Recovery From Aphasia After Hemicraniectomy for Infarction of the Speech-Dominant Hemisphere

Frank Kastrau, MD; Marcus Wolter, MD; Walter Huber, PhD; Frank Block, MD

Background and Purpose—The space-occupying effect of cerebral edema limits survival chances of patients with severe ischemic stroke. Besides conventional therapies to reduce intracranial pressure, hemicraniectomy can be considered as a therapeutic option after space-occupying cerebral infarction. There is controversy regarding the use of this method in patients with infarction of the speech-dominant hemisphere.

Methods—In 14 patients with infarction of the dominant hemisphere and subsequent treatment with hemicraniectomy, recovery from aphasic symptoms was evaluated retrospectively. A group of patients who were treated between 1994 and 2003 in our aphasia ward was selected for the study. In all patients, a psychometric quantification was accomplished applying the Aachen Aphasia Test at least twice within a mean observation period of 470 days.

Results—A significant improvement of the statistical parameters representing different aspects of aphasia was observed in 13 of 14 patients. Also, an increase of the ability to communicate was evident in 13 patients. Young age at the time of stroke and early poststroke decompressive surgery were identified as main predictors for recovery from aphasia.

Conclusions—A significant improvement of aphasic symptoms can be observed in a preselected group of patients after a massive stroke of the speech-dominant hemisphere treated by consecutive hemicraniectomy. Therefore, decompressive surgery can be considered for the treatment of this kind of stroke. (Stroke. 2005;36:825-829.)

Key Words: aphasia ■ cerebral infarction ■ craniotomy ■ recovery of function

The majority of stroke patients with space-occupying supratentorial infarctions have a fatal outcome. Conservative therapy of brain edema and consecutive transtentorial brain herniation is confined to hyperventilation, osmotherapy, barbiturate, and tris(hydroxymethyl)aminomethan buffer infusions. Despite this treatment, mortality of patients is up to 80%. Frequently, removal of a bone flap and opening of the dura to relieve pressure and prevent transtentorial and uncal herniation can be appropriate life-saving procedures. This technique was first applied in 1905, and since 1950, it was more frequently reported in the context of therapy of space-occupying infarction. Besides the improvement of cerebral perfusion, hemicraniectomy protects against herniation and may lower the mortality of stroke patients. Recent studies have shown that decompressive hemicraniectomy can decrease mortality to 21% to 35%. After hemicraniectomy, the Barthel Index was reported to vary from 56% to 65% in unselected patients with middle cerebral artery territory stroke. Clinical observations suggest that the long-term quality of life and the functional outcome of rehabilitation in surviving patients may significantly improve after hemicraniectomy. Presently, to our knowledge there is no existing randomized prospective trial of patients with space-occupying infarctions in evaluation of functional outcome.

A series of factors is likely to affect long-term functional outcome after successful hemicraniectomy. For example, Schwab et al reported early decompressive surgery (<24 hours) to act as an important predictor of a good functional outcome. In elderly patients (older than 55 years) with a space-occupying infarction, hemicraniectomy also improves survival rates compared with medical treatment alone. However, the functional outcome and the level of the patients’ autonomy are rather poor, suggesting that predominantly younger patients should be considered for decompressive surgery. The conclusion of a recent systematic review by Gupta et al verifies age as the crucial factor in predicting the functional outcome after hemicraniectomy.

Although the clinical features of malignant middle cerebral artery territory infarction are well-known, limited data exist referring to the clinical course of aphasic symptoms after space-occupying infarction of the speech-dominant hemisphere. Only approximately one-quarter of available data on decompressive craniectomy after infarction characterize sequelae of massive stroke of the speech-dominant hemisphere, even though functional outcome was no worse among the patients with left hemisphere infarctions as compared with patients with right hemisphere infarctions. The clinical course and recovery from aphasia after decompressed infarc-
tions of the speech-dominant hemisphere have not been described so far.

In our article, we present follow-up data for the recovery from aphasia in patients after hemicraniectomy caused by infarction of the speech-dominant hemisphere.

**Patients and Methods**

The clinical and neurolinguistic data from 14 patients (9 men, 5 women; mean age 39 ±7 years) with severe supratentorial infarctions of the speech-dominant hemisphere (13 left side, 1 right side) and consecutive hemicraniectomy were evaluated retrospectively. The initial treatment, including decompression surgery after stroke, was performed in different clinics in Germany. Between 1994 and 2003, the patients were evaluated and treated for at least 7 weeks in our aphasia ward (7 patients were treated once, 5 patients twice, and 2 patients 4 times). Only patients without a higher requirement of assistance in every-day life were treated on this ward. The mean treatment frequency in our ward was ~10 hours of therapy per week. The average latency period from acute stroke until admission was 538 days (range, 105 to 1207). An examination of speech is routinely performed before their admission and at the end of their stay in hospital.

Aphasia was assessed using the Aachen Aphasia Testing Battery. For clinical classification of speech dysfunctions, subtests of oral repetition, written language, naming, comprehension, and the Token Test, as well as the analysis of spontaneous speech (communication behavior, articulation and prosody, automated language, semantics, phonetics, and syntax), were applied. A nonparametric discrimination analysis program (ALLOC) was used for the classification of patients with language disorders. The comparison of test results in observation of the recovery from aphasia based on a psychometric single case assessment proposed by Huber was developed in a computer program for practical use by Willmes (CASE123/version beta 0.6). After applying the subtest scores to a profile level is ascertained as global index of each test result. A comparison of subtest differences and global profile level differences in a clinical course is easily realizable by a 1-sample t Test. The comparison between the consecutive global profile levels and the clinical syndrome classification in each patient was performed for the first and the last available test results (median whole observation period, 470 ±477 days; range, 44 to 1552). Additionally, a comparison has been performed between the next to last and the last test results (median observation period, 176 ±141 days; range, 44 to 427).

The psychometric classification procedure with ALLOC gives a probability for the name of syndrome and a syndrome severity grading for each examination. A change in the aphasic syndrome can be characterized by changing the syndrome-specific severity grading, as well as the syndrome naming.

All values are expressed either as median or as mean ± standard deviation. The influence of clinical parameters and of temporary factors on the recovery from aphasia is determined for the univariate subgroup analysis with a 2-sample t test and for multivariate examinations with the multiple linear regression analysis from the program package SPSS (version 10.0).

The assessment of the final infarct demarcation in all patients was performed with a cranial computed tomography after the re-implantation of the bone flap. The configuration and the size of the cerebral defect were assigned descriptively to the artery territory.

**Results**

Decompressive surgery was accomplished 2.1 ±1.4 days after the occurrence of the ischemic event. In all patients, the territory of the middle cerebral artery was damaged in the respective hemisphere. In 3 cases, there was additional damage within the region of the anterior cerebral artery. A symptomatic seizure disorder developed during the course of the disease in 9 of 14 patients. Table 1 displays demographic data, infarct localization, and the single case analysis of the aphasic disorder for each single patient.

**Test Performance**

For the whole observation period, a significantly positive improvement was observed for 13 of 14 patients in the level of their aphasic test results. On average, performance improved by 11% (range, 2% to 25%). For the 6-month period

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**TABLE 1. Clinical and Demographic Data**

<table>
<thead>
<tr>
<th>No.</th>
<th>Age (y) and Sex</th>
<th>Delay Stroke-Surgery, d</th>
<th>Infarction</th>
<th>Latency Until First Examination, d</th>
<th>Profile Level</th>
<th>Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22, F</td>
<td>1</td>
<td>Partial left MCA</td>
<td>380</td>
<td>58.5</td>
<td>60.1*</td>
</tr>
<tr>
<td>2</td>
<td>50, M</td>
<td>3</td>
<td>Partial left MCA</td>
<td>643</td>
<td>38.9</td>
<td>38.6*</td>
</tr>
<tr>
<td>3</td>
<td>38, M</td>
<td>1</td>
<td>Partial left ACA, partial left MCA</td>
<td>109</td>
<td>41.1</td>
<td>51.6*</td>
</tr>
<tr>
<td>4</td>
<td>35, M</td>
<td>1</td>
<td>Partial left MCA</td>
<td>104</td>
<td>47.1</td>
<td>53.0*</td>
</tr>
<tr>
<td>5</td>
<td>45, M</td>
<td>4</td>
<td>Partial right MCA</td>
<td>319</td>
<td>54.0</td>
<td>60.6*</td>
</tr>
<tr>
<td>6</td>
<td>35, F</td>
<td>1</td>
<td>Partial left ACA, nearly complete left MCA</td>
<td>722</td>
<td>47.3</td>
<td>50.9*</td>
</tr>
<tr>
<td>7</td>
<td>45, M</td>
<td>3</td>
<td>Nearly complete left MCA</td>
<td>1064</td>
<td>38.1</td>
<td>40.6*</td>
</tr>
<tr>
<td>8</td>
<td>42, M</td>
<td>1</td>
<td>Partial left MCA</td>
<td>673</td>
<td>41.9</td>
<td>43.0*</td>
</tr>
<tr>
<td>9</td>
<td>44, M</td>
<td>0</td>
<td>nearly complete left MCA</td>
<td>145</td>
<td>42.2</td>
<td>45.9*</td>
</tr>
<tr>
<td>10</td>
<td>37, F</td>
<td>2</td>
<td>Partial left ACA, partial left MCA</td>
<td>429</td>
<td>40.4</td>
<td>42.4*</td>
</tr>
<tr>
<td>11</td>
<td>34, F</td>
<td>2</td>
<td>Nearly complete left MCA</td>
<td>102</td>
<td>36.0</td>
<td>36.9†</td>
</tr>
<tr>
<td>12</td>
<td>42, M</td>
<td>1</td>
<td>Nearly complete left MCA</td>
<td>33</td>
<td>41.3</td>
<td>52.9*</td>
</tr>
<tr>
<td>13</td>
<td>32, F</td>
<td>2</td>
<td>Partial left MCA</td>
<td>843</td>
<td>47.7</td>
<td>55.2*</td>
</tr>
<tr>
<td>14</td>
<td>45, M</td>
<td>2</td>
<td>Partial left MCA</td>
<td>175</td>
<td>40.3</td>
<td>42.8*</td>
</tr>
</tbody>
</table>

*Significant change to the last profile level.
†Not significant.

A indicates amnesic aphasia; ACA, anterior cerebral artery; B, Broca aphasia; G, global aphasia; MCA, middle cerebral artery; W, Wernicke aphasia.
5 indicates severe; 4, severe medium; 3, medium; 2, medium slight; 1, slight aphasia.
between the 2 latest examinations, the significant gain in aphasia profile level is clearly lower (6%). Figure 1 shows the patient’s average percentage of improvement in aphasia profile level for each period of interest.

Aphasic Syndrome

Initially, 10 patients had global aphasia, 3 patients had Broca aphasia, and 1 patient had Wernicke aphasia. A positive change of syndrome was recognized in 13 of 14 patients over the whole period. At the time of our last examination, we classified 7 slighter global aphasia syndromes, 5 Broca aphasia syndromes, just 1 amnesic aphasia syndrome, and 1 medium/medium-slight Wernicke aphasia syndrome in the group of patients. The improvement of the aphasic syndrome, within the time of our observation, depends on patient’s age. A subgroup of elderly patients (n=6, 43.9±5.2 years) had an improvement of, at most, 1 level on the syndrome-specific severity grading. The younger patients’ subgroup (n=8, 36.1±7.2 years) revealed a stronger improvement (≥1 level on syndrome-specific severity grading; P=0.037), and in their latest examination the aphasic syndrome was significantly less classified as a global aphasia. A multivariate regression analysis (including age, sex, time to surgery, starting profile level, latency to first and latest examination, and frequency of intensive therapy) identified only lower age as a significant positive predictor for considerable increase in syndrome grading. There seems to be a correlation between the patient’s age and an early decompressive surgery, whereby younger patients receive an earlier hemicraniectomy. In the multivariate regression analysis, a lower age and an early surgery mark a positive predictor for a maximal gain in the aphasia profile level (age, P=0.0005; time of surgery, P=0.0025).

A variable frequency of inpatient treatment and a varying initial appearance in the aphasia ward caused the wide interindividual range of examination dates within our patients’ group. A significant correlation between the data of first examination with Aachen Aphasia Test, the first inpatient treatment, and a modification of profile levels could not be found.

Independent from the observation period, patients with slighter aphasic syndromes with initially good aphasia test results have better chances to reach a higher aphasia score over time. Those who have a severe aphasia initially only show little improvements in the aphasia score (P<0.0001).

The results of the Aachen Aphasia Test in our patients are comparable with aphasia profiles from a historical group of treated aphasic patients after ischemic infarction without hemicraniectomy. These subjects were grouped in patients with an early-phase (duration, 1 to 4 months), a late-phase (duration, 4 to 12 months), and a chronic-phase (duration, >12 months) aphasia, patient selection and order of therapy were the same in both the present group and the historical group. The estimated influence of spontaneous recovery on individual improvement was obtained by subtracting the corresponding mean t score difference (beginning and end of treatment period) from an untreated control group. A correction for spontaneous recovery is necessary in the early and late group data, but not in the chronic group. The comparison between the late and the chronic group is somewhat limited because of differences in age (Table 2). These patients without hemicraniectomy displayed a similar distribution of aphasic syndromes as those with hemicraniectomy. The increase of subtest scores and profile levels are comparable.

Discussion

The most frequent cause of death after space-occupying supratentorial middle cerebral artery infarction is the massive brain swelling with a consecutive transtentorial herniation. In those stroke victims with unilateral hemispheric edema, surgical decompression through hemicraniectomy may be an effective alternative. A series of reports indicate higher survival rates and a better functional outcome in patients with a severe ischemic stroke who are treated with decompressive hemicraniectomy. Although hemicraniectomy may save the patient’s life, it may lead to a severely impaired life with numerous social, occupational, and psychological consequences. However, it is rather difficult to make the decision for surgical intervention in individual patients. In this context, aphasic symptoms are serious profound disabilities. Decompressive surgery in patients with infarction of the speech-dominant hemisphere is 4-times lower than in patients with infarction of the nondominant hemisphere. The most important reason for this is the difficulty to come to an ethically responsible decision for each individual patient before the surgical intervention. Hence, the question arises whether the outcome after intensive aphasia therapy is really hopeless. There has not yet been any detailed research performed regarding aphasic dysfunctions in patients with hemicraniectomy. However, the present data show an increase in profiles of subtest scores and an improvement in aphasic syndrome classifications, including the spontaneous speech within a mean observation period of 16 months. A comparison with historical outcome data from aphasic patients without hemicraniectomy shows a similar recovery from aphasia. The validity of our data is limited by retrospective analysis, the small number of subjects, and the kind of patient selection: only patients without a higher requirement of assistance in everyday life were treated on the ward and could be included in the study. This selection is essential for the learning ability required during the demanding aphasia...
TABLE 2. Distribution of Type of Aphasia, Initial AAT Subtest t Score Means and Mean t Score Improvement

<table>
<thead>
<tr>
<th>No. of Patients; Median Age, y</th>
<th>Initial t Score Means Improvement</th>
<th>Initial t Score Means Improvement</th>
<th>Initial t Score Means Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAT subtests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Token test</td>
<td>42.0 (6.5) 1.8 (4.0)</td>
<td>47.5 (12.2) 1.0 (4.1)</td>
<td>44.7 (5.8) 1.1 (2.8)</td>
</tr>
<tr>
<td>Repetition</td>
<td>44.0 (6.5) 5.5 (5.2)</td>
<td>45.9 (7.9) 2.2 (2.1)</td>
<td>45.4 (6.1) 0.7 (2.1)</td>
</tr>
<tr>
<td>Written language</td>
<td>46.5 (12.2) 2.5 (3.7)</td>
<td>47.1 (11.3) 3.5 (4.4)</td>
<td>45.2 (6.4) 1.9 (2.5)</td>
</tr>
<tr>
<td>Naming</td>
<td>45.3 (9.7) 1.5 (2.9)</td>
<td>47.0 (11.3) 2.6 (3.8)</td>
<td>46.2 (8.2) 1.4 (1.6)</td>
</tr>
<tr>
<td>Comprehension</td>
<td>43.8 (5.3) 1.3 (3.6)</td>
<td>48.1 (13.2) 4.0 (7.5)</td>
<td>47.9 (10.2) 4.3 (3.5)</td>
</tr>
<tr>
<td>Profile level</td>
<td>44.5 (8.0) 3.1 (2.8)</td>
<td>46.8 (9.4) 2.5 (2.3)</td>
<td>45.5 (6.4) 1.2 (0.8)</td>
</tr>
<tr>
<td>Type of aphasia (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global</td>
<td>2 (50)</td>
<td>12 (46)</td>
<td>5 (56)</td>
</tr>
<tr>
<td>Broca</td>
<td>1 (25)</td>
<td>5 (19)</td>
<td>3 (33)</td>
</tr>
<tr>
<td>Wernicke</td>
<td>1 (25)</td>
<td>5 (19)</td>
<td>0</td>
</tr>
<tr>
<td>Nonclassifiable</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Amnesic</td>
<td>0</td>
<td>4 (15)</td>
<td>1 (11)</td>
</tr>
</tbody>
</table>

Initial mean AAT subtest t score and profile level, mean t score and profile level improvement after a first intensive treatment (7 weeks), and distribution of type of aphasia in patients with and without decompressive hemicraniectomy in subgroups with first treatment 4 to 12 months or >12 months after onset of aphasia (standard deviation in parentheses unless otherwise noted).

therapy. Even with such restrictions, our data emphasize an almost “normal” recovery of aphasic symptoms after space-occupying infarction with consecutive hemicraniectomy. The mechanisms of recovery from aphasia have not been examined thoroughly enough and are currently the subject of functional imaging studies. Both the contralateral activation in homologous areas of speech processing and the perilesional activation in the ipsilateral speech areas may be used as the preferred explanatory model. An existing correlation between the intensity of aphasia therapy and speech-related improvements seems quite obvious. Patients who received more intensive therapy besides the common outpatient treatment of speech therapy have an even significantly higher increase in the psychometric test results. This observation is supported by a meta-analysis that evaluates the therapy intensity and the recovery from poststroke aphasia.23 Our data suggest a correlation between the age at the time of ischemic stroke and the recovery from aphasia. Younger patients achieve milder forms and the velocity of recovery is higher. Comparable results were already reported earlier.8.24 Another independent and significant connection exists between an early decompressive surgery and a higher increase of the test scores. Correlation between an early decompressive surgery without any sign of herniation and a better Barthel Index score after 3 months were detected by Schwab.3 The question of for who and when a decompressive surgery after space-occupying cerebral infarction produces best functional results can thus be answered easily in this context: younger patients and patients with short delay to surgery after stroke have the best outcome.

The results of our investigation display a broad variety of improvements of aphasia in nearly all patients (93%). At present, an aphasic disturbance after infarction of the speech-dominant hemisphere has an important impact on the decision for hemicraniectomy in many centers. Our data demonstrate that aphasic patients can benefit from a hemicraniectomy.

Acknowledgments
This research was supported by the Interdisciplinary Centre for Clinical Research (ICCR) CNS Division, University Hospital Aachen.

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Stroke. 2005;36:825-829; originally published online February 10, 2005;
doi: 10.1161/01.STR.0000157595.93115.70
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

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