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ORIGINAL ARTICLE

Survival following spinal cord infarction

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Study design: Retrospective open cohort.
Objectives: To calculate the survival of patients with spinal cord infarction and to compare the cause of death in patients with different mechanisms of ischaemic injury.
Setting: Spinal Rehabilitation Unit, Melbourne, Victoria, Australia.
Methods: Consecutive admissions between 1 January 1995 and 31 December 2008 with recent onset of spinal cord infarction. Linkage to the Registry of Births, Deaths and Marriages (Victoria) was used to determine survival following discharge from in-patient rehabilitation and cause of death.
Results: A total of 44 patients were admitted (males = 26, 59%), with a median age of 72 years (interquartile range (IQR) 62–79). One patient died during their in-patient rehabilitation programme. In all, 14 patients ($n = 14/44$; 33%) died during the follow-up period. The median survival after diagnosis was 56 months (IQR 28–85) and after discharge from in-patient rehabilitation was 46 months (IQR 25–74). The 1- and 5-year mortality rates were 7.0% ($n = 3/43$; 95% confidence interval (CI) = 2.4–18.6%) and 20.9% ($n = 9/43$; 95% CI = 11.4–35.2%). There was no statistically significant difference in survival between patients with the different aetiologies of spinal cord infarction (other *vs* idiopathic: $\chi^2 = 0.6$, $P = 0.7$; other *vs* vascular: $\chi^2 = 1.9$, $P = 0.3$). There was no relationship between survival and gender ($\chi^2 = 0.2$, $P = 0.6$), age ($\chi^2 = 3.0$, $P = 0.08$), level of injury ($\chi^2 = 0.0$, $P = 1$) or American Spinal Cord Society Impairment Scale grade of spinal cord injury ($\chi^2 = 0.02$, $P = 0.9$).
Conclusion: Patients with spinal cord infarction appear to have a fair survival after discharge from in-patient rehabilitation, not withstanding the occurrence of risk factors of vascular disease in many patients.
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Keywords: spinal cord ischemia; spinal infarction; spinal cord myelopathy; rehabilitation; survival analysis; outcome assessment (health care)

INTRODUCTION

Ischaemic spinal cord injury is rare, accounting for 1% of acute stroke hospitalisations.[1] The incidence, however, is unknown. In patients admitted to spinal rehabilitation units, the proportion of patients with spinal cord ischaemia varies between 1%[2,3] and 11%.[4] This range probably reflects referral and selection bias,[5,6] the availability of diagnostic services and the prevalence of underlying diseases in different countries.

It is well established that spinal cord infarction is associated with vascular diseases, although a notable proportion are idiopathic. A number of publications describe outcomes in these patients.[4,7–13] Although a few reports have described the survival of these patients,[7–9] no formal survival analysis has been reported. Knowledge of survival is important for patients, their families and health-care providers because of the multiple vascular risk factors and comorbidities that these patients are likely to have. The objective of this project was to determine the survival of patients with spinal cord infarction discharged from rehabilitation. A secondary objective was to compare the survival of patients with different aetiologies of spinal cord infarction and report the causes of death for these patients.

METHODS

Study population and design

The Spinal Rehabilitation Unit at Caulfield Hospital (Melbourne, Victoria, Australia) provides a 12-bed in-patient service. It is a tertiary medical unit located in a public hospital, which is funded by the State health department. Patients are referred from both private and public acute hospitals, mainly in Melbourne, and also from elsewhere in the State. The Unit specializes in the rehabilitation of patients with spinal cord myelopathy (non-traumatic SCI) and is the primary rehabilitation centre for these patients in the State.

The hospital health information department used the International Classification of Diseases and Related Health Problems, 10th edition, Australian modification (ICD-10-AM)[14] coding to identify patients with spinal cord myelopathy due to infarction admitted between 1 January 1995 and 31 December 2008. The medical records of these patients were reviewed by one of us (CLM) to confirm the aetiology of spinal cord myelopathy and that patients met the inclusion criteria. Only patients with a new onset of spinal cord infarction were included. The clinical features, MRI imaging and other relevant investigations (for example, serology, cerebrospinal fluid analysis, angiography) needed to suggest an ischaemic pathogenesis in the absence of another cause in order for the patient to be included. Patients admitted for management of late complications were excluded. A total of 44 patients were identified who fulfilled these criteria.

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Outcome measures

The medical records of eligible patients had key clinical and demographic details extracted. This included date of birth, gender, classification of the aetiology of spinal cord infarction using the criteria used previously,[9] the discharge level of injury (paraplegia or tetraplegia) and neurological grade according to the American Spinal Cord Society (ASIA) Impairment Scale (AIS).[15] The aetiology was grouped into three categories, as described previously:[4] idiopathic, vascular and other. The dates of acute hospital admission, admission to the Spinal Rehabilitation Unit and subsequent discharge were also recorded. Information collected was recorded in a password-protected database.

Information identifying individuals was submitted to the Registry of Births, Deaths and Marriages (Department of Justice, Victoria, Australia) to determine survival. Patients' details were provided to the Registry in July 2010 to identify the date of death of any patient until 31 December 2009 (one year after the inclusion cut-off date), as well as the cause(s) of death as recorded on the death certificate. On the basis of the reported cause of death, this was classified (by PN) as due to SCI complications, vascular or other causes (yes, no or possibly).

Statistical analysis

Statistical analysis was performed using Stata (version 11; Statacorp, Austin, TX, USA). Descriptive statistics were calculated for demographic characteristics and clinical features. Associations between categorical variables were estimated using the χ^2-test and the Kruskal–Wallis test was used when comparing the medians (for example, age) between groups.

Survivorship was calculated using both survival (in months) after discharge from the Spinal Rehabilitation Unit and survival since diagnosis. Because patients with spinal cord infarction are at risk of dying while still in hospital,[16] and they can have lengthy admissions in both acute and rehabilitation hospital (as reported below), we were interested in the patient-centred outcome of survival after discharge from in-patient rehabilitation. We argue that from the patients' perspective the survival after discharge from hospital is important. To facilitate comparison with other studies that use the time since diagnosis for survival analysis, we also calculated survival using this as the starting point. Survival analysis was performed using the log-rank test with adjustment for multiple comparisons and reporting the Sidak *P*-values. Kaplan–Meier survival curves were plotted for each of the three groups of aetiology of spinal cord infarction. *P*-values <0.05 were deemed statistically significant. Patients did not give consent for involvement in this project. We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

RESULTS

The demographic characteristics, vascular risk factors, aetiology of spinal cord infarction, level and grade of injury, complications and functional outcomes for the 44 patients admitted for rehabilitation are described elsewhere.[4] In summary, there were 26 male patients (59%) and 18 female patients (41%) in the cohort, with a median age of 72 years (interquartile range (IQR) 62–79, range 21–89). Acute hospital length of stay was a median of 25 days (IQR 18–37, range 6–169). The length of stay in rehabilitation was a median of 86 days (IQR 48–133, range 12–301). The aetiology was vascular in 19 cases (43%), other causes in 14 (33%) and the remainder were idiopathic ($n=11$, 25%). Most ($n=41$, 93%) patients had a paraplegia level of injury and only three (7%) had tetraplegia. One patient died during their in-patient rehabilitation programme. At discharge from rehabilitation, there were 10 patients with AIS grade A (23%), 7 with AIS grade B (16%), 7 with AIS grade C (16%) and 19 with AIS grade D (44%).

Survival

Of the 43 patients who survived until discharge, the aetiology of the infarction was vasculopathic processes in 19 cases (44%), other causes in 14 cases (33%) and the remainder were idiopathic ($n=10$, 23%). In all, 14 patients (33%) died during the follow-up period. The median survival after diagnosis was 56 months (IQR 28–85) and the median survival after discharge from in-patient rehabilitation was 46 months (IQR 25–74). Those who survived till the end of the study period remained alive for a median of 51 months (IQR 17–97) since discharge. The median duration of follow-up for all subjects from discharge was 48 months (IQR 16.5–79, range 0–139). There was no relationship between survival and gender ($\chi^2=0.2$, $P=0.6$), age ($\chi^2=3.0$, $P=0.08$), level of injury ($\chi^2=0.0$, $P=1$) or AIS grade of SCI ($\chi^2=0.02$, $P=0.9$).

The 1- and 5-year mortality rates were 7.0% ($n=3/43$; 95% confidence interval (CI) = 2.4–18.6%) and 20.9% ($n=9/43$; 95% CI = 11.4–35.2%). There was no statistically significant difference in survival between patients with the different aetiologies of spinal cord infarction (other vs idiopathic: $\chi^2=0.6$, $P=0.7$; other vs vascular: $\chi^2=1.9$, $P=0.3$), although there was a trend towards the idiopathic cohort having a better survival and the vascular cohort a worse survival. The Kaplan–Meier survival curves and 95% CIs for each of the three groups of aetiology of spinal cord infarction are shown in Figure 1.

Causes of death

The cause of death as recorded on the death certificate was available for 12 of the 14 patients who died after discharge and also for the patient who died during rehabilitation. Death was due to vascular conditions in four cases (stroke and ischaemic heart disease; cardiac failure; ischaemic heart disease; and aortic arch aneurysm) and possibly due to vascular causes in three cases (renal failure two times and ischaemic bowel). In four cases, the cause was related to spinal cord myelopathy complications (pneumonia was implicated in all of these, plus one case had pulmonary embolism and another urinary tract sepsis) and possibly due to spinal cord myelopathy complications in two cases (pneumonia and renal failure). In two cases, the cause of death was related to other aetiologies (chronic obstructive pulmonary disease/respiratory failure and lung cancer).

DISCUSSION

We found that patients with spinal cord infarction who died following discharge have a median survival after discharge from inpatient rehabilitation of just under 4 years. Although there was a trend towards patients with an idiopathic cause of spinal cord infarction having a better survival than those with other or vascular causes, the results were not statistically significant. There was no influence on the survival of patients from their gender, age at onset, level or grade of injury. Both the consequences of spinal cord myelopathy and vascular risk factors appeared to contribute toward patients' death.

There are few reports available for comparison with our results and all have major limitations. Reporting the proportion of patients who died at the end of follow-up and the duration of this period does not give an indication of actual survival. However, this is what most previous studies in this area have done. The 1-year survival following aortic aneurysm repair has been reported as 67%, with 2 of the 15 patients who died having a spinal cord infarction.[16] A retrospective study covering a 10-year period on the rehabilitation outcomes of 36 patients with spinal cord infarction reported a mortality of 22% during their rehabilitation admission.[8] There were no factors described in the study that would explain this high rate, which contrasts with our mortality during in-patient rehabilitation of only 2%. Another retrospective study conducted over 10 years on 44 patients admitted to acute medical hospitals reported that 18% ($n=8/44$) had died at follow-up, which varied from 1 week to

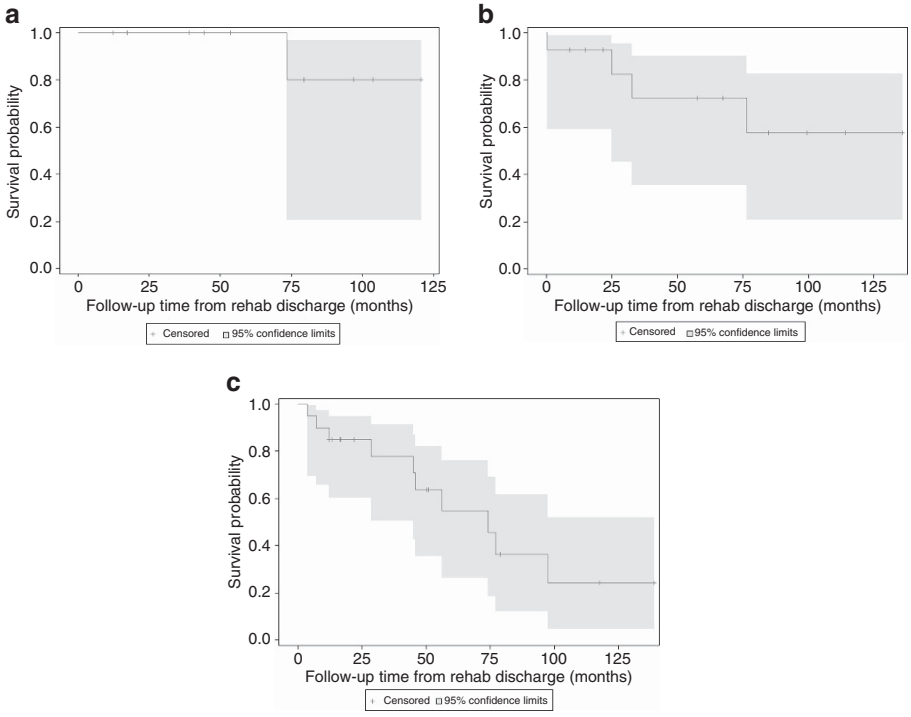

Figure 1 Kaplan–Meier survival curves for the three groups of aetiology of spinal cord infarction. (**a**) Ideopathic, (**b**) other and (**c**) vascular.

12 years.[7] An accompanying literature review reported that 22% ($n = 35/158$) of patients with spinal cord infarction described in various studies died; however, no specific 1- or 5-year survival rates or median survival duration was reported for either the formal study or the review.[7] Finally, a retrospective study conducted over a 13-year period on 57 patients discharged from a neurology and neurosurgery department reported a mortality of 9%, with a mean follow-up period of 4.5 years and 3 patients lost to follow-up.[9] This study also failed to report any formal survival analysis.

The strength of our results is that this is the first reported survival analysis for patients with spinal cord infarction. No studies have reported on the cause(s) of death in those patients who died. We have found that both spinal cord myelopathy and vascular factors appear to have a role in influencing the cause of death in these patients.

A limitation of our study is the small number of patients, which restricted the power of analyses performed. However, our sample is one of the largest involving patients with spinal cord infarction reported in the literature. It took 14 years to recruit these patients. A significantly larger sample would take either many decades to accumulate or require a multicentre study, both of which would necessitate considerable resources. Neither of these options were available for us to implement in this project. Although the Unit specialises in spinal cord myelopathy and is the primary centre for the rehabilitation of these patients in the State, it is likely that some patients may have been admitted for rehabilitation to other centres. We believe, however, that our sample would have included the majority of patients with this condition. We do not believe that the potential omission of some patients with spinal cord ischaemia from this study who were admitted elsewhere would affect the generalisability of the survival analysis results. We believe that our results may possibly be extended to reflect trends in other developed countries with a similar health system. In particular, where patients have access to both primary care and specialist health services that provide affordable treatments to optimise patient survival. The study was not adequately powered to detect differences between the survival of patients in the comparison groups of the different aetiologies of spinal cord infarction, although there was a trend towards patients in the idiopathic cohort having an improved survival. This trend was consistent with our expectations. The vascular diseases group would have comorbidities that adversely influence their survival and the idiopathic group would be expected to have fewer comorbidities and a lower risk for death, after allowing for age and level and grade of injury. The trend needs to be substantiated in an adequately powered study. Nevertheless, our sample is one of the largest cohorts reported.

In conclusion, patients with spinal cord infarction appear to have a fair survival after discharge from in-patient rehabilitation. Given the rarity of this condition, it is important that multicentre studies of outcome and survival following spinal cord infarction are conducted in order to perform adequately powered statistical analyses and better understand the factors influencing the outcomes for these patients.[4] Factors that may influence survival for these patients are additional areas for exploration. This includes optimising the management of vascular risk factors and diseases and the role of antithrombotic agents (e.g. aspirin) in patients with an idiopathic spinal cord infarction.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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