Effect of Age on Functional Outcomes After Stroke Rehabilitation

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Background and Purpose—The incidence of stroke and the demand for stroke rehabilitation services continues to increase, and it has been proposed that age be used in combination with severity of stroke to determine type of rehabilitation. It is important to identify the impact of age on functional outcome before embracing a system that limits access to rehabilitation on the basis of age.

Methods—This prospective study includes all patients admitted to an inpatient stroke rehabilitation program for 6 years. Demographic and clinical data were extracted by means of chart review. Functional status at admission and discharge was evaluated by means of the FIM™ instrument. Multivariate regression techniques were used to assess the relationships between age, functional outcome, and other predictive variables. Particular attention was paid to the $r^2$ values to assess the amount of variation accounted for by the predictors.

Results—Age alone was a significant predictor of total FIM score and Motor FIM score at discharge, but not FIM change. For both total FIM score and Motor FIM score at discharge, age alone accounted for only 3% of the variation in outcome. For all the models, age explained at the most 1.3% of the variation in functional outcome after adjustment for other factors, such as admission FIM score.

Conclusions—The small amount of variation that can be explained by age alone and the questionable clinical relevance of such a small effect suggest that there is no justification to deny patients access to rehabilitation solely because of advanced age. (Stroke. 2002;33:179-185.)

Key Words: aging ■ disability evaluation ■ outcome ■ rehabilitation ■ stroke

The incidence of stroke is increasing once again, primarily in relation to the aging population.1,2 Unfortunately, acute interventions, such as tissue plasminogen activator, have not had a large impact on stroke-related disability, primarily because this treatment can be offered to only a minority of ischemic stroke survivors. Subsequently, the demand for stroke rehabilitation services continues to increase,3 and there is a growing need to optimize both the effectiveness and the efficiency of these limited resources. Age has been identified as a significant prognostic factor for recovery in a number of studies.4–7 Jongbloed5 has identified 14 studies that found age to be negatively correlated with function at or after discharge and 4 that did not find such a relationship. Such information has led to the suggestion that age be used in combination with severity of stroke to determine whether a patient should receive intensive interdisciplinary stroke rehabilitation, geriatric reactivation, or a “slower-stream” rehabilitation unit.8 In view of the strong evidence supporting the effectiveness of intensive stroke rehabilitation units, it is important to clearly identify the impact of age on functional outcome before embracing a system that denies access to these units based on a person’s age.

Numerous studies have reported associations between age and poor outcome. The predictive value of age in the literature, however, depends on evaluation of the outcome. The negative impact of age on functional outcome is most apparent when functional status at discharge is being assessed. Conversely, when change of function is assessed, age tends not to influence outcome negatively.4 It is difficult to distinguish between age itself and such age-associated factors as comorbidities that have a negative influence on functional outcome, including ischemic heart disease, hypertension, diabetes, and altered cognitive capacity.5,9–11 In addition, several articles have clearly demonstrated the definite benefits of intensive stroke rehabilitation programs in maximizing functional recovery regardless of age and without increased therapy resources.2,12,13

Another important measure of outcome is patient discharge disposition after rehabilitation. Although it has been demonstrated that elderly stroke survivors are more likely to need long-term care in a nursing home setting,14,15 this fact alone...
should not be interpreted to suggest that those individuals do not improve functionally. Clearly, such additional factors as cognitive status, medical comorbidities, and the lack of a supportive caregiver have a significant impact on discharge disposition after rehabilitation.

Because of contradictory evidence regarding the influence of age on functional recovery after stroke, the purpose of this article is to discern the true effect of age from other measurable factors.

**Methods**

This prospective study includes all patients admitted to an inpatient stroke rehabilitation program in a Canadian rehabilitation hospital between January 1994 and December 1999. The hospital serves a population of ~300,000 people from 3 counties in southeastern Ontario with a rural population of ~45%. The inpatient stroke rehabilitation program is composed of an interdisciplinary team, including a physiatrist, several nurses, physiotherapists, occupational therapists, speech therapists, a social worker, a clinical psychologist, and a nutritionist. Over the 6 years of the study, the number of available beds has decreased from 18 to 15. Three of the 15 beds are dedicated to slow-paced rehabilitation, generally for patients with severe physical disability and no supportive caregiver. The remaining beds are used for stroke survivors who are expected to return to their home or a residential home after completing their inpatient rehabilitation.

Stroke was defined according to World Health Organization criteria of acute onset of neurological deficit lasting >24 hours, with no apparent cause other than cerebrovascular accident.17 The diagnosis of stroke was based on clinical assessment supported by CT scanning or MRI. Patients were referred to the unit by internists or neurologists in the regional tertiary acute care center or from the surrounding community hospitals by general practitioners. After a predischARGE physiatrist consultation to assess the patients’ medical and social situations, they were added to the waiting list for admission to the stroke unit, which is geographically separate from the tertiary acute care center. Admission criteria included medical stability, absence of severe cognitive impairment, and ability to participate in 2 hours of therapy per day. The usual daily treatment consists of 2 to 3 hours of therapy, based on individual needs and tolerance.

Data were initially collected for a total of 640 patients. Those who died (n=11), were admitted for rehabilitation after a recurrent stroke (n=33), had a tumor (n=11), or were found to be inappropriate shortly after admission because of noncompliance, confusion, or medical instability (n=24) were excluded from the analysis, however, for a sample size of 561 eligible patients. The data analyzed in this study are routinely collected at admission and at discharge as part of the total quality management process for the stroke rehabilitation program, so a separate ethics approval process was not required.

Functional status was evaluated by means of the Functional Independence Measure (FIM) instrument. FIM scores were recorded by each patient’s treating therapists and primary nurse within 48 hours of admission and discharge. FIM training began almost 2 years before the present study and consisted of a team learning process using the training manual and material.19 During the training years, team members also had interdisciplinary discussions on FIM scoring at the time of admission and at the time of discharge to reach consensus for any difficult items. Some evidence suggests that use of untrained but experienced raters may not be optimal, because their agreement with an expert rater has been shown to be low even when they agree reasonably well with each other. The untrained experienced raters cluster their answers close to the expert rating, however, with the expert simply rating more to the extreme of the scale in most cases. Moreover, an evaluation of 11 published studies reporting estimates of reliability for FIM scores reported acceptable reliability across a wide variety of settings, raters, and patients, and an excellent level of interrater reliability has also been demonstrated.22 The FIM has good internal consistency and better than average face validity, as well as good concurrent validity, predictive validity, and construct validity in a number of studies. Its validity has been demonstrated in a number of conditions, including stroke. FIM scores can be represented in 3 different ways, including a global score (full-scale), 2 domains (cognitive and motor), and 6 subscales, including self-care, mobility, locomotion, sphincter, social cognition, and communication. The first 2 outcomes we assessed included functional status at discharge (FIM total score) and change in functional outcome. Both were assessed, because the effect of age and factors associated with age may be different for functional status at discharge than for change in functional outcome. The third outcome measure was Motor FIM score at discharge, because this domain has been shown to be one of the strongest predictors of length of stay (LOS) and also improves much more than the executive functions of communication and cognition.

Patient demographics included age, sex, marital status, prestroke employment status, and residence. Clinical data included stroke type (embolic, thrombotic, or hemorrhagic), type of impairment (side of hemiparesis, sensory loss, hemianopia, dysphasia, dysphagia, inattention, impulsion, or impaired problem solving), and stroke risk factors. FIM scores at admission were also tested as predictors to control for baseline functional status. Complications of stroke were not included as potential predictors, because we wanted to identify predictors of functional outcome using data available at the time of admission to the rehabilitation unit.

The analysis was done in 3 stages. First, descriptive data were generated, and Pearson correlation coefficients were calculated for age and FIM score at admission (using the global score, then the 2 domain scores, then the 6 subscales of the FIM instrument). Second, we assessed the relationship between the 3 FIM score outcomes (FIM global score at discharge, change in FIM global score, and FIM motor score at discharge) and all variables other than age (eg, demographic and clinical data) to identify those that were significantly associated with the 3 outcomes. This was done by means of stepwise regression models, using 0.05 probability of entry and 0.1 probability of removal, allowing us to assess the R² for the 9 models before adding age as a predictor. Third, we developed the models used to differentiate the effect of age from the other factors. This was done in 3 steps, initially using age as the only predictor, then adding the FIM scores at admission, then adding the demographic and clinical data identified as significant in the second stage of the analysis. We report the regression coefficient and partial R² for age at each of the 3 steps, to identify the variation in outcome explained solely by age.

**Results**

**Stage One: Descriptive Analysis**

Table 1 presents the mean, median, SD, and range for age, days to rehabilitation, LOS at the rehabilitation facility, and the 3 representations of FIM scores at admission and discharge. Internal consistency reliability for the FIM full scale was excellent at admission (α=0.95) and at discharge (α=0.91). LOS is also presented in 10-year increments of age. There were small increases in the mean LOS as age increased, but the median LOS did not increase with age. Table 2 contains the frequencies and percentages for a number of patient characteristics and clinical characteristics, such as sex, living arrangements, and stroke type. The median age for this cohort was 72.7 years, and 32.8% of these patients were living alone.

The Pearson correlations (not shown in Table 2) between age and FIM score at admission were significant for the FIM full scale (r=-0.16, P<0.001) and for the motor (r=-0.14, P<0.001) and cognitive (r=-0.16, P<0.001) domains. The
relationship was also significant at P<0.001 for the self-care ($r=-0.16$), sphincter control ($r=-0.15$), and social cognition ($r=-0.17$) subscales. The mobility ($r=-0.09$) and communication ($r=-0.10$) subscales were significant at $P<0.05$. The final subscale, locomotion, was not significantly associated with age ($r=-0.05$, $P=0.23$).

Stage Two: Regression Analysis of Predictors Other Than Age

The predictive models (without age) are presented in Table 3. The 3 outcomes (discharge FIM full scale, change in FIM score, and discharge Motor FIM) are listed across the top of the table, and the predictors are listed in the column on the left. In addition to FIM at admission, the regression analyses identified only 6 demographic and clinical characteristics that were significantly associated with at least 1 of the 3 outcomes tested. These included female sex, hemorrhagic stroke, presence of dysphasia, impulsivity, impaired problem solving, and current smoking.

Nine models are represented in Table 3, because the models for each of the 3 outcomes were developed using 3 forms of admission FIM. For each outcome, we used the FIM full scale (global score), then the motor and cognitive domains, then the 6 subscales. Negative and positive symbols are used in Table 3 to indicate the direction of the relationship, and NS is used to indicate lack of significance. For example, for the first model in Table 3, the FIM full-scale score at admission, female sex, and hemorrhagic stroke had a positive association with discharge FIM scores, whereas impaired problem solving had a negative association with this outcome. Dysphasia, impulsivity, and smoking were significant in some of the other models but not in this model. Most of the variance in the models (55% to 59%) was explained by the FIM at admission, with the

| TABLE 1. Quantitative Characteristics of the Stroke Rehabilitation Patients (n=561) |
|---------------------------------|--------|--------|--------|
|                                 | Median | Mean   | SD     |
| Age, y                         | 72.7   | 71.0   | 11.6   |
| Days to rehab admission        | 22.0   | 29.7   | 28.5   |
| LOS, d                         | 44.0   | 49.2   | 31.8   |
| LOS, age <50 y (n=34)          | 45.0   | 46.4   | 33.3   |
| LOS, age 50–59 y (n=53)        | 44.0   | 46.7   | 26.1   |
| LOS, age 60–69 y (n=144)       | 44.0   | 48.5   | 26.0   |
| LOS, age 70–79 y (n=208)       | 44.0   | 49.6   | 31.3   |
| LOS, age 80+ y (n=122)         | 44.0   | 51.2   | 40.1   |
| FIM at admission               | 78.0   | 78.1   | 24.7   |
| FIM full scale at admission     | 113.0  | 103.1  | 23.7   |
| Cognition                      | 27.0   | 25.9   | 7.3    |
| Motor                          | 53.0   | 52.2   | 20.4   |
| Self-care                      | 3.8    | 4.0    | 1.7    |
| Sphincter                      | 5.5    | 4.8    | 2.2    |
| Mobility                       | 4.0    | 3.9    | 1.7    |
| Locomotion                     | 3.5    | 3.4    | 1.7    |
| Communication                  | 6.0    | 5.6    | 1.7    |
| Social cognition               | 5.0    | 4.9    | 1.6    |
| FIM subscales at admission     | 7.0    | 5.8    | 1.6    |
| Self-care                      | 6.7    | 5.8    | 1.6    |
| Sphincter                      | 7.0    | 6.1    | 1.6    |
| Mobility                       | 6.4    | 5.7    | 1.5    |
| Locomotion                     | 6.0    | 5.3    | 1.5    |
| Communication                  | 6.5    | 5.9    | 1.4    |
| Social cognition               | 5.7    | 5.5    | 1.4    |
remaining variables explaining only an additional 2% to 4% of the variance.

For each outcome in Table 3, the amount of variation accounted for \((R^2)\) increased with the precision of the representation of the FIM score at admission. The combination of predictors explained from 61% to 67% of the variation of FIM score at discharge, 17% to 31% of the variation in change of FIM score, and from 58% to 60% of the variation of Motor FIM score at discharge. Use of the full scale accounted for the least amount of variation and use of the subscales accounted for the most variation in all 3 outcomes. The effect is most noticeable in the models for change in FIM score, where the \(R^2\) ranged from 0.17 when the FIM full scale (global score) was used to 0.31 when the subscales were used.

Stage Three: Regression Analysis Using Age as a Predictor of FIM Score

Table 4 focuses on the predictive value of age. Age was first tested alone (unadjusted model), then adjusted for FIM score at admission, and finally adjusted for FIM score at admission and the clinical variables identified in Table 3. FIM score at admission was again represented in 3 ways, first as the FIM full scale, then as the 2 domains, then as the 6 subscales. In the unadjusted model, age alone was a significant predictor of both FIM score at discharge and discharge Motor FIM score \((P<0.001\) in both cases) but was not a significant predictor of change in FIM score. In both cases, however, age accounted for only 3% of the variation in outcome, as indicated by the partial \(R^2\) values of 0.032 and 0.030, respectively.

When FIM score at admission was added to the models, the important effect of this variable on the apparent
The association between increasing age and poor outcome can be seen. For example, when the full scale of FIM score at admission is added as a predictor of FIM score at discharge, the coefficient for age drops from −0.29 to −0.17, and the amount of variance accounted for by age drops from 3% (partial $R^2$ of 0.032) to <1% (partial $R^2$ of 0.007). This is even more apparent when we examine the results for the discharge Motor FIM score, where the coefficient for age drops from −0.29 to −0.10 and the variation accounted for also drops to <1% (partial $R^2$ of 0.004). The influence of age on outcome becomes even smaller as the representation of FIM score at admission becomes more specific. For example, the coefficient for age in predicting FIM score at discharge ($−0.29$) drops to $−0.17$ (full scale), $−0.14$ (2 domains), and $−0.13$ (6 subscales) depending on the specificity of FIM representation. The addition of the remaining clinical variables identified in Table 3 had little impact, other than to decrease the coefficient for age and the amount of variation accounted for by age even further in some of the models.

Smaller regression coefficients and smaller partial $R^2$ values indicate that the strength of the association between age and functional outcome decreases both with more precision in the representation of FIM score at admission and the addition of other predictors. Age remained statistically significant in some of the models, but explained, at the most, only 1.3% of the variation in functional outcome after adjustment for FIM score at admission and the clinical variables.

**Discussion**

This study attempted to discriminate between the influence of age and factors associated with age on functional outcome. Age alone shows a significant ($P<0.001$) but small effect on functional outcome when outcome is measured as FIM score at discharge or Motor FIM score at discharge. Advanced age, however, appears to have no effect on the very important outcome of change in FIM score. These results are in agreement with others that show that both functional status at admission and age are significant prognostic factors.3–7,28 Age has an insignificant clinical impact, however, as indicated by the small variation in outcome ($\approx 1\%$) that can be attributed solely to age. Cohen20 defines a small effect size as one that accounts for <2% of the variation in outcome, indicating that the true effect of age in our sample is very small. Hence, the results of this study support previous reports that have concluded and recommended that age should not be a factor that influences access to intensive stroke rehabilitation.30

In contrast to the small effect of age, FIM score at admission alone explained from 15% to 66% of the variation in functional outcome, indicating the clinical importance of functional status at admission relative to age in assessment of patients with stroke in the rehabilitation setting. Because age is associated with FIM score at admission, most of the apparent relationship between age and functional outcome appears to be due to the functional status at admission.

The association between increasing age and poor outcome can be explained by patient characteristics associated with age, such as additional disabilities or comorbidities.5,31,32 These were measured in this study but did not enter the regression models when criteria of 0.1 were used for removal. To evaluate the residual effect of those variables in distorting the relationship between age and functional outcome, we built backward regression models, keeping any variables that were significant at a 0.2 level.53 Although this added several variables to the models, the regression coefficients of age changed by <10% when admission FIM score was included in the model. Therefore, we presented only the models built with the conservative but standard significance criteria (0.1 for removal).

Different prognostic expectations could also influence both the treatment received and the outcome, because health professionals tend to underestimate a patient’s functional

<table>
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<th>Outcome</th>
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<td>Discharge Motor FIM score</td>
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The partial $R^2$ for the model of age alone is the amount of variation accounted for by age alone. The partial $R^2$ for the additional models is the ($R^2$ of the model with all the predictors including age) minus (the model without age).

*P<0.05; †P<0.01; ‡P<0.001.
potential, especially in the elderly. This may result in different rehabilitation input for older patients, as suggested by a direct association between patient age and rehabilitation program intensity. Advanced age by itself could also be associated with lower functional outcome because of a limited physical tolerance to intense rehabilitation or slower functional recovery. Finally, a combination of those factors could explain the statistical association between age and outcome.

The range of $R^2$ values in our study is comparable to that of most outcomes studies, in which the combination of predictors accounts for <60% of the variance and usually much less. One limitation of our study is that it did not include any measure of rehabilitation intensity or any other measure of process of care. Another potential limitation is the ceiling effect of the FIM scores, which could affect the relationship between age and functional outcome (those achieving the maximum score cannot improve further). Because younger patients generally have better FIM scores at admission, the maximum score is more likely to be achieved in younger patients. As a result, the lack of improvement will tend to be observed in younger patients and the observed negative association between age and functional outcome could be less than the true association. In our sample, however, only 2 patients (0.2%) were at the maximum total FIM score at admission.

An assessment of FIM scores 3 months after discharge would also be helpful. A higher percentage of the elderly patients are likely to be discharged to a nursing home. In this environment, it is very possible that stroke survivors will be unable to maintain the functional gains achieved during rehabilitation. Thus, although age itself may not be a significant factor in identifying those who will benefit from rehabilitation, it may nevertheless serve as an indicator of those who will fail to retain the maximum benefit of rehabilitation. Additional research that assesses maintenance of functional recovery after stroke rehabilitation is needed to address this very important issue.

In conclusion, although there was a statistically significant association between age and functional outcome, the small amount of variation that can be explained by age alone and the questionable clinical relevance of such a small effect provide support for Stineman and Granger, who concluded that there is no justification to deny patients rehabilitation solely because of advanced age. Considering the expected increase in the population >75 years of age, the incidence of stroke is also expected to increase. Many of these elderly stroke survivors will be unable to return to their homes because of the lack of a supportive caregiver. Hence, there is an urgent need to determine how we will provide timely access to effective stroke rehabilitation programs for all stroke survivors, regardless of age, and also to determine what resources are necessary to ensure maintenance of functional gains after rehabilitation.

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