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Original Article

Factors affecting functional outcome in patients with traumatic brain injury sequelae: Our single-center experiences on brain injury rehabilitation

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ABSTRACT

Objectives: This study aims to investigate the effect of rehabilitation on functional level of traumatic brain injury (TBI) patients and to examine the associated factors on functional gain in this patient population.

Patients and methods: Between October 2010 and November 2015, a total of 71 patients (63 males, 8 females; mean age 26.6±8.1 years; range, 18 to 56 years) who were admitted to our rehabilitation clinic with moderate-to-severe TBI were retrospectively analyzed. Functional recovery was assessed using the Functional Independence Measure (FIM) and Functional Ambulation Classification (FAC) scales. The patients were divided into two groups according to time from TBI to the initiation of rehabilitation: early (<6 months) and late (≥6 months). Possible predictive factors associated with FIM gain were evaluated.

Results: There was a significant improvement in the FIM scores from admission to discharge ($p<0.001$). There was a statistically significant difference in the FIM gain and FIM efficiency between the patient groups according to the initiation of rehabilitation ($p<0.001$). The FAC scores increased from admission to discharge, showing statistical significance ($p<0.001$). Duration of rehabilitation, early rehabilitation, heterotopic ossification, and deep venous thrombosis were found to be significant factors associated with FIM gain ($p<0.001$).

Conclusion: Our study results suggest that rehabilitation is effective for functional gain, particularly in the early period in patients with moderate-to-severe TBI and duration of rehabilitation, early rehabilitation, heterotopic ossification, and deep venous thrombosis are also predictors of functional improvement.

Keywords: Functional outcome, rehabilitation, traumatic brain injury.

Traumatic brain injury (TBI) is recognized as a serious public health concern, accounting for 1.5 million deaths and several million hospitalizations worldwide.[1,2] It often requires significant and expensive interventions, including prolonged length of stay during acute care and inpatient rehabilitation, which poses considerable economic consequences, as well.[3]

Uncertainty regarding the effect of rehabilitation is a source of significant anguish to the families and patients with TBI. Therefore, it is of utmost importance to identify specific factors influencing patient's functional outcomes. Identification of predictive factors of functional improvement may have important implications for the intervention development, cost projection, and allocation of funding for TBI treatment. Age, sex, altered cognitive status, bowel and bladder continence, and post-traumatic amnesia have been found to be associated factors with functional gain in patients with TBI.[4-7]

In the present study, we aimed to investigate the effect of rehabilitation on functional level of TBI

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patients and to examine the associated factors on functional gain in this patient population.

PATIENTS AND METHODS

Between October 2010 and November 2015, medical records of a total of 71 patients (63 males, 8 females; mean age 26.6±8.1 years; range, 18 to 56 years) who were admitted to our rehabilitation clinic with moderate-to-severe TBI were retrospectively analyzed. The study protocol was approved by the Ethics Committee of Gulhane Military Medical Academy. The study was conducted in accordance with the principles of the Declaration of Helsinki.

In this study, patients who were diagnosed with moderate-to-severe TBI and hospitalized at our clinic and underwent rehabilitation were included. The diagnosis of the patients with TBI was based on abnormal neurological clinical and imaging findings on admission to inpatient rehabilitation. All patients underwent cranial magnetic resonance imaging (MRI) prior to admission. Inclusion criteria were as follows: *(i)* history of post-injury Glasgow Coma Scale[8] 3-8, *(ii)* presence of neurological fallout; *(iii)* having no other medical condition which could affect cognitive and functional status; *(iv)* being medically stable at the time of physical examination; and *(v)* ≥18 years of age at the time of injury.

On admission, data including age, sex, marital status, education status, etiology of TBI, complications, the time from TBI to rehabilitation admission, duration of rehabilitation, and cranial MRI findings were recorded. The patients were divided into two

Table 1. Demographic and clinical features of the patients

	n	%	Mean±SD
Age (year)			26.6±8.1
Sex			
Male	63	88.7	
Female	8	11.3	
Age at the time of injury (year)			25.1±7.9
Time since injury (months)			17.1±23.2
Duration of rehabilitation (months)			3.1±2.4
Education			
Primary education	13	18.3	
High school	29	40.8	
University	29	40.8	
Marital status			
Single	49	69	
Married	22	31	
Etiology			
Motor vehicle accident	42	59.2	
Pedestrian accident	16	22.5	
Violence	7	9.9	
Fall from height	6	8.5	
Complications			
Speech disorders	43	60.6	
Spasticity	38	53.5	
Seizure	20	28.2	
Dysphagia	18	25.4	
Contracture	15	21.1	
Heterotopic ossification	13	18.3	
Pressure sore	5	7	
Deep venous thrombosis	3	4.2	
Functional Ambulation Classification			
0	36	50.7	
1	8	11.3	
2	4	5.6	
3	11	15.5	
4	8	11.3	
5	4	5.6	

SD: Standard deviation.

groups according to time from TBI to the initiation of rehabilitation: early (<6 months) and late (≥6 months).

Rehabilitation protocol

All TBI patients were evaluated by a physiatrist and treatment through a neurological rehabilitation program was planned and administered regularly during the hospital stay. The primary goals of specialized inpatient rehabilitation of TBI were to reduce impairment, to increase functional independence, to restore social participation, and to minimize distress of the patient as well as of the caregivers. There was a particular focus on the personal and domestic activities of daily life. All patients received a minimum of two to three hours daily individual treatment including physiotherapy, occupational therapy, speech therapy, cognitive training, nutrition, dietary services, and psychosocial support.

Assessment

Primary outcome measure

The primary outcome measure was the Functional Independence Measure (FIM) which evaluates functional independence in self-care activities, mobility, and cognition. Items are summed into a cognitive subscale, motor subscale, and overall FIM total score. The FIM is a well-validated tool which measures disability with 18 items rated on a scale from 1 (complete dependence) to 7 (complete independence).[9] The scores range from 18 to 126, and higher scores indicate a higher level of independence. The adaptation of the Turkish version of the FIM was done, and it was found to be reliable and valid.[10] Motor FIM is composed of 13 items assessing mobility, bowel and bladder control, and activities of daily living. Cognitive FIM (five items) assesses language, memory, and problem solving skills. Admission FIM scores were evaluated within the first 72 h after admission, while discharge FIM scores were evaluated within the 24 h prior to discharge from the inpatient rehabilitation clinic. In addition to the FIM scores, both FIM gain, which is calculated as the difference between the FIM scores of before the initiation of rehabilitation and at discharge, and the FIM efficiency,[11] which is obtained by dividing the FIM gain to the total length of hospital stay, were calculated.

Secondary outcome measure

The Functional Ambulation Classification (FAC) scale classifies patients according to basic motor

Table 2. Comparison of outcomes between early and late rehabilitation

	Total							Early (<6 months) rehabilitation							Late (>6 months) rehabilitation						
	Admission			Discharge				Admission			Discharge				Admission			Discharge			
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p*	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p*	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p*
FIM	55.4±29.4			79.5±33.5			<0.001	63.0±28.3			94.6±27.8			<0.001	48.0±28.9			65.0±32.4			<0.001
FIM motor	36.2±20.8			56.4±25.1			<0.001	40.6±20.5			67.5±21.4			<0.001	32.0±20.5			45.6±23.9			<0.001
FIM cognitive	19.1±10.1			23.1±9.1			<0.001	22.3±9.6			27.0±7.3			<0.001	15.9±9.7			19.3±9.1			<0.001
FIM gain	N/A			24.1±22.1			N/A	N/A			31.5±24.1			N/A	N/A			17.0±17.4*			N/A
FIM efficiency	N/A			0.3±0.4			N/A	N/A			0.4±0.4			N/A	N/A			0.3±0.3*			N/A
FAC		0	0-5		5	0-5	<0.001		0	0-5		5	0-5	<0.001		0	0-5		0	0-5	<0.001

SD: Standard deviation; Min-Minimum; Max: Maximum; FIM: Functional independence measure; N/A: not applicable; FAC: Functional Ambulation Classification; * There was a statistically significant difference between the groups according to the timing of rehabilitation (early vs late).

skills necessary for functional ambulation and ranges from independent walking outside (Category 5) to non-functional walking (Category 0).[12] Both primary and secondary outcomes were assessed before the initiation of rehabilitation and at the time of discharge by the physiatrist.

Statistical analysis

Statistical analysis was performed using the SPSS for Windows, version 16.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed in mean or median and standard deviation (SD) or min-max values. Categorical variables were presented in frequency (%). The Kolmogorov-Smirnov test was used to confirm that the data were within the ranges of normal distribution. The Student's t-test and Pearson test for normally distributed data and Mann-Whitney U and Spearman tests for abnormally distributed data were also performed. The chi-square test or Fisher's exact test was used to compare categorical data. Bivariate analysis was carried out first between all possible risk factors (sex, age, time since injury, duration of rehabilitation, timing of rehabilitation, education status, marital status, etiology, and complications) and FIM gain. Variables with $p<0.1$ in bivariate analysis (marital status, duration of rehabilitation, timing of rehabilitation, swallowing dysfunction, heterotopic ossification, and deep venous thrombosis) were included in the multiple linear regression analysis for FIM gain. A p value of <0.05 was considered statistically significant with 95% confidence interval (CI).

RESULTS

In this study, the male-to-female ratio was 7.8:1. The mean time since injury was 17.1±23.2 months. The time from injury to the initiation of rehabilitation was <6 months in 35 patients and >6 months in 36 patients. The mean duration of rehabilitation was 3.1±2.4 months. The most common mechanism of injury was motor vehicle accident (59.2%), followed by pedestrian accidents (22.5%). There were several complications related with TBI. The main complications were speech disorders (60.6%), spasticity (53.5%), and seizures (28.2%). Demographic and clinical data are presented in Table 1.

The mean FIM score was 55.4±29.4 on admission and 79.5±33.5 at the time of discharge. The mean FIM gain and efficiency were 24.1±22.1 and 0.3±0.4, respectively. There was a significant improvement on FIM scores from admission to discharge ($p<0.001$). The mean admission FIM score was found to be 63.0±28.3 in the early group and 48.0±28.9 in the late group. The mean discharge FIM score was 94.6±27.8 in the early group and 65.0±32.4 in the late group. There were statistically significant differences in the FIM gain and efficiency between the patients in acute and chronic phase ($p<0.001$). The FAC scores increased from admission to discharge, indicating statistical significance ($p<0.001$) (Table 2). There was also a significant correlation between the admission FAC and FIM scores ($r=0.813$, $p=0.0001$) and discharge FAC and FIM scores ($r=0.897$, $p=0.0001$).

Diffuse axonal injury was detected on 25 (35.2%) patients. Among the affected areas, temporoparietal region was the most commonly injured part of the brain (35.2%). The patients were also divided into two subgroups: FIM gain in patients with or without diffuse axonal injury. There was no statistically significant difference between the two groups (21.7±23.6 vs. 25.5±21.4) ($p>0.05$). Similarly, FIM gain was compared according to temporoparietal lesions and no statistically significant difference was found between the two groups (28.1±21.2 vs. 22.1±22.5) ($p>0.05$).

Multiple linear regression analysis revealed that duration of rehabilitation, timing of rehabilitation

Table 3. Multiple linear regression analysis of functional independence measure gain

Risk factors	B	SE	Beta	*p*
Marital status	-0.623	0.499	-0.122	0.217
Duration of rehabilitation (days)	0.012	0.004	0.353	0.002
Timing of rehabilitation (early/late)	1.543	0.455	0.326	0.001
Swallowing dysfunction	-0.288	0.587	-0.054	0.625
Heterotopic ossification	-1.222	0.611	-0.200	0.049
Deep venous thrombosis	-3.973	1.106	-0.337	0.001

B: Regression coefficient; SE: Standard error.

(early vs. late), heterotopic ossification, and deep venous thrombosis were significant factors associated with FIM gain (Table 3).

DISCUSSION

This study was conducted in a brain injury rehabilitation center where comprehensive rehabilitation including physiotherapy, occupational therapy, recreational activities, speech-language, and cognitive therapy were able to be applied to the TBI patients. According to the study results, our comprehensive rehabilitation program was effective in improving functional level in TBI patients. However, this improvement was more prominent in patients who were admitted to our hospital within six months following injury. In addition, regression analysis showed that duration of rehabilitation, timing of rehabilitation, heterotopic ossification, and deep venous thrombosis were significantly associated with FIM gain.

There is high-quality evidence on rehabilitation recommendation following TBI. Our results are also consistent with a large body of work suggesting rehabilitation as effective to improve functionality in disabled TBI patients, and similar trends in motor and cognitive improvement were reported previously.[13-16]

In our study we used FIM to assess the level of physical and cognitive disability which indicates the burden of care and is widely used in TBI and other populations in need of rehabilitation.[17,18] In addition, as previously reported in the literature, the FIM was developed to evaluate progress in functional level during inpatient rehabilitation.[19] In our study, a significant improvement in the FIM scores was observed in the discharge scores (79.5) compared to the admission scores (55.4). These findings are also consistent with previous studies using the FIM scale and showing significant functional recovery in TBI patients.[19,20]

In the present study, we also used the FAC scale to assess the impact of the rehabilitation on patients' ambulatory capacity, and patients showed a significant improvement in locomotion, compared to baseline, in consistency with previous studies.[21,22] In addition, there was a strong correlation between the FAC and FIM scores in the current study.

Timing of rehabilitation is critical to evaluate functional improvement.[5,23-25] Therefore, we compared early and late rehabilitation groups and found that there was a significant improvement in the early rehabilitation group. Sandhaug et al.[23] also reported a similar functional improvement within three months after injury in a TBI population in whom the FIM scores improved significantly from rehabilitation to discharge at 24 months after injury with peak levels at 3 and 24 months after injury for the all TBI group and severe TBI group. Similarly, Andelic et al.[24] concluded that better functional outcomes were achieved in patients who received early rehabilitation. Tepas et al.[25] also showed that delay in rehabilitation decreases outcomes and efficiency of rehabilitative care. Overall, we suggest that TBI patients presenting acutely to hospital with moderate-to-severe brain injury should be routinely evaluated for their altering needs for rehabilitation, since earlier gains can be attained with intensive rehabilitation.[26]

Outcome prediction after brain injury is of significant research interest, as accurate prediction can shape the treatment efforts and policy and to predict prognosis. In the current study, multiple linear regression analysis was performed to predict FIM gain in the TBI patients. Regression analysis showed that duration of rehabilitation, early rehabilitation, heterotopic ossification, and deep venous thrombosis were significantly associated with FIM gain, and these factors can be used for FIM gain prediction. It can be commented that in a model created with marital status, duration of rehabilitation, early and late rehabilitation, swallowing dysfunction, heterotopic ossification, deep venous thrombosis, and early rehabilitation (compared to late rehabilitation) would probably increase FIM gain by 1.54 points. Similarly, one more day in rehabilitation would result in 0.012 point FIM gain increase. On the other hand, it can be suggested that heterotopic ossification and deep venous thrombosis would probably result in 1.22 and 3.97 point decrease in FIM gain, respectively. Sandhaug et al.[14] reported that predictors of functional level at the time of discharge from rehabilitation were Glasgow Coma Scale scores at the time of admission to rehabilitation, FIM total score at the time of admission to rehabilitation, length of stay in the rehabilitation unit, and length of post-traumatic amnesia. deGuise et al.[27] also indicated that FIM, the Extended Glasgow Outcome Scale, and Neurobehavioral Rating Scale-revised scores at the time of discharge were important predictors of functional outcome. In another study, McLafferty et al.[28] found that normotension at the time of admission and length of stay in the rehabilitation unit were associated with a response to inpatient rehabilitation. In their study, Johns et al.[29] evaluated the effect of heterotopic ossification on functional outcome

after TBI and showed that patients with heterotopic ossification had significantly lower FIM scores with significantly lower FIM efficiency. Consistent with our study results, Yablon et al.[30] demonstrated a negative relationship between deep venous thrombosis and FIM locomotion subscale scores.

Nonetheless, several limitations should be recognized for the present study. First, the lack of a control group might have interfered with an unbiased comparison of the results. Second, small sample size might have precluded generalization of the results. Other limitations are the lack of diversity of outcome measures and lack of standard physiotherapy. However, the findings of the present study provides long-term experiences of a single rehabilitation center on TBI and to be a guide for clinicians for the evaluation of TBI patients.

In conclusion, our study results suggest that tailoring a rehabilitation program for functional needs of patients may be useful in improving rehabilitation outcomes. In addition, TBI patients who receive early rehabilitation may have better functional outcomes than those receiving late rehabilitation. Duration of rehabilitation, timing of rehabilitation, heterotopic ossification, and deep venous thrombosis are also significant predictors of FIM gain. However, further large-scale, long-term, multi-center studies investigating cost-effectiveness of early rehabilitation after severe TBI are required.

Declaration of conflicting interests

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