

Cite this article as: Neural Regen Res. 2012;7(24):1900-1905.

# Outcomes of early physiotherapy in patients with cerebral aneurysms treated by surgical clipping or endovascular embolization☆

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## Abstract

Early physiotherapy was given to 124 patients with ruptured or unruptured cerebral aneurysms who were treated by surgical clipping or endovascular embolization. Patients were divided into four groups according to their Hunt and Hess grade at admission and aneurysm treatment modality: Group 1, Hunt and Hess grade  $\leq$  II and surgical clipping; Group 2, Hunt and Hess grade  $\leq$  II and endovascular embolization; Group 3, Hunt and Hess grade  $\geq$  III and surgical clipping; Group 4, Hunt and Hess grade  $\geq$  III and endovascular embolization. Level of consciousness was evaluated using the Glasgow Coma Scale, functional status using the Glasgow Outcome Scale, level of the mobility using the Mobility Scale for acute stroke patients, and independence in activities of daily living using the Barthel Index. After early physiotherapy, the level of consciousness and functional status improved significantly in Groups 1, 3, and 4; mobility improved significantly in all groups; and independence in activities of daily living improved significantly in Groups 1 and 3. At discharge, Groups 1 and 2 had better functional status than Groups 3 and 4. Level of consciousness, functional status, mobility and independence in activities of daily living improved after early physiotherapy. These findings suggest that early physiotherapy improved the prognosis of patients with cerebral aneurysms who were treated by surgical clipping or endovascular embolization. Patients with a worse clinical status at presentation had a poorer functional status at discharge. The outcome of physiotherapy was not affected by whether surgical clipping or endovascular embolization was chosen for treatment of the aneurysm.

## Key Words

cerebral aneurysm; Hunt and Hess grade; Glasgow Coma Scale; Glasgow Outcome Scale; functional status; surgical clipping; endovascular treatment; physiotherapy; neural regeneration

## Research Highlights

- (1) Patients with cerebral aneurysms who underwent surgical clipping or endovascular embolization and early physiotherapy were grouped according to their Hunt and Hess grade at admission.
- (2) Level of consciousness, functional status, mobility and independence in activities of daily living improved after early physiotherapy.
- (3) Patients with a worse clinical status at admission had a poorer functional status at discharge.

## Abbreviations

GCS, Glasgow Coma Scale; GOS, Glasgow Outcome Scale; MSAS, Mobility Scale for Acute Stroke patients; BI, Barthel Index

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Received: 2012-04-19  
Accepted: 2012-07-03  
(NY20120413003/H)

Guclu-Gunduz A, Bilgin S, Köse N, Oruckaptan H. Outcomes of early physiotherapy in patients with cerebral aneurysms treated by surgical clipping or endovascular embolization. Neural Regen Res. 2012;7(24):1900-1905.

www.crter.cn  
www.nrronline.org

doi:10.3969/j.issn.1673-5374.2012.24.009

## INTRODUCTION

A cerebral aneurysm is an abnormal bulging outward of one of the arteries in the brain. Cerebral aneurysms are often discovered after rupture, which causes subarachnoid, or rarely parenchymal, hemorrhage<sup>[1]</sup>. Unruptured intracranial aneurysms are frequently diagnosed incidentally in patients who undergo evaluation for various complaints such as mild headache or minor head trauma, or who undergo central nervous system evaluation for other reasons<sup>[2-4]</sup>. A cerebral aneurysm can cause motor and cognitive impairments as a result of subarachnoid hemorrhage, mass effects or complications of treatment. These impairments reduce quality of life<sup>[5-6]</sup>. Clinical experience and observation suggest that early physiotherapy might improve functional outcomes. It has been reported that early physiotherapy improves outcomes in patients with ruptured and especially unruptured aneurysms<sup>[6-9]</sup>. The aim of this study was to analyze outcomes in patients with Hunt and Hess grades of  $\leq$  II and  $\geq$  III who received early physiotherapy after

surgical clipping or endovascular embolization of a cerebral aneurysm.

## RESULTS

### Quantitative analysis of subjects

A total of 149 patients with cerebral aneurysms received early physiotherapy, of which 101 (67.8%) underwent surgical clipping and 48 (32.2%) underwent endovascular embolization. The aneurysm had ruptured causing subarachnoid hemorrhage in 110 patients (73.8%), and 39 patients (26.2%) were treated for unruptured aneurysms. Twenty-five patients (16.9%) died during hospitalization, and the remaining 124 patients were included in this study. Among patients with a Hunt and Hess grade of  $\leq$  II, 51 (41.1%) underwent surgical clipping (Group 1) and 18 (14.5%) underwent endovascular embolization (Group 2). Among patients with a Hunt and Hess grade of  $\geq$  III, 29 (23.4%) underwent surgical clipping (Group 3) and 26 (21.0%) underwent endovascular embolization (Group 4) (Table 1).

Table 1 Patient characteristics

	Hunt and Hess Score $\leq$ 2 ( <i>n</i> = 69)		Hunt and Hess Score $\geq$ 3 ( <i>n</i> = 55)		Total ( <i>n</i> = 124)
	Clipping ( <i>n</i> = 51)	Embolization ( <i>n</i> = 18)	Clipping ( <i>n</i> = 29)	Embolization ( <i>n</i> = 26)	
<b>Age (year)</b>					
mean $\pm$ SD	51.4 $\pm$ 13.7	50.2 $\pm$ 11.7	52.0 $\pm$ 12.9	47.6 $\pm$ 13.6	50.6 $\pm$ 13.2
Range	19-83	16-63	20-78	19-75	16-83
<b>Sex [<i>n</i> (%)]</b>					
Female	33 (26.6)	11 (8.9)	17 (13.7)	18 (14.5)	79 (63.7)
Male	18 (14.5)	7 (5.6)	12 (9.7)	8 (6.5)	45 (36.3)
<b>Location of aneurysm [<i>n</i> (%)]</b>					
Middle cerebral artery	27 (43.5)	7 (11.3)	14 (22.6)	14 (22.6)	62 (41.6)
Anterior communicating artery	12 (30)	4 (10)	16 (40)	8 (20)	40 (26.8)
Internal carotid artery	11 (44)	6 (24)	2 (8)	6 (24)	25 (16.8)
Anterior cerebral artery	5 (71.4)	0	1 (14.3)	1 (14.3)	7 (4.75)
Posterior communicating artery	3 (75)	1 (25)	0	0	4 (2.68)
Basillar artery	2 (50)	1 (25)	0	1 (25)	4 (2.68)
Inferior posterior cerebellar artery	3 (100)	0	0	0	3 (2.01)
Posterior cerebral artery	0	1 (50)	0	1 (50)	2 (2.01)
Superior cerebellar artery	0	0	0	1 (100)	1 (0.67)
Vertebral artery	1 (100)	0	0	0	1 (0.67)
<b>Admission at the hospital Hunt and Hess Score (I-V)</b>					
Median (25 <sup>th</sup> -75 <sup>th</sup> IQR)	1 (1-2)	1 (1-2)	4 (3-4)	3 (3-4)	2 (1-3)
Number of patients [ <i>n</i> (%)]					
I	35 (68.6)	12 (66.7)	0	0	47 (37.9)
II	16 (31.4)	6 (33.3)	0	0	22 (17.7)
III	0	0	12 (41.4)	14 (53.9)	26 (21)
IV	0	0	11 (37.9)	9 (34.6)	20 (16.1)
V	0	0	6 (20.7)	3 (11.5)	9 (7.3)
<b>Length of hospital stay (day)</b>					
Median (25 <sup>th</sup> -75 <sup>th</sup> IQR)	29 (19-45)	19 (15-27)	28 (17-47.5)	26.5 (13.8-49.8)	11(7-24.8)
Range	11-211	8-270	10-125	7-108	2-145
<b>Length of inpatient physiotherapy (day)</b>					
Median (25 <sup>th</sup> -75 <sup>th</sup> IQR)	13 (7-29)	8 (5.8-15.5)	16 (7.5-25)	9 (5.8-22.8)	27 (16.2-45)
Range	3-145	3-116	3-83	2-60	7-270

### Demographic characteristics of patients

The demographic characteristics of patients are shown in Table 1. The study included 79 females and 45 males with a mean age of 51 years (range 16–83 years). There were no significant differences in gender distribution ( $P > 0.05$ ) or age ( $P > 0.05$ ) among the four groups. Twenty-three patients had multiple aneurysms. Aneurysms were mainly located in the middle cerebral artery (41.6%), anterior communicating artery (26.8%) and internal carotid artery (16.8%). There were no significant differences in length of hospital stay or length of physiotherapy among the study groups ( $P > 0.05$ ).

### Changes in Glasgow Coma Scale (GCS), Glasgow Outcome Scale (GOS), Mobility Scale for Acute Stroke patients (MSAS) and Barthel Index (BI) scores after early physiotherapy

The GCS and GOS scores had improved significantly at the time of discharge in Groups 1, 3 and 4 ( $P < 0.05$ ) but not in Group 2 ( $P > 0.05$ ). The MSAS score improved significantly in all groups after early physiotherapy ( $P < 0.05$ ). The BI score improved significantly in Groups 1 and 3 only ( $P < 0.05$ ). The GOS, MSAS and BI scores showed that all patients were severely disabled at the time of discharge (Table 2; Figure 1).

Table 2 GCS, GOS, MSAS and BI scores before and after early physiotherapy

Hunt and Hess score	Group	GCS			GOS		
		Admission	Discharge	<i>P</i>	Admission	Discharge	<i>P</i>
≤ II	Clipping Median (25 <sup>th</sup> –75 <sup>th</sup> IQR)	13 (11–15)	14 (11–15)	0.016 <sup>a</sup>	3 (2–3)	3 (3–4)	0.002 <sup>a</sup>
	Embolization Median (25 <sup>th</sup> –75 <sup>th</sup> IQR)	14 (10–15)	15 (11.8–15)	0.289 <sup>a</sup>	3 (2.8–3)	3 (2.8–3)	0.157 <sup>a</sup>
≥ III	Clipping Median (25 <sup>th</sup> –75 <sup>th</sup> IQR)	12 (7.5–13.5)	13 (8–15)	0.041 <sup>a</sup>	2 (2–3)	2 (2–3)	0.025 <sup>a</sup>
	Embolization Median (25 <sup>th</sup> –75 <sup>th</sup> IQR)	12,5 (9.75–14)	14 (10.75–15)	0.023 <sup>a</sup>	3 (2–3)	3 (2–3)	0.046 <sup>a</sup>
<i>P</i>		0.007 <sup>b</sup>	0.044 <sup>b</sup>		0.004 <sup>b</sup>	0.017 <sup>b</sup>	
Group differences		1 vs. 3 (0.005) <sup>c</sup> , 1 vs. 3 (0.004) <sup>c</sup> 2 vs. 3 (0.002) <sup>c</sup>			1 vs. 3 (0.001) <sup>c</sup> , 1 vs. 3 (0.004) <sup>c</sup> 2 vs. 3 (0.002) <sup>c</sup>		
Change, Δ <i>P</i>		0.767 <sup>b</sup>			0.767 <sup>b</sup>		
Hunt and Hess score	Group	MSAS			BI		
		Admission	Discharge	<i>P</i>	Admission	Discharge	<i>P</i>
≤ II	Clipping Median (25 <sup>th</sup> –75 <sup>th</sup> IQR)	8 (6–14)	15 (8–24)	0.001 <sup>a</sup>	0 (0–30)	10 (0–50)	0.001 <sup>a</sup>
	Embolization Median (25 <sup>th</sup> –75 <sup>th</sup> IQR)	12 (6.8–15.2)	15, 5 (7–21.5)	0.001 <sup>a</sup>	5 (0–31.2)	15, 5 (0–46.2)	0.068 <sup>a</sup>
≥ III	Clipping Median (25 <sup>th</sup> –75 <sup>th</sup> IQR)	6 (6–7)	6 (6–11.5)	0.001 <sup>a</sup>	0 (0)	0 (0–12.5)	0.027 <sup>a</sup>
	Embolization Median (25 <sup>th</sup> –75 <sup>th</sup> IQR)	6 (6–12)	9 (6–17.5)	0.001 <sup>a</sup>	0 (0–7.5)	0 (0–22.5)	0.102 <sup>a</sup>
<i>P</i>		0.008 <sup>b</sup>	0.001 <sup>b</sup>		0.050 <sup>b</sup>	0.019 <sup>b</sup>	
Group differences		1 vs. 3 (0.008) <sup>c</sup> , 1 vs. 3 (< 0.001) <sup>c</sup> , 2 vs. 3 (0.002) <sup>c</sup>			1 vs. 3 (0.005) <sup>c</sup> , 1 vs. 3 2 vs. 3 (0.005) <sup>c</sup> (< 0.001) <sup>c</sup>		
Change, Δ <i>P</i>		< 0.001 <sup>b</sup> 1 vs. 3 (< 0.001) <sup>c</sup>			0.006 <sup>b</sup> 1 vs. 4 (0.002) <sup>c</sup>		

GCS: Glasgow Coma Scale; GOS: Glasgow Outcome Scale; MSAS: Mobility Scale for Acute Stroke patients; BI: Barthel Index.  $P < 0.05$  for <sup>a</sup>Wilcoxon signed-rank test and <sup>b</sup>Kruskal-Wallis test,  $P < 0.008$  for <sup>c</sup>Mann Whitney *U* test. Change, Δ*P* (changes in GCS, GOS, MSAS and BI scores after early physiotherapy). Changes in GCS and GOS scores were not significant ( $P > 0.05$ ). Changes in MSAS and BI scores were significant. There were significant differences in MSAS scores between Groups 1 and 3; and in BI scores between Groups 1 and 4.

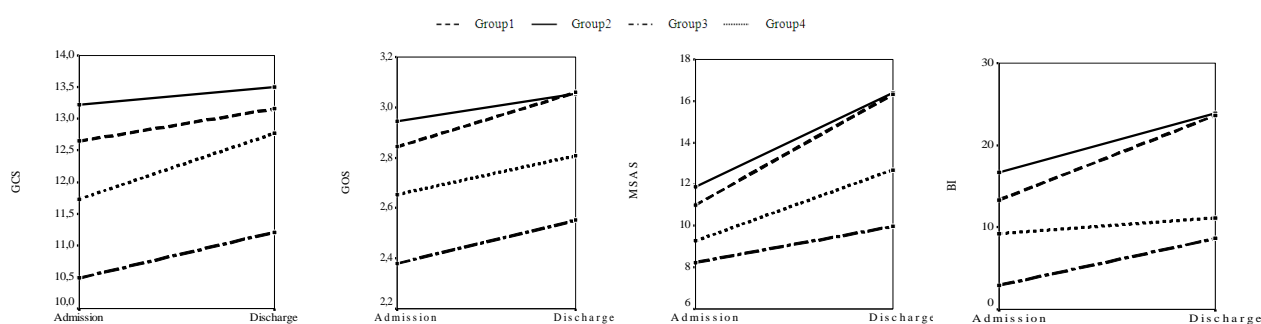


Figure 1 Changes in Glasgow Coma Scale (GCS), Glasgow Outcome Scale (GOS), Mobility Scale for Acute Stroke Patients (MSAS) and Barthel Index (BI) scores after early physiotherapy.

GCS and GOS scores had improved significantly at discharge ( $P < 0.05$ ) in Groups 1, 3 and 4. MSAS scores improved significantly in all study groups after rehabilitation ( $P < 0.05$ ). BI scores improved significantly in Groups 1 and 3 only ( $P < 0.05$ ). Analyses were performed using the Wilcoxon signed-rank test.

### Comparison of GCS, GOS, MSAS and BI scores at admission and discharge

There were significant differences among groups in the GCS, GOS, MSAS and BI scores at admission and discharge ( $P < 0.05$ ; Table 2). At admission, these differences were most significant between Groups 1 and 3 and between Groups 2 and 3 ( $P < 0.008$ ). At discharge, the GCS, GOS and BI scores were significantly different only between Groups 1 and 3 ( $P < 0.008$ ), and the MSAS score was significantly different between Groups 1 and 3 and between Groups 2 and 3 ( $P < 0.008$ ). These results indicate that patients with a Hunt and Hess grade of  $\leq$  II had a better functional status than those with a Hunt and Hess grade of  $\geq$  III after treatment with surgical clipping or endovascular embolization (Figure 1, Table 2).

The changes in GCS and GOS scores were not significantly different among the study groups ( $P > 0.05$ ; Table 2). The changes in the MSAS and BI scores were more significantly different in patients with a Hunt and Hess grade of  $\leq$  II than with a Hunt and Hess grade of  $\geq$  III ( $P < 0.008$ ) (Figure 1, Table 2).

## DISCUSSION

The results of this study demonstrate that level of consciousness, functional status, mobility and independence in activities of daily living improved after early physiotherapy in patients with cerebral aneurysms who had undergone surgical clipping or endovascular embolization. Additionally, patients with a worse clinical status at onset tended to have a poorer functional status at discharge.

Only a few studies have described the outcomes of early physiotherapy in patients with cerebral aneurysms<sup>[6-9]</sup>. Clinchot *et al*<sup>[7]</sup> reported that the average length of rehabilitation stay was 41 days (range 11–188 days) in patients with aneurysmal subarachnoid hemorrhage. Saciri *et al*<sup>[6]</sup> reported that the average length of hospital stay was 21 days (range 8–105 days) and the average duration of early physiotherapy was 21 days (range 6–85 days) in patients who had undergone surgical repair of ruptured aneurysms, which is similar to our results.

Saciri *et al*<sup>[6]</sup> and Clinchot *et al*<sup>[7]</sup> reported that patients with motor impairment had the longest length of hospital stay and the longest period of in-hospital rehabilitation. Our results show that the length of hospital stay and length of early physiotherapy were similar between groups with a Hunt and Hess grade of  $\leq$  II and  $\geq$  III. Clinchot *et al*<sup>[7]</sup> found that most patients with aneurysmal subarachnoid hemorrhage who had received early physiotherapy required constant supervision after

discharge. Dombovy *et al*<sup>[8]</sup> showed that patients with subarachnoid hemorrhage (mostly due to cerebral aneurysm) achieved functional gains after inpatient rehabilitation, but the gains were less than those achieved after traumatic brain injury or stroke. Saciri *et al*<sup>[6]</sup> showed that 56.6% of patients who underwent surgical repair of a cerebral aneurysm after subarachnoid hemorrhage and received early physiotherapy needed intermittent or constant supervision because of motor or cognitive impairment. Kara *et al*<sup>[9]</sup> demonstrated that functional status improved following early physiotherapy in patients with aneurysmal subarachnoid hemorrhage. However, they did not analyze independence in activities of daily living. In this study, we found that functional status and independence in activities of daily living improved after inpatient rehabilitation in all patients who underwent surgical clipping or endovascular embolization.

The results of previous studies and the current study show that early physiotherapy after treatment for cerebral aneurysms is not sufficient for patients to achieve full independence<sup>[6-8]</sup>. Rehabilitation should therefore be continued after discharge. Previous studies have shown that the severity of cognitive impairment affects the functional status and the degree of supervision required<sup>[1,6]</sup>. For this reason, patients cannot achieve full independence in activities of daily living even though they have achieved recovery of motor skills<sup>[1,6]</sup>. In conclusion, the results of the current study demonstrate that level of consciousness, functional status, mobility and independence in activities of daily living improved after early physiotherapy in patients with cerebral aneurysms who underwent surgical clipping or endovascular embolization. Patients with a worse clinical status at onset tended to have a poorer functional status at discharge. The choice of surgical clipping or endovascular embolization did not affect outcomes.

## SUBJECTS AND METHODS

### Design

A retrospective review of medical records.

### Time and setting

This study was performed at Hacettepe University Hospital, Turkey from January 2007 to November 2009.

### Subjects

Patients with ruptured or unruptured cerebral aneurysms who underwent surgical clipping or endovascular embolization were given early physiotherapy at the Department of Neurosurgery, Hacettepe University Hospital. The diagnosis of cerebral aneurysm was

confirmed by CT, MRI or angiography.

### Methods

Patients were clinically assessed by a neurosurgeon at admission using the Hunt and Hess grading system<sup>[10]</sup>. This system is widely used to predict prognosis, with a higher score correlating with a lower survival rate. Patients were divided into two groups according to a Hunt and Hess grade of  $\leq$  II or  $\geq$  III. Patients in each group were then divided into two subgroups according to whether they underwent surgical clipping or endovascular embolization: Group 1, Hunt and Hess grade  $\leq$  II and surgical clipping; Group 2, Hunt and Hess grade  $\leq$  II and endovascular embolization; Group 3, Hunt and Hess grade  $\geq$  III and surgical clipping; Group 4, Hunt and Hess grade  $\geq$  III and endovascular embolization. Medical reports, endovascular and surgical reports, discharge summaries, age, gender, aneurysm location, length of hospital stay, and length of inpatient physiotherapy were retrospectively reviewed.

### Early physiotherapy program

The aims of the physiotherapy program were to avoid complications of bed rest, improve postural control and functional activity, and provide post-discharge education for patients and their families. Physiotherapy was based on the Bobath concept and included individualized therapy sessions. Patient-centered goals were developed at the start of therapy. Physiotherapy focused on muscle control, quality of movement, weight bearing and trunk stability. Unilateral or bilateral activities were undertaken in the lying, sitting or standing positions depending on the condition of the patient. Activities were active or passive, again depending on the condition of the patient. Throughout the session, patients were given stimuli to develop a normal sense of movement. Caregivers were trained in correct patient positioning at all times, and were taught exercises that patients could perform during weekends. Physiotherapy was given 5 days a week until hospital discharge.

### Outcome measures

All patients were evaluated in the intensive care unit by a physiotherapist before and after early physiotherapy. Level of consciousness, functional status, mobility and independence in activities of daily living were assessed. The GCS was used to evaluate the level of consciousness and degree of brain injury<sup>[11]</sup>. This score evaluates visual, motor and verbal responses to stimuli. GCS scores range from 3 to 15, with a lower score indicating more severe damage and a poorer prognosis. A score of 15 indicates normal, 13–14 indicates mild disability, 9–12 indicates moderate disability, and 3–8 indicates severe disability.

The functional status of patients was assessed using the GOS. This is a global score of functional outcome that classifies patients into five categories: 5, excellent (return to the original functional level and employment with no deficits); 4, good (minor neurological deficit that does not interfere with daily functioning or employment); 3, fair (significant neurological deficit that interferes with daily activities or prevents return to employment); 2, poor (coma or severe deficit rendering the patient totally dependent); and 1, death<sup>[12]</sup>.

Mobility was evaluated using the MSAS. This score is based on the amount of assistance needed for six mobility tasks: bridging, sitting from supine, sitting balance, standing from a chair, and standing balance and gait. Performance is scored from 1 (patient makes no contribution to the activity) to 6 (patient performs the activity unassisted) with a maximum total score of 36<sup>[13]</sup>. Functional performance and independence in activities of daily living were evaluated using the BI, which has a maximum score of 100. A higher score indicates better functional performance and more independence. The ten activities of daily living assessed are feeding, moving from a wheelchair to a bed and returning, grooming, transferring to and from a toilet, bathing, walking on a level surface, going up and down stairs, dressing, and bowel and bladder continence<sup>[14]</sup>.

### Statistical analysis

All data were analyzed using SPSS 11.5 for Windows (SPSS, Chicago, IL, USA). The normality of data was tested using the Kolmogorov-Smirnov test. Normally distributed data (age) were compared using analysis of variance and expressed as mean  $\pm$  SD unless otherwise stated. The chi-square test was used to compare categorical variables. For non-normally distributed data (Hunt and Hess grade, length of hospital stay, length of inpatient physiotherapy, GCS, GOS, MSAS and BI), comparisons of values before and after early physiotherapy were performed using the Wilcoxon signed-rank test and data were expressed as median and interquartile range. Statistical significance was set at  $P < 0.05$ . The four groups were compared using Kruskal-Wallis analysis of variance, followed by paired Mann-Whitney  $U$  tests with statistical significance set at  $P < 0.008$ .

**Acknowledgments:** We would like to thank Celik Bulent from the Department of Biostatistics, Faculty of Health Sciences, Gazi University, Turkey for help with statistical analysis.

**Author contributions:** All authors participated in the study design, conduct, and evaluation. All authors contributed to preparation of the manuscript.

**Conflicts of interest:** None declared.

**Ethical approval:** The study protocol was approved by the Ethics Committee of Hacettepe University, Turkey.

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(Edited by Li S, de Oliveira MF/Song LP)