

Received: 2011.11.04
Accepted: 2012.05.15
Published: 2012.11.01

Functional Capacity Scale as a new tool for early functional assessment in patients after surgical treatment of intracranial aneurysms: A prospective study involving 128 patients

Authors' Contribution:

- A** Study Design
- B** Data Collection
- C** Statistical Analysis
- D** Data Interpretation
- E** Manuscript Preparation
- F** Literature Search
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Source of support: Departmental sources

Summary

Background:	Functional assessment of a patient focuses on the assessment of independence in activities of daily living. The aim of the study was to verify the usefulness of a new tool (<i>Functional Capacity Scale – FCS</i>) for early functional assessment of patients after surgical treatment of an intracranial aneurysm.
Material/Methods:	The study was conducted in the Neurosurgical Department and Clinic, CM in Bydgoszcz, NCU, within a group of 128 patients after surgical treatment of an intracranial aneurysm. Direct observation and measurement were used in the study. In clinical assessment, the Hunt and Hess Scale was applied. For the final functional assessment, the Functional Capacity Scale (FCS), the Glasgow Outcome Scale, the Functional Index “Repty”, the Barthel Index, and the Rankin Scale were used.
Results:	The study shows that on the day of discharge almost 60% of patients are independent or slightly dependent on others for functional capability, and 15% are significantly or totally dependent. FCS significantly correlates with FIR (0.93, p<0.001), GOS (0.89, p<0.01), RS (–0.88, p<0.01) and BI (0.82, p<0.001).
Conclusions:	1. Fifty percent of patients with intracranial aneurysm assessed at the early postoperative stage leave the ward as functionally capable of performing everyday activities. 2. There are significant correlations between FCS and the other scales used for functional assessment. 3. There is a significant relationship between functional capacity of the patient on the day of discharge and clinical condition before the surgical treatment.
key words:	aneurysm • subarachnoid hemorrhage • Functional Capacity Scale

Full-text PDF: <http://www.medscimonit.com/fulltxt.php?ICID=883547>

Word count: 2383

Tables: 4

Figures: 5

References: 35

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BACKGROUND

Researchers use many different methods in their studies. The results of different studies should be comparable with data in the literature. Comprehensive assessment of a patient with a nervous system disorder should include 3 basic consequences of the disease: damage, disability and impairment. In cerebral diseases and cerebrovascular defects (stroke, hemorrhage, aneurysm) there are 3 areas that should be assessed: clinical condition (damage of the nervous system), functional capacity, and quality of life.

Significant neurological deficit (including functional deficit) may be caused by subarachnoid hemorrhage (SAH), often resulting from ruptured intracranial aneurysms [1-4].

Intracranial aneurysms are the most common vascular anomaly [5,6]. In most cases any rupture results in a subarachnoid hemorrhage, which very often leads to death. The available sources state that the death rate of patients after a subarachnoid hemorrhage is 15% to 45%, 25% of these deaths occur within the first 24 hours [3,6]. The necessity of quick surgical removal of ruptured intracranial aneurysms seems to be unquestionable. Postponing surgical treatment carries the risk of rebleed, vasospasm and post-hemorrhage hydrocephalus, which in effect aggravates the results of the surgical treatment [2,3]. Despite the advancements in the treatment of subarachnoid hemorrhage, many patients who survived the treatment experience debilitating cognitive, emotional and behavioral symptoms [7,8].

The multicenter randomized study of the International Subarachnoid Aneurysm Trial (ISAT) sets new standards for intracranial aneurysms treatment, indicating the advantage of endovascular coiling over surgical clipping, and presents the long-term results of clinical assessment concerning complications and death [9].

Other authors have presented prospective comparisons of outcomes of early surgical and endovascular treatments for aneurysms in the aspect of clinical and neuropsychological assessment within 3 to 12 months after the procedure [10].

Results of studies on clinical assessment of intracranial aneurysms and subarachnoid hemorrhage (intracranial malformation) are well documented in the specialist literature worldwide, especially long-term outcomes 3, 6, and 12 months after the procedure [8,11,12]. On the other hand, little is known about functional capacity assessment in the early period after the procedure, which is crucial from the nursing standpoint.

Results of functional capacity assessment in patients after surgical treatment of intracranial aneurysm are presented with various functional assessment scales.

The Glasgow Outcome Scale (GOS) [10,13], Extended Glasgow Outcome Scale (GOSE) [14,15], Barthel Index (BI) [10,16], Karnofsky Performance Scale (KPS) [17], Rankin Scale (RS) [18], Functional Status Examination (FSE) [14], Short Form-36 (SF-36) [19] and Sickness Impact Profile (SIP) [20] are the most common scales used for functional assessment of patients with SAH caused by ruptured aneurysm.

Table 1. Demographic characteristics.

Variables	N=128 (%)	
Sex		
Male	43	(33.6)
Female	85	(66.4)
Age (average age 51±14)		
0–20 years of age	3	(2.3)
21–40 years of age	19	(14.8)
41–60 years of age	73	(57.1)
Over 60 years of age	33	(25.8)
Clinical display		
Ruptured aneurysm – SAH	117	(91.4)
Unruptured aneurysm	11	(8.6)
Location of aneurysms		
Anterior communicating artery – ACoA	44	(34.4)
Medial carotid artery – MCA	45	(35.2)
Internal carotid artery – ICA	35	(27.3)
Posterior communicating artery – ACoP	4	(3.1)
Hunt and Hess Scale/Grades – H-H – group		
0	11	(8.6)
I	34	(26.6)
II	28	(21.9)
III	21	(16.4)
IV	31	(24.2)
V	3	(2.3)

The variety of the scales makes it impossible to compare the results of studies. Apart from the most popular ones (BI and GOS), other scales are used more or less frequently by the researchers.

This study is based on the authors' personal experience of using the new Functional Capacity Scale (FCS) in the early period after surgical treatment of intracranial aneurysm.

The aim of the study was to verify the usefulness of the new tool (FCS) for early functional assessment of patients after treatment of intracranial aneurysm.

The study covered the following issues:

1. What is the patient's functional capacity immediately after surgical treatment of intracranial aneurysm?
2. Does FCS correlate with other scales used for functional assessment of patients immediately after surgical treatment of intracranial aneurysm?
3. Is there a relationship between functional assessment of the patient on the day of discharge and clinical condition before the surgery?

Table 2. Patient's functional capacity on the day of discharge (FCS, GOS, FIR, BI, RS).

Group				Measurement scale				
				FCS*	GOS**	FIR***	BI***	RS****
*	**	***	****	N (%)	N (%)	N (%)	N (%)	N (%)
		V	0	–	–	–	0 (0.0)	0 (0.0)
I	5	IV	1	43 (44.3)	37 (38.1)	38 (39.2)	39 (40.1)	33 (34.0)
II	4	III	2	35 (36.1)	24 (24.7)	12 (12.4)	28 (28.9)	24 (24.7)
III	3	II	3	15 (15.5)	28 (28.9)	23 (23.7)	18 (18.6)	28 (28.9)
IV	2	I	4	4 (4.1)	8 (8.3)	24 (24.7)	12 (12.4)	12 (12.4)
	1		5	–	0 (0.0)	–	–	0 (0.0)
Total				97 (100.0)	97 (100.0)	97 (100.0)	97 (100.0)	97 (100.0)
Average number of points in scale ± standard deviation								
				37.0±7.2	3.2±1.5	65.4±30.2	62.7±23.6	2.68±1.55

MATERIAL AND METHODS

Material

The research was conducted in the Neurosurgical Department and Clinic, Collegium Medicum (CM) in Bydgoszcz, Nicolaus Copernicus University (NCU) in Torun, Poland. The research included 128 patients: 43 males and 85 females (Table 1). In the presented material, the 24.2% level of morbidity was mainly the result of early post-surgical complications such as recurrent intracranial hemorrhage and, more importantly, premature cerebral vasospasm. The final assessment covered 97 patients.

The inclusion criteria were: (1) patients with a diagnosed vascular anomaly (intracranial aneurysm) on the basis of angiography; (2) patients having undergone surgical removal of aneurysm through clipping and then wrapping; (3) patients after surgical treatment of an intracranial aneurysm; and (4) patients who remained conscious on admittance (possibility of maintaining coherent verbal contact). The exclusion criteria were: (1) patients with several vascular anomalies (multiple aneurysms, angiomas) diagnosed by angiography; (2) patients having undergone more than 1 surgical intervention of clipping and wrapping; (3) patients having undergone embolization; (4) patients treated conservatively, not surgically; and (5) patients not able to remain conscious on arrival (lack of coherent verbal contact).

Methods

The research was conducted through direct observation and measurement. The first measurement was done before the operation, using the Hunt and Hess Grades/Scale (H-H) [21] (Table 1). The second measurement was done on the day of discharge, functional capacity was measured by Functional Capacity Scale (FCS), Glasgow Outcome Score (GOS), Functional Index "Repty" (FIR), Barthel Index (BI), and Rankin Scale (RS) (Table 2).

The research used the following assessment tools:

1. Functional Capacity Scale (FCS) [22–24]. This scale enables recognition of the patient's abilities in the particular clinical condition in the range of functional outcome, as well as the patient's dependence on the nursing staff, which equals defining the deficit in a particular marker. The scale has 12 markers: ambulation, alimentation, personal hygiene, physiological needs, life functions measurement (GCS), breathing, diagnosis, pre- and post-surgical treatment, dressing and drainage, acuteness of pain, pharmacotherapy, and neuropsychological outcome). Each marker is displayed by means of 4 points (from 4 to 1) depending on the group within the range of a particular marker. On observing the patient and using the markers of this scale, the patient may be classified into 1 of the 4 nursing groups: Group I (patient does not need assistance) (48–40 p.), group II (patient needs assistance) (39–31 p.), group III (patient needs significant help) (30–21 p.), and group IV (patient needs intensive care) (20–12 p.).

Assessment using FCS according to the above criteria was made on the day of discharge. Final outcomes (on the day of discharge from a ward/hospital) are shown in Table 2.

2. Glasgow Outcome Score (GOS) [13]. The GOS assesses the patient's postoperative condition, level of self-reliance, and ability to perform social and vocational roles. It is the most common scale used for measurement of the results of intensive care and long-term assessment of the recovery process after head and nervous system injuries. It is a relatively simple measurement tool used worldwide, which facilitates comparison between reports including GOS outcomes. There are 5 grades: grade 5 represents Good Recovery and resumption of normal life, grade 4 is Moderate Disability with independent lifestyle, grade 3 is Severe Disability with need for daily support, grade 2 is Persistent Vegetative State, and grade 1 is Death. These measurements, in accordance with the criteria given by the authors, were made on discharge (Table 2).
3. Functional Index "Repty" (FIR) [25]. FIR is a universal tool for assessment of activities of daily living in patients

Table 3. Spearman correlation coefficients, N=97 (for points).

	FCS	GOS	FIR	BI	RS
FCS	1.00000	0.89**	0.93*	0.82*	-0.88**
GOS	0.89**	1.00000	0.90	0.89	-0.89
FIR	0.93*	0.90	1.00000	0.97	-0.96
BI	0.82*	0.89	0.97	1.00000	-0.96
RS	-0.88**	-0.89	-0.96	-0.96	1.00000

* $p < 0.001$; ** $p < 0.01$.

with various neurological and motor system disorders. It is simple and easy to use. The minimum and maximum scores range from 15 to 105. For the present study, the following classification was adopted: group IV (105–185 points) is full independence, group III (84–65 points) is partial independence, group II (64–41 points) is partial dependence, and group I (40–15 points) is full dependence (Table 2).

- Barthel Index (BI) [16]. The BI is the most common scale used for assessment of activities of daily living (ADL). Many authors use this scale for assessment of patients with cerebral stroke and/or subarachnoid hemorrhage. Scores of 0, 5, 10 and 15 are assigned for everyday activities (dressing, feeding, grooming, etc.) performed by the patient. For the present study the following classification was adopted: group V (100 points) is full functional capacity, group IV (95–75 points) is slight limitation of functional capacity, group III (70–50 points) is partial limitation of functional capacity, group II (45–25 points) is considerable limitation of functional capacity, and group I (20–0 points) is very serious limitation of functional capacity (Table 2).
- Rankin Scale (RS) [18]. Many modifications of this scale are used. The classic version of the scale ranges from 0 (patient does not show any symptoms) to 5 (patient is severely disabled). Most researchers who use the RS divide patients into 3 groups: independent, partly dependent and fully dependent. Because of its clarity, the scale is often used for functional assessment of patients in multicenter trials. For the present study the following classification was adopted: 0 is no symptoms at all, 1 is no significant disability despite symptoms, 2 is slight disability, 3 is moderate disability, 4 is moderately severe disability, and 5 is severe disability (Table 2).

Ethical considerations

To conduct the research, the consent of the Bioethics Commission of Nicolaus Copernicus University in Torun, Collegium Medicum in Bydgoszcz, was obtained. On arrival, each patient accepted for the research gave written consent to the procedure.

Statistical analyses

Methods of statistical analysis were used (arithmetic average \bar{x} , and the standard deviation SD) for the presentation of general characteristics of the examined patients and their functional state in FCS, GOS, FIR, BI and RS in consecutive

measurements. In order to check if there were statistically significant differences between mean values in compared groups of scales (FCS, GOS, FIR, BI and RS) and H-H scale, the Kruskal-Wallis test was used. Correlation was calculated using Spearman's rank correlation coefficient (r_s). Statistical hypotheses were verified according to relevance level $p < 0.05$.

RESULTS

On the discharge day, patients classified into the group I FCS (43 people, 44.3%) were dominant (Table 2). This means that this is a self-sufficient population that does not require assistance from nursing personnel (the average number of points in FCS was: 37.0 ± 7.2). Four patients (4.1%) were classified as group IV FCS (fully dependent patients who require intensive care). The other assessment tools show similar classification (Table 2).

The scales for the assessment of the patient's functional capacity and final assessment of treatment results were verified (Table 3). The highest values of the coefficient were obtained in correlations between FIR and BI ($r_s = 0.97$) and between FIR and RS ($r_s = -0.96$) and BI and RS ($r_s = -0.96$). High, statistically significant ($p < 0.001$), values of Spearman's rank coefficient ($r_s = 0.93$), specified for the correlation between FCS and FIR, result from the similarity of structures of these scales. FCS components are similar to FIR components, and both scales classify patients into 4 groups. In the case of the GOS, RS, and BI scales, correlation coefficients are lower, but also statistically significant.

Functional capacity of patients after surgery assessed using FCS, GOS, FIR, BI and RS was dependent on the initial condition measured by the H-H scale. There is a statistically significant difference in the mean number of points received by the patient on the day of discharge on particular functional scales and the patient's H-H group before the surgery ($p < 0.001$) (Table 4), indicating that better initial condition on H-H scale improves the patient's functional capacity (and vice versa) on FCS (Figure 1), GOS (Figure 2), FIR (Figure 3), BI (Figure 4) and RS (Figure 5).

DISCUSSION

We performed functional capacity assessment of patients with intracranial aneurysm/SAH in the early post-operative period. The assessment criteria were the markers/components of particular scoring scales (eg, ambulation, alimentation, personal hygiene). Almost 50% of patients assessed

Table 4. Outcome scores based on grade on presentation (with the standard deviation).

	Hunt-Hess Grade				
	0	I	II	III	IV
FCS	43.0±3.0	40.0±4.8	36.1±6.6	31.4±5.3	30.8±8.4
GOS	4.8±0.4	4.2±0.9	3.6±1.3	2.1±1.2	2.1±1.2
FIR	93.5±15.6	78.5±23.4	61.7±28.5	35.7±14.3	44.8±30.7
BI	85.9±18.4	72.4±23.8	57.4±18.6	41.8±6.0	49.1±18.8
RS	1.0±1.1	2.0±1.4	2.9±1.3	4.0±0.8	3.8±1.3

Test Kruskal-Wallis

35.78; p <0.001 for FCS

38.59; p <0.001 for GOS

35.13; p <0.001 for FIR

32.92; p <0.001 for BI

37.06; p <0.001 for RS

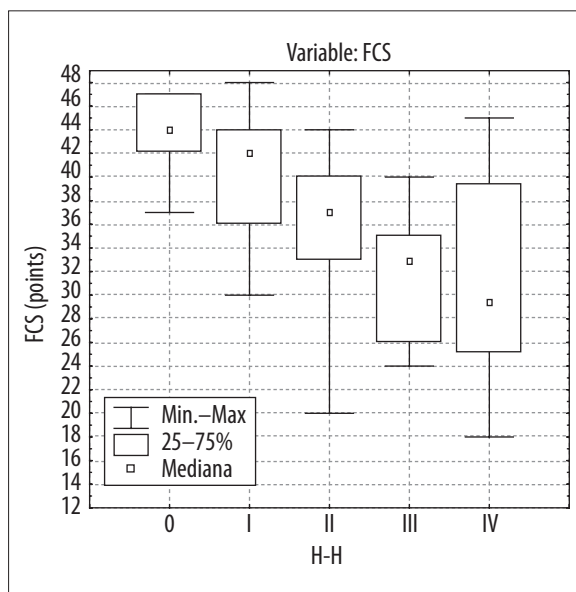


Figure 1. Analysis of patient condition using H-H and FCS scales.

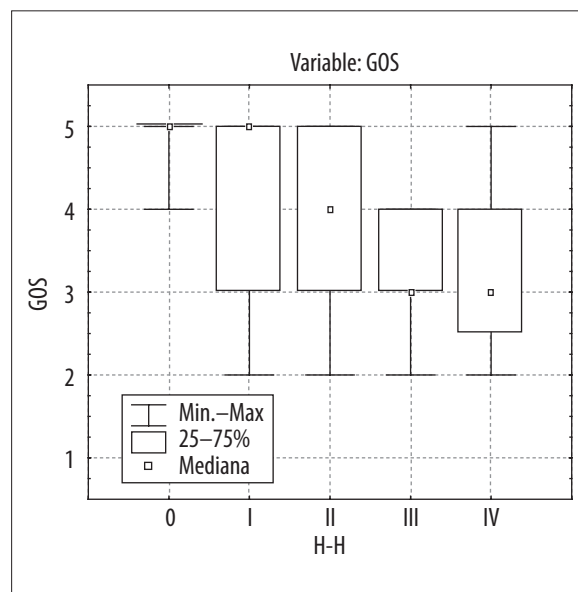


Figure 2. Analysis of patient condition using H-H and GOS scales.

at the early stage after surgical treatment of intracranial aneurysm leave the ward as functionally able in the scope of basic daily living activities. Results obtained from 5 different assessment scales confirm this observation.

Deruty et al. [26] present a very good and average result obtained in 85% of the patients, and a poor result obtained in the case of 4% of patients. Saciri and Kos [27] state that on discharge, 72.7% of patients never displayed motoric problems.

Correlations between particular scales prove the usefulness of these assessment scales in patients with SAH and/or intracranial aneurysms. Other authors also confirm the correlation between scales for assessment of functional capacity in patients after SAH, directly after the surgery and

at the remote period [10,28]. Kirkness et al. [14] showed correlations between 2 recently improved scales: GOSE (Extended Glasgow Outcome) [15] and FSE (Functional Status Examination) [29] used for final assessment (functional capacity – recovery) of patients after subarachnoid hemorrhage, 3 months after discharge. They suggest that final outcomes measured by GOSE and FSE are closely related and show statistically significant relationship with other clinical scales (eg, GCS, BDI, SF-36 and GOS) [29,30]. Kim et al. [10] compared and looked for correlations between functional scales in a group of 385 patients at between 3 and 12 months after SAH. They analyzed GOS, Barthel, Rankin and SF-36, and also compared NIHSS and MMSE.

Many authors [9,11] who verified quantitative methods used for assessment in patients with SAH/intracranial aneurysm

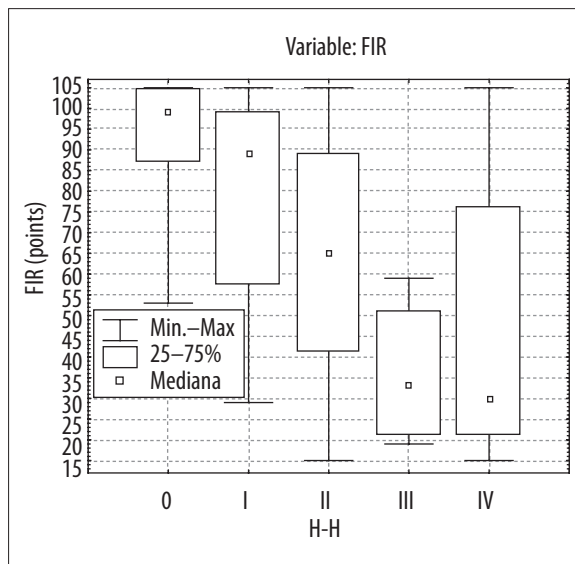


Figure 3. Analysis of patient condition using H-H and FIR scales.

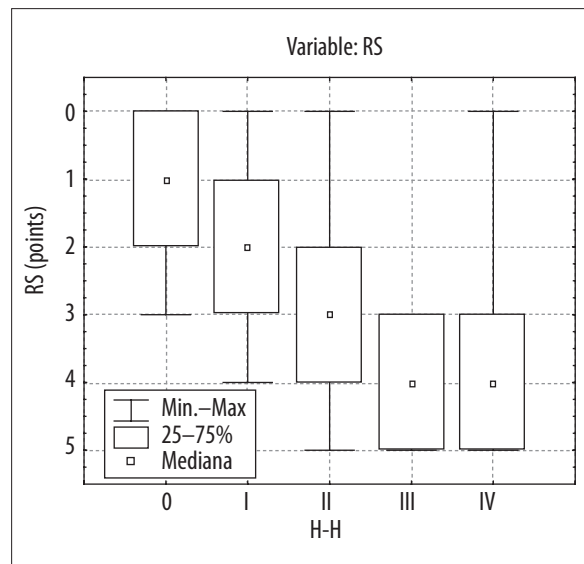


Figure 5. Analysis of patient condition using H-H and RS scales.

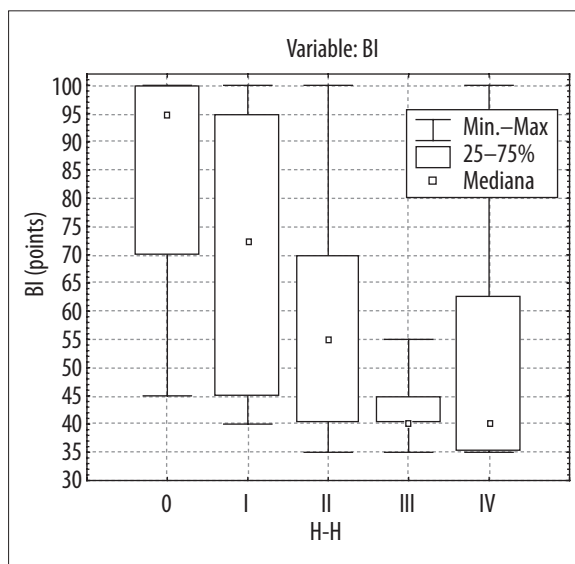


Figure 4. Analysis of patient condition using H-H and BI scales.

confirm a high correlation between clinical scales (Hunt and Hess Scale – H&H, World Federation of Neurological Surgeons Scale – WFNS, GCS and Fisher Scale – FS) and functional scales in the immediate and long-term period after intracranial aneurysm surgery.

Clinical condition assessed using the H-H scale has an important influence on the final outcomes measured by the functional scales. Most authors confirm worse final outcomes and greater mortality of patients with worse initial condition measured by the H-H scale [31,32]. It is still controversial whether patients classified as H-H groups IV and V should undergo surgery. Many authors suggest that clinical condition of groups IV and V SAH patients can improve after individual treatments. Analysis of final outcomes of these patients shows some discrepancies between direct and remote final results, which range from satisfactory to bad. Undoubtedly, it is influenced by many factors [33–35].

CONCLUSIONS

1. Fifty percent of patients assessed at the early stage after surgical treatment of intracranial aneurysm leave the ward as functionally able in the scope of basic daily living activities.
2. There are significant correlations between FCS and the other scales used for functional assessment of patients, indicating that FCS meets the criteria for early functional assessment of patients after surgery.
3. There is a significant relationship between functional capacity of the patient on the day of discharge and clinical condition before the surgery, indicating that worse condition before surgery predicts poorer functional capacity after the procedure.

Acknowledgements

The author thanks all the nurses working in the neurosurgery ward who helped during data collection for this study.

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