Management of cervical spinal cord trauma in Southern California

JAMES S. HEIDEN, M.D., MARTIN H. WEISS, M.D., ALAN W. ROSENBERG, M.D., MICHAEL L. J. APUZZO, M.D., AND THEODORE KURZE, M.D.

Department of Surgery, Division of Neurosurgery, University of Southern California School of Medicine and University of Southern California Medical Center, Los Angeles, California

Acute cervical spinal cord injuries were reviewed in 356 patients treated by the neurosurgical community in Southern California. Neurological recovery was compared in operated and nonoperated patients with complete and incomplete cervical myelopathies. The complications of nonsurgical and surgical therapy are identified. No neurological improvement was noted in any patient with a complete lesion who underwent early surgical decompression. In those with incomplete sensorimotor paralysis, it was difficult to document any effect of surgical decompression on neurological recovery. Patients with some degree of sensory preservation had a similar incidence of motor recovery in both surgical and nonsurgical groups. With complete sensorimotor paralysis, anterior cervical fusion within the first week of injury was associated with increased pulmonary morbidity.

KEY WORDS • cervical spinal cord injury • spinal cord decompression • anterior cervical fusion • anterior cervical cord syndrome • central cervical cord syndrome

A considerable controversy exists as to the preferred method of treatment in acute spinal cord trauma. Some advocate early surgical decompression, while others recommend a more conservative, nonoperative approach. Part of the disagreement is concerned with the significance of residual bone deformity from spinal injury and whether apparent cord compression as a consequence of this represents a dynamic or an adynamic neurophysiological process. In countries such as Britain, France, Germany, and Australia, where spinal cord injury centers have existed for some time, a nonoperative approach has been uniformly favored. Sir Ludwig Guttman championed the method of postural reduction for spinal cord trauma; and accused surgeons of excessive operative intervention for acute spinal cord injury without significant statistical documentation as to the efficacy of an operative approach.

Methods of patient selection have not been uniformly agreed upon by those who favor a surgical approach, nor has the use of manometry or myelography gained universal acceptance as an index for surgery. Recognizing this diversity in the approach to spinal cord trauma, we have reviewed the management of acute cervical spinal cord in-
Management of cervical spinal cord trauma

### Table 1

Management of cervical spinal cord injuries

<table>
<thead>
<tr>
<th>Surgical treatment</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>early decompression</td>
<td>121</td>
<td>89</td>
</tr>
<tr>
<td>laminectomy</td>
<td>37</td>
<td>25</td>
</tr>
<tr>
<td>anterior discectomy</td>
<td>26</td>
<td>14</td>
</tr>
<tr>
<td>with fusion</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>delayed surgery</td>
<td>84</td>
<td>64</td>
</tr>
<tr>
<td>laminectomy</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>anterior discectomy</td>
<td>62</td>
<td>41</td>
</tr>
<tr>
<td>with fusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsurgical treatment</td>
<td>78</td>
<td>67</td>
</tr>
<tr>
<td>total</td>
<td>199</td>
<td>156</td>
</tr>
</tbody>
</table>

### Table 2

Causes of cervical cord injury

<table>
<thead>
<tr>
<th>Cause of Injury</th>
<th>No. of Cases</th>
<th>Cause of Injury</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road accidents:</td>
<td></td>
<td>Sports</td>
<td></td>
</tr>
<tr>
<td>automobile</td>
<td>153</td>
<td>diving</td>
<td>61</td>
</tr>
<tr>
<td>pedestrian</td>
<td>8</td>
<td>surfing</td>
<td>18</td>
</tr>
<tr>
<td>motorcycle</td>
<td>18</td>
<td>water skiing</td>
<td>4</td>
</tr>
<tr>
<td>Work</td>
<td></td>
<td>gymnastics</td>
<td>10</td>
</tr>
<tr>
<td>fall</td>
<td>4</td>
<td>football</td>
<td>10</td>
</tr>
<tr>
<td>dropped upon</td>
<td>2</td>
<td>other</td>
<td>1</td>
</tr>
<tr>
<td>Domestic</td>
<td></td>
<td>Suicide</td>
<td>4</td>
</tr>
<tr>
<td>fall</td>
<td>37</td>
<td>Unspecified</td>
<td>16</td>
</tr>
<tr>
<td>dropped upon</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Jury in a large series of patients over a 10-year period from 1963 to 1972. The purposes of this review are to identify 1) the incidence of surgical intervention in cervical cord injury; 2) the time relationship of surgery to injury; 3) the effectiveness of spinal cord decompression in the face of complete and incomplete cervical myelopathies; and 4) the complications attendant to surgical and nonsurgical management of acute cervical cord injury.

**Clinical Material**

This study represents a retrospective chart review of 356 patients with major cervical spinal cord injury. The patient population for this study is from the greater Los Angeles area, a community of approximately 7 million people, treated by approximately 135 practicing neurosurgeons. Thirty percent of the patients were given primary care at the Los Angeles County-University of Southern California Medical Center; the remainder were transferred after initial treatment to the Spinal Cord Injury Service at Rancho Los Amigos Hospital. Only charts containing adequate clinical information were included in this study.

We divided the cases into two groups: Group 1: patients with initial complete areflexic motor paralysis and absence of response to all somatic sensory modalities (199 cases); and Group 2: patients whose initial neurological deficit was incomplete (156 cases). Within each group, patients are further categorized as having early surgical therapy (within 48 hours of injury), delayed surgery, or nonsurgical therapy (Table 1).

Summary of Cases

Cervical spinal injury strikes men five times more frequently than women. A younger population is at risk, with one-half of the patients between 16 and 25 years of age. Automobile accidents were the cause of injury in half of the cases (Table 2). Interestingly, water sports comprised of diving, surfing, and water skiing caused 88% of athletic injuries. Associated cervical spine pathology consisted of nondisplaced fracture in 30%, fracture dislocation in 65%, severe degenerative arthritis in 3%, and normal cervical spines in 2%. Fracture dislocation was reported in three-quarters of Group 1 patients and half of Group 2 patients.

The C-5 vertebral body was the most common site of fracture; C5–6 was the most common dislocation site.

**Group 1 (Complete Sensorimotor Paralysis)**

Surgical treatment undertaken within 48 hours of injury was aimed at spinal cord decompression. Both laminectomy and anterior cervical approaches were used for cord decompression (Table 1). In these cases with complete deficits, there was no improvement in neurological status in any patient who underwent early surgical decompression. Of 84 patients who underwent delayed surgical treatment for reduction and/or stabilization, no significant neurological recovery was observed; this was parallel to the experience with acute decompression. Of 78 patients managed nonoperatively, two regained useful motor function of the legs and could walk with the assistance of braces.
TABLE 3
Complications in Group 1 patients (complete sensorimotor paralysis)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Nonsurgical (n = 78)</th>
<th>Anterior Cervical Fusion (n = 73)</th>
<th>Laminectomy (n = 48)</th>
</tr>
</thead>
<tbody>
<tr>
<td>severe pulmonary</td>
<td>32%</td>
<td>34%</td>
<td>15%</td>
</tr>
<tr>
<td>thrombophlebitis and/or pulmonary emboli</td>
<td>7.9%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>upper gastrointestinal hemorrhage</td>
<td>4%</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>wound-site infection</td>
<td>—</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>injury to contiguous structure (esophageal fistula or CSF fistula)</td>
<td>—</td>
<td>3%</td>
<td>—</td>
</tr>
<tr>
<td>cervical bone graft displacement</td>
<td>—</td>
<td>5%</td>
<td>—</td>
</tr>
<tr>
<td>increased neurological deficit</td>
<td>—</td>
<td>1.5%</td>
<td>—</td>
</tr>
</tbody>
</table>

Table 3 summarizes the early complications reported in the treatment of patients in Group 1. We have defined early complications as those occurring within the first 6 weeks following injury. A total of 37% of patients in the nonsurgical group had one or more early complications. By comparison, 37% of those patients with anterior cervical fusion and 27% of those with laminectomy sustained some complication. In 50% of the anterior cervical fusion group, the complications were multiple. The complication most frequently encountered in the nonsurgical group was pulmonary. We found that patients undergoing anterior cervical fusion within the first week of injury sustained a 46% incidence of severe respiratory problems. This complication was reduced to 27% when the anterior fusion was delayed 1 to 4 weeks after injury. Of the Group 1 patients who underwent laminectomy, the incidence of pulmonary complication was evenly distributed with reference to timing of surgery. Their overall complication rate was inexplicably the lowest for this group (Table 3).

Group 2 (Incomplete Sensorimotor Paralysis)

With incomplete traumatic myelopathy, effectiveness of spinal cord decompression is difficult to document. This is particularly true in those patients with preservation of some degree of lower extremity motor function following injury. The records of the preoperative neurological examination lacked any uniform quantification of residual motor activity, so that it was impossible to establish an accurate base of comparison. One can, however, evaluate the results of therapy in those patients whose motor deficit was reportedly complete but who had some degree of sensory preservation. This group of 57 patients included those with retained posterior column function, sensory sparing, spotty sensation, or greater than three-segment disparity between sensory and motor level. In these patients, 12% of the non-operated and 13% of surgically treated patients could walk at follow-up. All surgically treated patients were operated on within 1 week of injury.

Of the incomplete cervical cord injuries, two distinct clinical syndromes were examined, the anterior and central cervical cord syndromes. Anterior cervical cord syndrome is a well-defined condition in which early surgical treatment is recommended. Five patients treated operatively within 1 week of injury had no motor recovery. Two patients had spontaneous recovery of lower extremity motor function prior to operative stabilization of a cervical fracture at 1 month. One of four patients treated nonoperatively could later walk. In summary, all of the five surgically treated patients failed to improve, while three of seven patients showed improvement unrelated to surgical intervention.

Acute central cervical cord injury was found in 36 patients. Radiographic studies revealed nondisplaced cervical fractures (30%), fracture dislocations (30%), cervical spondylosis (28%), and normal findings in 12%. No early operations were performed in
Management of cervical spinal cord trauma

TABLE 4

<table>
<thead>
<tr>
<th>Complication</th>
<th>Nonsurgical (n = 67)</th>
<th>Anterior Cervical Fusion (n = 52)</th>
<th>Laminectomy (n = 37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>severe pulmonary thrombophlebitis and/or pulmonary emboli</td>
<td>16.9%</td>
<td>12.3%</td>
<td>12.3%</td>
</tr>
<tr>
<td>upper gastrointestinal hemorrhage</td>
<td>1.5%</td>
<td>—</td>
<td>2.0%</td>
</tr>
<tr>
<td>increased neurological deficit</td>
<td>1.5%</td>
<td>2.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>wound-site infection</td>
<td>—</td>
<td>—</td>
<td>5.0%</td>
</tr>
<tr>
<td>cervical bone graft displacement</td>
<td>—</td>
<td>9.5%</td>
<td>—</td>
</tr>
</tbody>
</table>

accordance with the recommendations of Schneider, et al.7,14 One-half of these patients underwent a delayed operative procedure, eight laminectomy and 10 anterior cervical fusion. At follow-up, 17% of the patients are severely impaired, with significant upper extremity paralysis, severe paraparesis, or both. These patients with residual deficit are evenly distributed between surgical and nonsurgical groups. Interestingly, 60% of these patients with significant residual disability were found in that group of patients whose radiographic findings consisted solely of cervical spondylosis.

Table 4 documents the complications encountered with the management of incomplete cervical injuries. The patients with surgical intervention had an overall complication rate of 29%, with the same incidence in both anterior fusion and laminectomy cases.

**Discussion**

Surgical therapy for spinal cord decompression, reduction of fracture dislocation, or stabilization is a common treatment of cervical cord trauma; in this review 60% of the patients had at least one operative procedure. In Group 1 patients (complete sensorimotor paralysis), 30% of the surgical procedures were performed early for spinal cord decompression. No neurological improvement occurred after early decompression. Only 1% of patients with initial complete sensorimotor paralysis could eventually walk, and these two patients were in the nonsurgical group. This experience appears to emphasize the futility of surgical intervention in the presence of an initial complete cervical transverse myelopathy. The decision to undertake early anterior fusion is based on the concept of rapid stabilization of injuries with fracture dislocation, which allows early mobilization of patients with a major traumatic myelopathy.10,12 However, early anterior cervical fusion within the first week after trauma was associated with what we would deem unacceptable pulmonary morbidity; 46% of these patients suffered severe postoperative pneumonitis. The incidence of pulmonary compromise was reduced to 27% if anterior cervical fusion was delayed 1 to 4 weeks postinjury. By way of comparison, the nonoperative group experienced a 32% incidence of severe pulmonary compromise. The similar frequency of those managed with delayed surgery suggests an irreducible minimum frequency for this complication.

For Group 2 patients (incomplete neurological syndromes), the efficacy of spinal cord decompression is open to question. In the group with some degree of sensory preservation only, surgical and nonsurgical patients had a similar incidence of motor recovery. Patients with anterior cord syndromes who did not show preoperative evidence of neurological improvement failed to respond even to early surgery. The 27% of patients with anterior cord syndromes who could eventually walk achieved neurological recovery unrelated to surgical intervention. Schneider, et al.,7,13 in their description of central cervical cord injury, stated that neurological recovery is a function of the pathophysiological process, whether in-
tramedullary edema or hematomyelia, but the overall prognosis is generally favorable and early surgery is not recommended. Our review of 36 patients with acute central cervical cord injury supports this, since only 17% of Group 2 patients had severe persistent neurological impairment, and these were evenly distributed between surgical and nonsurgical groups. A separate category may exist in those patients with central cervical cord injury associated with cervical spondylosis. Sixty percent of the severely disabled patients had cervical spondylosis which carried a poor prognosis. A prospective study certainly should be undertaken to define more fully neurological recovery of this group.

This review provides an epidemiological conspectus of the state of management of acute cervical spinal cord injury in a population of 7 million people served by approximately 135 neurosurgeons. The guidelines for management of cervical cord injury obviously vary within this large neurological community. In addition, experience in treatment of spinal cord injuries must be diluted to a few patients per year. This may explain in part the high incidence of complications with anterior cervical fusion; errors in surgical technique such as injury to contiguous structure, bone graft displacement, and neurological operative injury comprised 23% of the complications in complete and 40% of the complications in incomplete cervical cord syndromes. These figures seem unacceptable when compared to other surgical series from a single university center. 10,12

In addition, this review emphasizes the need for more accurate documentation of the neurological examination in spinal cord injury. Detailed baseline information, especially with incomplete neurological syndromes, is frequently inadequate. The motor examination was found particularly lacking in sufficient data to allow quantification of initial motor function. Such inadequacies in baseline documentation mitigate against a reliable evaluation of any surgical procedure which is designed to improve neurological function.

References


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