Functional Outcome of Ischemic and Hemorrhagic Stroke Patients After Inpatient Rehabilitation
A Matched Comparison

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Background and Purpose—The goal of this study was to assess the specific influence of stroke etiology on rehabilitation results.

Methods—This was a case-control study of 270 inpatients with sequelae of first stroke who were enrolled in homogeneous subgroups and matched for stroke severity, basal disability, age (within 1 year), sex, and onset admission interval (within 3 days) who were different only in terms of stroke origin, infarction versus hemorrhage. We compared the groups’ length of stay, efficiency and effectiveness of treatment, and percentage of low and high responder patients. Odds ratios of dropouts and of low and high therapeutic response were also quantified.

Results—Compared with ischemic patients, hemorrhagic patients had significantly higher Canadian Neurological Scale and Rivermead Mobility Index scores at discharge; higher effectiveness and efficiency on the Canadian Neurological Scale, Barthel Index, and Rivermead Mobility Index; and a higher percentage of high responders on the Barthel Index. Hemorrhagic patients showed a probability of a high therapeutic response on the Barthel Index that was 2.5 times greater than that of ischemic patients (odds ratio, 2.48; 95% confidence interval, 1.19 to 5.20; accuracy on prediction, 87.06%).

Conclusions—The results of this study provide further evidence of better functional prognosis in stroke survivors with hemorrhagic stroke. (Stroke. 2003;34:2861-2865.)

Key Words: measures, outcome ■ rehabilitation ■ stroke

Strokes can be broadly classified as hemorrhagic or non-hemorrhagic. Intracerebral hemorrhage (ICH), classified as either primary or secondary, occurs in ~10% to 15% of all strokes and is associated with a higher risk of mortality compared with cerebral infarction (CI). Primary ICH, ranging from 78% to 88% of all hemorrhages, derives from the spontaneous rupture of small vessels damaged by chronic hypertension or amyloid angiopathy. Secondary ICH occurs in a minority of patients in association with vascular abnormalities, tumors, or impaired coagulation. About one half of all patients with primary ICH die within the first month after the acute event.

Regarding recovery, it is generally believed that hemorrhagic stroke survivors have better neurological and functional prognoses than nonhemorrhagic stroke survivors, but currently available data do not definitively answer all questions. In a case-control study, hemorrhagic stroke patients showed functional gains somewhat faster than ischemic patients, but their data were in disagreement with those of a prior study. In other outcome studies, other prognostic factors such as stroke severity, age, and onset-admission interval (OAI) showed to be relevant prognostic factors in functional outcome. However, multivariate models, used in most outcome studies, tend to be specific but less sensitive and do not allow a careful evaluation of the specific role of each factor in determining functional outcome.

Therefore, to obtain a clear characterization of the role of a potential prognostic factor on functional outcome, it should be necessary to perform a case-control study, with groups matched by a large number of variables, to avoid, minimize, or control for the role of several well-recognized risk factors.

Stroke severity is considered the most powerful prognostic factor because disability is a consequence of the severity of neurological impairment. Similarly, the strong positive relationship between initial and later disability is well known. Shah et al reported that initial disability was a powerful predictor of discharge Barthel Index (BI) score, and Oczkowski and Barreca found that the
absolute admission functional independence measure score was the best predictor of outcome disability and place of discharge. The strong positive relationship between increasing age and disability is well established. Recently, it was assessed that patients ≥85 years of age had a risk of low response in activities of daily living (ADL) that was ≈10 times greater than that of younger patients. Similarly, a short OAI has been recognized as a relevant favorable prognostic factor, and it has been reported that rehabilitation treatment begun within 20 days is associated with a 6-times-greater probability of high response compared with delayed treatment.

The aim of the present study was to clarify whether rehabilitation results were different between ischemic and hemorrhagic patients matched for several other factors and different only in stroke origin. Stroke severity, basal disability, age, sex, and OAI were controlled for in this study to rule out the influence of these relevant prognostic factors.

Methods

Subject Selection
Patients were recruited from stroke inpatient survivors admitted to our rehabilitation unit (50 beds) for rehabilitation of sequela of their first stroke. Our rehabilitation ward is part of a large, free-standing, university-affiliated rehabilitation institute. It is not associated with an acute general hospital. Admission is possible for all recent stroke survivors with functional disability or cognitive loss (International Classification of Diseases, ninth revision, diagnosis codes 431 through 438) without severe medical conditions that contraindicated physical therapy. A specific request for admission must be made by an acute care general hospital. In particular, threshold criteria for hospital admission included the possibility of participating actively in rehabilitation and tolerating intense daily treatment.

Ward physicians carefully evaluated the medical conditions of all patients before they were admitted. The rehabilitation staff included physicians (physiatrists, neurologists, cardiology, urologists, and otolaryngologists), neuropsychologists, nurses, physiotherapists, occupational and speech therapists, a social services care manager, dietitians, and support staff.

Stroke was defined as a sudden, nonconvulsive, focal neurological deficit persisting for >24 hours. On admission, patients were submitted to clinical, neurological, neuropsychological, and functional examinations. All patients were also submitted to neuroradiological examination. CT scan was performed in all patients because it is considered the most sensitive and specific test to evaluate ICH. In several cases, MRIs were also performed.

Patients with absence of brain lesion on CT scans or MRI were excluded to avoid enrolling transient ischemic attack patients. ICH was defined as a homogeneous, well-defined area of hypertenuous on CT scan. Among ICH patients, we enrolled only patients with sequelae of primary hemorrhage. Patients with sequelae of secondary hemorrhages (neurological deficits after surgical decompression of hemorrhages or trauma-, tumor-, or surgery-related hemorrhages) were excluded.

Also excluded were patients with subarachnoid hemorrhage, patients with previous strokes (including patients with full clinical remission), and those with other chronic disabling pathologies (ie, severe Parkinson’s disease; polyneuropathy; severe cardiac, liver, or renal failure; and cancer).

Patients were discharged after stabilization of functional status, revealed by 2 consecutive BI evaluations performed every 2 weeks.

Neuroradiological Classifications
From CT and/or MRI findings, patients’ strokes were classified as ICH or CI. CT scans and MRI were read independently and blindly by 2 hospital neuroradiologists, regardless of whether the patient was included in the present sample. Results were compared. In case of disagreement, the final interpretation was reached by consensus.

CIs were classified, according to Bamford and coworkers, as total anterior circulation infarcts, partial anterior circulation infarcts, posterior circulation infarcts, and lacunar infarcts. ICH were divided into deep and lobar hemorrhages. Deep hemorrhages included putaminal and thalamic hemorrhages; lobar hemorrhages included frontal, parietal, temporal, and parieto-occipital bleedings.

Neurological, Neuropsychological, and Functional Assessments
To measure severity of stroke, we used the revised and validated version of the Canadian Neurological Scale (CNS), with a cutoff score of 11.5 for normal patients. Functional data included rehabilitation length of stay (LOS), degree of autonomy in ADL (evaluated by BI), mobility status (evaluated by Rivermead Mobility Index [RMI]), effectiveness, and efficiency, and percentage of low and high responders to treatment.

Efficiency is the amount of improvement in the rating score of each scale divided by duration of rehabilitation stay; it represents the average increase per day obtained by therapy. Effectiveness is the proportion of potential improvement achieved during rehabilitation, calculated by the following formula: (discharge score–initial score)/(maximum score–initial score)×100. Therefore, if a patient achieves the top score after rehabilitation, effectiveness is 100%. Effectiveness and efficiency have been used in several recent studies on stroke rehabilitation.

As previously reported, patients whose treatment effectiveness on ADL and mobility was lower or higher than the mean±SD were considered low or high responders. The model was studied according to the concept that, in normal distribution, mean±SD generally includes two thirds of all observations. In the final sample, the distribution of effectiveness on ADL (measured by BI) was normal; the value of the ratio of skewness to its standard error value was 0.61 (0.093/0.152).

Matching
From the results of neuroradiological screening at the time of admission, stroke patients were divided into 2 groups, ischemic and hemorrhagic, matched by basal stroke severity (same CNS score), basal disability (same BI score), age (within 1 year), sex, and OAI (within 3 days). Matching was carried out by the ward physicians regardless of whether the patients were included in the present sample. The ward physicians were unaware of both the study design and patient outcome.

Treatment
Physical Rehabilitation
The rehabilitation plan, essentially based on practical ADL skills, was designed by the same physiatrist for all patients. Individual physiotherapy was performed for 60 minutes twice a day (only once on Saturday) for 6 days a week. Rehabilitation treatment began within 24 hours of admission. Each pair of patients was treated by the same therapists. If necessary, patients had access to daily training for unilateral spatial neglect or speech therapy or to individual training for swallowing, bowel, and bladder dysfunction.
Physiotherapy and language treatment continued throughout the hospital stay. Training for unilateral neglect lasted 8 consecutive weeks.

Data and Statistical Analyses
First, we compared demographic, clinical, neuroradiological, and functional data of the 2 age-matched subgroups using parametric or nonparametric analyses. Then, we performed logistic regressions to quantify the probability of poor or excellent therapeutic response, the risk of dropouts, and discharge destination. We considered “no home return patients” those who were admitted to institutional care after discharge or to other rehabilitation wards. If not otherwise noted, variables were coded as 1 or 0, depending on the presence or absence of the event. Independent variables were as follows: stroke severity (1=CNS score < 6, 0=CNS score ≥ 6), male sex, age ≥ 45 years, age 45 to 64 years, age 65 to 74 years, age 75 to 84 years, age ≥ 85 years, OAI ≤ 30 days, right hemiparesis/plegia, Broca’s aphasia, global aphasia, unilateral neglect, urinary incontinence, high school degree (> 8 years), poststroke late seizures, and hemorrhagic origin. Data analyses were performed with the SPSS 8.0 statistical package.

Results
We successfully matched 135 ischemic patients with hemorrhagic patients for stroke severity, age, basal disability, sex, and OAI. Clinical characteristics of the subgroups are shown in Table 1. As shown, characteristics of the 2 groups were the same except for hypertension (significantly more frequent in hemorrhagic patients), diabetes, and heart diseases (significantly more frequent in ischemic patients).

Among CIs, 46.7% were total anterior circulation infarcts, 13.3% were partial anterior circulation infarcts, 23% were lacunar infarcts, and 8.9% were posterior circulation infarcts. Among hemorrhagic patients, 56.3% of patients had had a deep hemorrhage, and 43.7% had had a lobar hemorrhage.

At discharge, both hemorrhagic and nonhemorrhagic patients had made significant gains in their CNS, BI, and RMI scores (P < 0.001 per all analyses, Wilcoxon test).

As shown in Table 2, ICH patients had a better rehabilitative prognosis than CI patients. In particular, at discharge, ICH patients showed significantly higher CNS score (see Figure 1); higher RMI score; higher effectiveness (see Figure 2) and efficiency on neurological, functional, and mobility status (on CNS, BI, and RMI); a significantly higher percentage of high responders on BI; and a significantly lower percentage of persistent incontinence (4.7% versus 12.4%). No difference was found in LOS and percentages of dropouts, low responders, and patients returning home. A trend toward better BI at discharge was observed in ICH patients compared with CI patients (P = 0.055, z = −1.92, Mann-Whitney test).

Patients with ICH showed a probability of a high therapeutic response on ADL that was 2.5 times greater than that of ischemic patients (odds ratio, 2.48; 95% CI, 1.19 to 5.20; B = 0.91; SE = 0.38; P < 0.05). The significance of the model was P < 0.001 (df = 5; \( \chi^2 = 192.14 \); accuracy of prediction, 87.06%).

Stroke origin did not enter models with low therapeutic response, dropout, and discharge destination as dependent variables.

Discussion
The question of whether hemorrhagic patients experience a better prognosis is currently inconclusively answered and merits further studies. In outcome studies, other prognostic factors (stroke origin, stroke severity, age, and OAI) were shown to strongly affect functional outcome. However, as previously reported, multivariate models, used in most outcome studies, tend to be specific but less sensitive and do not allow careful evaluation of the specific role of each factor in determining functional outcome. Using a case-control study, preferable for focusing on the role of each factor, has

| TABLE 1. Baseline Characteristics of the 2 Subgroups After Matching by Age and OAI |
|-----------------|-----------------|-----------------|
| ICH             | CI              | P               |
| n               | 135             | 135             | NA              |
| Age, y          | 66.22±10.57     | 66.24±10.47     | NS              |
| OAI, d          | 35.90±17.84     | 35.97±17.67     | NS              |
| Male sex, %     | 53.3            | 53.3            | NA              |
| CNS score at admission (mean±SD) | 5.60±2.07      | 5.60±2.07      | NA              |
| BI score at admission (mean±SD) | 25.48±20.07  | 25.48±20.07     | NA              |
| RMI score at admission (mean±SD) | 1.64±2.09      | 1.83±2.14      | NS              |
| Broca’s aphasia, % | 11.1           | 11.9           | NS              |
| Wernicke’s aphasia, % | 6.7           | 3.7            | NS              |
| Global aphasia, % | 12.6           | 17.8           | NS              |
| Unilateral spatial neglect, % | 23.7           | 24.4           | NS              |
| Urinary incontinence, % | 37.0           | 36.3           | NS              |
| Hypertension, %  | 60.0            | 44.4           | <0.05 (\( \chi^2 = 6.55 \)) |
| Heart disease, % | 12.6            | 28.1           | <0.005 (\( \chi^2 = 10.07 \)) |
| Diabetes, %     | 8.9             | 19.3           | <0.05 (\( \chi^2 = 6.00 \)) |
| Post-stroke seizures, % | 11.1       | 11.9           | NS              |
| PSD, %          | 40.0            | 35.6           | NS              |

PSD indicates poststroke depression.
produced contrasting data. On one hand, Chae and coworkers reported that hemorrhagic stroke patients showed functional gains somewhat faster than ischemic patients, but generalizability of these data was limited because of the use of few variables and the small size of the sample. On the other hand, Franke et al observed no difference in frequency in functional independence after 1 year of follow-up between ICH and CI patients.

Our data showed that ICH may have a better prognosis, but only in the absence of other more powerful prognostic factors. However, the impact of type of lesion on rehabilitative results is clear but not strong enough. If 2 patients at the beginning of rehabilitation had the same basal neurological severity, same basal functional disability, same age, same sex, and same OAI, hemorrhagic patients showed better neurological and functional prognosis compared with ischemic ones.

This better neurological and functional prognosis in the ICH group is due mainly to the different origins because the study design ruled out the influence of other well-known prognostic factors such stroke severity (measured by CNS), basal disability (measured by BI), age, sex, and OAI.7,8,10–21 Moreover, the 2 groups had no significant differences in other factors such as presence of different types of aphasia, unilateral spatial neglect, poststroke seizures or depression, and other relevant prognostic factors.11,28,29,33–36

The better functional recovery in ICH patients compared with CI patients is presumably due to a better neurological recovery. In fact, ICH patients had a higher effectiveness and a higher CNS score at discharge. Neurological status, evaluated by CNS, is considered to reflect recovery from the stroke lesion itself. Therefore, because the mechanisms for neurological deficit from ICH may be caused by brain compression, as the hematoma resolves, neurological functions recover and functional status, evaluated by BI and RMI, improves. Functional status is due to neurological recovery and compensatory capacity.

Care must be taken in generalizing our results. In particular, this was not a population-based study; therefore, not all stroke survivors were included. It was performed in a population admitted to a rehabilitation hospital and therefore selected on the basis of the need for physical rehabilitation. Obviously, our hemorrhagic patients represent the middle band of all hemorrhagic patients, ranging from dead patients in the acute phase to patients without sequelae. Furthermore,

**Figure 1.** Neurological status (CNS score) at admission and discharge. Admission ICH vs admission CI: not applicable. Discharge ICH vs discharge CI: z = −2.18, P < 0.05 (Mann-Whitney test). Discharge ICH vs baseline: z = −8.39, P < 0.001 (Wilcoxon test). Discharge CI vs baseline: z = −8.33, P < 0.001 (Wilcoxon test).

**Figure 2.** Effectiveness on neurological (CNS) and functional (BI and RMI) recovery (CNS < 0.01, F = 7.53; BI < 0.05, F = 6.34; RMI < 0.01, F = 6.94).

<table>
<thead>
<tr>
<th></th>
<th>ICH</th>
<th>CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths, %</td>
<td>0.7</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>Transfers, %</td>
<td>5.2</td>
<td>1.5</td>
<td>NS</td>
</tr>
<tr>
<td>CNS score at discharge (mean ± SD)</td>
<td>7.30 ± 2.05</td>
<td>6.68 ± 2.27</td>
<td>&lt;0.05 (z = −2.19)</td>
</tr>
<tr>
<td>BI score at discharge (mean ± SD)</td>
<td>60.47 ± 28.24</td>
<td>53.84 ± 28.89</td>
<td>NS</td>
</tr>
<tr>
<td>RMI score at discharge (mean ± SD)</td>
<td>6.57 ± 4.33</td>
<td>5.42 ± 3.90</td>
<td>&lt;0.05 (z = −2.07)</td>
</tr>
<tr>
<td>Effectiveness on CNS (mean ± SD)</td>
<td>27.80 ± 25.57</td>
<td>19.85 ± 20.54</td>
<td>&lt;0.01 (F = 7.53)</td>
</tr>
<tr>
<td>Effectiveness on BI (mean ± SD)</td>
<td>50.10 ± 30.45</td>
<td>40.83 ± 28.41</td>
<td>&lt;0.05 (F = 6.34)</td>
</tr>
<tr>
<td>Effectiveness on RMI (mean ± SD)</td>
<td>38.01 ± 28.84</td>
<td>29.27 ± 24.05</td>
<td>&lt;0.01 (F = 6.94)</td>
</tr>
<tr>
<td>Efficiency on CNS (mean ± SD)</td>
<td>0.02 ± 0.04</td>
<td>0.01 ± 0.01</td>
<td>&lt;0.01 (F = 7.55)</td>
</tr>
<tr>
<td>Efficiency on BI (mean ± SD)</td>
<td>0.50 ± 0.53</td>
<td>0.34 ± 0.27</td>
<td>= 0.002 (F = 9.50)</td>
</tr>
<tr>
<td>Efficiency on RMI (mean ± SD)</td>
<td>0.07 ± 0.07</td>
<td>0.05 ± 0.05</td>
<td>&lt;0.005 (F = 8.65)</td>
</tr>
<tr>
<td>LOS (mean ± SD), d</td>
<td>83.46 ± 43.97</td>
<td>85.00 ± 41.55</td>
<td>NS</td>
</tr>
<tr>
<td>Incontinence at discharge, %</td>
<td>4.7</td>
<td>12.4</td>
<td>&lt;0.05 (χ² = 4.80)</td>
</tr>
<tr>
<td>Low response on BI, %</td>
<td>18.9</td>
<td>23.4</td>
<td>NS</td>
</tr>
<tr>
<td>High response on BI, %</td>
<td>24.4</td>
<td>11.7</td>
<td>&lt;0.005 (χ² = 6.94)</td>
</tr>
<tr>
<td>Discharge home, %</td>
<td>88.2</td>
<td>86.8</td>
<td>NS</td>
</tr>
</tbody>
</table>
because these patients were selected to be matched, the study sample represents only a fraction of all stroke patients admitted to the study facility during the study period. Therefore, our data are useful for improving knowledge on rehabilitative prognosis of stroke survivors, not on the overall prognosis of patients. Despite these limitations, our study provides further evidence for better functional prognosis in survivors of hemorrhagic stroke.

References

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Stroke. published online November 13, 2003;

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