Original Research Article

A Study of Traumatic Cord Contusions - Management and Outcomes

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Abstract

Background: There is convincing preclinical evidence that early decompression in the setting of spinal cord injury (SCI) improves neurologic outcomes. However, the effect of early surgical decompression in patients with acute SCI remains uncertain. **Aims:** To study the long-term outcomes of patients presenting with spinal cord contusions and to compare the neurological outcomes in patients who underwent surgery and those who were managed conservatively. **Materials and methods:** A prospective study was conducted on all patients admitted with features of cord contusions and central cord syndrome for 2 years. Information gathered included mechanism of injury, previous neurological status, length of hospital stay and functional status. Group 1 included patients younger than 50 years of age, Group 2 included from 50 to 70 years of age and Group 3 had patients who were above 70 years of age. **Results:** Out of the 147 patients only 26 patients had a single level involvement. Around 61.6% of study subjects with injury of spinal cord at >2 levels were found to have good outcome. Almost 54.5% of study subjects had good outcome in which spinal cord injury was at 2 levels and 34.6% of study subjects had good outcome among whom spinal cord injury was at 1 level only. The difference was found to be significant statistically. Patients undergoing early surgical intervention have better outcomes. **Conclusion:** It is concluded that Surgery is a better mode of management for cervical cord contusions.

Keywords: spinal cord injury, Neurologic outcomes, surgical decompression

Introduction

Spinal cord injury (SCI) is "an insult to the spinal cord resulting in a change, either temporary or permanent, in its normal motor, sensory, or autonomic function". This study is designed to look at the outcomes of spinal cord injury with contusions. Cord Contusion in spinal injuries can be observed with or without bony injuries or instability. A Spinal cord contusion is said to occur when the spinal cord is injured and vascular injury occurs along with bleeding from the blood vessels near the injury site associated with neural tissue injury. Subsequently further inflammatory changes set in, leading to secondary neural injury causing neurological tissue damage with gliosis[1].Spinal cord contusion means neural tissue injury together with bleeding (the primary injury). A complex of deleterious substances is released out from the primary injury site initiating the cascade of secondary injury. The contusion has a surrounding ischemic zone which is prone for secondary neuronal damage due to the cascade of events triggered by tissue damage if proper care is not taken to protect the neuronal cells. Primary SCI results from the physical forces delivered at the time of injury and is the most important determinant of SCI severity. This primary injury cannot be altered. Most commonly, displaced elements of the vertebral column subject the spinal cord to compressive forces; sustained compression is seen in many cases. Primary injury forces may also involve shearing, laceration, and acute stretching[2].These forces disrupt axons, blood vessels, and cell membranes. Primary injury mechanisms only very rarely fully disrupt the anatomic continuity of the cord. Secondary SCI is a delayed and progressive. This secondary injury to the neuronal tissue can be altered by medical or surgical interventions during the window period. Because these injurious, highly interrelated cellular processes lead to cell and axonal loss in a delayed fashion, these events represent potential therapeutic targets. These secondary SCI processes include ischemia, ion-mediated cell damage and excitotoxicity, neuroinflammation, mitochondrial dysfunction, and oxidative cell damage[3].The progression of this secondary injury can be altered by various interventions targeting the factors influencing the secondary injury. If there is a compression caused by the bony elements, a decompressive procedure is done. Methylprednisolone, Riluzole and granulocyte colony stimulating factors and certain intrathecal pharmacotherapy with fibroblast growth factors have been tried with not much better outcomes. These cord contusions can present with Brown Sequard syndrome, Anterior Cord Syndrome, Central Cord syndrome and Posterior cord syndrome. Central cord syndrome is a common neurological presentation in these patients. It is characterized by disproportionately more motor impairment of the upper than the

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lower extremities, bladder dysfunction, usually urinary retention, and varying degrees of sensory loss below the level of the lesion."

A degenerative spine and otherwise any pathological spine with focal and multilevel stenosis is most commonly affected following a simple fall with neck hyperextension result in central cord syndrome. However younger patients can be affected following high-energy trauma or those with congenital cervical stenosis. The cause for the involvement of the central portion of the cord is basically differential movement of the central portion against an osteophyte or a disc. From a biological perspective, evidence suggests that persistent compression of the spinal cord after the primary injury, which, if ameliorated quickly, may lead to reduced neural tissue injury and improved outcomes. Schneider et al advocated conservative management because the natural history of cord contusion and central cord syndrome is to improve neurological status rapidly in the early stages; surgery is therefore unnecessary and even detrimental. Since then various studies been reported that many conservatively managed patients experience late-onset neurological deterioration and only 60% remained functional despite a period of initial improvement. With improvements in stabilization techniques of spine and decompression there have been a number of limited and retrospective studies showing favourable results for surgical intervention and early decompression in cases with cord contusion and central cord syndrome. It was therefore the aim in this study to review the management and outcomes of patients with Spinal cord injury and Cord Contusions admitted at Gandhi Hospital, Secunderabad, India in 2 years.

Patients and Methods

A prospective study was conducted on all patients admitted with features of cord contusions and central cord syndrome at Gandhi Hospital, Secunderabad,India from January 2018 to December 2019. Information gathered included mechanism of injury, previous neurological status, length of hospital stay and functional status. Group 1 included patients younger than 50 years of age, Group 2 included from 50 to 70 years of age and Group 3 had patients who were above 70 years of age. The outcomes were analysed basing the ASIA scores and the Functional Independence measure (FIM) scores at the time of admission, after 10 days and at follow ups, up to 6 months. ASIA score at the end of 6 months was considered the best attainable score. The patients who underwent surgery were operated and classified basing on the following criterion:

1) Those with multi-level spinal cord compression along with contusion.
2) Those with diffuse cord edema
3) Those with traumatic disc prolapse and focal cord edema.

The common procedures done were as follows:

1) Cervical laminectomy in cases of multiple level cord compression.
2) Cervical laminectomy + Lateral Mass screw fixation + Expansion duroplasty in cases with diffuse cord edema and loss of normal cervical curvature.
3) Anterior cervical decompression and fusion with cervical screws and locking plate in cases with traumatic disc prolapse and focal cord edema.

Data was entered in Microsoft excel and analysis was done using SPSS version 20. Descriptive statistical analysis was done . Results on continuous measurements are presented as Mean & Standard Deviation. Results on categorical measurements are presented as Percentages. Significance is assessed at 5 % level of significance. Student t test (independent, two tailed) has been used to find out the significance of study parameters on a continuous scale between two groups .

Results

Past studies indicate that the age is an important factor as far as outcome is concerned. Younger patients (<50 years of age) have relatively less degenerative changes in the spine and hence are thought to have better outcomes. In this study, 78 patients were below 50 years of age, whereas 69 patients were above or equal to 50 years. There was no significant difference in the final outcomes of both groups. 56.41 % of patients of Group I (<50 years) had good outcomes whereas 54.68 % patients of group II and 60 % of Group III had good outcomes. The difference was not statistically significant. (P Value 0.96). Mode of injury is a significant factor in cervical cord contusions. In our study 57 patients sustained injuries in a road traffic accident. Coexisting brain injuries must be given due importance in road traffic accidents as they can cause motor system deficits by themselves. In our study population, coexisting brain trauma was excluded. The younger population were found to be more frequently involved in road traffic accidents (30.6%)

Table 1: Comparison of mode of injury in groups

Mode Of Injury	Group I (<50 years)	Group II (50-70 years)	Group III (>70 years)
Simple Fall	26 Patients	48 Patients	.5
RTA	45 Patients	12 Patients	Nil
Electric Shock	1 Patient	Nil	Nil
Fall from height	5 Patients	4 Patients	Nil
Others	1 Patient	Nil	Nil

Simple fall leading to cervical cord injury was significantly higher in the elderly population (36%). The clinical sequelae after the fall, could be a result of a pre-existing stenotic canal. A fall sustained with a hyperextended neck in a pre-existing stenotic canal is a very common cause of central cord syndrome. 92% of the population sustained injuries by these two modes i.e., Road traffic accidents and simple falls.

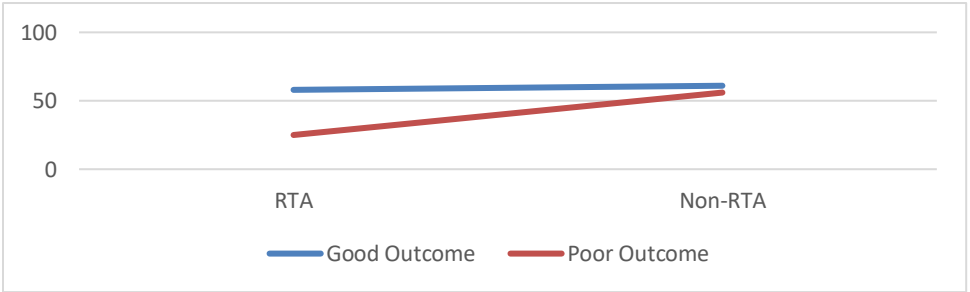

Fig 1: Outcomes with respect to Mode of Injury

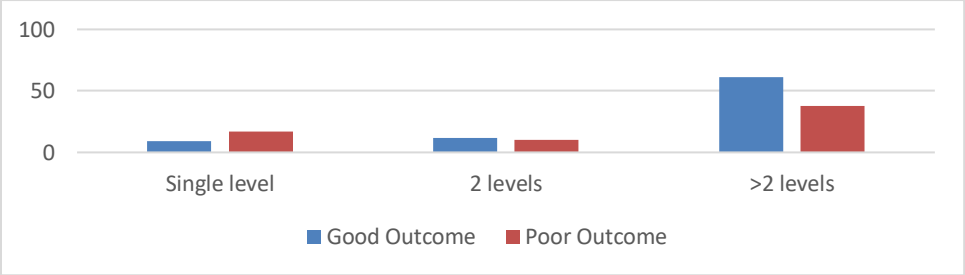

Fig 2: Outcomes based on number of spinal levels involved

Outcomes based on plan of management

Three different procedures are considered for our study as Cervical laminectomy in cases of multiple level cord compression, Cervical laminectomy + Lateral Mass screw fixation + Expansion duroplasty in cases with diffuse cord edema and loss of normal cervical curvature and Anterior cervical decompression and fusion with cervical screws and locking plate in cases with traumatic disc prolapse and focal cord edema.

A total of 95 patients were managed with surgical intervention, and the rest 52 patients conservatively. Of the 95 patients managed surgically, 67 patients had a good outcome i.e., 70.5 % among the surgical group. Of the 52 patients managed conservatively only 15 patients had a good outcome i.e., 28.8%. The difference in the two groups was statistically highly significant. (P Value 0.001). Hence, it is evident that surgery is a better management policy when indicated.

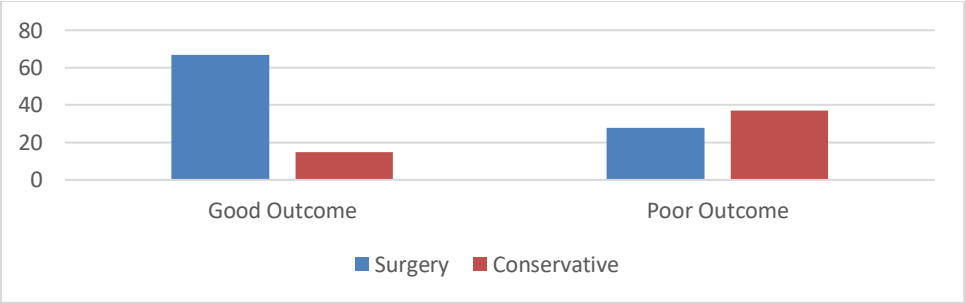

Fig 3: Outcomes based on plan of management

Timing of surgical intervention: Patients operated on or less than 24 hours have ultimately better ASIA motor scores at follow up and there is a progressive deterioration the longer the delay to surgery. Keeping this outcome in mind, the patients who were considered for surgery were operated as soon as possible. Most of the patients, presented after 48 hours of injury, some even after 10 days of injury. Hence, the duration between the injury and the surgery was taken into consideration and used for analysing the outcomes depending on the time to surgery.

Out of the 95 patients who underwent surgery only 31 patients were operated within 24 hours of injury and 30 of them had good outcome. This is a clear indication that early surgical intervention can help in achieving a better outcome. The statistical difference in the final outcomes of the surgical group between early and delayed interventions was highly significant. (P-Value 0.001). Number of patients depending on the time to surgery.

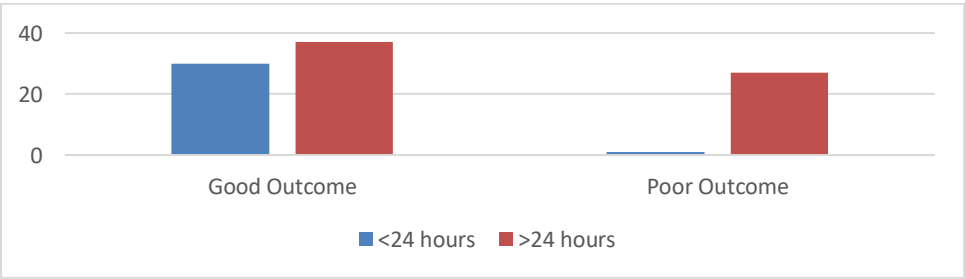

Fig 4: Outcomes based on time to surgery

Table 2: Outcomes in relation to the different factors studied

Factor		Good Outcome (%)	Poor Outcome (%)	Total	P value
Age	<50 years	44 (56.41)	34 (43.58)	78 (100)	**0.96**
	50-70 years	35 (54.68)	29 (45.31)	64 (100)	
	>70 years	3 (60)	2 (40)	5 (100)	
Mode of Injury	RTA	25 (43.8)	32 (56.2)	57 (100)	0.02*
	Non-RTA	57 (63.3)	33 (36.7)	90 (100)	

Number of Spinal Levels	1 level	9 (34.6)	17 (65.4)	26 (100)	0.04*
	2 levels	12(54.5)	10 (45.5)	22 (100)	
	>2 levels	61(61.6)	38 (38.4)	99 (100)	
Management	Surgery	67 (70.5)	28 (29.5)	95 (100)	0.001**
	Conservative	15 (28.8)	37 (71.2)	52 (100)	
Time to Surgery	<24 hours	30 (96.7)	1 (3.3)	31 (100)	0.001***
	≥24 hours	37(57.8)	27 (42.2)	64 (100)	

*Significant
**Highly significant
***Highly significant
Fisher exact test of significance used

In this study age was not found to be significantly associated with good outcome. Around 56.41% of study subjects who were <50 years had good outcome as compared to 54.68% in study subjects whose age between 50-70 years and 60 % of patients had good outcome who among the patients who were above 70 years of age. This was statistically insignificant. (P Value 0.96) Mode of injury is significantly associated with a good outcome with p value <0.05. Around 63.3% of Non-RTA injuries had good outcome as compared to 43.8% of RTA injuries. The difference of 19.5% was found to be statistically significant. Around 61.6% of study subjects with injury of spinal cord at >2 levels were found to have good outcome. Almost 54.5% of study subjects had good outcome in which spinal cord injury was at 2 levels and 34.6% of study subjects had good outcome among whom spinal cord injury was at 1 level only. The difference was found to be significant statistically. Management of cervical cord contusions was found to have good outcome significantly with surgery as compared to conservative management. Almost 70.5% of study subjects had good outcome after surgery as compared to conservative management in which only 28.8% of them had good outcome. The difference of 41.7% was found to be highly significant. In this study it was observed that 96.7% of study subjects had good outcome when surgery was done within 24 hours of injury and only 57.8% of them had good outcome when surgery was done beyond 24 hours. The difference of 38.9% was found to be statistically highly significant.

Fig 5: MR Imaging with mid sagittal image showing the division of vertebral body as two segments and the disc as another segment

Discussion

The management of a patient with spinal cord contusion has been a point of great debate over the years. Studies on cord contusions and central cord syndrome gave a conclusion that surgery is not indicated and at times can be detrimental to a patient with cervical spinal cord contusions. Since then, owing to advances in the instrumentation of the spinal cord, and advent of refined surgical techniques, various authors published their studies advocating surgical management for cord contusions. A recent study by Brodell et al., assessed trends in the treatment of 16,134 patients with central cord syndrome in the United States between 2003 and 2010. The study found that 60% of patients were treated non-operatively. Patients treated surgically underwent anterior cervical discectomy and fusion (ACDF) most commonly (19%), followed by posterior cervical discectomy and fusion (PCDF; 7%) and posterior cervical discectomy (PCD, 7%). The number of patients treated surgically increased from about 500 patients in 2003 to more than 2000 in 2013[4]. Similarly, Yoshihara et al., assessing treatment trends in 19,451 patients with central cord syndrome without bony injury between 2000 and 2009 in the United States, reported an increase of surgical treatment from 15 to 31%[5].There are no evidence-based guidelines for the choice of treatment. Current literature and studies are confined to lower levels of evidence, specifically levels 3 and 4, and most studies are limited by small sample size, heterogeneous study population, and possible residual confounding. Systematic reviews are based on this weak evidence, and thus results must be interpreted with caution. In this section, a review of the current scientific evidence with respect to the final outcomes of this study and comparison of various prognostic factors along with comparison of surgical and conservative treatment will be done. Ishida et al., described a study of 22 patients treated non-surgically with the aim of finding predictors of a good neurologic recovery[6]. The study showed full motor recovery in 77% of patients, while the remaining had mild dysfunction of hands at 2-year follow-up. Full sensation was recovered in about 60% of patients. Both motor and sensory recovery occurred rapidly until 3 weeks and remained constant after approximately 6 weeks[7]. In agreement with these findings, Newey et al., reported that all patients younger than 50 years of age returned to independent ambulation and full bladder control, while only 69% and 88% of patients from 50 to 70 years recovered these functions, respectively, in a case series of 32 conservatively managed patients[7].A few analytical studies comparing surgical and conservative treatment failed to show a benefit of surgical intervention. In 1997 Chen et al., retrospectively reviewed 114 patients of which 25% of patients were treated surgically. No significant difference between surgical and non-surgical groups was found for functional and motor outcome, as well as bladder control[8].Regardless of treatment, bladder control and walking ability recovered on average after less than 6 days. In 2007 Aito et al., described 82 patients that were treated surgically or conservatively and found no difference in short- or long-term outcomes between surgical and conservative treatment[9].Similar results were found in 2015 by Schroeder et al., who retrospectively examined 80 patients with central cord syndrome. About the half of these patients underwent surgical treatment within 24 hours. However, surgery within 24 hours was not found to significantly affect changes in motor function[10] .Gu et al., compared 31 patients who underwent laminoplasty to 29 patients treated conservatively in 2014. All patients had spinal cord injury with signs of cord compression by OPLL and MRI signal changes. In the surgical group, 18% of patients had central cord syndrome, while this was

found in 16% of cases in the non-surgical group. Mean hospital stay was shorter in the operative group. Motor scores were higher in the surgical group compared to the conservative group at 6 months and 3 years. Similarly, sensory scores were higher in the surgical group.[11]

Stevens et al., conducted a retrospective review of 126 patients of which 67 patients were treated surgically and 59 non-surgically. Surgical procedures included anterior, posterior or combined decompression with or without instrumentation. Of the 67 surgical patients, 16 were treated within 24 hours, 34 patients after 24 hours, and 17 patients on readmission after a mean time of 137 days. Patients in the surgical group were significantly younger. The study demonstrated a significant difference in improvement in Frankel grade between surgical and non-surgical groups. No difference of neurologic outcome between the three surgical subgroups was found[12]. Finally, in two systematic reviews of case series and retrospective studies in 2013, Aarabi et al., and Dahdaleh et al., concluded that there was level 3 evidence to support the benefit of surgical treatment in patients with central cord syndrome[13,14].In our study, out of 147 patients, 95 underwent surgery. 67 of these patients had a good outcome (70.5%). This strongly suggests that surgical intervention is beneficial in patients when there is a clear indication for the same. Outcomes with surgery can have many influencing factors. Age is one important factor. The younger age group may not have a degenerative component in the spine and the causative factor for the effects of contusion can be the injury only. In this setting once the canal diameter is increased by surgery, obvious improvement in the neurological status is anticipated. The same principal may not hold good for an older patient, who might be having a chronic compression over the spinal cord due to degenerative changes. The cord, by the time of the injury is already under compressive forces which may have lead to a subclinical myelopathy, over and above which the forces causing the contusion may lead to neurological impairment. This double-hit scenario over the cord leads to a more debilitating neurological status, which after surgery may or may not have the desired outcome. In various previous studies the younger aged patients had a better outcome when compared to older age group. Our study showed no such relationship with age. There was no significance of age as an independent factor. Surgery, although was significantly producing better outcomes. Hence, surgery is a preferred modality when there is a clear indication for the same. A few analytical studies support early surgical intervention. Fehlings et al., conducted a prospective, multi center study between 2002 and 2009, with 222 spinal cord injury patients with a follow-up of 6 months. In multivariate analysis, the odds of improvement of at least 2 grades in ASIA Impairment Scale were 2.8 times higher in patients who underwent surgery within 24 hours. It is unclear if these findings can be applied to patients with central cord syndrome[14].Guest et al., reported on 50 patients with central cord syndrome treated surgically. Surgery was performed via posterior or anterior approaches, within 24 hours in 16 patients, and after 24 hours in 34 patients. Patients with acute disc herniation, cervical fractures or dislocations had a better motor recovery than patients with spondylosis or stenosis, if the surgery was performed within 24 hours. After 36 months of follow-up, all patients with early intervention for disc herniation, fracture or dislocation were able to walk independently, while 88% of patients who underwent delayed surgery had the same outcome. Patients with spondylosis or stenosis required no assistance walking in 66% of early surgical cases and in 61% of delayed surgical cases[15].Yamazaki et al., studied 47 patients with central cord syndrome of which 23 were treated with surgical decompression. The study showed that lesser interval between injury and surgery were significantly associated with a better recovery[16]. These results have been confirmed in a meta-analysis by La Rosa et al., Early decompression in patients with incomplete spinal cord injury resulted in significantly better outcome compared to late and conservative treatment[17]. In 2013, a study by Stevenson et al conducted in Belfast concluded that early surgical intervention (less than 48hrs) will produce improved motor and sensory ASIA scores at follow-up. For those patients operated on late perhaps the role of surgery is to prevent further neurological deterioration. In a systematic review in 2015, Anderson et al., reported low-level evidence suggesting that surgery within 24 hours significantly improved recovery of ASIA motor scores, while there was weak evidence that patients operated within 2 weeks have a higher recovery rate measured by the Japanese Orthopaedic Association score[18,19].Similarly, Fehlings et al., conducted a systematic review in 2006 and concluded early decompressive surgery (within 24 hours) can be performed safely[14].In a systematic review, Molliqaj et al., concluded that early decompression might be indicated in patients who exhibit progressive neurological deficits. Controversy persists, however, and no clear recommendation can be proposed, because current systematic reviews are based on low-level evidence[20].In the present study, 31 cases were operated within 24 hours of injury, of which 30 cases had a better outcome (96.7%). In a patient with spinal cord contusion, the surrounding edema along with the contusion itself entrapped in a closed compartment leads to several secondary changes as described earlier. The idea of early surgical intervention is to allay those secondary changes and preserve as much of motor power as possible. Our study clearly showed that early surgery is beneficial to the patient. One analytical study showed benefits in patients treated with delayed surgery. In 2015 Samuel et al. retrospectively reviewed 1060 patients with central cord syndrome treated surgically. Surgical timing was found to be associated with a 19% decrease in the odds of mortality with each 24-hour increase in time. Thus, delayed surgery was associated with reduced odds of mortality. Time to surgery was also associated with a 7% increase in odds of minor adverse events with each 24-hour increase in time to surgery. However, delayed surgery was not associated with more severe adverse events. In the present study, 64 cases were operated beyond 24 hours and only 37 cases out of these had good outcome (57.8 %). On comparing early vs delayed surgery, outcomes of early surgery were significantly better. (P value-0.001). Expectant management was followed initially in few patients who were operated beyond 24 hours. Any improvement in the neurological status was noted and then the patients were counselled regarding the surgical approach. Most of the patients, themselves sought medical attention from us in a delayed manner, sometimes beyond 5 days after injury. A few analytical studies did not show a difference between early and delayed surgical intervention. In 69 patients treated surgically for spinal instability or declining neurologic status, Anderson et al. found an overall increase of 63 points on the American Spinal Injury Association (ASIA) motor score scale to 90 points. About 70% of patients improved 1 or more grades on the ASIA Impairment Scale. There was no difference in motor function outcome between early (less than 24 hours after injury), midrange (24 to 48 hours), and late (more than 48 hours) surgical treatment.

In 2009 Chen et al., assessed a study population of 49 patients who were treated surgically with an anterior or posterior approach within 4 days or after 4 days of admission. Significant improvement in ASIA scores was noted during the first 6 months after surgical intervention. No difference with regards to timing of surgical intervention was found. Full bladder control recovered from 56% to 80%, while ASIA motor scores improved from 50 and 60 to 99 and 90 in the early and delayed surgical group respectively. Spasticity and neuropathic pain were major factors leading to a poor quality of life as reported by patients. In 2015 Kepler et al., reported of 68 patients who underwent surgery within 24 hours in 28% of cases, while the remaining 72% had delayed surgical intervention[21].Patients in the early intervention group were younger. The study showed no difference in motor improvement, or morbidity and mortality after 7 days. Finally, a systemic review by Aarabi et al., in 2013 concluded that most class III evidence did not show advantages of early versus late surgical treatment[22].Several

studies proved that MRI had been the gold standard in prognostication of cervical SCI. It allows good visualization of neurological tissues such as cord, ligaments, discs, vessels as well as soft tissues. In the literature, sagittal T2 sequences had the highest correlation with patient prognosis as they can identify and measure the extent of contusion within the spinal cord. In this study, we divided the vertebral body into two equal halves which were considered as two segments. The disc was considered as another segment. The number of levels involved was considered according to the length of the contusion along with the surrounding edema in relation to the segments described above. In this study, the patients were categorised into three groups for statistical analysis, those with only a single level of involvement (Most of which were due to a traumatic disc prolapse), 2 level involvement and > 2 level involvement. The better outcomes of patients with multiple levels of injuries can probably be attributed to the fact that most of them underwent surgery and thus could be a confounding factor. This result was not in line with few previous studies where multiple level involvement was shown to have a poorer outcome.

Conclusion

Management policies of Cervical cord contusions has been a debatable subject since the past 60 years. Various studies differ in the line of management employed in these patients. Some of them conclude a conservative line while others advocate surgery.We conclude that Surgery is a better mode of management for cervical cord contusions. Overall, our conclusions from this study as Patients suffering from cord contusion sustained in a road traffic accident have poorer outcome. Patients having more than 2 levels of contusion and undergoing early surgical intervention have better outcomes. Certain aspects of this study do not align with previous literature, like the number of levels involved, if less, had better outcomes in the past studies. Patients younger than 50 years had a better outcome in previous studies. These 2 findings were consistent in the previous literature but were not so in our study. Most of our patients hail from endemic areas of fluorosis. Hence, a fluorotic spine in most of them is common. This involves multiple levels and an injury can easily lead to multiple levels of contusion. They also have long standing myelopathic changes and fused spinal column. These findings may be relevant and can have a bearing on our contrasting results.

References

1. Sekhon LH, Fehlings M. Epidemiology, demographics, and pathophysiology of acute spinal cord injury. Spine. 2001; 26:S2-S12.
2. Baptiste DC, Fehlings M, Pharmacological approaches to repair the injured spinal cord. J Neurotrauma. 2006; 23:318-334.
3. Epidemiology of Traumatic Spinal Cord Injury: A SAARC Perspective, Rajeshwar N Srivastava, International Journal of Molecular Biology & Biochemistry. ISSN 2349- 2341. 2015; 3(1):9-22
4. 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; 15:435-442.
5. Yoshihara H, Yoneoka D. Trends in the treatment for traumatic central cord syndrome without bone injury in the United States from 2000 to 2009. J Trauma Acute Care Surg. 2013; 75:453-458.
6. Ishida Y, Tominaga T. Predictors of neurologic recovery in acute central cervical cord injury with only upper extremity impairment. Spine, 2002, 1652-1658.
7. 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; 82:851-855.
8. Chen TY, Lee ST, Lui TN, Wong CW, Yeh YS, Tzaan WC et al. Efficacy of surgical treatment in traumatic central cord syndrome. Surg Neurol. 1997; 48:435-440.
9. Aito S1, D'Andrea M, Werhagen L, Farsetti L, Cappelli S, Bandini B et al. Neurological and functional outcome in traumatic central cord syndrome. Spinal Cord. 2007; 45:292-297.
10. Schroeder, Hjelm N, Vaccaro AR, Weinstein MS. The effect of vertebral fracture on the early neurologic recovery in patients with central cord syndrome. Eur Spine J. 2015; 24:985-989.
11. Gu Y, Chen L, Dong RB, Feng Y, Yang HL, Tang TS. Laminoplasty versus conservative treatment for acute cervical spinal cord injury caused by ossification of the posterior longitudinal ligament after minor trauma. Spine J. 2014; 14:344-352.
12. 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; 10:874-880.
13. Dahdaleh NS, Lawton CD, E Ahmadieh TY, Nixon AT, El Tecle NE, Oh S et al. Evidence-based management of central cord syndrome. Neurosurg Focus. 2013; 35:E6.
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 (Phila Pa 1976). 2006; 31:S28-35.
15. Guest J, Eleraky MA, Apostolides PJ, Dickman CA, Sonntag VK. Traumatic central cord syndrome: results of surgical management. J Neurosurg. 2002; 97:25-32.
16. Yamazaki T, Yanaka K, Fujita K, Kamezaki T, Uemura K, Nose T. Traumatic central cord syndrome: analysis of factors affecting the outcome. Surg Neurol. 2005; 63:95-99.
17. 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; 42:503-512.
18. Anderson KK, Tetreault L, Shamji MF, Singh A, Vukas RR, Harrop JS et al. Optimal Timing of Surgical Decompression for Acute Traumatic Central Cord Syndrome: A Systematic Review of the Literature. Neurosurgery. 2015; 77:S15-32.
19. 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 (Phila Pa 1976). 2010; 35:S180-186.
20. Molliqaj G, Payer M, Schaller K, Tessitore E. Acute traumatic central cord syndrome: a comprehensive review. Neurochirurgie. 2014; 60:5-11.
21. Kepler CK, Kong C, Schroeder GD, Hjelm N, Sayadipour A, Vaccaro AR et al. Early outcome and predictors of early outcome in patients treated surgically for central cord syndrome. J Neurosurg Spine. 2015; 23:490-494.
22. Aarabi B, Hadley MN, Dhall SS, Gelb DE, Hurlbert RJ, Rozzelle CJ et al. Management of acute traumatic central cord syndrome (ATCCS). Neurosurgery. 2013; 72:195-204.

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