

Deterioration following spinal cord injury

A multicenter study

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✓ The results are presented of a prospective study of the course of 283 spinal cord-injured patients who were consecutively admitted to five trauma centers participating in the Comprehensive Central Nervous System Injury Centers' program of the National Institutes of Health. Of the 283 patients, 14 deteriorated neurologically during acute hospital management. In 12 of the 14, the decline in neurological function could be associated with a specific management event, and in nine of these 12 the injury involved the cervical cord. Nine of the 14 patients who deteriorated had cervical injuries, three had thoracic cord injuries, and two had thoracolumbar junction injuries. Management intervention was identified as the cause of deterioration in four of 134 patients undergoing operative intervention, in three of 60 with skeletal traction application, in two of 68 with halo vest application, in two of 56 undergoing Stryker frame rotation, and in one of 57 undergoing roboted rotation. Early surgery on the cervical spine when cord injury is present appears hazardous, since each of the three patients with a cervical cord injury who deteriorated was operated on within the first 5 days. No such deterioration was observed following surgery performed from the 6th day on. In two other patients, deterioration did not appear to be related to management but was a direct product of the underlying disease or of systemic complications.

Deterioration following hospitalization for spinal cord injury is relatively uncommon — 4.9% in this large series. In most instances, decline in function could be attributed to specific management procedures. These changes must not be interpreted as representing failure to provide optimal care but rather should be seen as the inevitable product of an attempt to manage patients with spinal cord and column injuries, many of which are clearly unstable.

KEY WORDS • spinal cord injury • early deterioration • multicenter study

IN spite of major advances in prehospital emergency medical services and in regional trauma care, the outcome from spinal cord injury appears to be little changed in recent series. Given the fact that at present we can have only a limited effect on neurological function in spinal cord-injured patients, it becomes especially important to identify factors that are responsible for further neurological deterioration in these cases. Surprisingly, this subject has been infrequently studied. Frankel, *et al.*,⁵ reported a 2% incidence of deterioration in their review of the Stoke Mandeville experience. In their paper on the management of cervical spinal

cord trauma in Southern California, Heiden, *et al.*,⁷ described the neurological complication rate, and Wagner and Chehrizi⁸ touched on this subject in their report on cervical spinal cord injuries. Tator has indicated that the incidence of deterioration following cord injury is approximately 10% (personal communication, July, 1984). Most neurosurgeons have expressed the view that deterioration is due to spontaneous events; that is, that the initial level of cord injury ascends because of the extension of hemorrhage or edema. Because the Comprehensive Central Nervous System Injury Centers for Defined Geographic Regions were charged with

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TABLE 1

Distribution of level and degree of spinal cord injury in 283 patients in this series

Degree of Injury	Level of Injury		
	Cervical	Thoracic	Lumbar
complete	69 (44.8%)	69 (69.7%)	3 (10.0%)
incomplete	85 (55.2%)	30 (30.3%)	27 (90.0%)
total cases	154 (100%)	99 (100%)	30 (100%)

attempting to improve spinal cord injury care in their regions, it appeared appropriate for the investigators in this collaborative effort to attempt to determine the incidence of deterioration following spinal cord injury and the etiology, where possible.

Clinical Material and Methods

Prospective data were collected on spinal cord-injured patients who were consecutively admitted to five regional trauma centers with major experience in care and management of that type of injury (LF Marshall, *et al.*, unpublished data, 1986). An extensive data-collection system was designed to capture information from as close as possible to the time of injury to the end of the patient's rehabilitation course. During each phase of management the patient's neurological status was detailed and the neurological assessment form was immediately filled out following specific interventions, which included: 1) initial spinal stabilization; 2) a neuroradiological diagnostic procedure; 3) skeletal traction application; 4) halo vest application; 5) Stryker-frame rotation; 6) rotobed rotation; or 7) surgery. In addition, the presence of specific underlying disease processes, multiple levels of injury, or severe multisystem injury was recorded in order to develop a complete picture of those individuals who deteriorated following admission. Characteristics pertaining to each intervention were assessed so that the incidence of deterioration could be compared to the number of times the procedure was performed. Deterioration was attributed to a specific intervention only if there was a clear temporal relationship between the two events.

Results

Table 1 demonstrates the distribution of the 283 spinal cord injuries by spinal level and whether the injury was complete or incomplete. In 14 patients, a clear decline in neurological function could be identified. In 12 of the 14, deterioration was related to the time of a specific type of intervention. These procedures are summarized in Table 2. Deterioration was specifically defined as a worsening in motor function in one or more spinal nerve roots above the level of injury or ascension of the sensory or motor level attributable to spinal cord injury. This definition was chosen in order to avoid confusion regarding more subtle changes in

TABLE 2

*Patient deterioration compared to type of intervention and level of injury**

Intervention	No. Deteriorating	No. Treated	Level of Injury	
			Cervical	Thoracic
surgery	4	134	3	1
halo vest application	2	68	2	0
Stryker frame rotation	2	56	1	1
skeletal traction application	3	60	3	0
rotobed rotation	1	57	0	1

* There were 375 interventions among 283 patients.

root function that occurred in cases where the initial injury was incomplete but had produced some diminution in root function. It was found during pilot study sessions in San Diego that occasionally there were subtle changes in root function at the level of injury, but that these changes proved unreliable as predictors of worsening and that function often returned to the baseline state in the absence of intervention. It is particularly noteworthy that in this entire series there was only one patient in whom deterioration occurred in the cephalad root. In the remaining 13 cases, deterioration was clearly due to a change in cord rather than root function since the deterioration involved several levels and multiple modalities. This would appear to indicate that ascension to the cephalad root is an extremely uncommon event. Deterioration of cord function appears to be much more frequent and, in most instances, was related to specific management procedures.

In nine of the 14 patients who deteriorated, the initial injury involved the cervical cord. In three the thoracic spinal cord was involved, and two patients had thoracolumbar junction injuries. Although the sample size studied is large, the frequency of deterioration was low. Thus, statistical differences between different types of intervention are not meaningful.

Three of 60 patients became worse immediately after application of skeletal traction. In one of these patients ankylosing spondylitis was the predisposing disturbance. This patient initially had a central cord syndrome, but changes in the application of skeletal traction in an attempt to produce better alignment caused almost complete quadriplegia (Fig. 1). This is an extremely unstable injury, and distraction of the fracture can follow the application of skeletal traction. It is difficult to manage patients with ankylosing spondylitis, and only minimal degrees of skeletal traction are likely to be safe. In the other two patients appropriate techniques were used in applying skeletal traction but deterioration in cord function occurred.

In two of 56 patients, definite deterioration was observed following rotation on a Stryker frame from the supine to the prone position. One patient suffered a respiratory arrest when placed prone. In this individual the lesion ascended so that he became ventilator-

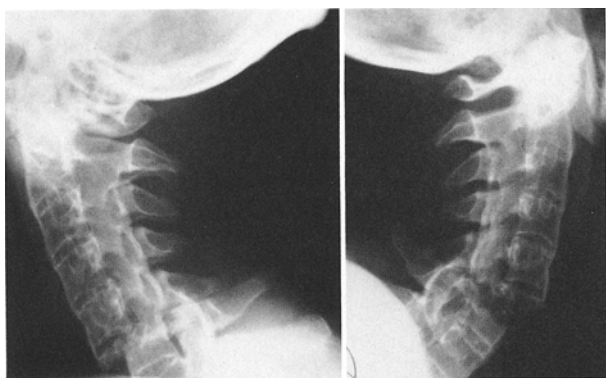


FIG. 1. *Left:* X-ray film of a patient with a central cord syndrome and the clinical diagnosis of ankylosing spondylitis. This initial film demonstrates significant subluxation. *Right:* X-ray film in the same patient following the application of 5 lb of skeletal traction, after which the injury became complete.

dependent and eventually died from this complication. In the second instance, a patient with an incomplete thoracic cord injury underwent surgical stabilization of a mid-thoracic fracture. However, 14 hours following surgery the injury became complete immediately after the patient was rotated on the Stryker frame. Both the patient and the nurses indicated that the frame had slipped during rotation, causing the patient to undergo an acute and abrupt downward motion of approximately 6 in.

One hundred and thirty-four patients underwent surgery. Four of the 26 patients who were operated on within 5 days after their injury deteriorated, whereas none of the 44 patients operated on after the 5th day but before the 10th day deteriorated ($p = 0.15$ by Fisher's exact test). None of the 64 patients operated on at varying times after the 10th day deteriorated. Of the four patients who were clearly worse after spinal surgery, the first had a complete loss of motor and sensory function at the C-5 level but underwent surgical intervention on the day of admission because of what appeared to be an incomplete loss of rectal tone. The aim of surgery was to reduce the fracture and to provide posterior stabilization. On the 1st postoperative day the patient developed severe respiratory failure, had a respiratory arrest, and became totally ventilator-dependent and quadriplegic with a level at C3-4. While one cannot absolutely attribute this deterioration to the operation, this appears the most likely cause. A second patient with a C5-6 complete injury, except for sparing of light touch sensation, was operated on within 72 hours to stabilize the spine. The lesion in this patient also ascended within hours of surgery, and he became quadriplegic and permanently dependent on a ventilator. Emergency postoperative myelography failed to demonstrate evidence of a block. The third patient who deteriorated following surgery had a severe but incom-

plete cervical cord injury. This patient underwent surgery on the 3rd day following spinal cord injury in an attempt to obtain better alignment and stabilization. Postoperatively, the injury was complete, although no untoward specific event during operation could be identified. The fourth patient deteriorated following a laminectomy performed in an attempt to halt a decline in neurological function on the 1st day following admission. Although myelography showed an incomplete block at the thoracolumbar junction, a decompressive procedure was performed. Following the operation, the patient was paraplegic at the level of surgical intervention.

Two of the 68 patients treated with halo vests deteriorated after vest application. This is not surprising since some immobilization is lost during placement in the halo vest. In one instance a radiograph taken immediately following halo vest application demonstrated an increase in the degree of flexion at the site of injury. Despite almost immediate correction of bone angulation in this case, the patient, who had incomplete motor and sensory function, developed a complete injury.

One patient was clearly worse after being rotated on a rotobed. This change was rather striking because it only occurred when the patient was rotated to the left side. The sensory level ascended approximately six segments, and a clear loss of abdominal motor tone was noted. When the patient was rotated to the right side and held in that position, the neurological deficit improved rather rapidly, but worsened again upon rotation to the left. This patient was taken to the operating room for stabilization of his thoracic injury and ultimately showed substantial recovery of function below T-10, the level of initial injury.

Deterioration was due to spontaneous events in two patients. In the first patient, plain x-ray films showed progressive movement of a fracture-dislocation of the thoracolumbar junction in spite of complete immobilization of the patient in the supine position. The second patient, who had suffered polytrauma, deteriorated after the development of severe metabolic instability with major tissue acidosis and electrolyte abnormalities.

Discussion

In the five hospitals participating in this study, deterioration following spinal cord injury was relatively uncommon, with an overall incidence of 4.9%. Given the fact that stabilization was the major goal of surgery in 121 of the 134 patients who underwent operative intervention, worsening after surgical intervention in less than 3% of cases is not surprising. However, it is important to note that deterioration occurred only in patients operated on within 5 days after injury. This trend is quite disturbing and suggests that there is an increased risk of deterioration when the cervical cord is operated on within the first 5 days postinjury. Because more patients with incomplete injuries were operated

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on later than the 5th day, it is unlikely that the sample was biased to a higher-risk group of patients operated on early rather than late. Heiden, *et al.*,⁷ have previously shown that surgery during the first 7 days following cervical cord injury is associated with a significant increase in morbidity and should be avoided. Our present experience supports that view. Obviously, patients with an initial incomplete injury in whom progressive deterioration occurs must be managed in such a way that compression of the cord is relieved. With this exception, however, neurosurgeons and orthopedists are cautioned against early intervention in such patients.

Two patients clearly became worse when rotated on the Stryker frame, indicating that there is some management hazard associated with this bed. However, one patient of 57 deteriorated in relation to rotation on a rotobed. Although Brackett and Condon² have noted a substantial difference between the rotobed and the Stryker frame, the number of patients in the present series who deteriorated while being turned with either system was too small to permit a statistical comparison.

Of the 14 episodes of deterioration described here, three of the four that were related to surgical intervention on the cervical spine might have been avoided by an alteration in surgical philosophy. In an additional instance, an error in nursing management during Stryker frame rotation appeared to be the cause. If one considers these four cases to be instances of avoidable deterioration, then the remaining 10 must be considered unavoidable. While deterioration in most of these 10 cases was associated with a specific management procedure, this outcome is the inevitable consequence of providing care for such patients. It is difficult, even in retrospect, to determine how management could have been altered to avoid the complications that occurred in these 10 patients. Therefore, even though 14 (5%) of the 283 patients in this study deteriorated following spinal injury, this incidence appears close to the minimal incidence of deterioration that one might expect in the management of these patients, whose spinal column and medical condition are both unstable. Thus, the small number of patients who deteriorated in this large series of consecutive patients should offer a reasonable estimate of the likelihood of deterioration.

Clearly, the definition of deterioration utilized here can be criticized in that initial impairment of root function at the level of injury was not considered to be of significance. This was because only modest changes in function were noted and these were almost always reversible. It is important to note that cephalad extension of root level was extremely uncommon in this large series, with only one patient demonstrating this phenomenon. Thus, the concept that this is a common occurrence in patients with spinal cord injury needs to be reexamined. It is likely that ascension of the root level may in fact represent evidence of further cord involvement, and that this is often related to specific management procedures.

One-third of the management-related complications were associated with spine surgery. The caution that Heiden, *et al.*,⁷ have suggested with regard to early surgery in patients suffering cervical cord injuries is supported by the present experience. Both their study and ours indicate that early surgical intervention on the cervical spine should be performed under only one circumstance; namely, to avoid further deterioration in neurological function.

The fact that specific procedures were related to deterioration in these spinal cord-injured patients does not imply that poor management was involved: there is a minimal level of neurological sequelae that will occur in the management of these patients. No comparable series of patients managed entirely conservatively with bed rest is available for comparison. While one could argue that the complication rate in such a nonsurgical series would be lower than that described here, the change would be small at best because it would only eliminate those patients undergoing early surgery. For example, the complications associated with spinal distraction for reduction and external immobilization, as reported here and by others,³⁻⁶ would still have occurred. Thus, the complications associated with application of skeletal traction and the halo vest would also have occurred in the conservatively managed patients. Furthermore, although the systemic and psychiatric risks of prolonged bed rest have not been assessed in a conservatively managed series of patients in the United States, there must be some risks associated with such management. Braakman and Penning¹ have suggested that the remarkably low incidence of neurological deterioration of 2% in the review by Frankel, *et al.*,⁵ of the Stoke Mandeville experience may have underestimated the incidence of progressive myelopathy. Thus, it appears unlikely that any substantive improvement in the incidence of deterioration following spinal cord injury could be produced in a series of patients managed completely conservatively.

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