Improved Functional Outcome in Patients With Hemorrhagic Stroke in Putamen and Thalamus Compared With Those With Stroke Restricted to the Putamen or Thalamus

Ichiro Miyai, MD, PhD; Tsuchikiko Suzuki, MD, PhD; Jin Kang, MD, PhD; Bruce T. Volpe, MD

Background and Purpose—We analyzed the effect of late intensive inpatient rehabilitation on the functional outcome of patients with subcortical hemorrhagic stroke.

Methods—Patients who were nonambulatory with hemorrhagic stroke in the internal capsule and putamen (n=55), the thalamus (n=24), or all 3 regions (n=15) underwent intensive inpatient rehabilitation. Patients with surgical intervention or an episode of ventricular hemorrhage were excluded. Lesion location was evaluated by MRI 4 months after the ictus.

Results—Demographic data, initial disability, and impairment measures were comparable in the 3 groups. Functional outcome demonstrated significant differences in mobility subscores (P<0.05) of the Functional Independence Measure such that patients with injury in the 3 regions were more likely to ambulate independently than were patients in the other groups. Lesion location data demonstrated that the ventral anterior nucleus of the thalamus was always spared; the ventral posterior (lateral and medial) nucleus was always damaged, and the ventral lateral nucleus was frequently damaged. Putaminal damage always included the postcommissural area. In addition, the entire posterior half limb of the internal capsule was always damaged.

Conclusions—Subcortical lesions to multiple structures in the basal ganglia–thalamocortical motor circuits permitted enhanced motor recovery. Lesion location predicted the level of independent ambulation and the rate of recovery in patients with stroke who were nonambulatory before neurorehabilitation therapy. (Stroke. 2000;31:1365-1369.)

Key Words: cerebral hemorrhage • putamen • rehabilitation • thalamus

Outcomes and functional imaging studies have demonstrated that recovery mechanisms proceed at different rates1-4 and as a function of lesion size and location.5-7 Furthermore, they have enhanced an understanding of the pathogenesis of the late consequences of stroke by suggesting candidate brain regions that may underlie recovery. For example, recent studies have demonstrated that middle cerebral artery stroke in which damage extends to the premotor cortex (PMC) has been associated with poor functional outcome.8,9 Clearly, damage that includes the parallel outputs from the primary motor area, PMC, and supplementary motor area (SMA) magnifies the functional disability and diminishes the response to rehabilitation efforts.10-12 These structure-function relationships prompted us to test whether location of damage restricted to the subcortical structures (putamen [Pt] and thalamus [Th]) differentially affected functional outcome. Neuroimaging information was obtained during a chronic stable phase after hematoma and edema resolution.

Subjects and Methods

We screened 132 consecutive patients with subcortical hemorrhage and without a previous history of cerebrovascular disease. The conventional treatment required patients to remain in the local acute care hospitals and receive some physical therapy for 2 to 3 months. Patients who remained persistently dependent and nonambulatory were transferred to the Bobath Memorial Hospital for inpatient rehabilitation. On average, 106 days (±6 SEM) after the acute stroke, the patients who were persistently nonambulatory began this study and their rehabilitation.13 Patients with severe medical complications (n=17) participated in abbreviated programs, but they were excluded because they were not available for weekly assessments. Patients with isolated motor or visual deficits (n=14) were excluded in favor of patients with more severe deficits in motor, vision, and sensory processing.14 Patients who required surgical intervention (n=20) or who sustained ventricular hemorrhage (n=12) were excluded. With these criteria, 94 patients with subcortical hemorrhage with motor, vision, and sensory deficits were identified for further study.

The location and distribution of the lesion were specified with MRI (1.0-T superconductive: Shimadzu MAGNEX Epios10, 8.5 mm, slice thickness) that included T2-weighted (repetition time...
3630 ms, echo time 110 ms) axial spin echo images and T1-weighted (repetition time 500 ms, echo time 15 ms) axial spin echo images. MRIs were taken an average of 4 months after the ictus. The rationale for this timing is delineated later. On the basis of image anatomic information, patients were divided into 3 groups: those with damage to the Pt (n=55), Th (n=24), and Pt and Th (P+T; n=15). Lesion volume was calculated with NIH Image Version 1.60.9

There is information about the change in hemorrhage size over time with CT images15; less information is available for MRIs, so in 7 patients, we evaluated the change in size of the hematoma with serial T1- and T2-weighted images taken on admission and repeated every 2 months. Lesion density maps for each patient were made with the use of standardized horizontal templates16 and NIH Image 1.60.

At Bobath Memorial Hospital, all patients participated in rehabilitation according to the standards of the neurodevelopmental technique, which includes one 45-minute session of physical therapy and one 45-minute session of occupational therapy, 5 days a week.15,17 On admission and discharge, functional outcome was evaluated with the use of standardized measures of documented reliability: the Functional Independence Measure (FIM) for disability18 and the Stroke Impairment Assessment Set (SIAS) for neurological impairment19,20 We also analyzed motor and cognition subscores of FIM. Motor subscores of SIAS (0 to 25) consist of 2 tests for the upper extremity (0 to 10) and 3 tests for the lower extremity (0 to 15). Sensory subscores of SIAS (0 to 12) evaluate superficial sensation and deep sensation of the affected upper (0 to 6) and lower (0 to 6) extremities. The sitting balance subscore of SIAS ranges from 0 (cannot sit without support) to 3 (normal sitting balance). Trained nurses rated the FIM, and physicians, who were blinded to lesion location, rated the SIAS. FIM evaluation was performed every 2 to 3 weeks, and when FIM score reached a plateau, the patient was discharged. Interrater reliability for individual items of SIAS and FIM was estimated with the use of a weighted \( \kappa \) statistic (n=16).21 and the correlation among raters was good to very good (\( \kappa =0.62 \) to 0.93). Spearman correlation coefficients across the raters were significant for total SIAS score (0.944, \( P<0.0005 \)) and total FIM score (0.973, \( P<0.0005 \)). These reliability measures have been used and tested previously.9

Because of the interval impairment and disability outcome measures, the statistical analysis was performed with the Kruskal-Wallis test. Demographic data were analyzed with ANOVA and \( \chi^2 \) test. Changes in lesion volume was analyzed with a repeated measures ANOVA followed by a post hoc test (Fisher’s least significant difference test). The level of significance was accepted at \( P<0.05 \).

All statistical analyses were performed with the use of SPSS for Microsoft Windows, version 8.0J.

**Results**

Lesion volume shrank significantly between 2 and 4 months on the T1- and T2-weighted images, but lesion volume was unchanged between 4 and 6 months on both the T1- and T2-weighted images (Figure 1 and Table 1). We used the T2-weighted image of MRI taken 4 months after hemorrhage to evaluate the site and volume of lesions, because the border of the lesion was easier to delineate on T2- than on T1-weighted images. As expected, lesion volume on T2-weighted image at 4 months after the onset was larger (\( P<0.05 \)) in \( P+T \) (8.48 cm\(^3 \)) than in Pt (6.42 cm\(^3 \)) or Th (6.25 cm\(^3 \)) groups. The incidence of the wallerian degeneration as detected with MRF22 was comparable in the groups (Table 2).

| TABLE 1. Changes in Lesion Volume on MRI in Patients With Subcortical Hemorrhage |
|---------------------------------|--------|--------|--------|
|                                 | 2 mo   | 4 mo   | 6 mo   |
| Volume, cm\(^3\)               |        |        |        |
| T1 WI                           | 6.20 (0.61) | 4.17 (0.51)* | 4.10 (0.52)* |
| T2 WI                           | 6.20 (0.64) | 4.19 (0.55)* | 4.13 (0.57)* |
| Reduction in volume, %          |        |        |        |
| T1 WI                           | 0      | 33.1 (3.2)* | 34.6 (3.4)* |
| T2 WI                           | 0      | 33.9 (3.5)* | 34.8 (3.5)* |

WI indicates weighted image. Values in parentheses indicate SEM. \( n=7 \).

*\( P<0.001 \) from baseline at 2 mo (Fisher’s least significant difference test).
Demographic data are shown in Table 2. Mean age, days after stroke, length of stay, Mini-Mental State Examination, sex, and location of lesion were comparable in the 3 groups. All patients had hemiparesis and hemisensory deficits (as scored on the sensory subscale of SIAS). All patients in the Th and P+T groups and most of the patients in the Pt group had spastic hemiparesis. Six of 55 patients in the Pt group had flaccid hemiparesis.

Baseline scores of FIM and SIAS on admission and gain after inpatient rehabilitation are shown in Table 3. The Kruskal-Wallis test demonstrated that the groups were comparable on admission impairment and disability scales. By discharge, the analysis revealed significant differences among the groups on disability measures but not impairment measures. Specifically, there was a significant difference in the gain of mobility subscore of FIM, and there were no significant differences in the gain of total FIM scores, ADL subscores, cognition subscores, motor scores of SIAS, SIAS for sensation, and SIAS for sitting balance. Subsequent Mann-Whitney test showed that the gain in mobility subscore of FIM was significantly higher in the P+T group than in the Th group ($P < 0.05$). There was a trend indicating the P+T group also gained more on the mobility subscore than the Pt group ($P = 0.058$).

These statistical changes have clinical relevance in that 53.3% (8 of 15) of the P+T group were independent in ADL and mobility on discharge, whereas these levels of functional independence were attained by only 41.8% in the P group and 33.3% in the T group. Because ambulation was crucial for a discharge to home instead of a long-term care facility, we performed an additional analysis on the probability that the lesion site predicted independent ambulation. The probability of ambulation without physical assistance was 60% (33 of 55) in the Pt group, 62.5% (15 of 24) in the Th group, and 93.3% (14 of 15) in the P+T group ($\chi^2, P < 0.05$).

Discussion

These data demonstrate that patients with stroke who experienced intensive multidisciplinary rehabilitation 3 months later continued to improve their functional outcome, particularly with regard to independent ambulation. The results suggest that patients with sensorimotor deficits after hemorrhagic injury of both the Pt and Th have better functional outcome than those with less extensive hemorrhagic injury limited to either the Pt or Th alone. Significant changes in disability or functional outcome occurred in the context of comparable improvement in impairment among all groups. Because the treatment for each group was similar, the different outcomes may depend on the characteristics of the injury. Indeed, our patients form a special subgroup of those with subcortical hemorrhage; namely, they survived a subcortical hemorrhagic stroke without surgical intervention, and they were evaluated during the initial 4 months after the ictus. Several studies have demonstrated that patients with acute thalamic hemorrhage, particularly with extension to the ventricles, often require surgical intervention and have a poor prognosis.23–25 Although the present data cannot specify the mechanism by which combined damage to the Pt and Th (the P+T group) leads to enhanced functional outcome, there are a number of possible explanations.
Disability measures. FIM mobility scores, and ambulation demonstrated greater improvement in P+T than in Pt or Th, but there were no significant differences in the change in impairment scores. Our previous report demonstrated that disability recovery might occur without a change in impairment. In fact, there are several precedents for significant reduction in disability without change in impairment score. In general, rehabilitation efforts have been concerned with compensation for function rather than amelioration of neurologic deficit. As our understanding of the pathogenesis of disability grows, it may be possible to focus on changing the level of impairment, too.

Acknowledgments
This work was supported by funds for the comprehensive research on aging and health in Japan. We thank Naomi Hoshina for assistance with data collection.

References


Improved Functional Outcome in Patients With Hemorrhagic Stroke in Putamen and Thalamus Compared With Those With Stroke Restricted to the Putamen or Thalamus
Ichiro Miyai, Tsunehiko Suzuki, Jin Kang and Bruce T. Volpe

Stroke. 2000;31:1365-1369
doi: 10.1161/01.STR.31.6.1365

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2000 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/31/6/1365

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org//subscriptions/