Predicting Survival After Stroke: A Three-Year Follow-Up

Ruth Bonita, MPH, PhD, Michael A. Ford, MSc, and Alistair W. Stewart, BSc, DiplSc

We examined characteristics associated with a high risk of mortality within 3 years after a stroke. Analyses are based on data from a population-based register of stroke events that occurred in Auckland (total population 829,545), New Zealand during a 1-year period in 1981–1982 and a 3-year follow-up study of all survivors (97% complete). Statistical techniques that allow for the simultaneous evaluation of multiple factors indicated that retention of consciousness, decreasing age, and place of residence at the onset of the stroke were the strongest predictors of survival over 3 years. The survival rate for those living at home at the onset of the stroke who did not lose consciousness was 98% compared with 5% for people in institutional care who lost consciousness. Marital status, history of stroke, and ethnic group also predicted survival. Most of the important prognostic factors we identified in our study cannot be modified, testifying to the importance of the prevention of stroke in the first place. (Stroke 1988;19:669–673)

Stroke is the third most common cause of death in Western industrialized countries and a leading cause of chronic disability and suffering. Although many follow-up studies based on hospital series have been reported, little is known about the long-term outcome of stroke within a total community setting. Many studies—often based on selected cases—have described factors influencing survival, but only a few have allowed the simultaneous analysis of multiple factors. We describe the 3-year outcome of all stroke patients registered in a large community-based study and examine the prognostic significance of a range of factors to identify those characteristics associated with a high risk of mortality following stroke.

Subjects and Methods

The data came from a population-based stroke register compiled in the 12-month period ending March 1, 1982. The definitions and methods have been published. Briefly, a representative sample (50%) of all episodes of stroke occurring in Auckland were registered. Auckland, with a total population of 829,545 in the 1981 census, encompasses a quarter of the total population of New Zealand. Multiple case-finding sources were used to ensure the completeness of the register. Stroke was defined as the acute onset of focal or global neurologic deficit presumably of vascular origin lasting ≥24 hours or leading to death. This definition included subarachnoid hemorrhage, but for the purposes of this article, patients with subarachnoid hemorrhage were excluded.

All patients who met the inclusion criteria and survived were interviewed as soon after the event as possible; for those who died shortly after the event, a family member was interviewed approximately 6 weeks later. Loss of consciousness, duration of unconsciousness, and presence and severity of motor deficit and speech impairment during the first 48 hours after onset were noted. In the group of patients who died having been unconscious or who were very drowsy initially, presence and side of hemiparesis noted by the attending physician were accepted as evidence of a motor deficit, but no attempt was made to determine the severity of the deficit in these patients. Analyses relating to the severity of motor deficit were restricted to those patients who survived at least 1 week to avoid the problem of incomplete data related to early deaths. For the same reason, assessment of speech impairment was restricted to those patients whose speech problem persisted beyond the first 2 days and who had survived 1 week.

Information on medical history was determined from all available records and sources and frequently involved recourse to the general practitioner for verification of data. Socioeconomic status was assessed using a modified version of the British Registrar-General’s classification of social class. An obesity index classification was based on self-reported heights and weights as described by Bray. Follow-up by telephone and letters was undertaken at 1 year and again at 3 years after the initial episode to establish status as dead or alive.

The effects on survival of the variables listed in Table 1 were examined by use of the log-rank test and Cox’s proportional hazards regression model using binary dummy variables to represent categorical measures. Proportional hazards analysis assumes that the “haz-
Meier method, and residual plots were examined to identify 3 years after the stroke. Of the 16 who were lost to follow-up, 13 were younger than 65 years. A search of all death certificates in the Auckland region did not reveal any recorded deaths in the names of these 16 people. It was known that 10 had emigrated, and although it is likely that these patients were alive at 3 years, only the information that they were still alive at 1 year was included in the survival analysis. Sixty-three percent of the men and 65% of the women died during the first 3 years after their stroke.

In determining factors predicting survival, all variables or groups of variables with a high $\chi^2$ value on the log-rank test and few missing values were included in the full proportional hazards model using a stepwise fit (601 observations, 34 missing values). Loss of consciousness during the first 48 hours, increasing age, being in institutional care at the onset of the stroke, and marital status (being married rather than not being married) were the only variables to enter the final model (Table 2). Variables (apart from those related to motor or speech deficits, which had not been included in the model) were individually added to see if they had effect, but none did.

Because loss of consciousness was so powerful a predictor (odds ratio = 5.2) and because there were 27 people for whom no information on this variable was available, a second model was created excluding this variable to determine whether any other variables were being masked. Table 3 indicates that ethnic group was important, with more Maoris dying than non-Maoris (Europeans, other Polynesians, and other ethnic groups). Those people with a history of stroke did less well than those with no such history. When categories representing the duration of unconsciousness were substituted for the presence/absence of unconsciousness, it was found that longer periods of unconsciousness predicted poorer survival.

Information on the impact on survival of differing degrees of severity of motor and/or speech deficit was restricted to those patients who survived the first week because complete clinical details on the degree of severity of motor and speech deficits were available only for these patients (469 observations). Stepwise models were repeated, fitting different deficits in turn. Again, age, institutional care at onset, and loss of consciousness shortly after onset were the most important factors predicting mortality at 3 years (Table 4). Those patients who were married at the time of their stroke were more likely to survive.

Results

There were 657 stroke events in 635 people aged ≥15 years registered in the study year. All but 16 people were identified 3 years after the stroke. Of the 16 who were lost to follow-up, 13 were younger than 65 years of age. A search of all death certificates in the Auckland region did not reveal any recorded deaths in the names of these 16 people. It was known that 10 had emigrated, and although it is likely that these patients were alive at 3 years, only the information that they were still alive at 1 year was included in the survival analysis. Sixty-three percent of the men and 65% of the women died during the first 3 years after their stroke.

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Table 3. Second Model, Factors Predicting 3-Year Mortality (Excluding Loss of Consciousness) After Stroke, Auckland, New Zealand

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>$\beta$</th>
<th>SEE</th>
<th>$\chi^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>In institution at onset</td>
<td>0.911</td>
<td>0.114</td>
<td>63.8</td>
<td>0.000</td>
</tr>
<tr>
<td>Age</td>
<td>0.031</td>
<td>0.005</td>
<td>37.1</td>
<td>0.000</td>
</tr>
<tr>
<td>Maori</td>
<td>0.753</td>
<td>0.244</td>
<td>9.5</td>
<td>0.002</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>0.273</td>
<td>0.113</td>
<td>5.8</td>
<td>0.016</td>
</tr>
</tbody>
</table>

SEE, standard error of the estimate.

Table 4. Third Model, Factors Predicting 3-Year Mortality After Stroke, Auckland, New Zealand

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>$\beta$</th>
<th>SEE</th>
<th>$\chi^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>In institution at onset</td>
<td>0.911</td>
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</tr>
</tbody>
</table>

SEE, standard error of the estimate.
Table 4. Factors Predicting 3-Year Mortality (Assuming Survival of 1 Week)

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>β</th>
<th>SEE</th>
<th>χ²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of consciousness</td>
<td>1.127</td>
<td>0.157</td>
<td>51.3</td>
<td>0.000</td>
</tr>
<tr>
<td>Age</td>
<td>0.060</td>
<td>0.007</td>
<td>69.1</td>
<td>0.000</td>
</tr>
<tr>
<td>In institution at onset</td>
<td>0.850</td>
<td>0.158</td>
<td>29.0</td>
<td>0.000</td>
</tr>
<tr>
<td>Severe motor deficit (left side)</td>
<td>0.679</td>
<td>0.162</td>
<td>17.6</td>
<td>0.000</td>
</tr>
<tr>
<td>Maori</td>
<td>1.176</td>
<td>0.304</td>
<td>14.9</td>
<td>0.000</td>
</tr>
<tr>
<td>Married</td>
<td>0.381</td>
<td>0.148</td>
<td>6.6</td>
<td>0.180</td>
</tr>
<tr>
<td>Severe motor deficit (right side)</td>
<td>0.390</td>
<td>0.158</td>
<td>6.1</td>
<td>0.014</td>
</tr>
</tbody>
</table>

SEE, standard error of the estimate.

stroke had a worse prognosis than those not married (p = 0.035). Patients with a severe deficit were less likely to survive than those with a mild or moderate deficit, irrespective of the side of the deficit. A comparison of people having a left-sided deficit with those having a right-sided deficit showed that there was no significant difference in survival between the two (χ² = 2.1, p = 0.15).

The survival curves in Figure 1 examine the combined effect of two of the three major variables predicting outcome: place of care at the time of the stroke and state of consciousness immediately after the onset. The survival rate for people at home who did not lose consciousness was 58% compared with only 5% for those in institutional care who lost consciousness after the onset.

Increasing age was found to have a significant effect on outcome, with older patients having a poorer prognosis (Figure 2). The 3-year survival rate for people aged 40 years was 74% compared with 28% for those aged 80 years.

The survival rate for patients with no history of stroke was 42% compared with 30% for those with such a history.

Finally, for patients who had already survived 1 week, the survival rate for those with an initial severe motor deficit was 36% compared with 49% and 59% for those who had initial moderate and mild motor deficits, respectively (Figure 3).

Discussion

Our population-based study confirms the high case-fatality rate following stroke; in particular, older patients who lose consciousness after the onset of the stroke and who are already in institutional care at the time of the stroke have a very low chance of surviving.

There are two important features of our study. The first is that because it is population-based, there is no case selection; in a recent review of stroke incidence studies, ours is one of the few to meet the "ideal" criteria. Most studies that have investigated outcome in relation to the severity of the stroke have been restricted to highly selected cases such as those referred for rehabilitation. Factors predicting outcome for patients who have survived the acute phase and who
enter rehabilitation programs are, by their very nature, restricted in value. Studies that rely on selected patients do not reflect the general pattern of survival after stroke. In our study, for example, only two thirds of all patients entered a hospital and more than half of the survivors were discharged within 3 weeks. This largely explains why large-scale epidemiologic studies are unable to differentiate between subcategories of stroke with any degree of accuracy. Substantial intraobserver and interobserver biases have been found in attempts at diagnosis of the subcategories of stroke (apart from subarachnoid hemorrhage), although the diagnosis of stroke (i.e., presence or absence regardless of subcategory) can be established relatively accurately.

The second feature is that our study is based on statistical techniques that allow the simultaneous evaluation of multiple factors rather than relying on univariate methods of analyses. In our study, a large number of variables had high log-rank scores when considered in a univariate fashion although only three emerged as strong independent predictors of mortality with multivariate analysis. Indeed, because of the problem of age as a confounder and because of the intervariable correlations, the log-rank test was not a particularly useful guide in determining the most appropriate variables to include in the regression model.

Other population-based studies have also shown that increasing age and loss of consciousness are the most important predictors of mortality. A third variable, place of care at the time of the stroke, also emerged in our study as an important predictor, with those already in institutional care at the onset of the stroke having a poor prognosis. Although not unexpected, this latter finding has not previously been documented. Similarly, our finding that married people do less well than nonmarried people is unexpected; the reason for this is unclear.

After the two most important factors were removed from the model, only two other variables emerged as important predictors of mortality—ethnic group and history of stroke—suggesting that people falling into those two categories have a more severe onset of stroke involving loss of consciousness. It has been shown that Maoris have both higher stroke incidence rates and higher national mortality rates than non-Maoris. Our finding that patients with a history of stroke do worse than those with no such history emphasizes the need to distinguish between first and recurrent episodes of stroke in epidemiologic studies. Prestroke cardiac disease has been well documented as a predictor of poor survival; a history of stroke is less well established. In a large study of 4,219 hospitalized stroke patients, which used proportional hazards analyses, previous stroke was also only marginally significant as in our study and suggests that such a history is possibly a marker for advanced atherosclerosis.

Information on history of both heart disease and diabetes was gathered in our study, but as the information obtained could be validated in only two thirds of the cases, these variables were not included in the initial analyses. Subsequent log-rank tests did not reveal significant effects. Similarly, in attempting to fit them as additional independent variables in the proportional hazards regression model, it was found that they made no difference to the final model. This nonsignificant result may reflect the quality of data rather than the true situation.

The lack of any effect of sex on long-term survival demonstrated in our study has been reported previously. In this population women did worse than men in short-term (6 months) survival, but the differences between the sexes had disappeared by 1 year. A history of neither hypertension nor smoking was found to be an important predictor of long-term outcome. Although perhaps surprising since both have been shown to be important predictors of the onset of stroke, it may well be that different risk factors determine the poststroke course.

Given survival for 1 week, it is clear that people with a severe motor deficit regardless of the side of the deficit are more likely to die than those with either a mild or a moderate deficit. This finding confirms many other studies that have used similar measures of severity of stroke. Similarly, no differences in outcome between patients with left-sided and right-sided weakness were observed, confirming the results of two other studies of patients in a rehabilitation ward, which found that laterality did not influence eventual outcome.

Estimates of survival from this large unselected group of stroke patients highlight the characteristics that predict an individual's chance of surviving for 3 years. Such information is useful both for clinicians in the management of individual patients and for health planners in assessing health and personal resources to meet the needs of those who require ongoing care. Finally, our study emphasizes the importance of prevention since most of the factors identified that predicted survival are not amenable to change.

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References

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