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Original Article

Early Surgical Decompression versus Medical Treatment in Acute Traumatic Central Cord Syndrome: Prospective Randomized Controlled Study

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BACKGROUND: Traumatic central cord syndrome was first described by Schneider and colleagues as a spinal cord injury in 1954. Other definitions were not apart from the fact of greater weakness of upper limbs than lower limbs. Surgical treatment was mentioned frequently for plateaued neurological insult.

OBJECT: This study aimed to examine the functional outcome of early surgical decompression for acute traumatic central cord syndrome.

METHODS: After gaining ethical approval, 37 patients with acute traumatic central cord syndrome (ATCCS) were randomized into two groups, (medical and surgical group). The medical group was treated by intravenous fluids, neurotonics, and high doses of steroids. The surgical group was treated by laminectomy of the affected levels and duraplasty with fascia lata. The American Spinal Injury Association (ASIA) impairment scale, the incidence of neuropathic pain, urinary symptoms, and hospital stay were tested.

RESULTS: It has been found that both the surgical group and the conservative group had a great improvement in ASIA motor function score with a highly statistically significant difference (<0.001) at 3 months follow up. Neuropathic pain showed more improvement in the surgical group and reached a dramatic response at the final visit. Urine retention declined in prevalence at discharge and the final visit was not dramatic. Hospital stay exhibited lengthy admission in the conservative group than the surgical group (p<0.0001).

CONCLUSION: Surgical decompression offers clinical improvement that might be superior to medical treatment. The decision of surgery should be closely disclosed with patients' family and relatives.

KEYWORDS: Central cord syndrome, spinal cord injury, hyperextension injury.

INTRODUCTION

Traumatic central cord syndrome was first described by Schneider and colleagues as a spinal cord injury (SCI) in 1954.[1] The exact definition of it is “disproportionately more motor deficit of the arms, especially the hands, than the legs, bladder dysfunction and varying degrees of sensory loss below the lesion”.[2–4] Other definitions were not apart from the fact of the greater weakness of upper limbs than lower limbs.[4–6] With both definitions, sacral sparing is always highlighted. Urinary retention is the usual bladder abnormality as part of the spectrum. This made it different from other incomplete cervical cord injuries like Brown-Sequard syndrome, posterior or anterior cord syndrome, or differently located lesions like cauda equina syndrome.[7]

The mechanism of injury is always a hyperextension injury to the cervical spine.[6] The most frequent example is anterior to posterior compression force to the cervical spine. The presence of bony spur (osteophyte) or preexisting canal stenosis may facilitate the possibility of injury.[8–10] Somatotopic distribution of nerve fibers in descending corticospinal tract (CST) is responsible for this discrepancy in motor weakness presentation.[11,12]

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Management of acute traumatic central cord syndrome (ATCCS) is started in the field of injury by providing neuroprotection and prevention of secondary injury. Medical treatment consists of providing good hydration and preventing the decrease in preload as well as methylprednisolone administration.[4] Surgical treatment of ATCCS is controversial; Brodkey and colleagues assessed 7 patients who underwent decompressive duraplasty for ATCCS.[13] Surgical treatment was mentioned frequently in the past not as an early as possible strategy, but as a strategy for plateaued neurological insult.[3,14,15]

This study aims to evaluate the functional outcome of early surgical decompression for ATCSS.

METHODS

Study Criteria

This was a prospective randomized controlled interventional trial conducted on 37 patients over 16 months (from April 2018 to August 2019). Cases were diagnosed with traumatic central cord syndrome (CCS) in patients with the exact definition of discrepancy in motor weakness between upper and lower limbs. Ethical approval was obtained by our institutional review board (IRB). Patients with cervical disc herniation, other clinical incomplete spinal cord syndromes (Brown-

Sequard, anterior cord syndrome, and posterior cord syndrome), complete spinal cord injury, death prior final visit assessment, grade E & D on ASIA score or presenting after 24 hours of trauma were excluded from this study.

Randomization

Cases were randomized into two groups; conservative group and surgical group. The conservative group included 22 patients with ATCCS who received medical treatment only in form of intravenous (IV) fluids and high doses of corticosteroids. The surgical group included 15 patients who underwent laminectomy and decompressive duraplasty (from fascia lata graft). The study conformed to the Consolidated Standards of Reporting Trials (CONSORT) flow chart in **Fig. 1**

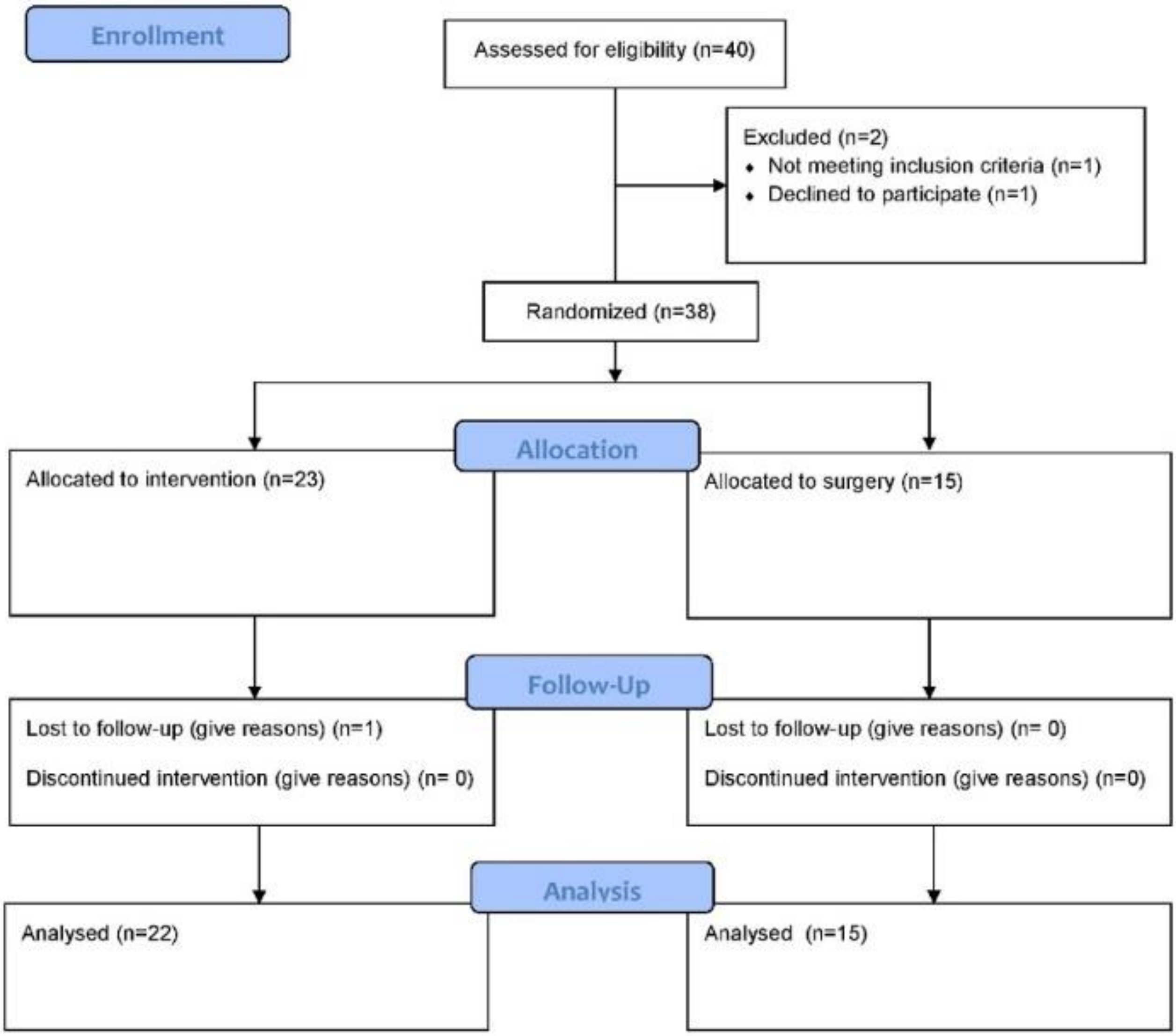

Fig 1: CONSORT flow chart for patient allocation.

Surgical Intervention

As regards the surgery group, laminectomy and decompressive duraplasty were the main steps in the surgery group. The steps of the definitive technique are described elsewhere.

Study Outcomes

American Spinal Injury Association (ASIA) impairment scale was examined at the time of admission, at discharge, and 3-month intervals. Other parameters were tested like bladder dysfunction and neuropathic pain at admission, discharge, and at the final visit. The hospital stay was also evaluated between the two groups including the intensive care unit (ICU) stay period.

Statistical Analysis

Frequency distribution, hypotheses testing, and regression analysis were all done by the Statistical Package for the Social Sciences (SPSS version 25).

Student t-test was used to compare means of numerical variables.

RESULTS

General Criteria

Study demographics are illustrated in **Table 1.** There was no statistically significant difference between both groups as regard age (p value = 0.677) and sex (p value = 0.51). As regards extra cervical spine injuries, in the surgical group there were 2 cases of pelvic fracture (treated conservatively), 3 cases of clavicular fracture, 4 cases with traumatic brain injury (TBI) of mild-moderate scale and one case exhibited pneumothorax. In the medical group, upper limb fractures were found in 6 cases, hemothorax and critical head injury was seen in 4 cases. Diabetes mellitus was seen in 2 cases in the surgical group and 5 cases in the medical group. Hypertension was seen in 3 cases in the medical group with no case registered in the surgical group.

Table 1: Study criteria

Item	Surgical Group (15)	Conservative Group (22)
Age (Mean±SD) years	48.8±2.4	52.1±2.7
Sex (male)	9/15	14/22
Mode of Injury		
-FFH	-5	-4
-Pedestrian	-3	-4
-Car driver	-7	-14
Associated cervical Spine injury		
-axial	-2	-3
-subaxial	-3	-6

In the surgical group, C3-4 was the most prominent level (4/15) while C4-5 was more prevalent in the other group (7/22) as shown in **Table 2**. Instability was diagnosed in 9 cases out of 15 cases in the surgical group which was later treated by lateral mass fixation.

On the other side, instability was found in 10/22 cases which mandates external immobilization by Philadelphia neck collar.

ASIA Impairment Scale

The distribution of cases in either group according to the ASIA scale is best illustrated in **Table 3**. The ASIA motor function was coded into a numerical value. It has been found that both the surgical group and the conservative group had great differences in ASIA motor function score with highly statistically significant difference (<0.001) at 3 months follow up **(Fig. 2)**. However, the conversion from A to C was seen more often in surgical group than the conservative one (20% vs. 13.6%) with a greater statistically difference (p=0.001) in favor of surgical decompression.

Table 2: Affected Cord Levels data

Item	Surgical Group (15)	Conservative Group (22)
C1-2	1	2
C2-3	2	2
C3-4	4	5
C4-5	3	7
C5-6	3	2
C6-7	1	1
C7-8	1	1
C8-T1	0	2
2 levels	2	2
3 levels	1	3
Evidence of instability	9/15	10/22

Prevalence of Neuropathic Pain and Urine retention

As regards neuropathic pain, both groups had a near equal prevalence of pain on admission (around 30-35%), but they decreased after either intervention with more declining at the surgical group and reached dramatic response at the final visit **(Table 4)**. Urine retention was present at admission in nearly half of each group; the declining in the prevalence at discharge and at the final visit was not dramatic.

Hospital Stay

According to **Fig. 3**, the hospital stay is composed of both ICU and in-ward admission. The mean and standard deviation (SD) of hospital stay (days) of surgical and conservative groups were (9.4±2.1 and 19.9±4.4) days, respectively. By using student t-test, comparing both means, there was a statistically significant difference in hospital stay with lengthy admission in the conservative group than surgical group (p<0.0001).

DISCUSSION

In this study, functional assessment by the ASIA impairment scale showed a statistically significant improvement in both groups, with better and earlier recovery in the surgical group. Neuropathic pain recovered earlier in the surgical group with better rates of improvement than the conservative group, both at discharge and at 3 months postoperatively. Urinary abnormality showed minimal improvement in both groups. The duration of hospital stay (in-ward and ICU) was much shorter in the surgical group than in the medical group (p<0.05).

The patients' age and sex were homogenously distributed between both groups with no statistically significant difference. Older age was a poor prognostic factor in SCI in general.[15–18] In this study, older patients had poor clinical outcomes at short and relatively remote intervals. Aarabi and coworkers reported early clinical improvement (motor) in the patients under 60 years old.[7] Liu et al. stated better neurological outcomes in younger patients if compared to older ones with the

Table 3: ASIA scores of both group

ASIA score of the conservative group (22)			
	Admission	**Discharge**	**3 months**
ASIA A	4 (18.18%)	3 (13.63%)	3 (13.63%)
ASIA B	8 (36.36%)	7 (31.81%)	6 (27.2%)
ASIA C	10 (45.45%)	12 (54.5%)	13 (59%)
ASIA score of the studied surgical group (15)			
	Admission	**Discharge**	**3 months**
ASIA A	3 (20%)	3 (20%)	2 (13.3%)
ASIA B	5 (33.3%)	4 (26.6%)	3 (26.6%)
ASIA C	7 (46.6%)	8 (53.2%)	10 (66.6%)

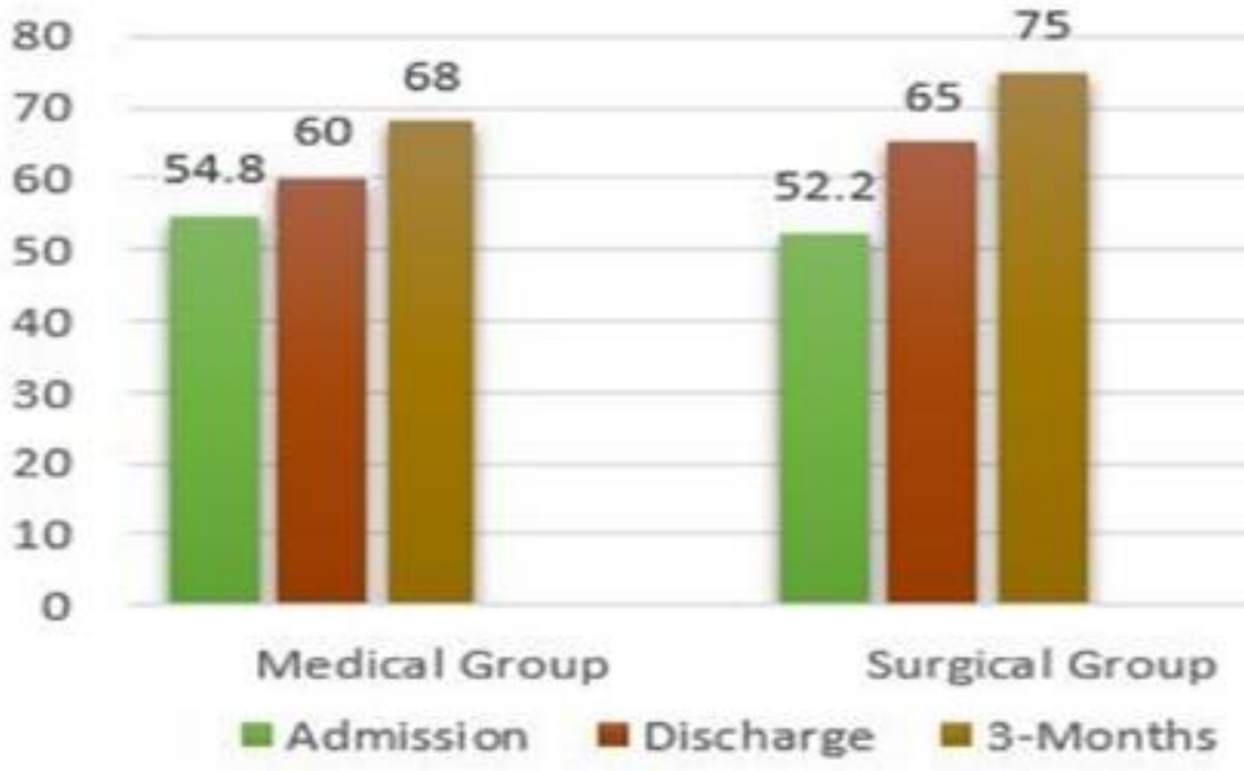

Fig 2: Comparison in ASIA motor function between groups.

Table 4: Prevalence of neuropathic pain and urine retention in both groups at all intervals

	Admission	Discharge	3 months
Neuropathic Pain			
Surgical Group	5 (33.3%)	2 (13.3%)	1 (6.6%)
Conservative Group	8 (36.3%)	7 (31.8%)	4 (18.18%)
Urine retention			
Surgical Group	7 (46.6%)	6 (40%)	6 (40%)
Conservative Group	11 (50%)	10 (45.45%)	10 (45.45%)

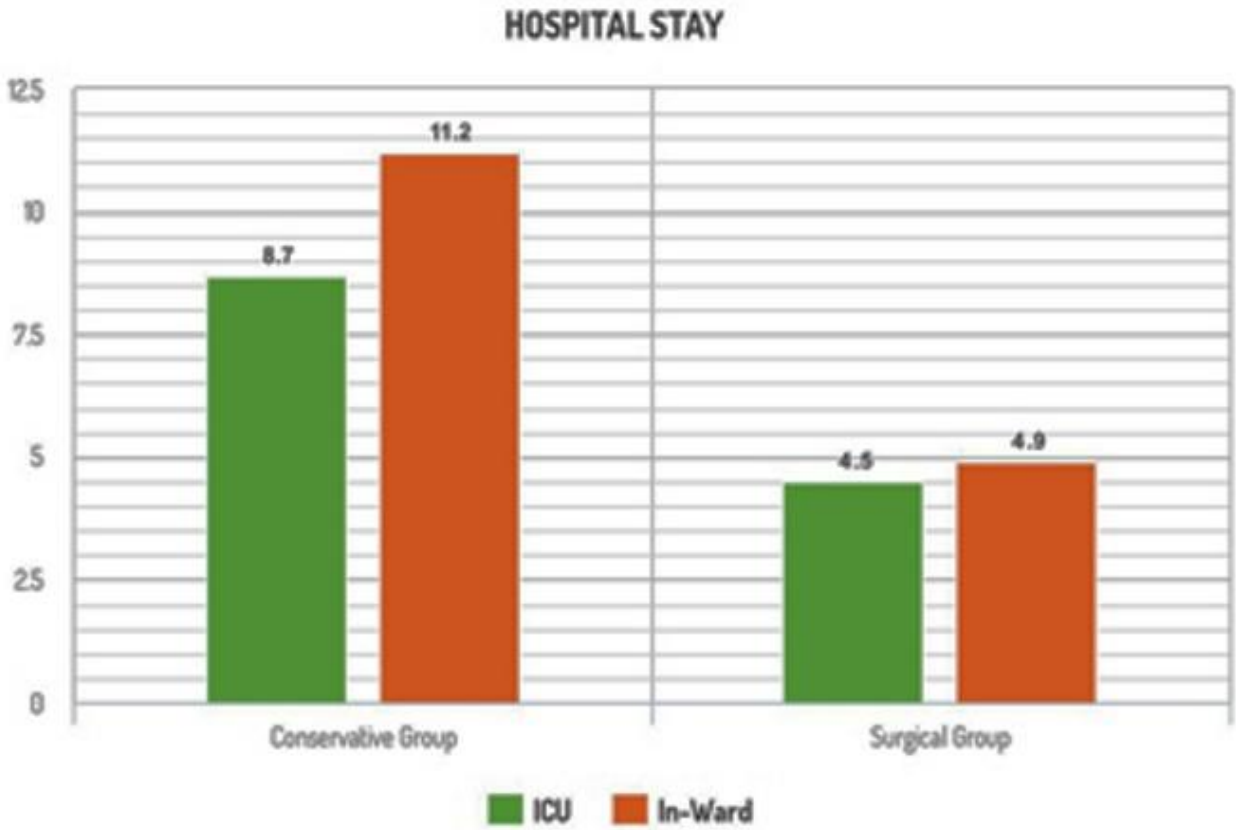

Fig 3: Bar chart of mean hospital stay between two groups.

same degree. They reported independent ambulation in 87-97% in younger patients compared to less than 40% in the elderly.[12]

The medical treatment as suggested by Schneider and coworkers has been widely accepted.[19] This agreement was no longer applied in the early 1970s when a study published by Bosch and colleagues mentioned late-onset clinical deterioration.[20] Also, Molliqaj and colleagues reported delayed clinical deterioration in 7 patients with traumatic central cord syndrome.[2] Several studies reported better outcomes in surgery than the medical conservative group. However, early surgery did not heighten many surgeons' appetite in this spectrum of cord injury. Bose et al. compared motor function recovery in patients treated surgically versus conservatively after acute traumatic central cord syndrome. They found that although both groups showed significant motor recovery using a modified ASIA scoring, a greater degree of motor recovery was found in the operative group.[21] Early decompression offers an alternative modality of treatment for the contused cord.[5,14,15]

Two thousand patients have been operated upon from 2010 and thereafter for ATCCS in comparison to 500 patients before 2003. The increasing trend for surgery might be due to that scattered research articles mentioned even a slight improvement in motor function recovery. A systemic review on the surgical management of central syndrome noted that 46% of surgeons would operate on an ASIA D central cord patient and 63% would operate on an ASIA C central cord patient.[22] Thus, practice patterns may be changing towards surgery for central cord syndrome and the role of surgery for central cord syndrome is an area of active research.

The golden question was in the timing of surgery; is it best to do it early or late? Guest and coworkers found excellent motor recovery and the difference between early (<24h) versus delayed (>24h) decompression according to ASIA grading motor score was 90 vs. 85.3, respectively.[23] The Surgical Timing in Acute Spinal Cord Injury Study (STASCIS) study enrolled more than 300 patients with cervical spine injury including CCS. Early (<24h) versus delayed (>24h) groups were created with patient's randomization established. It has been found that the early surgical group had significant improvements in the ASIA impairment scale as compared to the late group at 6-month follow-up. A non-operative cohort was not present in this study but would have been interesting to quantify if there was any neurological improvement in central cord patients management non-operatively.[24] A systematic review published by Yelamarthy and colleagues showed reasonable evidence that patients with ATCCS secondary to vertebral fracture, dislocation, traumatic disc herniation or instability have better outcomes with early surgery (< 24 h).[25]

Neurological recovery has been intensely studied and shown to occur in a definitive pattern. Many researchers have contributed this pattern of recovery to the regression of spinal cord edema. They postulated that as the edema subsides, motor function follows a definite pattern, with the lower extremities recovering first, followed by bladder recovery, and finally movement of the upper extremities, with finger movements recovering last.[14,17,18,26–28]

As we have mentioned earlier, decompression offers relief of cord edema. Laminoplasty as tried by Ghasemi and Behfar offers no superior benefits over laminectomy; indeed, they induce limitation of movement and axial pain.[29,30]

Experimental studies by Smith and colleagues to simulate SCI in rats found that decompressive duraplasty improved handgrip strength if compared with durotomy or conservative treatment only.[31] Jalan and coworkers designed similar methodology and concluded extremely different fact; decompressive laminectomy and durotomy did not improve motor function recovery, and rats in both of these treatment modalities developed neuropathic pain.[32]

CONCLUSION

Surgical decompression offers clinical improvement that might be superior to medical treatment. The decision of surgery should be closely disclosed with patients' family and relatives.

List of abbreviations

ASIA: American Spinal Injury Association.
ATCCS: Acute traumatic central cord syndrome.
CCS: Central cord syndrome.
CONSORT: Consolidated Standards of Reporting Trials.
CST: Corticospinal tract.
ICU: Intensive care unit.
IRB: Institutional review board.
IV: Intravenous.
SCI: Spinal cord injury.
SD: Standard deviation.
SPSS: Statistical Package for the Social Sciences.
STASCIS: Surgical Timing in Acute Spinal Cord Injury Study.
TBI: Traumatic brain injury.

Disclosure

The authors report no conflict of interest in the materials or methods used in this study or the findings specified in this paper.

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REFERENCES

1. Segal DN, Grabel ZJ, Heller JG, et al. Epidemiology and treatment of central cord syndrome in the United States. J Spine Surg. 2018;4(4):712-716.
2. Molliqaj G, Payer M, Schaller K, Tessitore E. Acute traumatic central cord syndrome: A comprehensive review. Neurochirurgie. 2014;60(1-2):5-11.
3. Newey ML, Sen PK, Fraser RD. The long-term outcome after central cord syndrome: A study of the natural history. J Bone Joint Surg Br. 2000;82(6):851-855.
4. Samuel A, Anandasivam N, Diaz-Collado P, Lukasiewicz A, Webb M, Grauer J. Management of acute traumatic central cord syndrome. Contemp Spine Surg. 2016;17(10):1-7.
5. Ramírez NB, Arias-Berríos RE, López-Acevedo C, Ramos E. Traumatic central cord syndrome after blunt cervical trauma: A pediatric case report. Spinal Cord Ser Cases. 2016;2:16014.
6. Stevens EA, Marsh R, Wilson JA, Sweasey TA, Branch CL, Powers AK. A review of surgical intervention in the setting of traumatic central cord syndrome. Spine J. 2010;10(10):874-880.
7. Aarabi B, Alexander M, Mirvis SE, et al. Predictors of outcome in acute traumatic central cord syndrome due to spinal stenosis. J Neurosurg Spine. 2011;14(1):122-130.
8. Aarabi B, Olexa J, Chryssikos T, et al. Extent of spinal cord decompression in motor complete (American Spinal Injury Association impairment scale grades A and B) traumatic spinal cord injury patients: Post-operative magnetic resonance imaging analysis of standard operative approaches. J Neurotrauma. 2019;36(6):862-876.
9. Divi SN, Schroeder GD, Mangan JJ, et al. Management of acute traumatic central cord syndrome: A narrative review. Global Spine J. 2019;9(1_suppl):89S-97S.
10. Brodell DW, Jain A, Elfar JC, Mesfin A. National trends in the management of central cord syndrome: An analysis of 16,134 patients. Spine J. 2015;15(3):435-442.
11. Stevenson CM, Dargan DP, Warnock J, et al. Traumatic central cord syndrome: Neurological and functional outcome at 3 years. Spinal Cord. 2016;54(11):1010-1015.
12. Liu Y, Wang Z, Yang S, Yang H, Zou J. The effect of surgical intervention for delayed cervical central cord syndrome. BioMed Res Int. 2017;2017:1-6.
13. Brodkey JS, Miller CF, Harmody RM. The syndrome of acute central cervical spinal cord injury revisited. Surg Neurol. 1980;14(4):251-257.
14. Lee SE, Chung CK. Risk prediction for development of traumatic cervical spinal cord injury without spinal instability. Global Spine J. 2015;5(4):315-321.
15. Epstein NE, Hollingsworth R. Diagnosis and management of traumatic cervical central spinal cord injury: A review. Surgl Neurol Int. 2015;6(Suppl 4):S140-153.
16. Fehlings MG, Tetreault LA, Wilson JR, et al. A clinical practice guideline for the management of patients with acute spinal cord injury and central cord syndrome: Recommendations on the timing (<=24 hours versus >24 hours) of decompressive surgery. Global Spine J. 2017;7(3 Suppl):195S-202S.
17. Park MS, Moon S-H, Lee H-M, et al. Delayed surgical intervention in central cord syndrome with cervical stenosis. Global Spine J. 2015;5(1):69-72.

18. Wilson JR, Tetreault LA, Kwon BK, et al. Timing of decompression in patients with acute spinal cord injury: A systematic review. Global Spine J. 2017;7(3 Suppl):95S-115S.
19. Paul S, Jennifer S, Giradi FP. Central cord syndrome: A review of epidemiology, treatment and prognostic factors. JSM Neurosurg Spine. 2016;4(3):1075.
20. Bosch A, Stauffer ES, Nickel VL. Incomplete traumatic quadriplegia: A ten year review. JAMA. 1971;216(3):473-478.
21. Bose B, Northrup BE, Osterholm JL, Cotler JM, DiTunno JF. Reanalysis of central cervical cord injury management. Neurosurgery. 1984;15(3):367-372.
22. Lenehan B, Fisher CG, Vaccaro A, Fehlings M, Aarabi B, Dvorak MF. The urgency of surgical decompression in acute central cord injuries with spondylosis and without instability. Spine. 2010;35(21 Suppl):S180-S186.
23. Guest J, Eleraky MA, Apostolides PJ, Dickman CA, Sonntag VKH. Traumatic central cord syndrome: Results of surgical management. J Neurosurg. 2002;97(1 suppl):25-32.
24. 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.
25. Yelamarthy PKK, Chhabra HS, Vaccaro A, et al. Management and prognosis of acute traumatic cervical central cord syndrome: Systematic review and Spinal Cord Society—Spine Trauma Study Group position statement. Eur Spine J. 2019;28(10):2390-2407.
26. Zhang R, Chen Q, Xiao Y, Chong Z. Pretest of the clinical application of a management model for comprehensive treatments of acute spinal cord injury. Int J Clin Exp Pathol. 2015;8(8):9342-9350.
27. Visocchi M, La Rocca G, Signorelli F, Roselli R, Jun Z, Spallone A. 10 Levels thoracic no-intrumented laminectomy for huge spontaneous spinal subdural hematoma removal. Report of the first case and literature review. Int J Surg Case Rep. 2015;15:57-62.
28. Rath N, Balain B. Spinal cord injury-The role of surgical treatment for neurological improvement. J Clin Orthop Trauma. 2017;8(2):99-102.
29. Ghasemi AA, Behfar B. Outcome of laminoplasty in cervical spinal cord injury with stable spine. Asian J Neurosurg. 2016;11(3):282-286.
30. Zadegan SA, Rahimi-Movaghar V. There is no evidence that laminoplasty results in improved outcomes compared with laminectomy in cervical spinal cord injury without instability. Asian J Neurosurg. 2017;12(3):347.
31. Smith JS, Anderson R, Pham T, Bhatia N, Steward O, Gupta R. Role of early surgical decompression of the intradural space after cervical spinal cord injury in an animal model. J Bone Joint Surg Am. 2010;92(5):1206-1214.
32. Jalan D, Saini N, Zaidi M, Pallottie A, Elkabes S, Heary RF. Effects of early surgical decompression on functional and histological outcomes after severe experimental thoracic spinal cord injury. J Neurosurg: Spine. 2017;26(1):62-75.