Time of Surgery in the Outcome of Cervical Spinal Cord Injury: the University of Puerto Rico Experience

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Objective: The purpose of this study was to determine the effect of the timing of surgery on the neurological function of patients with a cervical spinal cord injury.

Methods: Retrospectively, an analysis was done of patients who underwent decompression and/or spinal cord stabilization surgeries from 2010 through 2014 for cervical trauma. All patients were older than 18 years of age, had had surgery at our facility, and had made at least 1 follow-up visit. American Spinal Injury Association (ASIA) Impairment Scale (AIS) scores were compared for patients who underwent early surgeries (less than 72 hours after trauma) and for those who underwent late surgeries (more than 72 hours after trauma).

Results: There were a total of 107 patients. Sixty-two patients had spinal cord injuries. The average age was 38.6 years, and 84% of the participants were male. The most common mechanism of trauma was motor vehicle accident. Twenty-nine percent of the patients developed neurogenic shock and 27% experienced respiratory failure during the first week after admission. Seventeen patients died during the study period. A multivariate analysis of AIS score improvement revealed that the only significant factor was incomplete neurological injury. There was no significant difference in the percentage of patients that improved with early surgery compared to that of those that improved after late surgery.

Conclusion: Traumatic cervical spinal cord injury is associated with high mortality and morbidity. Early surgery was not associated with an improved neurological outcome at long-term follow-up. The benefit of early surgery was seen only in terms of decreasing each patient's length of hospital stay. [*P R Health Sci J 2019;38:109-112*]

Key words: Spinal cord injury, Early surgery, Cervical spine

Spinal cord injury (SCI) is one of the most common and devastating traumatic injuries that can be sustained by a human. It is estimated that the incidence of such injuries is from 25 to 59 new cases per million population per year in the United States (1). One third of patients with an SCI are reported to be tetraplegic, while 50% of patients with an SCI are reported to have a complete lesion (2). The mortality is 38.6%, due to the complications associated with this traumatic injury (3). Moreover, the patients that suffer cervical SCI and survive usually develop a disability of some kind (3). Since SCIs affect mostly young patients in their most productive years, the social impact is immense (2). The estimated lifetime cost of caring for a person living with an SCI can reach up to $4.5 million per patient (4).

The pathophysiology of SCI is poorly understood. It consists of an immediate injury and a post-inflammatory response (5). Many factors have been studied to see the effect of this injury on the neurological outcomes of those patients who suffer this kind of trauma, including the grade of the initial neurological damage, the age of the patient, the mechanism of the trauma, the severity of the trauma, and the acute hospital treatment received by the patient (e.g., high dose steroids and hypothermia) (6,7,8). Regarding the latter (treatment), the most frequently studied factor is the timing of surgery. There are no level I studies that have clearly stated that acute surgery has an advantage over delayed intervention. In addition, level 3 studies have so far failed to determine absolutely that early surgery is associated with the recovery of neurological spinal function (4,9). Supporters of early surgery state that it is associated with improved neurological outcomes, decreases in the number of ventilator days, and lower incidences of in-hospital complications, all of which lead indirectly to fewer hospital days (10,11,12,13). On

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the other hand, the advocates for delayed surgery state that the timing of surgery (early vs. late) does not alter a given patient's neurological outcome and that the procedure is safer when done later, after the complete resolution of cord edema and the attaining of hemodynamic stability (14).

The purpose of this study was to determine the effect of the timing of surgery (early vs. late) on the outcomes of patients with cervical SCIs at the Puerto Rico Medical Center, the referral trauma center for Puerto Rico and the Virgin Islands.

Methods

A retrospective case study analysis was done on all the patients who had undergone decompression and/or spinal cord stabilization surgeries for cervical spine trauma from January 2010 through December 2014. All the patients had been admitted to the emergency room at the Puerto Rico Medical Center. Approval from the institutional review board of the University of Puerto Rico, Medical Sciences Campus, was obtained for the study.

Patients were included if they were older than 18 years of age, had had surgery in our facility, and had made at least 1 follow-up visit. Information regarding the mechanism and level of trauma and the presence (when such was the case) of neurogenic shock was recorded. For each patient, a description of the time (early vs. late) of his or her surgery was obtained. If a patient had a successful closed reduction using skull tongs for cervical spine traction, the moment of its occurrence was assigned as the time of decompression. Respiratory failure was documented as a complication of spine trauma if it occurred during the first week after the accident. None of the patients had undergone steroid treatment. All the patients had mean arterial pressures above 85 during the first week after their traumas. Patients were excluded if their complete follow-up information was not available or if they sustained a cervical pathology suggestive of central cord syndrome.

Upon admission, after discharge, and at a follow-up visit, each patient received a neurological examination. The Glasgow Coma Scale (GCS) and the American Spinal Injury Association (ASIA) Impairment Scale (AIS) were used to assess consciousness level and sensory and motor function, respectively. A patient whose AIS score increased by 1 grade or more was said to have experienced neurological improvement In addition, trauma severity was assessed using the Injury Severity Score (ISS).

Statistical analyses were conducted using an unpaired t-test and a chi-square test. In. addition, univariate and multivariate logistic regression analyses were performed to evaluate the odds ratio (with 95% confidence interval) for potential risk factors for AIS changes, using Excel 2007.

Results

There were a total of 107 patients that were surgically treated at our institution for cervical spine trauma during the study period and who had complete information regarding trauma period and follow-up. Of these, only 62 patients had an SCI (defined as having an AIS score of A, B, C, or D). The study was done using these 62 patients. The average age of the cohort was 38.6, and 84% of the participants were male (Table 1). The most common mechanism of trauma was motor vehicle accident. The average follow-up time was 29 months.

Initial neurological evaluations revealed that AIS A was the most common category of SCI seen in 20 of our patients (32%) (Table 1). The most common site of injury was between the C3 and C7 vertebral segments. Eighteen patients developed spinal shock, and 17 experienced respiratory failure during the first week after admission. The average ISS was 19. A total of 17 patients died during the study period. Of those who died, 12 were AIS A on admission.

Table 1. Demographics of patients with spinal cord injury

	Value (%)
No. of patients	62
Age	38.6
Sex	
Male	52 (84)
Female	10 (16)
GCS	14
Mechanism of injury	
MVA	21 (34)
Diving	12 (19)
Fall	18 (29)
Blunt trauma/Sports	5 (8)
Unknown	6 (10)
Level of injury	
C1–C2	7 (11)
C3–C5	30 (49)
C6–C7	25 (40)
AIS score	
A	20 (32)
B	11 (18)
C	14 (23)
D	17 (27)
Spinal shock	18 (29)
Respiratory failure	17 (27)

GCS: Glasgow Coma Scale; MVA: motor vehicle accident; AIS: American Spinal Injury Association Impairment Scale

Neurological-outcome improvement was analyzed by comparing admission AIS scores with the AIS scores at the patient's last follow-up visit (Table 2). Patients who died were eliminated from this analysis; thus, AIS changes were recorded

Table 2. ASIA Impairment Scale changes

Admission		Follow-up				
		A	B	C	D	E
A	8	7	0	0	0	1
B	9	1	5	0	3	0
C	12	0	1	3	7	1
D	16	0	0	2	1	13

for the remaining 45 patients. "AIS improvement" was defined as any positive change of 1 or more AIS grades. There was a total of 30 patients whose AIS scores had improved by the time said patients were evaluated at follow-up. Multivariate analysis was performed to assess AIS improvement. There was only 1 significant factor: incomplete neurological deficit, defined as an AIS score of B, C, or D (Table 3).

Table 3. Multivariate regression analysis of the improvement of AIS grade at follow-up

	P-value
Age	0.519
Gender	0.479
GCS	0.170
ISS	0.578
Surgery ≤24 hrs	0.964
Shock	0.262
Ventilation	0.722
Complete injury	0.491
Incomplete injury	0.001

GCS: Glasgow Coma Scale; ISS: Injury Severity Score

Different time frames for surgical stabilization were studied (Table 4). The mean time from accident to surgery was 12 days, with a variance of from 0 days to 67 days. Early surgery was divided into the following periods: less than or equal to 24 hours, from 25 to 48 hours, and from 49 to 72 hours. The number of patients that improved at early surgery was divided by the total number of patients who underwent early surgery. This percentage was compared to the percentage of patients that improved at delayed surgery. There was no significant difference in the percentage of patients that improved in any of the different time frames of early surgery. However, there was a statistically significant correlation between the prompt intervention of surgery (≤24hrs) and the number of hospitalization days ($p<0.03$) (Table 5).

Table 4. Comparison of percentages of patients who improved in terms of AIS grade in different surgery time frames

	Early surgery		Delayed surgery		
	Total	Patients with improvement (%)	Total	Patients with improvement (%)	P value
< 24 hrs	13	10 (77%)	32	20 (63%)	0.3522
25–48 hrs	16	12 (75%)	29	18 (63%)	0.3784
49–72 hrs	18	13 (72%)	27	17 (63%)	0.5186

Table 5. Length of hospital stay

	>24 hrs	<24 hrs	p-value
Mean no. of hospital days	37	13*	0.03
Variance	1257.31	175.93	

*t-Test: two-sample, assuming unequal variances

Discussion

The optimal time for surgical intervention for an SCI is not yet known. Currently, there is a controversy regarding the timing of decompression in an acute cervical SCI (4). Some studies suggest that patients who undergo early surgical decompression have similar outcomes to patients who receive delayed operations (9,15). Other studies state that there is a neurological benefit conferred by early intervention (4,15,16). Furthermore, the time frame for "early" intervention remains to be clearly defined (15). Some authors suggest that it—early decompression—should take place as early as 8 hours after the injury was received (9).

The purpose of this study was to determine the impact of surgical timing on the neurological outcomes of those patients at our institution suffering from SCIs. As yet, no standardized algorithm regarding surgical timing has been implemented at our institution The decision regarding whether to perform early or delayed surgery is based on operating room availability, instrumentation availability, the cardiovascular status of the patient, and the preference of the surgeon. In addition, there are external factors that determine the timing of surgical intervention at our institution; these include how far from the hospital the accident occurred and how long it took for the patient to arrive.

We retrospectively analyzed the timing of our patients' surgeries. We found a heterogeneous group in terms of the timing of surgery. The mean time from accident to surgery was 12 days, with a variance of from 0 days to 67 days. In this cohort, early surgery was not associated with improved neurological outcomes at long-term follow-up. Within the context of early vs. delayed spinal decompression surgery, how to define "early" surgery" remains the subject of debate, with the range of wait times going from as few as 6 hours to as many as 4 days (9). Our group studied the effects of early surgery by looking at different trauma-to-surgery wait times: 24 hours or less, 25 to 48 hours, and 49 to 72 hours. We found that that earlier surgeries did not lead to improvements in AIS grades. Neurological improvements were seen in 35 patients in the early-surgery cohort. However, said improvements were significantly associated only with those patients' AIS grades at admission. Our findings support previous results that have found that most patients improve at least 1 grade and that early and late surgery has minimal effect in neurological improvement (4). A statistically significant correlation between the prompt intervention of surgery (≤ 24 hours) and the number of hospitalization days was identified in our study.Third, our study had a longer follow-up period, with an average of 2.4 years. Interestingly, other studies have recently reviewed this issue and revealed that extraspinal factors, such as hypotension and brain trauma, rather than SCI characteristics were the ones associated with the functional disability of cervical trauma patients (17).

Our study had limitations. First, it was a retrospective study, and as such did not have the same statistical impact as a prospective study would. Second, the study group was small. There were many patients that had to be eliminated from the

study because their complete follow-up information was not available. Third, the exact reason for the delay (when such occurred) in surgery was not recorded in the database. This information is vital for the assessment of those factors that preclude early surgery at our institution.

Definitely, early surgery has its benefits. These patients can be mobilized earlier, start therapy earlier, and leave the hospital earlier. The patients in our study who received early surgery had marked decreases in their hospital stays. Fewer hospital days can be associated with fewer intra-hospital complications—which complications include nosocomial infection and deep-vein thrombosis—and lower health costs. In our study, mortality was lower in the patients receiving early surgical intervention. Three of the 17 patients who died had received early surgery. Due to the retrospective nature of this study, is it difficult to assess the relationship of mortality and early surgery. It can be hypothesized that patients with poor hemodynamic status and multiple body traumas were withheld from surgery until stable or that, to the contrary, early surgery prevented mortality because of the early mobilization of such patients. In the literature, mortality prevention has not been proven to result from early surgery. Mortality depends on other factors, such as systemic trauma, ISS, age, and hemodynamic status (17).

Conclusion

Early surgical intervention was not associated with improved neurological outcome after a cervical SCI. Traumatic SCI is associated with high mortality and great morbidity, including devastating neurological sequelae. Further studies are warranted in order to explore what factors can reverse the damage and stop secondary injury.

Resumen

Objetivo: El propósito de este estudio fue determinar el efecto del tiempo en el que se realiza la cirugía para traumatismo de la medula espinal cervical y la recuperación neurológica. Métodos: Se realice un análisis retrospectivo de pacientes que fueron sometido a cirugías de descompresión y estabilización para traumatismo de la medula espinal cervical entre el 2010 y el 2014 en el Centro Medico de Puerto Rico. La gradación en la escala de discapacidad conocida por sus siglas en ingles como "AIS" de la "American Spinal Injury Association" fue comparada entre los pacientes a los que se sometido a cirugía temprana (menos de 72 horas después del trauma) and cirugía tardía (después de 72 horas del trauma). Resultados: Hubo un total de 107 pacientes. Sesenta y dos pacientes tuvieron daño a la medula espinal cervical. La edad promedio fue de 38.6 años y 84% de los sujetos eran varones. Diecisiete pacientes murieron durante el período de estudio. Análisis de múltiples variables para el mejoramiento neurológico demostró que el único factor significativo para la mejoría neurológica era daño a la medula espinal incompleto. No se identificó una diferencia significativa en el porciento de pacientes que mejoraron con cirugía temprana versus cirugía tardía. Conclusión: Traumatismo de la medula espinal cervical está asociado con una alta mortalidad y morbididad. La cirugía temprana no demostró un aumento en la mejoría del estatus neurológico a largo plazo. El único beneficio que se demostró con cirugía temprana fue una disminución en el tiempo de hospitalización.

References

1. Dimar JR 2nd, Glassman SD, Raque GH, Zhang YP, Shields CB. The influence of spinal canal narrowing and timing of decompression on neurologic recovery after spinal cord contusion in a rat model. Spine (Phila Pa 1976) 1999;24:1623–1633.
2. Devivo MJ. Epidemiology of traumatic spinal cord injury trends and future implications. Spinal Cord 2012;50:365-372.
3. Furlan JC, Noonan V, Cadotte DW, Fehlings MG. Timing of decompressive surgery of spinal cord after traumatic spinal cord injury: an evidence-based examination of pre-clinical and clinical studies. J Neurotrauma 2011;28:1371-1399.
4. 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:e32037.
5. 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.
6. Carlson GD, Minato Y, Okada A, et al. Early time-dependent decompression for spinal cord injury: vascular mechanisms of recovery. J Neurotrauma 1997;14:951-962.
7. Kwon BK, Tetzlaff W, Grauer JN, Beiner J, Vaccaro AR. Pathophysiology and pharmacologic treatment of acute spinal cord injury. Spine J 2004;4:451-464.
8. Tee JW, Chan PC, Fitzgerald MC, Liew SM, Rosenfeld JV. Early predictors of functional disability after spine trauma: a level 1 trauma center study. Spine (Phila Pa 1976) 2013;38:999-1007
9. Kingwell SP, Noonan VK, Fisher CG, et al. Relationship of neural axis level of injury to motor recovery and health-related quality of life in patients with a thoracolumbar spinal injury. J Bone Joint Surg Am 2010;92:1591-1599.
10. 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;52:323–332.
11. Pollard ME, Apple DF. Factors associated with improved neurologic outcomes in patients with incomplete tetraplegia. Spine (Phila Pa 1976) 2003;28:33-39.
12. Liu JM, Long XH, Zhou Y, Peng HW, Liu ZL, Huang SH. Is Urgent Decompression Superior to Delayed Surgery for Traumatic Spinal Cord Injury? A Meta-Analysis. World Neurosurg 2016;87:124-131.
13. Umerani MS, Abbas A, Sharif S. Clinical Outcome in Patients with Early versus Delayed Decompression in Cervical Spine Trauma. Asian Spine J 2014;8:427-434.
14. Mirza SK, Krengel WF 3rd, Chapman JR, et al. Early versus delayed surgery for acute cervical spinal cord injury. Clin Orthop Relat Res 1999;(359):104-114.
15. Furlan JC, Fehlings MG. The impact of age on mortality, impairment, and disability among adults with acute traumatic spinal cord injury. J Neurotrauma 2009;26:1707-1717.
16. Levi L, Wolf A, Rigamonti D, Ragheb J, Mirvis S, Robinson WL. Anterior decompression in cervical spine trauma: does the timing of surgery affect the outcome? Neurosurgery 1991;29:216-222.
17. Tee JW, Chan PC, Gruen RL, et al. Early predictors of mortality after spine trauma: a level 1 Australian trauma center study. Spine (Phila Pa 1976) 2013;38:169-177.