Outcome of Delayed Surgery in Treatment of Acute Traumatic Central Cord Syndrome without Fracture or Instability: A Retrospective Study

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Research article

Keywords: Central Cord Syndrome, Delayed Surgery, Surgical procedure, Timing of Surgery, Cervical Spine, Neurological evaluation, Decompression

Posted Date: August 3rd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-46811/v1>

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Abstract

Background: The optimal surgical timing for acute traumatic central cord syndrome (ATCCS) without fracture or instability has not been established. The purpose of this study is to explore the outcome of delayed surgery in treatment of ATCCS and to investigate potential factors associated with postoperative neurological improvement. **Methods:** Patients who underwent delayed surgery for ATCCS with at least 2 year follow up time were retrospectively reviewed. Parameters including age, gender, traumatic mechanism, interval to operation, surgical procedures, and complications were collected. Magnetic resonance imaging was performed to determine levels of spinal cord signal change and concomitant pathology. American Spinal Injury Association (ASIA) classification and Japanese Orthopedic Association (JOA) scores were evaluated and compared at admission and the 2 year follow-up visit for neurologic function assessment. Correlations of neurological improvement and age, traumatic mechanism, interval to operation, surgical procedures, concomitant pathology, and preoperative neurological function were investigated by Spearman ' s correlation test. **Results:** A total of 39 patients (M:F=28:11, mean age 52.2 ± 10.4 yrs) were enrolled into this study. 21 cases were caused by falls followed by 16 by motor-vehicle accidents and 2 by sports. 19 patients presented with preexisting cervical disc herniation (CDH) 12 with spinal canal stenosis (SCS), 5 with OPLL, and 3 with a combined pathology of CDH and CS. 14 samples received ACDF procedure, 8 obtained ACCF, and 17 underwent posterior unilateral open-door laminoplasty. The mean interval from trauma to surgery was 20.8 ± 3.7 days. All cases except three (ASIA B) showed improvement of ASIA grades with a mean improvement of 1.1 ± 0.5 grades at 2-year follow-up. JOA scores significantly improved from 6.3 ± 3.1 points at admission to 11.4 ± 3.9 points at 2-year follow up. No difference of neurological improvement was found between different procedures groups. No correlation was showed between neurological improvement and age, concomitant pathology, traumatic mechanism, interval to operation, surgical procedures, or preoperative neurological function. **Conclusions:** Delayed surgery was a feasible and effective therapy for ATCCS without fracture or instability although long-term outcome and more details still need to be investigated.

Background

Since first described by Schneider et al^{1,2} in 1954, acute traumatic central cord syndrome (ATCCS), characterized by more impairment of the upper extremities, bladder dysfunction and varying degrees of sensory loss below the traumatic level, has become the most common incomplete spinal cord injury. With the advancement of anesthetic and surgical technique, the prevailing therapy has transformed from conservative treatment to surgical management²⁻⁴. For ATCCS secondary to spinal column fracture or instability, early decompression and stabilization has been universally approved for satisfactory neurologic recovery, decreased possibility of secondary injury, low rate of complications, and shorter length of hospitalization^{5,6}. However, for patients suffering CCS without fracture or instability, up to now, controversy still exists on the optimal surgical timing⁷. Although delayed surgery performed on clinical plateau stage has been proposed, the rationality and necessity are still controversial for mixed results of previous studies^{6,8,9}. So, it is of significance to explore the prognosis of patients with ATCCS without

fracture or instability treated by delayed operation and to investigate factors related to neurological recovery.

The purpose of this article is to investigate the outcome of delayed surgery in treatment of ATCCS without fracture or instability and to investigate potential factors associated with neurological improvement thus to provide a reference in determining appropriate surgical timing for ATCCS.

Methods

Patient Population

We obtained the ethic approval of this study from our hospital's Ethics Board. Patients who underwent delayed surgery on time greater than 2 weeks after trauma for ATCCS without fracture or instability were retrospectively reviewed. All patients were followed up for more than 2 years. The diagnosis of ATCCS was made by conformity of clinical and radiographic presentations. Variables including age, gender, traumatic mechanism, interval from injury to operation, surgical procedures, and complications were collected from medical records.

Radiographic Parameters

X-ray and computed tomography (CT) scan of cervical spine were performed to identify and exclude patients with spinal fracture, instability or other pathologic lesions. Magnetic resonance imaging (MRI) was conducted to detect levels of spinal cord signal change (high intensity in T2-weighted image) and concomitant pathologies such as cervical disc herniation (CDH), spinal canal stenosis (SCS), and ossification of posterior longitudinal ligament (OPLL).

Neurological Assessment

American Spinal Injury Association (ASIA) classification and Japanese Orthopedic Association (JOA) score were evaluated and compared at admission and the 2 year follow-up visit for neurologic function assessment.

Statistical Analysis

Normality of continual data was assessed by visual inspection of normality plots and paired t test was used to compare the pre- and postoperative change. Ordinal data were analyzed by Wilcoxon ranks test. Difference of neurological improvement among different procedure groups was compared by Kruskal Wallis test. Spearman's correlation test was used to analyze the relationship between neurological improvement and several potential factors. All the statistical analysis were performed by using SPSS 21.0 software (IBM, Armonk, NY), and $P \leq 0.05$ was considered as statistically significant.

Results

A total of 39 patients (M:F=28:11) with a mean age of 52.2 ± 10.4 (range 26-72) years old were enrolled into our study. All patients presented with some degree of neurological symptoms at admission. For traumatic mechanism, falls accounted for 21 (53.8%) cases, motor-vehicle accidents (MVA) for 16 (41.0%), and sports for 2 (5.1%). All cases underwent some hyperextension injury during their traumatic process. 14 (35.9%) samples received anterior cervical discectomy and fusion (ACDF) procedure, 8 (20.5%) obtained anterior cervical corpectomy and fusion (ACCF), and 17 (43.6%) underwent posterior unilateral open-door laminoplasty (U-LAP). The mean interval from trauma to surgery was 20.8 ± 3.7 (range 15-29) days (Table 1).

Radiographic Parameters

All the patients presented with high-intensity intramedullary signal in preoperative T2-weighted MR images. Of them, 5 cases at C4 level, 5 at C5, 3 at C4/5, 3 at C5/6, 3 at C3-4, 10 at C4-5, 8 at C3-5, and 2 at C4-6. Preexisting CDH was found in 19 (48.7%) patients. SCS was observed in 12 (30.8%) samples and OPLL was presented in 5 (12.8%) cases. A combination of CDH and SCS was revealed in 3 (7.7%) patients (Table 1).

Neurological assessment

All cases except three showed improvement of ASIA grades at the 2 year follow-up visit ($P < 0.05$). Of the 14 patients classified into grade B at admission, 8 improved to grade C, 3 to grade D, and 3 had no change at the 2 year follow-up point. Among the 16 cases with grade C at admission, 12 improved to grade D and 4 to grade E. In the 9 patients evaluated as grade D at admission, all recovered to grade E at last follow up. The mean improvement of ASIA grades was 1.1 ± 0.5 (range 0-2) grades and there was no patient with deterioration of ASIA grades (Table 2). Improvement of JOA scores were found in all patients and the mean JOA scores significantly improved from 6.3 ± 3.1 (range 2-12) points at admission to 11.4 ± 3.9 (range 4-17) points at the 2 year follow up visit with an average improvement of 5.1 ± 1.9 (range 1-10) ($P < 0.05$) (Table 3). No difference of ASIA grades and JOA scores was found between different procedure groups (Table 3). Spearman's correlation test showed no significant correlations of improvement in ASIA grades and JOA scores with age, traumatic mechanism, concomitant pathology, interval to operation, surgical procedures, or preoperative neurological evaluation scale (Table 4).

Discussion

As a clinically prevailing spinal cord injury, the most common causes of CCS are falls, motor-vehicle accidents, and diving injuries^{2,10}. Base on etiologies and relevant demographic factors, the whole population with CCS can be divided into three subgroups⁹. First are younger patients, less than 50 years, usually with high-energy traumatic spinal column injuries and subsequent spinal fracture or instability. The second also commonly consists of younger population with an acute central disc herniation. The last is the "classic" central cord injury in elderly patients greater than 50 years, of whom CCS usually occurs after a hyperextension injury and cord compression on the preexisting spondylosis or spinal canal

stenosis². In our study, the most popular etiology of CCS was falls followed by motor-vehicle accidents, which was consistent with findings of previous reports.

Prior studies reported that hyperextension injury was the most common mechanism of CCS^{11,12}. Under neck hyperextension situation, the ligamentum flavum buckles inward against the posterior aspect of the spinal cord; meanwhile a bulging disc compresses the cord anteriorly^{10,13}. In addition, pre-existing pathologies such as CDH, SCS or OPLL have been reported to contribute to the occurrence of CCS, and patients, especially the elderly population, with such lesions might be more inclined to suffer CCS even after a minor injury^{2,9}. In the present study, all patients underwent a hyperextension trauma before CCS and most cases had pre-existing CDH or SCS, noting that extra caution should be paid to patients with CDH and SCS after a hyperextension neck injury.

Conservative treatment was previously favored for CCS mainly for the risk of damage to the already injured spinal cord and previously poor prognosis of surgery^{7,10,14,15}. However, with more understanding of spinal cord function division and pathophysiological mechanism of CCS, the dominant therapy for CCS has changed gradually^{3,4,6}. In clinical practice now, surgery is usually recommended for CCS with spinal fractures or instability if no significant contraindication exist^{7,16}. But for CCS without fracture or instability, although controversy does not disappear completely, a decompression surgery is also widely proposed^{4,12,17}. In our study, while the patients had no fracture or instability, an anterior or posterior decompression operation was still performed to remove the compression and/or widen the spinal canal volume whose benefit for neurological recovery has been proved by various studies^{5,7}.

Controversy on the surgical timing for CCS still exists^{6,18,19}. Marshall et al¹⁵ revealed in a multicenter study that patients operated on within 5 days might have a higher rate of neurologic deterioration and suggested that early surgical intervention should be avoided unless progressive neurologic worsening might occur. Samuel et al⁸ explored the association of time to surgery with mortality and adverse events in patients with ATCCS treated surgically and found that delayed surgery was associated with a decreased odd of inpatient mortality which meant waiting to optimize general health state and allow some recovery of spinal cord may be advantageous for ATCCS treatment. However, Daniel Review et al¹⁶ reported that patients operated on within 24 hours did better than those operated on later and concluded that most patients should underwent early decompression unless there was a contraindication. Fehlings et al¹⁴ systematically reviewed clinical evidence regarding surgical intervention timing for spinal cord injury and suggested that decompression procedure should be performed within 24 hours. Brain et al¹⁸ conducted a systemic review to explore whether urgent surgical decompression was the optimal treatment for enhancing neurologic recovery in patient with acute CCS without fracture or instability and concluded that early surgical decompression should be considered in patients with profound neurologic deficit (ASIA = C) and persistent spinal cord compression whereas those with less severe deficit (ASIA = D) could be treated with observation followed by surgery at a later date. Besides, there have been various publications reporting no significant difference of prognosis between early and delayed surgery for ATCCS^{4,5,11,17,20}. In our clinical experience, we prefer to choose a delayed surgery as our priority unless

early operation is obligatory or definite benefits of early surgery exist. Most patients in our study had neurological improvement after a delayed decompression procedure. Although no change of ASIA grades was found in 3 cases at 2 year follow-up visit, it does not mean the ineffectiveness of delayed surgical procedure considering the improvement of self-reported symptoms and JOA scores. The non-improvement in ASIA grades might be attributed to the less quantitative evaluation of ASIA grades which might be unable to distinguish a slight neurological change.

The reported time definition of delayed operation for CCS varied greatly from hours to weeks^{17,20,21}. Surgeons favoring delayed surgery usually conduct an operation for CCS at one week after trauma. However, in our study, the mean interval from injury to surgery was 20.8 (range, 15-29) days, much bigger than that most surgeons adopted in clinics, and there was enough time for spontaneous recovery of general health state and spinal cord function, whose effectiveness in decreasing iatrogenic complications and promoting neurological improvement has been reported previously^{6,8,19}. Ventilator dependence, a disturbing morbidity, can occur after surgery to CCS involving or proximal to C3-C5 levels. Earlier operation performed before the arrival of an abundant spontaneous neurological recovery and unexpected surgical stimulus to pre-traumatic spinal cord may contribute to this catastrophic complication¹. In our study, postoperative was found in 3 cases with ASIA B grade at admission which suggested that extra caution should be paid to prevent ventilator dependence for patients with poor neurological function.

Previous studies suggested that different surgical procedures might provide different neurological improvement for CCS. However, in our study, no difference was found among different surgery groups. Besides, Spearman's correlation test showed there was no significant correlation between neurological improvement and age, traumatic mechanism, concomitant pathology, interval to operation, surgical procedures, or preoperative neurological status. The heterogeneity of samples in different studies might contribute to the difference of outcomes.

Our approval of delayed surgery does not mean we resist other surgical timing; in contrary, we applaud any researches on optimal operative timing for CCS. Clinically, we also conduct surgery for patients with CCS on early stage if necessary. But for patients whose general conditions are unstable or cases that are admitted or transformed to medical centers at time exceeding early surgical timing, a delayed operation should be taken into consideration.

Although we tried to objectively explore the outcomes of delayed surgery for CCS without fracture of instability, the inherent limitations of retrospective study in efficacy evaluation should be noted. Besides, the small sample size may compromise the reliability of outcomes in our study. Randomized controlled studies involving large numbers and multi-centers are warranted to further investigate the optimal surgical time for CCS.

Conclusions

Our study preliminarily suggested that delayed surgery was a feasible and effective therapy for ATCCS without fracture or instability although long-term effectiveness and more details still need to be investigated.

Abbreviations

ATCCS: acute traumatic central cord syndrome; CT: computed tomography; MRI: Magnetic resonance imaging; CDH: cervical disc herniation; SCS, spinal canal stenosis; OPLL: ossification of posterior longitudinal ligament; ASIA: American Spinal Injury Association; JOA: Japanese Orthopedic Association; M: male; F: female; MVA: motor-vehicle accidents; ACDF: anterior cervical discectomy and fusion; ACCF: anterior cervical corpectomy and fusion; U-LAP: unilateral open-door laminoplasty.

Declarations

Ethics approval and consent to participate: We obtained the ethics approval and consent of this study from the Ethics Committee of General Hospital of Southern Theatre Command of PLA.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

Funding: This study was supported by Science and Technology Project of Guangzhou, China [grant number 201803010046].

Authors' contributions: The design of the whole study was made by Binbin Wang, Yuemian Huang, Haozhi Yang, and Xiangyang Ma. The whole study was conducted by Binbin Wang, Yuemian Huang, Haozhi Yang, Ling Ni, Su Ge, Xiaobao Zou, Shuang Zhang, and Yuyue Chen under the supervision of Xiangyang Ma. The data was collected, interpreted, and analyzed by Binbin Wang, Yuemian Huang, Haozhi Yang, and Ling Ni. All authors contributed to the final version of the manuscript.

Acknowledgements: Not applicable.

References

1. Schneider RC, Cherry G, Pantek H. The syndrome of acute central cervical spinal cord injury. *Journal of neurosurgery Pediatrics*. 1954; 11: 546-77.
2. Harrop JS, Sharan A, Ratliff J. Central cord injury: pathophysiology, management, and outcomes. *The Spine Journal*. 2006; 6: 198S-206S.

3. Brodell DW, Jain A, Elfar JC, et al. National trends in the management of central cord syndrome: an analysis of 16,134 patients. *The Spine Journal*. 2015; 15: 435-42.
4. Stevens EA, Marsh R, Wilson JA, et al. A review of surgical intervention in the setting of traumatic central cord syndrome. *The Spine Journal*. 2010; 10: 874-80.
5. Dahdaleh NS, Lawton CD, Ahmadieh TYE, et al. Evidence-based management of central cord syndrome. *Neurosurgical focus*. 2013; 35(1): E6.
6. Anderson KK, Tetreault L, Shamji MF, et al. Optimal timing of surgical decompression for acute traumatic central cord syndrome: a systematic review of the literature. *Neurosurgery*. 2015; 77 (Suppl 4): S15-S32.
7. Guest J, Eleraky MA, Apostolides PJ, et al. Traumatic central cord syndrome: results of surgical management. *J Neurosurg: Spine*. 2002; 97: 25-32.
8. Samuel AM, Grant RA, Bohl DD, et al. Delayed surgery after acute traumatic central cord syndrome is associated with reduced mortality. *Spine*. 2015; 40(5): 349-56.
9. Hashmi SZ, Marra A, Jenis LG, et al. Current concepts: central cord syndrome. *Clin Spine Surg*. 2018; 31: 407-12.
10. Song J, Mizuno J, Nakagawa H, et al. Surgery for acute subaxial traumatic central cord syndrome without fracture or dislocation. *Journal of Clinical Neuroscience*. 2005; 12(4): 438-43.
11. Aarabi B, Koltz M, Ibrahimi D. Hyperextension cervical spine injuries and traumatic central cord syndrome. *Neurosurgical focus*. 2008; 25(5): E9.
12. Molliqaj G, Paye M, Schaller K, et al. Acute traumatic central cord syndrome: A comprehensive review. *Neurochirurgie*. 2014; 60: 5-11.
13. Li XF, Dai LY. Acute central cord syndrome: Injury mechanisms and stress features. *Spine*. 2010; 35(19): 955-64.
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:S28-S35.
15. Marshall LF, Knowlton S, Garfin SR, et al. Deterioration following spinal cord injury. *Journal of neurosurgery*. 1987; 66: 400-4.
16. Riew KD, Kang DG. Central cord syndrome: is operative treatment the standard of care? *The Spine Journal*. 2015; 15: 443-5.
17. Chen L, Yang HL, Yang TQ, et al. Effectiveness of surgical treatment for traumatic central cord syndrome. *Journal of neurosurgery Spine*. 2009; 10(1): 3-8.
18. Lenehan B, Fisher CG, Vaccaro A, et al. The urgency of surgical decompression in acute central cord injuries with spondylosis and without instability. *Spine*. 2010; 35: S180-S186.
19. Fehlings MG, Perrin RG. The role and timing of early decompression for cervical spinal cord injury: Update with a review of recent clinical evidence. *Injury, Int J Care Injured*. 2005; 36: S-B13-S-B26.
20. Kepler CK, Kong C, Schroeder GD, et al. Early outcome and predictors of early outcome in patients treated surgically for central cord syndrome. *Journal of neurosurgery. J Neurosurg Spine*. 2015; 23:

21. 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.

Tables

Table 1. Demographic and surgical characteristics of 39 patients.

Variables	Values (No. %)
Age (yrs)	
Mean $\pm$ SD (range)	52.2 $\pm$ 10.4 (26-72)
Gender	
Male	28 (71.8)
Female	11 (28.2)
Type of trauma	
Fall	21 (53.8)
MVA	16 (41.0)
Sports	2 (5.1)
Concomitant pathology	
CDH	19 (48.7)
SCS	12 (30.8)
OPLL	5 (12.8)
CDH+SCS	3 (7.7)
Procedure	
ACDF	14 (35.9)
ACCF	8 (20.5)
U-LAP	17 (43.6)
Interval to op (months)	
Mean $\pm$ SD (range)	20.8 $\pm$ 3.7 (15-29)
MVA, motor vehicle accident; CDH, cervical disc herniation; SCS, spinal canal stenosis; OPLL, ossification of posterior longitudinal ligament; ACDF, anterior cervical discectomy and fusion; ACCF, anterior cervical corpectomy and fusion; U-LAP, unilateral open door laminoplasty; Op, operation.	

Table 2. Outcomes of ASIA grades at admission and the 2 year follow up of 39 patients.

	Admission 2 year follow up (No.)					Total
	A	B	C	D	E	
B	0	3	8	3	0	14
C	0	0	0	12	4	16
D	0	0	0	0	9	9
Total	0	3	8	15	13	39

ASIA, American spinal injury association.

Table 3. Neurological improvement of patients undergoing different procedures.

Procedure	ASIA grades improvement Mean $\pm$ SD (Median, range)	P	JOA scores improvement Mean $\pm$ SD (Median, range)	P
ACDF	1.1 $\pm$ 0.4 (1.0, 1-2)	0.078	5.8 $\pm$ 1.3 (5.5, 5-10)	0.108
ACCF	0.75 $\pm$ 0.5 (1.0, 0-1)		4.3 $\pm$ 1.8 (5.0, 2-7)	
U-LAP	1.2 $\pm$ 0.6 (1.0, 0-2)		4.9 $\pm$ 2.3 (5.0, 1-9)	
Total	1.1 $\pm$ 0.5 (1.0, 0-2)		5.1 $\pm$ 1.9 (5.0, 1-10)	

ASIA, American spinal injury association; JOA, Japanese Orthopedic association; Kruskal Wallis test, P $\leq$ 0.05 means statistically different.

Table 4. Correlation analysis of improvement of ASIA grades and JOA scores with some factors.

Factors	Improvement of ASIA grades		Improvement of JOA scores	
	Correlation coefficient	P	Correlation coefficient	P
Age	-0.162	0.326	-0.064	0.699
Traumatic mechanism	0	0.999	-0.024	0.885
Concomitant pathology	0.09	0.585	-0.017	0.919
Interval to operation	-0.241	0.139	-0.265	0.102
Surgical procedure	0.118	0.476	-0.186	-0.256
Pre-op ASIA	0.03	0.857	0.258	0.113
Pre-op JOA score	0.153	0.352	0.183	0.264

Spearman's correlation test, $p \leq 0.05$ means statistically different.