ORIGINAL ARTICLE

Functional improvement for patients with stroke receiving postacute care rehabilitation program

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Background: Few studies explore the patient heterogeneity, trajectory development, and factors influencing the functional recovery of the postacute care cerebrovascular disease (PAC-CVD) program. The objective of the study was to analyze the group-based trajectory and different functional improvement for patients with acute stroke participating in the PAC-CVD program. **Materials and Methods:** A total of 328 patients with acute stroke who had participated in PAC-CVD program in rehabilitation departments of three hospitals from 2014 to 2017 were enrolled in this retrospective cohort study. Latent profile analysis (LPA) was applied to analyze the clinical characteristics between high- and low-function groups (LFGs). The analysis of variance and Chi-square test were used to analyze the association between functional grouping and patients' characteristics. **Results:** In the study baseline, patients could be divided into high function group (HFG; 85/328 = 25.9%), medium function group (MFG; 128/328 = 39.02%), and (LFG; 115/328 = 35.06%) by LPA. age (P = 0.001), length of hospital stays (P = 0.001), male sex (P = 0.048), and lesion type (P = 0.023) were significantly associated with being grouped in the high-function group. After 6 weeks of rehabilitation training, 100% of HFG remained as HFG, 49.04% of MFG transitioned to HFG, and 50% of MFG continued to remain as MFG. 8.41% of LFG transitioned to HFG, 57% of LFG transitioned to MFG, but still, 34.58% of LFG continued to remain as LFG. **Conclusion:** Identifying initial functional groups can guide medical professionals to target patients for PAC service use. PAC-CVD high-intensity rehabilitation significantly enhances acute stroke patients' functional recovery, though effectiveness varies over time. These factors highlight the need for further development of rehabilitation programs to boost patient independence.

Key words: Acute stroke, functional improvement, latent profile analysis, postacute care

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INTRODUCTION

Stroke is one of the most devastating neurological diseases with increasing prevalence worldwide and also the second leading cause of death and disability-adjusted life year lost globally.[1] Stroke often causes physical impairment, and different types, sizes, and locations of stroke may induce sequelae of various degrees and dimensions, including physical motion, sensation, swallowing, speech, cognition, and quality of life (QoL). It also results in death,[2] disability, and even leads to depression and affects self-image.[3] Patients with stroke often experience varying periods of disability that result in a significant burden on the family, society, and health-care system.[4] The effects of stroke on a patient's length of hospital stay (LOS), timing for returning home, QoL, and social roles are more pronounced.[3]

Postacute care (PAC) could decrease disabilities, improve functional recovery and outcomes,[5] accelerate patients' return to their families, and restore normal social function. Moreover, it reduces subsequent readmission rates[6] and

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health-care resource consumption,[7] thereby alleviating family and social care burdens and improving the allocation efficiency of medical resources.[8,9] Key factors affecting patient outcomes and shortening hospitalization stay include whether patients receive rehabilitation intervention[10] and intervention site.[11] The Taiwan National Health Insurance Administration (NHIA) of the Ministry of Health and Welfare started the PAC cerebrovascular disease (CVD) program in 2014. High-intensity rehabilitation program was introduced in community hospitals, comprising a rehabilitation period of 6–12 weeks. The program aimed to reduce disability, shorten the LOS, and improve the function of patients with acute stroke.

Some studies had explored the functional improvement of stroke patients with PAC training. However, there are few studies focusing on the patient group characteristics for the effectiveness of PAC-CVD program and the differences in the effectiveness of various rehabilitation indicators under PAC-CVD program. Latent profile analysis (LPA) is a patient-centered approach that classifies individuals from a heterogeneous population into homogeneous subgroups from observed data or variables.[12-14] This study analyzed 15 assessment metrics using LPA to elucidate hidden subgroups[15,16] and intergroup mobility status of patients. LPA has been used in the medical field to cluster individuals into subgroups and to unveil hidden association patterns. Based on the above, our study aimed to investigate the population heterogeneity, trajectory development, and factors influencing the functional recovery of stroke patients enrolled in the PAC-CVD program. We examined the underlying subgroups and clinical characteristics of these patients and explored the features of the cohort that showed functional improvement after the PAC-CVD intervention. This study provides a screening basis for the implementation of the PAC-CVD program.

METHODS

A total of 328 patients with acute stroke participating in the PAC-CVD program in rehabilitation departments of three hospitals from 2014 to 2017 were enrolled in this retrospective cohort study. The initial PAC-CVD program was a pilot program from the NHIA of Taiwan. At the end of 2017, the Taiwan NHIA transformed the PAC-CVD program into a formal program. In the formal program, the payment, inclusion criteria, and evaluation indicators were adjusted. The demographic characteristics of stroke patients participating in the PAC-CVD program were slightly different from those in the pilot study, and the number of evaluation items decreased at the same time. For this reason, our study only collected the patients from 2014 to 2017. The inclusion criteria were stroke episode within the last 30 days, suitable for rehabilitation training, modified Rankin scale (MRS) score between 2 and 4, and available data from at least two evaluations (initial and close-out). Patients who died or did not complete the initial and close-out evaluations were excluded.

Independent variables were the subject's demographics and clinical characteristic variables, including age, sex, lesion side/site, lesion type, and LOS (the duration from admission to the PAC ward until close-out). LPA was applied to identify the subgrouping of individuals and intergroup moving. Variables in LPA for subgroup classification were the following 15 evaluation indicators: MRS, Barthel Index, Functional Oral Intake Scale,[17] Mini-nutrition Assessment (MNA),[18] Euro QoL-5 dimensions questionnaire, Lawton and Brody Instrumental ADL scale,[19] Berg Balance Scale,[20] gait speed, 6-min walk test, Fugl-Meyer Assessment-motor and modified sensation scales, 2 indicators,[21] mini–mental state examination, motor activity log-quality of movement scale, and amount of use scale, 2 indicators,[22] and Concise Chinese Aphasia Test.

Statistical analysis

Descriptive statistics were expressed as the mean and standard deviation (SD) for continuous variables and as frequency and proportions for categorical variables. The paired *t*-test was used to compare changes in the 15 indicators during time I (initial evaluation) and time II (6-week evaluation). LPA was further performed to examine the aggregative effects of the potential grouping and intergroup moving of patients.

LPA is a mixed model used for examining unobserved categorical variables by dividing populations into different exclusive latent classes. Initially, we assessed the model's fit by comparing the Akaike information criterion (AIC), Bayesian information criterion (BIC), and entropy in two, three, four, and five profile levels.[13-16] After comparing the AIC, BIC, and entropy at different number profiles, the AIC and BIC dropped slightly from four profiles to five profiles, whereas the entropy values were 0.83 and 0.77, respectively. We decided to use the three-profile model, and the AIC, BIC, and entropy were 1424.95, 1688.47, and 0.90, respectively, indicating that the three profiles LPA model was acceptable for use in further analysis.

The analysis of variance and Chi-square test were then used to analyze the interrelationships between subgroups and subject's demographics/clinical characteristic variables. The threshold of type I error is set as $P < 0.05$. The data were analyzed using the M-plus 7.0 for LPA and SPSS Statistics software (version 22, IBM Corporation, Armonk, NY, USA) for other analysis. This study was approved by the Medical Ethics and Institutional Review Board of Taoyuan General Hospital, Ministry of Health and Welfare, Taiwan (IRB No.: TYGH106031).

RESULTS

Three hundred and twenty-eight acute stroke patients who met the inclusion criteria were enrolled in this study, of whom 211 (64.3%) were male and 117 (35.7%) were female. The mean age was 65.34 ± 12.86 years, and the average LOS was 44.4 ± 22.86 days. Of the patients, 70.7% had ischemic strokes and 28.4% had hemorrhagic strokes. Right-sided, left-sided, bilateral, and brainstem strokes accounted for 41.8%, 51.2%, 4.6%, and 1.5%, respectively.

Table 1 demonstrates the classification of subgroups by LPA grouping. After LPA grouping by the 15 evaluation indicators at the time I (before receiving the PAC-CVD) in 328 patients, a division into three subgroups was the best-fit model. The optimal value of entropy (0.940) emerged when the patients were divided into three subgroups, and the minimal value of the sample size-adjusted BIC was 31468.29.[23] The patients were divided into three subgroups, namely, high-function group (HFG), medium-function group (MFG), and low-function group (LFG). In total, 14 indicators showed significant differences between subgroups, except for the MNA (P = 0.566). The HFG had the best performance in the remaining 14 indicators among the three subgroups, followed by the MFG and then LFG [Table 1].

Table 2 shows the three subgroups' clinical characteristics after grouping at time I. Patients in the HFG had the lowest mean age (57.9 years) and shortest LOS (35.6 days). Patients in the LFG had a moderate mean age (67.8 years) and the longest LOS (54.3 days). There were significant differences in age and LOS between the three subgroups (P = 0.001). The HFG had the highest male-to-female ratio (M:F = 74:26), followed by the MFG (62:38), whereas the LFG had the lowest ratio (60:40). Besides, the HFG had the highest ischemia/hemorrhage ratio (78/22), followed by the MFG (74/26), whereas the LFG had the lowest ratio (64/36). The P values of sex and lesion type were 0.048 and 0.023, respectively, with statistically significant differences.

Table 3 demonstrates the differences in 15 assessment metrics between time I and time II after 6 weeks of intensive rehabilitation training. All 15 evaluation indicators showed significant improvement after training in all indicators.

As shown in Table 4, a significant moving pattern of patients was observed between the three subgroups after 6 weeks of rehabilitation training. At time I, there were 115 patients in the LFG, of whom 37 remained in the LFG at time II, whereas 61 advanced to the MFG and 9 had moved straight up to the HFG. Of 128 patients in the MFG at time I, 52 remained in the MFG at time II, 51 advanced to the HFG, and only one patient downgraded to the LFG. Of 85 patients in the HFG at time I, 51 remained in the HFG at time II. The number of patients who had closeout before 6 weeks in these three subgroups were 8, 24, and 34 in the LFG, MFG, and HFG, respectively [Table 4].

Based on the above, patients who were upgraded from the LFG to MFG or HFG (LFG→MFG/HFG) and those from the MFG to HFG (MFG→HFG) were classified into the high-improvement group, whereas patients in the LFG or MFG who remained in the original subgroups (LFG→LFG or MFG→MFG) were classified into the low-improvement group. The significant clinical characteristics between the

Table 1: Latent profile analysis on indicators performance at Time I (initial evaluation)

	Mean±SD			$F^{\dagger}$
	LFG (n=115) (n=115/328; 35.06%)	MFG (n=128) (n=128/328; 39.02%)	HFG (n=85) (n=85/328; 25.9%)	
BBS	7.41±6.847	32.49±10.009	47.44±6.259	630.694
6MWT	1.29±7.201	70.96±61.915	278.90±79.073	630.659
GS	0.009±0.048	0.22±0.19	0.76±0.284	396.903
BI	21.52±15.463	45.55±18.014	74.29±17.375	236.078
MRS	3.99±0.162	3.78±0.434	3.16±0.614	96.988
EQ-5D	10.02±1.834	8.81±1.468	7.13±1.572	75.669
MAL-Q	0.47±0.906	1.64±1.478	2.56±1.577	61.398
MAL-A	0.43±0.830	1.58±1.555	2.58±1.659	60.311
FMA-M	25.06±20.670	43.46±14.846	44.15±9.571	50.005
IADL	0.78±0.944	1.62±1.329	2.53±1.849	39.711
FMA-S	33.57±16.651	43.62±11.174	46.51±12.783	25.815
MMSE	17.33±8.740	21.04±7.586	24.93±5.348	24.535
CCAT	9.03±3.342	10.48±2.225	11.03±1.628	16.873
FOIS	5.39±2.281	6.35±1.461	6.69±0.951	16.566
MNA	16.10±4.806	16.66±5.179	15.97±5.453	0.570

†All indicators showed statistic differences (P<0.001), except for the MNA (P=0.57). LFG=Low function group; MFG=Medium function group; HFG=High function group; BBS=Berg Balance Scale; 6MWT=6-min walk test; GS=Gait speed; MRS=Modified Rankin Scale; EQ-5D=Euro quality of life-5 dimensions; MAL=Motor activity log; FMA=Fugl-Meyer assessment; MMSE=Mini–mental state examination; CCAT=Concise Chinese Aphasia Test; FOIS=Functional Oral Intake Scale; BI=Barthel index; MNA=Mini-nutrition assessment; SD=Standard deviation

Table 2: Differences in clinical characteristics of subgroups at Time I[#] (initial evaluation*)

	LFG		MFG		HFG		*P*
	Mean	Percentage	Mean	Percentage	Mean	Percentage	
Age	67.8		68.1		57.9		0.001
Length of hospital stay[†]	54.3		41.3		35.6		0.001
Sex							
Male		60.0		61.7		74.1	0.048
Female		40.0		38.3		25.9	
Lesion type							0.023
Ischemia		63.5		74.4		77.6	
Hemorrhage		36.5		25.6		22.4	
Lesion site							
Right		47.0		42.1		35.7	0.124
Left		49.6		48.4		59.5	
Bilateral/brainstem		3.5		9.5		4.8	
Lesion site (right/left comparison)[‡]							
Right		48.6		46.5		37.5	0.140
Left		51.4		53.5		62.5	

*Initial evaluation was performed within 72 h after admission; [#]The ANOVA and Chi-square test were applied for analysis of the differences in clinical characteristics of 3 subgroups; [†]Length of hospital stay is the admission duration (days) in PAC wards; [‡]Lesion site (right/left comparison) is the direct comparison of right and left-sided lesions that excluded out bilateral and brainstem lesions due to small size of lesions amount. ANOVA=Analysis of variance; LFG=Low function group; MFG=Medium function group; HFG=High function group; PAC=Postacute care

Table 3: Comparison of indicators performance at Time I and Time II

	Time I (initial evaluation), mean±SD	Time II (6-week evaluation), mean±SD	*P**
MRS	3.70±0.535	2.95±0.952	0.001
FMA-M	37.15±18.392	41.42±18.271	0.005
FMA-S	40.85±14.739	45.50±14.803	0.001
BI	44.57±26.529	65.73±27.593	0.001
IADL	1.56±1.527	2.30±1.832	0.001
MAL-A	1.43±1.608	2.22±1.866	0.001
MAL-Q	1.46±1.563	2.28±1.851	0.001
MNA	16.28±5.119	17.19±5.494	0.041
BBS	27.63±17.885	39.49±17.354	0.001
GS	0.28±0.350	0.52±0.460	0.001
6MWT	100.51±123.375	190.24±168.310	0.001
EQ-5D	8.78±1.972	7.77±2.065	0.001
MMSE	20.78±8.051	23.16±8.365	0.001
FOIS	6.10±1.781	6.64±1.040	0.001
CCAT	10.11±2.683	10.66±2.363	0.009

*All indicators showed statistical differences ($P<0.05$). MRS=Modified Rankin Scale; FMA=Fugl-Meyer assessment; BI=Barthel index; IADL=Instrumental ADL Scale; MAL=Motor activity log; MNA=Mini-nutrition assessment; BBS=Berg Balance Scale; GS=Gait speed; 6MWT=6-min walk test; EQ-5D=Euro quality of life-5 dimensions; MMSE=Mini–mental state examination; FOIS=Functional Oral Intake Scale; CCAT=Concise Chinese Aphasia Test; SD=Standard deviation

high- and low-improvement groups were age and LOS (data were not shown).

DISCUSSIONS

Our study identified the effectiveness of the PAC-CVD program in promoting functional recovery and enhancing the QoL. This was evidenced by significant changes observed in all 15 evaluation indicators following high-intensity rehabilitation training during the PAC program. Furthermore, the classification of different subgroups based on the performance of functional indicators among acute stroke patients participating in the PAC-CVD program showed varying degrees of functional improvement and distinct patterns of upward mobility within these subgroups. It is important to note that the demographic characteristics of stroke patients significantly influenced the classification of these subgroups.

The PAC program targets patients with rehabilitation potential and who are physically able to handle it. The program aims to help them undergo an intensive rehabilitation program during the critical period of neurological recovery after a stroke and to be able to take care of themselves after returning home. This study conducted the LPA grouping and found that before receiving the PAC for PAC-CVD program, patients were divided into high function, medium function, and LFGs.

Younger male patients with ischemic stroke and shorter LOS were more likely to be grouped in HFG. Age is an important factor influencing the functional outcome of stroke patients; it also has a significant impact on the quality of care. Givi *et al*. found that age was a significant prognostic factor for 1-year survival of stroke patients,[2] so as other studies did.[24] The reason for poor outcome in aged patients may be due to worse physical condition for recovery or compensation of brain damage and poorer socioeconomic support than nonaged patients. The similar phenomenon was seen in other conditions or diseases. Poststroke aphasia showed more prevalent in older patients and worse recovery than younger ones.[25] Age is also an influencing factor

Table 4: Moving model between the subgroups

Initial evaluation		6-week evaluation		Percentage	Total cases
Subgroup	Cases*	Subgroup	Cases*		
HFG	51	HFG	51	100	111
MFG	104	HFG	51	49.04	113
		MFG	52	50	
		LFG	1	0.96	
LFG	107	HFG	9	8.41	38
		MFG	61	57	
		LFG	37	34.58	

*The number of cases in each subgroup that were initially evaluated and followed up for 6 weeks. LFG=Low function group; MFG=Medium function group; HFG=High function group

for increasing risk of serologic screening of gastric cancer and reduced immune protective effect of the COVID-19 vaccine in the elder.[26,27] LOS is another important factor for functional outcome. Previous studies had shown that stroke patients with shorter LOS had better functional performance and long-term outcome.[28,29] The results indicated that age and LOS were two major factors that influenced the ability to sustain upward recovery.

After 6 weeks of rehabilitation training, all 15 functional indicators showed a significant improvement compared to initial status. It indicated the effectiveness of PAC-CVD program, as previous studies did.[30] PAC-CVD program represented its strength in improvement of QoL and functional recovery indeed, including physical performance, walking ability, upper extremity function, balance, sensation, cognition, ADL, nutrition, speech, and swallowing function.

Patients initially attributed to HFG showed the best functional improvement and around half of MFG patients could upgrade to the HFG after PAC-CVD rehabilitation training. Most patients in the LFG could also move upward, the majority upgraded to the MFG, and some patients upgraded to the HFG. Nevertheless, nearly one-third of the patients in the LFG and MFG subgroups still remained in the original subgroups. Our study demonstrated that most acute stroke patients receiving the PAC-CVD program could follow a gradient, hierarchical upward functional improvement. It provides the importance of assessing the starting functional status of patients with acute stroke before they enter the PAC-CVD program. Determining the initial functional subgroups and their potential developmental trajectories are also important information provided by this study. The reason is that once an acute stroke patient enters the rehabilitation phase, it is important for the patient and his or her family to develop a positive attitude toward the accident and for the rehabilitation goals to be set on an individual basis. Furthermore, from this study, it can still be observed that some patients may face stagnation or limited improvement even after rehabilitation training with the PAC-CVD, although their function does not deteriorate. This is similar to the findings of previous studies, including patient age, sex, lesion type, disease severity, and LOS are factors that must be considered, so how to apply and plan the related professional support or feedback mechanism is worthy of continued investigation in future studies.[5,6,8,10,11]

Strengths and limitations

This study possesses strengths in simultaneously evaluating various functional indicators for acute stroke patients undergoing PAC, allowing for a comprehensive and dynamic illustration of transition groupings. This study also reveals varying effectiveness of rehabilitation training in different subgroups classified by LPA, a methodology and findings that are distinct from previous research. Besides, the PAC-CVD program required one case manager in each participating hospital, and the trained case manager had to collect the complete data of every participant, including the general data of the patient and every evaluation session by specialized professionals. All the collected data had to be saved and delivered to NHIA. Therefore, the possibility of potential information bias was very low. However, there are some limitations that should be considered when interpreting these findings. First, there was a difference in the number of patients between the initial and subsequent evaluations (times I and II), which may have led to a misestimation of the rehabilitation's efficacy. Initially, 328 patients were included in the PAC-CVD program, but only 262 patients remained for 6 weeks or longer. The primary reason for early discontinuation among most patients in the HFG and MFG subgroups was due to significant functional improvement, allowing them to return to their families or communities. Conversely, early discontinuation in the LFG and some of the MFG was mainly attributed to the poor medical or cognitive condition of the patients, or decisions made by family members for nonmedical reasons. Consequently, the overall efficacy of the PAC-CVD rehabilitation program is likely underestimated.

CONCLUSION

Determining the initial functional subgroups and their potential developmental trajectories can help medical professionals to identify patients for utilizing PAC service during the critical period. Patients with acute stroke can be categorized into distinct subgroups based on their initial functional indicator performance. Clinical characteristics such as patient age, LOS, sex, and lesion type play a significant role in determining these functional groupings. Following 6 weeks of intensive rehabilitation training, the overall performance of these indicators showed varying degrees of improvement, with patients demonstrating a gradient and upward trend across the three subgroups. As acute stroke patients undergo high-intensity rehabilitation therapy, the

evolving effectiveness of functional indicators and their related factors warrant further development of rehabilitation programs aimed at enhancing patient independence.

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Conflicts of interest

There are no conflicts of interest.

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