STROKE IS A MAJOR CAUSE of mortality throughout the world and several studies have reported survival experience following stroke in different populations. What has not been reported is how survival following stroke has changed over time. The recent collation of data from several epidemiological studies of stroke in Rochester, Minnesota has enabled a comparison of survival experience following stroke to be carried out during different time periods using the same definition, uniform diagnostic criteria and the same method of case ascertainment in a stable, well-defined population.

**Methods**

Medical practice in Rochester and the surrounding area of Olmsted County has been centered on the Mayo Clinic since the beginning of this century. Diagnoses made by Mayo Clinic physicians for all patients, whether they are seen in hospitals, as outpatients, on home visits or at autopsy are all indexed in the patient’s medical record and are retrievable, by diagnosis, for the study of a variety of medical problems. A medical record indexing and retrieval system similar to that used at the Mayo Clinic has been established for local residents seen in all of the other medical institutions in and around Rochester. Thus, virtually complete case ascertainment is assured for all residents of Rochester who have a diagnosis of stroke made in any medical facility in the community. Only patients who had been living in Rochester for a continuous period of one year before their stroke were considered to be bonafide residents. This rule was designed to exclude those patients who might have migrated into the community to obtain medical care.

Records were retrieved for all diagnostic categories in which the diagnosis might have been stroke for the period January 1, 1945 to December 31, 1979 using the following definition: — the onset of a focal neurological deficit lasting for more than 24 hours and due to a presumed local disturbance in blood supply to the brain.
Stroke is considered to include brain infarction due to arterial thrombosis, stenosis or embolism, primary and secondary intracerebral hemorrhages and subarachnoid hemorrhage. Criteria used to differentiate stroke into different diagnostic groups have been reported elsewhere. No attempt was made to separate cerebral infarction into embolic and non-embolic lesions because of major changes in investigative techniques or diagnostic criteria for concurrent conditions which might potentially produce emboli. In this study, the small number of cases in which there were incomplete clinical details at the onset of the acute episode but a history of onset and residual deficit sufficiently well documented to ensure a high likelihood that a stroke had occurred have been included in the diagnostic group of cerebral infarction. If computed tomography scan was performed, the information obtained was a determining factor in placing a patient into a diagnostic category. Computed tomography head scan was introduced in Rochester in 1973 but was not widely used in stroke diagnosis until the 1975-79 period of observation. During this period, CT scan confirmation was obtained in the diagnosis of 48% of cerebral infarction and 85% of intracerebral hemorrhage. The overall autopsy rate among Rochester residents during the period of study was 58%. The autopsy rate among patients with a diagnosis of stroke varied in each quinquennial period, showing an overall decline from 49% during 1945-49 to 35% during 1975-79. Autopsy rates by diagnostic type of stroke during this last 5-year period of observation were 27% for cerebral infarction, 70% for intracerebral hemorrhage and 69% for subarachnoid hemorrhage.

Follow-up was carried out by letter or telephone interview and all patients can be accounted for during the relevant time intervals being considered in this study. The number and diagnostic types of new episodes of stroke which occurred in each 5-year period from 1945-49 to 1975-79 are presented in table 1. Survival was determined for varying periods up to 30 days after onset in patients who had first episodes of stroke during each 5-year period from 1945-49 to 1975-79 and for each year up to seven years after onset in patients who had first episodes of stroke during each quinquennial period up to 1970-74.

**Results**

**Short-term survivorship**

A comparison of survival up to 30 days after onset of first episodes of different diagnostic types of stroke in 1945-49 and 1975-79 was made (table 2). There was virtually no improvement in survival up to three days for cerebral infarction or subarachnoid hemorrhage between these periods. The improvement in survival for subarachnoid hemorrhage mainly occurred 10 days after onset in patients who had first episodes of stroke during each 5-year period from 1945-49 to 1975-79 and for each year up to seven years after onset in patients who had first episodes of stroke during each quinquennial period up to 1970-74.

**Table 1 Number of First Episodes of Stroke by Diagnostic Type in Various Time Periods**

<table>
<thead>
<tr>
<th>Time period</th>
<th>Cerebral infarction</th>
<th>Intracerebral hemorrhage</th>
<th>Subarachnoid hemorrhage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945-49</td>
<td>213</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>1950-54</td>
<td>247</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>1955-59</td>
<td>282</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>1960-64</td>
<td>279</td>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td>1965-69</td>
<td>302</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>1970-74</td>
<td>271</td>
<td>17</td>
<td>31</td>
</tr>
<tr>
<td>1975-79</td>
<td>226</td>
<td>38</td>
<td>30</td>
</tr>
</tbody>
</table>

**Table 2 Survival to 30 Days after Onset by Diagnostic Type of Stroke in Various Time Periods**

<table>
<thead>
<tr>
<th></th>
<th>Cerebral infarction</th>
<th>Intracerebral hemorrhage</th>
<th>Subarachnoid hemorrhage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945-49</td>
<td>CI 92 86 81 77 76</td>
<td>ICH 38 19 14 0 0</td>
<td>SAH 64 57 43 43 43</td>
</tr>
<tr>
<td>1950-54</td>
<td>CI 91 87 81 76 73</td>
<td>ICH 25 21 21 21 21</td>
<td>SAH 82 82 73 45 45</td>
</tr>
<tr>
<td>1955-59</td>
<td>CI 94 92 87 83 82</td>
<td>ICH 33 33 33 22 22</td>
<td>SAH 75 69 63 63 63</td>
</tr>
<tr>
<td>1960-64</td>
<td>CI 88 84 80 77 75</td>
<td>ICH 44 40 24 24 24</td>
<td>SAH 65 62 50 39 39</td>
</tr>
<tr>
<td>1965-69</td>
<td>CI 93 88 87 83 80</td>
<td>ICH 28 20 16 12 12</td>
<td>SAH 72 64 52 48 48</td>
</tr>
<tr>
<td>1970-74</td>
<td>CI 92 90 88 84 82</td>
<td>ICH 47 35 24 18 12</td>
<td>SAH 77 77 68 55 55</td>
</tr>
<tr>
<td>1975-79</td>
<td>CI 95 94 93 88 84</td>
<td>ICH 63 63 55 45 42</td>
<td>SAH 70 70 67 63 63</td>
</tr>
</tbody>
</table>

CI = cerebral infarction; ICH = intracerebral hemorrhage; SAH = subarachnoid hemorrhage.
was seen in intracerebral hemorrhage. In 1945–49, only 14% of cases survived to seven days and no cases survived beyond 21 days. A major improvement in survival following intracerebral hemorrhage had occurred by 1975–79 such that 63% of cases survived to 5 days and 45% to 21 days. Thus, the 30-day survival following first episodes of intracerebral hemorrhage is now much closer to that of subarachnoid hemorrhage with survival rates of 42% and 63% respectively during the latest 5-year period of observation, 1975–79. Cerebral infarction had the best short-term survival with 84% of cases alive at 30 days in 1975–79.

The number of cases of intracerebral hemorrhage and subarachnoid hemorrhage in 1945–49 and 1975–79 were too small to enable survival to be compared by sex or in different age groups. But as regards cerebral infarction, there were no differences in the rate of improvement up to 30 days between males and females. There was an improvement in 30-day survival for patients under the age of 65 years during the period of observation. In 1945–49, 51 of the 66 patients (77%) aged 65 years or less survived to 30 days after onset compared with 45 out of the 47 patients (96%) aged 65 years or less who had a first episode of cerebral infarction in 1975–1979. There were more modest improvements in survival following cerebral infarction for older age groups.

Long-term survival

There were an insufficient number of cases of subarachnoid hemorrhage or intracerebral hemorrhage surviving to one year to be able to compare long-term changes in survival over time. Long-term comparisons of observed and expected survival following cerebral infarction were made at annual intervals for first episodes occurring in 1945–49 and 1970–74, the latter period being used in order to ensure complete follow-up of all cases up to seven years after onset. Table 3 (a) demonstrates observed survival up to seven years between first episodes of cerebral infarction which occurred in 1945–49 and 1970–74. The expected probability of survival for death from all causes was calculated for persons of similar age, sex and calendar year of diagnosis from relevant life tables based on the West North Central Region of the U.S.A., and is presented in table 3 (b). The difference in observed survival at 7 years following onset of cerebral infarction between 1945–49 and 1970–74 was highly significant ($p < 0.01$, using the Log Rank Test). Observed survival following cerebral infarction has moved closer to that which would be expected in an equivalent population which had not experienced cerebral infarction during the 30-year interval between the two quinquennial periods being compared. In 1945–49, observed survival up to seven years was only 22% compared with 63% for expected survival. This changed to 40% observed and 59% expected survival in 1970–74. The overall improvement in observed survival has increased at each annual interval up to seven years with patients aged 75 years and over experiencing the greatest rate of improvement in long-term survivorship. The proportion of the 88 patients aged 75 years and over in 1945–49 and the 89 patients in this age group at the time of their first episodes of cerebral infarction in 1970–74 who survived to five, six, and seven years more than doubled from 14%, 12% and 9% to 30%, 25% and 20% respectively. The rate of improvement in long-term survival is summarized in fig. 2. This showed a stepwise increase in the rate of improved survival ranging from 14% at one year after onset to an increase of 82% at seven years.

Discussion

Marked improvements in survival following stroke have occurred over the past 35 years in Rochester,
Minnesota. The progressive improvement in long-term survival following cerebral infarction is particularly striking and has been such that a higher proportion of patients survived for six years after onset of a first episode in 1970-74 (45%) than survived for three years following onset in 1945-49 (42%). These data cannot reveal what factors have caused this major change in the natural history of stroke. But speculation leads us to conclude that differences in the management of cerebral infarction over time which might have contributed to increased long-term survival include the management of associated conditions such as cardiac disease which may have been present before or after the onset of cerebral infarction, the treatment of complications following onset such as respiratory infection, and the improvement in functional independence as a result of more widespread use of rehabilitation therapy.

In marked contrast is the almost total lack of any improvement in survival up to three days following onset of cerebral infarction despite the many attempts which have been made to improve the outcome of acute ischemic cerebrovascular disease by drug therapy. Although claims for improvements in immediate survival have been made, a recent review of the design and conduct of therapeutic trials in acute ischemic cerebrovascular disease revealed that the positive conclusions regarding therapeutic intervention reached by some studies could not be substantiated because of methodological shortcomings in the design and conduct of the studies. The indications for definitive medical treatment following cerebral infarction remain few and this is reflected by the fact that the immediate outcome following cerebral infarction changed very little during the period of our observation. Moreover, changing the organization of stroke care to provide intensive care equipment, facilities and staffing did not make an impact on survival during the immediate period following onset. The moderate improvement in survival in the "subacute" period of 5 days and longer might have occurred as a result of a reduction in the number of secondary complications following cerebral infarction which have been observed in studies which have evaluated the role of a neurovascular care unit and a stroke rehabilitation unit. The modest improvement in 30 day case-fatality emphasizes that it is the declining incidence of stroke which was the dominant factor in the reduction in mortality from stroke which has occurred in Rochester, Minnesota through the period of observation covered by this study.

A striking finding was the improvement in survival following intracerebral hemorrhage. Virtually all the improvement occurred in comparing the consecutive 5-year periods of 1970-74 and 1975-79 when the probability of survival improved from 47% to 63% at three days; 24% to 55% at 10 days and 12% to 42% at 30 days after onset. This marked change in survival following intracerebral hemorrhage has occurred largely as a result of the wide application of computed tomography in the diagnosis of intracerebral hemorrhage in this community since 1974. Computed tomography has identified smaller, less severe intracerebral hemorrhages during the period 1975-79 which were previously classified as cerebral infarction on clinical grounds alone. The non-progressive nature of these smaller hemorrhages likely accounts for the improvement in survival being observed beyond three days after onset, the lack of improvement earlier than this being due to larger catastrophic hemorrhages which have usually been identified correctly. It is apparent that intracerebral hemorrhage is not always the catastrophic event it was traditionally thought to be but has a wider spectrum of severity than was previously recognized. The improvement in the rate of survival which has occurred in subarachnoid hemorrhage is most prominent at 10 days following onset which may be a reflection of the influence of favorable results of surgical intervention following subarachnoid hemorrhage from intracranial aneurysms.

Acknowledgments
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Hemiplegics after a First Stroke: Late Survival and Risk Factors
PABLO SOLZI, M.D., HAIM RING, M.D., THEODORE NAJENSON, M.D., AND YAIR LUZ, I.E.

SUMMARY Scanning 3000 cases admitted for rehabilitation after cerebrovascular accident over a 20 year period produced a sample of 1369 subjects, without age restrictions, admitted within six months of a first stroke of thrombotic etiology.

In this sample, survival rates showed no significant difference between men and women. Age at onset, however, clearly influenced survival chances; the expected mean survival was 6 years at 40 and 2 at age 80; average loss of life was 14 years for the whole sample, meaning a vital prognosis two to three times worse than that of the general population.

At least 86% of the sample presented one or more of five etiological antecedents to stroke: hypertensive heart disease, peripheral vascular disease, diabetes mellitus, myocardial infarction and atrial fibrillation. In 87% of those, HHD and/or PVD were present. Presence of hypertension significantly lowered life expectancy and so did PVD; their influence is felt from the earliest stages. In contrast, diabetes mellitus, the next most common factor, has a late influence, starting about the fifth year after stroke. MI and AF were present in relatively fewer patients, but they contributed towards a considerable decrease in life expectancy, evident from the first stages, the more drastic reduction being observed in the AF group.

STROKE is recognized as both a killer disease and a major cause of disability. Consequently, in recent years, more research has been directed towards the study of its etiology, incidence, effect on mortality rates and, finally, of means which might help to prevent its occurrence. At the same time, great progress has been recorded in the rehabilitation of stroke-disabled patients and in the improvement of their chances of both surviving and living a satisfactory life afterwards.

This work studies in retrospect data on patients after cerebrovascular accidents causing hemiplegia who were hospitalized at the Loewenstein Rehabilitation Center (Ra'anana, Israel) over a period of twenty years. Its purpose is twofold: to assess the survival rates of these patients after their admittance for rehabilitation, and to identify risk factors which, besides provoking C.V.A. onset, might in the long run affect these patients' mortality and survival rates.

Materials and Methods
About 3,000 records built up in the years 1958–1977 were screened according to the following criteria: stroke was of a clearly vascular origin, the patient had had a single stroke prior to admittance, and the patient had been admitted for rehabilitation within six months from onset of C.V.A.

This selection left 1700 well-documented cases answering the criteria and constituting the sample for this investigation. Each file was attentively studied. The first item to be checked was the patient's status, using the State of Israel population registry; death dates of those deceased were noted down. The following item was etiology. Cases whose etiology could not be incontestably established were left out and the remaining cases were classified into five groups, in whom stroke had been caused by:

The changing pattern of survival following stroke.
W M Garraway, J P Whisnant and I Drury

Stroke. 1983;14:699-703
doi: 10.1161/01.STR.14.5.699

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