



Stratification of stroke rehabilitation: Five-year profiles of functional outcomes

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Background: Stroke rehabilitation in inpatient setting requires high intensity of manpower and resources. Early stratification of patients with stroke could facilitate early discharge plan and reduce avoidable length of stay (LOS) in hospital. Stratification of patients with stroke in clinical setting is usually based on functional scores which are quite time-consuming and require a special training to complete the full score.

Objective: The objective of the study was to explore whether Modified Functional Ambulation Category (MFAC) can serve as a stratification tool of patients with stroke in inpatient rehabilitation.

Methods: This was a retrospective, descriptive study of the demographic, functional outcomes of patients with stroke in an inpatient rehabilitation center. A total of 2,722 patients completed a stroke rehabilitation program from 2011 to 2015 were recruited. The patients were divided into seven groups according to their admission MFAC. The between-group difference in LOS, functional outcomes at admission and discharge including Modified Rivermead Mobility Index (MRMI) and Modified Barthel Index (MBI) as well as MRMI gain, MRMI efficiency, MBI gain, and MBI efficiency were analyzed.

Results: Subjects with admission categories of MFAC 2 and 3 had a highly significant ($p < 0.001$) MRMI gain (6.2 and 6.6, respectively) and subjects with admission categories of MFAC 3 to 5 had highly significant ($P < 0.001$) MRMI efficiency (0.34, 0.40, and 0.39, respectively). The subjects with admission categories of MFAC 2 to 5 had a highly significant ($p < 0.001$) MBI gain (9.7, 10.2, 9.3, and 7.0, respectively) and the subjects with admission categories of MFAC 4 to 5 had a highly significant ($p < 0.001$) MBI efficiency (0.70 and 0.72, respectively). The subjects with admission categories of MFAC 1 and 2 had a highly significant ($p < 0.001$) LOS (27.7 and 26.6, respectively). MFAC profile was also established to represent the distribution of discharge MFAC of subjects according to their admission MFAC. The chance of subjects with admission categories of MFAC 1 and MFAC 2 progress to any kind of walker (MFAC > 2) is 12.7% and 58.2%, respectively. The chance of subjects with admission MFAC 3, MFAC 4 and MFAC 5 progress to independent walker (MFAC > 5) is 6.7%, 14.8%, and 50.3%, respectively. Both admission MFAC and

admission MBI had strong correlations with discharge MFAC ($r = 0.84$, $P < 0.0001$ and $r = 0.78$, $P < 0.0001$, respectively), discharge MRMI ($r = 0.82$, $P < 0.0001$ and $r = 0.78$, $P < 0.0001$, respectively) and discharge MBI ($r = 0.78$, $P < 0.0001$ and $r = 0.94$, $P < 0.0001$, respectively).

Conclusion: This study showed that patients on admission with moderate disability in term of MFAC had the greatest mobility gain and basic activities of daily living (ADL) gain from inpatient stroke rehabilitation. Admission MFAC could be a stratification tool of patients with stroke in inpatient rehabilitation.

Keywords: Stroke rehabilitation; physiotherapy; functional outcome; stratification.

Introduction

Stroke, also known as cerebrovascular accident (CVA), is an acute disturbance of focal or global cerebral function with signs and symptoms lasting more than 24 h or leading to death, presumably of vascular origin.¹ Stroke was the fourth leading cause of deaths in Hong Kong in 2014² and around 25,000 of patients with stroke are admitted to public hospitals under the Hong Kong Hospital Authority annually.² The most widely recognized impairment causing stroke is motor impairment which restricts functional mobility including walking.^{3,4} Therefore, to improve functional mobility of patients with stroke is one of the main goals of rehabilitation.⁴ However, stroke rehabilitation in inpatient setting requires high intensity of manpower and resources. Early stratification of patients with stroke is useful for clinicians to recognize patients' possible functional outcomes, level of disability and requirement for social support so as to facilitate early discharge plan and reduce avoidable length of stay (LOS) in hospital. Stratification in clinical setting is usually based on admission functional scores such as Functional Independence Measure (FIMTM),⁵ Barthel Index (BI),⁶ Modified BI (MBI),⁷ and classification system such as Inpatient Rehabilitation Facility-Case-Mix Group (IRF-CMG).⁸ However, these assessment tools are quite time-consuming and require a special training to complete the full score. Using functional scores in terms of simple mobility categories to stratify patients with stroke and predict functional scores of patients with stroke at discharge is worth exploring. Modified Functional Ambulation Category (MFAC) is a 7-point Likert Scale⁹ which is easy-to-use, inexpensive and commonly used to classify walking capacity of patients with stroke in Hong Kong^{10,11} and Korea.¹² The objective of the study was to explore whether MFAC can serve as a stratification tool of patients with stroke in inpatient rehabilitation.

Methods

Demographic characteristics and average functional outcomes

This was a retrospective descriptive study of patients with principal diagnosis of CVA, stroke, or hemiplegia and had received stroke rehabilitation program in a hospital in Hong Kong between the periods of 1st January 2011 to 31st December 2015. Patient's demographic and hospital information including age, gender, premorbid accommodation, stroke type, days post stroke, discharge destination and LOS were retrieved from the database of physiotherapy department of the hospital and Clinical Management System of Hong Kong Hospital Authority. LOS is the total number of days spent in the rehabilitation program. The demographic characteristics and average functional outcomes of all subjects were demonstrated in number and percentage or mean and standard deviation.

Clinical outcomes

The subjects were divided into seven groups according to their admission MFAC. The between-group differences of clinical outcomes were analyzed. Clinical outcomes including LOS, admission Modified Rivermead Mobility Index (MRMI), discharge MRMI, MRMI gain, MRMI efficiency, admission MBI, discharge MBI, MBI gain, and MBI efficiency. MRMI gain is the difference between discharge MRMI and admission MRMI. MRMI efficiency is the average change in total MRMI ratings per day, which were calculated for each subject by subtracting admission MRMI from discharge MRMI ratings and then dividing by the LOS measured in days. MBI gain and MBI efficiency were measured by the same methods. The gain of a score indicates the total gain within the LOS. The efficiency of a score indicates the daily

gain of the score. Both gain and efficiency of scores were included to facilitate comparisons to other studies.

MFAC profile

MFAC profile represented the distribution of possibility of discharge MFAC by subjects' admission category of MFAC. The results were expressed in a matrix table and in a rank order for each group of subjects. The possibilities were expressed in percentage (%).

Correlation

Since previous studies showed that functional outcome at admission is positively correlated with the functional outcome at discharge,^{13,14} the correlation of admission MFAC and admission MBI to discharge MFAC, discharge MRMI, and discharge MBI were measured.

Modified Functional Ambulation Category

MFAC is a 7-point Likert Scale (1–7) that is used to classify a subject's walking capacity. It was modified from Functional Ambulation Classification (FAC). FAC includes six ordinal categories (0–5) of support needed for gait, but does not evaluate whether or not an aid was used.¹⁵ MFAC divided gait into seven categories (Category I to Categories VII), ranging from no ability to walk and requires manual assistance to sit or is unable to sit for 1 min without back or hand support (MFAC 1; Category: I, stage: Lyer) to the ability to walk independently on level and non-level surfaces, stairs, and inclines (MFAC 7; Category: VII, stage: Outdoor walker).⁹ The inter-rater reliability of the MFAC (intraclass correlation coefficient (ICC)) was 0.982 (0.971–0.989), with a kappa coefficient of 0.923 and a consistency ratio of 94% for stroke patient¹² and the ICC of the MFAC in patients with hip fractures is 0.96, with a construct validity of $r = 0.81$ on the Elderly Mobility Scale (EMS).⁹

Modified Rivermead Mobility Index

MRMI was used to assess subjects' mobility in this study. The MRMI is highly reliable between raters (ICC = 0.98) and has high internal consistency

(Cronbach's $\alpha = 0.93$) to early stage patients with stroke. The MRMI consists of eight test items, including turning over, changing from lying to sitting, maintaining sitting balance, going from sitting to standing, standing, transferring, walking indoors, and climbing stairs. The score of MRMI ranges from 0 to 40. One main characteristic of the MRMI is that participants are scored by observation of their performance on the items directly.¹⁶

Modified Barthel Index

MBI was used to assess subjects' basic activities of daily living (ADL) in this study. MBI measures the subject's performance on 10 functional items including self-care, continence, and locomotion. The values assigned to each item are based on the amount of physical assistance required to perform the task and added to give a total score ranging from 0 to 100 (0 = fully dependent, 100 = fully independent) with higher scores indicating higher levels of physical function.¹¹ There are no subtotal score because there is no subscale.¹¹ The internal consistency reliability coefficient for MBI is 0.90.¹⁷

Statistical Analysis

In order to stratify subjects with greatest functional gain from the stroke rehabilitation program, the subjects were divided into seven groups according to the admission categories of MFAC. The between-group differences of the characteristics including LOS, admission MRMI, discharge MRMI, admission MBI and discharge MBI, MRMI gain, MRMI efficiency, MBI gain, and MBI efficiency were analyzed by one way analysis of variance (ANOVA), post-hoc Bonferroni's test was administered to identify subsets of each group. For each characteristic, the groups with relative high score and without within-group post-hoc difference were highlighted.

In order to compare the correlation of admission MFAC and admission MBI to functional outcomes of subjects, Spearman's rank correlation coefficient (r_s) was used to test the relationship between admission MFAC and admission MBI to discharge MFAC, discharge MRMI and discharge MBI. Results were considered statistically significant when $p < 0.05$. Data were analyzed with the use of the SPSS – V20 statistical package (SPSS Inc., Chicago, LL).

Ethics Statement

Ethics approval was granted by the Joint Chinese University of Hong Kong — New Territories East Cluster Clinical Research Ethics Committee.

Results

Demographic characteristics and average functional outcomes

Medical records of 2,722 of 3,085 subjects admitted to a rehabilitation hospital were analyzed for this study. A total of 363 subjects were excluded, in which, 187 subjects were transferred back to acute hospital due to unstable medical conditions, 18 subjects were discharged against medical advice (DAMA) and 158 subjects died. Of the 2,722 subjects, the mean age was 74.6 in which 1,433 (52.7%) subjects were male and 1,289 (47.3%) subjects were female. There were 2,333 (85.7%) subjects lived at home whereas 389 (14.3%) subjects were institutionalized. There were 2,312 (84.9%) subjects suffered from cerebral infarction and 410 (15.1%) subjects suffered from cerebral hemorrhage. A total of 1,955 (71.8%) subjects were first-time stroke patients and 767 (28.2%) subjects had recurrent stroke. The mean days post stroke was 12.5 days and the mean LOS in the rehabilitation program was 22.3 days (Table 1). Before the admission, 139 (5.1%) subjects were lyers (MFAC = 1), 168 (6.2%) subjects were sitters (MFAC = 2), 97 (3.6%) subjects were dependent walkers (MFAC = 3), 193 (7.0%) subjects were assisted walkers (MFAC = 4), 70 (2.6%) subjects were supervised walkers (MFAC = 5), 396 (14.3%) subjects were independent indoor walkers (MFAC = 6) and 1,665 (61.2%) subjects were independent outdoor walkers (MFAC = 7) (Table 1). The average MRMI was increased from 13.7 at admission to 18.1 at discharge. The average MRMI gain was 4.4 and the average MRMI efficiency was 0.26 (Table 1). The average MBI was increased from 32.5 at admission and 39.7 at discharge. The average MBI gain was 7.2 and the average MBI efficiency was 0.4 (Table 1).

Clinical outcomes

The outcomes among the seven groups of subjects with different admission MFAC were shown in Table 2. On admission, 889 (32.7%) subjects were lyers (MFAC = 1), 546 (20.6%) subjects were

Table 1. Demographic characteristic and average functional outcomes of patients ($N = 2,722$).

Demographic characteristic	N (%)	Mean (SD)
Age	—	74.8 (12.24)
Gender	—	
Male	1,433 (52.7)	—
Female	1,289 (47.3)	—
Premorbid MFAC		
Category 1	139 (5.1)	—
Category 2	168 (6.2)	—
Category 3	97 (3.6)	—
Category 4	193 (7.0)	—
Category 5	70 (2.6)	—
Category 6	390 (14.3)	—
Category 7	1,665 (61.2)	—
Premorbid accommodation		
Home	2,333 (85.7)	—
Institution	389 (14.3)	—
Stroke type (%)		
Cerebral infarction	2,312 (84.9)	—
Cerebral hemorrhage	410 (15.1)	—
First stroke	1,955 (71.8)	—
Recurrent stroke	767 (28.2)	—
Days post stroke (day)	—	12.5 (7.65)
LOS in rehabilitation	—	22.3 (18.24)
Discharge destination	—	
from rehab		
Home	1,690 (62.1)	—
Institution	1,032 (37.9)	—
Admission MRMI	—	13.7 (11.07)
Discharge MRMI	—	18.1 (12.83)
MRMI gain	—	4.4 (6.14)
MRMI efficiency	—	0.26 (0.43)
Admission MBI	—	32.5 (29.19)
Discharge MBI	—	39.7 (32.33)
MBI gain	—	7.2 (12.00)
MBI efficiency	—	0.40 (0.77)

sitters (MFAC = 2), 439 (16.1%) subjects were dependent walkers (MFAC = 3), 570 (20.9%) subjects were assisted walkers (MFAC = 4), 190 (7.0%) subjects were supervised walkers (MFAC = 5), 74 (2.7%) subjects were independent indoor walkers (MFAC = 6) and 14 (0.5%) subjects were independent outdoor walkers (MFAC = 7) (Table 2). The LOS of subjects with admission categories of MFAC 1 and 2 (27.7 and 26.6, respectively) had significant differences ($p < 0.05$) when compared to subjects with admission categories of MFAC 3 to 7 (21.8, 16.1, 10.9, 8.3, and 6.1, respectively). The MRMI gain of subjects with admission categories of MFAC 2 and 3 (6.2 and 6.6, respectively) had significant differences ($p < 0.05$) when compared to subjects with admission categories of MFAC 1 and 4 to 7

Table 2. Clinical outcomes of subjects.

Outcome	Admission MFAC							<i>P</i> -value
	1 (<i>n</i> = 889)	2 (<i>n</i> = 546)	3 (<i>n</i> = 439)	4 (<i>n</i> = 570)	5 (<i>n</i> = 190)	6 (<i>n</i> = 74)	7 (<i>n</i> = 14)	
LOS	27.7 (22.74)	26.6 (17.52)	21.8 (14.36)	16.1 (11.47)	10.9 (7.08)	8.3 (7.54)	6.1 (4.94)	<i>P</i> < 0.001*
Admission MRMI	2.0 (3.12)	10.2 (4.26)	15.7 (4.28)	23.4 (5.55)	30.5 (4.54)	37.2 (2.59)	37.1 (8.74)	<i>P</i> < 0.001*
Discharge MRMI	4.7 (7.05)	16.4 (8.37)	22.3 (7.96)	28.1 (6.71)	33.9 (4.91)	38.2 (2.46)	37.5 (7.42)	<i>P</i> < 0.001*
Admission MBI	5.6 (10.98)	25.9 (18.91)	41.3 (20.14)	54.3 (22.03)	71.6 (18.78)	80.6 (21.36)	82.3 (23.51)	<i>P</i> < 0.001*
Discharge MBI	8.6 (15.60)	35.6 (23.80)	51.5 (22.50)	63.6 (22.56)	78.6 (18.07)	84.3 (20.67)	85.5 (24.21)	<i>P</i> < 0.001*
MRMI gain	2.7 (5.91)	6.2 (6.97)	6.6 (6.86)	4.8 (4.91)	3.4 (3.90)	1.0 (1.69)	0.4 (1.34)	<i>P</i> < 0.001*
MRMI efficiency	0.11 (0.35)	0.26 (0.34)	0.34 (0.41)	0.40 (0.53)	0.39 (0.51)	0.15 (0.26)	0.05 (0.17)	<i>P</i> < 0.001*
MBI gain	3.0 (8.94)	9.7 (14.84)	10.2 (12.81)	9.3 (12.10)	7.0 (8.51)	3.7 (6.11)	3.2 (4.76)	<i>P</i> < 0.001*
MBI efficiency	0.10 (0.35)	0.38 (0.70)	0.51 (0.74)	0.70 (1.04)	0.72 (0.96)	0.51 (0.88)	0.52 (0.65)	<i>P</i> < 0.001*

Notes: All scores are reported as a mean (SD). *For each characteristic, one-way ANOVA with admission MFAC as a fixed factor, post-hoc differences exist between the shaded and non-shaded scores, but no post-hoc difference among the shaded scores.

(2.7, 4.8, 3.4, 1.0, and 0.4, respectively). The MRMI efficiency of patients with admission categories of MFAC 3 to 5 (0.34, 0.40, and 0.39) had significant differences ($p < 0.05$) when compared to subjects with admission categories of MFAC 1, 2, 6, and 7 (0.11, 0.26, 0.15, and 0.05, respectively). The MBI gain of subjects with admission categories of MFAC 2 to 5 (9.7, 10.2, 9.3, and 7.0) had significant differences ($p < 0.05$) when compared to subjects with admission categories of MFAC 1, 6, and 7 (3.0, 3.7, and 3.2, respectively). The MBI efficiency of subjects with admission categories of MFAC 4 and 5 (0.70 and 0.72) had significant differences ($p < 0.05$) when compared to subjects with admission categories of MFAC 1 to 3 and 6 to 7 (0.10, 0.38, 0.51, 0.51, and 0.52, respectively) (Table 2).

MFAC profile

FAC profile is a matrix table representing the distribution of discharge MFAC of subjects according to admission category of MFAC (Table 3). The left-hand column of this profile lists the admission

categories of MFAC and the top row lists the discharge categories of MFAC. At the intersection of the rows and columns, the possibility in percentage (%) of discharge categories of MFAC of subjects in a rank order for each admission categories of MFAC of subjects could be identified. For example, the change of subjects with admission category of MFAC 2 (sitter) progress to dependent walkers, assisted walkers, supervised walkers, indoor walkers and outdoor walkers upon discharge is 23.9%, 22.2%, 10.1%, 2%, and 0%, respectively (Table 3). The chance of subjects with admission categories of MFAC 1 and 2 progress to any kind of walker (MFAC 3 to 7) is 12.7% and 58.2%, respectively. The chance of subjects with admission categories of MFAC 3 to 5 progress to independent walker (MFAC 5 to 7) are 6.7%, 14.8%, and 50.3%, respectively.

Correlation

Both admission MFAC and admission MBI had strong correlations with discharge MFAC ($r = 0.84$, $P < 0.0001$ and $r = 0.78$, $P < 0.0001$,

Table 3. MFAC profile of subjects ($n = 2,722$).

	Discharge MFAC (%)						
	1 Lyrer	2 Sitter	3 Dependent walker	4 Assisted walker	5 Supervised walker	6 Indoor walker	7 Outdoor walker
Admission MFAC							
1 Lyrer	74.8	12.5	6.7	5.1	0.8	0.1	0
2 Sitter	2.8	39.0	23.9	22.2	10.1	2.0	0
3 Dependent Walker	0.4	4.2	34.4	34.9	19.4	6.5	0.2
4 Assisted Walker	0.2	0.7	1.4	43.4	39.5	13.0	1.8
5 Supervised Walker	0	0.5	0	0.5	48.7	42.3	8.0
6 Indoor Walker	0	0	0	0	0	77.5	22.5
7 Outdoor Walker	0	0	0	0	0	0	100

Table 4. Spearman's rank correlation coefficients (r_s) of functional score at admission and discharge.

	Discharge		
	MFAC	MRMI	MBI
Admission			
MFAC	0.84*	0.82*	0.78*
MBI	0.78*	0.78*	0.94*

Notes: * $p < 0.0001$.

respectively), discharge MRMI ($r = 0.82$, $P < 0.0001$ and $r = 0.78$, $P < 0.0001$, respectively) and discharge MBI ($r = 0.78$, $P < 0.0001$ and $r = 0.94$, $P < 0.0001$, respectively) (Table 4).

Discussion

MFAC is easy to be scored by clinicians and to be understood by patients and their families. To our best knowledge, this is the first study to demonstrate that admission MFAC could be a stratification tool for patients with stroke in inpatient rehabilitation. The present study showed that the groups of patients who had the greatest benefit from stroke rehabilitation program were those with admission categories of MFAC 3 to 5 in terms of MRMI efficiency and those with admission categories of MFAC 4 to 5 in terms of MBI efficiency. The present study echoes with Louie's study⁷ that patients with stroke with moderate disability on admission presented the best rate of improvement in functional outcomes on discharge. Under resource constraints, stroke rehabilitation teams have to stratify patients with stroke as soon as possible so as to allocate suitable resources, such as therapy sessions or LOS in hospital, to patients with stroke. Therefore, according to the result of present study, the rehabilitation team could allocate more resources to patients with moderate disability on admission, and formulate early discharge plan for severe and mild disability. However, our finding was a little different from previous studies by Gagnon and colleagues⁵ and Lin.⁸ Gagnon and colleagues⁵ showed that the best total (41.6) and motor-FIM (38.9) gains were observed in most severely disabled patients with stroke (IRF-CMG classification system: 114). In addition, Lin⁸ showed that patients with stroke admission FIM total scores of ≥ 73 were scored lower

functional gain (16.6 ± 11.7) than those who scored of ≤ 36 and functional gain of (27.6 ± 23.3). When considering the functional gain, present study still showed that the best MRMI gains (6.6) and best MBI gain belonged to the patients with moderate disability, i.e., admission category of MFAC 3, but not the most severely disabled patients, i.e., MFAC 1 and 2.

The present study also showed that MFAC and MBI at admission had similar correlation to MFAC, MRMI, and MBI of patients with stroke upon discharging from inpatient rehabilitation program. The admission MFAC had a strong correlation ($r_s = 0.84$, $P < 0.0001$) with discharge MFAC. This finding echoed with previous studies which found that functional score at admission is positively correlated with the functional score at discharge.^{13,14} However, how to apply that strong correlation between admission and discharge MFAC and in clinical situation is a challenge. Hence, the present study developed the MFAC profile which makes use of admission mobility level to estimate various possibility of discharge mobility level of patients with stroke. For instance, the chance of patients with admission categories of MFAC 1 and 2 progress to any kind of walker (MFAC 3 to 7) is 12.7% and 58.2%, respectively. Therefore, the sitter has 4.5 times of chance to walk again upon discharge than the lyer. The chance of patients with admission categories of MFAC 3 to 5 progress to independent walker (MFAC 5 to 7) is 6.7%, 14.8% and 50.3%, respectively. The possible mobility level of patient upon discharge (discharge MFAC) from stroke rehabilitation program is useful information for discharge planning with patients and their family.

The present study had its limitations. First, sampling bias may exist due to all subjects which were recruited from only one local rehabilitation hospital. Further studies are suggested to verify the pattern of MFAC profile and functional outcomes stratified by admission MFAC of patients with stroke in different setting, different phases, and different countries.

Conclusion

This study showed that patients on admission with moderate disability in terms of MFAC had the greatest mobility gain and basic ADL gain from inpatient stroke rehabilitation. Admission

MFAC could be a stratification tool of patients with stroke in inpatient rehabilitation.

Conflict of Interest

The author declares that he has no financial affiliations (including research funding) or involvement with any commercial organization that has a direct financial interest in any matter described in this manuscript. The author has no other financial or nonfinancial conflicts of interest related to any matter in this study.

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Author Contributions

Bryan Ping Ho Chung contributed to the design, data collection, data analysis and manuscript writing of the study.

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