.

Magnetic resonance imaging (MRI) has a role in cases when spinal cord injury, ligamentous damage or intervertebral disc prolapse is suspected. Its wide coverage may also demonstrate non-contiguous injuries.

Radiographs and how to read them

Plain radiographs are the usual first-line investigation for suspected cervical spine injuries. Most significant injuries will be apparent on the lateral view of the spine which forms part of the trauma series with chest and pelvic radiographs. It is important to assess the adequacy of the film which may have been taken in a sub-optimal situation with the patient immobilized on a spinal board and wearing a hard collar.

Table 1. Clinical assessment of the cervical spine may be performed in patients who satisfy these criteria

Fully alert and orientated
No head injury
No sedative drugs or alcohol
No neck pain, swelling or tenderness
No neurological deficit
No significant distracting injury

From British Trauma Society (2003)

Dr Declan O'Regan *is Radiology Research Fellow,* **Dr Chris Harvey** *is Consultant Radiologist and* **Dr Steve Allen** *is Radiology Specialist Registrar, Department of Imaging, Imaging Sciences Department, Hammersmith Hospital, Imperial College Faculty of Medicine, London W12 0NN*

Correspondence to: Dr D O'Regan

First, count the number of cervical vertebrae shown. The film is inadequate if the whole cervical spine from the occiput to the C7/T1 junction is not shown, especially as this level is vulnerable to injury as a result of the relative mobility of the neck compared to the thoracic spine. In some circumstances it may be possible to cautiously apply shoulder traction to reveal the lower cervical vertebrae. Alternatively, a 'swimmers' view may be performed with one arm pulled down and the other arm elevated beside the head.

Trauma obliques are performed less commonly but are used to demonstrate the posterior cervical elements and the alignment of C7/T1. Flexion and extension views of the cervical spine may be hazardous in the acute setting and are performed only under expert supervision.

The craniocervical junction should also be clearly seen on an adequate lateral radiograph. The width of the median atlanto-axial joint (pre-dental space) should not exceed 3 mm in adults. The outline of each cervical vertebra should be scrutinized carefully to look for fractures, and the equal spacing of the intervertebral discs reviewed.

Three lines may be drawn on the lateral radiograph to ensure normal alignment (*Figure 1*). The anterior spinal line extends from the anterior margin of C1 along the anterior borders of the vertebral bodies. The posterior spinal line passes behind the odontoid peg and along the posterior borders of the vertebral bodies. Lastly, the spinolaminar line forms a smooth curve where the laminae fuse at the base of the spinous process. The normal facet joints should also have a regular overlapping configuration.

Finally, indirect evidence of a fracture may be provided by the presence of paraspinal swelling or a haematoma. The soft tissues anterior to C1–C4 should measure no more than 4 mm, but below this up to the full width of a vertebral body is acceptable.

The AP projection is particularly helpful for identifying rotation of a vertebra such as in unifacetal dislocation (*Figure 2*). Again a line should be drawn down the spinous processes between each vertebra to establish this. Occasionally unilateral or bilateral cervical ribs may be seen arising from C7. The craniocervical junction is obscured by the mandible and skull base on the AP view. An open mouth 'peg view' is performed to demonstrate the odontoid peg and its relationship to the adjacent lateral masses (*Figure 3*). The lateral borders of the lateral masses should align with the vertebra below. The palette may cast a line across the peg (Mach effect) but this is distinguished from a fracture as it extends beyond the anatomical borders of the bones.

Figure 1. A normal lateral cervical radiograph. Superimposed red lines (labelled the anterior spinal line, the posterior spinal line and the spinolaminar line) ensuring normal alignment.

Figure 2. A normal anteroposterior cervical radiograph showing the alignment of the spinous processes.

Figure 3. A normal 'peg' view taken through the open mouth. The teeth and palette are frequently projected over the peg.

Unstable injuries

While there is no universally accepted classification of what amounts to stable or unstable injuries it is reasonable to consider some injuries as having a higher risk of causing neurological damage.

A three column model of the spine has been widely used for thoracolumbar injuries and is applicable to the cervical spine. The anterior column is composed of the anterior two thirds of the vertebral body and intervertebral disc, and the anterior longitudinal ligament. The middle column is composed of the posterior third of the vertebral body and intervertebral disc, and the posterior longitudinal ligament. The posterior column is comprised of the posterior elements formed by the pedicles, facet joints, transverse processes, laminae and the spinous process. Disruption of at least two columns is associated with instability.

The following list of cervical spine injuries is not exhaustive but includes examples of important unstable fractures seen in clinical practice. Spinous process fractures (*Figure 4*), compression fractures (≤25%), osteophyte fractures and fractures of the transverse process are considered stable (Van Goethem et al, 2005).

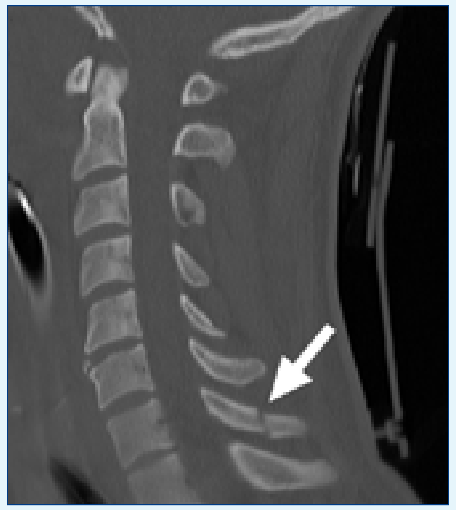

Figure 4. Sagittal reformat of a computed tomogram showing a fracture of the spinous process of C7 (Clay shoveller's fracture).

Odontoid fracture

Fractures of the peg may occur at the tip of the dens, at its base or may extend into the vertebral body (*Figure 5*). The prevalence of spinal cord injury is high. There is also a risk of avascular necrosis of the dens with non-union of the fracture. The well-corticated os odontoideum may be mistaken for a fracture, and clinical correlation is important in this situation (*Figure 6*). Widening of the pre-dental space (atlanto-axial subluxation) is seen when there is rupture of the transverse ligament which may lead to cord compression.

Atlanto-occipital dissociation

A rare but severe injury which results in complete rupture of the craniocervical junction and is associated with life-threatening spinal cord damage.

Figure 5. Sagittal reformat of a computed tomogram showing a fracture through the base of the dens.

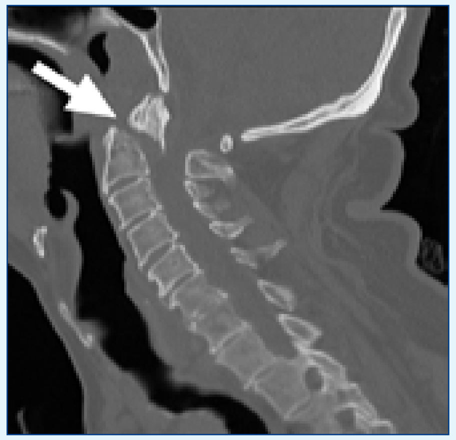

Figure 6. A lateral radiograph showing an os odontoideum.

Atlas fractures

C1 forms a ring and the stability of a fracture will depend on the point at which the fractures lie (*Figure 7*). A fracture may cause lateral displacement of the lateral mass on the open-mouth peg view. An axial load may lead to the unstable Jefferson fracture where the bony ring is disrupted in four places.

Hangman fracture

This is a hyperextension injury causing bilateral fractures through the pedicles of C2. It is usually evident on the lateral radiograph and may be associated with facet joint dislocation (*Figure 8*).

Figure 7. An axial computed tomogram demonstrating fractures of the C1 vertebra (atlas).

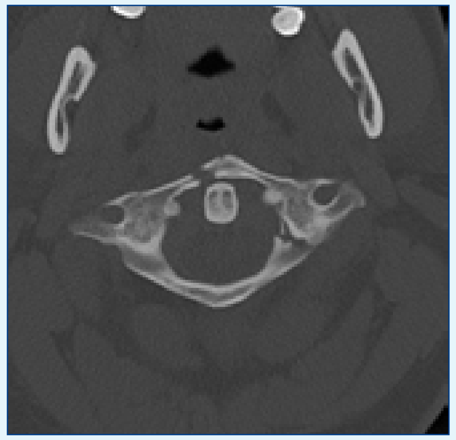

Figure 8. A lateral radiograph demonstrating a hangman's fracture of C2.

Flexion teardrop

This is a severe and highly unstable injury which results from hyperflexion of the spine with an axial load. A triangular fragment of the antero-inferior vertebral body, the flexion teardrop, remains attached to the anterior longitudinal ligament with posterior displacement of the middle and posterior columns. This is invariably associated with spinal cord injury.

Burst fracture

A fall from a height may result in a compressive fracture of a vertebral body causing disruption of the anterior and middle columns. A CT scan is usually performed to assess the extent of neural canal narrowing by retropulsed bone. If there is ≥25% loss of vertebral body height, retropulsion or neurological deficit the injury is unstable.

Bilateral facet joint dislocation

In this injury the facet joints dislocate antero-superiorly causing displacement of more than half the width of a vertebral body on the lateral radiograph (*Figure 9*). There is extensive disruption of ligamentous stability and a high incidence of spinal cord injury. A flexion-rotation injury is responsible for the stable injury of unilateral facet joint dislocation. This causes less anterior displacement on the lateral view, and the spinous process is rotated with respect the adjacent levels on the AP view (*Figure 10*).

Figure 9. a. Lateral radiograph showing a bilateral facet joint dislocation. b. Sagittal T2-weighted magnetic resonance image, in a different patient, showing compression of the cervical cord.

Conclusions

Spinal injury is common and may have serious neurological consequences. However, not all patients require imaging and a clear evidence-based protocol should make decision making easier. Conversely, not all spinal injuries are evident on plain radiographs and further imaging should be sought if there is a high clinical suspicion. Recognition of fractures requires an active structured approach to interpreting radiographs. BJHM

Conflict of interest: Dr D O'Regan is supported by a grant from Schering Healthcare Ltd.

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Figure 10. A lateral radiograph showing unilateral facet joint dislocation, with subluxation on the other side.

KEY POINTS

- Use a risk assessment protocol.
- Ensure lateral radiographs include C1/C2 and C7/T1.
- Spinal injury in unconscious patients may require computed tomography.
- Always use a lightbox or workstation to review radiographs.
- Have a systematic method of review.
- Extra vigilance in degenerate spines or osteoporosis.
- Spinal cord injury can occur despite normal radiographs.