THE CERVICAL SPINE AFTER HALO-PELVIC TRACTION

AN ANALYSIS OF THE COMPLICATIONS IN 83 PATIENTS

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This retrospective study assesses the complications affecting the cervical spine after halo-pelvic traction in 83 patients who were followed up for a minimum of five years. Forty-four patients (53 per cent) had significant cervical complications such as radiological degenerative changes, avascular necrosis of the dens, loss of movement, pain or spontaneous fusion. The most important predisposing factors were a long period in the halo-pelvic apparatus, tuberculous kyphosis, stiffness of the spinal deformity and an age of 15 years or more at the time of application.

Previous reports have made specific mention of complications in the cervical spine after halo-pelvic traction (Hodgson 1973; O'Brien, Yau and Hodgson 1973; Yau *et al.* 1974; O'Brien 1975; Tredwell and O'Brien 1975; Kalamchi *et al.* 1976; O'Brien 1977), and these have now become a major limiting factor in the use of the halo-pelvic apparatus in this hospital. The apparatus remains, however, an invaluable aid in the management of carefully selected cases. This review was carried out in an attempt to assess the relatively long-term complications and the factors most important in their production.

MATERIAL AND METHODS

Only patients whose halo-pelvic apparatus had been removed at least five years previously were reviewed. Of the total of 130 patients, five had died and 42 either could not be traced or had returned to their country of origin, leaving 83 patients for review. There were 40 boys and 43 girls and the average period spent in the halo-pelvic apparatus had been six months (range 1 to 16 months). The apparatus had been used both for distraction and for rigid immobilisation so that not all of the time in the apparatus had involved distraction. The average time since the removal of the apparatus was six and a half years (range 5 to 10 years) and the average age at follow-up was 23 years. Fifty-four patients had been treated for scoliosis and 29 for a tuberculous kyphosis.

Scoliotic group. In 28 patients the scoliosis had been paralytic in origin, in 14 idiopathic and in six congenital. In four it was due to neurofibromatosis, in one it was secondary to paraplegia and another was a primary lumbosacral hyperlordosis.

Using Cobb's method of measurement, the average angle of the deformities at diagnosis was found to have been 87.6 degrees (range 51 to 151 degrees). The stiffness of the scoliosis was indirectly measured from the angles on the initial erect and supine radiographs. The difference between the two was then expressed as a percentage of the angle on the erect radiograph, the result being the "supine correction". Thus, if the angle on the erect radiograph was 100 degrees and that on the supine radiograph 80 degrees, the patient was said to have a 20 per cent supine correction. The average supine correction was 19.6 per cent.

Thirty-six of the 54 patients with scoliosis had required more than one major surgical procedure to correct the deformity: 16 had required two, 15 had required three and five had required four major surgical procedures.

Kyphotic group. It is known from the work of Yau *et al.* (1974) on tuberculous kyphosis that this deformity is always stiff. The average angle of the kyphosis in these 29 patients had been 115 degrees (range 65 to 165 degrees) and despite the full programme of corrective surgery, as described by Yau *et al.*, the average correction had been only 27 per cent (range 7 to 76 per cent).

Clinical assessment. At follow-up the patients were assessed clinically and the symptoms in the neck were graded into four categories: *none*;

Fig. 1

Fig. 2

Figure 1—Mild degenerative changes. An oblique view of the cervical spine of a 21-year-old boy with a thoracolumbar tuberculous kyphosis of 130 degrees. He was in the halo-pelvic apparatus for 13 months, and nine years later has no symptoms in his neck. Figure 2—Severe degenerative changes. A lateral view of the cervical spine of a 14-year-old boy with a paralytic scoliosis of 110 degrees and a supine correction of only 12 per cent. He was in the halo-pelvic apparatus for four months, and six years later he has only mild symptoms.

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mild—occasional pain or stiffness only; *moderate*—frequent pain and stiffness but not sufficient to require time away from work; and *severe*—pain and stiffness requiring time away from work. Rotation of the cervical spine was considered separately from the other movements. The range of movement lost was expressed as a percentage of normal.

Radiological assessment. A full series of cervical radiographs was taken comprising anteroposterior, lateral, lateral flexion and extension, and right and left oblique views, and an open-mouth view of the dens. In assessing these radiographs the following definitions were employed. *Degenerative changes.* The follow-up radiographs were compared with those taken before or at the start of halo-pelvic traction, and subsequent degenerative changes were graded as: *none*; *mild*—definitely abnormal but minimal changes only (Fig. 1); *moderate*—marked changes but without gross distortion of the intervertebral foramina or gross osteophyte formation; and *severe*—gross anatomical distortion (Fig. 2).

Atlanto-axial instability. This was defined as an anteroposterior shift of more than four millimetres between the dens and the back of the anterior arch of the atlas in the lateral radiographs in flexion and extension.

Definition of significant complications. In order to determine the factors predisposing to complications, any one of the following was deemed to be a significant complication: a loss of 50 per cent or more in rotation or in the other cervical movements combined; moderate or severe symptoms; moderate or severe degenerative changes; avascular necrosis of the dens; spontaneous fusion; or atlanto-axial instability.

RESULTS

Symptoms. Fifty-six patients (67 per cent) had no symptoms; 15 had mild symptoms, nine had moderate symptoms and three had severe symptoms. Of the 12 patients with moderate or severe symptoms, 11 had moderate or severe radiological degenerative changes.

Range of movement. The average loss of rotation of the cervical spine was 24 per cent, but 11 patients had lost 50 per cent or more (maximum 85 per cent). The average loss of all the other movements considered together was 18 per cent, but six patients had lost 50 per cent or more

Fig. 3

A lateral view of the cervical spine of a girl who was aged 19 when the halo-pelvic apparatus was applied for a tuberculous kyphosis. She was in the apparatus for 15 months and developed avascular necrosis of the dens which had healed seven and a half years later.

(maximum 70 per cent). Of the 15 patients who had lost 50 per cent or more of either type of movement, 13 had moderate or severe degenerative changes.

Degenerative changes. Thirty-one patients (37 per cent) had no degenerative changes, 31 had mild changes, 12 had moderate changes and nine had severe changes. In addition, 23 patients (28 per cent) were noted to have a cervical kyphosis after halo-pelvic traction (maximum 25 degrees).

Avascular necrosis of the dens. Of 31 patients with avascular necrosis of the dens, 13 had symptoms but none showed atlanto-axial instability. The bony changes of avascular necrosis had healed gradually (Fig. 3).

Fig. 4

Fig. 5

Figure 4—A 19-year-old girl with a tuberculous kyphosis at the start of halo-pelvic traction. Figure 5—After 12 months in the apparatus she developed anterior and posterior fusion from C2 to C5.

Spontaneous fusion. In five patients spontaneous fusion of the cervical spine had occurred and this was confirmed by tomography where necessary; none of them had evidence of Still's disease, ankylosing spondylitis or infection which might have resulted in a similar appearance. Two other cases were excluded, however, because a congenital cervical fusion could not be discounted. In three of these patients the radiographs showed posterior fusion between C2 and C3, in one a posterior fusion from C2 to C4 and interbody fusion between C2 and C3, and in the fifth an anterior and posterior fusion from C2 to C5 (Figs 4 and 5). Four of these five patients had had a tuberculous kyphosis and the other had an idiopathic scoliosis with only six per cent supine correction.

Atlanto-axial instability. Only one patient showed radiographic instability. She had had an idiopathic scoliosis of 82 degrees with 15 per cent supine correction, had been 15 years old when the halo-pelvic apparatus had been applied and had worn it for 10 months. Six years later there was a six-millimetre shift of the dens between flexion and extension but she had only mild symptoms and no abnormal neurological signs. She did not have avascular necrosis of the dens.

Analysis of predisposing factors

Forty-four patients (53 per cent) had at least one of the six significant complications: 17 had one complication, 19 had two, seven had three and one had four. These complications were related to the following factors.

Fig. 6

The relationship between time in the halo-pelvic apparatus and the incidence of cervical complications.

Time in halo-pelvic apparatus. Figure 6 relates the incidence of cervical complications to the time in the apparatus. There were no complications when the apparatus had been applied for three months or less but if the period had been four to six months, 35 per cent were affected; if seven to nine months, 69 per cent; and if 10 months or more, 89 per cent.

Aetiology of spinal deformity. When the complications in the cervical spine were related to the aetiology of the

deformity it was found that the incidence was 79 per cent of those with a tuberculous kyphosis but that only 32 per cent of those with a paralytic scoliosis were so affected. Complications also occurred in six of the 14 patients with idiopathic scoliosis, in three of the six with congenital scoliosis, and in three of the four with neurofibromatosis.

Fig. 7

The relationship between stiffness of spinal deformity and cervical complications.

Stiffness of the spinal deformity. Figure 7 relates the stiffness of the scoliotic deformities to the incidence of cervical complications. If the supine correction was 26 per cent or more, there were no complications; if it was 16 to 25 per cent, 30 per cent were affected, but if it was 15 per cent or less, 58 per cent were affected. The average supine correction of those with cervical complications was only half that of those without complications. When the stiffness of the scoliosis was related to the aetiology, it was found that in the paralytic group the average supine correction of those with complications was 14 per cent and of those without complications was 26 per cent; in the idiopathic group the figures were respectively 8 per cent and 19 per cent, in the congenital group 11 per cent and 23 per cent, in those with neurofibromatosis 7 per cent and 17 per cent. The other two patients had no cervical complications.

Age of the patient. Figure 8 relates the incidence of complications to the age of the patient when the halo-pelvic apparatus was applied. If the patient was aged 14 years or less, 23 per cent were affected; but if aged 15 years or more, 70 per cent were affected.

DISCUSSION

The striking feature of this study is that 53 per cent of the patients had significant cervical complications although only 15 per cent had more than mild symptoms. Moderate or severe radiological degenerative changes were found in all but three of the patients with moderate or severe symptoms or more than 50 per cent loss of

movement of the neck. It is emphasised that these are young people whose average age at this review was only 23 years and that they may well develop symptoms in line with the alarming radiological changes.

When considering the range of cervical movement, rotation was recorded separately from the combined measurement of the other movements because O'Brien *et al.* (1973) showed that in halo-pelvic traction the maximal distraction occurs between the atlas and the axis and that this is also the level of maximal rotation of the cervical spine. This approach was justified in that the average loss of rotation was one third greater than the average loss of the other movements.

Fig. 8

The relationship between age and cervical complications.

Avascular necrosis of the dens was reported in detail by Tredwell and O'Brien (1975) who noted that three of their 13 patients showed atlanto-axial instability. There was no such instability after avascular necrosis of the dens in this study. Thus it seems that in time the initial instability resolves as the bony changes heal.

Spontaneous fusion of the cervical spine as a complication of halo-pelvic traction has been reported

in detail elsewhere (Dove, Hsu and Yau 1980). The precise cause of the fusion is not known but it has been shown from studies of the visco-elastic behaviour of the spine that the posterior ligaments stiffen abruptly when subjected to more than 60 per cent of their breaking strain (Clark, Hsu and Yau 1975). All five cases who developed spontaneous fusion were being treated for stiff spinal deformities and it is conjectured that the distraction force resulted in disturbance of the bony attachments of the cervical ligaments causing local haemorrhage and later bone formation.

This study shows that the time in the halo-pelvic apparatus, the aetiology and stiffness of the spinal deformity, and the age of the patient are all clearly related to the production of cervical complications. The distraction force used seems also to be important but this information was not available from a sufficient number of patients for statistical analysis. The predisposing factors are also probably interrelated in that the greater the time in the apparatus, the longer the cervical spine is immobile and therefore the greater the incidence of degenerative changes. In addition, the stiffer the spinal deformity, the greater the distraction force that has to be used and therefore the greater the strain on the neck. This is confirmed in those with scoliosis by the finding that the stiffness of the spinal deformity in those with cervical complications is twice that of those without complications. Finally, the importance of the age of the patient is thought to be related to the greater powers of recovery in the young.

Thus, in assessing whether an individual patient in the halo-pelvic apparatus is a candidate for complications of the cervical spine, one or more of the following factors gives a high probability: treatment for more than six months in the halo-pelvic apparatus; a tuberculous kyphosis; a scoliosis with a supine correction of 15 per cent or less; and an age of 15 years or more at the time of application of the halo-pelvic apparatus.

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REFERENCES

- Clark JA, Hsu LCS, Yau ACMC. Viscoelastic behaviour of deformed spines under correction with halo-pelvic distraction. *Clin Orthop* 1975;110:90-111.
- Dove J, Hsu LCS, Yau ACMC. Spontaneous cervical spine fusion: a complication of halo-pelvic traction. *Spine* 1980, in press.
- Hodgson AR. Halo-pelvic traction in scoliosis. *Isr J Med Sci* 1973;9:767-9.
- Kalamchi A, Yau ACMC, O'Brien JP, Hodgson AR. Halo-pelvic distraction apparatus. *J Bone Joint Surg [Am]* 1976;58-A:1119-25.
- O'Brien JP. The halo-pelvic apparatus. *Acta Orthop Scand* 1975;Suppl 163:91-103.
- O'Brien JP. The management of severe spinal deformities with the halo-pelvic apparatus: pitfalls and guidelines in its use. *J Bone Joint Surg [Br]* 1977;59-B:117-8.
- O'Brien JP, Yau ACMC, Hodgson AR. Halo-pelvic traction: a technic for severe spinal deformities. *Clin Orthop* 1973;93:179-90.
- Tredwell SJ, O'Brien JP. Avascular necrosis of the proximal end of the dens. *J Bone Joint Surg [Am]* 1975;57-A:332-6.
- Yau ACMC, Hsu LCS, O'Brien JP, Hodgson AR. Tuberculous kyphosis. *J Bone Joint Surg [Am]* 1974;56-A:1419-34.