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ORIGINAL REPORT

SECONDARY MEDICAL COMPLICATIONS AFTER TRAUMATIC SPINAL CORD INJURY IN STOCKHOLM, SWEDEN: TOWARDS DEVELOPING PREVENTION STRATEGIES

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Objectives: **(*i*) To determine the prevalence of secondary complications after traumatic spinal cord injury during acute care and rehabilitation; (*ii*) to investigate whether associations exist between level and completeness of injury and the development of common complications; and (*iii*) to assess whether associations exist between secondary complications and return-to-work 1 year after injury.**
Design and participants: **A prospective, population-based study, including all newly-injured persons with traumatic spinal cord injury for an 18-month period.**
Methods: **The International Spinal Cord Injury Core Data Set was used to capture injury characteristics, as well as associated injuries and neurological severity. All secondary medical complications (e.g. pressure injuries, pulmonary embolism, pneumonia, urinary tract infection) were screened for during acute care and rehabilitation. Inferential statistics were carried out.**
Results: **Out of the 45 persons undergoing acute care, the 3 most common complications were urinary tract infections (47%), pneumonia (22%) and neuropathic pain (18%). Of the 31 persons who received rehabilitation, the most common complications were urinary tract infections (42%), neuropathic pain (42%), and spasticity (35%). A significant association was found between injury level and development of neuropathic pain during rehabilitation.**
Conclusion: **Although a specialized system for spinal cord injury management is available in Sweden, secondary complications are still common. These findings could be used to inform the development of strategies for prevention of secondary complications.**

Key words: traumatic spinal cord injury; secondary medical complications; acute care; rehabilitation; return-to-work.

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LAY ABSTRACT

Development of secondary complications is common after acute traumatic spinal cord injury. The presence of secondary complications may influence one's livelihood and quality of life. This study examined the nature and number of secondary complications among persons with acute traumatic spinal cord injury throughout the care pathway in Sweden. All patients with a traumatic spinal cord injury were observed for 18 months and followed through acute, inpatient rehabilitation, up until 12 months after injury. Certain secondary complications, such as urinary tract infections, pneumonia, neuropathic pain, were common during acute care and rehabilitation. Subjects with tetraplegia reported neuropathic pain more than those with paraplegia during both phases of care. In conclusion, complications occur despite the specialized system of care for persons with traumatic spinal cord injury in Sweden. This information should be used to develop and implement appropriate prevention programmes.

Spinal cord injuries (SCI) typically result in sensory, motor, and autonomic deficits below the level of the lesion (1). These hallmark impairments provide conditions for the development of secondary medical complications, which have been found to influence survival status (2), neurological and functional recovery (3), and health-related quality of life (3). Furthermore, the development of secondary medical complications has been associated with extended length of hospital stays, impacting hospital efficiency, an important target since severe reductions in the availability of scarce resources, such as specialist services, are experienced globally (4, 5).

Specialized care is available for people with SCI, including state-of-the-art emergency care at the scene of injury, efficient and safe transfer to a specialized trauma unit, availability of all diagnostic equipment, skilled and experienced multidisciplinary teams, as well as the availability of acute (primary) and active rehabilitation (6). Perhaps, the single most important outcome of the specialized approach followed in Sweden has been its effect on survival, where a zero percentage mortality was found for a 1-year period in a population-based cohort (7). However, research reports from 20 and 10 years ago, respectively, found that selected secondary medical complications, such as pressure injuries, urinary tract infections (UTIs),

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and heterotrophic ossification, were prevalent during acute care (8, 9).

Previous reports from Sweden did not provide a comprehensive audit of secondary medical complications during different episodes of care, i.e. acute and rehabilitation (8, 9). For example, previous international literature has found direct associations between outcomes, such as survival and recovery, and other secondary medical complications, including pneumonia, pulmonary embolism, and deep vein thrombosis (10, 11). There is therefore a need to provide a more comprehensive audit of the nature and prevalence of secondary medical complications throughout the chain-of-care, with the aim of informing prevention strategies as well as further strengthening the specialized approach followed in Sweden.

Given these knowledge gaps, the aims of this study were: (*i*) to determine the prevalence of secondary medical complications during acute care and rehabilitation; (*ii*) to assess whether associations exist between level, as well as completeness, of injury and the development of the most common complications; and (*iii*) to determine the associations between having a secondary medical complication, the number of complications during acute care, rehabilitation and return-to-work one year after injury.

METHODS

Design and participants

A prospective, population-based design was implemented between May 2014 and October 2015 (18-month period) to determine the incidence and aetiology of traumatic SCI (TSCI), secondary medical complications, as well as outcomes following TSCI in Stockholm, Sweden. The Regional Board of Ethics in Stockholm approved the project prior to the start of data collection (dnr: 2014/137-31/1). All principles related to research conducted on humans, as stipulated in the Declaration of Helsinki, were adhered to throughout the study period. The first part of the larger project, i.e. the epidemiology of TSCI in Stockholm, Sweden, has been reported previously (12).

In the Greater Stockholm region, several level 1 trauma units provide immediate and comprehensive intensive care, whereas the only spinal injury unit provides post-acute/primary rehabilitation. Furthermore, 3 active inpatient rehabilitation units, as well as one outpatient clinic delivering lifelong follow-up care, are available. Newly-injured patients satisfying the following criteria were eligible to participate in this study: (*i*) abnormal imaging, such as with magnetic resonance imaging scan or multi-slice computerized tomography scan, confirming an acute TSCI or cauda equina lesion; (*ii*) the injury must have resulted in persisting impairment (i.e. not just a concussion) after emergence from neurogenic shock, which generally occurs within the first 24–72 h after injury; (*iii*) age 18 years or older; (*iv*) surviving at least 7 days post-trauma; (*v*) admittance to the spinal injury unit; and (*vi*) legitimately residing in Stockholm, Sweden. All participants (n=45) enrolled in the incidence cohort were followed throughout acute care, inpatient rehabilitation, and up until 1-year follow up. Only 31 participants received inpatient rehabilitation, while the rest received home/frail care (n=2) or only outpatient rehabilitation (n=12) due to their mild injury severity grade (American Spinal Injury Association Impairment Scale; AIS D).

Data collection variables and procedure

The SCI Basic Core Data Set, a questionnaire covering the most essential data elements for the description of persons with TSCI, was completed upon admission to the acute unit. The data-set covers aspects of the injury event, extent of the injury including neurological severity, and hospitalization (13). Assessment of neurological severity was performed by 2 attending physicians on both admission to and discharge from the spinal injury unit (acute care) in accordance with the international standards (1). The list of variables was extended by including secondary medical complications, which included the following: pressure injuries, pulmonary complications (atelectasis and pneumonia), UTIs, deep vein thrombosis, autonomic dysreflexia, pulmonary embolism, postural hypotension, spasticity, neuropathic/spinal cord pain (i.e. pain at-level or below-level pain originating from spinal cord ischaemia or trauma) and "other". The selected medical complications were screened weekly by the medical team for the duration of acute care and inpatient rehabilitation. Centralization of information on secondary medical complications was improved by developing a standardized list containing operational definitions of complications, a box indicating the presence of respective complications, and, where possible, severity of complications. In addition, information on return-to-work/study and mortality was collected one year after injury.

Statistical analysis

Concerning participants' characteristics and the prevalence of secondary medical complications, descriptive statistics were used. Output was expressed as mean (SD) and median (range), whereas the prevalence data were expressed as counts (percentage). Concerning objective *ii* and *iii*, determining the association between level and completeness of injury and the 3 main secondary medical complications, as well as between secondary complications and return-to-work, inferential statistics, i.e. Fisher's exact test, was used.

The ASIA neurological classification system was simplified by creating 2 categories for completeness of injury, i.e. complete (AIS A) and incomplete (AIS B, C, and D), due to the lack of statistical power for carrying out inferential statistics. A similar approach was used for the number of complications, where zero and 1 complication were grouped vs 2 or more complications. The alpha level was set at 0.05 for measures of association.

RESULTS

Participants' characteristics

Following an 18-month observation period, 49 newly-injured persons with TSCI were registered in the Stockholm area, of whom 45 took part in the study. Of the 4 dropouts, 2 patients declined consent, 1 died after 7 days, and 1 was not part of the chain of care. Table I illustrates the injury characteristics of those enrolled in the study on admission to acute care.

Table I. Participants' characteristics on acute care admission ($n = 45$)

Variables	
Age at injury, years	
Mean (SD)	54.9 (16.6)
Median (min–max)	58.0 (18–85)
Age categories, *n* (%)	
18–30 years	4 (9)
31–45 years	10 (22)
46–60 years	12 (27)
61–75 years	14 (31)
>75 years	5 (11)
Duration of acute hospital stay, days	
Mean (SD)	44.4 (25.0)
Median (min–max)	42.0 (3–131)
Sex, *n* (%)	
Male	27 (60)
Female	18 (40)
Aetiology, *n* (%)	
Sport	1 (2)
Assault	– (–)
Transport	18 (40)
Falls	26 (58)
Level of injury, *n* (%)	
Tetraplegia	32 (71)
Paraplegia	13 (29)
Completeness of injury, *n* (%)	
Complete	13 (29)
Incomplete	32 (71)
Associated injury*, *n* (%)	
Yes	31 (69)
No	14 (31)
Vertebral injury, *n* (%)	
Yes	43 (96)
No	2 (4)
Spinal surgery, *n* (%)	
Yes	43 (96)
No	2 (4)

*Associated injuries included moderate to severe traumatic brain injury, non-vertebral fractures requiring surgery, severe facial injuries, major chest injury requiring mechanical ventilation and severe haemorrhaging, or damage to internal organs. SD: standard deviation.

Secondary complications during acute care and inpatient rehabilitation

As seen in Table II, the majority (78%) of participants experienced at least one complication during acute care. The most common secondary complications during this phase of care were UTIs (47%), pneumonia (22%), and neuropathic pain (18%). Concerning rehabilitation, 84% experienced at least one complication, while the most common complications were UTIs (42%), neuropathic pain (42%), and spasticity (35%).

Table II. Prevalence of secondary medical complications during acute care ($n = 45$) and rehabilitation ($n = 31$)

Secondary medical complication	Acute care *n* (%)	Rehabilitation *n* (%)
Any secondary complications	35 (78)	26 (84)
Pneumonia	10 (22)	0 (0)
Pressure injuries	2 (4)	5 (16)
Urinary tract infection	21 (47)	13 (42)
Autonomic dysreflexia	0 (0)	0 (0)
Deep vein thrombosis	1 (2)	0 (0)
Pulmonary embolism	5 (11)	0 (0)
Postural hypotension	0 (0)	2 (6)
Cardiovascular disease	0 (0)	2 (6)
Neuropathic pain	8 (18)	13 (42)
Other		
Spasticity	4 (9)	11 (35)
Infection	3 (7)	2 (7)
Respiratory failure	1 (2)	–
Anaemia	1 (2)	–

Association between level and completeness of injury and selected complications

As seen in Table III, no statistically significant associations were found between the level of injury, i.e. tetraplegia vs paraplegia, and the presence of any complication, number of complications, and the 3 most common complications found during acute care. However, a close to significant finding was found for neuropathic pain, where all cases occurred in those with tetraplegia and none in those with paraplegia. Similarly, no association was found between completeness of injury and the presence of any complication, number of complications, and the 3 most common complications, respectively.

As seen in Table IV, the only significant association ($p = 0.02$) was found between level of injury and neuropathic pain during inpatient rehabilitation. No further

Table III. Association between injury characteristics and the 3 most common complications during acute care ($n = 45$)

Variable, *n*	Tetraplegia	Paraplegia	*p*-value
Any complication			0.44
Yes	26	9	
No	6	4	
Number of complications			0.59
Zero or 1	20	7	
Two or more	12	6	
Pneumonia			1.0
Yes	7	3	
No	25	10	
Urinary tract infections			0.32
Yes	13	8	
No	19	5	
Neuropathic pain			0.08
Yes	8	0	
No	24	13	
	Complete	Incomplete	
Any complication			0.24
Yes	12	23	
No	1	9	
Number of complications			0.59
Zero or 1	7	20	
Two or more	6	12	
Pneumonia			0.44
Yes	4	6	
No	9	26	
Urinary tract infections			0.74
Yes	7	14	
No	6	18	
Neuropathic pain			1.0
Yes	2	6	
No	11	26	

Table IV. Association between injury characteristics and the 3 most common complications during rehabilitation ($n = 31$)

Variable, *n*	Tetraplegia	Paraplegia	*p*-value
Any complication			0.30
Yes	19	7	
No	2	3	
Number of complications			0.24
Zero or 1	11	9	
Two or more	9	2	
Spasticity			0.45
Yes	6	5	
No	13	6	
Urinary tract infections			0.13
Yes	11	2	
No	10	8	
Neuropathic pain			0.02
Yes	12	1	
No	9	9	
	Complete	Incomplete	
Any complication			0.62
Yes	11	15	
No	1	4	
Number of complications			1.0
Zero or 1	5	15	
Two or more	2	9	
Spasticity			0.37
Yes	4	7	
No	3	16	
Urinary tract infections			0.71
Yes	6	7	
No	6	12	
Neuropathic pain			1.0
Yes	5	8	
No	7	11	

associations were found between completeness of injury and the presence of any complication, number of complications, and the 3 most common complications during rehabilitation.

Association between secondary complications and return-to-work one year after injury

Out of the initial 45 persons enrolled, 29 were eligible for return-to-work, while the rest were retired prior to injury ($n = 12$) or lost to follow-up ($n = 3$). The remaining person died during acute care. No association was found between return-to-work and having a complication during acute care ($p = 0.16$), as well as during rehabilitation ($p = 1.0$). Similarly, no association was found between the number of complications, i.e. zero-to-1 vs 2-or-more, and return-to-work during both acute and inpatient rehabilitation. Level of injury, as well as completeness of injury, had no association with return-to-work.

DISCUSSION

The aim of this study was to determine the prevalence of secondary medical complications during acute care and inpatient rehabilitation, and assess for associations between level, as well as completeness, of injury and the most common secondary complications during both phases. Lastly, this study assessed whether the presence and number of complications had an effect on return-to-work one year after injury. Secondary complications were present during both acute care and inpatient rehabilitation. The most common complications, i.e. UTIs and neuropathic pain, were the same for both episodes of specialized care. In addition, neuropathic pain was more common in those with tetraplegia than paraplegia during both phases.

The prevalence of secondary medical conditions during acute care appears high despite the use of specialized services in the management of SCI in Sweden. The findings of the current study on the most common complications during acute care share similarities with international literature. For example, a study from the Netherlands found pressure injuries (32%) and pulmonary complications (28%) to be the leading secondary complications during acute care (14), while another study, conducted in South Africa, found pressure injuries (30%), pulmonary complications (23%) and UTI (17%) to be the leading complications during this care phase (4). The findings of the current study thus imply better prevention of pressure ulcers during acute care in Sweden. However, a better understanding of the influences leading to the development of UTIs is required in order to optimize patient-oriented, as well as healthcare efficiency, outcomes.

Concerning the prevalence of complications during inpatient rehabilitation, the findings of the current study corroborate with findings from the Netherlands (15). In the latter study, the most common complications during this care episode were neurogenic pain and spasticity (15). Again, the current findings indicate a high prevalence of UTIs during the acute phase. Furthermore, pressure injuries were not as rare during rehabilitation as in acute care. Interestingly, we found no or only a few cases of several complications, such as deep vein thrombosis, autonomic dysreflexia, and postural hypotension. On the contrary, the lack of postural hypotension and autonomic dysreflexia in acute care and rehabilitation, respectively, is peculiar. There is therefore a need to investigate the evaluation criteria of secondary medical complications in the current healthcare context in order to assess its alignment with international guidelines, which may improve both diagnosis and treatment of preventable complications.

Another aim of the current study was to assess for associations between some injury characteristics and

the development of secondary medical complications. Limited associations were found between level, as well as completeness, of injury and the development of complications. The only significant association was found between level of injury, tetraplegia vs paraplegia, and prevalence of neuropathic pain, with those with tetraplegia being at greater risk. The literature offers little explanation as to why those with tetraplegia are more affected by neuropathic pain (16). Finding ways of managing neuropathic pain in acute care and rehabilitation is a priority, since neuropathic pain is found to contribute to reduced quality of life in patients with SCI (17). We further found no noteworthy association between injury characteristics and return-to-work after one year, as well as the development of secondary complications during acute care and rehabilitation and return-to-work.

This study presents some noteworthy limitations. It reports only on the presence of secondary medical complications and not the severity of the problem. It is likely that severity may play a role in return-to-work, for example. This study did not collect information on quality-of-life in order to assess the effect of complications on overall well-being. In addition, no information of other noteworthy concomitant injuries was collected. Taken together, this information is required in order to advocate for the development or implementation of interventions targeting complications impacting on quality of life. Therefore, future studies should collect data on the severity of secondary medical complications, concomitant injuries and quality of life more consistently, with the aim of providing comprehensive management plans.

In conclusion, Sweden offers specialized care to people with TSCI. However, some complications, i.e. UTIs, pneumonia, neuropathic pain and spasticity, are still prevalent. In order to optimize people's recovery, attention should be focused on reducing the occurrence of these common complications.

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