Factors influencing survival after stroke in Western Australia

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ABSTRACT

Objective: To determine the factors influencing survival among patients admitted to Western Australian hospitals for the first time with stroke or transient ischaemic attack (TIA).

Design, setting and patients: Linked hospitalisation and death records of 7784 patients admitted to hospital for first-ever stroke or TIA between July 1995 and December 1998 were retrieved retrospectively to determine survival; effects of risk factors on death due to stroke were assessed using the Cox proportional hazards regression model.

Main outcome measures: All-cause stroke survival; short- and long-term stroke survival probabilities.

Results: Survival at 28 days was lowest for haemorrhagic stroke. However, following the first month after admission survival after haemorrhagic stroke was similar to, if not higher than, after ischaemic stroke. Among all patients, significant predictors of death were age (all subtypes of stroke), atrial fibrillation (intracerebral haemorrhage and ischaemic stroke), other cardiac conditions (ischaemic stroke and TIA), and sex and diabetes (TIA). Further predictors of death were residence in rural or remote areas (ischaemic stroke), and Aboriginality (TIA). Among 28-day survivors of ischaemic stroke, additional predictors of death were sex, diabetes and urinary incontinence still present 7 days after admission.

Conclusion: Use of linked hospitalisation and death data allowed us to increase the scope and size of our study compared with previous studies of survival after stroke and TIA in WA. We confirmed the importance of type of stroke, age and comorbidities to this survival, and found that Aboriginality and place of residence are also important.

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THE ANNUAL CRUDE incidence of stroke in Perth, Western Australia, has been estimated as 178 per 100 000.[1] Around 90% of these acute stroke events are estimated to result in hospital admission, with rapidly fatal cases not admitted.[2]

About a quarter of people suffering stroke die within a month, and 40% within the first year.[3] A major influence on survival is the stroke subtype, with patients suffering haemorrhagic stroke more likely to die within the first 30 days than those suffering ischaemic stroke.[4] Access to treatments may also influence outcome. Early acute care is essential for optimal outcome,[5] but may be compromised by delays in response, transportation to an appropriate medical facility and diagnostic procedures.

This hospital-based study aimed to determine risk factors that influence survival of stroke patients admitted to hospital for first-ever stroke throughout WA. The study was facilitated by the WA Data Linkage System, which links records of individuals from a number of health and administrative data sets, including hospital separation and death records.[6] This system enabled us to assess prognostic factors with high statistical power and to include rural and remote areas in the study, so that we could investigate the influence of place of residence and Aboriginality on stroke survival.

METHODS

Data sources

The WA Data Linkage System[6] links hospital separation records in the WA Hospital Morbidity Data System (which contains all separations from all hospitals in the state [population, 1.8 million]) with death records in the Australian Bureau of Statistics mortality database. The linkage system attaches a unique patient identifier to all hospital separation records for an individual, which enabled us to identify the first admission for stroke for that individual from among multiple admissions. The quality of hospital morbidity data linkage has been assessed, with the proportions of invalid and missed links estimated at 0.11%.[6]

Patients

Patients were identified who had an admission between 1 July 1995 and 31 December 1998 with a principal diagnosis of stroke. This study period was chosen to ensure continuity of coding for the principal diagnosis for acute cerebrovascular events (before 1 July 1995, coding did not differentiate between ischaemic cerebrovascular disease with or without infarction of the brain).

Admissions for stroke were defined as those with a principal diagnosis coded according to the International classification of diseases, 9th revision, clinical modification (ICD-9-CM)[7] as code 430 (subarachnoid haemorrhage), 431 (intracerebral haemorrhage), 433.x1 (where x = 0–3, 8, 9; occlusion and stenosis of precerebral arteries with cerebral infarction), 434.x1 (where x = 0, 1, 9; occlusion of cerebral arteries with cerebral infarction), 435 (transient

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1: Demographic and other characteristics of 7784 patients with stroke and transient ischaemic attack (TIA) at baseline

	Subarachnoid haemorrhage (*n*=322)	Intracerebral haemorrhage (*n*=807)	Ischaemic stroke (*n*=4681)	TIA (*n*=1974)
Characteristics				
Mean age in years (95% CI)	54.3 (52.3–56.3)	68.4 (67.3–69.5)	73.2 (72.8–73.6)	72.6 (72.0–73.2)
Male (%)	42.5	50.3	52.8	50.5
Aboriginal (%)	3.1	2.0	3.2	2.7
Rural or remote (%)	24.5	14.4	21.7	31.7
Comorbidities				
Diabetes (%)	5.9	10.7	20.1	14.9
Atrial fibrillation (%)	3.4	12.8	23.2	12.1
Cardiac condition (%)	14.9	21.7	32.5	28.4
Urinary incontinence (%)	3.1	5.2	6.7	2.0
Hospitalisation and treatment				
Stroke unit (%)	68.6	58.1	39.9	25.1
Transferred (%)	23.0	5.1	4.7	1.3
Carotid endarterectomy (%)	NA	0.5	1.3	0.5
Outcome				
Survived* (%)	66.5%	52.2%	66.6%	84.8%
Mean survival time in days (95% CI)	835 (770–900)	668 (625–711)	857 (839–875)	1083 (1063–1103)

NA = not applicable. *Survived until date of censoring (31 December 1998).

2: Survival probability (95% CI) at index admission by subtype of stroke

Time after admission	Subarachnoid haemorrhage (*n*=322)	Intracerebral haemorrhage (*n*=807)	Ischaemic stroke (*n*=4681)	Transient ischaemic attack (*n*=1974)
7 days	0.82 (0.78–0.86)	0.71 (0.68–0.74)	0.91 (0.90–0.92)	1.00 (0.99–1.00)
28 days	0.72 (0.67–0.77)	0.65 (0.62–0.68)	0.85 (0.84–0.86)	0.99 (0.99–1.00)
1 year	0.68 (0.62–0.73)	0.56 (0.52–0.59)	0.72 (0.71–0.74)	0.89 (0.88–0.90)

ischaemic attack [TIA]) or 436 (ischaemic stroke).

The first admission for an individual during the study period defined the initial hospitalisation for stroke (index stroke). To ensure that no patients had previous admissions for stroke, we also identified in the morbidity records all acute cerebrovascular events from 1 January 1989 to 31 December 1998, and excluded patients who had a stroke before July 1995 from the study.

Data extraction

Patient medical history was extracted from hospital separation records, and date and cause of death, if death occurred, from the mortality database, and compiled into a data set containing one record per patient admitted for an initial stroke or TIA during the study period.

Each record included date of admission, demographic characteristics (age at admission, sex, Indigenous status and place of residence — a dichotomous variable defined as either the Perth metropolitan area or other areas [rural/remote]) and hospitalisation details (including admission to a hospital with a stroke unit or transfer to another acute hospital during the index admission). The record also included presence of comorbid conditions: history of diabetes (ICD-9-CM codes 250 to 250.9[7]), atrial fibrillation (427.31) and other cardiac conditions (410 to 429.9, excluding 427.31), as well as urinary incontinence (788.30 to 788.39) diagnosed on index admission. As urinary incontinence was coded on the hospital separation record only if still present 7 days after admission, it could not be used in the survival analysis from admission but was included in the model for patients surviving 28 days. Procedures performed, including carotid endarterectomy, were also recorded.

Stroke survival analysis

Cerebrovascular events were grouped into four subtypes for analysis — ischaemic stroke, TIA, intracerebral haemorrhage and subarachnoid haemorrhage. Survival time for each patient was calculated from the date of admission for the index stroke to the date of death or the census date at the end of the study period (31 December 1998). Survival probabilities were estimated using Kaplan–Meier estimation.[8] To assess the effect of risk factors on death, the Cox proportional hazards regression model was applied in the framework of survival analysis.[9] In particular, a backward model selection approach was adopted with removal probability set at 5%. The adjusted hazard ratios and 95% CIs for risk factors associated with death were of main interest. All statistical analyses were conducted using the SAS software package.[10]

RESULTS

From 1 July 1995 to 31 December 1998, 7784 residents of WA were admitted to hospital for the first time with a principal diagnosis of stroke or TIA. Most of these admissions were for ischaemic stroke (4681; 60%), followed by TIA (1974; 25%) while intracerebral and subarachnoid haemorrhage were less common (807 [10%] and 322 [4%], respectively).

Patient characteristics

Patient characteristics and outcome are shown in Box 1. Most patients with TIA survived over the study period (85%), but the proportions were much lower for the other stroke subtypes (67% for ischaemic stroke, and 52% and 66% for intracerebral and subarachnoid haemorrhage, respectively). Patients admit-

ted for haemorrhagic stroke were younger and had shorter mean survival than patients admitted for ischaemic stroke. A high proportion of women was observed among patients with subarachnoid haemorrhage. Carotid endarterectomy is not applicable to subarachnoid haemorrhage, and was undertaken in only a few patients with intracerebral haemorrhage.

Stroke survival analysis

During the study period, 2360 (30%) of the patients hospitalised for stroke died. Of these, 1049 (44%) died during their index hospitalisation. Most of these patients (66%) had an ischaemic stroke, while 26% had an intracerebral and 7% a subarachnoid haemorrhage, and 1% a TIA. Of the remaining patients who died during the study period, 41% died of stroke.

Survival probabilities for each stroke subtype at 7 days, 28 days and 1 year are shown in Box 2. Across all time periods, the lowest survival was for intracerebral haemorrhage, and the highest for TIA. For both subarachnoid and intracerebral haemorrhage, the highest risk of death was in the first week after initial admission whereas, for ischaemic stroke and TIA, the highest risk was after the first month from admission. After this time, the risk of death was similar, if not higher, for ischaemic stroke and TIA compared with subarachnoid and intracerebral haemorrhage.

Risk factors for death

Adjusted hazard ratios of significant risk factors, based on Cox proportional hazards modelling, are shown in Box 3. Age was an important risk factor for death for all stroke subtypes. For every year increase in age, there was an increase in death hazard: 4% for subarachnoid haemorrhage, 3% for intracerebral haemorrhage, and 6% for both ischaemic stroke and TIA.

For patients admitted initially with TIA, four significant risk factors were identified in addition to age: men experienced a 45% higher death hazard than women, and Aboriginal patients had a death hazard more than double that of non-Aboriginal patients, while a history of diabetes increased the death hazard by 66%, and a history of cardiac conditions other than atrial fibrillation by 39%.

For ischaemic stroke, three significant risk factors were identified in addition to age: a history of atrial fibrillation or of other cardiac conditions increased the death hazard by 29% and 47%, respectively, while residence in a rural or remote area increased hazard by 34% compared with residence in the metropolitan area.

For subarachnoid haemorrhage, no risk factor other than age affected death hazard significantly, while for intracerebral haemorrhage, a history of atrial fibrillation also increased death hazard (by 42%).

Admission to a hospital with a stroke unit or transfer on index admission had little influence on death hazard, regardless of stroke subtype.

Box 3 also shows the significant risk factors associated with death among patients who survived 28 days. All characteristics found to be significant risk factors among all patients were also significant among patients who survived 28 days. Other characteristics that were significant risk factors among patients who survived 28 days, but not among all patients, were male sex and diabetes (for patients with ischaemic stroke) and history of a cardiac condition other than atrial fibrillation (for those with TIA). In addition, urinary incontinence still present 7 days after index admission increased death hazard by 45% for patients with ischaemic stroke who survived 28 days, but occurred in only 6.7%.

3: Adjusted hazard ratios (95% CI) for significant risk factors associated with all death events based on Cox proportional hazards modelling

	All patients				Patients who survived 28 days			
Risk factor	Subarachnoid haemorrhage (*n*=322)	Intracerebral haemorrhage (*n*=807)	Ischaemic stroke (*n*=4681)	Transient ischaemic attack (*n*=1974)	Subarachnoid haemorrhage (*n*=231)	Intracerebral haemorrhage (*n*=519)	Ischaemic stroke (*n*=3918)	Transient ischaemic attack (*n*=1915)
Age (per year increase)	1.04 (1.03–1.05)	1.03 (1.02–1.03)	1.06 (1.05–1.07)	1.06 (1.05–1.08)	1.08 (1.04–1.11)	1.04 (1.02–1.06)	1.07 (1.06–1.08)	1.07 (1.05–1.08)
Male	–	–	–	1.45 (1.15–1.83)	–	–	1.20 (1.05–1.38)	1.50 (1.18–1.91)
Aboriginal	–	–	–	2.37 (1.20–4.67)	–	–	–	2.31 (1.13–4.74)
Rural/remote	–	–	1.34 (1.19–1.51)	–	–	–	1.31 (1.11–1.54)	–
Diabetes	–	–	–	1.66 (1.25–2.22)	–	–	1.19 (1.00–1.42)	1.68 (1.25–2.26)
Atrial fibrillation	–	1.42 (1.08–1.85)	1.29 (1.15–1.44)	–	–	1.71 (1.01–2.89)	1.27 (1.09–1.48)	–
Urinary incontinence	NA	NA	NA	NA	–	–	1.45 (1.17–1.80)	–
Other cardiac condition	–	–	1.47 (1.32–1.63)	1.39 (1.10–1.76)	–	–	1.50 (1.30–1.73)	1.39 (1.10–1.77)

– = not significant. NA = not applicable.

As for all patients, admission to a hospital maintaining a stroke unit or transfer during the index admission had little influence on death hazard regardless of stroke subtype among patients who survived 28 days. Similarly, no effect on death hazard could be attributed to carotid endarterectomy among the small number of patients who underwent that procedure.

DISCUSSION

Our study confirms the importance of stroke subtype, age and comorbidities to survival after stroke and TIA. We also found that Aboriginality and place of residence are important factors affecting survival after stroke in WA, with Aboriginal people less likely to survive than non-Aboriginal people after TIA, and residents of rural or remote areas less likely to survive than residents of metropolitan areas after ischaemic stroke.

We found that survival among patients admitted to hospital for haemorrhagic stroke was lower than among patients hospitalised for ischaemic stroke and TIA in the first 28 days after the index stroke, but was similar if not higher between 28 days and 1 year after admission. The Perth Community Stroke Study similarly observed higher 30-day case fatalities for haemorrhagic stroke than for ischaemic stroke.[4]

Consistent with other community-based stroke registry and hospital-based studies, advancing age,[11-15] sex,[16] diabetes[11,14,15] and cardiac disease, specifically atrial fibrillation,[3,4,11-17] were found to increase the risk of death from first-time stroke or TIA. Urinary incontinence, which has been associated with a poor outcome of first-time stroke and suggested as a proxy for stroke severity,[4,18] increased death hazard among 28-day survivors of ischaemic stroke.

Admission to a stroke unit had no significant influence on survival after stroke in our study. During the study period, stroke units were established in two metropolitan hospitals, which probably had a different casemix to other hospitals. Previous studies have found that care in a stroke unit has a beneficial effect on survival, after adjusting for age, sex and stroke severity.[19] As we could not determine stroke severity from the hospital separation records, our conclusions about stroke unit care are limited.

Both the survival probabilities and factors which influence the prognosis of stroke patients found in this study appear to have clinical validity.[3,4,11-18] The use of linked hospitalisation data enabled study of other prognostic factors, such as place of residence and Aboriginality. Additionally, linked hospitalisation data have the advantage of providing access to a large sample size, which can enhance the accuracy of the predictive relationship.

Including non-urban areas of WA in the study population allowed the survival of Aboriginal patients to be investigated, as most of the Aboriginal population resides in non-urban areas.[20] Survival after stroke among Aboriginal people was similar to that in the total WA population for most subtypes except TIA. As mortality after TIA is low, the increased risk of death among Aboriginal people probably reflects the differential in all-cause mortality between Aboriginal and non-Aboriginal people.[21] However, the high hazard ratio of TIA among Aboriginal people presents an opportunity to implement secondary stroke prevention at the time of hospitalisation. Further investigation is also warranted into whether the increased risk is due to genetic susceptibility or to environmental factors such as poor living conditions or limited access to appropriate healthcare.

Although our study design enabled the identification of risk factors in a large and diverse sample, it also had some intrinsic limitations. Firstly, the use of hospital separation data meant that the 10% of stroke patients who do not reach hospital were excluded. Secondly, the hospital separation records did not contain enough information to assess stroke severity or lifestyle risk factors, such as smoking, alcohol consumption, obesity and physical activity, which are available in prospective cohort studies.[22] Lastly, the accuracy of our results depended on the reliability of case coding. Ischaemic stroke is known to be overestimated by coding in some hospital data collections.[23] However, in the WA Hospital Morbidity System, the quality of information is assured by use of trained coders who assign ICD codes based on Australian national coding standards.[24] All hospitals undergo continual auditing for adherence to these standards; an audit in 1998 to validate diagnosis-related groups derived from coding by checking against those derived from discharge summaries showed 4%–20% changes across all WA hospitals in 1998.[25] In addition, we excluded from our analysis conditions known to be recorded unreliably. For example, it is coding practice to record hypertension and hypercholesterolaemia only when the medical record documents their control through drug therapy or previous diagnosis. As incomplete reporting in some records may lead to under-estimation of these conditions, they were not included in our statistical analysis.

Despite the limitations of this study, the linkage of hospitalisation and death records provided an extremely large data set spanning several years. The results demonstrated that Aboriginality and place of residence are important factors affecting survival after stroke and TIA in WA.

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COMPETING INTERESTS

None identified.

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