Severe Injuries of the Cervical Spine Treated by Early Anterior Interbody Fusion and Ambulation

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The care and treatment of the patient suffering from acute traumatic quadriplegia can be demanding, tedious, and often discouraging. The usual procedure involves 6 to 12 weeks of immobilization in skeletal traction on a Stryker or Foster frame and appropriate physiotherapy.

The heavy demands made upon the hospital and its personnel by the quadriplegic patient are familiar; any measure that can shorten the acute phase and aid in early rehabilitation deserves consideration. If a fractured cervical vertebra could be stabilized satisfactorily, earlier mobilization would be possible. The anterior approach to the cervical spine used for treatment of disc disease and spondylosis offers a method of accomplishing this. We have now treated 14 patients in this manner (Table 1). The following four cases are illustrative of the methods of management and the problems encountered.

Case Reports

Case 1 (R.M.G.). This 18-year-old boy was admitted to Columbus Hospital, December 31, 1964, because of quadripleasis following an automobile accident.

Examination. There was total paralysis below the C-7 level and marked weakness of the portion of the arm innervated by C-6. Perception of position and vibratory sensation was good in the toes but absent in the fingers. Touch and superficial pain were not perceived below C-7. X-rays of the cervical spine showed a compression fracture of the sixth cervical vertebra with good alignment.

Because of a previous cranioplasty it was not possible to institute skeletal traction, so the patient was placed on a Stryker frame in head halter traction. On January 9, slight voluntary motion in the upper musculature of the legs was noted. By the second week the patient complained of skin irritation on his chin because of pressure from the head halter. Weight was reduced to 7 lbs, but the problem became worse. A discogram done on January 13 showed that the discs between C5–6 and C6–7 had been shattered (Fig. 1 left).

Operation. Through an anterior approach, the cervical spine was explored and fused following excision of the discs. The posterior longitudinal ligament was found torn in both interspaces, and disc material protruded posteriorly. The dowel hole for fusion was placed predominately in C-5 while at the C5–6 level, and mostly in C-7 while at the C6–7 level, in an effort to save as much of the C-6 bone as possible.

Postoperative course. The patient was kept on the Stryker frame in traction, but the weight was reduced to 2 lbs. Immediately postoperatively he was able to move his toes and legs. Leg motion continued to improve rapidly, but the arms showed only minimal improvement. Traction was discontinued on the 9th postoperative day, and the patient moved to a bed after he was fitted with a four-poster collar which was worn at all times. On the 16th postoperative day, he was allowed out of bed. Power in the legs had improved considerably. The position of the bone plugs was checked serially by x-ray. On February 16, he was transferred to a rehabilitation facility.

When seen 2 years later he was walking without any mechanical support. He was able to walk on heels or toes unaided. Leg strength was almost normal, but there was some increased muscle tone. Although the patient was able to button his clothes and tie his shoelaces, there was still moderate weakness in the hands. Reflexes were hyperactive in the legs, and the Babinski sign was present bilaterally. X-rays of the cervical spine showed excellent fusion of C5–6–7 (Fig. 1 right).

Comment. This case illustrates two points. First, fragmented cervical discs had caused
pressure on the spinal cord. Following their removal the patient showed rapid neurological improvement. Second, bone plugs inserted under tension provided sufficient stabilization of the cervical spine so that, even with a compression fracture, early mobilization was possible.

Case 2 (C.W.). This 40-year-old man fell down a flight of stairs on November 1, 1964, and was unable to get up.

Examination. On admission to Harlem Hospital, there was marked weakness in the arms and moderate weakness in the legs. No sensory deficit was present. Plain x-rays showed cervical osteoarthritis but no fracture. Skeletal traction was instituted but, since the patient was febrile, diagnostic studies were delayed until November 23, when discograms at C4-5 and C5-6 showed extravasation of contrast material at both levels (Fig. 2), indicating protrusion of the intervertebral disc.

Operation. Through an anterior approach on December 2, the fragmented discs were removed and iliac bone plugs inserted.

Postoperative course. Immediately following surgery the patient was able to make a fist

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Dislocation</th>
<th>Preoperative Neurological Status</th>
<th>Interval to Operation (days)</th>
<th>Postoperative Neurological Status</th>
<th>Immediate Status†</th>
<th>Day Out of Bed</th>
<th>Final Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.W.</td>
<td>30</td>
<td>C5-6</td>
<td>slight arm weakness that cleared with traction moderate arm weakness</td>
<td>56*</td>
<td></td>
<td>0</td>
<td>4</td>
<td>none</td>
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<tr>
<td>F.R.</td>
<td>38</td>
<td>C4-5</td>
<td>moderate arm, severe hand, slight leg weakness, mild sensory deficit moderate arm, slight leg weakness</td>
<td>56*</td>
<td></td>
<td>+</td>
<td>-</td>
<td>slight arm weakness</td>
</tr>
<tr>
<td>J.W.</td>
<td>35</td>
<td>C5-6</td>
<td>severe quadriparesis; minimal leg sensation</td>
<td>27</td>
<td></td>
<td>+</td>
<td>-</td>
<td>slight arm weakness</td>
</tr>
<tr>
<td>G.A.</td>
<td>45</td>
<td>C6-7</td>
<td>severe arm, slight leg weakness; normal sensation</td>
<td>4</td>
<td></td>
<td>++</td>
<td>3</td>
<td>slight hand, arm weakness</td>
</tr>
<tr>
<td>R.M.G.</td>
<td>18</td>
<td>C-6 compression, no dislocation; extruded discs at C5-6, C6-7 extruded discs at C4-5, C5-6; no dislocation</td>
<td>20</td>
<td>++</td>
<td>16</td>
<td></td>
<td>moderate hand weakness</td>
<td></td>
</tr>
<tr>
<td>C.W.</td>
<td>40</td>
<td>C5-6</td>
<td>complete quadriplegia &amp; sensory loss</td>
<td>11</td>
<td>+++</td>
<td>6</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>R.M.</td>
<td>46</td>
<td>C5-6</td>
<td>complete quadriplegia &amp; sensory loss</td>
<td>13</td>
<td>0</td>
<td>6</td>
<td>no change</td>
<td></td>
</tr>
<tr>
<td>D.A.</td>
<td>30</td>
<td>C5-6</td>
<td>moderate left arm weakness</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>no change</td>
<td></td>
</tr>
<tr>
<td>J.S.</td>
<td>37</td>
<td>C2-3</td>
<td>moderate arm weakness, mild arm hypalgiesia marked arm, moderate leg weakness; normal sensation</td>
<td>10</td>
<td>+++</td>
<td>4</td>
<td>none</td>
<td></td>
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<tr>
<td>W.M.G.</td>
<td>34</td>
<td>C5-6</td>
<td>marked arm, moderate leg weakness; normal sensation</td>
<td>23</td>
<td>+</td>
<td>5</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>H.S.</td>
<td>64</td>
<td>C5-6</td>
<td>marked, moderate arm leg weakness</td>
<td>23</td>
<td>++</td>
<td>5</td>
<td>slight arm, leg weakness; moderate hand weakness too soon to evaluate no change</td>
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<tr>
<td>D.D.</td>
<td>50</td>
<td>C4-5; C-4 fracture C6-7</td>
<td>marked, moderate arm leg weakness</td>
<td>6</td>
<td>+</td>
<td>5</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>S.W.</td>
<td>28</td>
<td>C6-7</td>
<td>complete quadriplegia &amp; sensory loss</td>
<td>9</td>
<td>0</td>
<td>11</td>
<td>no change</td>
<td></td>
</tr>
<tr>
<td>C.H.</td>
<td>25</td>
<td>C6-7</td>
<td>complete quadriplegia &amp; sensory loss</td>
<td>7</td>
<td>0</td>
<td>10</td>
<td>no change</td>
<td></td>
</tr>
</tbody>
</table>

* Subluxation recurred when skeletal traction removed preoperatively.
† Immediate neurological status was observed during the first 3 to 4 days after operation; 0 = no improvement, ++++ = normal neurological status, with the range in between being classified by +, ++, +++.
with both hands, and upper arm function also improved markedly. Traction was removed on the third postoperative day; the patient walked on December 8, using only a cervical collar for neck support. On December 21 he was transferred to a rehabilitation facility from which he was discharged 10 days later, using no assistive devices. Muscle power was good in all extremities.

Comment. No fracture was present in this case, but diagnostic studies indicated disruption of two discs with pressure on the spinal cord. Presumably there was other soft tissue injury affecting the stability of the spine. The surgery here both insured stability of the spine and decompressed the spinal cord. This patient would have benefited by earlier surgery.

Case 3 (D.A.). A 30-year-old man was admitted to Harlem Hospital on May 20, 1966, with quadriplegia following a fall.

Examination. There was complete loss of all sensory modalities up to the C-5 dermatome.
and partial loss there. No motor function was present below C-5. X-rays showed C-5 dislocated posteriorly on C-6 with locked articular facets. Skeletal traction was instituted and the dislocation reduced with 45 lbs of weight, which was then decreased to 10 lbs. There was no change in the patient's neurological status.

**Operation.** The cervical spine was explored through an anterior approach on May 26; 25 lbs of traction were maintained during the procedure. Marked mobility of the C-5 vertebra was present, and the disc between C-5 and C-6 was fragmented into large pieces. The posterior longitudinal ligament was torn; there was also a small rent in the dura. A bone plug from the iliac crest was inserted, but minimal motion between C-5 and C-6 persisted.

**Postoperative course.** There was no change in the patient's neurological status. Traction was removed on the 5th postoperative day, and a Thomas collar substituted. X-rays showed the plug to be in good position and vertebral alignment to be normal. There was no neurological change. The patient was transferred to a rehabilitation facility where he was mobilized several days after arrival. No collar or cervical support was used. X-rays taken 5 weeks after surgery showed that dislocation had recurred although the bone plug was still in place. There had been no improvement in neurological status.

**Comment.** To obtain reduction of the dislocation, traction of 45 lbs was required. At surgery only 25 lbs of traction were used when the dowel hole was drilled, and the plug was not inserted under tension. This resulted in an unstable graft. Adequate traction during surgery, namely, the weight necessary to effect the initial reduction, would have placed the graft under compression from the vertebral bodies above and below. If there is any question of stability, postoperative traction initially and then a brace should be used for 4 to 6 weeks. Alignment is checked by serial x-ray.

**Case 4 (W.M.G.).** This 34-year-old woman fell from a fourth story window on January 3, 1966.

**Examination.** At Harlem Hospital the patient was found to have bilateral weakness of the biceps and triceps muscles. There was bilateral hypalgesia of the C-6 dermatome with C-5 also involved on the right. X-rays of the cervical spine showed posterior displacement of the fifth cervical vertebra onto the fourth. Crutchfield tongs were inserted, serial x-rays taken, and the weight gradually increased to 35 lbs, but some displacement remained. As soon as the weight was reduced, the original displacement recurred. Discography performed at C4-5 showed a small amount of contrast material extravasated laterally on the left side.

**Operation.** On January 12, still under 20 lbs of traction, the cervical spine was explored through an anterior approach. When the disc had been excised, vertebral displacement was visible. Traction weight was increased to 35 lbs without any perceptible movement of the vertebral bodies. A periosteal elevator was then used as a lever with the lower edge of C-4 acting as the fulcrum, since C-5 was posteriorly displaced. With a seemingly small amount of pressure on the lever the interspace was opened up, and the bodies appeared to slip into proper alignment. This was verified by x-ray. A dowel hole was then drilled and a bone plug inserted under tension. The upper edge of the bone plug could not be driven below the cortical surface of C-4 with the usual amount of force but appeared to be firmly seated, so no effort was made to drive it in (Fig. 3).

**Postoperative course.** The patient's weakness improved rapidly. Traction was reduced...
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gradually and serial x-rays taken because of the questionable plug placement. No change in plug position was noted, and traction was discontinued on January 23. The patient was moved to a bed and was walking on January 25. X-rays taken January 27 showed some posterior displacement of C-5 onto C-4. Cervical traction was re instituted, but the patient was uncooperative and would not remain in it for any length of time. There was no change in vertebral alignment or neuro- logical findings when the patient was officially allowed out of bed 2 weeks later; she had actually been getting up for more than a week before that. On discharge in mid-March no neurological deficit was present; C-5 was posteriorly displaced about 5 mm but ap- peared firmly fused to C-4.

Comment. A traction tension of 35 lbs did not reduce the dislocation, but it was easily accomplished under direct vision. Although the bone graft appeared to be firmly in place, its anterior surface of cortical bone was not in contact with the cortical bone of C-4. This allowed some anterior angulation of C-4 with subsequent posterior displacement of C-5 where the cortical face of C-4 eroded the cancellous surface of the graft. We feel that if the graft is firmly seated under tension below the vertebral body surfaces, this complica- tion can be avoided.

Discussion

Severe injuries to the cervical spine are a difficult problem to manage. The earliest recorders of quadriplegia in the Edwin Smith papyrus, 2500 B.C., felt that “crushed verte- bra is an ailment not to be treated.” However, Hippocrates appears to have taken a slightly more optimistic approach in that he advocated traction. At present, some form of traction is the generally accepted method of treatment, with skeletal traction used in the more severe cases.  

When vertebral dislocations occur, traction initially provides a means of restoring normal anatomical relationships and then serves to protect the spinal cord from further injury by providing effective immobilization.  From 6 to 12 weeks are usually necessary to allow adequate healing of the damaged cervical structures.  

In some instances, the posterior elements of the cervical spine are fused to provide stabi- lization. These patients are allowed up in a few days to several weeks if no neurological deficit is present. Since fusion takes 8 to 12 weeks, however, the severely injured patient is usually kept immobilized.

Our study and those of others have shown that, with injuries of the cervical spine, disc fragments can cause cord compression even when no dislocation has occurred. It is difficult and hazardous to attempt to remove a midline disc in the cervical region from a posterior laminectomy approach, especially when the spinal cord and contiguous structures are edematous due to injury. Unless the patient’s condition is deteriorating, the justifica- tion for laminectomy is questionable. Many of these patients have central cord injuries with greatest involvement of the upper extremities. If the patient is improving, surgical intervention has been felt to be contraindi- cated, at least until the neurological picture stabilizes short of complete recovery.  

Early anterior fusion of the cervical spine in selected cases offers a solution to these problems. For the patient with moderate to severe neurological involvement, good decompression and stabilization can be obtained when disc fragments cause pressure on the spinal cord or roots at one or two levels. Even though there may be no displacement on x-ray, it is likely that many of the supporting structures were disrupted when the injury occurred (Case 2). This method of stabiliza- tion requires only minimal postoperative devices if serious displacement of the vertebra is not present. When diagnostic studies are required to localize the level, discography is performed with the patient on the frame in traction, thereby avoiding the manipulation of myelography.

Even in the quadriplegic patient with minimal function below the lesion, reduction and immobilization are desirable in an effort to improve and maintain whatever capabilities are still left. Anterior fusion usually allows earlier mobilization of these patients and can help the morale factor in addition to simplifying nursing care. Several days should elapse before mobilization, to allow the bone graft to become firmly seated. Some supportive device, either a collar or a fourposter brace, may be necessary for 4 to 6 weeks thereafter. The rigidity and type of brace used depends on the amount of bone and tissue disruption.
These precautions were not followed in one case, and dislocation recurred. There was an extreme degree of ligamentous and supporting tissue damage in this case and the bone plug was not firmly wedged into place.

The problem of the patient with severe deficit and a crushed vertebra, as illustrated by Case 1, is the most difficult. In this instance, the patient was markedly improved by removal of the extruded disc material. Since the stability of the spine was in question, however, postoperative mobilization was slower, and the patient was kept in a fourposter collar for several months. The appearance of the vertebral body at surgery and the relative immobility of the bodies after insertion of the graft will determine when to mobilize the patient. The x-ray evidence of damage usually seems greater than is actually the case. Early postoperative mobilization is still possible in these patients, but daily x-rays are done for 10 days to check the stability and alignment of the vertebral bodies.

Unless neurological deterioration develops, the patient with moderate to severe injury of the cervical spine should be allowed several days to a week for the spine to stabilize. During this time the usual methods of treatment, such as traction and intensive nursing care, are followed. An anterior approach to the cervical spine at the earliest opportune moment will then allow early mobilization and rehabilitation. Rapid improvement may result in some cases because of the decompression afforded by excision of a protruding disc. We experienced problems in only two of 14 patients (Cases 3 and 4), because the plug had not been firmly seated and dislocation recurred.

Of the 14 patients operated on, four had no function below the level of the lesion; as expected, this did not change postoperatively.

Ten patients did improve after surgery, three dramatically and seven more slowly. All were mobilized early.

Summary

The care and rehabilitation of patients with severe injuries to the cervical spine present complex problems and place a heavy burden on hospital facilities. Early anterior fusion in selected patients with moderate to profound neurological deficit allows early mobilization. Moreover, marked functional improvement may occur in certain patients if an extruded disc causing pressure on the spinal cord is removed. We have given the details of cases to illustrate the various problems encountered in a series of 14 patients.

References