Stroke Rehabilitation Outcome
A Potential Use of Predictive Variables to Establish Levels of Care

Michael P. Alexander, MD

Background and Purpose The most powerful predictors of functional recovery and eventual home discharge among stroke survivors are the initial severity of the stroke and the patient's age. We analyzed a large population of stroke rehabilitation admissions by stratifying subgroups with coherent outcomes in an attempt to define potentially more efficient patterns of providing rehabilitation care.

Methods We retrospectively analyzed 520 consecutive patients admitted to a rehabilitation hospital (1 calendar year) with cerebral infarction or hemorrhage. Side of index stroke, age, and functional disability at admission were the independent variables. Change in functional disability and home versus nursing home discharge were the dependent measures.

Results Recovery was overall most closely related to admission severity and age, but the relations between recovery and independent measures were complex. Patients aged <55 years all were discharged home whatever their initial severity.

Conclusions Standard clinical measures available at rehabilitation admission carry enough predictive power to define management strategies for stroke survivors. A management algorithm is proposed that might increase the efficiency of stroke rehabilitation programs and might allow comparisons of efficacy between different treatment settings. (Stroke. 1994;25:128-134.)

Key Words • cerebrovascular disorders • prognosis • rehabilitation

Stroke is one of the most common causes of chronic neurological disability in adults. Among neurological diseases only dementia of the Alzheimer type and traumatic brain injury have comparable medical, social, and financial impact. There are now approximately 400,000 stroke patients discharged from acute care hospitals annually. During the last several decades, it has become common practice for many of these patients to be admitted to a hospital (or specialized unit within a hospital) for rehabilitation or to receive outpatient or home rehabilitation services.

There are three general questions to be asked of this rehabilitation effort, and much energy from many investigators has been invested to answer at least two of them. First, is rehabilitation of stroke disability effective? This question is tacitly questioning the effectiveness of stroke rehabilitation compared with no special management beyond the straightforward compensatory (eg, bracing) or secondarily symptomatic (eg, treatment of painful shoulders). Recent reviews of stroke rehabilitation are mixed in regard to efficacy. In 11 reviews in major publications during the past 10 years, there is little unambiguous citation of specific additive benefit of specific stroke rehabilitation. Individual clinical studies, whether retrospective or prospective, have been descriptive. These studies can produce expectations in regard to likely outcome in a similar population but cannot speak to the value of the hospitalization itself. Conventional practice virtually precludes creation of a control population sent home with only essential compensatory and symptomatic treatments. This is precluded for social and not for scientific reasons, because there is little evidence that such a program would have a worse outcome.

Second, is rehabilitation delivered in specialized stroke units more effective than that delivered in general rehabilitation units? Considerable effort has also gone into answering this question, but the research currently available is again equivocal about additional benefit from specialized stroke rehabilitation. A 1993 review of this question using meta-analysis of a variety of types of stroke rehabilitation units concluded for social and not for scientific reasons, because there is little evidence that such a program would have a worse outcome.

Third, could stroke rehabilitation be provided in one of several settings, determined by the patient's functional needs, and how would appropriate settings be specified for any given patient? There has been less investigation of this question, probably because of both patients' expectations of getting maximum rehabilitation and logistic limitations to generating multiple levels of care. A recent study from Sweden has outlined an algorithm for determining appropriate levels of rehabilitative intensity (using the Katz index of activities of
daily living [ADL]),28 but the implications for current US practice are uncertain. This report describes the analysis of a large cohort of stroke rehabilitation admissions. The goal was to identify and differentiate groups of patients with different functional outcomes. Characterization of such groups could be a first step toward implementation of an algorithm that would specify appropriate rehabilitation settings.

Subjects and Methods

All patients admitted to Braintree Hospital with a diagnosis of cerebral infarction or hemorrhage in 1991 were reviewed. Only patients actually admitted for a recent stroke were included; those admitted for some other diagnosis but with a remote stroke were excluded. For the analysis in this report there were several exclusions. Patients with primary subarachnoid hemorrhage and aneurysm clipping and patients who had had surgical evacuation of intracerebral hemorrhages were excluded because the complexity of medical neurological issues would only confuse analysis of more straightforward strokes. Brain stem and cerebellar strokes were excluded because of small numbers. There were 520 included admissions. Admission selection bias no doubt exists, but there are only two explicit exclusionary criteria for stroke patients. First, patients had surgical evacuation of intracerebral hemorrhages were excluded because the complexity of medical neurological issues would only confuse analysis of more straightforward strokes. Brain stem and cerebellar strokes were excluded because of small numbers. There were 520 included admissions. Admission selection bias no doubt exists, but there are only two explicit exclusionary criteria for stroke patients. First, patients who had had surgical evacuation of intracerebral hemorrhages were excluded because the complexity of medical neurological issues would only confuse analysis of more straightforward strokes. Brain stem and cerebellar strokes were excluded because of small numbers. There were 520 included admissions. Admission selection bias no doubt exists, but there are only two explicit exclusionary criteria for stroke patients. First, patients who had surgical evacuation of intracerebral hemorrhages were excluded because the complexity of medical neurological issues would only confuse analysis of more straightforward strokes. Brain stem and cerebellar strokes were excluded because of small numbers. There were 520 included admissions. Admission selection bias no doubt exists, but there are only two explicit exclusionary criteria for stroke patients. First, patients who had surgical evacuation of intracerebral hemorrhages were excluded because the complexity of medical neurological issues would only confuse analysis of more straightforward strokes. Brain stem and cerebellar strokes were excluded because of small numbers. There were 520 included admissions. Admission selection bias no doubt exists, but there are only two explicit exclusionary criteria for stroke patients. First, patients who had surgical evacuation of intracerebral hemorrhages were excluded because the complexity of medical neurological issues would only confuse analysis of more straightforward strokes. Brain stem and cerebellar strokes were excluded because of small numbers. There were 520 included admissions. Admission selection bias no doubt exists, but there are only two explicit exclusionary criteria for stroke patients. First, patients who had surgical evacuation of intracerebral hemorrhages were excluded because

### Table 1. Average Functional Independence Measure Change by Age and Admission Functional Independence Measure Class

<table>
<thead>
<tr>
<th>A-FIM</th>
<th>Class</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;55</td>
<td>55-64</td>
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<tr>
<td>&lt;10</td>
<td>45.600</td>
<td>27.095</td>
</tr>
<tr>
<td></td>
<td>(n=10)</td>
<td>(n=21)</td>
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<tr>
<td>10-20</td>
<td>41.600</td>
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<tr>
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<td>(n=10)</td>
<td>(n=20)</td>
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<tr>
<td>20-30</td>
<td>33.381</td>
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<td></td>
<td>(n=21)</td>
<td>(n=11)</td>
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<td>&gt;30</td>
<td>22.615</td>
<td>21.737</td>
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<td>(n=13)</td>
<td>(n=19)</td>
</tr>
<tr>
<td>Total</td>
<td>34.574</td>
<td>26.225</td>
</tr>
</tbody>
</table>

A-FIM indicates admission Functional Independence Measure.

Significant effects (with FIM-change as dependent variable): age, F=5.45, df=4, P<.0003; A-FIM, F=6.05, df=3, P<.0005.

Discharge criteria were not as well specified as admission criteria. The maximum goals would be independent ambulation (with assistive devices if necessary and at least indoors), continence, and self-care independently or with assistance that can be provided in the home setting. At or within 2 weeks of admission, it is apparent if those goals are reachable. At that time, goals are fixed based on a best assessment of potential gains over 4 to 6 additional weeks. Most decisions about nursing home placement are made in the next 2 to 4 weeks when the family decides that the level of care required cannot be met. Patients discharged from Braintree to acute care hospitals or other rehabilitation facilities or who died at Braintree were not considered for outcome analyses. There were 464 patients meeting the inclusion criteria who were eventually discharged to home or to a nursing home. The functional measure for every patient is the Functional Independence Measure (FIM), an 18-item rating scale of functional capacities in dressing, walking, toileting, communicating, etc.29 The ratings are assigned by nurses and therapists caring for the patient. They are performed within 1 to 2 days of admission (A-FIM) and at discharge (D-FIM).

The following measures were available for every patient at admission: (1) duration of acute hospitalization; (2) age, stratified as <55, 55 through 64, 65 through 74, 75 through 84, and >85 years; (3) A-FIM, stratified as <40, 40 through 60, 61 through 80, and >80; and (4) hemisphere of index stroke. The overall matrix of patients, age by A-FIM, is summarized in Table 1. Measures available at discharge were (1) D-FIM; (2) length of stay; and (3) discharge setting (home or nursing home). Measures computed at discharge were (1) FIM-change (D-FIM−A-FIM) and (2) FIM-efficiency (FIM-change/length of stay).

Functional improvement is the apparent "product" of rehabilitation, and therefore the dependent variable for most analyses was the FIM-change for all included cases (n=520). One important goal of rehabilitation is home discharge, and therefore for some analyses the dependent variable is discharge to home or nursing home (n=464). FIM-change may be a factor in the discharge setting, and in these analyses FIM-change can appear as an independent variable.

Results

Patients ranged in age from 16 to 97 years (mean±SD age, 72.2±12.75 years). The mean duration of acute hospitalization was 18.27 days, and the average length of rehabilitation hospitalization was 33.75 days. The duration of acute hospitalization was significantly related to A-FIM (F=3.778, df=2, P=0.0106). The low A-FIM group had duration of acute hospitalization almost twice as long as all other groups (P<.001 for post hoc comparisons of all three groups to low A-FIM). Age also had a relation to acute hospitalization (F=3.379, df=2, P=.0096), with the major significance that the youngest group had the longest acute stays. Although the age×A-FIM interaction was nonsignificant, the young, low A-FIM group had, by far, the longest acute stays.
The interaction of A-FIM and side of lesion was significant (Table 2). There was significantly greater FIM-change for those aged <55 years than for all other groups and significantly less FIM-change for those aged >75 years. Although the FIM-change for the A-FIM >80 group was significantly less than for the A-FIM 40 through 80 groups, the absolute mean differences were only approximately 15% (Table 1). The A-FIM >80 group was not simply admitted at a functional ceiling; their functional status improved considerably. There was an excess of cases (53% over all age groups) in the lowest A-FIM group (<40) discharged to nursing homes. The Figure displays all of the relations between A-FIM, age, and FIM-change.

One purpose of this analysis is to understand the relation between A-FIM, age, FIM-change, and discharge setting. For this analysis, FIM-change was made the dependent variable and discharge setting an independent variable because discharge is a categorical variable (Table 5). Patients aged <55 years and patients with A-FIM >80 were not included for this analysis because these categories, by themselves, effectively predicted home discharge. The main effect of A-FIM was again significant; discharge setting was also significant. But most importantly, the interaction of A-FIM and discharge setting was quite significant. Interpreted in the direction of likely causality, patients with low admission FIM and poor FIM-change are particularly likely to face nursing home discharge.

However, it is not clear where in the interactions of A-FIM, FIM-change, and age the probability of nursing home discharge starts to rise. In Table 5, the 12 groups (4 age groups x 3 A-FIM classes) are reorganized into two groups. For the 136 patients within the shaded box, there is a 44.8% likelihood of nursing home discharge. For the subgroup with A-FIM <40 and age >65 years, the risk of nursing home discharge is particularly great: 62%. For the other 328 cases, there is only a 12.8% likelihood of nursing home discharge (x^2=57.173, df=1, P<.0001). The box in Table 5 identifies the general boundary of high probability of nursing home discharge. For each A-FIM/age group inside the box, functional recovery is critical for home discharge. For the patients aged <75 years, those discharged home had a mean FIM-change of 35.5 and those discharged to a nursing home, 16.7 (Mann-Whitney U=112, P=.0071). For the three cases (n=44) in the youngest group (aged <55 years) were discharged to home. There was also a significant excess of patients aged ≥75 years discharged to nursing homes. The youngest group was not considered in subsequent analyses.

The effect of A-FIM on discharge setting was analyzed for all patients aged ≥55 years (n=420). The overall effect (Table 4) was very significant. Virtually every patient (89 of 93) in the high A-FIM group went home whatever their age, even those aged >90 years. Although the FIM-change for the A-FIM >80 group was significantly less than for the A-FIM 40 through 80 groups, the absolute mean differences were only approximately 15% (Table 1). The A-FIM >80 group was not simply admitted at a functional ceiling; their functional status improved considerably. There was an excess of cases (53% over all age groups) in the lowest A-FIM group (<40) discharged to nursing homes. The Figure displays all of the relations between A-FIM, age, and FIM-change.

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TABLE 4. Frequency Testing of Admission Functional Independence Measure Class and Discharge Setting (Excluding Young Patients)

<table>
<thead>
<tr>
<th>Discharge Setting</th>
<th>A-FIM Class</th>
<th>&lt;40</th>
<th>40-60</th>
<th>61-80</th>
<th>&gt;80</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td></td>
<td>34</td>
<td>(11%)</td>
<td>89</td>
<td>(28%)</td>
<td>105</td>
</tr>
<tr>
<td>Nursing home</td>
<td></td>
<td>42</td>
<td>(11%)</td>
<td>30</td>
<td>(29%)</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>76</td>
<td>119</td>
<td>132</td>
<td>93</td>
<td>420</td>
</tr>
</tbody>
</table>

A-FIM indicates admission Functional Independence Measure.

Total $\chi^2=60.587; df=3; P=.0001$.

Discussion

There have been many clinical studies of stroke rehabilitation outcome in the past 20 years. However, it is difficult to assemble a fully informative summary of these studies (or reviews of the studies) for three reasons. First, studies differ in the time after onset of patient inclusion. Some begin with all acute strokes and others only with rehabilitation admissions, a much narrower clinical population. A second problem comes from variability and limitation in measurement strategies. Variability arises because different functional measures have been used, although the three most commonly used measures are roughly comparable. The use of only broad functional measures across a heterogeneous population may limit understanding of outcome. Specific neurological variables that might predict outcome for only a portion of the functional disability spectrum are not isolated. The third obstacle to interpretation of outcome studies comes from differences in clinical practice across time and space. Studies from the United States in the 1960s, 1970s, and early 1980s are irrelevant to current practice because allowable inpatient lengths of stay are so much shorter now. The value to US practitioners of the several excellent studies from England in the 1980s is reduced because of the substantial practice differences.

Some general conclusions do emerge from this literature. In outcome studies from the United States, Britain, or Sweden whatever the practice pattern, the index population, or the outcome variable measured, a worse functional outcome is seen in older patients and in patients with more severe initial disability. Literature reviews on the topic of stroke outcome and rehabilitation have also emphasized these two main effects—age and initial functional disability—on outcome. Our results confirm this general conclusion in a large population from a single setting.

If it is clear that severity and age are the major factors in stroke rehabilitation outcome, it is less clear how to use that fact to predict outcome for individual patients or how to construct rehabilitation programs for individuals or groups of patients at any given level of severity. Groups from Britain and from Sweden have used two very different approaches in an attempt to establish such predictive models and treatment strategies.

The groups in Britain analyzed prospectively studied populations and computed regression formulas to weight predictor variables and allow prediction of eventual functional capacity. The groups did not develop identical formulas, but both heavily weighted initial functional impairment and age. When the formulas were retested against a second prospectively studied population at the same hospital, they were not very precise in predicting functional outcome, although the same variables emerged as important.

Gladman et al went further and compared the predictive accuracy of five multivariate models on a prospective series of 102 patients. None of the models was accurate enough at predicting death or functional outcome to have clinical utility. All five models identified approximately the same variables, but simple univariate models (level of consciousness at admission to predict mortality and urinary continence at 4 weeks to predict functional outcome) were more effective.

The problem of using multivariate analyses is also highlighted by Lincoln et al in which the best predictor of ADL status at 9 months after stroke was a neuropsychological test for delayed recognition of unfamiliar faces. Single variables may be stand-ins for...
TABLE 5. Average Functional Independence Measure Change by Admission Functional Independence Measure, Age, and Discharge Class

<table>
<thead>
<tr>
<th>Age Class, y</th>
<th>55-64</th>
<th>65-74</th>
<th>75-84</th>
<th>&gt;85</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-FIM</td>
<td>Home</td>
<td>Nursing Home</td>
<td>Home</td>
<td>Nursing Home</td>
</tr>
<tr>
<td>(n=12)</td>
<td>(n=6)</td>
<td>(n=11)</td>
<td>(n=13)</td>
<td></td>
</tr>
<tr>
<td>(n=16)</td>
<td>(n=4)</td>
<td>(n=32)</td>
<td>(n=7)</td>
<td></td>
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<tr>
<td>61-80</td>
<td>24.600</td>
<td>44.000</td>
<td>29.317</td>
<td>24.400</td>
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<td>(n=10)</td>
<td>(n=1)</td>
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<td>(n=38)</td>
<td>(n=11)</td>
<td>(n=84)</td>
<td>(n=30)</td>
<td></td>
</tr>
</tbody>
</table>

A-FIM indicates admission Functional Independence Measure.

Significant effects (with FIM-change as dependent variable): A-FIM, F=4.144, df=2, P=.0168; discharge setting, F=13.024, df=1, P=.0004; A-FIM×discharge setting, F=3.973, df=2, P=0.0196.

many different processes. In fact, age is probably a stand-in for many medical, psychosocial, and psychiatric factors, no one of which is potent enough to emerge alone. In a similar manner, recognition of faces is probably a stand-in for numerous perceptual, memory, language, and attentional factors, no one of which emerges alone.

The same group has provided a lucid summary of what these stroke outcome studies and formulas can and cannot illuminate. Formulas and correlations only have actuarial (ie, group) significance; they have weak predictive power for individuals. Claims for rehabilitation programs should speak to groups, but the multivariate models developed in Europe may actually have few advantages over simpler analyses.

Åberg and Nydevik from Sweden also attempted to develop a predictive strategy. They found that a low initial (5 to 7 days after onset) ADL score alone was a very accurate predictor of nursing home discharge (χ²=55.68, df=1, P=.0001; my calculation from their data), but only 28 of 61 (44.9%) of the patients with low ADL scores actually ended up in nursing homes. This result is nearly identical to the proportion of low A-FIM patients who actually had nursing home discharges (44.8%) in our study. The authors suggested that the stratified risk of nursing home discharge justified a clinical algorithm for management decisions.

Åberg and Nydevik recommended that the first assessment for rehabilitation services should come on acute care hospital day 5 to 7. A high ADL measure (Katz index F through G or FIM >80) identifies patients who will be home at 1 month. They propose that these patients be assessed for specific home needs such as meal preparation and home safety. Depending on the discharge setting and the severity of cognitive deficits, these patients would be sent home from the acute care hospital with outpatient or home services or be sent to rehabilitation for management of some specific issue. Patients with low initial ADL measures (Katz index F through G or FIM <40) represent a heterogeneous group, with some low because of stroke severity and some because of comorbid medical factors. In either case, at this point they are probably not able to participate in active rehabilitation. Åberg and Nydevik recommended that no decision be made at the initial assessment. For the patients in the “middle band” at any evaluation (Katz index D through E or FIM 40 through 80), Åberg and Nydevik recommended transfer to rehabilitation. The implication is that these patients have the most to gain and are able to participate fully.

These management strategies emerged from analysis of the probability of various outcomes in subgroups of the larger population of stroke patients. The data from the current report support the rehabilitation management strategy proposed by Åberg and Nydevik. The strength of the support comes from three sources. First, the current study population was large enough to create several strata. Some neurological sources of variability were eliminated (eg, subarachnoid hemorrhage was excluded), but great functional heterogeneity remained. Second, only a few readily available and reliable measures were used. In addition, the proposed stratification of patients suggests several research investigations that parallel the clinical recommendations.

Patients with high A-FIM show improvement comparable to that in more severely affected groups. They...
show this improvement quickly, and they have an extremely high probability of home discharge. If elected, a brief rehabilitation admission would allow for assessment of home safety, establishment of prognosis, treatment plans for cognitive or aphasic deficits, and comprehensive family education. Whether there is any short- or long-term advantage for hospital-level rehabilitation over home care services or outpatient services is an unresolved and virtually unaddressed scientific question. As a strategy for future care, moving this group to outpatient services should be considered. A clinical research strategy might be to compare short- and long-term outcome between two groups matched for high A-FIM receiving services in the two different settings.

For patients with A-FIM <40, there are two decision tracks. Young patients (aged <55 years) should be admitted to rehabilitation because there is a high probability of exceptional improvement (FIM-change >40) and home discharge. For other patients with A-FIM <40 there is a much lower probability (approximately 50%) of home discharge, probably because they have a lower probability of the substantial FIM-change required for adequate function at discharge. The functional prognosis is particularly guarded for low A-FIM patients with right brain strokes. For patients aged ≥75 years even an A-FIM of 40 to 60 carries the same high risk of nursing home discharge as the lowest A-FIM group. For all of these patient groups with a low likelihood of home discharge even with maximum hospital-level services, perhaps transfer to a less intensive rehabilitation setting is proper. Follow-up assessments every 7 to 10 days can identify a subset that is improving. Transfer to more intensive rehabilitation for that subset might accomplish more improvement, but for the older patients eventual home discharge was less linked to functional improvement than in the younger patients. This investigation did not collect data on this point, but for the older patients, the home setting and the health of the spouse were probably more critical to discharge than was improvement. It is again an unanswered question if rehabilitation services provided in the less intense, more graduated, and probably less expensive setting of a nursing home discharge accomplish the same long-term home discharge rate for this very impaired group. It is a plausible strategy for future care to shift rehabilitation services for this group to nursing home-level services. It is also a reasonable research project to compare outcomes in groups matched for low A-FIM given services in the hospital versus nursing home-level facilities. For these groups simple tabulation of home discharges would probably suffice as a dependent measure.

Most patients in the middle band (A-FIM 40 through 80) are appropriate for intensive (hospital-level) therapy. They show substantial improvement and are discharged home in high numbers. For these patients an interesting research strategy would be comparison of the effects of different theoretically motivated treatments for specific impairments. Hospitalization would allow greater control over the treatments provided.

These recommendations have implications for current practice and hospital utilization. If implemented for the population of the current study, the effect on hospitalization rate would have been considerable. Of the 520 patients, 21.2% (FIM >80) might have gone directly from acute care hospitals to outpatient or home services, and 31.7% (FIM <40 and aged ≥55 years; FIM 40 through 60 and aged ≥75 years) might have gone directly to nursing home rehabilitation.

Results from our hospital cannot help to resolve the debate about the relative efficacy of rehabilitation administered in general rehabilitation units (such as ours) versus that in specialized stroke units.18-27 Just as there is no certainty that rehabilitation provides any gains over spontaneous recovery, there is also no certainty that specialized units affect functional outcome.3,16,17 This uncertainty primarily arises from methodological limitations in available studies.

Conclusion

A merger of the proposed treatment algorithm from Sweden, the broad actuarial data already available in the existing literature, and the results from this population may define a strategy for rehabilitation management of stroke survivors. None of these sources provides any guidance regarding the proper level of rehabilitation services in any particular setting or resolution of questions about the basic utility of rehabilitation hospitals versus a mixture of nursing home-level and home care services for all patients. Utilization of this strategy could, however, allow reasonable comparison studies of rehabilitation services in different settings and at different levels of intensity. Comparison studies could be targeted for a particular band of severity. No patient would be untreated, and assignment to different levels of care would be clinically principled.

The present utility of rehabilitation hospitals seems to be determined by external factors. Acute care hospitals, squeezed in their reimbursements by diagnosis-related groups and managed care, are anxious for early discharge of medically stable patients. Families are reluctant to take on the home care of substantially disabled patients and cannot afford nursing homes that are not considered part of the medical care system and thus not covered by insurance. Until the conflicting issues are resolved, hospital-level rehabilitation has a practical role to play in stroke care. The multilayered admission strategies suggested here could be a practical approach to the care of disabled stroke survivors in the least costly environment that respects their prognoses for improvement.

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