Functional Recovery After Rehabilitation for Cerebellar Stroke

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Background and Purpose—Relatively few data exist concerning functional recovery after ischemic and hemorrhagic cerebellar stroke. We studied patients admitted to a rehabilitation hospital after cerebellar stroke to quantify recovery after rehabilitation therapy and to identify variables that predicted functional outcome.

Methods—This study was a retrospective review of consecutive cases admitted in a 4-year period with new cerebellar infarct or hemorrhage. Clinical features of stroke were recorded and comorbidities scored with the Charlson Index. Follow-up information was obtained by telephone interview. The Functional Independence Measure (FIM) was scored at admission (AFIM), discharge (DFIM), and follow-up (FFIM). Outcome measures were DFIM and FFIM. Univariate and multivariate analyses were performed.

Results—Fifty-eight cases were identified (mean age 69.2 years; 49 infarcts, 9 hemorrhages). Mean AFIM was 65.5, and mean DFIM was 89.8. Mean AFIM was significantly higher in the infarct than in the hemorrhage subgroup (70 versus 43, \(P = 0.006\)). Mean DFIM was also higher in the infarct subgroup but did not reach statistical significance (93 versus 74, \(P = 0.1\)). Follow-up information was obtained for 45 cases (78%) (mean interval 19.5 months). Median FFIM was 123.5. Outcome was significantly positively correlated with AFIM and initial presenting syndrome of vertigo/vomiting/ataxia/headache. Outcome correlated negatively with preexisting comorbidity score, altered level of consciousness at initial presentation, and superior cerebellar artery infarction. On multivariate analysis, AFIM and comorbidity score were independent predictors of outcome.

Conclusions—Substantial improvement of mean FIM score frequently occurs after rehabilitation after cerebellar infarction. Functional outcome is best predicted by preexisting comorbidities and functional status at the time of discharge from acute hospitalization. (Stroke. 2001;32:530-534.)

Key Words: cerebral infarction ■ cerebral hemorrhage ■ cerebellum ■ rehabilitation

Cerebellar ischemic and hemorrhagic stroke are important causes of acute neurological morbidity, accounting for 2% to 3% of the 600,000 strokes occurring annually in the United States. Although the clinical syndromes, complications, and underlying pathophysiological mechanisms have been well characterized, fewer data are available concerning outcome after acute cerebellar stroke. Most studies that have examined prognosis have expressed outcome in terms of survival or dependency, either at the time of discharge from acute care or after relatively short durations of follow-up.\(^{2,6–11}\) In recent years, the mortality rate has declined, largely owing to earlier diagnosis facilitated by CT and MRI, as well as earlier surgical treatment of hydrocephalus and brain stem compression, which frequently complicate cerebellar ischemic or hemorrhagic stroke in the acute setting.\(^{1,4,5}\)

Among survivors of cerebellar stroke, relatively few detailed data exist concerning functional outcome, degree of disability, and time course of recovery after discharge from acute hospital care. Such information may be of practical use to advise individual patients and to guide therapeutic decisions in the acute and subacute stages.

We performed a retrospective study of patients admitted to a rehabilitation hospital after a new cerebellar stroke. The principal aim of our research was to quantify changes in functional outcome after an inpatient rehabilitation program. Secondary aims were to identify variables present at the time of the acute stroke that were important predictors of outcome and to describe functional status before and after rehabilitation therapy in ischemic versus hemorrhagic cerebellar stroke. Our primary hypothesis was that excellent functional...
recovery frequently occurs after rehabilitation therapy for ischemic cerebellar infarction, despite significant functional impairment at the onset of therapy. Our secondary hypotheses were that functional outcome after rehabilitation therapy may be related to readily identifiable variables present in the acute stage after the stroke and that cerebellar hemorrhage may be associated with greater functional impairment at the beginning and end of rehabilitation therapy than that found with cerebellar infarction.

Methods
Using a large database of all patients admitted to Spaulding Rehabilitation Hospital (Boston, Mass) with a diagnosis of new ischemic or hemorrhagic stroke, we retrospectively identified all consecutive cases of new cerebellar stroke admitted between January 1, 1996, and December 31, 1999. Inclusion criteria were a primary indication for admission for inpatient rehabilitation of first cerebellar hemorrhage or cerebellar infarction (with and without secondary hemorrhagic change) and availability of complete Functional Independence Measure (FIM) data. Exclusion criteria were a primary indication for inpatient rehabilitation other than new cerebellar stroke (including functional impairment related to previous stroke or other neurological disease), absence of neuroimaging data, and death during inpatient rehabilitation therapy.

After cases had been identified, the medical records were reviewed, and demographic, clinical, and neuroimaging information was abstracted. Presenting clinical features at the time of acute hospitalization were recorded from referral information and categorized as (1) vertigo/vomiting/ataxia/headache without other deficits, (2) altered level of consciousness with or without other symptoms, (3) hemiparesis with or without other symptoms, or (4) other syndrome. When available, original CT and MRI scans were obtained from the referring hospital and reviewed by the study neuroradiologist, who assigned the territory of cerebellar infarction according to the vascular maps described by Tatu and coworkers. When the scans could not be obtained, neuroimaging information was extracted from referral data provided by the acute-care hospital. Preexisting comorbid conditions were scored by one of us (P.J.K.) according to the Charlson Index. This validated instrument assigns a weighted score ranging from 0 to 6 to each patient based on the Charlson comorbidity score, age, and sex.

Baseline characteristics of the study cohort are displayed in Table 1. Fifty-eight cases were identified that fulfilled inclusion criteria (37 men, 21 women; 49 infarcts, 9 hemorrhages). Fifteen cases with infarcts (30%) had 1 or more additional infarcts in the cerebral hemispheres or brain stem, whereas 1 (11%) of the hemorrhage cases also had a small extracerebellar hemorrhage (in the right frontal lobe). No significant differences in age, sex, or Charlson score were present in the subgroup only. The study was approved by the Institutional Review Board at Spaulding Rehabilitation Hospital.

Results

Patient Sample
Baseline characteristics of the study cohort are displayed in Table 1. Fifty-eight cases were identified that fulfilled inclusion criteria (37 men, 21 women; 49 infarcts, 9 hemorrhages). Fifteen cases with infarcts (30%) had 1 or more additional infarcts in the cerebral hemispheres or brain stem, whereas 1 (11%) of the hemorrhage cases also had a small extracerebellar hemorrhage (in the right frontal lobe). No significant differences in age, sex, or Charlson score were present in the subgroup with hemorrhage compared with that with infarction.

Clinical characteristics of the cohort are displayed in Table 2. Initial clinical syndromes at the time of presentation to the acute-care hospital were classified into 4 categories based on their anticipated effect on functional outcome (Table 2). All patients underwent neuroimaging, 54 (93%) by CT and 39 (67%) by MRI. The original films were available for review in 71% (41/58) of cases. Information concerning the arterial distribution of infarction was available in 92% (45/49) of infarct cases (Table 2). Overall, 43 patients (74%) were treated medically, and 15 (26%) underwent surgery (ventricular drainage or suboccipital craniectomy with resection of necrotic cerebellar tissue). Although mean rehabilitation hospital length of stay was significantly longer in the hemorrhage subgroup than in the infarct subgroup ($P=0.05$), no statistically significant difference in mean acute hospital length of stay was present ($P=0.09$) (Table 2).

<table>
<thead>
<tr>
<th>TABLE 1. Baseline Characteristics of Study Cohort</th>
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<tr>
<td>Sex, n (%)</td>
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<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
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<tr>
<td>Age, mean (range), y</td>
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<tr>
<td>Charlson comorbidity score, mean (range)</td>
</tr>
</tbody>
</table>

Institutes of Health Stroke Scale.\textsuperscript{14–17} Follow-up information was obtained by telephone interview, which has been validated for administration of the FIM.\textsuperscript{18} After informed consent was obtained, a follow-up FIM (FFIM) score was obtained from the patient or caregiver.

Statistical Analysis
Primary outcome measures were total AFIM and total FFIM. Two-sample $t$ tests and Fisher’s exact tests were used to compare patient characteristics between the infarct and hemorrhage subgroups. Because FIM scores were not normally distributed, median tests and Spearman correlation coefficients were used to examine the univariate relationship between predictors and outcome, and multiple regression analyses were performed on the ranks of the FIM scores. Independent variables included age, type of stroke (infarct or hemorrhage), extent of stroke (isolated cerebellar involvement versus cerebellar plus brain stem/cerebral hemispheric involvement), clinical syndrome at acute presentation, preexisting comorbidities (Charlon score), total AFIM, and arterial territory involved (infarct subgroup only). The study was approved by the Institutional Review Board at Spaulding Rehabilitation Hospital.
At admission to the rehabilitation facility, the hemorrhage subgroup had more significant functional impairment than the infarct subgroup, both for total AFIM (\(P=0.006\)) (Table 3) and for motor (\(P=0.04\)) and cognitive (\(P=0.01\)) FIM subscores. However, no statistically significant differences in total DFIM (\(P=0.1\)) or the inpatient rehabilitation FIM change (\(\Delta\)FIM) (\(P=0.16\)) was present between the subgroups.

At the time of discharge from inpatient rehabilitation, almost 80% of patients with cerebellar infarction had FIM scores.72 (corresponding on average to minimal or no assistance needed for items measured), whereas two thirds had FIM scores.90 (corresponding on average to functional independence). Among the 30 patients with infarcts for whom FFIM data were available, 87% required minimal or no assistance, and 83% were classified as independent. Almost 30% (\(n=8\)) of this group had maximal FIM scores at follow-up, indicating no residual deficits in the items measured. These findings are particularly noteworthy given that one third of the original group of patients with infarction had 1 or more additional infarcts in the brain stem or cerebral hemispheres.

In contrast to these findings, only 50% and 40% of patients with cerebellar hemorrhage had FIM scores corresponding to minimal/no assistance and functional independence, respectively, at the time of discharge. It was not possible to reach conclusions about long-term functional recovery in the patients with hemorrhages, because FFIM data were available for only 2 cases.

Follow-up information was available on 78% of cases (45/58). The mean interval between stroke onset and follow-up was 19.5 months (range 3 to 64 months). Thirteen patients (22%; 10 infarcts, 3 hemorrhages) had died by the time of follow-up. FFIM data were obtained for 32 (71%) of the remaining 45 cases (30 infarcts, 2 hemorrhages). The overall median FFIM was 123.5 (Table 3). When the change in FIM over time for the infarct cohort was examined, a clear

<table>
<thead>
<tr>
<th>Presenting clinical syndrome, n (%)</th>
<th>All (n=58)</th>
<th>Infarcts (n=49)</th>
<th>Hemorrhages (n=9)</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/V/A/H alone</td>
<td>34 (58.6)</td>
<td>29 (59.2)</td>
<td>5 (55.6)</td>
<td>1.0</td>
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<tr>
<td>Hemiparesis +/- other symptoms</td>
<td>9 (15.5)</td>
<td>9 (18.4)</td>
<td>0 (0)</td>
<td>0.3</td>
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<tr>
<td>Altered LOC +/- other</td>
<td>8 (13.8)</td>
<td>5 (10.2)</td>
<td>3 (33.3)</td>
<td>0.1</td>
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<tr>
<td>Other syndrome</td>
<td>7 (12.1)</td>
<td>6 (12.2)</td>
<td>1 (11.1)</td>
<td>1.0</td>
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<tr>
<td>Arterial territory, n (%)</td>
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<tr>
<td>PICA only</td>
<td>43 (74.1)</td>
<td>39 (79.6)</td>
<td>4 (44.5)</td>
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<tr>
<td>SCA only</td>
<td>15 (25.9)</td>
<td>10 (20.4)</td>
<td>5 (55.5)</td>
<td>0.1</td>
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<tr>
<td>AICA only</td>
<td>12.2 (9.5, 3-64)</td>
<td>10.3 (8, 3-32)</td>
<td>22.7 (18, 4-64)</td>
<td>0.09</td>
</tr>
<tr>
<td>PICA + SCA</td>
<td>24 (18.5, 4-97)</td>
<td>21.9 (17, 4-97)</td>
<td>35.4 (29, 10-96)</td>
<td>0.05</td>
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<tr>
<td>Undetermined</td>
<td>30 (63.2)</td>
<td>28 (57.1)</td>
<td>2 (22.2)</td>
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<td>Acute treatment, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Medical treatment</td>
<td>36 (62.1)</td>
<td>31 (63.3)</td>
<td>5 (55.6)</td>
<td></td>
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<tr>
<td>Surgery</td>
<td>10 (17.2)</td>
<td>8 (16.3)</td>
<td>2 (22.2)</td>
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<tr>
<td>A-LOS, mean (median, range), d</td>
<td>24 (18.5, 4-97)</td>
<td>21.9 (17, 4-97)</td>
<td>35.4 (29, 10-96)</td>
<td>0.05</td>
</tr>
<tr>
<td>R-LOS, mean (median, range), d</td>
<td>24 (18.5, 4-97)</td>
<td>21.9 (17, 4-97)</td>
<td>35.4 (29, 10-96)</td>
<td>0.05</td>
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<tr>
<td>Discharge destination, n (%)</td>
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<tr>
<td>Home</td>
<td>36 (62.1)</td>
<td>31 (63.3)</td>
<td>5 (55.6)</td>
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<tr>
<td>Nursing home</td>
<td>10 (17.2)</td>
<td>8 (16.3)</td>
<td>2 (22.2)</td>
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<tr>
<td>Acute hospital</td>
<td>10 (17.2)</td>
<td>8 (16.3)</td>
<td>2 (22.2)</td>
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</tr>
<tr>
<td>Other</td>
<td>2 (3.5)</td>
<td>2 (4.1)</td>
<td>0 (0)</td>
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</tbody>
</table>

V/V/A/H indicates vertigo/vomiting/ataxia/headache; LOC, level of consciousness; A-LOS, acute hospital length of stay; and R-LOS, rehabilitation hospital length of stay.
improvement was present between admission and follow-up ($P<0.001$).

For the infarction cohort, univariate and multivariate analyses were performed with DFIM ($n=49$) and FFIM as the dependent variables. On univariate analysis, median DFIM was significantly higher in cases with infarcts who presented acutely with vertigo/ataxia/vomiting/headache without hemiparesis or impaired consciousness ($P=0.01$) and in those with higher AFIM ($P=0.001$). Median DFIM was significantly lower among patients who presented acutely with reduced consciousness ($P=0.02$) and those with superior cerebellar artery (SCA) territory involvement ($P=0.03$), with a trend toward lower DFIM in those with cerebellar plus extracerebellar infarcts ($P=0.07$). On multivariate analysis, AFIM ($P=0.0001$), presentation with impaired consciousness ($P=0.005$), comorbidity score ($P=0.05$), and SCA infarction ($P=0.04$) were independent predictors of DFIM.

The analysis of predictors of FFIM in the infarct subgroup ($n=30$) was limited because of the small sample size. On univariate analysis, age ($P=0.03$), Charlson score ($P=0.05$), and AFIM ($P=0.001$) were the only significant independent predictors of FFIM. On multivariate analysis, both Charlson score ($P=0.01$) and AFIM ($P=0.0001$) independently predicted FFIM.

**Discussion**

These data confirm and extend previous reports indicating that excellent functional recovery frequently occurs among survivors of cerebellar infarction.$^{6,9--11}$ In addition, the data provide new information concerning clinical variables present at the time of the acute hospitalization that significantly predicted functional recovery after inpatient rehabilitation therapy and long-term functional outcome. Overall, we found that most patients in the cohort were moderately disabled at the time of admission to inpatient rehabilitation, attained FIM scores consistent with functional independence by the time of discharge, and continued to functionally improve after discharge.

Compared with patients with cerebellar infarction, those with cerebellar hemorrhage had greater degrees of functional impairment at admission and at discharge from inpatient rehabilitation, most of which was attributable to greater impairment in items measured by the FIM motor subscore. Despite the small size of the hemorrhage subgroup, we included these cases in the analysis because they provide an insight into initial disability and subsequent recovery of these patients compared with those with cerebellar infarction. However, these findings should be considered preliminary until more detailed studies of functional outcome after cerebellar hemorrhage are performed.

As anticipated from clinical experience, we found strong correlations between outcome and functional status at the start of rehabilitation therapy and preexisting comorbid conditions, as measured by the Charlson score. Perhaps less expected, we found that the clinical syndrome at the time of presentation to the acute-care hospital was also highly correlated with postrehabilitation functional outcome. The positive correlation between outcome and the presenting syndrome of vertigo/vomiting/ataxia/headache likely reflects isolated cerebellar involvement without brain stem infarction or significant mass effect. Conversely, the strong inverse correlation between outcome and altered level of consciousness at presentation is probably related to early hydrocephalus and/or brain stem compression associated with larger cerebellar strokes. This finding is consistent with other studies$^{10,11}$ that have reported that reduced level of consciousness at initial presentation is strongly correlated with poor outcome.

We found that patients with SCA territory infarction had significantly worse functional outcome after inpatient rehabilitation. Others have described conflicting results regarding outcome after SCA infarction. One study reported good recovery in a cohort with a high frequency of partial SCA territory infarction.$^{9}$ However, a more recent report described more severe disability associated with SCA compared with posterior inferior cerebellar artery (PICA) and anterior inferior cerebellar artery (AICA) infarcts, which is consistent with our findings.$^{13}$ The explanation for this observation is unclear. It may be related to more frequent brain stem compression due to mass effect from large infarcts or possibly to involvement of anatomic structures supplied by the SCA that are important for motor control, such as the dentate nucleus and superior cerebellar peduncle, which carries most of the motor pathway efferent fibers.$^{11}$

Previous studies have also described outcome after cerebellar stroke, usually in terms of neurological status or disability at follow-up. Kase and coworkers$^8$ described 66 patients with cerebellar infarction in the territories of the PICA and SCA who were studied in the acute-care hospital setting. Among patients with PICA infarcts, mortality was 17%, whereas 50% had neurological sequelae at the time of acute hospital discharge. In the SCA group, mortality was 7%, 67% were minimally disabled, and 23% were neurologically intact at the time of acute hospital discharge. Macdonell and colleagues$^8$ reported 30 patients with cerebellar infarction who were followed up for an average of 21 months. At the time of acute hospital discharge, 23% had died, 17% were fully dependent, 20% were ambulatory with walking aids, and 40% had mild or no residual neurological signs. An additional 17% had recurrent stroke after discharge that resulted in death or severe disability. A Japanese study$^{11}$ reported outcome figures similar to our findings in 282 patients with cerebellar infarction. At 3 months, 69% were independent, 26% were partially/completely dependent, and 5% had died. Jauss and others$^{10}$ recently reported that 74% of 84 patients with cerebellar infarction had Rankin scores consistent with independence at 90 days.

Our study has certain limitations that must be borne in mind when interpreting these results. In particular, our findings may not be generalized to all patients with cerebellar stroke but are likely to be representative of recovery only in that subset of patients who undergo inpatient rehabilitation therapy. This referral bias likely resulted in exclusion of certain patients, either because they were considered too impaired or not sufficiently impaired to be appropriate candidates for inpatient rehabilitation therapy. This is particularly likely to have been a factor with regard to the subgroup of patients with cerebellar hemorrhage, who are more likely to die or be severely disabled during the acute hospital stay.
In addition, the ceiling effect of the FIM may render it insensitive to residual deficits in activities of daily living, which are important for living in the community after hospital discharge. Also, we did not use a quality-of-life measure to evaluate residual effects of cerebellar stroke on physical, psychological, social, and economic domains, which are important from the patient’s perspective.19 Finally, because of the unavailability of some of the original CT and MRI scans, we relied on referral data describing the anatomic locations of stroke in some cases, which may have led to inaccuracy in assignment of vascular distribution of infarction for some of these patients.

Despite these considerations, the study has several advantages. First, we measured functional impairment and recovery, which is of greater relevance to the patient than measures of poststroke neurological deficit. Second, use of the FIM rather than the modified Rankin score allowed more accurate quantification of functional improvement, because the FIM is more highly responsive to change over time. Third, we describe new information concerning significant predictors of postrehabilitation and long-term outcome, which may be of practical utility in determining prognosis at the time of acute presentation. Fourth, preexisting comorbid conditions were taken into account in the analysis, which used a weighted, validated scale. Finally, long-term outcome after hospital discharge was assessed, because follow-up information was obtained in 75% of cases.

Overall, the data provide a more detailed description of factors affecting functional outcome after cerebellar stroke than has previously been available. Additional studies of larger cohorts of patients that include measures of both function and quality of life are required. These data will improve determination of prognosis in the acute stage and may help refine strategies for rehabilitation therapy.

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