TRANSVERSE LIGAMENT RUPTURE AND ATLANTO-AXIAL SUBLUXATION IN CHILDREN

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We report four children aged two to nine years with traumatic tears of the transverse ligament of the atlas and atlanto-axial subluxation. This is extremely rare in this age group since trauma usually causes a skeletal rather than a ligamentous injury. The injuries resulted from falls or motor vehicle accidents, with considerable delay in diagnosis.

Flexion radiographs showed atlas–dens intervals (ADI) of 6, 7, 8 and 13 mm; all four patients were treated by posterior fusion at C1–C2 after the failure of conservative treatment. In one child with quadriplegia and a fixed ADI of 13 mm, transoral anterior resection of the odontoid was performed before the fusion.

Diagnosis of this traumatic lesion requires a high level of suspicion. Conservative treatment is likely to fail; surgical stabilisation is indicated.

Trauma to the cervical spine in adults most commonly involves its lower part, but in children, although such lesions are rare, they are mostly found in the region of C1 and C2 (Fielding 1984). Ligament injuries at the atlanto-axial level in children are even more rare, since local trauma usually causes a fracture through the synchondrosis of the dens.

We report four children with traumatic ruptures of the transverse ligament and C1–C2 subluxation. Two of the four cases have been briefly reported elsewhere (Blatt et al 1981).

PATIENTS

The four children, aged two to nine years, were seen at Hadassah University Hospital over an 11-year period (Table I). One child had fallen from a height, two were hit by vehicles when walking and one was a car passenger in an accident. All four had head injuries, one with a depressed fracture of the skull; two had fractured ribs, and one had a supracondylar fracture of the humerus.

All the children had a painful torticollis, one had frank signs of quadriplegia and one had some long tract signs. The delay in the diagnosis of transverse ligament rupture ranged from six to 14 days, and when the diagnosis of ligamentous C1–C2 instability was made, three of the children had had a trial of conservative treatment, two in Minerva casts for six to eight weeks, and one in traction. Despite this treatment, the atlanto-axial subluxation persisted, and the patients were referred to our spine centre.

Lateral radiographs of all four showed an intact dens with increase in the atlas–dens interval (ADI) of 6, 7, 8 and 13 mm respectively (Figs 1, 2 and 3). Flexion–extension views showed that the ADI increased in flexion and decreased in extension in three of the four children. In the child with an ADI of 13 mm, the dens appeared to be fixed near the posterior part of the atlas and did not move forward with cervical extension (Figs 4 and 5), the space between the dens and the anterior atlas being filled with calcified dystrophic tissue (Fig. 5c). This tissue, presumably the remnants of the ruptured ligament, appeared to block movement.

TREATMENT

All four children had a posterior C1–C2 fusion, two with sublaminar wires, using autogenous iliac crest bone grafts. Three were performed after immobilisation in a halo cast which was retained for six to eight weeks after surgery. In one child a ‘rigid’ collar was used. The child...
Table I. Clinical details of four children treated by C1–C2 fusion for transverse ligament rupture

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Injury</th>
<th>Other injury</th>
<th>Delay in diagnosis</th>
<th>ADI* (mm)</th>
<th>Neurology</th>
<th>Conservative management</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>M</td>
<td>Fall</td>
<td>Concussion</td>
<td>12 days</td>
<td>7</td>
<td>Normal</td>
<td>Traction</td>
<td>Fusion</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>M</td>
<td>RTA†</td>
<td>Concussion</td>
<td>12 days</td>
<td>8</td>
<td>Hyper-reflexia</td>
<td>Halo-cast</td>
<td>Fusion</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>F</td>
<td>RTA Car passenger</td>
<td>Concussion Fracture of humerus and ribs</td>
<td>14 days</td>
<td>6</td>
<td>Normal</td>
<td>Minerva plaster</td>
<td>Gallie fusion</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>F</td>
<td>RTA Pedestrian</td>
<td>Depressed fracture of skull Fractured ribs</td>
<td>6 days</td>
<td>13</td>
<td>Quadriaparesis</td>
<td>Minerva halo-cast</td>
<td>Gallie‡ fusion</td>
</tr>
</tbody>
</table>

*ADI, atlas-dens interval
†RTA, road traffic accident
‡fusion preceded by transoral resection of the dens

Fig. 1 – Lateral radiograph of a two-year-old girl injured in a motor-vehicle accident, showing an atlas–dens interval of 6 mm in forward flexion. Figure 2 – CT scan confirming the increased atlas–dens interval. Figure 3 – After C1–C2 posterior fusion with sublaminar wires.

Case 4. Figure 4 – Lateral radiograph of a four-year-old girl knocked down by a car. There is extreme displacement of the dens, with an ADI of 13 mm. Figure 5a – Initially, a CT scan in a Minerva cast shows that the ADI is only moderately increased. Figure 5b – Another section at a later date shows flecks of bone avulsed from the atlas. Figure 5c – The space between atlas and dens contains calcified dystrophic tissue.
with fixed atlanto-axial dislocation had anterior transoral resection of the odontoid process before the posterior fusion (Fig. 6).

RESULTS
At follow-up, ranging from six months to 10 years, all the children had a satisfactory fusion with complete relief of pain and torticollis. Two had a normal ADI and one had a 4 mm interval. There was resolution of the abnormal neurological signs in both affected children.

DISCUSSION
Cervical spine injuries are rare under the age of seven years, and 75% of these are odontoid fractures (Sherk, Nicholson and Chung 1978). Traumatic rupture of the transverse ligament is extremely rare in children, since the synchondrosis of the dens is usually weaker than the ligaments. In their classic paper on this ligament injury, Fielding et al (1974) reported 11 patients, only one being under six years of age, while the others were young adults or teenagers. Pennecot et al (1984) reported three children with traumatic atlanto-axial instability, of which one was shown at post-mortem to have a transverse ligament rupture. Birney and Hanley (1989) surveyed 84 paediatric and adolescent cervical spine injuries finding only two cases of transverse ligament rupture. We have seen four paediatric cases in 11 years.

Ligament insufficiency or rupture secondary to inflammatory or rheumatoid disease may be seen (Werne 1957; Fielding 1984) and transverse ligament rupture due to trauma is found in adults (Levine and Edwards 1986).

The transverse ligament is a tight band between the tubercles on the medial side of the lateral masses of the atlas, passing behind the dens and holding it against the articular notches on the posterior surface of the anterior arch of the atlas. It provides primary stability and is supplemented by the alar, apical cruciate, accessory and capsular ligaments. In a biomechanical study, Fielding et al (1974) found two modes of failure of the transverse ligament: usually the body of the ligament ruptured, but occasionally a fleck of bone was avulsed from the lateral masses of the atlas (see Fig. 5b).

Mechanisms of injury to the ligament include forced forward flexion and axial loading of the atlas, opening the ring and causing secondary rupture of the transverse ligament, as in a Jefferson fracture with atlanto-axial subluxation. In cadaveric specimens, Spence, Decker and Sell (1970) showed that a 6 to 9 mm displacement of the lateral masses of the atlas will rupture the transverse ligament.

The diagnosis of transverse ligament rupture is radiological. An intact atlanto-axial ligamentous complex will maintain, in adults, an ADI of 3 mm or less during flexion or extension. Injury allows the atlas to be displaced anteriorly and increases the ADI.

In a review of 200 normal children, Locke, Gardner and Van Epps (1966) found that the widest ADI in flexion was 3.5 mm, while most were 3 mm or less. They consider that an ADI of 4 mm or more should be considered pathological in children. Cattell and Filtzer (1965) reported an ADI of 3 mm or more in 20% of children under the age of seven years, but consider that displacement by over 5 mm in flexion indicates ligament rupture, especially with a history of trauma. Filipe, Demay and Zakine (1989) believe that anterior displacement of over 10 to 12 mm signifies a tear of the entire ligamentous complex. In such a case, the displaced dens must endanger the spinal cord in the ‘safe zone’ (Steel 1968). Such excessive displacement also raises the possibility of obstruction of the vertebral arteries (Werne 1957).

Atlanto-axial ligament injuries may easily be missed, leading, in our own cases to several days delay in diagnosis and up to five years in those few cases published previously (Pennecot et al 1984). A high level of suspicion is important, since neurological compromise or deterioration may occur. The atlanto-axial subluxation may become fixed, as in one of our patients (Fig. 5).

Fielding et al, in 1974, stated that treatment for transverse ligament rupture should be surgical, but in 1984 Fielding suggested that conservative measures should be tried. We consider that conservative treatment is unlikely to succeed or to provide a stable atlanto-axial articulation. Conservative treatment failed to produce a stable reduction in our series: we consider that a posterior fusion, in the reduced position, preferably by the Gallie method, is the treatment of choice (Hensinger, Fielding and Hawkins 1978). Where there is fixation of the odontoid process in the ‘safe zone’ of Steel, a transoral
approach should be used to resect the displaced dens and decompress the spinal cord (Fang and Ong 1962; Pásztor 1985).

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REFERENCES


