Motor Impairment as a Predictor of Functional Recovery and Guide to Rehabilitation Treatment After Stroke
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Objective: This study tests three hypotheses relevant for the efficient use of rehabilitation services after stroke: (a) the severity of initial motor impairment after stroke predicts discharge motor impairment and self-care mobility scores; (b) identification of those unlikely to show improvement in motor impairment can focus rehabilitation efforts on use of compensatory techniques and assist devices; and (c) improvement in self-care mobility scores without change in motor impairment, balance, or cognition is a quantitative estimate of the value of teaching compensatory techniques and use of assist devices. Methods: We studied 171 sequential patients previously independent in the community who were admitted for inpatient rehabilitation within 17 ± 12 SD days of an initial, unilateral, hemispheric, ischemic stroke. Impairment was assessed using the Fugl-Meyer upper limb motor (ULM), lower limb motor (LLM), and upper plus lower limb total motor (TM) subscores. Disability was assessed using the Functional Independence Measure (FIM), FIM self-care (FIMS), FIM mobility (FIMM), and FIM self-care plus FIM mobility (FIMSM) subscores. Spearman correlation coefficients tested strength of association between dependent and independent variables, stepwise linear regression tested the effects of clinically relevant co-variables, and positive and negative predictive values (PPV, NPV) assessed the clinical relevance of outcome-prediction models. Results: The highest correlations observed were between admission TM scores and the following discharge scores: TM (R = 0.92; p < 0.01), ULM (R = 0.91; p < 0.01), LLM (R = 0.82; p < 0.01), FIMSM (R = 0.67; p < 0.01), FIMM (R = 0.67; p < 0.001), FIM (R = 0.58; p < 0.0001). An admission TM score in the lowest quartile had a PPV of 0.74 for a discharge ULM score in the lowest quartile. An admission TM score in the highest quartile had a PPV of 0.86 for a discharge ULM score in the highest quartile. Similar but weaker PPVs were seen for admission TM scores and discharge LLM scores. Patients without significant change in TM scores (≤2 points) had a 17 ± 9 SD improvement in FIMSM scores. Conclusions: Admission motor impairment scores (a) predict discharge impairment and activities of daily living mobility functional outcome; and (b) guide treatment toward improving motor impairment versus use of compensatory techniques and assistive devices. The use of compensatory techniques and assistive devices, without change in motor impairment, is associated with a 17 ± 9 SD improvement in FIMSM score. Key Words: Stroke—Motor recovery—Rehabilitation—Outcome.
hemi-sensory loss (5,6), hemispatial visual deficits or neglect (2,4,6–8), cognitive deficits (2,8), urinary incontinence (9), interval from stroke to rehabilitation (2,10), and postural balance (5,11–13) also are important.

The current study applies sophisticated predictive modeling techniques to study relations between initial motor impairment and discharge motor and functional recovery. Upper limb motor impairment, wrist and hand movement, and the degree of weakness at the time of admission to rehabilitation have all been shown to predict final disability (5,14–17). The amount of upper limb strength observed as early as 1 week after stroke predicts the likelihood of future functional use of the hand (18). If there is no measurable hand grip at 3–4 weeks after the stroke, it is unlikely that any useful hand function will be present at 3–6 months after stroke (19,20). Such generalizations are warranted based on the references cited. We have been unable to find more specific assessments of the linkage between the severity of initial motor impairment and subsequent motor and functional recovery based on linear regression modeling techniques. Previous authors also have not quoted positive and negative predictive statistics for their initial motor impairment scores. Such parameters are necessary for current evidence-based rehabilitation care decisions.

There is general consensus that the presence of significant residual motor function on the affected side is associated with faster and more pronounced functional improvement. Mild weakness allows functional improvement with the affected hand. Severe weakness requires that the patient learn one-handed self-care techniques. Nakayama et al. (21) showed that independence for upper-limb–related activities was achieved by 79% of the patients with mild upper extremity weakness, but by only 18% of patients with severe deficits. The latter group had to rely on the unaffected hand only. The unaffected hand is often weak and dyspraxic compared with that of age-matched controls (10,22–24), especially in patients with more significant hemiparesis.

Some investigators have suggested that change in motor impairment is often minimal and that it is poorly correlated with change in disability (3,9,10,25). They advocated functionally oriented rehabilitation programs for patients with moderate to severe weakness, stressing the use of compensatory activity-of-daily-living (ADL) techniques, walking assistive devices, and braces.

There is no consensus in the rehabilitation literature about when to focus on recovery of motor impairment and when to teach the use of compensatory ADL–mobility techniques and assist devices.

This observational study was designed to use linear regression modeling and predictive value statistics to test three hypotheses relevant for the efficient use of rehabilitation services after stroke: (a) the severity of initial motor impairment after stroke predicts discharge motor impairment and self-care mobility scores; (b) identification of those unlikely to show improvement in motor impairment can focus rehabilitation efforts on use of compensatory techniques and assist devices; (c) improvement in self-care mobility scores without change in motor impairment, balance, or cognition is a quantitative estimate of the value of teaching compensatory techniques and use of assist devices.

Methods

We analyzed prospectively collected data on all patients (224) admitted over a 2-year period, with a first, single, unilateral, hemispheric, ischemic stroke. Of the initially selected patients, 53 were excluded for one of the following reasons: incomplete Functional Independence Measure (FIM) and Fugl-Meyer admission and discharge scores, history of preexisting musculoskeletal or neurologic problem interfering with independent function, and date of stroke >90 days before admission to our rehabilitation unit. The remaining 171 patients compose our study group.

Motor impairment was assessed with the Fugl-Meyer motor scale and was scored by the patient’s physical therapist, unaware of this study’s test hypothesis, at the time of rehabilitation hospital admission and discharge (26). The Fugl-Meyer motor impairment scale has been previously standardized and is widely used. It is composed of five subscores: (a) motor assessment of upper limb, (b) motor assessment of lower limb, (c) balance, (d) sensory status, and (e) joint pain on passive motion. In studying motor impairment, we recorded the upper and lower limb motor-assessment subscores. We did not include scores for deep tendon reflexes and coordination, as these components of the Fugl-Meyer assessment are not of primary interest in studying volitional movement in patients with isolated hemispheric strokes. Throughout this study, the maximum possible upper limb Fugl-Meyer motor score is, therefore, 58, and the maximum possible lower limb motor score is 26. These will be referred to as the upper-limb motor (ULM) and lower-limb motor (LLM) scores, respectively. The sum of the ULM and LLM scores, ranging from 0 to 84, was called the total motor score (TM).

Disability was assessed with the FIM and was scored by members of the patient’s rehabilitation care team, unaware of this study’s test hypothesis, at the time of rehabilitation hospital admission and discharge (27). The FIM is a standardized assessment of disability. It assesses 18 items: feeding, upper body dressing, lower body dress-
ing, grooming, bathing, toileting, bowel and bladder control, bed/chair-toilet-tub transfer skills, walking, stair climbing, expressive-receptive language function, memory, social skills, and problem-solving ability. Each item is graded using a 7-point scale, with 1, total assistance, and 7, complete independence without use of compensatory techniques or assistive devices. Total scores ranged from 18 to 126.

Because motor impairment of the upper limb is expected to affect self-care function preferentially, we focused on the self-care items of the FIM (FIMS), which include eating, grooming, bathing, dressing upper and lower body, and toileting (i.e., managing toilet items and clothing). FIMS scores range from 6 (totally dependent) to 42 (independent without modifications).

Because motor impairment of the lower extremity specifically affects locomotion and transfer function, we focused on mobility items of the FIM (FIMM): ability to transfer (to and from bed/chair/wheelchair, toilet, and tub/shower), walk or propel a wheelchair, and climb stairs. FIMM scores range from 5 (totally dependent) to 35 (independent without modifications).

The sum of scores for FIMS and FIMM was called FIM self-care plus mobility score (FIMSM), ranging from 11 to 77.

We used the term FIM cognition score (range, 5-35) to designate the summation of the following five FIM items: language comprehension, language expression, social interaction, problem solving, and memory. The FIM cognition score and the Folstein Mini-Mental Status Exam (MMSE) (28) were used to test the influence of cognitive status on motor recovery.

To test the effect of the extent of neurologic impairment on motor and functional recovery, patients were grouped according to the presence or absence of hemiparesis, hemisensory deficits, and hemianopic visual deficits as follows: patients with hemiparetic motor deficits only (M); hemiparetic motor plus hemisensory deficit or hemianopic visual deficits (MS/MV); motor plus hemisensory plus hemianopic visual deficits (MSV); or other combinations of deficits (O) (6). The presence of visual neglect or hemianopsia was determined by confrontation testing. The presence of a somatic sensory deficit was assessed using a modification of the previously standardized digit localization test (29). The patient was asked to locate his or her affected index finger by touching it with the unaffected index finger (with eyes occluded) as the affected hand was moved randomly by the examiner into all four spatial quadrants. A reproducible error of $\geq 15.2$ cm indicated a significant somatosensory deficit.

To serve as a reference for the reader, Table 1 lists the multiple abbreviations referred to earlier, and describes their meaning.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>ULM</td>
<td>Upper limb motor component of the Fugl-Meyer Scale (see text)</td>
</tr>
<tr>
<td>LLM</td>
<td>Lower limb motor component of the Fugl-Meyer Scale (see text)</td>
</tr>
<tr>
<td>TM</td>
<td>Total upper limb motor + lower limb motor component of the Fugl-Meyer Scale</td>
</tr>
<tr>
<td>FIM</td>
<td>Functional Independence Measure</td>
</tr>
<tr>
<td>FIMS</td>
<td>Functional Independence Measure self-care items (see text)</td>
</tr>
<tr>
<td>FIMM</td>
<td>Functional Independence Measure mobility items (see text)</td>
</tr>
<tr>
<td>FIMSM</td>
<td>Functional Independence Measure self-care + mobility items (see text)</td>
</tr>
<tr>
<td>MMSE</td>
<td>Mini Mental State Examination</td>
</tr>
<tr>
<td>M</td>
<td>Patients with motor impairment</td>
</tr>
<tr>
<td>MS/MV</td>
<td>Patients with motor plus hemisensory or hemianopic visual impairments</td>
</tr>
<tr>
<td>MSV</td>
<td>Patients with motor plus hemisensory plus hemianopic visual impairments</td>
</tr>
<tr>
<td>O</td>
<td>Patients with other combination of neurologic impairments</td>
</tr>
</tbody>
</table>

The effect of lesion location on motor recovery was assessed by categorizing computerized tomographic (CT) or magnetic resonance (MR) images as follows: infarct confined to cortex or subcortical white matter, but not extending into the centrum semiovale (cortical); infarct sparing the cortex but affecting centrum semiovale, basal ganglia, internal capsule or thalamus (subcortical); and infarct affecting both cortical and subcortical structures (mixed cortical–subcortical).

Rehabilitation treatments were provided by therapists and nursing personnel on a designated stroke-rehabilitation unit. Patients received 1.5 h of physical therapy, 1.5 h of occupational therapy, and an additional 1 h of speech or dysphagia therapy if indicated. Nursing care was supervised by nurses certified in neurologic rehabilitation. Rehabilitation treatment approaches were not controlled by the study protocol, and were determined by each therapist based on the patient's empiric response to current stroke-rehabilitation techniques: neurodevelopmental technique, motor learning theory, proprioceptive neuromuscular facilitation technique, and functionally oriented use of adaptation strategies.

Fugl-Meyer motor impairment scores and self-care mobility FIM scores are nonlinear and nonparametric, with floor and ceiling effects. For this reason, nonparametric Spearman rank–order correlation coefficients were
used to assess relations between initial motor impairment scores and (a) discharge motor impairment scores, (b) discharge FIM, FIMS, FIMM, and FIMSM functional scores, and (c) change in Fugl-Meyer and change in FIM measures from admission to discharge.

Linear regression analysis assessed the relation between change in motor impairment and change in FIMSM function from admission to discharge. Stepwise linear regression analysis assessed the effects of clinically relevant covariables on the relation between initial motor impairment and discharge impairment and functional scores.

Outcome prediction models were based on admission TM scores ranked by quartiles. It was hypothesized that those in the lowest and highest quartiles would show the lowest and highest discharge motor impairment scores, respectively. Positive and negative predictive values (PPVs, NPVs), sensitivity, and specificity statistics were computed to assess the clinical utility of predictive models on motor impairment and functional outcome.

To estimate the effect of teaching compensatory techniques and use of assist devices, we analyzed the change in FIMSM scores for patients without significant change in motor impairment (change in TM, ≤2). Because it is possible that improvement in FIMSM might be explained by improvement in nonmotor covariables, we also assessed change in Fugl-Meyer balance scores and change in FIM cognition scores as potential covariables within this subset of patients.

Nonparametric Mann–Whitney U or Kruskal–Wallis statistics were used to test the effects of categoric variables such as gender, side of stroke, location of stroke (cortical, subcortical, or mixed), handedness, presence or absence of hemisensory loss, presence or absence of visual field defects, and interval from stroke onset to rehabilitation hospital admission (<2 weeks, 2–4 weeks, >4 weeks) on discharge impairment and functional scores.

Results were considered statistically significant if the two-tailed probability statistic was <0.05. Mean values ± SD are used to describe variance throughout the text and in the accompanying tables.


Results

The demographic covariables for the study population are shown in Table 2. The mean age and sex ratio are as expected for stroke patients, and the distribution of handedness follows that of the general population. Both cerebral hemispheres are similarly affected. All categories of hemispheric stroke (cortical, subcortical, mixed) are adequately represented.

Table 3 shows data testing the relation between relevant clinical parameters scored at the time of admission, and motor recovery scored at the time of acute rehabilitation hospital discharge. Gender, handedness, side of stroke were not associated with significantly different discharge motor impairment scores. Discharge motor impairment did vary significantly across the three stroke lesion location groups (cortical, subcortical, mixed cortical–subcortical) and the four neurologic impairment groups (M, MS/MV, MSV, O) as shown.

Table 4 shows Spearman rank–order correlations (rho) used to assess relations between ordinal nonparametric admission covariables and discharge motor impairment scores. Significant correlations were observed between UM, TM, FIMC, and discharge motor impairment scores as listed. Age and interval from stroke to rehabilitation-hospital admission were not significantly related to discharge motor impairment scores.

With stepwise linear regression analysis, the following covariables were entered to assess their effect on discharge UM scores: admission TM score, age, minimal state score, interval after stroke, and neurologic impairment categories (M, MS/MV, MSV, O). Only the admission TM score was retained, with other variables
Table 3. Discharge motor impairment scores categorized by patient demographic features

<table>
<thead>
<tr>
<th></th>
<th>ULM Score</th>
<th>LLM Score</th>
<th>TM Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (M/F)</td>
<td>29 ± 22/24 ± 22</td>
<td>16 ± 8/15 ± 8</td>
<td>45 ± 29/39 ± 28</td>
</tr>
<tr>
<td>Handedness</td>
<td>Right</td>
<td>Left</td>
<td>Ambidextrous</td>
</tr>
<tr>
<td></td>
<td>25 ± 22</td>
<td>37 ± 22</td>
<td>46 ± 15</td>
</tr>
<tr>
<td>Side of stroke (R/L)</td>
<td>27 ± 22/26 ± 23</td>
<td>16 ± 7/15 ± 8</td>
<td>43 ± 28/41 ± 29</td>
</tr>
<tr>
<td>Stroke location</td>
<td>Cortical</td>
<td>Subcortical</td>
<td>Mixed cortical/subcortical</td>
</tr>
<tr>
<td></td>
<td>32 ± 20</td>
<td>30 ± 22</td>
<td>21 ± 22</td>
</tr>
<tr>
<td>Neurologic Impairments</td>
<td>M</td>
<td>MS/MV</td>
<td>MSV</td>
</tr>
<tr>
<td></td>
<td>24 ± 17</td>
<td>21 ± 19</td>
<td>9 ± 15</td>
</tr>
<tr>
<td></td>
<td>17 ± 5</td>
<td>15 ± 7</td>
<td>10 ± 7</td>
</tr>
<tr>
<td></td>
<td>78 ± 3</td>
<td>36 ± 25</td>
<td>19 ± 21</td>
</tr>
</tbody>
</table>

ULM, upper limb motor score; LLM, lower limb motor score; TM, upper limb plus lower limb total motor scores; M, motor impairment only; MS/MV, motor-hemisensory or motor-hemianopic-visual deficit; MSV, motor plus hemisensory plus hemianopic-visual deficit; O, other combination of deficits.

Motors scores are listed as mean ± SD.

Table 4. Spearman correlation coefficients (Rho) for admission parameters versus discharge motor impairment scores

<table>
<thead>
<tr>
<th></th>
<th>ULM Score</th>
<th>LLM Score</th>
<th>TM Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Days post stroke</td>
<td>0.01</td>
<td>0.07</td>
<td>0.02</td>
</tr>
<tr>
<td>FIMC</td>
<td>0.36b</td>
<td>0.30b</td>
<td>0.35b</td>
</tr>
<tr>
<td>ULM score</td>
<td>0.91b</td>
<td>0.74b</td>
<td>0.90b</td>
</tr>
<tr>
<td>LLM score</td>
<td>0.77b</td>
<td>0.84b</td>
<td>0.82b</td>
</tr>
<tr>
<td>TM score</td>
<td>0.91b</td>
<td>0.82b</td>
<td>0.92b</td>
</tr>
</tbody>
</table>

Abbreviations as for Table 2.

Table 3 and its sensitivity and specificity for defining an outcome event of clinical importance. Table 5 lists these statistics for the following three outcome groups: (a) an admission TM score in the lowest quartile (TM ≤5 of 84) as a predictor of a discharge ULM and/or LLM score in the lowest quartile (≤3 of 58 and ≤10 of 26, respectively); (b) an admission TM score in the intermediate interquartile range (5 of 84 < TM < 61 of 84 ) as a predictor of a discharge ULM and/or LLM score in the intermediate interquartile range (3 of 58 < ULM < 53 of 58, and 10 of 26 < LLM < 23 of 26, respectively); (c) an admission TM score in the highest quartile (TM ≥61 of 84) as a predictor of discharge ULM and/or LLM scores in the highest quartile (≥53 of 58 and ≥23 of 26, respectively).

Linear regression analysis showed that for every 10-point change in ULM score from admission to discharge, there was a 1.5-point change in discharge FIMS score (p < 0.0001). Similarly, for every 10-point increase in LLM score, there was a 1.9-point increase in discharge FIMM score (p < 0.0001). For every 10-point increase in TM, there was a 3-point increase in discharge FIMSM (p < 0.0001).

For patients without significant change in TM score (ΔTM, ≤2 ), there was a mean change of 17 ± 9 SD in FIMSM score. There was no correlation between non-motor covariables such as Fugl-Meyer balance score or...
Figure 1. Linear regression plot of discharge upper limb motor (ULM) scores versus admission upper limb plus lower limb total motor (TM) scores.

Figure 2. Linear regression plot of discharge lower limb total motor (LLM) scores versus admission upper limb plus lower limb total motor (TM) scores.

Discussion

Our data show that both the severity of initial motor impairment and the change in motor impairment are significantly related to functional recovery after stroke. The data presented in Table 5 can be used to support improvement in motor impairment as the primary therapeutic goal for patients with admission TM scores ≥ 61 of 84. Those with admission TM scores of 6 to 60 will show variable improvement in motor impairment, allowing some functional use of the affected upper limb, but are still likely to benefit from the use of compensatory techniques and assistive devices. Those with admission TM scores ≤ 5 of 84 will show minimal change in ULM scores and will need to rely on learning compensatory techniques and use of assistive devices to improve FIMS function. For such patients, compensatory strategies should be instituted early in the course of rehabilitation.

The data presented in Table 5 also allow estimation of discharge LLM impairment scores based on admission TM scores. These data support improvement in LLM impairment as the primary therapeutic goal for patients with admission TM scores ≥ 61 of 84. Those with admission TM scores of 6 to 60 will show variable improvement in their LLM impairment scores, but will not achieve independence with FIMS function by discharge. They will require setup or minimal assistance to perform at least one of the FIMM tasks. They will achieve this goal both by

<table>
<thead>
<tr>
<th>Admission Score</th>
<th>Discharge Score</th>
<th>PPV</th>
<th>NPV</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM ≤ 5/84</td>
<td>ULM ≤ 3/58</td>
<td>0.74</td>
<td>0.88</td>
<td>0.67</td>
<td>0.91</td>
</tr>
<tr>
<td>5/84 &lt; TM &lt; 61/84</td>
<td>3/58 &lt; ULM &lt; 53/58</td>
<td>0.77</td>
<td>0.80</td>
<td>0.80</td>
<td>0.77</td>
</tr>
<tr>
<td>TM ≥ 61/84</td>
<td>ULM ≥ 53/58</td>
<td>0.86</td>
<td>0.96</td>
<td>0.88</td>
<td>0.95</td>
</tr>
<tr>
<td>TM ≤ 5/84</td>
<td>LLM ≤ 10/26</td>
<td>0.83</td>
<td>0.91</td>
<td>0.74</td>
<td>0.94</td>
</tr>
<tr>
<td>5/84 &lt; TM &lt; 61/84</td>
<td>10/26 &lt; LLM &lt; 23/26</td>
<td>0.72</td>
<td>0.78</td>
<td>0.77</td>
<td>0.73</td>
</tr>
<tr>
<td>TM ≥ 61/84</td>
<td>LLM ≥ 23/26</td>
<td>0.70</td>
<td>0.90</td>
<td>0.70</td>
<td>0.90</td>
</tr>
</tbody>
</table>

TM, Total Motor score; ULM, Upper Limb Motor score; LLM, Lower Limb Motor score.
showing improvement in their LLM scores, and by use of compensatory techniques and of assistive devices. Their mobility function may be enhanced by treatments focused on enhancing motor recovery. Those with admission TM scores ≤5 of 84 will not show significant improvement in their LLM impairment score, and must depend on learning compensatory techniques and using assistive devices to improve FIMM function. Our data would argue for the early use of a walking assistive device and bracing in such patients.

Patients without significant change in TM score (≤2 points) had a 17 ± 9-point SD increase in their FIMSM scores. Those with more marked improvement in TM score (≥16 points) showed a 24 ± 8-point increase in FIMSM score. Linear regression analysis showed that for every 10-point change in ULM score from admission to discharge, there was a 1.5-point change in discharge FIMS score (p < 0.0001). Similarly, for every 10-point increase in LLM score, there was a 1.9-point increase in discharge FIMM score (p < 0.0001). For every 10-point increase in TM, there was a 3-point increase in discharge FIMSM (p < 0.0001). The correlation between change in motor impairment and change in disability was greater for the upper limb than for the lower limb. Motor impairment of the upper limb is difficult to circumvent by use of compensatory ADL techniques or assistive devices. Leg weakness is easily managed using a brace and cane.

Improvement in FIMSM without significant change in TM score implies that the functional improvement was due to improvement in nonmotor impairments (balance, cognition, perception), use of compensatory techniques, or use of assistive devices. Further analysis showed that for patients without significant change in TM score, there was no correlation between change in FIMSM and change in balance, as measured by the Fugl-Meyer balance scale, or change in cognitive status, as measured by the FIM cognition subscore. This implies that teaching compensatory techniques and use of assistive devices alone can improve the FIMSM score by 17 ± 9 points. To the extent that rehabilitation is able to improve motor impairment, functional gains should be further enhanced, with less need for compensatory techniques and assistive devices. Rehabilitation goals based on improving motor impairment and goals based on using compensatory strategies are not mutually exclusive. Our data simply allow the clinician to allocate treatment time based on which patients are most likely to show improvement in motor impairment.

Cognitive status on admission significantly correlated with change in TM impairment scores in our study population. Admission MMSE scores (largely dependent on verbal communication) and FIM cognition scores (less dependent on verbal communication) were higher for patients with the greatest change in TM scores. It is not clear how cognition influences motor recovery. This may be a factitious finding related to better understanding and performance of the Fugl-Meyer motor tasks. Patients with higher cognitive scores may, however, participate more actively in therapy, with better motor outcome.

Age was not a significant factor influencing motor recovery. Others have shown that it may interfere with functional outcome (2-4), probably because older individuals tend to have worse strokes with greater motor impairment (3). Previous studies indicated that older patients show improvement and retention of functional gains comparable to those of younger patients (30,31).

Our data did not show a significant influence of handedness on motor improvement. The small number of left-handed and ambidextrous patients in our study population precludes further comment.

Other studies have shown that patients transferred to rehabilitation units >30 days after stroke are more likely to have poor motor recovery (8,32). In our study population, the time from stroke to admission to our unit did not affect the magnitude of change in motor impairment during rehabilitation. Only 12% of our patients were admitted >30 days after stroke. To see if these patients had less motor recovery during rehabilitation, we divided our patient sample into three groups according to the interval from stroke to rehabilitation hospital admission (<2 weeks, 2-4 weeks, >4 weeks). The relation between interval from stroke to rehabilitation hospital admission and change in score was still not significant (Kruskal-Wallis test).

Length of rehabilitation hospital stay did not significantly correlate with motor recovery. Length of stay depends greatly on the patient's community support and has been shown to be an unreliable marker for the patient's self-care and mobility function. Jimenez and Morgan (3) found that 44% of patients independent with self-care were discharged to other institutions, whereas 35% of those who were dependent were discharged home. Discharge disposition was a function of how much support families were able to provide.

Unlike those of other studies (7,33), our data do not show a relation between side of stroke and degree of motor improvement for either the upper or the lower limbs. Some authors commented that patients with right hemisphere lesions have poorer functional outcome because of anosognosia associated with right parietal lesions. Others have found poorer functional recovery for patients with left hemisphere stroke and have attributed this to dyspraxia of the ipsilateral left hand and aphasia seen with left frontotemporal lesions.

Location of stroke within the hemisphere (cortical, subcortical, mixed cortical–subcortical) did affect final motor scores. Highest discharge motor scores were seen for
those with isolated cortical strokes. This may reflect the
ability of premotor and supplemental motor areas to com-
penate for primary motor cortex lesions. The lowest dis-
charge motor scores were seen in patients with mixed corti-
cal–subcortical lesions. This probably reflects larger stroke
volume rather than a specific effect of lesion location.

Conclusions

In summary, we used newer statistical techniques to
validate and further quantify previously reported relations
between the severity of initial motor impairment and
motor and functional outcome after stroke. Our data
show that the highest correlations are between admission
TM scores and the following discharge scores: TM (R =
0.92; p < 0.01), ULM (R = 0.91; p < 0.01), LLM (R =
0.82; p < 0.01), FIMSM (R = 0.67; p < 0.01), FIMM
(R = 0.67; p < 0.001), and FIM (R = 0.58; p < 0.0001).
With predictive value statistics, we found that an ad-
mission TM score in the lowest quartile had a PPV of
0.74 for a discharge ULM score in the lowest quartile.
An admission TM score in the highest quartile had a PPV
of 0.86 for a discharge ULM score in the highest quartile.
Linear regression analysis allowed quantification of rela-
tions between change in ULM impairment and im-
provement in upper limb-based self-care function, and
change in LLM impairment and improvement in FIMM
mobility function. In the subset of patients without sig-
ificant change in TM scores (≤ 2 points), there was a
17 ± 9 SD improvement in FIMSM scores, which, we
suggest, is an indirect estimation of the value of teach-
ing compensatory rehabilitation techniques.

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References

1. Good DC. Treatment strategies for enhancing motor recovery in
2. Feigenson JS, McCarthy ML, Greenberg SD, et al. Factors influ-
encing outcome and length of stay in a stroke rehabilitation unit.
3. Jimenez J, Morgan PP. Predicting improvement in stroke patients
from stroke and factors influencing outcome. Stroke 1984;15:
1039–44.
5. Prescott RJ, Garnsway WM, Akhtar AJ. Predicting functional out-
come following acute stroke using a standard clinical examina-
6. Reding MJ, Potes E. Rehabilitation outcome following initial uni-
lateral hemispheric stroke: life table analysis approach. Stroke
and recovery from hemiplegia: a follow-up study. Brain 1982;105:
543–52.
impairments in acute stroke patients: effects on self-care ability.
11. Bohannon RW. Gait performance of hemiparetic stroke patients:
12. Bohannon RW, Walsh S. Association of paretic lower extremity
muscle strength and standing balance with stair-climbing ability
13. Bohannon RW. Determinants of transfer capacity in patients with
tion in studies of chronic disability. Rheumatol Rehabil 1980;19:
83–90.
15. Olsen TS. Arm and leg paresis as outcome predictors in stroke re-
covery after stroke: the place of early shoulder and hand move-
17. Sarabia B, Mokler PJ, Hoppe CM. Discharge destination and
motor function outcome in severe stroke as measured by the Func-
tional Independence Measure/Function-Related Group classifi-
493–500.
an evaluation of grip strength as a measure of recovery and
a prognostic indicator. J Neurol Neurosurg Psychiatry 1989;52:
1267–72.
measurement and recovery over the first three months. J Neurol
upper extremity function in stroke patients: the Copenhagen
22. Bohannon RW, Andrews AW. Limb muscle strength is impaired
brain damage on contralateral and ipsilateral upper extremity
tion test: performance of the uninvolved hand in hemiplegia and
of right-handed, right and left hemiplegic persons. Arch Phys Med
25. Olsen TS. Motor impairment, functional improvement, and goals
for rehabilitation following stroke. [Abstract]. Neurology 1989;39
(suppl 1):146.


