Mortality in patients with traumatic spinal cord injury: Descriptive analysis of 62 deceased subjects

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Study design: Retrospective study.
Objective: To investigate the causes of death in patients who were ≤50 years at the time of traumatic spinal cord injury (tSCI).
Setting: Convenience sample of a tertiary rehabilitation center.
Methods: All deceased patients with tSCI who survived a minimum of 10 years post-injury, were included. In addition, causes of death were compared between subjects surviving <10 years and ≥10 years. Neurological assessments were performed according to the American Spinal Injury Association scale. Data on causes of death were analyzed using the ICD-10 classifications. Differences were calculated using the Mann–Whitney and chi-square tests.
Results: A total of 100 patients, with 38 and 62 surviving <10 and ≥10 years, respectively, were included. No significant differences in causes of death were identified between these two groups. In patients surviving ≥10 years, paraplegia was associated with a higher life expectancy compared with tetraplegia, 34 and 25 years ($p = 0.008$), respectively, and the leading causes of death were septicemia ($n = 14$), ischemic heart disease ($n = 10$), neoplasms ($n = 9$), cerebrovascular diseases ($n = 5$), and other forms of heart diseases ($n = 5$). Septicemia, influenza/pneumonia, and suicide were the leading causes of death in tetraplegics, whereas ischemic heart disease, neoplasms, and septicemia were the leading causes of death in paraplegia.
Conclusion: Our monocentric study showed that in 62 deceased patients with SCI, the leading causes of death were septicemia, cardiovascular diseases, neoplasms, and cerebrovascular diseases. In addition, no significant differences were identified between causes of death among patients surviving <10 years and ≥10 years post-injury.

Keywords: Spinal cord injuries, Paraplegia, Tetraplegia, Life expectancy, Mortality, Sepsis, Cardiovascular diseases, Neoplasms

Introduction

In the past six decades, survival rates have considerably improved in subjects with spinal cord injury (SCI) and consequently, this has allowed for the emergence of chronic health conditions not previously recognized.[1]

Although the mean age at injury has steadily increased from 29 to 40 years, SCI still primarily affects young adults.[2] Despite the large number of studies on post-SCI mortality, few studies actually investigated the long-term survival. To illustrate, several studies that analyzed the long-term survival in patients with SCI, studied a heterogeneous population in which the minimum survival period was 1 day,[3] several months,[4] or 1-year post-injury.[5]

Studies on mortality have shown that urinary tract complications and renal failure are no longer the leading causes of death in SCI.[1] Currently, the leading causes of death in several studies are pneumonia, septicemia, and suicide.[6,7] The frequencies of these complications varies considerably between tetraplegia and paraplegia.[8] Overall, the risk of dying from respiratory complications is considered to be higher in tetraplegia, whereas risk of dying from cardiovascular diseases is higher in paraplegia.[1]

With the current emergency medical services, surgical procedures, antibiotics, improved rehabilitation policies and services, and life expectancies for persons with SCI

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have increased over the years and are expected to increase in the future.[9,10] The data of the National Spinal Cord Injury Statistical Center showed that people who are ≤50 years at the time of injury and survive the first year after the SCI, have a life expectancy of at least 20 years.[2] Although it is an encouraging finding that people with SCI are surviving longer, they consequently may be at greater risk to develop chronic health conditions associated with aging. Knowledge of the specific causes of death in chronic SCI patients, especially when complicated by SCI, will help in making decisions about medical management. It also supports efforts to evaluate which preventative strategies are appropriate for extending long-term survival in SCI.

Recognizing the lack of previous studies on mortality in chronic SCI, the purpose of this study therefore was to perform a descriptive analysis of the causes of death in patients who were ≤50 years old at the time of traumatic spinal cord injury (tSCI) and survived a minimum of 10 years post-injury. In addition, this study compared the differences in causes of death between patients who died <10 years and ≥10 years post-injury.

Materials and methods

For this retrospective study, we used data from patients treated in the BG Trauma Hospital Hamburg. This is a tertiary SCI rehabilitation center for hospitals throughout Germany. Patients referred to this SCI center are enrolled consecutively into the 'Hamburg database'. Demographic, neurological, and functional data from the first admission post-injury, each follow-up appointment and hospitalization afterwards, are collected in this database. Most patients therefore remain life-long 'clients' of this SCI center. In addition, the dates and causes of death are registered in the database. Out-hospital death data were collected using an official death notification from the general practitioner or other physicians when patients died in another hospital. The clinical assessments in this monocentric database are conducted by certificated neurological and rehabilitation physicians having at least 1-year clinical experience in examining patients with SCI.

Study population

Data from the Hamburg database were used for this retrospective study. Data are included in this database since the first of January 1997, including a total of 3114 patients with traumatic SCI. For this study, a convenience sample was used. This sample consisted of all deceased patients with tSCI who were injured in the period 1942–1995. From the database, only patients who survived ≥10-year post-injury and who died before the first of January 2010 were included. However, the causes of death in patients surviving <10 years post-injury were also collected and compared with the causes of death among the patient who survived ≥10 years post-injury. Patients with a neurological level of injury (NLI) of C2-T1 were considered tetraplegic and patients with NLI T2-S4-5 were considered paraplegic. Only patients of ≤50 years at the time of injury were included. Causes of death were analyzed according to the International Classification of Diseases: Tenth Edition (ICD-10).[11] An institutional ethical board evaluated the study protocol and declared that the need for informed consent was waived.

Neurological outcomes

Neurological examinations were conducted according to the International Standards for the Neurological Classification of Spinal Cord Injury.[12] All patients with a completely conducted examination at admission were included for the analysis. When the examination at admission was absent, a follow up neurological examination was used. Based on the American Spinal Injury Association (ASIA) sensory and motor scores, the NLI and ASIA impairment scale (AIS) were determined in all patients.

Statistics

Descriptive statistics on age, gender, and AIS were used to provide general information about the study population. Differences in age and life-expectancy between motor complete/incomplete patients and tetraplegics/paraplegics were calculated using the Mann–Whitney test. Causes of death in all patients who had a post-injury survival of <10 years were compared with the causes of death among the patient who survived ≥10 years post-injury using the chi-square or Fisher's exact test as appropriate. The differences were considered statistically significant at $P < 0.05$. Data were analyzed using SPSS software (version 16.0, SPSS, Chicago, IL, USA).

Results

Of the 3114 tSCI patients in the Hamburg database, 268 patients had died. Of these 268 deceased patients, 168 individuals were older than 50 years at the time of the injury. Of the remaining 100 patients, 38 subjects had not survived a post-injury survival of ≥10 years. Most of the deceased patients had an AIS A. The major cause for tSCI was motor vehicle accidents. Of the 38 patients, 29 subjects (76%) had tetraplegia and 9 subjects (24%) had paraplegia.

A total of 62 deceased tSCI had a post-injury survival of ≥10 years. Of these 62 patients, 33 patients died

during hospital stays; the remaining 29 were out-patient deaths. Of the 62 patients, 41 subjects (66%) had paraplegia and 21 subjects (34%) had tetraplegia. Ninety-four percent of the patients were men. The mean age at time of injury in the patients was 32 years (range: 16–50 years). The mean age at injury for tetraplegia was 33 years and in paraplegia, 31 years ($P = 0.522$) (see Table 1).

The mean age at death in the 62 patients was 63 years (range 34–87 years) and patients died after an average of 31 years (range 12–67) post-injury. Life expectancy was higher in paraplegia compared with tetraplegia, 34 and 25 years ($P = 0.008$), respectively. Although higher spinal cord lesions were associated with a shorter mean life expectancy than lower lesions, this difference was non-significant ($P = 0.332$) (see Table 1). In addition, subjects with motor complete SCI (AIS A and B) and motor incomplete SCI (AIS C and D) had life expectancies of 31 and 34 years ($P = 0.412$), respectively.

The leading causes of death in the 38 patients who survived a period of <10 years were septicemia, influenza and pneumonia, and suicide. The secondary causes for septicemia were pneumonia ($n = 5$), intra-abdominal infections ($n = 3$), pressure ulcers ($n = 3$), and urinary tract infection ($n = 1$) (Table 2).

In the 62 patients, septicemia, ischemic heart diseases, neoplasms, and cerebrovascular diseases were the leading causes of death. The secondary causes for septicemia were pressure ulcers ($n = 7$), pneumonia ($n = 5$), and urinary tract infections ($n = 2$). Septicemia, influenza/pneumonia, and suicide were the leading causes of death in tetraplegia, whereas ischemic heart disease, neoplasms, and septicemia were the leading causes of death in paraplegia. No significant differences in causes of death were identified between patients surviving <10 and ≥10 years post-injury (Table 2).

Discussion

Data showed that in 62 deceased tSCI patients who were ≤50 years at the time of injury, the leading causes of death after a minimum survival period of 10 years were septicaemia, cardiovascular diseases (ischemic and nonischemic), neoplasms, cerebrovascular diseases, and pneumonia. In addition, no significant differences were identified between causes of death among patients surviving <10 years and ≥10 years post-injury.

This study identified that urinary complications and renal failure were not the leading cause of death in our monocentric chronic SCI population. Hackler[13] performed a mortality study in 1977 and identified that diseases of the urinary system (30%), ischemic heart diseases (11%), and respiratory diseases (8%) were the most frequent causes of death among 169 deceased patients. Another study investigated the mortality in 362 deceased SCI patients who had their SCI for a minimum of 20 years.[14] Whiteneck *et al.*[14] showed that most deaths were caused by genitourinary disorders (24%), cardiovascular diseases (23%), respiratory diseases (14%), and neoplasms (11%). Although genitourinary disorders were the leading cause, the authors showed that this cause of death decreased in frequency over time.[14] Although more studies showed that the primary cause of death in tSCI patients is due to urogenital diseases.[3,9,14] Soden *et al.*[8] also identified a reduction of the standardized mortality ratio by almost half in the urinary system diseases between the period prior to 1980 and the period from 1980 onwards.

We also showed that cardiovascular diseases are one of the leading causes of death in SCI patients.[8,13–17] Zeilig *et al.*[15] also showed in 10 deceased SCI veterans who had survived for a period of 20 years that ischemic (30%) and non-ischemic heart diseases (20%) were the leading causes of death in these individuals. It is hypothesized that a sedentary life style, glucose intolerance, insulin resistance, and a reduction in metabolic rate results in a general deconditioning.[18–20] Subsequently, patients with SCI are at increased risk of developing premature coronary heart disease than the general population.[1]

Although neoplasms were the third most common cause of death among our study population surviving ≥10 years post-injury, the risk for neoplasms does not appear to be more common in SCI compared to the general population.[8] However, it is reasonable to assume that patients with SCI could die from neoplasms more frequently due to late or occult sensation delaying detection and limiting success with curative surgical and medical treatment.

Suicide appears to be a common cause of death among individuals with SCI.[21,22] Several studies showed that SCI places individuals at considerable risk of suicide compared to the general population.[8,23] Although non-significant compared with subjects surviving ≥10 years post-injury, more subjects in our study appeared to have committed suicide within 10 years post-injury. Other studies have already emphasized that better screening measures should be adopted to offer psychological support and more intensive follow-up in the community.[8]

Septicemia remains a cause for concern among the chronic SCI population.[7] Soden *et al.*[8] identified that most cases of septicemia originated from infections of the urinary tract, pressure ulcers, and respiratory tract.

Table 1 Demographic characteristics of 38 and 62 deceased subjects with SCI who survived post-injury periods of <10 and ≥10 years, respectively

Variables		Number (%)	Number (%)
		38	62
NLI	C2	5 (13.2)	1 (1.6)
	C3	8 (21.1)	4 (6.5)
	C4	5 (13.2)	5 (8.1)
	C5	6 (15.8)	5 (8.1)
	C6	3 (7.9)	2 (3.2)
	C7	2 (5.3)	4 (6.5)
	T2	0	1 (1.6)
	T3	1 (2.6)	3 (4.8)
	T4	2 (5.3)	3 (4.8)
	T5	1 (2.6)	0
	T6	0	2 (3.2)
	T7	0	1 (1.6)
	T8	0	2 (3.2)
	T9	1 (2.6)	1 (1.6)
	T10	0	2 (3.2)
	T11	1 (2.6)	6 (9.7)
	T12	0	7 (11.3)
	L1	3 (7.9)	12 (19.4)
	L2	0	1 (1.6)
AIS			
	A	27 (71.1)	50 (80.6)
	B	1 (2.6)	1 (1.6)
	C	8 (21.1)	9 (14.5)
	D	2 (5.3)	2 (3.2)
Gender			
	Male	32 (84.2)	58 (93.5)
	Female	6 (15.8)	4 (6.5)
Age at injury		36 (9–50)	32 (16–50)
Mean interval from onset SCI until death			
	NLI	Years (range)	Years (range)
	C2–C3	4 (0–9)	26 (13–37)
	C4–T1	4 (0–8)	25 (14–44)
	T2–T6	1 (0–1)	34 (17–67)
	T7–T12	2 (0–3)	33 (13–55)
	L1-S4–5	1 (0–2)	36 (12–56)
Cause of injury			
	MVA	19 (50%)	22 (35.5%)
	Work	3 (7.9%)	21 (33.9%)
	Fall from height	13 (34.2%)	14 (22.6%)
	Penetrating trauma	2 (5.3%)	1 (1.6%)
	Other	1 (2.6%)	4 (6.5%)

NLI, neurological level of injury; AIS, ASIA impairment scale; SCI, spinal cord injury; NLI, neurological level of injury; MVA, motor vehicle accident.

In addition, Rish *et al.*[16] analyzed mortality in a cohort of Vietnam veterans. Of the 24 deceased patients, septicemia (38%) was the leading causes of death.[16] Our study also showed that a substantial number of patients still died of sepsis caused by pneumonia, despite the fact that the number of deaths caused by respiratory tract infections have decreased over time.[24] Although a proactive respiratory management caused a decline in deaths caused by pneumonia, it is still responsible for 16% of the deaths in our study. In addition, pressure ulcers were also responsible for a substantial number of sepsis deaths. Our previous study showed that despite intensive teaching methods, less than 50% of the patients with SCI obtained good knowledge about how to avoid pressure ulcers.[25] This was a disappointing result, since it is hypothesized that enhanced education results in fewer recurrences of pressure ulcers.[26]

Improvements in survival have been associated with improved acute hospital treatment and rehabilitation, as well as improved health maintenance after discharge.[27,28] However, this study has not investigated how causes of death could be related to the quality of care. Considering the disturbingly high number of deaths by septicemia and the fact that most patients will have a lifelong struggle with SCI and SCI-related complications, more studies are required to investigate

Table 2 The causes of death among 38 and 62 deceased subjects with SCI who survived post-injury periods of <10 and ≥10 years, respectively

Cause of death (ICD-10 numbers)	Number of subjects	Tetraplegia			Paraplegia		
	Total	Overall	<10 years	≥10 years	Overall	<10 years	≥10 years
Septicemia (A41)	26	16	8 (21%)	8 (13%)	10	4 (11%)	6 (10%)
Influenza and pneumonia (J09–J18)	13	11	8 (21%)	3 (5%)	2	0	2 (3%)
Ischemic heart disease (I20–I25)	11	2	0	2 (5%)	9	1 (3%)	8 (13%)
Neoplasms (C00–D48)	11	3	1 (3%)	2 (3%)	8	1 (3%)	7 (11%)
Intentional self-harm (X60–X84)	11	9	6 (16%)	3 (5%)	2	1 (3%)	1 (2%)
Cerebrovascular diseases (I60–I69)	7	3	2 (5%)	1 (2%)	4	0	4 (6%)
Other forms of heart disease (I30–I52)	6	1	1 (3%)	0	5	0	5 (8%)
Pulmonary heart disease and diseases of pulmonary circulation (I26–I28)	6	2	2 (5%)	0	4	2 (5%)	2 (3%)
Chronic lower respiratory diseases (J40–J47)	3	0	0	0	3	0	3 (5%)
Renal failure (N17–N19)	1	0	0	0	1	0	1 (2%)
Diseases of arteries, arterioles, and capillaries (I70–I79)	1	1	0	1 (2%)	0	0	0
Diseases of esophagus, stomach, and duodenum (K20–K31)	1	1	0	1 (2%)	0	0	0
Diseases of liver (K70–K77)	1	0	0	0	1	0	1 (2%)
Post-procedural disorder of circulatory system, unspecified (I97.9)	1	0	0	0	1	0	1 (2%)
Diseases of the nervous system (G40–47)	1	1	1 (3%)	0	0	0	0
Total number of patients	100	50	29 (76%)	21 (34%)	50	9 (24%)	41 (66%)

(1) the quality of care and (2) new in-hospital and post-discharge methods to teach patients and family members about SCI related complications. SCI physicians should therefore focus on patient education and routine long-term follow-up protocols for the skin, bladder and respiratory tract.[24]

The limitation of this study is the lack of comparison with mortality causes in the general German population. In Germany, however, adequate mortality statistics from the general population are not available and comparisons were thus not possible. Therefore, it remains uncertain whether the leading causes of death in our study are proportionally higher in the SCI population compared with the non-SCI population. In addition, the results from our convenience sample in this monocentric study prevents us from making generalizations about the total German SCI population. The small sample size also resulted in limited statistical power of the analyses. To illustrate, our data showed several differences in mortality causes between paraplegia and tetraplegia; however, the number of patients prevented us from giving a valid explanation for these differences. In addition, there may be an underestimation of the out-patient deaths, as not all patients with SCI will remain patients in our hospital after their rehabilitation. We recommend therefore that more studies should be performed in large multicenter networks to investigate the mortality statistics in the long-lived patients.

Conclusion

Our monocentric descriptive analysis showed that in 62 deceased patients who were ≤50 years at the time of tSCI and survived for a minimum of 10 years post-injury, the leading causes of death were septicemia, cardiovascular diseases (ischemic and nonischemic), neoplasms, and cerebrovascular diseases. In addition, no differences were identified between causes of death among patients surviving <10 years and ≥10 years post-injury.

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