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Original Article

The effect of etiological and clinical characteristics on the rehabilitation process and functional gains in pediatric severe acquired brain injury

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ABSTRACT

Objectives: The aim of this study was to investigate the etiological and clinical characteristics of pediatric patients with severe acquired brain injury and their effects on rehabilitation outcomes.

Patients and methods: A total of 67 pediatric patients (39 males, 28 females; mean age: 9.7±4.8 years; range, 3 to 18 years) who were hospitalized due to severe acquired brain injury between March 2020 and October 2021 were retrospectively analyzed. The patients were classified in five different groups according to the etiology: traumatic brain injury, anoxic brain injury (ABI), cerebrovascular accident, encephalitis, and brain tumors. The time of brain injury, etiology, length of stay in the intensive care unit, additional injuries, presence of operation, nutritional status, history of tracheotomy, duration of rehabilitation and complications were recorded. The factors affecting the difference between the Functional Ambulation Classification (FAC) scores of the patients before and after rehabilitation were evaluated.

Results: The mean time since injury was 83.04±57.29 days and the mean duration of rehabilitation was 55.37±37.15 days. Statistically significant improvements were found in all the groups in the functional levels and FAC scores after rehabilitation. In the inter-group comparisons, the ABI group showed statistically less improvement than the other groups. The functional level of the patients before rehabilitation, etiology and the presence of fecal incontinence were statistically significant factors that affected the change in FAC scores (p=0.043, p=0.049, p=0.048, and p=0.035, respectively).

Conclusion: Our study results show that rehabilitation yields in positive outcomes even in patients with severely acquired brain injury in the pediatric age group.

Keywords: Acquired brain injury, functional gain, pediatrics, rehabilitation.

Pediatric acquired brain injury is defined as brain damage of various causes in children with normally typical development.[1] It is a leading cause of neurodisability and social cost in the pediatric age group worldwide.[2] Many reasons such as trauma, anoxia, cerebrovascular accidents (CVAs), infection and tumor can cause severe acquired brain injury. Clinical presentations can vary widely, depending on the area of the brain affected and the severity of the injury. Although mild symptoms may occur, children's physical, cognitive, psychiatric and communication skills can be seriously affected.[3] With the developments in acute management of acquired brain injury, there has been a decrease in mortality and an increased need for rehabilitation. In a previous study, neurological morbidity was acquired in 26% of previously healthy children who survived to discharge from pediatric intensive care.[4]

Severity of brain injury refers to the degree of pathophysiological changes identified in the acute period following injury and this can help predict the long-term outcomes. Various standard scales are used by clinicians and researchers in pediatric brain injury. The Glasgow coma scale (GCS) was developed

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to assess neurological level and determine the degree of consciousness of the patient.[5] The GCS score directly reflects the primary event of brain injury in the parenchyma. Cicero and Cross[6] demonstrated that the initial GCS had predictive value for morbidity and long-term injury outcomes after traumatic brain injury (TBI). In addition, the duration of unconsciousness, the duration of post-traumatic amnesia (PTA) and intracranial pathologies obtained from neuroimaging tests are also used as indicators. In general, one or more of these severity measures are used in studies to establish mild, moderate, and severe brain injury categories. Severe acquired brain injury has been defined by the Centers for Disease Control and Prevention (CDC) as loss of consciousness for more than 24 h and PTA for more than seven days with a GCS of 3-8.[7]

The severe acquired brain injury rehabilitation is a long and complex process, in which there can be various complications and difficulties in many systems. Early rehabilitation is an extremely important goal for restoring motor functions.[8] Therefore, in this period, detailed evaluation, treatment and follow-up should be done with teamwork, of which the family is also a part. Although there are sufficient studies on severe acquired brain injury acute management, there is a limited number of studies in the literature on the management of children who have completed the intensive care or palliative care process and become eligible for rehabilitation.[9] The implementation of individual rehabilitation and determination of prognostic factors in advance would contribute to the management of severe acquired brain injury.

In the present study, we aimed to investigate the effects of rehabilitation on the functional level of children with severe acquired brain injury, identify the complications experienced during the process, and to examine the factors affecting functional gains.

PATIENTS AND METHODS

Study design and study population

This single-center, retrospective study was conducted at the Department of Physical Medicine and Rehabilitation, Pediatric Brain Injury Rehabilitation Clinic of Ankara Bilkent City Hospital between March 2020 and October 2021. Medical records of patients hospitalized in our clinic were screened. The patients analyzed were transfer patients from the intensive care unit (ICU) or palliative care unit of our own pediatric hospital or external hospitals. Inclusion criteria were as follows: *(i)* age <18 years; *(ii)* having brain damage as assessed by magnetic resonance imaging (MRI) findings as a result of trauma, anoxia, cerebrovascular event, encephalitis, or tumor; *(iii)* severe brain damage according to the initial GCS (3-8) within the first 72 h of brain damage; *(iv)* normal physical development before the development of brain damage; and *(v)* medical stability while starting rehabilitation. Children were excluded from the study if they had neurological disease (mental retardation, autism spectrum disorder, epilepsy) before developing brain damage. Finally, a total of 67 patients (39 males, 28 females; mean age: 9.7±4.8 years; range, 3 to 18 years) were included in the study. Since the study has retrospective nature, written informed consent was not obtained from the patients. The study protocol was approved by the Ankara City Hospital Ethics Committee (date: 01.09.2021, no: E2-21-785). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Data including age, sex, caregiver, time since injury, duration of ICU, number of hospitalizations, total duration of rehabilitation, history of tracheostomy and percutaneous endoscopic gastrostomy (PEG), previous surgeries, additional injuries, complications and/or accompanying problems (epilepsy, urinary and fecal incontinence, cognitive impairment, spasticity, contracture, pressure ulcers, dysphagia, aphasia, epilepsy, depression, agitation, visual disturbances, respiratory problems, heterotopic ossification, deep vein thrombosis, malnutrition, hypertension, involuntary movements) were recorded. The patients were classified in five different groups according to the etiology: TBI, anoxic brain injury (ABI), CVA, encephalitis, and brain tumors.

Rehabilitation process

In our 25-bed pediatric brain injury rehabilitation clinic, a detailed evaluation is made by the rehabilitation team, who are experts in their profession, after the children are admitted to the clinic. The children's examination, recording of medical history, assessment of functional level and treatment goals are performed by physiatrists. The physical condition and development of the patients are followed by physiotherapists. Urinary and fecal incontinence, skin integrity, pressure ulcers, tracheostomy and PEG care are evaluated by rehabilitation nurses. Upper extremity functions are evaluated by the occupational therapist, and speech and swallowing functions are evaluated by the swallowing and speech therapist. Visual functions and cerebral visual impairments are evaluated and followed by the

TABLE 1
Demographics of the patients according to brain injury etiology (n=67)

	TBI (n=33)				ABI (n=13)				CVA (n=7)				Encephalitis (n=7)				Brain tumor (n=7)				
	n	%	Median	Q1-Q3	n	%	Median	Q1-Q3	n	%	Median	Q1-Q3	n	%	Median	Q1-Q3	n	%	Median	Q1-Q3	*p*
Age (year)			9	4-12			12	4-16			9	9-15			12	9-16			7	5-12	0.330
Sex																					0.356
Female	13	39.4			4	30.8			4	57.1			5	71.4			2	28.6			
Male	20	60.6			9	69.2			3	42.9			2	28.6			5	71.4			
Care																					0.704
Mother	25	75.8			10	76.9			5	71.4			5	71.4			5	71.4			
Father	5	15.2			2	15.4			2	28.65			1	14.3			2	28.6			
Relative	0	0.0			1	7.7			0	0.0			1	14.3			0	0.0			
Caregiver	3	9.1			0	0.0			0	0.0			0	0.0			0	0.0			
Duration of ICU			20	13-53			30	17-53			12	7-21			14	7-30			12	4-45	0.076
Time before rehabilitation (days)			60	42-112			90	56-120			52	31-95			35	25-120			40	25-75	0.516
Duration of rehabilitation (days)			62	22-82			61	35-82			39	34-45			30	30-60			40	30-60	0.641
Number of hospitalizations																					0.817
1	20	60.6			8	61.5			6	85.7			5	71.4			3	42.9			
2	10	30.3			3	23.1			1	14.3			2	28.6			2	28.6			
3	2	6.1			2	15.4			0	0.0			0	0.0			2	28.6			
4	1	3.0			0	0.0			0	0.0			0	0.0			0	0.0			

TBI: Traumatic brain injury; ABI: Anoxic brain injury; CVA: Cerebrovascular accident; ICU: Intensive care unit; Q: Quartile; Chi-square test (group), Kruskal Wallis test (quantitative); p<0.05 statically significant.

visual rehabilitation therapist. Nutrition and calorie needs are evaluated by a dietitian, psychological evaluations are evaluated by a pediatric psychologist, social status and needs of the family are evaluated by a social worker, and educational status is assessed by a child development specialist.

The rehabilitation team gathers three times after the patient's hospitalization; on admission, during the rehabilitation period, and before discharge. In these team meetings, decisions are made on issues such as the patient's functional status, the need for orthoses and botulinum toxin, and treatment goals. Inpatients in the pediatric brain injury rehabilitation clinic receive treatments appropriate to their physical and functional level (joint range of motion, stretching and strengthening exercises, neurophysiological exercises, occupational therapy, robotic rehabilitation, aquatic therapy, neuromuscular and functional electrical stimulation, virtual and augmented reality applications, speech and language therapy, cognitive rehabilitation, dysphagia rehabilitation). The treatment program is given seven days a week, and the duration of treatment is between 2 to 5 h depending on the needs of the patient. The primary goals in treatment are to increase the functional level and independence of the child, to prevent or manage secondary complications, to increase social and school participation, and to provide support and motivation to the family.

Assessment

The functional status of the patients was classified in five different levels: *(i)* At bed level, fully dependent patients who can do in-bed activities partially, *(ii)* wheelchair level, patients whose sitting balance is achieved with minimal support, and who can be mobilized with a wheelchair, *(iii)* therapeutic ambulation, patients who are able to sit independently and can stand with assistive devices, *(iv)* in-home ambulation, patients who can stand and ambulate with short-distance assistive devices, but cannot walk for a long time or walk on uneven floors (level surfaces only), or climb stairs, *(v)* community ambulation, patients who can independently ambulate long distances in the community.

The walking levels of the children were evaluated with the Functional Ambulation Classification (FAC). A score of 0 represents non-functional ambulation for patients who cannot walk, a score of 1-3 represents dependent ambulation with the support of another person, and a score of 4-5 represents independent ambulation.[10] All evaluations of the children were made twice, before and after rehabilitation.

Statistical analysis

The sample size of the study was calculated with the G*Power version 3.1.9.6 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). As a result of the power analysis conducted in the study with five groups, the reliability was determined as 95%, the effect size was 0.50 and the power value was 0.80. Accordingly, the minimum number of samples was calculated as 55.

Statistical analysis was performed using the IBM SPSS for Mac version 20.0 software (IBM Corp., Armonk, NY, USA). The conformity of the data to normal distribution was evaluated with the Kolmogorov-Smirnov test. Continuous variables were expressed in mean ± standard deviation (SD) or median (1^{st}-3^{rd} quartiles), while categorical variables were expressed in number and frequency. Since there were not at least 30 patients in each group, non-parametric tests were used. The Kruskal-Wallis test was used to compare numerical measurements between the groups, Mann-Whitney U test was used for pairwise comparison, and Wilcoxon test was used to compare the before and after rehabilitation measurements. The chi-square test was used to compare the before and after rehabilitation categorical results and categorical observations by

TABLE 2
Pre-rehabilitation history of the patients

		TBI		ABI		CVA		Encephalitis		BT		
		n	%	n	%	n	%	n	%	n	%	*p*
Tracheotomy	Yes	15	45.5	9	69.2	2	28.6	2	28.6	2	28.6	0.375
PEG	Yes	6	18.2	5	38.5	1	14.3	0	0.0	1	14.3	0.320
Additional injury	Yes	1	7.7	13	39.4	1	14.3	0	0.0	1	14.3	0.070
Surgery	Yes	18	54.5	2	15.4	4	57.1	2	28.6	7	100.0	0.002*

TBI: Traumatic brain injury; ABI: Anoxic brain injury; CVA: Cerebrovascular accident; BT: Brain tumor; PEG: Percutaneous endoscopic gastrostomy; Chi-square test (group); * BT-ABI, CVA-ABI.

groups, and logistic regression analysis was used to identify the factors affecting the change in FAS level. In the established logistic regression model, FAS change was taken as the outcome variable (no FAS change=0, change=1). Risk factors on the identified outcome variable were tested. A *p* value of <0.05 was considered statistically significant.

RESULTS

The mean time since injury was 83.04±57.29 days and the mean duration of rehabilitation was 55.37±37.15 days. Etiologically, 33 (49.3%) of the patients were evaluated as TBI, 13 (19.4%) as ABI, seven (10.4%) as CVA, 7 (10.4%) as encephalitis, and seven (10.4%) as brain tumor. The demographic and clinical characteristics of the patients according to etiology are presented in Table 1. There was no statistically significant relationship between etiology and demographic and clinical features in the patients (p>0.05).

Before rehabilitation, the history of the patients included tracheostomy in 32 (47.7%), PEG in 14 (20.8%), additional injuries in 16 (23.8%) and surgery in 33 (49.2%). According to etiology, tracheostomy, PEG, and additional injuries were more common in the ABI group (69.2%, 38.5%, and 39.4%, respectively). There was a statistically significant relationship between the etiology groups and brain surgery history (p<0.05). Brain surgery was more frequently observed in patients with brain tumor (100%) and CVA (57.1%) etiologies (Table 2).

The most common complications in patients were spasticity, dysphagia, urinary incontinence and fecal incontinence (88.1%, 50.7%, and 43.3%, respectively). The distribution of complications according to the etiology is shown in Table 3. There was a statistically significant relationship between the etiology groups and spasticity (p=0.022) and hypertension (p=0.016). The incidence of spasticity was the highest among the patients with ABI (100.0%) and TBI (93.9%) etiologies. The incidence of hypertension was the highest among the patients with CVA etiology (57.1%). There was no statistically significant relationship between etiology and other clinical features (p>0.05).

Statistically significant improvements were observed in the functional levels and FAC scores of

TABLE 3
Complications and related problems after brain injury in patients

		TBI		ABI		CVA		Encephalitis		BT		
		n	%	n	%	n	%	n	%	n	%	*p*
Spasticity	Yes	31	93.9	13	100.0	5	71.4	4	57.1	6	85.7	**0.022***
Urinary incontinence	Yes	17	51.5	6	46.2	1	14.3	4	57.1	4	57.1	0.473
Fecal incontinence	Yes	14	42.4	7	53.8	1	14.3	4	57.1	3	42.9	0.510
Cognitive impairment	Yes	17	51.5	10	76.9	3	42.9	2	28.6	6	85.7	0.113
Dysphagia	Yes	17	51.5	7	53.8	4	57.1	5	71.4	4	57.1	0.862
Aphasia	Yes	13	39.4	10	76.9	1	14.3	2	28.6	3	42.9	0.056
Epilepsy	Yes	11	33.3	6	46.2	1	14.3	3	42.9	1	14.3	0.353
Depression	Yes	8	24.2	0	0.0	2	28.6	0	0.0	0	0.0	0.084
Agitation	Yes	8	24.2	3	23.1	1	14.3	0	0.0	2	28.6	0.056
Visual impairment	Yes	8	24.2	2	15.4	1	14.3	3	42.9	2	28.6	0.726
Contracture	Yes	7	21.2	4	30.8	2	28.6	1	14.3	0	0.0	0.599
Malnutrition	Yes	11	33.3	4	30.8	1	14.3	2	28.6	1	14.3	0.867
Deep vein thrombosis	Yes	5	15.2	1	7.7	0	0.0	2	71.4	0	0.0	0.457
Respiratory impairment	Yes	4	12.1	5	38.5	0	0.0	0	0.0	1	14.3	0.110
Heterotopic ossification	Yes	4	12.1	1	7.7	0	0.0	0	0.0	0	0.0	0.999
Hypertension	Yes	3	9.1	4	30.8	4	57.1	2	28.6	0	0.0	**0.016†**
Pressure ulcers	Yes	3	9.1	0	0.0	1	14.3	0	0.0	1	14.3	0.464
Involuntary movement	Yes	1	3.0	1	7.7	2	28.6	2	28.6	0	0.0	0.078

TBI: Traumatic brain injury; ABI: Anoxic brain injury; CVA: Cerebrovascular accident; BT: Brain tumor; Chi-square test (group); * TBI-BT; † TBI-CVA.

TABLE 4
Functional levels of patients before and after rehabilitation

	Pre-rehabilitation level			Post-rehabilitation level			
		n	%		n	%	
TBI	Bed	19	57.6	Bed	7	21.2	0.001
	Wheelchair	8	24.2	Wheelchair	8	24.2	
	Therapeutic ambulation	0	0.0	Therapeutic ambulation	3	9.1	
	In-home ambulation	6	18.2	In-home ambulation	8	24.2	
	Community ambulation	0	0.0	Community ambulation	7	21.2	
ABI	Bed	8	61.5	Bed	5	38.5	0.024
	Wheelchair	3	23.1	Wheelchair	3	23.1	
	Therapeutic ambulation	1	7.7	Therapeutic ambulation	2	15.4	
	In-home ambulation	1	7.7	In-home ambulation	2	15.4	
	Community ambulation	0	0.0	Community ambulation	1	7.7	
CVA	Bed	1	14.3	Bed	0	0.0	0.023
	Wheelchair	4	57.1	Wheelchair	1	14.3	
	Therapeutic ambulation	0	0.0	Therapeutic ambulation	2	28.6	
	In-home ambulation	2	28.6	In-home ambulation	1	14.3	
	Community ambulation	0	0.0	Community ambulation	3	42.9	
Encephalitis	Bed	1	14.3	Bed	0	0.0	0.016
	Wheelchair	4	57.1	Wheelchair	0	0.0	
	Therapeutic ambulation	2	28.6	Therapeutic ambulation	2	28.6	
	In-home ambulation	0	0.0	In-home ambulation	3	42.9	
	Community ambulation	0	0.0	Community ambulation	2	28.6	
BT	Bed	2	28.6	Bed	0	0.0	0.017
	Wheelchair	3	42.9	Wheelchair	0	0.0	
	Therapeutic ambulation	1	14.3	Therapeutic ambulation	2	28.6	
	In-home ambulation	1	14.3	In-home ambulation	3	42.9	
	Community ambulation	0	0.0	Community ambulation	2	28.6	
p	0.031*			0.029†			

TBI: Traumatic brain injury; ABI: Anoxic brain injury; CVA: Cerebrovascular accident; BT: Brain tumor; Chi-square test (group); * TBI-Encephalitis; † ABI-CVA, ABI-BT, ABI-TBH, ABI-Encephalitis.

the patients after rehabilitation in all the etiology groups (Tables 4 and 5). The inter-group analysis revealed that the ABI group showed statistically less improvement than the other groups.

Functional level during hospitalization (p=0.047), etiology (p=0.049) and fecal incontinence (p=0.035) had a significant effect on the change in FAS after rehabilitation. The positive change in FAS was observed more in those with better functional levels at the time of admission and those without fecal incontinence. Other factors were not found to be significant factors (p>0.05) (Table 6).

DISCUSSION

Our study results revealed that, even in severe forms of acquired brain injury, there were positive gains at the end of rehabilitation, and functional level of the patients before rehabilitation, etiology and presence of fecal incontinence were the factors affecting rehabilitation gains. While positive gains were observed in all acquired brain injury groups after rehabilitation, the gains in the ABI group were less than in the other groups. The most common complications in this complex process were spasticity, dysphagia, urinary incontinence, and fecal incontinence.

TABLE 5
FAC changes of patients before and after rehabilitation

	Pre-rehabilitation FAC level	n	%	Post-rehabilitation FAC level	n	%	*p*
TBI	0	27	81.8	0	13	39.4	0.001
	1	0	0.0	1	5	15.2	
	2	0	0.0	2	1	3.0	
	3	6	12.1	3	5	15.2	
	4	2	6.1	4	9	27.3	
ABI	0	11	84.6	0	8	61.5	0.034
	1	1	7.7	1	2	15.4	
	2	0	0.0	2	1	7.7	
	3	1	7.7	3	1	7.7	
	4	0	0.0	4	1	7.7	
CVA	0	5	71.4	0	1	14.3	0.039
	1	0	0.0	1	2	28.6	
	2	0	0.0	2	2	28.6	
	3	2	28.6	3	2	28.6	
	4	0	0.0	4	2	28.6	
Encephalitis	0	4	57.1	0	0	0.0	0.027
	1	3	42.9	1	2	28.6	
	2	0	0.0	2	1	14.3	
	3	0	0.0	3	3	42.9	
	4	0	0.0	4	1	14.3	
BT	0	5	71.4	0	0	0.0	0.016
	1	0	0.0	1	1	14.3	
	2	1	14.3	2	0	0.0	
	3	1	14.3	3	4	57.1	
	4	0	0.0	4	2	28.6	
p		0.052			0.040*		

FAC: Functional Ambulation Classification; TBI: Traumatic brain injury; ABI: Anoxic brain injury; CVA: Cerebrovascular accident; BT: Brain tumor; * ABI-CVA, ABI-BT, ABI-TBH, ABI-Encephalitis.

TABLE 6
Logistic regression analysis of functional ambulation classification gain

Risk	*B*	SE	*p*	OR	95% CI OR Min-Max
Pre-rehabilitation level	1.185	0.586	**0.043***	3.272	1.037-10.320
Age	–0.354	0.421	0.400	0.702	0.307-1.601
Time since injury	0.477	0.409	0.243	1.611	0.723-3.589
Etiology	1.563	0.796	**0.049***	4.772	1.002-22.718
Duration of rehabilitation	0.019	0.400	0.962	1.019	0.465-2.232
Duration of ICU	0.054	0.477	0.910	1.056	0.414-2.690
Contracture	1.131	1.214	**0.352**	3.098	0.287-33.481
Fecal incontinence	1.953	0.929	0.035*	7.052	1.142-43.538
Aphasia	1.826	0.963	0.058	6.212	0.940-41.048
Epilepsy	1.825	1.089	0.094	6.204	0.734-52.433
Depression	1.727	1.423	0.225	5.624	0.346-91.469

CI: Confidence interval; OR: Odds ratio; SE: Standard error; ICU: Intensive care unit; Logistic regression analysis.

In a retrospective study by Pozzi et al.,[11] patients with severe acquired brain injury were examined according to their etiology, and high rates of tracheostomy and PEG were found in ABI patients (29.3% and 20.9%, respectively), followed by TBI patients (28.0% and 20.1%, respectively). The mean duration before rehabilitation was 57±63.8 days, and the mean rehabilitation period was 121.9±72.9 days. In a global multi-center study evaluating patients admitted to the ICU after acute neurological insults in the pediatric age group, Fink et al.[12] reported the highest rate of tracheostomy in spinal cord injuries (33%), followed by ABI (21%). As PEG was most common in cardiac cases, it was performed in ABI patients after arrest (30%) and later in TBI patients (23%). In the present study, the group with the highest rate of tracheostomy and PEG was ABI (69.2% and 38.5%, respectively), followed by TBI (45.5% and 18.2%, respectively). The mean duration before rehabilitation was 83±57.2 days and the mean duration of rehabilitation was 55.3±37.1 days. In a multi-center study conducted in Italy by Gazzelini et al.,[13] 184 patients with severe acquired brain injury were evaluated. A traumatic etiology was determined in 51.9% of the patients and the remaining 48.9% had a non-traumatic etiology. Non-traumatic etiologies were 48.3% anoxia/hypoxia, 24.7% encephalitis, and 25.8% CVA. A history of surgical intervention was found in 39.1% of the patients, visual impairments in 45.5%, aphasia in 41.5%, agitation in 30%, and depression in 17.7%. In the current study, at similar rates, traumatic etiology was the cause in 49.3% of the patients and non-traumatic etiology in 50.7% of the patients. Non-traumatic etiologies were 38.2% anoxia/hypoxia, 20.5% encephalitis and 20.5% CVA. A history of surgical intervention was found in 49.2% of the patients, visual impairments in 23.8%, aphasia in 43.2%, agitation in 20.8%, and depression in 14.9%. The etiological distribution and complication rates of the current study are similar to these studies.

There is an agreement in the literature that rehabilitation contributes to recovery from brain injury. Overman et al.[14] concluded that there were benefits to rehabilitative intervention for moderate to severe brain injury and that there was strong evidence that more intense programs were associated with earlier functional gains. However, in the literature, pediatric data are too scant and heterogenous. Some studies have shown that rehabilitation gains in both adults and children with ABI are less than in other acquired brain injury.[15,16] Kelly et al.[17] evaluated 74 severe acquired brain injury patients with the Gross Motor Function Measure (GMFM-66) after rehabilitation. The patients were classified as TBI, ABI, and other acquired brain injury according to the etiology, and it was concluded that the GMFM-66 gained in the ABI group after rehabilitation were much poorer and slower. In a study conducted by Heindl et al.,[15] patients in the persistent vegetative state for at least 30 days were divided into two groups as TBI (n=82) and ABI (n=45) according to the etiology. After 19 months of follow-up, 84% of patients in the TBI group and only 55% of patients in the ABI group were weaned from the persistent vegetative state. The incidence of seizures and complication rates were higher in ABI patients. In the present study, the improvements in the ABI group were found to be less than in the other groups, in line with the literature.

Furthermore, TBI is the most common group among acquired brain injury in children and the most studies in the literature are in this group. In a retrospective study by Dumas et al.,[18] in which ambulation was evaluated in children with TBI after inpatient rehabilitation, 58% of the children achieved ambulation after discharge, but no information was given about the severity of this patient group. It was concluded that brain injury severity, lower extremity hypertonicity, and accompanying lower extremity injury were predictors of regaining walking ability. Although severe patients were included in present study, 45.2% of the patients regained ambulation after rehabilitation (21.2% community ambulation, 24.2% in-home ambulation), and 9.1% reached the therapeutic ambulation level.

The severe acquired brain injury rehabilitation process is different from other pediatric rehabilitation processes (such as cerebral palsy and spina bifida). After patients spend a long time in ICUs and palliative care, they are transferred to rehabilitation clinics. In our study, the mean time since injury was 83.04±57.29 days and the mean duration of rehabilitation was 55.37±37.15 days. The regression analysis revealed that the functional status before rehabilitation had a positive effect on rehabilitation gains. This shows how important acute interventions and ICU services are after brain injury. The treatment plan should be determined according to the needs of the patients during the period of their stay in rehabilitation and the treatment goals should be revised at certain intervals. In the study, the functional levels of the children in each etiological group improved after a comprehensive rehabilitation program.

Nonetheless, there are some limitations to this study. First, the heterogeneity of the groups and the low number of some groups reduce the generalizability of the study. Second, the lack of a control group and the fact that the rehabilitation received was not standard but individualized can also be considered limitations. However, this was a selected sample of children with severe acquired brain injury who presented at an inpatient rehabilitation service due to complex motor post-injury difficulties.

In conclusion, this study can be considered of value, as it shows that, even in pediatric acquired brain injury with severe brain injury, functional gains can be achieved with the appropriate rehabilitation program for the patient. The functional level of the patients before rehabilitation, etiology and presence of fecal incontinence are significant predictors of functional gain. However, there is still a need for further multi-center, large-scale, prospective studies to examine the long-term effects of rehabilitation in children with severe acquired brain injury.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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