Original Article

Predictors of Acute, Rehabilitation and Total Length of Stay in Acute Stroke: A Prospective Cohort Study

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Abstract

Introduction: The poststroke acute and rehabilitation length of stay (LOS) are key markers of stroke care efficiency. This study aimed to describe the characteristics and identify the predictors of poststroke acute, rehabilitation and total LOS. This study also defined a subgroup of patients as "short" LOS and compared its complication rates and functional outcomes in rehabilitation with a "long" acute LOS group. Materials and Methods: A prospective cohort study (n = 1277) was conducted in a dedicated rehabilitation unit within a tertiary academic acute hospital over a 5-year period between 2004 and 2009. The functional independence measure (FIM) was the primary functional outcome measure in the rehabilitation phase. A group with an acute LOS of less than 7 days was defined as "short" acute LOS. Results: Ischaemic strokes comprised 1019 (80%) of the cohort while the rest were haemorrhagic strokes. The mean acute and rehabilitation LOS were 9 ± 7 days and 18 ± 10 days, respectively. Haemorrhagic strokes and anterior circulation infarcts had significantly longer acute, rehabilitation and total LOS compared to posterior circulation and lacunar infarcts. The acute, rehabilitation and total LOS were significantly shorter for stroke admissions after 2007. There was poor correlation (r = 0.12) between the acute and rehabilitation LOS. In multivariate analyses, stroke type was strongly associated with acute LOS, while rehabilitation admission FIM scores were significantly associated with rehabilitation LOS. Patients in the short acute LOS group had fewer medical complications and similar FIM efficacies compared to the longer acute LOS group. Conclusion: Consideration for stroke type and initial functional status will facilitate programme planning that has a better estimation of the LOS duration, allowing for more equitable resource distribution across the inpatient stroke continuum. We advocate earlier transfers of appropriate patients to rehabilitation units as this ensures rehabilitation efficacy is maintained while the development of medical complications is potentially minimised.

Ann Acad Med Singapore 2016;45:394-403

Key words: Functional Outcomes, Haemorrhagic, Ischaemic

Introduction

Stroke is a major cause of morbidity and disability worldwide. It is also the most common diagnosis for inpatient rehabilitation admission in Singapore and many developed countries.[1-3] Stroke comprises up to 4% of the direct costs of healthcare in developed countries due to its substantial physical, social and economic burdens.[4,5] Hence, in our healthcare system, the poststroke acute and rehabilitation lengths of stay (LOS) are utilised as key markers of cost and care efficiency.[1,5]

Evaluating the determinants of poststroke acute LOS are important due to the rising costs of early stroke management, with in-hospital acute stroke units accounting for more than 65% of total inpatient costs.[6] This may be attributed to the increasing costs of acute hospital beds and the aggressive use of neuroimaging, medications and paramedical resources, although the literature on predictors of poststroke acute LOS is scarce.[7]

Determining factors that impact the rehabilitation LOS are also important as they are directly associated with

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rehabilitation costs and are considered to be a primary proxy for many insurance and reimbursement systems.[3] The rehabilitation LOS further assumes particular importance in inpatient stroke rehabilitation as the LOS is longer than other common diagnoses admitted for rehabilitation including hip fractures and falls in the elderly.[1,8] Full recovery is the exception and the risk for extended inpatient stay is high.[8,9] Apart from cost efficiency, accurate LOS estimates are also important for patients and their families to plan for eventual community reintegration or resource utilisation in healthcare institutions and nursing homes.[9,10]

Significant efforts have been made recently to reduce the poststroke acute and rehabilitation LOS while maintaining care efficiency. For example, the institution of early supported discharge (ESD) programmes has provided planned and coordinated discharge from the hospital with continued rehabilitation in homes, which may shorten acute LOS.[11,12] Benchmarking strategies, where clinicians are made aware of and held accountable for rehabilitation LOS through the feedback of baseline resource utilisation, also reduce the LOS while maintaining functional outcomes.[4] Integrated stroke rehabilitation pathways with early caregiver identification, active multidisciplinary goal-setting and timely involvement of discharge liaison persons and social workers also shorten rehabilitation LOS.[9,13] There are further moves towards very early rehabilitation (VER) in stroke which impacts acute and rehabilitation LOS.[14-16] In VER programmes, specific stroke rehabilitation services are commenced within 48 hours of stroke onset.[15,16] This is because earlier rehabilitation results in better functional recovery generally.[14]

The poststroke total LOS (which summates the acute and rehabilitation LOS) has received recent attention. Moves towards an integrated care of chronic diseases such as stroke have been proposed, with per-episode (per-case) funding looking at rationalising resources across the entire inpatient episode rather than splitting them between acute and rehabilitation phases.[17,18] The literature on total LOS and the relationships between acute and rehabilitation LOS in stroke is scarce, if any.

In this prospective cohort study, we aimed to:

1. Describe postacute stroke, rehabilitation and total LOS, and examine the correlations and trends by year of admission as well as categories of stroke type. This provides an important baseline data for future comparative studies as there were no significant interventions such as ESD or VER programmes throughout the duration of this study.
2. Identify the predictors of both acute and rehabilitation LOS using a comprehensive set of sociodemographic, medical and functional variables. Predictors of prolonged LOS differ considerably between acute and rehabilitation hospital phases and are often reported separately with different cohorts.[6] The predictors were evaluated in the context of the same cohort that went through both acute and rehabilitation phases.
3. Further define a group of having less than 7 days of LOS of acute stroke as "short" acute LOS and a group that had 7 days or more of LOS as "long" acute LOS.[6] Using the median acute LOS of 7 days to divide patients into 2 equal groups for further study has been reported previously.[19] We analysed the short acute LOS group and hypothesised that there are differences in the development of medical complications and functional outcomes during the rehabilitation phase as compared to the long acute LOS group.[20]

Materials and Methods

The Department of Rehabilitation Medicine, Singapore General Hospital (SGH) is located within the acute hospital premises and admits patients across a wide spectrum of stroke severities. All stroke patients admitted to the inpatient rehabilitation unit of SGH between 1 February 2004 and 31 January 2009 were prospectively recruited.

Stroke was defined based on clinical features consistent with a stroke and supported by neuroimaging findings.[13] Criteria for admission to the inpatient stroke rehabilitation programme include recent haemorrhagic or ischaemic stroke, significant functional impairments that may benefit from comprehensive inpatient rehabilitation, sufficient medical stability to allow for care in a rehabilitation setting and ability to participate in a goal-directed programme.

The parameters charted were determined through a review of relevant literature by a multidisciplinary team, focusing on variables identified as predictors of LOS and functional outcomes. In addition, data pertinent to local social context which may impact rehabilitation outcomes, were also included.[2,9] The data collected were classified into 6 categories: 1) demographics, 2) social characteristics, 3) stroke type and neuroimaging findings, 4) cerebrovascular risk factors, 5) medical complications, and 6) functional outcomes. Demographic data included age, gender, race and marital status. Social characteristics included housing and the availability of a caregiver. Each stroke type was first categorised as either ischaemic or haemorrhagic stroke. Ischaemic stroke was further classified according to the Oxfordshire Community Stroke Project criteria as anterior circulation infarcts (ACI), posterior circulation syndrome or lacunar infarctions.[21,22] The total ACI and partial ACI categories were grouped into a single entity, as a diagnosis of hemianopia was difficult, especially in the presence of cognitive impairment. Medical complications

recorded during the rehabilitation stay included depression, nosocomial infections, falls and deep vein thrombosis.[5,9] Depression was diagnosed by consensus amongst the managing team based on patient-reported symptoms and clinician or caregiver observations.[2] Patients were also regarded as having received acupuncture if the service was delivered regardless of duration.

The primary outcomes for this study were acute and rehabilitation LOS. The acute LOS was defined as the number of days from admission to discharge from the acute stroke unit. Rehab LOS was defined as the number of days from admission to discharge in the dedicated inpatient rehabilitation facility.[3] The year of admission to the inpatient rehabilitation facility determined the year in which the individual was included.[3] The year of admission was divided into those admitted before or after January 2007, yielding 2 approximately equal groups for further analyses by time of admission.

The functional outcome measure for our stroke rehabilitation programme was the functional independence measure (FIM).[3,10,23] The FIM is collected prospectively at admission and upon discharge from the rehabilitation unit. It consists of 13 motor (Motor FIM) and 5 cognitive (Cognitive FIM) items rated on a 7-point Likert scale. Scores range from 1 (totally dependent) to 7 (totally independent) for each of the 18 items, with a maximum score of 126 indicating total functional independence. The FIM has well established content and construct validity, sensitivity and inter-rater reliability in stroke patients.[3,23,24] The FIM gain is the difference between the discharge and admission FIM scores and it measures functional improvement. The FIM efficiency, which measures the rate of functional improvement, is calculated by dividing the FIM gain against the LOS. FIM efficiency is further multiplied by 30 to obtain a value per 30 days as the absolute values were small. The FIM effectiveness is calculated by dividing the FIM gain by the difference between the maximum FIM score of 126 and the FIM at admission. It is then multiplied by 100% and the result indicates the percentage of potential functional improvement actually achieved.[1,3,25]

All subjects participated in a comprehensive rehabilitation programme that comprised medical, nursing, physical and occupational therapy.[2,9,23] Subjects received 2 to 3 hours of therapy per day. Appropriate patients were provided speech and language therapy, psychology and medical social work interventions. Weekly multidisciplinary rounds were conducted to review progress, goals, and further therapies, and to formulate discharge plans.

This study was approved by the SingHealth Centralised Institutional Review Board.

Statistical Analysis

A total of 1300 stroke patients were admitted to our rehabilitation unit over a 5-year period from 1 February 2004 to 31 January 2009. Twenty-three patients who had acute or rehabilitation LOS exceeding 3 standard deviations (SD) from its mean were treated as outliers and excluded from statistical analyses.[26] For comparison of variables between short and long acute LOS, participants were dichotomised based on the median value of acute LOS, which was defined as 7 days in our study.[19] Independent T-test was used to examine the differences for continuous variables between the 2 groups, while Fisher's exact test and chi-square test were used to examine the differences for categorical variables. The linear association between acute LOS and rehabilitation LOS was evaluated using Pearson's correlation coefficient. The linear relationship between predictors and acute or rehabilitation LOS was examined using the backward selection method as defined by the Akaike Information Criterion (AIC). AIC balances parsimony with goodness-of-fit models by penalising those models with a greater number of parameters, i.e. more complex models.[27] The model with a smaller AIC is preferred. We fitted our linear regression model adjusting for age, gender, ethnicity and recurrence of stroke. Statistical analyses were done using R version 3.0 and statistical significance was set at $P < 0.05$.

Results

Study Population

There were 1277 subjects in this stroke cohort; 753 (59.0%) were male patients with a mean (± SD) age of 64.2 ± 12.3 years (Table 1). Chinese patients comprised 80.9% of the cohort, followed by Malay (11.3%) and Indian patients (6.2%). There were 1019 (79.8%) ischaemic stroke subjects while the rest were haemorrhagic stroke subjects (Table 1). Among those with ischaemic stroke, 471 (46.2%) sustained a lacunar stroke, 353 (34.6%) had an anterior circulation stroke, while the rest had posterior circulation strokes (19.1%). Hypertension (78.4%) and diabetes mellitus (41.0%) were the 2 most common cerebrovascular risk factors. Urinary tract infection (UTI) (21.0%), depression (17.2%) and pneumonia (7.1%) were the 3 most common complications during rehabilitation. In the rehabilitation phase, the mean admission FIM scores were 67.9 ± 22.8 points, mean discharge FIM scores were 83.2 ± 23.4 points and mean FIM gain was 15.2 ± 12.0 points. The FIM efficiency was 28.5 ± 26.4 per 30 days and FIM effectiveness was 28.1 ± 22.8%. The large majority of patients (88.1%) were discharged home successfully.

Table 1. Demographics and Characteristics of the Study Population

Characteristics	All* (n = 1277)
Age (in years)	64.2 ± 12.3
Sex	
Female	524 (41.0%)
Male	753 (59.0%)
Race	
Non-Chinese	244 (19.1%)
Chinese	1033 (80.9%)
Admission year	
Before 2007	622 (48.7%)
After 2007	655 (51.3%)
Marital status	
Single/separated/divorced/widowed	336 (26.3%)
Married	940 (73.7%)
Caregiver	
Available	997 (78.1%)
No caregiver	280 (21.9%)
Type of stroke	
Lacunar	471 (36.9%)
Anterior circulation	353 (27.6%)
Posterior circulation	195 (15.3%)
Haemorrhagic	258 (20.2%)
Acupuncture	
No	1154 (90.4%)
Yes	123 (9.6%)
Laboratory parameters	
Albumin (g/dL)	35.1 ± 8.1
Haemoglobin (mg/dL)	13.9 ± 6.8
Low-density lipoprotein (mmol/L)	3.4 ± 1.3
Risk factors	
Hypertension	1001 (78.4%)
Diabetes mellitus	523 (41.0%)
Smoking	269 (21.1%)
Ischaemic heart disease	266 (20.8%)
AF	103 (8.1%)
Complications developed in rehabilitation stay	
Falls	31 (2.4%)
Deep vein thrombosis	16 (1.3%)
UTI	268 (21.0%)
Pneumonia	91 (7.1%)
Depression	220 (17.2%)
Functional measures	
Motor FIM	
Admission	43.2 ± 16.6
Discharge	56.7 ± 17.8
Cognitive FIM	
Admission	24.7 ± 8.5
Discharge	26.5 ± 7.7
Total FIM	
Admission	67.9 ± 22.8
Discharge	83.2 ± 23.4
FIM gain	15.2 ± 12.0
FIM efficiency (per 30 days)	28.5 ± 26.4
FIM effectiveness (%)	28.1 ± 22.8
Length of stay (in days)	
Acute	8.9 ± 7.2
Rehabilitation	18.1 ± 9.6
Total	27.0 ± 13.0

AF: Atrial fibrillation; FIM: Functional independence measure; UTI: Urinary tract infection

*Continuous variables are expressed in mean ± SD while categorical variables are expressed in count (%).

Acute, Rehabilitation and Total LOS

For the entire cohort, the mean (± SD) and median (interquartile range, IQR) acute LOS were 8.9 ± 7.2 days and 7 (IQR: 4 to 11) days, respectively. Meanwhile, the mean and median rehabilitation LOS were 18.1 ± 9.6 days and 17 (IQR: 11 to 24) days, respectively (Table 2). There was poor correlation between acute LOS and rehabilitation LOS (r = 0.178). The correlation was even weaker after controlling for age, gender, admission period and stroke type (r = 0.123). On comparing the admissions period between pre- and post-January 2007, there was a significant shortening of the acute, rehabilitation and total LOS for admissions after January 2007. The mean total LOS of subjects admitted post-January 2007 was about 7 days less than those admitted prior to January 2007 (23.8 ± 12.3 days vs 30.4 ± 12.8 days). We also compared the acute, rehabilitation and total LOS by the primary stroke subtype, adjusting for age, gender and admission period. For the acute LOS, haemorrhagic stroke had the longest adjusted mean (standard error, SE) LOS (12.3 [0.4] days), followed by anterior circulation strokes (9.4 [0.4] days), posterior circulation strokes (9.2 [0.5] days) and lacunar strokes (6.5 [0.3] days). For the rehab LOS, haemorrhagic strokes (19.1 [0.6] days) and anterior circulation strokes (21.0 [0.5] days) had rather similar adjusted mean LOS, but these were significantly longer than posterior circulation strokes (17.1 [0.7] days) and lacunar strokes (15.9 [0.4] days). In the total LOS analyses, the order of longest to shortest LOS followed that of acute LOS, with haemorrhagic

Table 2. The Acute, Rehabilitation and Total LOS (in Days) by Admission Period and Stroke Type

	n	Acute LOS	Rehabilitation LOS	Total LOS
Admission period (unadjusted)*				
Admission prior to January 2007	622	10.2 ± 7.3	20.3 ± 9.6	30.4 ± 12.8
Admission in January 2007 or after	655	7.7 ± 6.8	16.1 ± 9.2	23.8 ± 12.3
P value		<0.001	<0.001	<0.001
Stroke type (unadjusted)*				
Lacunar	471	6.4 ± 4.4	15.6 ± 8.6	22.0 ± 10.2
Anterior circulation	353	9.3 ± 6.6	20.8 ± 10.2	30.1 ± 13.3
Posterior circulation	195	9.1 ± 6.9	16.8 ± 9.1	25.9 ± 12.4
Haemorrhagic	258	12.9 ± 9.8	20.0 ± 9.7	32.9 ± 13.9
P value		<0.001	<0.001	<0.001
Stroke type (adjusted)†				
Lacunar	471	6.5 (0.3)	15.9 (0.4)	22.4 (0.6)
Anterior circulation	353	9.4 (0.4)	21.0 (0.5)	30.5 (0.6)
Posterior circulation	195	9.2 (0.5)	17.1 (0.7)	26.2 (0.9)
Haemorrhagic	258	12.3 (0.4)	19.1 (0.6)	31.4 (0.8)
P value		<0.001	<0.001	<0.001

LOS: Length of stay
*LOS values are unadjusted (crude) mean ± SD.
†LOS values are predicted mean (SE), after adjusting for age, gender and admission period.

stroke subjects having an adjusted mean total LOS of 9 days more (31.4 [0.8] days) as compared to lacunar stroke subjects (22.4 [0.6] days).

Predictors of Acute and Rehabilitation LOS

In multiple regression analysis of acute LOS, haemorrhagic stroke was strongly associated with longer acute LOS. In addition, anterior and posterior circulation ischaemic stroke subjects had longer acute LOS compared to lacunar stroke subjects (Table 3). Absence of hypertension, presence of atrial fibrillation, lower albumin levels, admission date prior to January 2007, females, non-Chinese and younger patients were also associated with a longer acute LOS. Marital status, diabetes mellitus, ischaemic heart disease, smokers, haemoglobin levels and absence of a caregiver were not predictive of acute LOS. In the multivariate model on the rehabilitation LOS, lower admission FIM motor scores were strongly associated with a prolonged rehabilitation LOS. Higher cognitive admission FIM scores were associated with a prolonged rehabilitation LOS (Table 3). Males, Chinese, non-smokers, younger patients, recurrent stroke, an admission date prior to January 2007, UTI, depression, acupuncture and the lack of a caregiver were also associated with a statistically significant increase in rehabilitation LOS. Marital status, acute LOS, stroke subtype, cardiovascular risk factors, haemoglobin or albumin levels and pneumonia were not associated with rehabilitation LOS.

Short Acute LOS Group and its Impact on Medical and Functional Outcomes

The results are detailed in Table 4. There were 591 (46.3%) patients in the short acute LOS group with a substantial 30% increase in patients with short acute LOS for those admitted after January 2007. In the short acute LOS group, the patients were significantly older and it had significantly more patients with lacunar strokes and less patients with haemorrhagic strokes compared with the long acute LOS group. There were no differences in gender proportions, racial distribution, marital status and caregiver availability in the 2 groups. The short acute LOS group was associated with significantly fewer UTI and pneumonia episodes, a lower incidence of clinical depression during the rehabilitation phase and had significantly higher albumin levels. The motor, cognitive and total admission FIM scores as well as the cognitive and total discharge FIM scores were significantly higher in the short acute LOS group. The motor discharge FIM score was also higher in the short acute LOS group but this was not statistically significant. The absolute FIM gain and FIM effectiveness were significantly lower in the short acute LOS group. However, the FIM efficiency was similar in

Table 3. Predictors of Acute and Rehabilitation LOS That Were Obtained Using Backward Selection Method by AIC

	Acute LOS* (Adjusted R^2 = 0.17)		Rehabilitation LOS† (Adjusted R^2 = 0.37)	
	β-Estimate (95% CI)	*P* Value	β-Estimate (95% CI)	*P* Value
Age	-0.06 (-0.10 to -0.02)	0.002	-0.07 (-0.12 to -0.03)	<0.001
Male	-0.48 (-1.45 to 0.50)	0.340	2.42 (1.31 to 3.53)	<0.001
Chinese	-1.41 (-2.61 to -0.21)	0.022	0.73 (-0.58 to 2.05)	0.274
Recurrence of stroke	0.10 (-0.93 to 1.13)	0.849	0.76 (-0.36 to 1.88)	0.182
Admission after 2007	-1.16 (-2.17 to -0.14)	0.026	-4.38 (-5.48 to -3.29)	<0.001
Anterior circulation stroke	2.38 (1.15 to 3.61)	<0.001		
Posterior circulation stroke	3.12 (1.69 to 4.55)	<0.001		
Haemorrhagic stroke	6.68 (5.33 to 8.02)	<0.001		
Hypertension	-1.17 (-2.35 to 0.003)	0.051		
AF	2.03 (0.26 to 3.80)	0.025		
Albumin	-0.16 (-0.22 to -0.10)	<0.001		
Admission motor FIM			-0.33 (-0.37 to -0.29)	<0.001
Admission cognitive FIM			0.10 (0.02 to 0.17)	0.013
No caregiver			2.18 (0.87 to 3.49)	0.001
Smoker			-2.01 (-3.31 to -0.72)	0.002
UTI			2.46 (1.17 to 3.75)	<0.001
Depression			1.80 (0.44 to 3.16)	0.010
Acupuncture			2.49 (0.70 to 4.29)	0.007

AF: Atrial fibrillation; AIC: Akaike Information Criterion; FIM: Functional independence measure; LOS: Length of stay; UTI: Urinary tract infection
*Age, gender, ethnicity and recurrence of stroke were included as base model. Marital status, caregiver, diabetes mellitus, smoking status, ischaemic heart disease and haemoglobin levels were not associated with acute LOS in this model.
†Age, gender, ethnicity and recurrence of stroke were included as base models. Marital status, stroke types, hypertension, diabetes mellitus, ischaemic heart disease, AF, pneumonia, acute LOS, albumin levels and haemoglobin levels were not associated with rehabilitation LOS in this model.

both groups. The proportion of patients discharged home was slightly higher in the short acute LOS group (89.8%) compared to the long acute LOS group (86.6%, $P = 0.08$).

Discussion

We highlight 3 important findings in this study. Firstly, for the same cohort of stroke patients, FIM scores rather than stroke subtype are a better predictor of rehabilitation LOS, even though the stroke type is strongly associated with acute LOS. Indeed, there is poor correlation between acute and rehabilitation LOS. Secondly, there is no difference between the FIM efficiency of the short acute and the long acute LOS groups. Thirdly, the short acute LOS group had fewer complications in the rehabilitation phase compared to the long acute LOS group.

Our entire stroke rehabilitation cohort is generally similar to those reported worldwide. The mean age of our cohort of stroke subjects was 64 years, which was in the lower end of the range reported in the literature.[21] Our unit does not have a lower age cutoff for admission compared to some geriatric stroke units. The racial distribution is similar to other cohorts reported locally, although the proportion of widowed patients and those with caregivers was lower, possibly due to the younger age.[1,9,13,28] The proportion of haemorrhagic strokes (20%) and the high prevalence of hypertension and diabetes mellitus are also similar to prior descriptions.[2,9] Patients admitted in the second half of the study had shorter LOS and this trend towards shortened LOS in recent years are also reported worldwide.[1,3,29] This has been attributed to a range of reasons including better quality of rehabilitation, more outpatient rehabilitation resources or even fiscal pressures from insurance and funding systems for shorter inpatient stays.[1,3,29]

The mean and median acute LOS of 8.9 ± 7.2 days and 7 (IQR: 4 to 11) days, respectively, is much shorter than that generally described in the literature.[19,29,30] Reported mean acute LOS was 13.9 days in a Spanish group, 27.3 days in a United States cohort and 37 days in a Canadian study.[20] In fact, an acute LOS of 30 days has been taken as a cutoff for early admission to inpatient rehabilitation previously.[19,20,31] Our acute LOS is similar to an Israeli study which defined a short acute LOS group at 7 days.[6] We believe our short acute LOS may be attributed in part to the rehabilitation unit being sited in the acute hospital, allowing for earlier transfers to inpatient rehabilitation.

Table 4. Comparison of Short Acute and Long Acute LOS Subgroups

	Short Acute LOS* (n = 591)	Long Acute LOS* (n = 686)	*P* Value
Age	66.3 ± 11.3	62.4 ± 12.9	<0.001
Sex			
Female	248 (42.0%)	276 (40.2%)	0.568
Male	343 (58.0%)	410 (59.8%)	
Race			
Non-Chinese	109 (18.4%)	135 (19.7%)	0.617
Chinese	482 (81.6%)	551 (80.3%)	
Admission year			
Before 2007	206 (34.9%)	416 (60.6%)	<0.001
After 2007	385 (65.1%)	270 (39.4%)	
Marital status			
Single/separated/divorced/widowed	156 (26.4%)	180 (26.3%)	1.000
Married	435 (73.6%)	505 (73.7%)	
Caregiver			
Available	461 (78.0%)	536 (78.1%)	1.000
No caregiver	130 (22.0%)	150 (21.9%)	
Type of stroke			
Lacunar	298 (50.4%)	173 (25.2%)	
Anterior circulation	150 (25.4%)	203 (29.6%)	<0.001
Posterior circulation	80 (13.5%)	115 (16.8%)	
Haemorrhagic	63 (10.7%)	195 (28.4%)	
Acupuncture			
No	543 (91.9%)	611 (89.1%)	0.106
Yes	48 (8.1%)	75 (10.9%)	
Laboratory parameters			
Albumin (g/dL)	36.1 ± 10.5	34.4 ± 5.9	0.005
Haemoglobin (mg/dL)	13.8 ± 1.8	13.9 ± 9.1	0.783
Low-density lipoprotein (mmol/L)	3.5 ± 1.2	3.4 ± 1.3	0.106
Risk factors			
Hypertension	462 (78.2%)	539 (78.6%)	0.892
Diabetes mellitus	267 (45.2%)	256 (37.3%)	0.005
Smoking	147 (24.9%)	122 (17.8%)	0.002
Ischaemic heart disease	120 (20.3%)	146 (21.3%)	0.679
AF	42 (7.1%)	61 (8.9%)	0.258
Complications developed in rehabilitation stay			
Falls	10 (1.7%)	21 (3.1%)	0.144
Deep vein thrombosis	4 (0.7%)	12 (1.8%)	0.128
UTI	79 (13.4%)	189 (27.6%)	<0.001
Pneumonia	19 (3.2%)	72 (10.5%)	<0.001
Depression	84 (14.2%)	136 (19.8%)	0.009
Functional measures			
Motor FIM			
Admission	45.5 ± 15.5	41.2 ± 17.2	<0.001
Discharge	57.4 ± 16.8	56.1 ± 18.5	0.191

AF: Atrial fibrillation; FIM: Functional independence measure; LOS: Length of stay; UTI: Urinary tract infection
*Continuous variables are expressed in mean ± SD while categorical variables are expressed in count (%).

Table 4. Comparison of Short Acute and Long Acute LOS Subgroups (Con't)

	Short Acute LOS* (n = 591)	Long Acute LOS* (n = 686)	*P* Value
Cognitive FIM			
Admission	26.1 ± 7.7	23.5 ± 8.9	<0.001
Discharge	27.3 ± 7.2	25.8 ± 8.1	<0.001
Total FIM			
Admission	71.6 ± 21.1	64.8 ± 23.7	<0.001
Discharge	84.7 ± 22.2	81.9 ± 24.3	0.031
FIM gain	13.1 ± 10.4	17.1 ± 13.0	<0.001
FIM efficiency (per 30 days)	27.5 ± 23.8	29.5 ± 28.5	0.170
FIM effectiveness (%)	26.3 ± 20.5	29.7 ± 24.5	0.008

AF: Atrial fibrillation; FIM: Functional independence measure; LOS: Length of stay; UTI: Urinary tract infection
*Continuous variables are expressed in mean ± SD while categorical variables are expressed in count (%).

This arrangement also allows remaining investigations or specialist reviews from the acute phase to continue in the rehabilitation unit, as compared to an off-site rehabilitation unit. Nosocomial infections (UTI and pneumonia) and poststroke depression were common complications during rehabilitation, similar to that reported in other studies.[9,21] The poor correlation between the acute and rehabilitation LOS suggests a difference in predictor variables between both, which needs to be evaluated separately.

It is clinically important that the difference in acute LOS is demonstrated through a simple classification of stroke types. Physicians could utilise this widely used classification, taking into account each individual's presenting stroke impairments and functional limitations, to develop a more comprehensive integrated rehabilitation plan across the inpatient continuum. There are existing reports stating that the acute LOS for haemorrhagic strokes is longer than that for ischaemic strokes, though this was not reflected similarly for rehabilitation LOS.[2,6] The reasons may be that haemorrhagic stroke patients are more disabled on admission, require more time for surgical interventions, or need further neuroimaging to elucidate underlying causes.[28] Conversely, lacunar stroke patients are less disabled than other ischaemic stroke types and their acute LOS is correspondingly shorter.[6,21] Admission functional status has been established as a major predictor of rehabilitation LOS, and this was reflected in our study.[2,21,23] Reasons include that patients with more severe disability may take a longer time to recover or the rehabilitation team had recommended a longer rehabilitation LOS for longer rehabilitation intervention. The poor correlation between acute and rehabilitation LOS is surprising.[32] A longer acute LOS is often a proxy for strokes with more severe disability and this in turn usually requires a longer rehabilitation LOS. This may be due to a more heterogeneous sample that included both haemorrhagic and ischaemic strokes. Further studies exploring this relationship should use a narrower homogenous cohort.

The LOS efficiency provides a good metric in programme evaluation as it encourages facilities to include more severely impaired patients while monitoring efficiency and effectiveness of rehabilitation.[1,3,23] It is significant that FIM efficiencies were maintained in the short acute LOS group, suggesting that earlier rehabilitation transfers may reduce risks of medical complications including nosocomial infections and depression, which was reflected in our study. Earlier rehabilitation commencement can also optimise the capacity for brain plasticity.[2,13-15] The FIM effectiveness in the short acute LOS group is statistically significantly lower than the long acute LOS group and this suggests a ceiling effect for further FIM gains as the admission FIM scores for the short acute LOS group is higher.[2,19] However, clinically, the absolute 7-point difference in the admission FIM scores and the 3% difference in FIM effectiveness between the short acute and the long acute LOS cohorts do not approach a minimally clinically important difference.[3] Sensible decisions regarding timing of transfers would still need to be individualised, though further research may elucidate subsets of patients who may benefit more through earlier rehabilitation transfers.

With regard to other independent variables associated with LOS, older age was associated with both shorter acute and rehabilitation LOS. This inverse relationship has been reported previously.[23] For the acute LOS group, younger patients may be subjected to a more rigorous pursuit of an underlying etiology and further investigations, hence resulting in a later rehabilitation transfer. Older patients may have a shorter rehabilitation LOS as the goals of rehabilitation may be more modest with a greater focus on compensatory approaches.[23,33] Lower albumin levels was associated with longer acute LOS and this generally reflects

poor general health due to a variety of causes, including poor nutrition, medical complications, dysregulation of hormones and elevated cytokines levels.[22,24] Atrial fibrillation has been associated with increased acute LOS and is associated with more extensive cortical strokes, severe disability and a general higher comorbidity burden.[6] We believe that that the time required for discussion with patients, initiation and titration of anticoagulation prior to rehabilitation transfer also contributed to increased acute LOS.

The relationship between a longer rehab LOS and the absence of a caregiver is not surprising. An extended stay is required for families to explore care options, await the arrival of a domestic helper, or nursing home placement.[9] Depression prolongs rehabilitation LOS as rehabilitation is less efficient due to diminished motivation, nutrition, poor sleep or concentration, limiting recovery.[5,13] Nosocomial infections including UTI and pneumonia also prolong rehabilitation LOS as rehabilitation programmes are often interrupted or reduced in intensity while infections are being treated.[2,5] Acupuncture is a treatment method popular with Asian patients and it may prolong rehabilitation LOS as patients often request to complete extended courses of acupuncture as inpatients, due to transportation difficulties once discharged.[2] The reasons for male patients having longer rehabilitation LOS remains to be studied. Our findings conflict with other studies that did not find any gender associations[5,10] or even longer rehabilitation LOS associated with the female gender.[3]

Our study has several strengths and weaknesses. Major limitations include firstly, selection bias as only stroke patients deemed able and willing to undergo rehabilitation were transferred to our unit.[2,30] Secondly, only a single hospital rehabilitation unit was involved and the results may not be reflective of other rehabilitation facilities locally or in other countries.[8,19,21] Thirdly, there are many other known and unknown latent variables that have an impact on LOS and FIM scores but were not available or controlled for, such as the patient's financial capacity, different intensities and techniques of stroke therapy delivered, and specific impairments such as balance or vision.[3,8] The strengths of this study include the large sample size and prospective study design. A large number of evidenced-based and socially specific independent variables were also evaluated. In addition, the analyses of the acute and rehabilitation LOS were performed on the same cohort of patients from the time of acute admission to rehabilitation discharge in a single study, which allows for meaningful conclusions in the context of the total LOS.[6,13]

Conclusion

This study provides an important baseline data on acute, rehabilitation and total LOS on the same cohort of patients. This will facilitate stroke programme planning and serves as a comparison for future interventions. Certain stroke types, particularly haemorrhagic stroke and anterior circulation infarcts, had longer acute LOS while lower admission FIM scores were associated with longer rehabilitation LOS. Correlation between the acute and rehabilitation LOS was poor, reflecting differences in predictors. There is a trend towards shorter acute and rehabilitation LOS in recent years, similar to that reported worldwide. A shorter acute LOS was associated with less medical complications but with similar functional efficacy scores compared to longer acute LOS patients. We advocate earlier rehabilitation transfers, where appropriate, to optimise stroke recovery, but all patients should have an integrated individualised plan throughout their entire inpatient stay.

Acknowledgement

The authors would like to thank Dr Kiat Siong Cheah and Dr Hay Mar Saw for their assistance in data completion in this study.

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