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ORIGINAL ARTICLE

Surgical treatment of cervical spine trauma: Our experience and results

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ABSTRACT

Objective and Background: The objective of this study is to evaluate how the neurological outcome in patients operated for cervical spinal cord injury (SCI) is influenced by surgical timing, admission American Spinal Injury Association (ASIA) grading system, and age.

Materials and Methods: From January 2004 to December 2011, we operated 110 patients with cervical SCI. Fifty-seven of them (44 males and 13 females) with preoperative neurological deficit, were included in this study with a complete follow-up. Age, sex, associated comorbidities (evaluated with Charlson comorbidity index [CCI]), mechanism of trauma, preoperative and follow-up ASIA score, time elapsed from injury to surgical treatment, preoperative cervical computed tomography scan or magnetic resonance imaging, type of fractures, and surgical procedure were evaluated for each patient. The patient population was divided into two groups related to the timing of surgery: Ultra-early surgery group (within 12 h from the trauma, 27 patients) and early surgery (within 12–72 h from the trauma, 30 patients).

Statistical Analysis Used: The univariate analysis of data was carried out by the Chi-square test for discrete variables, the *t*-test for the continuous ones. Logistic regression was used for the multivariate analysis.

Results: Neurological outcome was statistically better in ultra-early surgery group (<12 h) than in patient underwent surgery within 12–72 h (82.14% vs. 31%, multivariate analysis $P = 0.005$). The neurological improvement was also correlated with the age and the ASIA grade at admission in the univariate analysis ($P = 0.006$ and $P = 0.017$ respectively) and in the multivariate 1 ($P = 0.037$ and $P = 0.006$ respectively) while the CCI was correlated with the improvement only in the univariate analysis ($P = 0.007$).

Conclusion: Nowadays, in patients with cervical SCI early surgery could be associated with improved outcome, most in case of young people with mild neurological impairment.

Key words: Spinal cord injury, spine trauma, surgical decompression, timing of operation, traumatic cervical spinal cord injury

Introduction

The prevalence of traumatic spinal cord injury (SCI) in USA is 750/million inhabitants and 12,000 people yearly are affected in North America.[1,2] These data show how spinal cord trauma negatively influences personal and familiar quality of life, as well as it represents a heavy financial burden because of its morbidity with prolonged duration of postoperative treatment and subsequent expensive cost. Authors like Kraus and Stripling estimated about thirty years ago in the United States an annual cost for the treatment of these injured people of two billion dollars in 1975, increased to four billion in 1990.

Cervical spinal cord injuries represent 20–33% of total spinal injuries with the prevalence of the subaxial levels. In patients with a preoperative neurological deficit due to spine trauma, in case of spinal cord compression or instability, surgery is often the treatment of choice to grant a chance of neurological recovery, early mobilization, and faster return to usual daily activities compared to the conservative treatment.[3] This is a particularly relevant topic since the largest group in spinal cord injured population is represented by young people. At present, the right

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surgical timing is one of the most controversial issues in spinal surgery. In the past, many authors suggested a delayed surgical treatment to reduce postoperative complications rate but recent studies have shown that an early decompression (<72 h) may facilitate a postoperative neurological improvement probably due to the prevention of the secondary mechanisms of damage in acute SCI.[4] The objective of our study is to evaluate the long-term results about neurological outcome in patients operated for cervical SCI regarding the surgical timing, the preoperative American Spinal Injury Association (ASIA) grading systems and the age of patients.

Materials and Methods

From January 2004 to December 2011, we operated 110 patients for cervical spine trauma at the Department of Neurosurgery, Umberto I General Hospital, Ancona. The preoperative neurological deficit, documented in 60 patients, is the inclusion criteria in this study, but a complete follow-up was possible in 57 patients only. This study group consists of 44 males and 13 females with a mean age of 50.2 years (range 16–83 years; standard deviation ± 21.26). Age, sex, associated comorbidities (Charlson comorbidity index [CCI]), preoperative and follow-up ASIA score, pre- and post-operative neuro-radiological exams (cervical X-ray, computed tomography [CT] scan or magnetic resonance imaging), type of fractures (according to Magerl classification), timing, and type of surgical procedures were evaluated in the study and are summarized in Table 1.

Spinal cord injuries were caused mainly by motor-vehicle accidents (54.38%), by falls (42.1%), and rarely by sports-related activities (3.5%). An associated cranial trauma was documented in 13 of 57 patients (22.8%). The most frequent cervical injured level was C5-6 and according to the Magerl classification 8 patients had a fracture type A, 46 type B, and 3 type C [Table 2]. The admission and follow-up ASIA score are reported in Table 3. The anterior approach (corpectomy or microdiscectomy and plating) was performed in 35 patients while a posterior (rods and screws fixation) or a combined approach was respectively made in 12 and 10 patients. When unilateral or bilateral cervical facet dislocation was diagnosed on initial X-ray or CT scan, closed reduction, if indicated, was attempted in the operating room just before surgery with Mayfield skull clamp under X-ray guidance. If an adequate reduction was not obtained, we proceeded with an open reduction. No patient underwent cervical traction prior to surgery. All patients with neurological deficits at admission were submitted to National Acute SCI Studies-2 protocol. Regard to surgical timing, an effort was made to conduct the surgical procedure as soon as possible; however, procedures were sometimes delayed due to a number of reasons including late presentation after the trauma, delay in consent or in diagnostic investigations and delay due to the medical condition of the patient. However, all patients were operated within 72 h from the traumatic event.

Then our study population is divided into two groups as regard the timing of surgery: Ultra-early surgery group (<12 h from the trauma, including 27 patients) and early surgery group (12–72 h, including 30 patients). At admission, there was no statistically significant difference in ASIA score between the two study groups [Table 1; $P = 0.99$]. A cervical postoperative CT scan was performed in all patients within 24–72 h after surgery. Clinical follow-up and radiological evaluation were achieved 3, 12, and 24 months after surgery [Table 3].

Statistical analysis was performed using SPSS software (version 20; SPSS Inc., Chicago, IL, USA). The univariate analysis of data was carried out by the Pearson Chi-square test for discrete variables, the *t*-test for the continuous ones. Logistic regression was used for the multivariate analysis. Statistical significance was set at $P < 0.05$. All patients granted their permission for this study before surgery. The risk to participants is minimal. The research data analysis has no effect on the participants and their medical care.

Results

American Spinal Injury Association grade of 57 patients at 3, 12, and 24 months follow-up is reported in Table 3. Two years after the operation, 12 (21%) patients were ASIA grade A, 6 (10.5%) ASIA B, 9 (15.7%) ASIA C, 14 (24.6%) ASIA D, and 16 (28.2%) ASIA E. Thirty-three patients (57.89%) with a neurological deficit at admission showed a neurological improvement after 24 months while none of the operated patients had a neurological worsening [Table 4]. The improvement in patients operated within 12 h (27 patients) from the trauma was obtained in 82.14% of the cases (22 of 27 patients) while it was obtained in 33.33% of the patients operated between 12 and 72 h only (10 of 30 patients) [Table 5]. These data confirm that 2 years after surgery the neurological improvement was related to the surgical timing both in the multivariate analysis ($P = 0.005$) and in the univariate 1 ($P = 0.008$) as illustrated in Table 6. The neurological improvement was also correlated with the age and ASIA grade at admission in the univariate analysis ($P = 0.006$ and $P = 0.017$ respectively) and in the multivariate 1 ($P = 0.037$ and $P = 0.006$ respectively), while CCI was correlated with the improvement only in the univariate analysis ($P = 0.007$) [Table 6]. Seven patients experienced postoperative complications [3 patients with cardiopulmonary diseases, 2 with wound infection, 1 with pulmonary embolism, and 1 with hardware breakage; Table 1].

Discussion

For spinal cord injured patients, with column instability or neurological deficits, the surgical decompression of spinal cord and the restoration of vertebral alignment are the gold standard treatment, anyway the timing of spinal surgery is still controversial.[3] For many years, no statistically relevant difference in neurological outcome in spinal cord injured

Table 1: Baseline data of overall patient population with cervical SCI and of ultra-early (surgery <12 h) and early surgery groups (surgery >12 <72 h) including age, sex, CCI, cause of trauma, level of fracture, type of fracture, the exact time of decompression from trauma, the surgical approach, ASIA score at admission, and postoperative complications. At admission, there was no statistically significant difference in baseline factors between the two study groups, except for age and CCI

	Total 57 patients	Ultra-early surgery group (<12 h) 27 patients	Early surgery group (>12 <72 h) 30 patients	*P*
Age (years)				
Mean (±SD)	50.2 (±21.26)	43.96 (±20.56)	56.17 (±20.51)	0.025
Range	16-84	16-83	18-84	
Sex (%)				
Male	44 (77.2)	20 (74.07)	24 (80)	
Female	13 (22.8)	7 (25.93)	6 (20)	
CCI				
0	22	15	7	0.0007
1	3	2	1	
2	7	1	6	
3	11	4	7	
4	11	2	9	
5	3	3	0	
Cause of trauma (%)				
MVA	31 (54.38)	16 (59.25)	15 (50)	0.24
Falls (ground level fall + fall from a height)	24 (42.1)	9 (33.33)	14 (46.66)	
Sports-related activities	2 (3.51)	2 (7.40)	1 (3.34)	
Level of trauma (%)				
C3-4	10 (17.55)	6 (22.22)	4 (13.33)	0.59
C4-5	15 (26.32)	7 (25.92)	8 (26.66)	
C5-6	20 (35.08)	8 (29.62)	12 (40)	
C6-7	12 (21.05)	6 (22.22)	6 (20)	
Type of fracture (Magerl classification)				
A	8	5	3	0.15
B	46	20	26	
C	3	2	1	
Surgical approach				
Anterior (corpectomy or microdiscectomy and plating)	35 (61.4%)	17	18	0.21
Posterior (rods and screws fixation + decompression)	12 (21.05%)	4	8	
Combined (anterior + posterior)	10 (17.55%)	6	4	
Time of decompression from trauma				
Mean (h)	17.20	7.84	25.43	
Range (h)	4-72	4-12	13-72	
ASIA score at admission				
A	18	9	9	0.99
B	6	3	3	
C	14	6	8	
D	19	9	10	
E	-	-	-	
Postoperative complications				
Cardiopulmonary	3		3	0.98
Construct failure	1	1		
Deep wound infection				
Neurologic deterioration				
Pulmonary embolism	1	1		
Systemic infection				
Wound dehiscence	2	1	1	
No complications	52	24	26	

SCI – Spinal cord injury; CCI – Charlson comorbidity index; ASIA – American Spinal Injury Association; MVA – Motor-vehicle accidents; SD – Standard deviation

Table 2: Correlation between injury levels and type of fracture according to Magerl classification

Level	Magerl classification			
	A	B	C	Total
C3-4	2	7	1	10
C4-5	3	11	1	15
C5-6	1	18	1	20
C6-7	2	10	0	12
Total	8	46	3	57

Table 3: ASIA score at admission and after 3, 12, and 24 months follow-up

ASIA score	Admission	3 months follow-up	12 months follow-up	24 months follow-up
A	18	15	13	12
B	6	7	5	6
C	14	11	9	9
D	19	18	14	14
E	-	6	16	16

ASIA – American Spinal Injury Association

Table 4: Evaluation of improved patients after 24 months follow-up for each ASIA score group

	24 months follow-up ASIA score							
Admission ASIA score		A	B	C	D	E	Improved patients	Percentage
A	18	12	4	1	1	0	6/18	33.33
B	6	0	2	2	1	1	4/6	66.6
C	14	0	0	6	8	0	8/14	57.1
D	19	0	0	0	4	15	15/19	78.1
Total	57	12	6	9	14	16	33/57	57.89

ASIA – American Spinal Injury Association

Table 5: Modification of ASIA score after 24 months follow-up for ultra-early surgery group (<12 h) and early surgery group (>12<72 h)

ASIA score	Admission			24 months follow-up		
	Total	Ultra-early surgery group	Early surgery group	Total	Ultra-early surgery group	Early surgery group
A	18	9	9	12	4	8
B	6	3	3	6	2	4
C	14	6	8	9	2	7
D	19	9	10	14	7	7
E	-	-	-	16	11	5

ASIA – American Spinal Injury Association

Table 6: Statistical analysis of relationship between ASIA score improvement at 24 months follow-up and admission ASIA score, timing of surgical procedure, age of the patient, and CCI

	24 months follow-up				
	Overall (*n*=57)	Improved patients (*n*=33)	Not improved patients (*n*=24)	Univariate analysis *P*	Multivariate analysis *P*
ASIA at admission					
A	18	6	12	0.017	0.006
B	6	4	2		
C	14	8	6		
D	19	15	4		
Surgical timing					
<12 h	27	22	5	0.008	0.005
12-72 h	30	10	20		
Age (years)					
Median	50,2	37	64	0.006	0.037
Range	(16-84)	(16-78)	(18-84)		
CCI, median (range)	2 (0-5)	0 (0-5)	3 (0-4)	0.007	NS

NS – Nonsignificant; ASIA – American Spinal Injury Association; CCI – Charlson comorbidity index

patients submitted to early or late surgery was found and still today there is not a clearly worldwide accepted definition of early or late surgery.[5,6] Recent studies underlined that the difference between early and late surgery and their consequences on postoperative outcome are closely related to the physiopathology of SCI. In literature there is no surgical procedure that can limit the primary damage while it is mandatory to prevent the secondary SCI, represented by vascular and biochemical changes (electrolytes modification, free radical production, serotonin, and catecholamine accumulation), edema formation and inflammation that appear within 72 h after spinal trauma.[7,8] According to the previous sentence, it is mandatory to operate the patient within 72 h after trauma but we think that to perform surgery as soon as possible can still further positively influence the neurological outcome.

In our study, the time of decompression was in fact closely related to the outcome. The best improvement was obtained in patients operated within 12 h from the spinal trauma (82.14% of patients in this group) while it happened in 31% of the patients operated between 12 and 72 h and this difference is statistically validated by the univariate and the multivariate analysis. These data suggest that performing the surgical procedure as soon as possible from the trauma influences a postoperative neurological improvement but at the same time we realize that we need a larger case series to better validate our statistical data. Besides, many studies have no demonstrated a higher rate of medical complications in "early surgery."[9,10]

The ASIA grade at admission appeared in our study as a still further element that can influence the postoperative outcome in the univariate and in the multivariate analysis confirming what other authors have proven in past years.[9] In our series in fact patients in grade D improved in 78.1% of the cases while patients in grade B improved in 66.6%, but it is really interesting to see that three months after the trauma even 3 patients out of 18 with ASIA grade A improved, probably due to the spinal shock that alters the actual initial clinical

assessment. At the end, the outcome demonstrates a relation also with the age of all patients. It is in fact easy to understand that younger patients with deficits have a better prognosis than older ones in the same neurological conditions whose outcome may be influenced by comorbidities.

Conclusion

This study shows how early cervical surgical procedures of decompression and eventual stabilization in SCI patients were performed safely and were associated with neurological improvement with statistical significance. ASIA grade at admission and patient's age were other factors closely correlated with the outcome. Thanks to technological and pharmacological improvement, at present surgery is the best valid treatment for patients with cervical SCI when indicated. Clearly to define better the role of the surgical timing larger case series and randomized controlled prospective trials are necessary.

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