The Natural History of Hemispheric and Brainstem Infarction in Rochester, Minnesota

THERESA M. TURNERY, M.B., B.S.*, W. MICHAEL GARRAWAY, M.D.†
AND JACK P. WHISNANT, M.D.

SUMMARY All cases of first episodes of brain infarction occurring in the population of Rochester, Minnesota, from 1960 through 1979 were categorized as hemispheric or brainstem (including cerebellar) on the basis of clinical criteria, autopsy evidence, and the results of computed tomography (from 1973 on). Hemispheric infarction was 5 times more frequent than infarction of the brainstem and/or cerebellum. The magnitude of the decline in incidence was the same in each group during the 20-year period of the study. Thirty-day case fatality was similar in each group, but patients with brainstem infarction had a better long-term survival. Functional outcome among survivors of brainstem infarction was also better, 35% having returned to independent living by 1 year after onset compared with 22% of survivors of hemispheric infarction. This may have been a consequence of the higher proportion of residual cognitive and sensory impairments present in survivors of hemispheric infarction.

Our understanding of the relationship of frequency, clinical presentation, and prognosis of brain infarction to whether it is located in the cerebral hemispheres, brainstem, or cerebellum is based on case series or autopsy studies. These have led to conflicting conclusions. For example, Marshall and Kaeser found that the prognosis was worse for patients with brainstem infarction than for those with hemispheric infarction. Others have concluded that patients with brainstem infarctions had a lower mortality than those with hemispheric infarctions.

The study reported here was carried out in a defined population in which virtually complete case ascertainment is ensured. Its goal was to clarify the frequency, clinical presentation, course, and prognosis of infarction in the cerebral hemispheres and in the brainstem or cerebellum.

Methods

Cases of brain infarction that occurred in the population of Rochester, Minnesota, in the period 1960 through 1979 were identified from the medical records at the Mayo Clinic. These records are indexed and are retrievable by diagnosis. The methods of ensuring complete case ascertainment have been described elsewhere.

A brain infarct was identified by the relatively rapid onset of a focal neurological deficit arising as a result of a presumed vascular lesion, persisting for 24 hours or longer, and associated with clear cerebrospinal fluid and no evidence of hemorrhage on a computed tomography (CT) scan (available from 1973 on).

All cases of brain infarction were included whether or not a recognized source of embolus was present. Transient ischemic attacks, in which the neurological deficit lasted less than 24 hours, were excluded as were primary subarachnoid hemorrhages and primary or secondary intracerebral hemorrhages. No attempt was made to separate brainstem and cerebellar infarcts because of the overlap of signs and symptoms occurring with lesions at these sites.

At least one of the following criteria had to be present in order to classify the infarct as being located in the brainstem or cerebellum: (a) bilateral motor signs; (b) bilateral sensory signs; (c) right, left, or bilateral cerebellar signs or symptoms; (d) diplopia plus any combination of a, b, c, d, e, f; (e) vertigo plus any combination of a, b, c, d, e, f; (f) dysphagia or dysarthria or both plus any combination of a, b, c, d, e, f.

A brain infarct with a focal neurological deficit that did not fit any of these criteria was classified as a hemispheric lesion. The infarct was classified as hemispheric if aphasia was present, unless all other signs were more compatible with brainstem infarction.

The medical records of all first episodes of brain infarction that occurred between January 1, 1960, and December 31, 1979, among residents of Rochester were reviewed, and the cases were assigned to one of the two anatomic diagnostic categories — brainstem/cerebellar or hemispheric infarction — according to the information available. If an autopsy or CT scan of the head had been performed, the information gained was a determining factor in assigning the case to a diagnostic category. In a few cases in which the predominant signs were hemispheric but there also were minimal signs compatible with a brainstem/cerebellar location — or in the converse situation — a clinical judgment was made by one of us (J.P.W.) as to the site of primary infarction. The autopsy rate was 43%. CT was introduced in Rochester in 1973; 49% of all cases of cerebrovascular disease occurring in residents of Rochester included this examination between 1975 and the end of 1979.

Information was obtained from the medical records

* From the Departments of Medical Statistics and Epidemiology and of Neurology, Mayo Clinic and Mayo Foundation, Rochester, Minnesota. This investigation was supported in part by Research Grants NS-06663 and AM-30582 from the National Institutes of Health, Public Health Service. Present Addresses: *Dr. Turney, Department of Family and Community Medicine, Newcastle-Upon-Tyne, NE1 7RU, England. †Dr. Garraway, Department of Community Medicine, Edinburgh, EH9 1DW, Scotland.

Address correspondence to: Jack P. Whisnant, M.D., Mayo Clinic, 200 First Street S.W., Rochester, Minnesota 55905.

Received November 30, 1983; revision #1 accepted February 22, 1984.
TABLE 1  Average Annual Incidence Rates, per 100,000 Population, for Hemispheric and Brainstem/Cerebellar Infarction in Various Periods

<table>
<thead>
<tr>
<th>Infarction group</th>
<th>1960-64</th>
<th>1965-69</th>
<th>1970-74</th>
<th>1975-79</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rate</td>
<td>No.</td>
<td>Rate</td>
<td>No.</td>
</tr>
<tr>
<td>Hemispheric</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M*</td>
<td>113</td>
<td>97</td>
<td>107</td>
<td>112</td>
</tr>
<tr>
<td>F*</td>
<td>90</td>
<td>120</td>
<td>61</td>
<td>102</td>
</tr>
<tr>
<td>Total†</td>
<td>101</td>
<td>83</td>
<td>63</td>
<td>15</td>
</tr>
<tr>
<td>Brainstem/cerebellar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M†</td>
<td>24</td>
<td>21</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>F†</td>
<td>14</td>
<td>18</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Total†</td>
<td>19</td>
<td>39</td>
<td>46</td>
<td>58</td>
</tr>
</tbody>
</table>

*Age-adjusted to 1960 US white population.
†Age- and sex-adjusted to 1960 US white population.

on presenting symptoms and signs, prior medical history, hospital course (including investigations performed and complications associated with the infarct), and functional outcome 1 year after onset. The functional outcome was graded according to the following classification:

Grade I — No significant disability; able to carry out all usual duties.
Grade II — Slight disability; unable to carry out some previous activities but able to look after own affairs without assistance.
Grade III — Moderate disability; requiring some help but able to walk without assistance.
Grade IV — Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance.
Grade V — Severe disability; bedridden, incontinent, and requiring constant nursing care and attention.

A total of 991 cases were identified for the study. Of these, 803 (81%) were classified as hemispheric and 188 (19%), as brainstem/cerebellar infarcts. In only one case had the patient been lost to follow-up.

Results

Incidence

The incidence rates of hemispheric and brainstem/cerebellar infarcts declined over the 20-year period of the study, reaching 55 and 11 new episodes of hemispheric and brainstem/cerebellar infarctions, respectively, per 100,000 population per year by 1975-79 (table 1). Overall, the decline was 46% for hemispheric infarcts and 42% for brainstem/cerebellar infarcts. Analysis of age- and sex-specific rates for hemispheric lesions indicated that females, particularly those age 75 years and over, showed the greatest decline. The number of brainstem/cerebellar infarcts was too small to permit analysis of age-specific trends.

Survival

Thirty-day case fatality was remarkably similar for both types of infarction. At 7 days, 91% of patients with hemispheric and 90% of those with brainstem/cerebellar infarcts were still alive (fig. 1). Patients with brainstem/cerebellar infarcts had an increased probability of survival over the longer term compared with those with hemispheric infarcts. At 5 years, a little over half of the patients with brainstem/cerebellar infarcts were alive, but the same percentage alive occurred at 3 years for patients with hemispheric lesions. Increased age at onset had an adverse effect on short- and long-term survival for both groups of patients, as did level of consciousness. When the patient was alert, the probability of survival to 30 days was 96% and 97% for hemispheric and brainstem/cerebellar infarction, respectively. When the patient was comatose, the probability of survival to 30 days was 35% for hemispheric infarction and 24% for brainstem/cerebellar infarction.

Clinical Presentation

The spectrum of clinical signs and symptoms in patients with brainstem/cerebellar infarctions was different from that in patients with hemispheric infarc-
tions, because that is the way the groups were defined. However, some symptoms could occur in either group (tables 2 and 3). Patients with brainstem/cerebellar infarcts had a disturbance of consciousness less often but had dysarthria more often. Motor impairment was more common among patients with hemispheric infarcts. Sensory symptoms were noted with equal frequency in both groups.

Neurologic Deficit
Loss of motor function was the most common neurologic deficit at 1 year after onset in both groups (table 4). Cognitive, social, and special sensory deficits were more frequent among those with hemispheric infarction. Improvement at 1 year after onset was more common among those with brainstem/cerebellar infarcts; this was particularly so for the special senses — 33% of these patients had returned to normal by 1 year whereas only 20% of those with hemispheric infarcts showed similar improvement.

Functional Outcome
There had been a high level of functional dependency present in both groups prior to onset of cerebral infarction: 18% of the hemispheric group and 14% of the brainstem/cerebellar group required some help in the activities of daily living (grade III or worse). Among the 51 patients in grades IV and V prior to infarct, 44 (86%) were age 75 or over (table 5). The proportions of independent persons (grades I and II) before and at 1 year after infarction decreased from 82% to 34% and from 86% to 46% with hemispheric and brainstem/cerebellar infarctions, respectively. The proportion of patients in the most heavily dependent grades (IV and V) increased from 6% to 13% among patients with hemispheric infarcts and from 2% to 8% among those with brainstem/cerebellar infarcts.

Complications
The prevalence of complications was greater after hemispheric infarction than after brainstem/cerebellar infarction (table 6). During the entire period of hospital stay, congestive cardiac failure or respiratory tract infection or both were present in 34% of the hemispheric group compared with 25% of those with brainstem/cerebellar infarcts. The great majority of complications occurred soon after the infarct. For example, 97% of the myocardial infarctions, 92% of the congestive cardiac failures, and 80% of the respiratory tract infections occurred within 7 days. In both infarction groups, persons age 75 or older had more complications than younger ones did. Patients who had a neurologic deficit were more likely to have other complications. The number of complications present increased with increasing functional dependency.

Involvement of Neurologists
Sixty-seven percent of all the patients in this study had been seen by a neurologist. Those with brainstem/cerebellar infarcts were seen by neurologists more often than those with hemispheric infarcts (81% and 63%, respectively). Thirty percent of the brainstem/cerebellar group were admitted to a neurology service, compared to 19% of the hemispheric group. The number of neurologic consultations for both groups increased steadily through the 20-year-period of the study; from 42% to 69% for hemispheric infarcts and from 48% to 88% for brainstem/cerebellar infarcts.

Discussion
The incidence rate for brain infarction in Rochester, Minnesota, has decreased over the past several decades, and this study shows that this occurred equally for hemispheric and brainstem/cerebellar infarcts. The
cause for the decline has not yet been determined, but these data suggest that the pathophysiologic mechanisms may be similar in the carotid circulation and in the vertebral-basilar circulation.

Patients with brainstem/cerebellar infarcts had a better long-term prognosis than those with hemispheric infarcts. The most likely reason for this is the higher proportion of patients with marked dependency in the latter group. Differences in extent of the severity or rate of progress of the atherosclerotic process also could be factors. Sterba et al. found that the amount of atherosclerosis present in the various cerebral arteries increased with age, but at a higher rate for the carotid arteries than for the vertebral and basilar arteries. The impression of an unduly grim prognosis for brainstem/cerebellar infarction portrayed in previous case series has not been confirmed in this study.

The level of consciousness of the patient at or shortly after onset of cerebral infarction has been noted to have an important bearing on survival. The 30-day survival was virtually identical in the two groups of our study, even though the proportion of patients with altered consciousness was much greater in the patients with hemispheric infarcts. Patients with brainstem/cerebellar infarcts who had altered consciousness had a worse outlook than those with hemispheric infarcts with the same level of consciousness.

There were some clinical signs and symptoms elicited on admission to the hospital that could not be explained by the presumed anatomic site of the infarct. For example, nystagmus was observed in 3% of the patients with hemispheric infarcts, but this was presumed to be physiologic nystagmus. There also were a few patients who had aphasia and a few with visual field defects in whom the primary infarct was in the brainstem. It is likely that these findings represent the effects of artery-to-artery embolization from the site of verteobasilar occlusive disease.

The fact that the hemispheric infarct group had more complications than the brainstem/cerebellar infarct group is probably a reflection of the higher level of functional dependency and greater frequency of altered consciousness in the hemispheric group. The frequency of complications such as congestive cardiac failure and respiratory infection is related to the level of functional dependency of patients in both the brainstem/cerebellar and hemispheric groups. Patients with hemispheric infarcts had a higher proportion of cognitive and special sensory deficits at 1 year compared to the brainstem/cerebellar group. Despite a similar proportion of patients with motor deficits in both groups, those with brainstem/cerebellar infarcts had a better functional outcome — 35% had regained complete independence at 1 year after onset, compared with 22% of those with hemispheric infarcts. This confirms the findings of others that functional outcome is not

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Dependency Before and 1 Year After Hemispheric or Brainstem/Cerebellar Infarction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infarction group</td>
<td>Rankin grade before infarction</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemispheric</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>III</td>
</tr>
<tr>
<td></td>
<td>IV/V</td>
</tr>
<tr>
<td>Total</td>
<td>177</td>
</tr>
<tr>
<td>Brainstem/cerebellar</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>III</td>
</tr>
<tr>
<td></td>
<td>IV/V</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
</tr>
</tbody>
</table>

*Excludes 11 patients for whom dependency could not be estimated.

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Prevalence of Complications Occurring Within 1 Week After Hemispheric or Brainstem/Cerebellar Infarction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications</td>
<td>Hemispheric (n = 803)</td>
</tr>
<tr>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Congestive cardiac failure</td>
<td>15 (16)</td>
</tr>
<tr>
<td>Respiratory tract infection</td>
<td>15 (18)</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>8 (12)</td>
</tr>
<tr>
<td>Pulmonary embolus</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>7 (7)</td>
</tr>
</tbody>
</table>

Values in parentheses represent complications occurring during hospital stay.
related only to the presence of a motor deficit. The presence of a higher proportion of hemispheric infarcts with a cognitive or special sensory deficit may have made it more difficult for these patients to regain functional independence.13

Until CT became available, there were no noninvasive neurologic tests that could be used to confirm a diagnosis of cerebral infarction. CT is best at differentiating infarction from hemorrhage, even though it does not always detect an infarct present in the hemisphere or in the brainstem. A recent population study14 estimated that 24% of hemorrhages in the brain were mislabeled as infarct prior to the use of CT. We have assumed that the hemorrhages among our patients that were mislabeled as ‘‘infarct’’ prior to the use of CT in 1973 were proportionately distributed in the hemisphere and brainstem/cerebellar groups.

Acknowledgments
We are grateful to Jon L. Kosanke for programming assistance and to Darcy Jacobson and Sherie L. Ohm for secretarial assistance.

References

The natural history of hemispheric and brainstem infarction in Rochester, Minnesota.
T M Turney, W M Garraway and J P Whisnant

Stroke. 1984;15:790-794
doi: 10.1161/01.STR.15.5.790

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/15/5/790

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/