HYPEREXTENSION-DISLOCATION OF THE CERVICAL SPINE

LIGAMENT INJURIES DEMONSTRATED BY MAGNETIC RESONANCE IMAGING

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We reviewed the magnetic resonance (MR) images of eight adults with acute hyperextension-dislocation of the cervical spine. The images were obtained to evaluate damage to the spinal cord.

All eight patients had disruption of the anterior longitudinal ligament and of the annulus of the intervertebral disc, and separation of the posterior longitudinal ligament from the subjacent vertebra. Some, but not all, showed widening of the disc space, posterior bulging or herniation of the nucleus pulposus, and disruption of the ligamentum flavum.

The MR demonstration of these ligament injuries, taken with the clinical and radiographic findings, establishes the mechanism of hyperextension-dislocation, confirms the diagnosis, and is relevant to management.

Hyperextension-dislocation of the cervical spine (HD) is an enigmatic injury because of the absence of gross displacement on lateral radiographs and the failure of conventional imaging techniques to demonstrate ligament damage. The clinical diagnosis is based on the presence of blunt facial trauma and signs of an acute central cervical cord syndrome (Taylor and Blackwood 1948). In adults with HD, the lateral radiograph reveals diffuse swelling of prevertebral soft tissues and practically normal alignment of the vertebrae (Fig. 1a). In about two-thirds of patients there is an avulsion fracture of the anterior aspect of the inferior end plate of the involved vertebra (Fig. 1b). Typically, the transverse dimension of the fragment exceeds its vertical height (Harris and Edeiken-Monroe 1987).

The ligament injuries of HD have been previously described only in post-mortem specimens (Taylor and Blackwood 1948; Borovich, Peyser and Gruskiewicz 1978) and from experiments in cadavers (Marar 1974) and animals (Macnab 1964; Gosch, Gooding and Schneider 1972). Magnetic resonance imaging (MRI) can delineate soft-tissue structures and provides, for the first time, a clear demonstration of the injuries of HD. This improves understanding of the injury, helps in

establishing the diagnosis, and gives a basis for management.

PATIENTS AND METHODS

We performed MRI of the cervical spines of eight adult patients with HD and signs of cervical myelopathy. None had radiographic evidence of any other cervical spine injury. The primary aim of the MR examinations was to determine the nature and extent of spinal-cord injury, but we now report details of the associated soft-tissue injuries.

We performed the MR examinations on a GE 1.5-Tesla Signa System (General Electric Medical Systems, Milwaukee, Wisconsin) at from three to 24 hours after injury, using a standard 5.5 inch (13.75cm) circular surface coil. The imaging protocol included axial and sagittal T1-weighted images with a repetition time (TR) of 800 msec and an echo time (TE) of 20 msec; sagittal T2-weighted and proton-density images (TR 2000, TE 20/80) with ECG gating; and axial and sagittal T2 (gradient-echo) sequences (TR 750 to 1000, TE 9/25). A 16 cm field of view was used in all sequences.

All the cervical spine MR images were reviewed and analysed, then correlated with the anteroposterior and lateral radiographs of the cervical spine taken at the time of admission.

RESULTS

All eight patients showed disruption of the anterior longitudinal ligament and the anterior portion of the annulus (Figs 2, 3a and 4), and transverse disruption of

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Figure 1a - Lateral radiograph of the cervical spine showing diffuse prevertebral soft-tissue swelling (asterisk) and normally aligned, intact vertebrae. Figure 1b - In another patient there is a characteristic avulsion fracture fragment (arrow) in addition to the prevertebral swelling.

Fig. 1a

Fig. 1b

Fig. 2a

Fig. 2b

Figure 2a - A T1-weighted spin-echo image showing disruption of the anterior longitudinal ligament and annulus (curved arrow), with posterior protrusion of the nucleus pulposus contained within an intact posterior longitudinal ligament (arrow). There is separation of the posterior longitudinal ligament from C4 (open arrow), and a diffuse prevertebral haematoma (asterisk). Figure 2b - A T2-weighted image shows the mixed-intensity signal of haemorrhage and oedema in the retropharyngeal space (asterisk) and the hypo-intense signal of haemorrhage at the site of disruption of the anterior longitudinal ligament and annulus (curved arrow) and within the disc (arrowhead).

Fig. 3a

Fig. 3b

Figure 3a - A sagittal MRI shows oedema and haemorrhage in the retropharyngeal space (asterisk), disruption of the anterior longitudinal ligament and annulus (curved arrow), a widened disc space containing the hypo-intense signal of haemorrhage (arrowhead), disruption of the posterior annulus (arrow), separation of the posterior longitudinal ligament from the posterior cortex of C7 (open arrow) and disruption of the ligamentum flavum (small arrow). Figure 3b - The axial projection confirms the elevation of the posterior longitudinal ligament (curved arrow) and also shows the haemorrhage in the retropharyngeal space (asterisk).

the intervertebral disc (Figs 2b, 3a and 4). The level of injury was at C2 in two patients, C3 in two, C4 in two, C5 in one and C6 in one. In four cases there was posterior bulging of the annulus (Fig. 2a) or disruption with herniation of the nucleus pulposus (Fig. 3a). There was disruption of the ligamentum flavum in five of the eight patients (Figs 3a and 4). At the sites of ligament and disc

disruptions the MR signals were compatible with the presence of oedema and haemorrhage (Figs 2b and 3a). There was disc space widening in two patients (Figs 3a and 4).

In all eight cases the ligamentous injury was at the same level as the MR evidence of damage within the spinal cord.

In all cases diffuse prevertebral soft-tissue haemorrhage was observed on both sagittal (Figs 2 and 3a) and axial (Figs 3b and 5) MR images. The axial images established that the bleeding was into the retropharyngeal fascial space (Fig. 5).

DISCUSSION

High-speed photography of anaesthetised animals (Gosch et al 1972) has confirmed that HD occurs as the result of abrupt deceleration by an impacting force on the front of the head, driving the neck into hyperextension, as described and illustrated (Fig. 6) by Forsyth (1964). The momentarily dislocated cervical vertebra returns to a normal position once the causative force has been dissipated (Gosch et al 1972).

The ligament injuries of hyperextension-dislocation are of the anterior and middle columns, and the anterior portion of the posterior columns of the cervical spine (Denis 1984), confirming the hyperextension mechanism of injury and explaining the mechanical instability in extension. The injuries that we found in all eight cases are exactly those described by Taylor and Blackwood (1948) and Marar (1974). MRI confirms the pattern of injury in acutely injured patients, and removes any ambiguity concerning the aetiopathology of HD.

The integrity of the posterior annulus and the state of the nucleus pulposus varied in our eight patients. The posterior annulus could be either normal, intact but

Fig. 4

A T2-weighted mid-sagittal image shows compression of the spinal cord between the body of the dislocated vertebra and the lamina and ligamentum flavum of the subjacent vertebra. The hypo-intense signal within the cord (arrow) represents haemorrhage. The anterior longitudinal ligament and annulus are disrupted (curved arrow), the intervertebral disc space is widened, and the ligamentum flavum is disrupted (small arrow).

Fig. 5

An axial T2-weighted image shows the mixed-intensity signal of haemorrhage and oedema (arrows) in the retropharyngeal space anterior to the vertebral body and the longus colli and longus capiti muscles (asterisk).

Fig. 6

Diagram showing the mechanism of injury of hyperextension-dislocation (A) and the ligament damage (B) (Reproduced with permission from Forsyth HF. Extension injuries of the cervical spine. *J Bone Joint Surg [Am]* 1964; 46:1792.

bulging posteriorly, or disrupted with extrusion of the nucleus pulposus. Such a protrusion or extrusion has important implications in management.

Since hyperextension-dislocation was the only injury of the cervical spine in our patients, the coincident level of the ligament and the spinal-cord injuries confirms that it is the posterior displacement of the involved vertebra which compresses the spinal cord between its postero-inferior margin and the superior articular process and ligamentum flavum of the subjacent vertebra (Fig. 4). This anteroposterior compression causes the acute central cervical cord syndrome (Taylor and Blackwood 1948; Schneider, Cherry and Pantek 1954; Harris and Edeiken-Monroe 1987; Harris and Yeakley 1989).

The signs and symptoms of acute central cord syndrome may be transient and relatively minor. In such patients, the early resolution of the myelopathy coupled with resorption of the prevertebral soft-tissue swelling may give the false impression that the injury is of minor significance or has healed. The instability of the cervical spine in these patients, however, as the result of disruption of anterior ligamentous structures, may persist. Their demonstration by MRI has important implications for management.

It was observed by Macnab in 1964 that in experimentally produced hyperextension-dislocation there were injuries to the anterior cervical muscles ranging from minor tears of the sternocleidomastoid to partial avulsion of the longus colli. He found that all longus colli tears were associated with retropharyngeal haemorrhage. The MR images of our patients did not show actual muscle tears, but a mass with an MR signal characteristic of recent haemorrhage was demonstrated in the retropharyngeal fascial space of all eight patients.

This haematoma produces the diffuse prevertebral soft-tissue swelling characteristically seen on the lateral cervical radiograph.

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