Hypertension Management and Stroke Recurrence in a Community (Rochester, Minnesota, 1950–1979)

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Population-based data from Rochester, Minnesota, have shown a decline in stroke mortality for several decades, which has been attributed primarily to the decline in incidence rates of ischemic cerebral infarction and primary intracerebral hemorrhage.1,2

Hypertension has been shown to be the major risk factor associated with both cerebral infarction and primary intracerebral hemorrhage.3 There is evidence that the prevalence of hypertension in Rochester has decreased.4,5 This decrease has been most pronounced in the elderly, particularly in women, and evidence from the medical records indicates that in this group there has been better recognition and better control of high blood pressure.4 There is inferential evidence supporting the contribution of antihypertensive therapy to the decline in stroke incidence.4

Reported stroke recurrence rates vary widely due to referral bias, difference in criteria for selection of patients, and variations in follow-up times. During a 15-year community study in Rochester, Minnesota, the nonactuarial recurrence rate was 10% within 1 year and 20% within 5 years.7 In the Framingham Study, recurrence rates in men were almost double those in women, 42% versus 24%, and there was a strong inverse relationship between the presence and management of hypertension and cardiac disease present before the first stroke.8 In both population samples, stroke recurrences were primarily of the same type as the initial stroke, with a predominance of nonembolic cerebral infarction.

The contribution of atrial fibrillation, with or without valvular heart disease, to embolic stroke and stroke recurrence is well recognized.9,10 Reports differ with respect to the temporal profile of stroke recurrence after onset of an underlying cardiac arrhythmia. In the Framingham cohort, an apparent early clustering of initial stroke was seen because of the selection of patients who had simultaneous or closely approximated diagnoses of both stroke and atrial fibrillation. However, recurrent stroke rates were not significantly different for patients with and without atrial fibrillation, 25% versus 20%. Other authors have noted high recurrence rates in patients with presumed embolic stroke. These are noted to be as high as 33% without regard to time11 but as high as 13% in the first 2 weeks after an embolic stroke.12 Many such patients had a history of previous embolic strokes. The data are insufficient to determine the timing of stroke recurrence after the first embolic infarction in an unselected population-based sample of patients.

There are conflicting reports concerning the relationship between the presence and management of hypertension and the stroke recurrence rates.13-16 Only one controlled clinical trial studied the effect of antihypertensive therapy on stroke recurrence rates.14 The belief that ischemic strokes could occur secondary to antihypertensive treatment is no longer prevalent.15

In more recent decades, this may have resulted in better antihypertensive control after the initial stroke. Observations regarding the effect of hypertensive treatment correlate well with the trend of the decline in stroke incidence rates in Rochester over the last 3 decades.

This study was performed to determine whether a similar trend could be detected with respect to the rate of stroke recurrence.

**Subjects and Methods**

The population of Rochester lends itself to epidemiologic studies because medical care is available from a limited number of providers (primarily the Mayo Clinic and one smaller group practice) and because all diagnoses made among Rochester residents by any of the providers are entered into a central index.18 This index made it possible to identify all Rochester residents who had a first episode of cerebral infarction...
or cerebral hemorrhage during the 30-year period from January 1, 1950, through December 31, 1979. Patients with focal cerebral ischemic symptoms of <24 hours’ duration (TIA) were not included. Patients with primary subarachnoid hemorrhage as their initial event also were excluded.

The complete medical record for each case was retrieved and reviewed. These records include the details of medical care provided by physicians of the community in the office, during hospitalizations or emergency room visits, and during home or nursing home visits as well as information obtained from autopsy reports, death certificates, and correspondence with patients, physicians, or families.

Blood pressure values were taken from any part of the medical record, inpatient or outpatient. The number of blood pressure recordings made before stroke varied because of different frequencies of visits noted in the medical record. Potentially unrepresentative blood pressure values due to unusual circumstances such as injury or acute infection at the time of assessment were excluded. Those patients whose blood pressure values were missing were not included in the analysis.

The patients were grouped according to mean blood pressure values within 1 year before the first stroke and according to management of high blood pressure during the first year after the initial stroke, as documented by medical care personnel. The blood pressure categories used in the actuarial analyses with death and stroke as end points included 1) last diastolic blood pressure (DBP) measurement before the initial stroke, divided into four levels (mm Hg): <95 \((n = 1,181)\), 95-104 \((n = 236)\), 105-114 \((n = 97)\), and \(\geq 115\) \((n = 80)\); 2) last systolic blood pressure (SBP) measurement before the initial stroke, divided into three levels (mm Hg): <160 \((n = 915)\), 160-189 \((n = 454)\), and \(\geq 190\) \((n = 225)\); and 3) postinitial stroke blood pressure status: normal, untreated values <140/90 mm Hg; borderline, values <160/95 mm Hg but \(\geq 140\) mm Hg systolic or 90 mm Hg diastolic; controlled hypertension, maintenance of previously increased DBP levels at <95 mm Hg, achieved with medication; and uncontrolled hypertension, DBP \(\geq 95\) mm Hg, with or without antihypertensive medication.

On the basis of these definitions, the patients were subdivided into the following groups: normal/ borderline \((n = 503)\), treated-controlled \((n = 177)\), treated-uncontrolled \((n = 104)\), and untreated-uncontrolled \((n = 225)\). Those patients for whom no appropriate blood pressure values could be found in the record were not included in this portion of the analysis.

Follow-up for all patients was to death or until June 1984. Overall survival and survival free of stroke recurrence were determined by Kaplan-Meier life table analyses beginning at the time of the first cerebral infarction for the total 30-year period (1950-1979) and for individual decennial periods (1950-1959, 1960-1969, and 1970-1979). Expected survival, analyzed in terms of an age- and sex-matched sample, was based on life tables for the Minnesota white population for 1950, 1960, and 1970. Mortality ratios (observed mortality/expected mortality) and cumulative recurrent stroke ratios (observed recurrent stroke rate/expected stroke rate) were calculated to adjust for age differences in each blood pressure subgroup.

"Stroke recurrence" denoted a cerebral infarction or an intracerebral or subarachnoid hemorrhage occurring at any time subsequent to stabilization of the initial stroke and fulfilling the same criteria. TIA was not considered to be a recurrence. For actuarial estimation of net probability of recurrent stroke (after cerebral infarction or hemorrhage), when death occurred from a cause other than recurrent stroke the patient was withdrawn from the sample under observation, such that recurrent stroke was used as an end point analogous to death in the life table analysis. The recurrent stroke incidence rates in the three decennial periods were compared with the expected Rochester stroke incidence rates for respective age- and sex-matched populations in 1950-1959, 1960-1969, and 1970-1979.

The mean population in Rochester was 29,873 for 1950-1954 and 57,033 for 1975-1979. The proportion of the population aged 65 years and older increased from 8.8% to 10.5% between these two periods.

**Results**

Survivorship

Among the Rochester residents, we identified 1,680 patients (780 men and 900 women), mean age 72 years, who had their first cerebral infarction or intracerebral hemorrhage between January 1, 1950, and December 31, 1979. The 1970-1979 30-day survival of 83% following the first cerebral infarction was minimally changed from the 1950-1959 rate of 78.5%. The respective survival rates in the three decennial periods were 39.3%, 36.6%, and 47.3% at 5 years; and 20.6%, 20.1%, and 26.2% at 10 years (Figure 1). For the overall 30-year period, survival was 64% at 1 year, 41% at 5 years, and 22% at 10 years.

**FIGURE 1.** Estimated probability of survival for 10 years after first cerebral infarction, for Rochester, Minnesota, residents for 3 decennial periods between 1950 and 1980. Expected survival was based on age- and sex-matched West North Central U.S. white 1960 life table.
**Table 1. Type of Stroke, Rochester, Minnesota, 1950–1979**

<table>
<thead>
<tr>
<th>Stroke</th>
<th>Initial</th>
<th>Recurrent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Cerebral infarction</td>
<td>1,546</td>
<td>92</td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>134</td>
<td>8</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Total</td>
<td>1,680</td>
<td>100</td>
</tr>
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</table>

*Not included in first strokes.

**Stroke Recurrence**

Of the 1,680 stroke incidence cases, 267 (136 men and 131 women) had had a recurrent infarction or cerebral/subarachnoid hemorrhage at follow-up. The mean time from first stroke to recurrence was 35 months. The major proportion, 88% (234 of 267), of recurrent strokes were ischemic cerebral infarctions (Table 1). Intracerebral hemorrhage occurred in 10% of the patients. Subarachnoid hemorrhage, excluded from the initial stroke cases because of the different pathophysiology involved, was responsible for only 7 of the 267 stroke recurrences. The overwhelming majority of recurrences (262 of 267) were in patients who had had a cerebral infarction as the initial stroke.

Figure 2 shows survival free of stroke recurrence among persons with first cerebral infarct and reflects stroke recurrence rates for 1950–1959, 1960–1969, and 1970–1979 of 5.6%, 6.5%, and 4.9% within 1 year and cumulative rates of 26.7%, 31.6%, and 27.2% within 10 years. The cumulative stroke recurrence rate, given survival, for the 30-year period was 5.7% within 1 year, 19.3% within 5 years, and 29% within 10 years (Figure 3).

The stroke recurrence rate was the same for men and women at 1 year. At 5 years, the cumulative stroke recurrence rate, given survival, was 21% for men and 17% for women, and at 10 years it was 32% for men and 26% for women. The observed rate at 5 years was 4.4 times the expected incidence of first stroke for men in the population of the same age distribution and was 3.6 times the expected rate for women. Corresponding ratios at 10 years were 2.5:1 for men and 3.1:1 for women. These differences for men and women at 5 and 10 years are not significant.

**Blood Pressure Control and Treatment Groups**

Figure 4 shows the comparative mortality ratios according to DBP before the initial stroke in stroke incidence cases over the 30-year period. There was the suggestion of a gradient for DBP (higher mortality ratios for the higher DBP groups), but this was not seen for SBP.

Mortality ratios within the various blood pressure treatment groups did not reveal any consistent survival trends. For example, mortality ratio for the treated-uncontrolled group was comparable with that of the normal/borderline group (Figure 5). The cumulative stroke recurrence rates, given survival, are summarized in Table 2 and are plotted in Figure 6, top as survival free of stroke. There was little difference between the
blood pressure treatment groups. When corrected for age by using cumulative recurrent stroke ratios (Figure 6, bottom), treated-uncontrolled hypertensive patients appeared to have a slightly higher risk of stroke recurrence compared with the other blood pressure groups. However, again the ratios showed no consistent difference in cumulative recurrent stroke, as seen by comparing the normal/borderline patients with untreated-uncontrolled hypertensive patients.

**Discussion**

This population-based study has determined the long-term prognosis with respect to stroke recurrence and death among 1,680 incidence cases of stroke in Rochester, Minnesota, residents. There was a trend toward increasing long-term survivorship between the second and third decennial periods. There appeared to be a direct relationship between DBP and mortality ratio (observed mortality/expected mortality) (Figure 4). This is the only evidence we found to indicate that patients with stroke who had lower blood pressures had a better outcome than those with higher blood pressures. We could not show that treatment aimed at controlling DBP after stroke had any effect on the mortality ratio. We could not find a consistent relationship between SBP and mortality ratio.

The overall cumulative stroke recurrence rate after cerebral infarction was <3%/yr over a 10-year period but was somewhat higher in earlier than in later years. There were no significant differences between the recurrence rates for men and women at 1, 5, and 10 years of observation. This represents observations on 718 men and 828 women with cerebral infarction. The Framingham Study noted a difference between stroke recurrence rates for 111 men and 111 women with cerebral infarction after 5 years of observation, but no significance testing was reported. The rate of recurrence among Framingham patients was higher than the rates we have noted for Rochester.

The recurrence rates did not change during 1950–1979, in contrast to the decline in incidence rates of first stroke during this time. Ischemic stroke represented 88% of stroke recurrences, almost identical to the distribution of stroke types in the initial stroke population. Intracerebral hemorrhage was underestimated in both initial and recurrent stroke groups because most of the diagnoses were made before the availability of computed tomographic scans of the head.

**Table 2. Cumulative Rate of Stroke Recurrence, Given Survival, by Postinitial Stroke Blood Pressure Status, Rochester, Minnesota, 1950–1979**

<table>
<thead>
<tr>
<th>Status</th>
<th>Cumulative rate, %</th>
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<tbody>
<tr>
<td></td>
<td>At 1 yr</td>
</tr>
<tr>
<td>Normal/borderline</td>
<td>6.5</td>
</tr>
<tr>
<td>Treated-controlled</td>
<td>7.1</td>
</tr>
<tr>
<td>Treated-uncontrolled</td>
<td>5.9</td>
</tr>
<tr>
<td>Untreated-uncontrolled</td>
<td>6.7</td>
</tr>
</tbody>
</table>

**Figure 5.** Mortality ratios after first cerebral infarction for residents of Rochester, Minnesota, 1950–1979, according to postinitial stroke blood pressure management categories (mortality ratio = observed/expected mortality). Expected mortality was based on age- and sex-matched West North Central U.S. white 1960 life table.

**Figure 6.** Top: Estimated probability of survival free of stroke recurrence among survivors of first cerebral infarction for residents of Rochester, Minnesota, 1950–1979, according to postinitial stroke blood pressure management categories. Bottom: Cumulative recurrent stroke ratios (observed stroke rate/expected stroke rate) after first cerebral infarction for residents of Rochester, Minnesota, 1950–1979, according to postinitial stroke blood pressure management categories. Expected stroke rates are based on Rochester, 1950–1979, stroke incidence rates (data from Garraway et al).
The majority (98%) of stroke recurrences were in patients whose first stroke was due to cerebral infarction. Intracerebral hemorrhage (as diagnosed) had a sufficiently high early mortality so as to contribute little to stroke recurrence rates.

Whereas there appears to be an association between increased detection and control of hypertension and the decline in stroke incidence rates in Rochester, neither blood pressure before the first stroke nor management of hypertension after the stroke had any apparent effect on stroke recurrence. There may be other reasons for treatment of hypertension after stroke, but the effect of treatment is not reflected in mortality or recurrent stroke morbidity. A potential effect of hypertension management on stroke recurrence and mortality could be masked by the more powerful overriding effect of the occurrence of the first stroke.

References


Key Words • cerebrovascular disorders • epidemiology • hypertension
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