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IMPACT OF EARLY VS DELAYED ADMISSION TO REHABILITATION ON FUNCTIONAL OUTCOMES IN PERSONS WITH STROKE

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Objective: **Delayed admission to rehabilitation may result in poorer outcomes by reducing exposure to therapeutic interventions at a time when the brain is primed for neurological recovery. The present study examined the effects of early vs delayed admission on functional outcome and length of stay in patients admitted to a rehabilitation unit for first-ever unilateral stroke.**

Design: **Retrospective chart review.**

Methods: **Differences in length of rehabilitation stay and functional outcome variables among 435 patients, grouped by interval from stroke event to rehabilitation admission ($\leq$30 days vs 31–150 days and 5 additional subgroups) were examined using a multivariate technique.**

Results: **Admission and discharge FIM™ scores, FIM™ change and FIM™ efficiency were significantly higher among early admission patients ($p < 0.01$), while length of stay was significantly longer among delayed admission patients ($p < 0.01$). A significant association was identified between age and admission ($p < 0.01$) and discharge FIM™ ($p < 0.01$) scores as well as FIM™ change scores ($p = 0.017$). Subgroup analyses revealed significant differences in FIM™ scores, FIM™ change and length of stay between groups of patients admitted 0–15 and 16–30 days ($p < 0.01$) and between patients admitted 16–30 days and 31–60 days post-stroke ($p < 0.01$). No significant differences were noted between patients admitted from 31–60 and 61–90 or 61–90 and 91–150 days.**

Conclusion: **Patients admitted to stroke rehabilitation within 30 days of first-ever, unilateral stroke experienced greater functional gains and shorter lengths of stay than those whose admission to rehabilitation was delayed beyond 30 days.**

Key words: stroke, rehabilitation, functional outcome.

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INTRODUCTION

Animal studies of the neurobiological mechanism of post-stroke recovery have demonstrated that there is a period of time shortly after a stroke event when the brain appears to be primed for recovery by a series of neuroreparative events (1–3). Biernaskie et al. (4) reported that rats exposed to enriched rehabilitation beginning on day 5 following the index stroke event, experienced a markedly greater recovery than rats whose rehabilitation commenced on day 14. For rats whose rehabilitation was delayed until day 30 post-stroke, there was no significant treatment effect associated with enriched rehabilitation when compared to rats that had received no rehabilitation. While animal studies have shown that very early, intensive therapy may have detrimental effects and exacerbate brain injury through overuse of the affected limb (5–7), the potential for rehabilitation to promote neurological recovery appears to be greatest early in the post-stroke period.

In clinical studies, patterns of post-stroke recovery reported in the rehabilitation literature support the model derived from animal-based trials. For most individuals receiving stroke rehabilitation, optimal recovery of motor function and activities of daily living (ADL) is achieved soon after stroke onset. It has been reported that the majority of recovery takes place within the first 30 days of a stroke event (8–11). In a large study of patients admitted to hospital following acute, first-ever stroke, Jorgensen et al. (12) reported that best neurological recovery was achieved within 11 weeks for 95% of patients admitted to a large urban center. Recovery of ADL function tended to occur more slowly, but at 12.5 weeks post-stroke, optimal recovery was achieved by most patients (12). The time course of functional recovery in rehabilitation is strongly influenced by the severity of the stroke as well as the severity of initial functional impairment (11–13). Moreover, it has been reported that, for patients with the most severe initial functional disability, best functional recovery is still achieved within the first 5 months (12, 14).

As in animal studies, delays between the onset of a stroke and the commencement of therapeutic rehabilitation in humans has been associated with poorer outcomes (13, 15–18). Patients who suffer more severe strokes tend to experience longer delays in admission to rehabilitation, perhaps due in part to more serious and frequent medical complications (15, 16) and a perceived lack of readiness to engage in a rehabilitation program. Delayed admission to rehabilitation may result in poorer outcomes by reducing exposure to therapeutic interventions during the period of time in which the brain is primed for recovery. Animal data has clearly shown that early rehabilitation is critical in

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maximizing post-stroke recovery; a finding supported by comparative associations in the clinical realm. Post-stroke rehabilitation should begin as soon as the patient is clinically stable, if not before (13, 15, 17).

In the present study, the effects of early vs delayed admission to stroke rehabilitation on functional outcome and length of stay (LOS) in a group of patients admitted for first ever unilateral stroke were examined as part of a retrospective review.

METHODS

A retrospective review was undertaken of 553 charts from patients admitted to a single, specialized inpatient stroke rehabilitation program at a regional rehabilitation facility in Ontario, Canada within 150 days of a first unilateral stroke from 1997–2001. Functional Independence Measure (FIM™) (19) total scores at admission and discharge, change in FIM™ scores (over the period of inpatient rehabilitation), FIM™ efficiency (FIM™ change/LOS) and LOS data were available and recorded for a total of 435 patients. The FIM™ is a commonly used composite measure of functional ability that assesses performance of items in 6 dimensions (self-care, sphincter control, mobility, locomotion, communication and social cognition) (20).

A data abstraction form was developed by the research coordinator (NF). Trained research associates, who were familiar with the process of chart review, extracted information from charts using the form provided. Data was reviewed, coded and entered into an SPSS database by a single research associate who addressed any omissions or obvious inconsistencies by reviewing the original chart.

The patients were divided into 2 groups based on the length of time from the stroke event to admission to the stroke rehabilitation unit. A time to rehabilitation admission (TRA) of 30 days or less from the stroke event represented early admission, while a TRA of 31–150 days was considered a delayed admission. The cut-off of 30 days, used to separate early from delayed admission, has been used previously in the literature (15). The expected time to optimal recovery of ADL function, for even the most severely affected stroke patients (12) is encompassed by the outer limit (150 days) of the timeframe examined. Each group (early vs delayed admission) was further subdivided into patients who were admitted to rehabilitation 0–15, 16–30, 31–60, 61–90 and 91–150 days post-stroke.

Potential differences between early and delayed admission groups were examined in terms of gender, age, side of lesion (left vs right), stroke type (ischemic or hemorrhagic), and presence of risk factors (history of any of the following: diabetes, hypertension, smoking, high cholesterol, atrial fibrillation and cardiac disorder). Unfortunately, insufficient information regarding the number or type of co-morbid conditions was available in the existing database. In addition, no information was available from the patient's acute admission for the stroke event including initial stroke severity or the number or type of acute medical complications.

Admission FIM™ scores were used as a surrogate measure of the severity of initial functional deficit attributable to the stroke event (16). The association between time from the stroke event to rehabilitation admission and the initial severity of functional deficit was examined using the Pearson product moment correlation coefficient (r). The association between TRA and FIM™ discharge scores and LOS were similarly examined.

Early vs delayed group differences on categorical variables were analyzed using the Pearson chi-square statistic. Age, sex, side of lesion, stroke type and risk factors were also entered as covariates using a multivariate analysis of variance (MANOVA) technique to examine group differences on admission and discharge FIM™ scores, change in FIM™ scores (over the duration of their rehabilitation stay), FIM™ efficiency (FIM™ change/LOS) and LOS. To examine whether the division between early and delayed admission at 30 days post-stroke was meaningful in describing differences in patient recovery, admission and discharge FIM™ scores, FIM™ change and LOS were also examined via multivariate analysis for subgroups of patients whose times to admission were 0–15 days, 15–30 days, 31–60 days, 61–90 days and 91–150 days. Statistical analyses were performed using SPSS for Windows version 12.0. A p-value <0.05 was considered statistically significant.

RESULTS

The amount of time that passed from the stroke event until admission to the rehabilitation program (TRA) was significantly and inversely associated with the initial severity of functional, stroke-related deficits as represented by the admission FIM™ score ($r = -0.354$; $p < 0.01$). A similar, inverse association was also demonstrated between discharge FIM™ scores and TRA ($r = -0.432$; $p < 0.01$), while the relationship between TRA and LOS was shown to be a positive one such that increased time from the stroke event until rehabilitation admission was associated with increased LOS ($r = 0.371$; $p < 0.01$).

Results of the initial between-group comparisons are shown in Table I. Mean age in the early and delayed groups did not differ ($F = 1.141$, $df = 1,434$, $p = 0.29$). No significant differences were found between early and delayed admission to rehabilitation groups with respect to gender, side of stroke lesion, or presence of risk factors, while significantly more patients from the delayed onset group had experienced a hemorrhagic stroke ($\chi^2 = 5.490$; $p = 0.028$).

When age, gender, side of stroke lesion and risk factors (as listed in Table I) were entered as covariates, MANOVA results identified age as the sole significant covariate associated with admission FIM™ ($F = 11.488$; $df = 1,434$; $p < 0.01$), discharge FIM™ ($F = 29.530$; $df = 1,434$; $p < 0.01$) and FIM™ change scores ($F = 5.701$; $df = 1,434$; $p = 0.017$). Increasing age was associated with lower FIM™ scores both at admission and discharge and with a smaller change in FIM™ scores over the course of the rehabilitation period. None of the potential covariates entered into the analysis were significantly associated with LOS.

Age-adjusted analysis of variance revealed significant differences between groups on admission FIM™ scores, discharge

Table I. *Group comparison for age, gender, side of lesion and type of stroke*

	Time to rehabilitation admission (days)	
	≤30 days; $n = 283$	30–151; $n = 152$
Age (years) (mean (SD))	68.8 (12.9)	70.22 (12.9)
Gender (female/male)	122/161	70/82
Type of stroke (ischemic/hemorrhagic)	252/31	123/29
Side of lesion (left/right)	142/141	79/73
Number of patients reporting presence of risk factors:		
Diabetes	73	36
Hypertension	164	100
Smoking	51	19
High cholesterol	66	25
Atrial fibrillation	60	29
Cardiac disorder	86	55

Chi-square analysis revealed no significant differences between groups for gender, side of lesion or presence of risk factors.

Table II. *Comparison of age-adjusted means between short vs delayed admission to rehabilitation groups for FIM™ scores and length of stay*

	≤30 days	31–150 days	F(df)	*p*
Admission FIM™	76.76	55.39	80.28 (1,432)	<0.01
Discharge FIM™	101.48	77.32	118.29 (1,432)	<0.01
Change in FIM™	24.68	21.93	2.498 (1,432)	0.115
Adj. FIM™ change*	26.81	17.97	32.802 (1,431)	<0.01
FIM™ efficiency	0.74	0.39	41.946 (1,432)	<0.01
Length of stay**	42.73	71.44	66/106 (1,433)	<0.01

* FIM™ change adjusted for admission FIM™ scores.
** Length of stay was not adjusted for age.

FIM™ scores, FIM™ efficiency and LOS (see Table II). No significant difference between groups was observed with regard to change in FIM™ over the period of rehabilitation. However, given that the observed amount of change in FIM™ scores might be limited by a ceiling effect among those individuals with relatively high admission FIM™ score, an analysis of covariance on FIM™ change scores, adjusted for both age and admission FIM™ scores was conducted. This additional adjusted analysis confirmed that the early-admission group experienced better functional improvement than the delayed-admission group ($p < 0.01$).

Given that lower FIM™ scores appear to be associated with later admission to rehabilitation and with older age, one might expect a greater number of older patients to be included in the delayed admission group. However, the ages of the 2 groups were not significantly different and age was not significantly associated with time to rehabilitation admission ($r = -0.11$; $p = 0.83$) (Fig. 1).

In sub-group analysis, there were also statistically significant differences in mean admission and discharge FIM™ scores, FIM™ change and LOS between patients admitted 0–15 and 16–30 days post-stroke as well as between patients admitted 16–30 days and 31–60 days post-stroke (Fig. 2 and Table III). No other significant differences were identified between sub-groups (comparing TRA of 31–60 vs 61–90 days or 61–90 vs 91–150 days). However, when patients admitted 31–60 days post-stroke were compared with patients admitted 91–150 days post-stroke, there was a trend toward increasing LOS ($p = 0.08$) as well as lower discharge FIM™ scores ($p = 0.08$). The magnitude of FIM™ change also declined across TRA groups in a similar fashion ($p = 0.05$; see Table III). All analyses were adjusted to take the effects of age into account and FIM™ change was adjusted for the effects of both age and FIM™ admission scores.

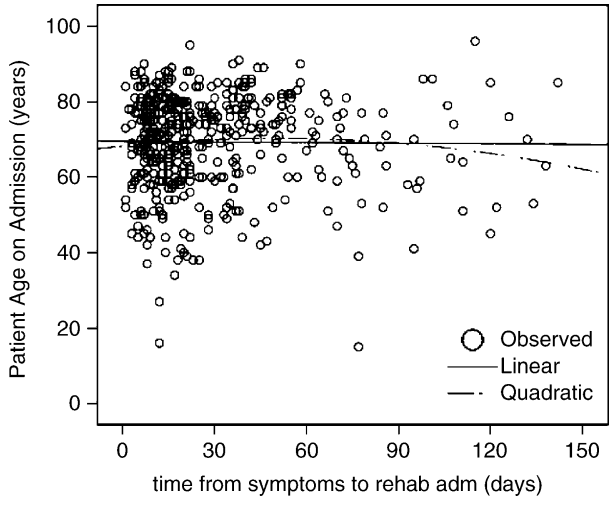

Fig. 1. Relationship between patient age and time to rehabilitation admission following stroke onset.

DISCUSSION

Both groups (early and delayed time to rehabilitation) were similar in terms of age, gender, side of lesion and the presence of risk factors for stroke. The delayed admission group contained proportionately more individuals who had suffered a hemorrhagic stroke than the early admission group ($p < 0.05$), however; it should be noted that this difference is represented by a relatively small number of individuals ($n = 32/178$ in the delayed group vs 43/375 in the early admission group).

Age was found to be the only significant covariate of admission and discharge FIM™ scores as well as change in FIM™. The relationship between age and FIM™ scores was not surprising, given that the association between age and disability has been well established (15, 21). Given the significant, inverse association between admission and discharge FIM™ scores and time to rehabilitation and the relationship between age and FIM™ scores, one might have anticipated an association

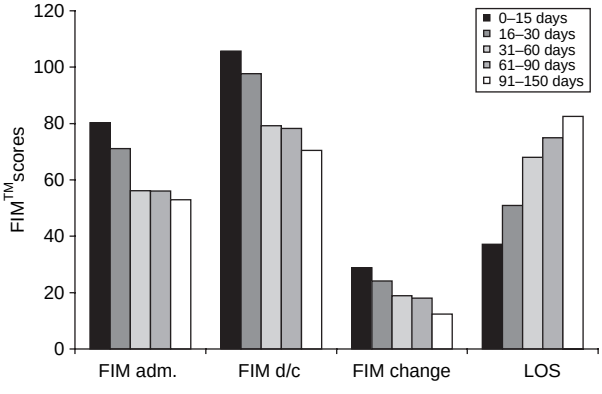

Fig. 2. Admission and Discharge FIM™ scores, change in FIM™ and length of stay for groups admitted to rehabilitation 0–15, 16–30, 31–60, 61–90 and 91–150 days following first-ever stroke.

Table III. *Comparison of age-adjusted means between admission subgroups for FIM™ scores and length of stay*

	0–15 days; $n=168$	16–30 days; $n=115$	p (0–15 days vs 16–30 days)	31–60 days; $n=100$	p (16–30 days vs 31–60 days)	61–90 days; $n=31$	p (31–60 days vs 61–90 days)	91–150 days; $n=21$	p (61–90 days vs 91–150 days)	p (31–60 days vs 91–150 days)
Admission FIM™	80.33	71.12	<0.01	56.2	<0.01	56.06	0.98	52.91	0.63	0.55
Discharge FIM™	105.66	94.72	<0.01	79.22	<0.01	78.3	0.83	70.46	0.19	0.08
Adj. FIM™ change*	28.78	24.18	<0.01	18.86	<0.01	18.02	0.77	12.34	0.15	0.05
Length of stay**	37.11	50.96	<0.01	68.01	<0.01	74.97	0.33	82.57	0.44	0.08

* FIM™ change adjusted for admission FIM™ scores.
** Length of stay was not adjusted for age.

between age and time to rehabilitation admission such that younger patients were admitted earlier with better results; however, this was not the case. Early and delayed admission patients did not differ with age and no association between age and TRA was identified.

The finding that patients admitted later to rehabilitation tend to have lower FIM™ admission and discharge scores was not surprising. Several recent reports have reported associations between increased intervals from stroke to rehabilitation and lower disability scores both at admission and discharge from rehabilitation (16, 17). The increased LOS associated with more severely affected, delayed admission group has also been reported previously (16, 17).

According to the present analysis, patients who were admitted to a specific stroke rehabilitation program within 30 days of the stroke event had higher admission FIM™ and discharge FIM™ scores than those admitted after 30 days. They also had shorter LOS and, therefore, higher FIM™ efficiency scores. Both groups experienced a positive change over the duration of rehabilitation admission and, at first glance, the amount of change shown by the earlier admission group did not appear to be significantly different from the amount of change experienced by patients who were admitted later. However, when functional ability at discharge was examined adjusting for the severity of functional deficit at admission, it became apparent that patients admitted earlier experienced greater functional improvement.

Further subgroup analysis demonstrated that the choice of 30 days, as a point in time around which to classify patients as having early as opposed to delayed admission to rehabilitation, was meaningful. Significant differences in FIM™ admission and discharge score, FIM™ change and LOS were identified between early admission groups and the group of patients admitted from 31–60 days post-stroke. The most dramatic group differences were identified between 16–30 days and 31–60 days post-stroke. Comparisons after 60 days demonstrated no further significant change, although identified trends suggest that from 31 days through 150 days, discharge FIM™ and FIM™ change continue to decrease, albeit more slowly, while LOS increases.

The finding that earlier admission to rehabilitation is associated with greater functional gains, regardless of initial functional deficit, provides support for the model derived from animal studies as reported by Biernaskie et al. (4) and is, in turn, supported by the results of previous clinical studies. Rossi et al. (17) reported that longer times from stroke onset to rehabilitation were associated with longer lengths of stay, lower admission and discharge FIM™ scores and reduced change in FIM™ scores. More recently, Paolucci et al. (13) reported that patients involved in early stroke-specific rehabilitation experienced greater improvement in functional activities (measured on the Barthel Index) than patients whose admission to rehabilitation was delayed for more than 20 days. Patients with greater functional deficits and delayed admission to rehabilitation have the poorest outcomes at discharge and report ongoing

difficulties in terms of quality of life 6 months after the stroke event (15, 16).

Study limitations

This study included patient data from a single, specialized stroke rehabilitation program in Southwestern Ontario, Canada. While this may raise concerns with regard to the generalizability of results, the main study findings are well supported within the literature on stroke rehabilitation. Nonetheless, the present study is limited in that it is a retrospective review of patient data and cannot effectively identify potential causes for delay in admission to rehabilitation following stroke. The effects of neurological impairment and medical status (including co-morbid conditions and acute medical complications) were not included in our analyses due to lack of sufficient data with regard to these variables. No information was available from the patient's acute admission for the stroke event. Additionally, questions with regard to differential effects of time to rehabilitation on the various dimensions of the FIM™ (i.e. motor FIM™ vs cognitive FIM™) could not be addressed as available data included only total FIM™ scores. Given that the reliability and responsiveness of the cognitive subscale is lower than that of the total scale and the contribution of the cognitive FIM™ items to the total FIM™ scale is questionable (22–24), examination of the effect of time to rehabilitation on cognitive outcomes might be examined more effectively by using a more reliable assessment tool specific to those outcomes.

In conclusion, while patients experiencing a delay in admission to rehabilitation following first-ever, unilateral stroke can achieve substantial functional improvements over the course of their rehabilitation admission, the present study demonstrates that these gains take significantly longer to achieve and are inferior to those achieved by patients admitted to rehabilitation earlier.

Despite the limitations associated with the present study, it reinforces the importance of early admission to rehabilitation following the onset of first-ever stroke and the need for closer examination of the characteristics of patients referred for early vs later admission to stroke rehabilitation.

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