Serial Assessment of Acute Stroke
Using the NIH Stroke Scale

Robert J. Wityk, MD; Michael S. Pessin, MD; Richard F. Kaplan, PhD; Louis R. Caplan, MD

Background and Purpose The National Institutes of Health (NIH) Stroke Scale has been used in clinical trials to assess neurological outcome after investigational therapy for acute stroke. We used the NIH Stroke Scale to study the degree and time course of recovery in patients with acute stroke who were treated with conventional therapy.

Methods We serially assessed 50 patients with ischemic stroke who presented within 24 hours of onset of symptoms. Patients were grouped by stroke subtype. Major neurological improvement was defined as a decrease in the stroke score by 4 points or more.

Results The mean NIH stroke score for all patients improved significantly by 7 to 10 days and at last follow-up (average, 44 days). Major neurological improvement was seen in 5 of 41 patients (12%; 95% confidence interval [CI], 2% to 22%) by 24 hours, 11 of 40 patients (28%; 95% CI, 14% to 41%) by 48 hours, and 19 of 37 patients (51%; 95% CI, 35% to 67%) by follow-up. The subgroup of patients with middle cerebral artery territory embolism showed a similar pattern of improvement; in contrast, patients with lacunar infarcts did not show significant change in scores during the study period. The score on admission did not correlate with the degree of subsequent improvement or deterioration.

Conclusions A significant percentage of patients with acute ischemic stroke treated with conventional therapy show early improvement as assessed by the NIH Stroke Scale. The degree and time course of recovery may be influenced by stroke type.

Key Words • stroke assessment • stroke outcome

Most patients have recovery of neurological function after acute ischemic stroke, but knowledge of the time course and extent of recovery is limited. Several recent clinical trials1–3 used the National Institutes of Health (NIH) Stroke Scale, a standardized measure of neurological function, to assess outcome after investigational therapy for acute stroke. We used this scale to study the recovery of patients with acute ischemic stroke receiving conventional therapy.

We predicted that most patients would show improvement (as evidenced by lower scores on the stroke scale) by 1 week or later after stroke onset. We also hypothesized that the pattern of recovery could be influenced by the type of stroke (eg, small-vessel disease causing lacunar infarcts versus large-vessel atherothrombosis or embolism). Finally, we were interested in what proportion of patients showed rapid neurological improvement during the first few days and whether scores on admission would correlate with subsequent outcome.

Subjects and Methods

Fifty-six consecutive patients with acute ischemic stroke presenting within 24 hours of onset were evaluated at the New England Medical Center between August 1991 and May 1992. Patients with an indeterminate time of onset (eg, those who awoke with a deficit) were considered to have onset at the last time the patient was known to be symptom free. Six patients were excluded because they received investigational therapy.

All patients had detailed clinical evaluation. Treatment was determined by the primary physician and could include antiplatelet agents or anticoagulants.

Patients were grouped as to stroke subtype: (1) middle cerebral artery (MCA) territory embolism: patients had sudden onset of neurological deficits and either computed tomography (CT) or magnetic resonance imaging (MRI) studies showing cortical infarcts in the MCA distribution consistent with embolism.4 Emboli could arise either from a cardiac source or secondary to internal carotid artery (ICA) occlusive disease. Some patients without a clear embolic source were still included in this group because clinical features and imaging studies were consistent with presumed embolism; (2) lacunar infarct: patients had typical lacunar syndromes5 on clinical examination and small, deep infarcts on CT or MRI. No patient had significant abnormalities on carotid noninvasive studies, transcranial Doppler studies, and cardiac evaluation; (3) ICA stroke: patients had carotid territory watershed infarctions on CT/MRI associated with ipsilateral occlusive disease of the ICA; (4) posterior circulation stroke: patients had clinical and imaging evidence for infarction involving either the brain stem, cerebellum, or the posterior cerebral artery territory. All had either cerebral embolism or large-vessel occlusive disease; patients with small infarcts in the posterior circulation territory and typical lacunar syndromes were classified as lacunar infarcts.

The NIH Stroke Scale is a 14-part assessment of neurological function modified from Brott et al6 (Table). Stroke scores were determined on admission, at 24 hours, 48 hours, 72 hours, 7 to 10 days, and in follow-up (average, 44 days; range, 22 to 90 days). Previous studies used an increase or decrease in the stroke score by 4 points or more as a marker for clinically important change.2,3 We therefore defined "major neurological improvement" as a decrease in the stroke score by 4 or more points and "major neurological deterioration" as either death or an increase in score by 4 or more points.

Serial stroke scores were analyzed by a one-way ANOVA using the scores at 24 hours, 48 hours, 72 hours, 7 to 10 days, and at follow-up as repeated measures. Patients who died were excluded from this part of the analysis. (Our conclusions were

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National Institutes of Health Stroke Scale

<table>
<thead>
<tr>
<th>Deficit Tested</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC</td>
<td>0-3</td>
</tr>
<tr>
<td>LOC questions</td>
<td>0-2</td>
</tr>
<tr>
<td>LOC commands</td>
<td>0-2</td>
</tr>
<tr>
<td>Gaze abnormality</td>
<td>0-2</td>
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<tr>
<td>Visual loss</td>
<td>0-3</td>
</tr>
<tr>
<td>Facial weakness</td>
<td>0-3</td>
</tr>
<tr>
<td>Motor weakness in arm</td>
<td>0-4 (right, left)</td>
</tr>
<tr>
<td>Motor weakness in leg</td>
<td>0-4 (right, left)</td>
</tr>
<tr>
<td>Limb ataxia</td>
<td>0-2</td>
</tr>
<tr>
<td>Sensory loss</td>
<td>0-2</td>
</tr>
<tr>
<td>Aphasita</td>
<td>0-3</td>
</tr>
<tr>
<td>Dysarthria</td>
<td>0-2</td>
</tr>
<tr>
<td>Extinction and Inattention</td>
<td>0-2</td>
</tr>
<tr>
<td>Distal motor function in hand</td>
<td>0-2 (right, left)</td>
</tr>
</tbody>
</table>

LOC indicates level of consciousness.

unchanged when the analysis was repeated using a maximal stroke score of 42 for time points after death.) Mean stroke scores were compared using Student's $t$ test. Proportions were compared using Fisher's exact test. Pearson's $r$ correlation coefficient was calculated to determine correlations between admission score and subsequent scores or changes in scores.

**Results**

Among 50 patients studied, 31 were men and 19 women; the average age was 66 years. Stroke scores for 94% of all possible time points were obtained, with the lowest acquisition at follow-up (86%). One individual (R.J.W.) performed 73% of all examinations. The mean time interval from stroke onset to admission exam was 9.2 hours, with 74% seen within 12 hours and 42% within 6 hours. Patients with MCA embolism were seen the earliest at 6.5 hours, and patients with lacunar infarcts were seen the latest at 16.7 hours. Evaluation included carotid noninvasive studies (90%), transcranial Doppler studies (68%), cerebral angiography (26%), magnetic resonance angiography (12%), echocardiography (40%), and either Holter or telemetry monitoring (44%).

Twenty-seven patients were classified as having MCA territory embolism. Among this group, 10 had cardiac source emboli, 8 had ICA occlusion, 2 were angiography related, and the remaining 7 had no identified embolic source. Fourteen patients had lacunar infarcts: 7 with pure motor hemiparesis, 3 with thalamic syndromes (pure sensory stroke), 3 with clumsy hand–dysarthria, and 1 with ataxic hemiparesis. Five patients had posterior circulation strokes, 3 had ICA territory watershed infarcts, and 1 had MCA stem stenosis and thrombosis.

All patients received conventional supportive therapy for acute stroke. Fifty-eight percent of patients were also treated with heparin and/or warfarin (the majority of these were patients with MCA territory embolism), and 4% were treated with aspirin. One patient had carotid endarterectomy. The remaining 36% of patients received only supportive therapy during the first week, without the use of anticoagulants, antiplatelet agents, or surgery.

The mean±SEM admission score for all patients was 11.2±1.3 (range, 1 to 29), which improved to a score of 5.5±1.2 by follow-up (Fig 1). Three patients died: 2 in the MCA embolism group (on days 5 and 16) and 1 patient with MCA stenosis and thrombosis (on day 10). Stroke scores improved significantly during the period of the study ($P<.0001$). Mean scores at 7 to 10 days and at follow-up were significantly different compared with admission ($P<.05$ and $P<.001$, respectively; one-tailed $t$ test). The score on admission correlated with the score at 7 to 10 days ($r=.68$; $P<.001$) and follow-up ($r=.61$; $P<.001$). The admission score, however, did not correlate with the degree of improvement or deterioration (ie, change in score) at any time point. We also found no correlation between the change in score from admission to any time point and the patient’s age or time interval between onset of symptoms and first evaluation. Early changes in the stroke score between admission and 24 hours did correlate with the degree of improvement seen at 7 to 10 days ($r=.711$; $P<.001$).

Patients with MCA territory embolism had a mean admission score (±SEM) of $13.9±1.7$ (range, 1 to 29) and improved to $6.9±2.1$ by follow-up ($P<.0001$) (Fig 1). Patients with lacunar infarcts, on the other hand, had lower admission scores (mean, $4.8±0.9$; range, 1 to 11), and while there was a trend toward improvement during the study period (score of $3.9±1.1$ at follow-up), this failed statistical significance ($P=.06$). There were too few patients with ICA or posterior circulation strokes for meaningful analysis.
We then analyzed the data in terms of the percentage of patients who showed major neurological improvement or deterioration (defined earlier) at various time points, because this information may be of more clinical relevance (Fig 2). This analysis was limited to the 42 patients with admission scores of 4 or greater. Major neurological improvement was seen in 5 of 41 patients (12%; 95% confidence interval [CI], 2% to 22%) by 24 hours, 11 of 40 patients (28%; 95% CI, 14% to 41%) by 48 hours, and 19 of 37 patients (51%; 95% CI, 35% to 67%) by the time of last follow-up. The five patients who improved by 24 hours went on to make nearly complete recoveries, and 91% of patients who improved by 48 hours remained improved at last follow-up. Major neurological deterioration occurred in 8 of 40 patients (20%; 95% CI, 8% to 32%) by 48 hours and remained essentially constant at subsequent time points. However, only 50% of patients with major neurological deterioration at 48 hours remained in that category by follow-up. The mean admission score of patients who improved was not different than the mean admission score of patients who deteriorated.

Of patients with MCA territory embolism, major neurological improvement was seen in 4 of 24 (17%; 95% CI, 2% to 32%) by 24 hours, 8 of 24 (33%; 95% CI, 14% to 52%) by 48 hours, and 13 of 21 (62%; 95% CI, 41% to 83%) by follow-up. In contrast, no patient in the lacunar infarct group showed major neurological improvement by 24 or 48 hours, and only 2 of 10 were improved at follow-up. The proportion of patients with major neurological improvement was significantly greater in the MCA territory embolism group than in the lacunar infarct group at 48 hours and at follow-up (P<.05, Fisher’s exact test). There was no significant difference between the two groups in the percentage of patients with deterioration.

Discussion

The NIH Stroke Scale is a convenient, rapidly applied scale for neurological assessment that correlates with other measures of stroke outcome, such as infarct size on CT. Because of its simplicity and high interrater reliability, it is well suited for clinical treatment trials of acute stroke, in which serial assessments may be performed by different persons. Since the majority of assessments in our study were performed by one individual, variability in application of the stroke score should have been small. Having one individual perform repeated scores, however, may have added bias to the results (eg, expecting gradual improvement over time). We tried to minimize bias by strict adherence to the stroke scale criteria and limited access to previous scores.
Using a modified NIH Stroke Scale, Biller et al. performed serial assessments over 6 hours on 29 patients with acute ischemic stroke. Most of the patients had embolic strokes, and all were evaluated within 12 hours of onset of symptoms. Major neurological improvement was defined as a decrease of 2 or more points in total score, but the scale used included a larger range of points for assessing motor deficit. By this criterion, 24% showed major neurological improvement at 1 hour, and 52% were improved by 6 hours.

Recently two nonrandomized trials of tissue plasminogen activator (TPA) for acute ischemic stroke have been reported using the NIH Stroke Scale to assess outcome. Major neurological improvement was defined as a decrease in the stroke score by 4 points or more from admission. Brott et al. reported 74 patients treated with TPA within 90 minutes of stroke onset. The majority of patients had large-vessel strokes in the MCA distribution, similar to our study population. Major neurological improvement was seen in 46% at 24 hours, and 69% were "subjectively rated" as partially or completely improved by 3-month follow-up. In a companion study, Haley et al. reported 20 patients treated with TPA between 91 and 180 minutes after stroke onset. Major neurological improvement was seen in 25% of patients at 2 hours but in only 15% at 24 hours because of recurrent deficits in 2 patients.

We found that mean stroke scores improved over time in patients receiving conventional therapy. Much of the change in mean stroke score appeared to occur at the later time points, particularly at 7 to 10 days and at follow-up. Using the same definitions as in the recent TPA trials, we found that almost a third of our patients showed major neurological improvement during the first few days, and half were improved at follow-up. Most patients with early improvement remained improved at follow-up. Admission stroke scores in our study were obtained later after onset of symptoms than the initial score of patients enrolled in the TPA trials, so we may have missed very early changes in our patients. How earlier assessment would have affected our results is uncertain. Another limitation in comparing results between studies is that our scale included a score for distal motor function in the hand (0 to 2 points), a category that was not used in the TPA trials. Our results were not significantly changed, however, on analysis of our data with these scores deleted (data not shown).

Patients with MCA territory embolism followed a pattern of recovery similar to the entire group, whereas patients with lacunar infarcts failed to show significant improvement during the study period. Patients with lacunar infarcts were different from patients with MCA territory embolism in that they had lower admission scores, presented for first evaluation later, and were less often treated with anticoagulants. However, we did not find a significant correlation between admission score and the degree of improvement at follow-up (using all patients), suggesting that low admission scores alone may not be the reason patients with lacunar infarcts showed little change.

If the NIH stroke score is a reflection of neurological deficit, then admission scores may be predictive of subsequent neurological status. We found a good correlation between admission score and the score at 7 to 10 days and follow-up. As noted earlier, however, neither the admission score nor the patient's age correlated with the degree of improvement or deterioration seen at subsequent time points. Patients presenting with high stroke scores, for example, may show significant decrease in score relative to admission but still have major neurological deficits at follow-up. Interestingly, the change in stroke score from admission to 24 hours correlated strongly with the change by 7 to 10 days, suggesting that early changes in stroke score may be a predictor of outcome. Further studies are needed to determine how factors such as admission score and change in score by 24 hours correlate with measures of functional outcome.

Our results indicate that significant recovery, as assessed by the NIH Stroke Scale, occurs early after acute stroke in patients treated with conventional therapy. The degree of spontaneous recovery and the influence of stroke subtype on the pattern of outcome have important implications for the design of future treatment trials.

References
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