Original Article

The Efficacy of Non-operative and Operative Intervention in Regards to Motor Recovery in the Setting of Cervical Spinal Cord Injury

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Objective: An assessment of nonoperative and operative intervention in regards to neurological improvement following traumatic closed cervical spinal cord injury (CSCI).
Method: A retrospective evaluation of a cohort of patients with a CSCI from C3 to T1 was reviewed. The analysis included a total of 13 eligible patients. The neurologic and functional outcomes were recorded from the acute hospital admission to the most recent follow-up. Data included patients' age; level of injury, neurologic exam according to the Frankel grading system, the performance of surgery, the mechanism and timing of the CSCI decompression, and motor index score (MIS).
Results: Ninety-two percent of the patients were male with the mean age of 28.2 ± 11.5. Before treatment, 10/13 patients (77.0%) had functionally complete neurological deficits below the level of injury. The median interval from injury to surgery was 16 days. Eight patients underwent surgical intervention and five were treated nonoperatively. The median length of follow-up was 14 months after surgery (Range: 7 - 93 months). Spinal cord functional improvement was observed in 2/8 (25%) of the surgically managed patients and in 4/5 (80%) of the patients treated nonoperatively. Root recovery was observed in 6/8 (75%) of the patients who were treated surgically and 4/5 (80%) of the patients treated nonoperatively.
Conclusion: Some degree of motor score improvement occurs following a closed cervical spinal cord injury with or without operative surgery in the follow up period.

Key words: *Cervical, Decompression, Spinal cord injury, Surgery*

Iran J Psychiatry 2009; 4: 131-136

The role and timing of surgical decompression after an acute spinal cord injury (SCI) remains one of the most controversial topics pertaining to spinal surgery (1–5). Blunt spinal trauma complicated by injury to the cervical spinal cord most frequently occurs in young male patients (6, 7). Lack of controlled, prospective, multicenter clinical studies has contributed to confusion in optimal treatment methods for patients with injuries of the cervical spinal cord. The cervical spinal cord is vulnerable to injuries caused by high-energy motor vehicle collisions and falls (8 – 11). Tator et al., showed that agreement among experienced trauma centers is inconsistent with regards to the type and timing of treatment in cervical spine injuries associated with a neurologic deficit. 23.5% of surgeons surveyed operated on cervical spinal cord injury patients within 24 hours postinjury, 15.8% operated between 25 and 48 hours postinjury, 19% between 48 and 96 hours, 41.7% chose to intervene surgically more than 5 days postinjury (12).

The formulation of a treatment plan for patients with injuries to the cervical spinal cord depends on the presence and extent of neurologic injury and existing spinal stability. Both nonsurgical and surgical treatment options are available to achieve the goals of preservation of neurologic function and restoration of spinal stability (7). To date, the role of decompression in patients with incomplete SCI is only supported by Class III and limited Class II evidence (7, 13). Due to the absence of scientific literature examining injuries specific to the cervical spinal cord, a retrospective pilot study was undertaken to access the efficacy and potential morbidities related to the surgical management (decompression and stabilization) of these injuries. This investigation will serve as a foundation for future prospective multicenter studies evaluating the safety and efficacy of surgical intervention in neurologically and mechanically unstable injuries to the cervical spinal cord.

Materials and Method

Between October 1994 and March 2005 a total of 108 patients with a blunt traumatic spinal cord injury were identified at a regional level I trauma in southeastern Iran. Of these patients a subset was identified in which: 1) a neurological deficit was attributable to a traumatic cervical spinal cord injury between C3 to T1; 2) follow-up was a minimum of 6 months; and 3) the

cervical spinal cord injury was due to an acute non penetrating traumatic event with radiographically documented cord compression due to cord encroachment by anterior vertebral body elements, disk material, or posterior vertebral elements as a result of a fracture subluxation or dislocation .
Patients were excluded if: 1) their neurologic deficit was associated with a preexisting spinal cord abnormality or disease process (e.g., multiple sclerosis or preexisting myelopathy as a result of severe spondylosis without trauma); 2) they could not actively participate in the follow up neurologic examination process; or 3) there were inadequate follow-up data available.

Data Collection
Data collected included: patients' age, sex, mechanism of injury, associated injuries, imaging studies documenting the spinal injury, admitting and follow-up Frankel grade and motor index score, time interval from injury to arrival at the Khatam-ol-anbia Emergency Department and to surgical decompression and stabilization, and the type of surgical procedure.

Neurologic Evaluation
Motor and sensory examinations (Frankel grade and motor index score) were performed at admission, daily during the acute hospitalization, and at all follow-up outpatient encounters. Patients were assigned an initial motor index score which included manual muscle test scores of all the key muscles, sensory examination (prick and touch), sacral and deep tendon reflexes, and muscle tone evaluation. Sensory level was recorded as the most caudal dermatomal level of bilateral intact sensation.

Treatment
Standard spinal immobilization and resuscitation were implemented by emergency medical personnel. All patients were prescribed intravenous methylprednisolone (30 mg/kg IV bolus over 15 minutes followed 45 minutes later by a 5.4 mg/kg/hr intravenous infusion over 23 hours) if they arrived to the emergency room within 8 hours of the accident (14). All patients underwent preoperative myelography, CT and/or magnetic resonance imaging. Patients with image documented spinal cord compression (from vertebral bony elements), spinal malalignment (subluxation or dislocation), or epidural hematoma were candidates for surgical decompression and spinal column stabilization. The determination of the type of treatment (i.e. nonoperative verse operative intervention) was determined by the discretion of the treating physician. The surgical approach was determined by the location of cord compression and the type and degree of spinal instability. Adequacy of decompression was determined by postoperative CT and magnetic resonance (MR) imaging (15). Nonoperatively treated patients were immobilized in a halo vest orthosis or hard collar until bony union or stability was obtained.
Statistical analysis was performed using SPSS-11.5 software application .

Outcome assessment
A patient was considered to have an excellent result if they became a household or community ambulatory or had marked improvement in ambulatory status. A good outcome was recorded if there was recovery of one or more motor-root levels in the lower extremities or partial recovery of multiple levels. A fair result was recorded if there was partial improvement of one or two motor-root levels and a poor result demonstrated no cord or root improvement.

Results
Thirteen patients satisfied the inclusion and exclusion criteria for this study (Table 1). Before treatment, 10/13 patients (77.0%) had a functionally complete (Frankel A) neurological deficit below the level of spinal injury.
The patients' mean age was 28.2±11.5, and 92.0% of the patients were male. The most frequent levels of spinal injury were C-5, and C-6 and the most frequent mechanism of injury was a motor vehicle accident. The median time interval from injury to surgery was 16 days with a range of 9.5 hrs to 180 days. The length of the follow-up ranged from 7 to 93 months with a median time period of 14 months after surgery. The primary indications for surgery were documented spinal cord compression in the setting of a neurologic complete deficit and instability. No significant difference was observed in age, associated injuries, medical comorbidities, type or degree of bony, ligamentous or neurologic injury between the patients treated operatively or nonoperatively. An anterior cervical decompression and bone fusion was the most common surgical procedure performed. Job distribution from most to less frequent were unemployed, member of staff, student, worker, housewife, driver and farmer, respectively.
Spinal cord functional improvement was observed in 2/8 (25%) and 4/5 (80%) of the patients who underwent surgery and nonoperative management, respectively. Root recovery was observed in 10/13 (77%) of the patients. Root recovery was seen in (6/8) 75% of the patients who underwent surgery and (4/5) 80% of the patients who underwent nonoperative management .
Overall, some degree of motor functional improvement was observed in (3/8) 37.5% of the surgically managed patients and (5/5) 100% of the nonoperatively managed patients.
A mean improvement of 1 Frankel grade was seen in the entire study population (13 patients).
Surgically managed patients improved an average of 0.63 Frankel grades. Nonsurgically managed patients improved an average of 1.60 Frankel grades (Table 2).

Table 1. Ptient Data by Frequency

Variable		# (percent)
Sex	F	1 (7.7)
	M	12 (92.3)
Level of injury	C5	4 (30.8)
	C6	3 (23.1)
	C4	2.5 (19.2)
	C7	2 (15.4)
	C3	1 (7.7)
	T1	0.5 (3.8)
Mechanism	Car accident	6 (46.1)
	Motorcycle	2 (16.7)
	Fall	1 (7.7)
	Not documented	3 (23.1)
Procedure	Anterior cervical decompression and bony fusion	5 (62.5)
	Anterior cervical decompression, bony fusion with instrumentation	2 (25.0)
	Posterior open reduction, spinous process wiring and bony fusion	1 (12.5)
Spinal Cord Injury	Complete	10(76.9)
	Incomplete	3 (23.1)
Result	Excellent	3(23.1)
	Good	8(61.5)
	Fair	0(0.0)
	Poor	2(16.7)

F=female; M=male

Table 2. Breaking down nonoperative and operative treatment groups and the improvement in Frankel grade and MIS

Treatment groups	Improvement in Frankel grade	Improvement in MIS	Number of patients
Nonoperative	1.6	43.0	5
Operative	0.63	13.3	8
Overall	1	25.9	13

There was overall average motor index score (MIS) improvement of 25.9 points in the entire study population. Surgically managed patients improved an average of 13.3 motor points; and nonoperatively managed patients improved an average of 43 motor points (Table 2.)

The timing of surgery was not correlated with the type or degree of neurologic improvement. At the most recent follow up, all patients were noted to be healed clinically and radiographically.

Complications were recorded in 4 patients, two in each group, including two cases of symptomatic bed sores, one urinary tract infection, and one death at 48 months following injury due to an unknown cause.

Discussion

It appears from this limited retrospective study that some degree of functional motor improvement is observed in patients following a closed, blunt, cervical spinal cord injury. This was noted in (3/8) 37.5% of the patients who underwent surgery and in (5/5) 100% of the patients who underwent conservative management. Root recovery was observed in (6/8) 75% of the patients who underwent surgery and in (4/5) 80% of patients who underwent conservative management.

The efficacy or futility of surgical intervention could not be determined due to the limited size of this study although no apparent benefit was noted compared to the patients treated nonoperatively. What makes this study unique is that both groups of patients, operative and nonoperative, were well matched in terms of their neurologic deficits and injury severity. Due to the preferences of the attending surgeon, vastly different treatment recommendations for each group were chosen which allowed a comparison, albeit in a retrospective fashion, of the benefits of surgery over nonsurgery. Unfortunately, the timing of surgery may be the ultimate factor responsible for the potential for neurologic improvement and again that was not controlled for. A delay in surgical intervention may have negated any possible benefit of surgical intervention in a patient with a complete neurologic injury.

Mirza et al., compared early versus delayed surgery for acute cervical spinal cord injury. They showed that patients who sustain acute traumatic injuries of the cervical spine with associated neurologic deficit may benefit from surgical decompression and stabilization within 72 hours of injury (17).

Vaccaro et al., performed a prospective analysis evaluating neurologic outcome after early versus late surgery for cervical spinal cord trauma. Comparison of the two groups showed no significant difference in length of acute postoperative intensive care or inpatient rehabilitation stay, or improvement in American Spinal Injury Association grade or motor score between early (mean, 1.8 days) versus late (mean, 16.8 days) surgery(18).

Wagner and Chehrazi evaluated early decompression and neurological outcome in acute cervical spinal cord injuries. They showed that the timing of treatment had no significant effect upon admission status or percent of neurologic recovery. In their study, there was no significant difference in the percent of recovery between patients decompressed within 8 hours of injury or between 9 and 48 hours after injury. Their findings supported the notion that the initial injury to the cervical spinal cord appears to be the primary determinant of neurological outcome (19).

Heiden et al., reviewed 356 patients with incomplete cervical myelopathies due to trauma managed operatively or nonoperatively. 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 (20).

The vast majority of patients in this study had a complete spinal cord injury (10/13-77%) and therefore significant spinal cord functional recovery is not expected.

The efficacy of spinal cord decompression in animal models of spinal cord injury has overwhelmingly supported early surgical decompression over nonoperative or delayed surgical management (13, 21–30). There are seven prospective nonrandomized case series (Class II evidence) (31–37), one controlled, prospective, randomized trial (Class 1 evidence) (18) and several retrospective case series with historical controls (Class III evidence) which have addressed the role of spinal cord decompression in the setting of a contused and compressed spinal cord. None have shown an advantage to surgery in the setting of a complete spinal cord injury.

Waters et al., evaluated the effect of surgery on motor recovery following traumatic spinal cord injury. They showed that motor recovery did not significantly differ between patients categorized in various surgical subgroups or between those having surgery and those treated non-operatively (36).

The majority of published clinical studies on the management of cervical spinal cord injury are retrospective but generally support the findings of neurologic improvement (Lower extremity/ bowel and bladder) in nonoperatively and operatively managed patients with an incomplete spinal cord injury (38–42).

Papadopoulos et al prospectively examined 91 patients with cervical SCI, 32 of whom had immediate spinal cord decompression by traction alone. They suggested that patients who had decompression with closed reduction alone (mean time to decompression 6.0 hours) had better neurologic outcomes than those requiring surgical decompression (mean time to decompression 12.6 hours) (40).

In a retrospective review of 412 patients with traumatic, incomplete, cervical spinal cord injuries, Pollard et al., showed that the most important prognostic variable relating to neurologic recovery is the completeness of the lesion. When an incomplete cervical spinal cord lesion exists, younger patients and those with either a central cord or Brown-Sequard syndrome have a more favorable prognosis for recovery. In this study, no evidence was found to support high-dose steroid administration, routine early surgical intervention, or surgical decompression in stenotic patients without fracture (43).

Anderson and Bohlman followed complete traumatic quadriplegic patients treated with an anterior decompression and arthrodesis of the cervical spine. They noted improvement of nerve root function in the upper extremities and therefore the ability of the patients to care for themselves with surgical intervention (44). In incomplete traumatic quadriparesis, improvement was less in the patients whose operative decompression had been done more than twelve months after the injury (16).

Donovan et al., evaluated the neurological, bony and ligamentous healing outcomes in 113 patients with closed injuries to the cervical spinal cord. They found that the extent of neurological recovery did not depend on surgical versus nonsurgical management, or the degree of spinal angulation, vertebral displacement, spinal stenosis, or inferred mechanism of injury based on the initial plain cervical x-rays. The assessment of bony and ligamentous healing demonstrated a significantly less vertebral angulation and more rapid stabilization among the patients in the surgical group. In addition, the surgical treated patients had marginally shorter lengths of hospital stays (45).

Limitations of the study

There are a few limitations in this study which are as follows: a nonrandomized retrospective evaluation of a small cohort of heterogeneous patients with variable severity and location of the pathology and varied treatment and time to decompression surgery from a few hours to 180 days. The statistical analysis was not used to compare the two groups of operative and nonoperative treatment in this small sample of the 13 eligible CSCI patients.

Conclusion

Long term longitudinal studies are necessary to observe if relieving spinal cord pressure in these patients' subgroup will prevent late cystic degeneration of the spinal cord and possible loss of neurologic function.Some degree of neurologic return is to be expected with either nonoperative or operative intervention. Root recovery is more predictable than cord recovery. Only well performed controlled, prospective, randomized multicenter studies(46) will shed light on the potential benefits of the timing of intervention and the value of surgery in the management of traumatic cervical spinal cord injury.

Acknowledgements

This study was supported by grant number 644 of Zahedan University of Medical Sciences.

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