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ARTICLE

Causes of death after spinal cord injury in the Czech Republic

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Abstract

Study design A retrospective cohort study

Objectives To determine the causes of death in people with spinal cord injury (SCI) admitted to the Spinal Cord Unit (SCU) of the University Hospital Motol from 2004 to 2018.

Setting University Hospital Motol, Prague

Methods From a cohort of people admitted to the SCU between 2004 and 2018, all deaths were identified based on the database of health insurance companies. The causes of death (ICD-10) were obtained from the Institute of Health Information and Statistics. The standardized mortality ratio (SMR) was calculated for most frequent causes of death.

Results During the study period, 990 patients with acute SCI were admitted to the SCU, out of which 183 (18.5%) died. Thirty-five people who had SCI due to cancer were excluded from the study. The leading cause of death in the remaining 148 people was pneumonia, followed by cardiac complications, pulmonary embolism, suicide, and urinary tract infection (UTI). In the group of the individuals who died within 1 year after SCI ($N = 41$), the main causes of death were pneumonia and pulmonary embolism (17.1% each). Among individuals who survived up to1 year after SCI ($N = 107$), the most common causes of death were pneumonia (14%) and pressure injuries (12.1%). The cause-specific SMRs were significantly increased for UTI, embolism, pneumonia, and suicide.

Conclusion The frequent causes of death in our study group were pressure injuries and suicides. These findings are fundamental to the development and implementation of preventive programs to reduce mortality and increase life expectancy.

Introduction

The treatment of persons with spinal cord injury (SCI) has improved considerably over the last few decades. In developed countries, advances in medical care have resulted in longer life expectancy for SCI people [1, 2], with the causes of death in this population comparable with those in the general population [3]. This is true, for instance, of cardiovascular or respiratory diseases [4]. However, some other causes of death are specific to SCI and may be the reason behind the fact that their average life expectancy is still shorter compared to the general population [5, 6]. Apart from the two causes mentioned above, cerebrovascular disease, suicide, urological disease, pressure injuries, other sepsis and cancer are mostly described as the predominant causes of death [3, 6, 7].

The spinal program in the Czech Republic offers high quality institutional care during the first 6–9 months after SCI. However, it is often followed by insufficient care as providers are inadequately trained in SCI specific treatment modalities. Complications which, in their early stage, can be underestimated by the patient and often by the physician, may become irreversible over time or even fatal. Therefore, during the last few years, we have been focusing on the improvement of follow-up care of SCI people in our country.

Information about causes of death could be highly pertinent to the development of preventive and therapy programs directed at SCI-specific complications. Following the EMSCI project [8], our department has been collecting long-term data from neurological and functional

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examinations. Nevertheless, the data about the causes of death have not been analyzed until now. This data will be beneficial to the improvement of the lifelong medical, rehabilitation, and psychosocial care of SCI population.

Methods

In the Czech Republic, acute and post-acute medical and rehabilitation care as well as social and psychological support is ensured by a network of specialized centers. Four spinal cord units (SCUs) in large hospitals provide care to people with SCI in the first 2–3 months, and three rehabilitation facilities provide following care for an additional 3–5 months. The SCU of the University Hospital Motol provides care in the region of central and western Bohemia. This represents ~25–30% of traumatic and non-traumatic SCI patients in the Czech Republic every year. All of them undergo a full rehabilitation program. The SCU Motol, as a part of the EMSCI project [8], uses an advanced system for neurological and functional assessment, data collection, and follow-up of SCI patients. This system has been the source of data for assessment of the cause of death in SCI patients over the past 15 years.

The overall number of deaths during the study period was obtained from the database of health insurance companies. The specific information about causes of death (ICD-10 codes) was obtained from the Institute of Health Information and Statistics. In addition to causes of death, information on primary and secondary diagnoses at last hospitalization before death was collected. The diagnosis which best specified cause of death was chosen. If the admission diagnosis was sepsis, we attempted to identify its source from other diagnoses and to establish the cause of death, e.g., sepsis from pressure injuries or urinary tract infections (UTI). In some cases, the source of sepsis was impossible to identify and the cause was classified as "Other sepsis". The SCI caused by a cancer diagnosis were excluded from the final study group, because the death was not related to SCI.

For each patient, data were available regarding age at the time of SCI, date and cause of SCI, the neurological level of injury (NLI), the American Spinal Injury Association (ASIA) Impairment Scale (AIS) based on the International Standards for Neurological Classification of Spinal Cord Injury at admission to the SCU, date and place of death, and cause of death. The people were grouped based on survival time from SCI to death, age, gender, NLI and completeness. The causes of death were compared between the groups.

For most frequent causes of death in our study, the standardized mortality ratio (SMR) was calculated as the ratio of the number of deaths in the study group to the number of deaths expected in the age- matched group of the general population. The expected number of deaths was obtained from the national data on age-specific mortality in 2004–2018, as reported by the Czech Statistical Office. All SMRs were calculated for the entire population and total follow-up time. For the SMR of each group, the 95% confidence interval (CI) was calculated. If the CI does not contain the value of 1.0, the cause-specific mortality of people with SCI statistically significantly differs from that of the general population at a significance level of 0.05. The differences between SMRs according to the stratification variables were tested using chi-square test with one degree of freedom. The Stata (StataCorp LP, College Station, TX, U.S.A.) was used for all analysis. The Stata command "stptime" was used to calculate person-time at risk and SMRs and time was allocated based on 10-years age groups.

Results

During the study period of 2004–2018, 990 patients with acute SCI were admitted to the SCU, (720 males and 270 females, mean (SD) age of 46.3 (18.1) years), out of which 183 patients (131 males and 52 females) died (18.5% of all hospitalized patients) (Table 1). Thirty-five patients with SCI caused by cancer were excluded from the study population. The mean (SD) age at the time of SCI for the remaining 148 patients was 60.6 (14.5) years. The majority of individuals (77.7%) died in a health care setting, 20.3% died at home, and 2.0% died in a social care facility (i.e., nursing home). The leading cause of death was pneumonia (14.9%), followed by cardiac complications (11.5%), pulmonary embolism (10.8%), suicide and UTI (9.5% each) (Table 2). When considering septicaemia as the cause of death, it was the main cause (26.4%), primarily due to UTI, pressure injuries, and respiratory and digestive complications.

When stratifying by interval from SCI to death, 41 people died within 1 year of SCI, and the leading cause of death was pneumonia and pulmonary embolism (17.1%), followed by cardiac disease (14.6%) and cerebrovascular complications (12.2%). Of those that died more than 1 year after SCI ($N = 106$), the leading cause of death was again pneumonia (14.0%), followed by pressure injuries (12.1%), UTI, and cardiac disease (10.3% each).

Causes of death also varied by age at the time of SCI. Among patients that were 60 years old or less at the time of SCI ($N = 60$), the leading cause of death was pressure injuries (16.7%), followed by suicide (15%) and UTI (11.7%). In 88 people aged over 60 at the time of SCI, the leading cause of death was pneumonia (18.2%), closely followed by cardiac complications (14.8%) and pulmonary embolism (11.4%).

Table 1 Characteristics of the study population—all SCI people versus deaths.

	All SCI	Deaths	%
Gender			
Male	720	131	18.2
Female	270	52	19.3
NLI			
Cervical	432	79	18.3
Thoracic	422	82	19.4
Lumbar/sacral	130	21	16.2
NT = Not testable	6	0	0.0
AIS			
A = Complete	405	75	18.5
B = Sensory incomplete	96	17	17.7
C = Motor incomplete	215	49	22.8
D = Motor incomplete	269	42	15.6
E = Normal/NT	5	0	0.0
Etiology of SCI			
Traumatic	681	90	13.2
Fall	287	57	19.9
Traffic accident	171	19	11.1
Sports injury	54	6	11.1
Diving into water	80	3	3.8
Other	89	5	5.6
Non-traumatic	309	93	30.1
Vascular	81	24	29.6
Degenerative	70	12	17.1
Infection	76	17	22.4
Tumor	82	40	48.8
Total	990	183	18.5

SCI Spinal Cord Injury, *NLI* Neurological Level of Injury, *AIS* ASIA Impairment Scale.

When stratifying by gender, pneumonia (15.2%) and embolism (12.4%) were the leading causes of death in men, while cardiac disease (16.3%), and pneumonia and pressure injuries (14.0%) were the leading causes in women.

The leading cause of death among patients with tetraplegia ($N = 75$) was pneumonia (17.3%), followed by pulmonary embolism and cardiac complications (12.0% each), and suicide (10.7%). Individuals with paraplegia ($N = 73$) died most often from pneumonia or pressure injuries (12.3% each) and cardiac complications (11%). When differentiating by SCI severity, embolism and pressure injuries were the leading cause of death in people with complete injury (16.4% resp. 13.1%), while pneumonia and cardiac disease in people with incomplete injury (17.2% resp. 13.8%) (Table 2).

The cause-specific mortality rates for selected causes of deaths are shown in Table 3. The overall mortality rate for individuals with SCI was estimated to be 2.3 times greater than that of the general population in the Czech Republic. People under 60 years of age at the time of SCI had a significantly higher mortality rate (SMR = 3.3, 95% CI 2.6–4.3) compared to those aged over 60 years (SMR = 1.9, 95% CI 1.6–2.4) ($p = 0.049$). Cause-specific SMRs were highest for causes of death such as UTIs (SMR = 122.4, 95% CI 72.5–206.7), embolism (SMR = 20.8, 95% CI 12.7–33.9), pneumonia (SMR = 14.5, 95% CI 9.6–22.1), and suicide (SMR = 12.9, 95% CI 7.6–21.7). No difference in cause-specific mortality rates was observed for cardiac complications between people with SCI and the general population. Differences of SMRs for specific complications according to age at SCI were not statistically significant (Table 3). In a sensitivity analysis assuming septicaemia to be the primary cause of death, individuals with SCI were 81 times more likely to die due to septicaemia in comparison to the general population (95% CI 58.8–110.2).

Discussion

This study investigates causes of death of people admitted to the SCU of the University Hospital Motol following acute SCI between 2004 and 2018. Apart from pulmonary and cardiovascular complications, UTIs, pressure ulcers and suicides were the leading causes of death in the SCI population. We specifically focused on the causes of death, the prevention of which we perceive as inadequate.

Pneumonia and cardiovascular diseases are reported in the literature as the most common causes of death in people with SCI [3, 4]. Van den Berg et al. also reported infection as one of the most frequent causes of death [4], which is consistent with our findings. In our cohort the UTI had a cause-specific mortality rate incomparably higher than general population. We also found a relatively high percentage of suicide in our study group. Similar results have been shown by Hartkopp et al. who found suicide to account for 10% of the overall mortality of people with SCI [9]. Ahoniemi et al. collected data about causes of death in SCI population in Finland and reported suicide in 10.3% of all causes [7]. In contrast, Savic et al. found that suicide was the cause of death only in 4.2% of all deaths [6]. Suicide following SCI was also addressed by Kennedy and Garmon-Jones. Their literature review focused on suicide as the cause or a consequence of SCI. They found eight studies reporting suicidal behavior as the cause of death in 5.8–11% of people with SCI. Possible causes of suicides appeared to be linked with a history of psychiatric disease, depression and isolation resulting from job loss which creates a negative impact on social integration and mental well-being [10]. Our data are close to the upper limit of the published range. Suicide occurred on average 3.4 years after SCI, mostly in men and people under 60 years of age. None of

Table 2 Causes of death in the SCI people.

Cause of death (ICD-10 code)	Death < 1 year		Death ≥ 1 year		Age < 60 year		Age ≥ 60 year		Men		Women		Tetraplegia		Paraplegia		Complete		Incomplete		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age et SCI	66.8	10.8	58.2	15.0	46.8	11.7	69.9	6.6	59.5	14.7	63.0	13.8	60.6	15.6	60.5	13.3	56.6	15.5	63.4	13.0	60.6	14.5
Interval SCI-death	0.5	0.2	4.7	3.2	4.4	3.3	2.9	3.1	3.4	3.2	3.8	3.6	3.1	3.2	4.0	3.3	3.0	2.7	3.9	3.6	3.5	3.3
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Pneumonia (J10-J22)	7	17.1	15	14.0	6	10.0	16	18.2	16	15.2	6	14.0	13	17.3	9	12.3	7	11.5	15	17.2	22	14.9
Respiratory failure (J80-J90)	3	7.3	2	1.9	2	3.3	3	3.4	4	3.8	1	2.3	1	1.3	4	5.5	3	4.9	2	2.3	5	3.4
Embolism (I26-I28)	7	17.1	9	8.4	6	10.0	10	11.4	13	12.4	3	7.0	9	12.0	7	9.6	10	16.4	6	6.9	16	10.8
Cardiac disease (I05–I09, I11; I30–I59)	6	14.6	11	10.3	4	6.7	13	14.8	10	9.5	7	16.3	9	12.0	8	11.0	5	8.2	12	13.8	17	11.5
Cerebrovascular disease (I60-I69)	5	12.2	6	5.6	4	6.7	7	8.0	9	8.6	2	4.7	6	8.0	5	6.8	4	6.6	7	8.0	11	7.4
Cancer (C00-D48)	2	4.9	10	9.3	4	6.7	8	9.1	10	9.5	2	4.7	7	9.3	5	6.8	3	4.9	9	10.3	12	8.1
Urinary tract infection (N30-N39)	3	7.3	11	10.3	7	11.7	7	8.0	10	9.5	4	9.3	7	9.3	7	9.6	6	9.8	8	9.2	14	9.5
Renal failure (N17–N19)	0	0.0	1	0.9	0	0.0	1	1.1	1	1.0	0	0.0	1	1.3	0	0.0	1	1.6	0	0.0	1	0.7
Pressure ulcer (L02, L89)	0	0.0	13	12.1	10	16.7	3	3.4	7	6.7	6	14.0	4	5.3	9	12.3	8	13.1	5	5.7	13	8.8
Digestive disease (K00-K95)	1	2.4	7	6.5	2	3.3	6	6.8	4	3.8	4	9.3	4	5.3	4	5.5	3	4.9	5	5.7	8	5.4
Suicide (X71-X83)	4	9.8	10	9.3	9	15.0	5	5.7	11	10.5	3	7.0	8	10.7	6	8.2	7	11.5	7	8.0	14	9.5
Unintentional injuries (V01-X59, Y40-Y84, Y88)	1	2.4	2	1.9	2	3.3	1	1.1	3	2.9	0	0.0	1	1.3	2	2.7	1	1.6	2	2.3	3	2.0
Other sepsis (A40-A41)	1	2.4	7	6.5	2	3.3	6	6.8	4	3.8	4	9.3	1	1.3	7	9.6	3	4.9	5	5.7	8	5.4
Unknown	1	2.4	3	2.8	2	3.3	2	2.3	3	2.9	1	2.3	4	5.3	0	0.0	0	0.0	4	4.6	4	2.7
Total	41		107		60		88		105		43		75		73		61		87		148	

Table 3 Cause-specific standardized mortality ratios for selected causes.

Cause of death	Age at SCI < 60 years			Age at SCI ≥ 60 years			Total			
	N	SMR	95 % CI for SMR	*N*	SMR	95 % CI for SMR	*N*	SMR	95 % CI for SMR	*p* value
Pneumonia	6	17.9	8.1–39.9	16	13.6	8.3–22.2	22	14.5	9.6–22.1	0.888
Embolism	6	31.6	14.2–70.3	10	17.2	9.3–32.0	16	20.8	12.7–33.9	0.818
Cardiac disease	4	1.2	0.5–3.2	13	0.9	0.5–1.6	17	1.0	0.6–1.6	0.683
Cerebrovascular disease	4	4.8	1.8–12.8	7	1.4	0.7–2.9	11	1.9	1.0–3.4	0.296
Urinary tract infection	7	639.3	304.8–1341.0	7	67.7	32.3–142.0	14	122.4	72.5–206.7	0.823
Digestive disease	2	1.4	0.4–5.5	6	3.8	1.7–8.4	8	2.6	1.3–5.3	0.380
Suicide	9	10.5	5.5–20.2	5	21.6	9.0–51.9	14	12.9	7.6–21.7	0.759
Total	60	3.3	2.6–4.3	88	1.9	1.6–2.4	148	2.3	2.0–2.7	0.049

the people who died from suicide had a pre-existing psychiatric condition stated in their documentation. Therefore, we assume the main reasons for suicide are the inability to cope on a long-term basis with a difficult life situation, unemployment, and social isolation [11]. For instance, the social system in the Czech Republic is not set up to encourage individuals with disabilities to seek employment. An added issue is that the available psychosocial support network is not fully functional. Moreover, after 40 years of communist rule, traditional spiritual values known to play a major part in the search for the meaning of life have been weakened. The first step toward advancement of the current situation in the Czech Republic is setting up a peer mentor system to help those individuals who are newly confined to a wheelchair. The positive effect of peer mentoring has been repeatedly proven [12]. Nevertheless, a thorough multiprofessional approach is crucial.

When the causes of death were analyzed based on the time since injury, significant differences were seen. In the group of people who died within 1 year after SCI, the leading causes of death were pneumonia and circulatory complications (cardiac, cerebrovascular, and embolic). These results are consistent with those reported by DeVivo et al. who ranked the causes of death in the following order: respiratory complications, cardiac complications, and pulmonary embolism [13]. The role of pneumonia as the cause of death in people with SCI is also underlined by Divanoglou et al. who found it to account for up to 50% of deaths [14]. Given that SCI has a largely negative effect not only on respiratory function but also on the cardiovascular system, such complications can be expected. Therefore, an important part of acute rehabilitation is intensive respiratory physiotherapy [15]. Other preventive measures are optimal setting of anticoagulation therapy and education of health professionals about the causes of and risks of autonomic dysreflexia [16].

In the group of people with chronic SCI, the leading causes of death were pneumonia followed by pressure injuries, UTI, and cardiac disease. Soden et al. studied the causes of death in 195 people after more than 18 months from SCI. They recorded significantly higher incidence rates of septicaemia, pneumonia, UTI, and suicide in comparison with the general population [17]. Thietje et al. analyzed the cause of death in 62 people with SCI aged over 50 years who had sustained their injuries more than 10 years prior. Septicaemia, cardiovascular disease, cancers, and cerebrovascular diseases were identified as the leading causes of death in these people [18]. In these studies the pressure injuries were classified as septicaemia. However, Savic et al. conducted a large study to analyze the causes of death in 2170 people who survived 1 year after SCI and found skin complications to account for 3% of deaths. Almost 30% of these people died from respiratory complications, and in 27% of cases, the cause of death were circulatory complications [19]. Lidal et al. analyzed the causes of death in 142 SCI people who survived more than 1 year after SCI. They reported pneumonia, coronary heart disease, urogenital tract disease, cancers, and suicide to be the major causes of death. Pressure injuries have not been recorded at all [3].

Our data significantly differs from that presented in the above-mentioned studies. The reasons for such a high incidence of pressure injuries as the cause of death in our cohort may be poor compliance, unsatisfactory follow-up care, and lack of psychosocial support. Despite repeated warnings that even small lesions need to be treated, people are often unwilling to give up their activities and undergo a strict relieving regimen. Large defects that develop slowly and gradually may become intractable. Moreover, sometimes people still develop pressure injuries while hospitalized with other complications in a setting outside the spinal programme. This can be explained by a limited knowledge

of SCI issues and the deep-rooted idea that pressure injuries are a natural consequence of SCI. Therefore, 2 years ago, we launched a campaign to reduce stage 3 and 4 pressure injuries. We organized a national conference on pressure injuries prevention and management in people with SCI for general practitioners and home care facilities. We present "Wound healing courses" for health care professionals on a regular basis. We attempt to raise awareness of both the general and professional public of pressure injuries by distributing booklets and posters. We provide systematic and repeated instruction to patients and plan to add a peer mentor program. If early stage pressure injuries appear, the individual is encouraged to present to our wound healing centre or to email photographs of the injury to this centre in order to initiate early therapy and to be instructed on the immediate need for 100% pressure reduction at the site of the lesion. Another step is to ensure generally accessible, personal assistance services to allow the person to rest as needed. However, a more difficult project remains and that is to change the commonplace approach to pressure injuries. They are to be taken not as a symptom of SCI, but as a SCI complication which should be prevented as well as actively treated.

Limits of the study

Given that statistical data from the other SCI units are not available, we were not able to perform the analysis at a national level and to present the summary data for the all of the Czech Republic. Despite this limitation, the spectrum of patients in different SCU in the Czech Republic is similar. We are aware, that using of ICD-10 codes to identify cause of death is limited. Nevertheless, we used above described steps to eliminate presumable inaccuracies. The possible influence of concomitant diseases on the death cause has not been included, as this data collection has started from 2010.

Conclusion

The distribution of the causes of death in people with SCI varies with time from SCI to death, age, and spinal lesion level. In our study group, the leading causes of death were pneumonia and cardiac complications, but we also found unusually high rates of deaths from suicides and pressure injuries. The reasons behind these facts may be inadequate psychological support provided to people with SCI and the lack of sustained education and long-term follow-up in the tertiary stage. The results of the present study suggest the need for improved long-term therapeutic and preventive care and follow-up of people with SCI. Particular emphasis should be placed on psychosocial support.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Author contributions JK was responsible for screening potentially eligible studies, designing the study protocol, extracting and analyzing data, interpreting results, creating 'Summary of findings' tables and writing the paper. KS contributed to extracting and analyzing data, interpreting results, creating 'Summary of findings' tables and writing the paper. MM conducted the statistical analyses and contributed to the preparation of results incl. tables. All authors reviewed the paper.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The study used administratively collected secondary data and no ethics committee approval was required.

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