

## Management of Acute Central Cervical Spinal Cord Injuries

### RECOMMENDATIONS

**STANDARDS:** There is insufficient evidence to support treatment standards.

**GUIDELINES:** There is insufficient evidence to support treatment guidelines.

#### OPTIONS:

- Intensive care unit (or other monitored setting) management of patients with acute central cervical spinal cord injuries, particularly patients with severe neurological deficits, is recommended.
- Medical management, including cardiac, hemodynamic, and respiratory monitoring, and maintenance of mean arterial blood pressure at 85 to 90 mm Hg for the first week after injury to improve spinal cord perfusion is recommended.
- Early reduction of fracture-dislocation injuries is recommended.
- Surgical decompression of the compressed spinal cord, particularly if the compression is focal and anterior, is recommended.

### RATIONALE

Central spinal cord injuries are among the most common, well-recognized spinal cord injury patterns identified in neurologically injured patients after acute trauma. Originally described by Schneider et al. (19) in 1954, this pattern of neurologically incomplete spinal cord injury is characterized by disproportionately more motor impairment of the upper than of the lower extremities, bladder dysfunction and varying degrees of sensory loss below the level of the lesion (19). It has been associated with hyperextension injuries of the cervical spine, even without apparent damage to the bony spine, but has also been described in association with vertebral body fractures and fracture-dislocation injuries. The natural history of acute central cervical spinal cord injuries indicates gradual recovery of neurological function for most patients, albeit usually incomplete and related to the severity of the original injury and the age of the patient (4, 13, 15, 17, 19–21). The role of surgery and its timing for patients with acute central spinal cord injuries without fracture compression or dislocation injuries are the subjects of considerable debate (3, 5–8, 19, 20). The optimal management of patients who have sustained acute central cervical spinal cord injuries is the subject of this review.

### SEARCH CRITERIA

A computerized search of the National Library of Medicine database of the literature published from 1966 to 2001 was undertaken. The medical subject heading “spinal cord injury” combined with “central cord syndrome” and “incomplete cervical spinal cord injury” yielded approximately 1450 citations. Non-English language citations were excluded. Titles and abstracts of the remaining publications were reviewed,

and relevant articles were selected to develop the guidelines. We focused on the specific issues of the natural history, medical management, and surgical treatment of human acute central cervical spinal cord injuries. These efforts resulted in 13 articles (all Class III studies) specifically describing management and outcomes of patients with central cervical spinal cord injuries. The Bibliography includes several articles on magnetic resonance imaging (MRI) of central cervical spinal cord injuries, many articles (all Class III studies) describing series of patients with acute spinal cord injuries, most of whom had incomplete cervical spinal cord injuries, and several general review articles that address issues of acute spinal cord injuries, including pathophysiology and treatment. The 13 case series describing the management of patients with acute central cervical spinal cord injuries are summarized in *Table 21.1*.

### SCIENTIFIC FOUNDATION

In 1951, Schneider (18) described two patients with acute neurologically incomplete cervical spinal cord injuries for whom he suggested that early operation was indicated. Both patients presented after trauma with sudden loss of motor function in the distal upper extremities, the torso, and the lower extremities, but with preservation of touch and vibration sense. Both patients had anterior spinal cord compression from acute traumatic cervical disc herniations (one had an associated vertebral endplate fracture). The diagnosis and anatomic localization were based on the clinical examination. Both patients made incomplete but significant neurological recoveries after delayed surgical decompression via laminectomy, dentate ligament sectioning, and transdural discectomy. Three years later, Schneider et al. (19) described eight

## Acute Central Cervical Spinal Cord Injuries

**TABLE 21.1. Summary of Reports on Acute Cervical Spinal Cord Injuries<sup>a</sup>**

Series (Ref. No.)	Description of Study	Evidence Class	Conclusions
Dai and Jia, 2000 (8)	Retrospective review of 24 patients with acute disc herniation as cause of ACCSCI treated with ACDF.	III	Disc herniation common cause. Surgery successful in all patients, more rapid improvement. Poor outcome with fracture dislocation injuries.
Newey et al., 2000 (15)	Retrospective review of 32 patients with ACCSCI managed conservatively.	III	Improvement seen in most patients over time. Older patients had worse outcome.
Chen et al., 1998 (6)	Retrospective review of 37 patients with ACSI with preexisting spondylosis. Many with central cord injury pattern. MRI assessment of compression, cord injury. 16 managed with surgical decompression, 21 medically.	III	MRI modality of choice to image cord compression/injury. Surgical decompression associated with more rapid improvement, shorter hospital and rehabilitation stay. No difference in outcome at 2-yr follow-up.
Chen et al., 1997 (7)	Retrospective review of 114 patients with acute or chronic CCSCI. 28 patients managed with surgery (3 chronic patients), 86 medically. No randomization.	III	Surgery associated with more rapid and complete recovery, particularly in upper extremities, compared with similar patients managed medically. Patients with long-segment stenosis had poor prognosis.
Bridle et al., 1990 (4)	Random late assessment of 18 patients with ACCSCI.	III	Most patients improved over time, although most with long-term deficits, pain, and dysfunction.
Roth et al., 1990 (17)	Retrospective review of 81 rehabilitation patients after ACCSCI.	III	2 age groups of patients, marked heterogeneity. In general, most patients improved over time. Outcome related to age and severity of initial injury.
Merriam et al., 1986 (13)	Retrospective review of 77 patients with ACCSCI. No patient with surgical decompression, 30 underwent late stabilization and fusion.	III	Marked variation among patients and injury patterns. Most improved. Outcome related to age and severity of initial injury.
Bose et al., 1984 (3)	Retrospective review of 28 patients with ACCSCI, 14 managed with aggressive medical therapy, 14 with medical therapy and surgical treatment. No randomization. Follow-up at time of discharge.	III	No patient worse with treatment, medical or surgical. Surgery provided more rapid, more complete recovery at time of discharge.
Brodkey et al., 1980 (5)	Retrospective review of 7 patients with ACCSCI operated on late after injury. All had stable, profound deficits and myelographic evidence of cord compression.	III	All had accelerated neurological improvement after surgery. 3 patients normal at late follow-up. Surgery of benefit in selected patients with persistent deficits and evidence of cord compression.
Shrosbree, 1977 (21)	Retrospective review with late follow-up of 99 patients with ACCSCI managed conservatively.	III	2 groups identified. Younger patients with flexion rotation injuries. Older patients with hyperextension injuries. Outcome related to severity of initial injury.
Bosch et al., 1971 (2)	Retrospective review and long-term follow-up of 42 patients with ACCSCI managed conservatively.	III	Most patients improved over time. 75% regained ambulatory skills, 56% regained functional hands. 10/42 patients had late deterioration after initial gains ("chronic central cord syndrome").
Schneider et al., 1958 (20)	Retrospective review of 12 additional patients with ACCSCI. 11 managed expectantly, 1 managed with surgical decompression 13 h after injury.	III	2 age groups of patients. Young patients with fracture dislocation injuries. Older patients with hyperextension injuries often without bony vertebral damage. Most patients improved. Expectant management is ideal treatment.
Schneider et al., 1954 (19)	Retrospective review (and first description) of 8 patients with ACCSCI they managed (6 expectantly, 2 surgically) and discussion of 6 cases from literature.	III	Most patients with ACCSCI improved with time and expectant management. Injury and its recovery follows specific pattern. Surgery contraindicated for this injury.

<sup>a</sup> ACDF, anterior cervical discectomy with fusion; ACCSCI, acute central cervical spinal cord injury; ACSI, acute cervical spinal cord injury; CCSCI, central cervical spinal cord injury; MRI, magnetic resonance imaging.

patients they managed along with six other patients culled from the available literature. All but two of these patients presented with disproportionately more motor impairment in

the upper extremities than in the lower extremities, bladder dysfunction with retention, and varying degrees of sensory loss below the level of the lesion. Two of the six patients

identified in the literature review had complete motor injuries in both the upper and lower extremities with some preservation of sensory function below the level of injury. These incomplete neurological deficits were related to acute traumatic central cervical spinal cord injuries, usually—but not exclusively—as a result of hyperextension of the head and neck relative to the torso. In several patients, there was no damage to the bony spine. In these instances, it was presumed that hypertrophic changes (spurs, ridges, thickened ligaments) within the spinal canal caused anterior and posterior cord compression in the position of hyperextension, resulting in injury to the central substance of the cervical spinal cord. Other patients had cervical compression fractures or fracture-dislocation injuries of the cervical spine that contributed to the central spinal cord injury. The authors operated on the first two of the eight patients they treated with this disorder. Both had central cervical spinal cord injuries without bony damage or displacement. Both were treated in delayed fashion via laminectomy with sectioning of the dentate ligaments and then transdural exploration anterior to the cervical spinal cord. In both cases, anterior bony osteophytes were identified but were not removed. Patient 1 was quadriplegic postoperatively. Patient 2 was neither better nor worse after surgery. Six additional consecutive patients were managed without surgical decompression (Patient 7 underwent delayed dorsal cervical fusion in treatment of fracture instability). Five of six patients were managed expectantly (Patient 4 had progression of neurological deficits despite immobilization and ultimately died 3 wk after injury), and three of six patients from the literature improved without surgery (75%). Most patients experienced permanent loss of hand function and strength. One of six patients from their series and three of six from the literature died without neurological recovery (25%). Conversely, one (50%) of two patients treated surgically was immediately neurologically worse; the second (50%) made a progressive albeit incomplete recovery over time, much like that observed in comparable patients managed without surgery. It was on the basis of this early experience that Schneider et al. determined that the prognosis after acute central cervical spinal cord injury was reasonably good. Surgery for these patients, they concluded, was contraindicated and in fact known to harm rather than improve them (19).

In 1958, Schneider et al. (20) added observations on 12 additional patients they managed with acute central cervical spinal cord injuries. One patient died of pneumonia without neurological recovery, one patient had a full neurological recovery, and the remaining 10 improved compared with their initial postinjury neurological status but were profoundly impaired at last follow-up. The authors noted two distinct age groups with acute central cervical spinal cord injuries. They described an older group of patients (mean age, 59 yr) without bony vertebral damage but with hypertrophic changes compromising the cervical spinal canal, and a younger group (mean age, 31 yr) with fracture or fracture-dislocation injuries of the cervical spine. They reported that central cord edema, venous congestion, and ischemia were components of the pathophysiology of this unique injury type. They advocated expectant management, including

closed reduction with skeletal traction for all patients with this syndrome (as for four patients in their study), despite important, near-complete neurological recovery in a 17-year-old patient after operative reduction and decompression of a unilateral facet dislocation injury within 13 hours of injury.

Schneider et al.'s (20) collective reported experience in the management of patients with acute central cervical cord injuries numbered 20 patients at the time of the report. Of the 20 patients, 17 were managed medically: 2 patients died without improvement, 14 patients improved but had profound residual deficits, and 1 patient regained normal function. Three patients were treated with surgical decompression: one early (hours) and two late (weeks). The patient with early decompression improved dramatically. One late decompression patient neither improved nor worsened immediately after surgery but showed progressive long-term improvement; the other was quadriplegic after surgery. From this experience, they concluded that accurate diagnosis is stressed, with emphasis placed on the fact that operation is contraindicated, that the prognosis may be good and that should recovery occur it will follow a definite pattern (20). These suggestions have guided the care of acute central cervical spinal cord injury patients ever since publication of their report.

In 1971, Bosch et al. (2) described observations made during their management of 42 patients with subacute central cervical spinal cord injuries treated at a rehabilitation hospital, with a follow-up period of 4 months to 26 years. At admission, 19% could walk independently, 14% were partial walkers, and 67% could not walk. Twenty-six percent had functional hands at admission. At discharge, 57% had functional walking skills, 20% were partial walkers, and 42% had functional hands. Bladder control improved from 17% at admission to 53% at discharge. A similar improvement in bowel control was documented. Importantly, these authors noted late deterioration in 24% of patients who showed initial improvements in neurological function after central cervical spinal cord injury. Ten (24%) of 42 patients experienced the late neurological sequelae of "chronic central cord syndrome" and lost walking, hand, and bladder control skills, as observed in long-term follow-up. The authors concluded that at least some return of neurological function in the immediate postinjury period could be expected in about 75% of cases, with 56% of patients regaining functional hands. In the long term, only 59% of the patients with central cervical spinal cord injuries they followed retained functional skills with conventional medical management.

In the same year, Turnbull (26) reported his studies on the microvasculature of the human spinal cord and postulated mechanisms of vascular insufficiency associated with various types of spinal cord displacement. His work speaks to the anatomic basis of the pathophysiology of acute cervical central spinal cord injuries, particularly those that occur in older patients with underlying cervical spondylosis who sustain acute central spinal cord injury without bony vertebral injury. He found that as the cord becomes compressed, whether owing to a mass lesion or progressive cervical spondylosis, it becomes flattened and widened. The vasculature of the cord is affected by cord distortion. Pial vessels become more tortu-

ous. Arteries of the lateral columns are elongated, narrowed, and flattened. Branches from the central arteries that reach the gray matter run laterally and are similarly stretched lengthwise and are compressed from side to side. Turnbull reported that vessels chronically deformed by cervical spondylosis cannot respond to additional anteroposterior flattening of the cord as would normal arteries in a younger patient. A little additional compression would pinch off side branches at their origins (26). He concluded that mechanical distortion of the cord and its blood supply plays a major role in the pathophysiology of spinal disease and spinal cord injury (26–28).

In 1977, Shrobbree (21) reported 99 patients with acute central cervical spinal cord injuries managed at a South African spinal cord injury center. Most of the patients were admitted within 72 hours of injury. All patients were treated conservatively. Fracture/injury reduction was accomplished via closed means in 92% of patients with dislocation, either by traction or by reduction under anesthesia, within 72 hours of admission. Two age groups of patients were identified. Younger patients (21–50 yr) had flexion-rotation injuries and a higher incidence of dislocation injuries. Older patients ( $\geq 50$  yr) were more likely to have hyperextension injuries superimposed on preexisting cervical spondylosis. Outcome was related to the severity of the initial neurological deficit. Only 5 (22%) of 23 patients with severe motor deficits became independent walkers. All of these patients had residual deficits in the hands. The author summarized by noting that early reduction may well be a factor in promoting more favorable neurological recovery (21) among patients with facet dislocation injuries, but he provided no data to support his claim.

In 1977, Maroon (12) reported that “burning hands” (severe dysesthesias in the hands and fingers after trauma despite normal motor function) may indicate acute central spinal cord injury. He described two football players with dysesthetic symptoms in the hands referable to modest injury to the central cervical spinal cord and warned physicians, trainers, and coaches of the importance of this syndrome.

In 1980, Brodkey et al. (5) revisited the management of the acute central cervical spinal cord injury syndrome. They provided operative treatment to seven patients with traumatic central cervical spinal cord injuries within 18 to 45 days after acute injury who had profound residual neurological deficits after attentive medical treatment. Myelography revealed significant defects in all of these patients. Four patients underwent anterior cervical discectomy with fusion (ACDF), one was treated with multilevel laminectomy, one had multilevel ACDF, and one received multilevel laminectomy and then delayed (4 yr) multilevel ACDF. All patients had an accelerated neurological recovery after the surgical procedure, even the patient who deteriorated years after laminectomy and required late multilevel ACDF. Three patients returned to normal after severe injuries that persisted until surgical decompression. The authors concluded that cord compression does play an important role in the pathophysiology of central cord syndrome and that, when present in the setting of a stable poor neurological condition after injury, decompression of the spinal cord may be of benefit.

Bose et al. (3) retrospectively analyzed their management of 28 patients with acute central cervical spinal cord injuries. In their 1984 report, they noted significantly improved motor scores at the time of discharge in patients managed with combined medical therapy and surgery, compared with those managed only medically. All were treated aggressively in the intensive care unit setting. Surgical patients had myelographic evidence of cord compression or evidence of cervical spinal instability. Although selection bias (surgical patients had cord compression and/or instability or subluxation) and several other study flaws precluded direct comparison between the groups, the authors noted that no surgical patient worsened as a result of surgery and all improved neurologically, several substantially. They argued that decompression of the compressed spinal cord in patients with acute central cervical spinal cord injury syndrome may be of benefit in selected patients.

Merriam et al. (13), Roth et al. (17), Bridle et al. (4), and Newey et al. (15) described the late outcomes of individual series of selected groups of patients after central cervical spinal cord injury. All four groups of investigators noted marked heterogeneity among patients in the central cervical spinal cord injury population. All patients were managed medically. Most patients improved somewhat over time, with more recovery in the lower extremities than in the upper extremities. All of these authors concluded that outcome was in general good for patients younger than 70 years. The final neurological result was influenced by patient age, particularly age older than 70 years, and the degree of initial neurological impairment. Hand function impairment was the most common long-term disability, even among patients with a “good” outcome. Only Merriam et al. (13) made reference to surgical treatment, involving 30 of 77 patients in their series, presumably to provide spinal stabilization and fusion. No association between surgical management and outcome was discerned.

Chen et al. (7) reported their experience with 114 patients with acute and chronic traumatic central cervical cord syndrome. Twenty-eight patients were managed with surgical treatment, and 86 were managed medically. The authors did not randomize patients to one treatment group or another. Selection criteria for surgical decompression included failure to improve with medical therapy or deterioration in neurological function despite medical treatment with radiographic (MRI or computed tomographic/myelographic) evidence of focal cord compression, or gross instability of the spine. They operated on three patients late (8, 12, and 24 mo after injury) for “chronic” central cord syndrome. Their 1997 retrospective review found that younger patients had better long-term results than did older patients (in both management groups) and that surgical decompression was associated with more rapid and complete motor improvement compared with patients managed medically, even if the operation was performed a long time after injury. Both management groups had similar outcomes over time with respect to lower extremity and bladder function. Patients selected for surgery had more rapid and more complete recovery of function, particularly in the upper extremities. The authors noted that patients with stenosis at multiple levels who were managed conservatively

had a poorer prognosis and a relatively higher chance to develop late myelopathy. The authors did not describe the outcome of similar patients with multilevel stenosis managed with operative decompression.

In 1998, Chen et al. (6) described the management of 37 patients with preexisting cervical spondylosis who sustained acute incomplete neurological cervical spinal cord injuries after trauma. Many of these patients had acute central spinal cord injuries. No patient sustained a bony vertebral column injury. In their retrospective review, patients were treated with surgical decompression if they did not improve more than one motor grade within 9 days of injury (range, 3–14 d). Patients were studied with MRI to document cord compression and/or signal change within the spinal cord. In total, 16 patients underwent surgical decompression, 9 anteriorly and 7 posteriorly. Twenty-one patients were managed medically. Thirteen (81%) of 16 surgical patients improved “remarkably” immediately after surgery. Thirteen (62%) of 21 patients managed medically improved to the same degree over time. As with surgical patients, patients with cervical stenosis in more than three vertebral levels fared less well than did patients with focal compression or with stenosis in three vertebral levels or fewer. There were no reported differences in outcome between patients in the two groups at 2-year follow-up. The authors concluded that surgical decompression might be associated with more rapid neurological improvement, early mobilization, and shorter periods of hospitalization and rehabilitation. They consider MRI to be the imaging modality of choice to assess the spinal cord in patients with acute central cervical spinal cord injuries, a conclusion consistent with those of other investigators of the role of MRI in the assessment of patients with spinal cord injuries (9, 14, 16, 25).

In 2000, Dai and Jia (8) described their experience with 24 patients with acute traumatic disc herniation as the cause of acute central cervical spinal cord injuries. Acute disc herniation was confirmed with preoperative MRI. The authors provided a retrospective assessment of patients operated on anteriorly (ACDF without internal fixation) for cord decompression and spinal stabilization. The timing of surgery relative to injury was not described. They noted an inverse correlation between rate of recovery and age and found that patients with fracture-dislocation injuries with acute disc herniation were more impaired preoperatively and fared less well than patients without fracture-dislocation injuries at late follow-up. They reported that surgical decompression, stabilization, and fusion were successful in all patients and described marked improvement in neurological function in most patients treated.

Contemporary reviews confirm early reports that most patients with incomplete cervical spinal cord injuries meeting the clinical neurological criteria of acute central spinal cord injury will show neurological improvement over time (2, 13, 15, 17, 19–21). Some patients with these injuries will die, and many will remain profoundly impaired at late follow-up. These patients in general are older, have spinal cord injuries without bony vertebral injury, and have medical comorbidity, or they are younger but have fracture-dislocation injuries as a cause of their neurological deficits. A large portion of patients will regain walking skills over time but will not have useful

hands. A smaller portion of patients will demonstrate significant neurological recovery and regain hand function. These patients are typically younger, do not have fracture-dislocation injuries, and have less severe neurological deficits at the outset. Up to 24% of patients managed nonoperatively will improve early but decline again years later (“chronic central cord injury syndrome”) (2).

Surgery for decompression of the spinal cord in patients with acute central cervical spinal cord injuries has been denounced on the basis of Schneider’s early poor experience with a single patient who underwent surgery (19, 20). That patient, quadriplegic after dorsal cervical exploration and decompression, experienced significant manipulation of the injured cord during the process of dentate ligament sectioning and transdural anterior cord exploration (19), a procedure unlikely to be performed in similar fashion today. The same group had a rewarding experience with early (13 h after injury) surgical decompression and facet fracture reduction in a 17-year-old boy with profound early central cord neurological deficits (20). Many other authors, including those reporting three contemporary series of patients with this disorder, have described good to excellent outcomes without neurological complications for surgical decompression of patients with spinal cord compression, particularly focal anterior cord compression (3, 5–8). However, no study to date has provided a randomized direct comparison of surgical patients with similar patients managed without surgery. Nor has any study adequately assessed the potential role of dorsal spinal decompression for multilevel cervical cord compression in patients with this disorder, particularly those with acute central cervical cord syndrome without bony vertebral damage. Surgery may have a role in the management of patients with acute central cervical spinal cord injury, but, as yet, that role has not been accurately defined by scientific study.

Schneider et al.’s (20) conclusion that central cord edema, venous congestion, and ischemia were important components of the pathophysiology of these injuries, combined with the hypothesis of Turnbull (26, 27) and Turnbull et al. (28) that vascular compression and distortion attributable to anteroposterior flattening of the cord plays a major role in the pathophysiology of cord injury, suggest several potential opportunities for treatment. The compression of the cord and distortion and compression of its blood supply might be relieved by surgical decompression. Ischemia of the cord, caused by either the primary injury or secondary events, might be improved with augmentation of spinal cord perfusion. Although Turnbull (26, 27) and Turnbull et al. (28) did not offer specific strategies, they did offer an anatomic and pathophysiological rationale for the potential of maintenance of spinal cord perfusion pressures and cervical cord decompression for patients who sustain an acute central cervical cord injury, particularly those with preexisting cervical spondylosis. Maintenance or increases in systemic blood pressure may improve perfusion to the injured, distorted spinal cord (1, 3, 10, 11, 22, 23, 29). Several contemporary series of patients with spinal cord injuries treated with aggressive medical management including maintenance of mean arterial blood pressure at high normal ranges (85–90 mm Hg) have sug-

gested improved neurological outcomes with this management plan (10, 11, 24, 29–31). Decompression of the cord has the potential to eliminate both cord compression and vascular compression and distortion (3, 5–8, 30). Either or both of these treatment strategies may improve spinal cord blood flow in the acute central cervical spinal cord injury setting, which could translate into preservation of neurological tissue and recovery of neurological function. The benefit may or may not be realized at the site of primary injury, but rather at vulnerable adjacent spinal cord levels fed by sulcal and collateral arteries that pass through the injury site but supply the cord rostral and caudal to the site of injury (1, 22, 23, 27, 28).

## SUMMARY

The ideal management strategy for patients with acute central cervical spinal cord injuries seems to be multifaceted. As Schneider et al. (20) insisted years ago, a rapid, accurate diagnosis is essential. A detailed clinical examination, cervical spinal x-rays to assess vertebral column injury (see recommendations in Chapter 5), and MRI assessment of the cervical spinal cord for intrinsic injury and/or compression will accomplish this goal. Many of these patients may require management in the intensive care unit setting (see recommendations in Chapter 7) for monitoring and treatment of cardiac, pulmonary, and blood pressure disturbances. Blood pressure augmentation to mean arterial blood pressure levels of 85 to 90 mm Hg may be of benefit (see recommendations in Chapter 8). Early reduction of fracture or fracture-dislocation injuries should be accomplished (see recommendations in Chapter 20). Administration of pharmacological agents may be of benefit according to specific parameters (see recommendations in Chapter 9). Surgical decompression of the compressed spinal cord, particularly if the compression is focal and anterior and is approached anteriorly, seems to be of benefit in selected patients.

## KEY ISSUES FOR FUTURE INVESTIGATION:

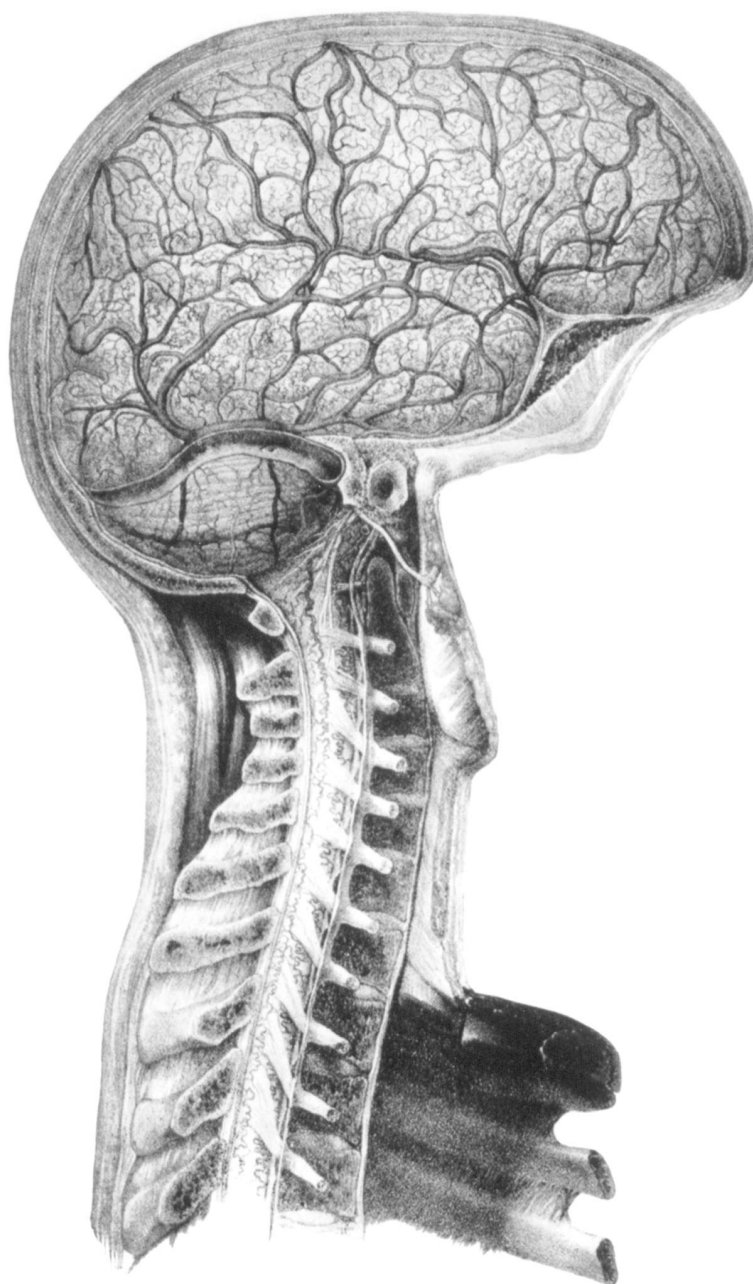
A prospective, controlled, randomized investigation of patients with acute central cervical spinal cord injuries treated with aggressive medical therapy alone (intensive care unit management, blood pressure augmentation, closed fracture-dislocation reduction), compared with patients managed with aggressive medical therapy *and* early surgical decompression of the spinal cord, is needed.

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