Acute Traumatic Cervical Central Cord Syndrome—Is Early Intervention Justified?

Rahul Saha[1] Sandip Chatterjee[1]

[1]Department of Neurosurgery, Park Clinic, Kolkata, West Bengal, India

Address for correspondence Rahul Saha, DNB (General Surgery), Department of Neurosurgery, Park Clinic, 4 Gorky Terrace, Kolkata 700017, West Bengal, India (e-mail: rahulsaha.cmc@gmail.com).

Indian J Neurotrauma 2018;15:94–99

Abstract

The clinical features suggestive of traumatic central cord syndrome (TCCS) were presented by Thorburn in his publication in 1887. Later in 1954, Schneider first mentioned the involvement of central cervical spinal cord after an acute cervical spine injury and described it as TCCS. This is generally caused due to an extreme hyperextension injury without vertebral damage and secondary to anteroposterior pinching or squeezing of the spinal cord. There exists a lot of controversy whether early surgical intervention is justified in these patients. It is to assess our own results that we decided to review 40 such cases treated by the senior author in the past 8 years. Twenty-four of these were managed with early surgical intervention (which we defined as within 48 hours), and 16 were treated conservatively. In all cases, the existence of fracture-dislocation, disc prolapse, as well as preoperative and postoperative Japanese Orthopaedic Association (JOA) scores and exact motor and sensory deficit were recorded. The numbers are too few, but there was definite evidence that patients with disc prolapse and fracture dislocation did better with surgery than with conservative treatment. Those with grade 0 power in the upper limbs however did significantly better with surgical treatment. Those with advanced pre-existing cervical spondylotic changes did better than those without these premorbid changes. However, the numbers are too small for meaningful statistical analysis. This is a retrospective study conducted as a pilot study to plan for a future randomized study, which is very necessary in our clinical practice. Currently, we still quote the pros and cons of surgical intervention to the relatives and go by their choice.

Keywords
- central cord syndrome
- early intervention
- spinal cord

Introduction

Traumatic spinal cord injury results in several syndromes among which traumatic central cord syndrome (TCCS) is the most common acute, incomplete spinal cord injury syndrome accounting for almost 70% of the cases.[1] About 20% patients with cervical spinal cord injury present with symptoms of acute TCCS.[2] The clinical features of central cord syndrome (CCS) were first described by Thorburn in his publication in 1887.[3] Later in 1954, Schneider et al first described the involvement of the central cervical cord in a case of cervical spinal cord injury and named it as TCCS.[4] It is clinically characterized by predominantly more motor weakness in the upper limbs (UL) than in the lower limbs (LL). Variable sensory diminution below the level of the lesion has been described. Bilateral decrease in pain and thermal sensations may occur due to involvement of the anterior white commissure giving rise to a cap distribution of sensory loss in the shoulders and UL. Sphincter disturbances may occur due to the involvement of the preganglionic autonomic neurons. Some reports have mentioned that a difference of 10 points in the American Spinal Injury Score (ASIA) between the upper and the LL is required to establish the injury as TCCS.[5] It has been documented that this syndrome occurs with a bimodal age distribution with young and elderly patients. In the young patients, it occurs due to high-energy trauma with

published online
July 23, 2019

DOI https://doi.org/10.1055/s-0038-1677637
ISSN 0973-0508.

or without a background of pre-existing canal stenosis. But in the elderly, it predominantly occurs due to hyperextension neck injuries in the setting of a pre-existing stenosed canal.[6,7] Taylor[8] and Schneider et al[4] have proposed that hyperextension of the cervical canal causes acute canal narrowing due to anterior protrusion of the ligamentum flavum with subsequent pinching effect of the cord. Initially Schneider attributed hematomyelia as the cause of CCS, but later studies by Quencer et al[9] found hematomyelia to be absent in most cases, rather they attributed the axonal lesions mainly to be caused by edema. Historically, the somatotopic organization of the corticospinal tract with more central location of the fibers of the upper extremities than those of the lower extremities has been thought to be the cause of significant UL involvement in CCS.[4,5]

Though Schneider initially advocated surgery as the treatment for this condition, after one of his patients became quadriplegic postoperatively, he subsequently managed his patients conservatively and noted that this disease had spontaneous recovery as the natural history. He concluded that surgical management was detrimental and unnecessary, and this philosophy guided the treatment protocol of CCS for 3 decades after that. It has been found that truly, most patients do improve initially. However the recovery is not complete and in most cases is not sustained. This late onset of neurological decline has been documented by Bosch et al[10] and Bose et al.[11] They also found that only 60% remained functional in the longer follow-up despite significant initial improvement. Several studies have demonstrated a favorable outcome with surgical intervention and early decompression.[11–13] Recent developments in anesthesiology and surgical techniques have made surgical decompression safer and very much feasible and beneficial for neurological outcome and prevention of late neurological deficits. Selection bias is an inherent problem in some of these studies. Fehlings and Perrin[14] and other studies[15,16] have suggested that urgent decompression is feasible and leads to improved outcomes in patients with progressive neurodeficits. What is "early" has not been strictly mentioned though in most studies 24 hours and in some 72 hours have been accepted as a time limit. The Surgical Timing in Acute Spinal Cord Injury Study (STASCIS) demonstrated recovery by > 2 ASIA grades in an additional 10% of cervical spinal cord injuries with surgery within 24 hours of injury.[17] However, it is very difficult to predict the expected neurological improvement that can be achieved with early intervention versus the inherent surgical risks to be encountered. Thus, till now, the management of CCS is controversial with large variabilities between different centers.

Material and Methods

Our study was a retrospective cohort analysis with prospective follow-up where we reviewed 40 consecutive patients who had been treated for TCCS by the senior author at a single institution, Park Clinic, Kolkata, India in the last 8 years between 2010 and 2018. Neurological examination and imaging confirmed the diagnosis. An inclusion criteria was a primary diagnosis of TCCS (defined as a cervical spinal cord injury producing disproportionately greater weakness in UL than in the lower limbs (LL) with variable degrees of sensory loss and bladder dysfunction). Magnetic resonance (MR) imaging was done in all cases except when it was contraindicated. In such cases, computed tomography (CT) scan was done. Demographics, mechanism of injury, and functional status were noted. Twenty-four patients were managed with early surgical intervention, which was defined as surgery within 48 hours of injury. Sixteen were managed conservatively. In each patient, fracture dislocation, disc prolapse, pre- and postoperatively modified Japanese Orthopaedic Association (JOA) score and exact motor and sensory deficits were recorded. Preoperative UL Medical Research Council (MRC) grading, LL MRC grading, JOA score, and Nurick grading were recorded and compared with postoperative follow-up at 6 months. Those patients who reached the hospital within 24 hours of injury received methyl prednisolone. Absolute indication for surgery was neurological deterioration with evidence of radiological compression and spinal instability. The timing of surgery depended on the duration after injury that the patient took to reach the hospital, neurological status, anesthetic fitness, expectation from the surgical outcome, and the relatives choice for opting either surgical intervention or go for conservative management after being explained in details about the pros and cons of each line of management. The choice of surgical approach depended on whether there was anterior or posterior compression and on the number of levels involved. Patients with single- or two-level anterior compression underwent anterior surgery, while those with three- or more level involvement and predominantly posterior compression underwent posterior decompression and fixation. In three cases with irreducible posterior subluxation, posterior and anterior decompression and fixation were performed. None of the patients were lost to follow up at 6 months.

Results

Amongst the 40 patients (►**Table 1**) whom we studied, 24 patients underwent surgical intervention, and 16 patients underwent conservative management. For analysis, we divided both the surgical and the conservative cohorts into two groups each—one having age < 40 years and the other having age > 40 years (surgical < 40 and > 40; conservative < 40 and > 40). In the surgical group, 17 (70.8%) patients' age was < 40 years (surgical < 40), and 7 (29.2%) patients' age was > 40 years (surgical > 40). In the surgical < 40 group, UL power improved by 1 Grade in 5 (29.4%) patients, by 2 or more grades in 11 (64.7%) patients, and did not improve in 1 (5.8%) patient. Lower limb (LL) power improved by 1 grade in 8 (47%) patients, by 2 or more grades in 2 (11.8%) patients, and remained same in 7 (41.2%) patients. JOA score improved by ≤ 2 grades in eight (47%) patients, by > 2 grades in eight (47%) patients, and remained unchanged in one patient (5.8%). Nurick grading showed improvement by 1 grade in eight (47%) patients, by 2 or more grades in seven (41%) patients, and remained unchanged in two (11.8%) patients. In

Table 1 Data on cervical spine: first 24 patients underwent surgery, and next 16 patients underwent conservative management

No.	Age	Sex	Disc prolapse	Fracture dislocation unilateral	Fracture dislocation bilateral	Upper limb (preoperative/ postoperative)	Lower limb (preoperative/ postoperative)	JOA	Nurick grade (preoperative/ postoperative)
1	34	M	Y	Y	N	2/3	4/4	11/13	3/2
2	29	M	N	N	N	3/ 3	4/4	10/11	3/3
3	37	F	N	Y	N	1/3	3/4	9/11	4/3
4	40	M	Y	Y	N	0/2	3/4	8/10	4/2
5	38	M	N	N	N	0/2	2/3	8/11	4/3
6	46	M	N	N	N	1/2	2/3	10/12	3/2
7	44	F	N	N	N	0/2	3/4	10/13	4/3
8	22	M	Y	N	N	2/4	3/4	12/16	3/1
9	19	M	Y	Y	N	2/4	3/4	13/15	3/2
10	32	M	N	N	N	1/2	3/3	11/12	3/2
11	36	F	N	N	N	2/3	4/4	14/15	3/1
12	16	M	Y	Y	N	0/3	3/4	10/15	3/1
13	31	F	N	N	N	1/2	3/3	11/8	3/3
14	48	M	Y	N	Y	2/4	3/4	10/16	3/1
15	23	F	N	Y	N	0/2	3/3	8/12	4/3
16	19	M	N	N	Y	1/3	2/4	10/15	3/1
17	54	M	N	N	N	2/	3/4	12/14	4/2
18	64	M	Y	N	N	0/3	2/4	10/14	3/1
19	22	F	Y	Y	N	0/3	2/4	9/13	4/1
20	20	M	N	N	Y	0/4	3/4	9/15	3/1
21	27	F	N	N	N	0/3	3/3	10/12	4/3
22	18	M	Y	Y	N	1/4	3/4	10/15	4/2
1	43	M	N	N	N	0/0	2/ 3	11/14	4/3
2	45	M	N	N	N	3/2	4/ 2	11/15	4/3
3	23	F	N	N	Y	3/3	3/4	9/10	4/3
4	38	M	N	N	Y	1/2	3/4	10/12	3/1
5	56	M	N	N	N	0/2	4/4	11/13	3/3
6	64	M	Y	N	N	2/3	3/3	11/12	3/3
7	57	F	N	N	N	0/1	3/3	10/13	4/3
8	60	M	Y	N	N	0/0	2/3	8/10	5/4
9	22	M	N	N	N	2/4	3/4	10/14	3/1
10	32	F	N	N	N	3/4	4/4	11/14	3/1
11	41	M	N	N	N	1/2	3/4	11/14	3/2
12	20	M	Y	N	Y	3/4	3/4	10/14	3/1
13	34	F	N	N	Y	0/1	2/3	9/12	4/3
14	22	M	N	N	N	0/0	2/2	9/10	4/4
15	34	F	N	N	N	1/3	3/4	10/13	3/2
16	23	M	N	N	N	0/0	3/3	10/11	4/3

Abbreviations: a, preoperative; b, postoperative; F, female; JOA, Japanese Orthopaedic Association; m, male; N, no; No., number; Y, yes.

the surgery > 40 group, UL power improved by 1 grade in two (28.6%) patients and by more than 2 grades in five (71.4%) patients. LL power improved by grade 1 in six (85%) patients and by more than 2 grades in one (15%) patient. JOA score improved by 2 or less grades in six (85%) patients and by more than 2 grades in one (15%) patient. Nurick grading improved by 1 grade in two (28.5%) patients and by 2 or more grades in five (72%) patients. In the conservative cohort, 10 (62.5%) patients were < 40 years of age, and the remaining 6 (37.5%) were > 40 years of age. In the conservative < 40 group, UL power improved by 1 grade in four (40%) patients and by 2 or more grades in two (20%) patients and remained unchanged in 4 (40%) patients. LL power improved by 1 grade in seven (70%) and remained unchanged in the remaining three (30%)

patients. Six (60%) patients had improvement in JOA score by 2 or less grades, three (30%) improved by more than 2 grades patients, and 1 (10%) patient remained unchanged. In this group, eight (80%) patients had improvement in their Nurick grading, while two (20%) patients remained unchanged. In the conservative > 40 group, three (50%) patients had grade 1 improvement in UL power, one (17%) patient had improvement by 2 grades, and two (33%) patients remained unchanged. LL power improved by 1 grade in two (33%) patients, but remained unchanged in the remaining four (66%) patients. JOA score improved in all six patients, by ≤ 2 score in four patients (67%), and > 2 scores in the remaining two (33%) patients. Nurick grade improved in four (67%) patients and remained unchanged in two (33%) patients. Among the surgical cohort, 15 patients had focal lesions in radiological imaging, while 9 did not have any radiological lesion. Of the 15 patients with focal lesions, all showed improvement in JOA and Nurick grading after 6 months. Of the nine patients with no radiological evidence of focal compression, seven (78%) patients had improvement in Nurick grading, and eight (89%) patients had improvement in JOA score. Thus, among those also who had no compressive lesion in radiology, a significant number improved with surgical intervention, and those with evidence of radiological compression definitely improved with surgical intervention. Among the < 40 years age group, the surgical cohort had significant improvement in JOA score (94%) and in Nurick scale (88%) at 6 months' follow-up, while in the conservative cohort, 90% had improvement in the JOA score, and 80% improved in Nurick grade. In this age group in the surgical cohort, UL power improved in 94% of patients and LL power in 59% patients. This is a better outcome in comparison to the conservative cohort where improvement in UL power was documented in only 60% and in LL power in 70% patients (►**Fig. 1**). In the > 40 years age group, the difference was more prominent as, in comparison to the conservative cohort, which showed UL power improvement in 67% and LL improvement in 33%, the surgical cohort showed improvement in the power of UL and LL in each and every patient (►**Fig. 2**). Nine patients in the surgical cohort and six in the conservative cohort had preoperative power zero in the UL. While all nine (100%) patients with initial power zero in the UL improved by 1 or 2 grades in the surgical cohort, only three (50%) out of six in the conservative cohort showed any improvement in UL motor power at 6-month follow-up (►**Fig. 3**). Thus, in a nutshell, patients with evidence of disc prolapsed or fracture dislocation undoubtedly fared better with surgery than conservative treatment. Even those without any evidence of anatomical lesion fared significantly better with surgical intervention (►**Fig. 4**). Those with grade 0 power in UL did better with surgery than with conservative management. However the numbers are too small for a reasonably detailed statistical analysis.

Discussion

The incidence and prevalence of incomplete spinal cord injury is on the rise probably due to ever-increasing fast-paced lifestyle and ill-regulated traffic rules. Among incomplete spinal cord injury, a large fraction comprises of what is defined by Schneider as CCS. It is a potentially disabling condition caused predominantly by hyperextension injury of the cervical spine. Hematomyelia, edema, and Wallerian degeneration all have been implicated to cause damage to the central part of the cervical spinal cord.[4,9,18] Direct trauma to the lateral corticospinal tract has been implicated in some studies to be the cause of CCS.[9,19] Though high-velocity trauma to the cervical spine is the main cause in young people, but on the other hand, most elderly people presenting with features of

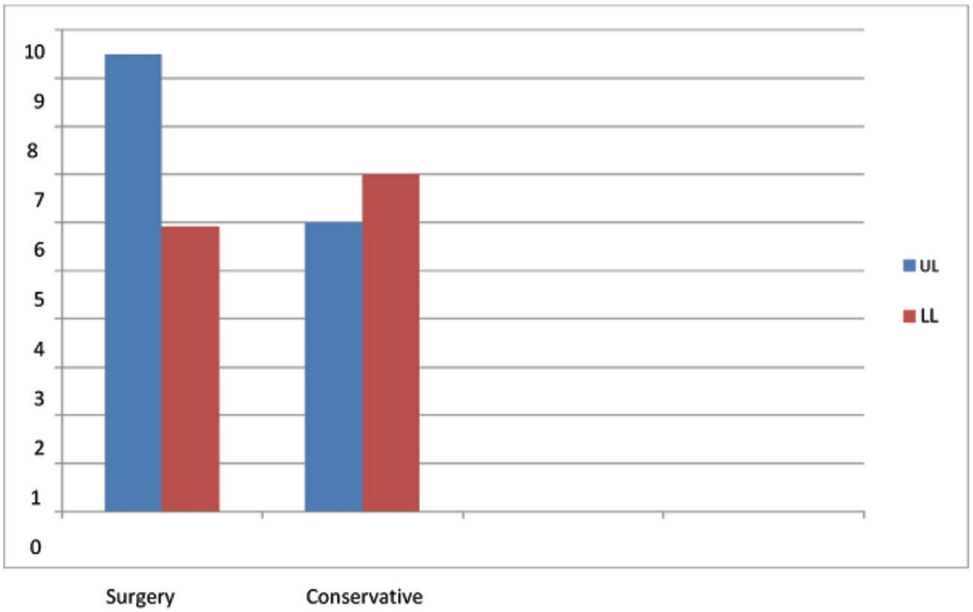

Fig. 1 Improvement in UL and LL power in the two cohorts in the age group < 40 years. *y*-Axis is represented as percentage. LL, lower limb; UL, upper limb.

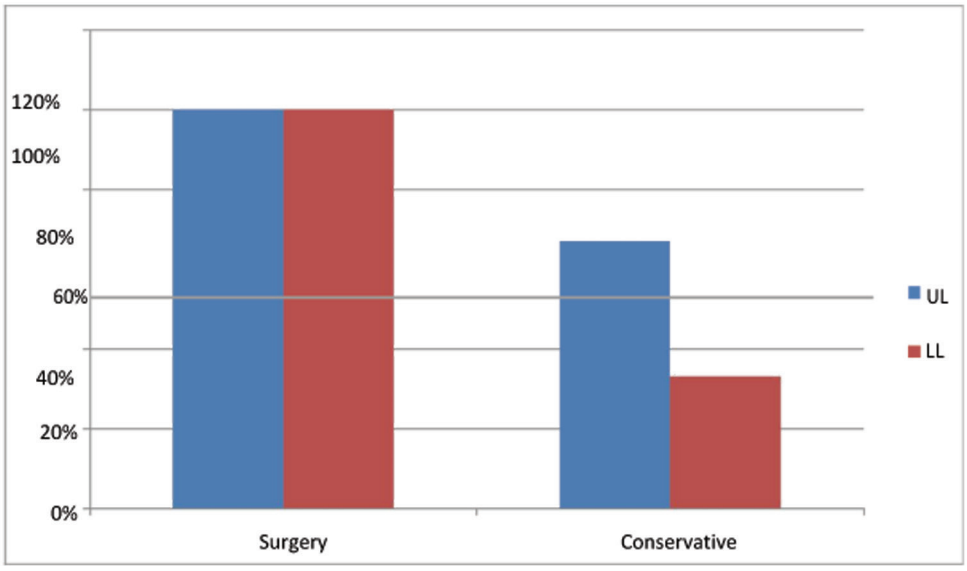

Fig. 2 Improvement in UL and LL power in the two cohorts in the age group > 40 years. LL, lower limb; UL, upper limb.

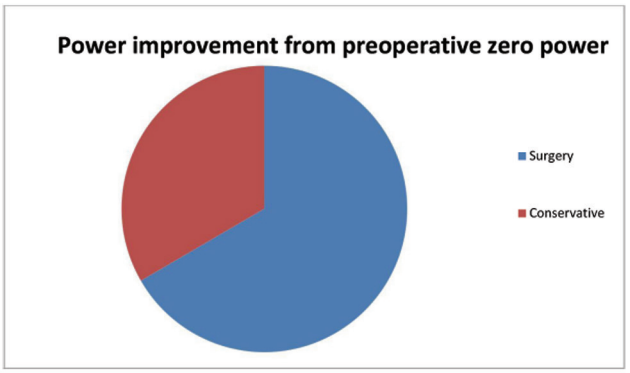

Fig. 3 Improvement in power in the two cohorts from those patients who had no power in upper limbs at presentation.

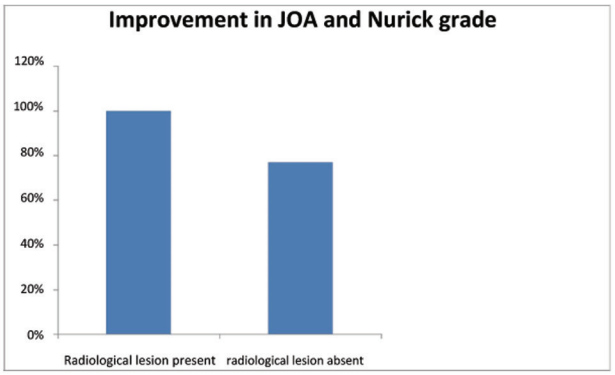

Fig. 4 Improvement in JOA and Nurick grade in relation to preoperative presence or absence of radiological evidence of lesion. JOA, Japanese Orthopaedic Association.

CCS have a pre-existing canal stenosis with cord compression, which gets exaggerated after the injury. The clinical picture comprises of significantly more weakness of the UL than the lower and variable degrees of sensory and bladder involvement. Different literature reviews have shown that, in most cases, the natural history of patients with CCS is of spontaneous neurological improvement. Younger patients show better recovery. But literature has also shown that in a subset of patients, the improvement becomes static after first 3 weeks or so, and also in some patients, there is evidence of late neurological deterioration. It is very difficult if not near impossible to predict the course of functional and neurological outcome at the time of presentation. Recent improvements in the surgical equipments and techniques have made surgical intervention feasible and safe for CCS. Various authors have documented that surgical intervention has two potential advantages over conservative management. First, improved neurological recovery achieved after early decompression of the cord and nerve roots permits earlier rehabilitation and second stable spinal fixation prevents further spinal cord injury and further deterioration. Early cervical orthotics and medical management such as volume restitution and normalization of blood pressure are important to maximize the chances of neurological improvement in cases of CCS by preventing the cascade of secondary injury. Non-surgical treatment can be advocated for those with mild CCS, though with full knowledge that there would be chances of persistence of neurodeficits and development of new spasticity in some cases.[10] Surgical decompression is favorably advised to patients with deteriorating neurology and in those in whom a focal anatomical cause for compression is identified radiologically.[5,14] Another important aspect in the management is the timing for intervention. While a few reports such as those of Aarabi et al,[5] Stevens et al,[21] etc. mention that the timing of intervention does not have significant impact on neurological outcome after surgery, but most authors such as Fehlings and Perrin,[14] La Rossa et al,[22] Guest et al,[15] and Papadopoulos et al,[16] etc. have suggested that early surgical intervention, i.e., surgery done in < 48 hours of injury in most cases, is definitely associated with better neurological outcomes. Park et al have reported that early and delayed

surgical intervention has no difference in outcome at 1-year follow-up though there was significant difference at more than 1-year follow-up where the early intervention group did significantly better in terms of functional ability.[23] Our small institutional study has limitations such as fewer number of cases, retrospective analysis, and need for a longer follow-up period, preferably for 3 years. This study is planned as a pilot study to plan for a future randomized study, which is very essential in our clinical practice. Till the time we come to a clear guideline for the management of this tricky condition, our institutional protocol is to explain the pros and cons of both surgical intervention and conservative management of CCS and go by the choice of the patients' relatives.

Conflicts of Interest
None.

Acknowledgment
No benefit in any form has been received from a commercial party related directly or indirectly to the subject of this article.

References

1 McKinley W, Santos K, Meade M, Brooke K. Incidence and outcomes of spinal cord injury clinical syndromes. J Spinal Cord Med 2007;30(3):215–224
2 Winston F, Eismont FJ. Controversies in the treatment of central cord injuries. Spine Surg 2007;19(4):260–271
3 Thorburn W. Cases on injury to the cervical region of the spinal cord. Brain 1887;9:510–543
4 Schneider RC, Cherry G, Pantek H. The syndrome of acute central cervical spinal cord injury; with special reference to the mechanisms involved in hyperextension injuries of cervical spine. J Neurosurg 1954;11(6):546–577
5 Aarabi B, Hadley MN, Dhall SS, et al. Management of acute traumatic central cord syndrome (ATCCS). Neurosurgery 2013;72(Suppl 2):195–204
6 Harrop JS, Sharan A, Ratliff J. Central cord injury: pathophysiology, management, and outcomes. Spine J 2006;6(6, Suppl):198S–206S
7 Ishida Y, Tominaga T. Predictors of neurologic recovery in acute central cervical cord injury with only upper extremity impairment. Spine 2002;27(15):1652–1658, discussion 1658
8 Taylor AR. The mechanism of injury to the spinal cord in the neck without damage to vertebral column. J Bone Joint Surg Br 1951;33-B(4):543–547
9 Quencer RM, Bunge RP, Egnor M, et al. Acute traumatic central cord syndrome: MRI-pathological correlations. Neuroradiology 1992;34(2):85–94
10 Bosch A, Stauffer ES, Nickel VL. Incomplete traumatic quadriplegia. A ten-year review. JAMA 1971;216(3):473–478
11 Bose B, Northrup BE, Osterholm JL, Cotler JM, DiTunno JF. Reanalysis of central cervical cord injury management. Neurosurgery 1984;15(3):367–372
12 Chen TY, Dickman CA, Eleraky M, Sonntag VK. The role of decompression for acute incomplete cervical spinal cord injury in cervical spondylosis. Spine 1998;23(22):2398–2403
13 Chen TY, Lee ST, Lui TN, et al. Efficacy of surgical treatment in traumatic central cord syndrome. Surg Neurol 1997;48(5):435–440, discussion 441
14 Fehlings MG, Perrin RG. The timing of surgical intervention in the treatment of spinal cord injury: a systematic review of recent clinical evidence. Spine 2006;31(11, Suppl):S28–S35, discussion S36
15 Guest J, Eleraky MA, Apostolides PJ, Dickman CA, Sonntag VK. Traumatic central cord syndrome: results of surgical management. J Neurosurg 2002;97(1, Suppl):25–32
16 Papadopoulos SM, Selden NR, Quint DJ, Patel N, Gillespie B, Grube S. Immediate spinal cord decompression for cervical spinal cord injury: feasibility and outcome. J Trauma 2002;52(2):323–332
17 Fehlings MG, Vaccaro A, Wilson JR, et al. Early versus delayed decompression for traumatic cervical spinal cord injury: results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS). PLoS One 2012;7(2):e32037
18 Jimenez O, Marcillo A, Levi AD. A histopathological analysis of the human cervical spinal cord in patients with acute traumatic central cord syndrome. Spinal Cord 2000;38(9):532–537
19 Levi ADO, Tator CH, Bunge RP. Clinical syndromes associated with disproportionate weakness of the upper versus the lower extremities after cervical spinal cord injury. Neurosurgery 1996;38(1):179–183, discussion 183–185
20 Dahdaleh NS, Lawton CD, El Ahmadieh TY, et al. Evidence-based management of central cord syndrome. Neurosurg Focus 2013;35(1):E6
21 Stevens EA, Marsh R, Wilson JA, Sweasey TA, Branch CL Jr, Powers AK. A review of surgical intervention in the setting of traumatic central cord syndrome. Spine J 2010;10(10):874–880
22 La Rosa G, Conti A, Cardali S, Cacciola F, Tomasello F. Does early decompression improve neurological outcome of spinal cord injured patients? Appraisal of the literature using a meta-analytical approach. Spinal Cord 2004;42(9):503–512
23 Park MS, Moon SH, Lee HM, et al. Delayed surgical intervention in central cord syndrome with cervical stenosis. Global Spine J 2015;5(1):69–72