ORIGINAL ARTICLE

Is the outcome in acute spinal cord ischaemia different from that in traumatic spinal cord injury? A cross-sectional analysis of the neurological and functional outcome in a cohort of 93 paraplegics

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Study design: Retrospective cohort study.

Objectives: To compare the neurological outcome between paraplegic patients with acute spinal cord ischaemia syndrome (ASCIS) or traumatic spinal cord injury (tSCI) and to investigate the influence of SCI aetiology on the total Spinal Cord Independence Measure (SCIM)-II score.

Setting: Level 1 trauma centre.

Methods: Initial (0–40 days) and chronic-phase (6–12 months) American Spinal Injury Association (ASIA) sensory scores, lower extremity motor score (LEMS) and chronic-phase total SCIM-II scores were analysed. Differences between ASCIS and tSCI patients were calculated using Student's *t*-tests and Wilcoxon signed-rank tests. To assess which variables give rise to the prediction of total SCIM-II score, a multiple linear regression analysis was used. These predictor variables included complete (ASIA impairment scale A) or incomplete SCI (AIS B, C, and D), aetiology, age and gender.

Results: Out of 93 included patients, 20 ASCIS and 73 tSCI patients were identified. In the complete SCI group, the initial pinprick scores were higher ($P < 0.05$) in ASCIS patients compared with tSCI patients, 37.9 (95% Confidence Interval (CI), 23.3–52.5) and 27.3 (95% CI, 24.1–30.4), respectively. No other relevant differences in neurological outcome were identified between ASCIS and tSCI patients; however, the total SCIM-II scores were higher ($P < 0.05$) in tSCI patients after 12 months. Using the linear regression analysis, we were able to predict 31.4% of the variability. The aetiology was not significant in this model.

Conclusion: The neurological outcome was independent of the diagnosis ASCIS or tSCI. Furthermore, the diagnosis ASCIS or tSCI was not a significant predictor for total SCIM II scores after 12 months.

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Introduction

In patients with spinal cord injury (SCI), the clinical diagnosis of 'acute spinal cord ischaemia syndrome' (ASCIS) is rare. Although the incidence is not precisely known, it probably accounts for 5–8% of all acute myelopathies.¹ Most of these spinal cord infarctions are located in the thoracic or thoracolumbar spinal cord.^{2–4}

Although several predictors of outcome, such as age, gender and American Spinal Injury Association (ASIA)

impairment scale, have been reported in patients with ASCIS,⁴ only one study compared the neurological and functional outcome between patients with traumatic spinal cord injury (tSCI) or non-traumatic SCI with a solely vascular origin.⁵ Iseli *et al.*⁵ identified that the rate of neurological and ambulatory recovery is quite similar in patients with tSCI and ASCIS. This study, however, is limited, as it compared tetraplegic patients with paraplegic patients and used a regression analysis without including the predictor variable aetiology.

Future interventions for the recovery of function following SCI probably include a combination of pharmacological,⁶ surgical⁷ and rehabilitation⁸ approaches. Therefore, it is important to investigate the effect of these in a homogenous

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group of patients with SCI. ASCIS and tSCI patients are sometimes grouped as they are considered to have the same neurological and functional recovery.⁹ One could question, however, whether it is justified to include SCI patients with a different aetiology in the same study population.

Therefore, the objective of this study was to compare the neurological outcome between paraplegic patients with ASCIS or tSCI. In addition, the influence of the diagnosis of ASCIS or tSCI on functional outcome was investigated. Our hypothesis is that ASCIS patients have a less favourable neurological outcome and are a negative predictor for functional outcome when compared with tSCI patients.

Materials and methods

For this study, we used outcome data from complete and incomplete SCI patients between January 2000 and July 2009 that were collected in a Level 1 trauma centre with a spinal care unit. Patients referred to this SCI centre enrol consecutively into this 'Hamburg database'. Data in this database are collected at several time intervals: during first admission after injury, during the subacute phase (3–5 months), the chronic phase (6–12 months) and at each follow-up appointment and/or hospitalization afterwards. Therefore, most patients remain life-long 'clients' of this spinal cord injury centre. Clinical assessments in this database are conducted by certificated neurological and rehabilitation physicians having at least 1-year experience in examining patients with SCI.

Study population

Data from the Hamburg database were used for this retrospective study. Paraplegic patients were included in the study if they had an ischaemic or tSCI at neurological levels T2–T11. The ASCIS was based on (1) an acute neurological deficit attributable to a non-traumatic spinal cord lesion, (2) spinal CT and/or MRI findings that were typical for ischaemic lesion and/or excluded an alternative diagnosis, such as extrinsic or intrinsic cord compression. Other possible causes were further ruled out with CSF examinations.^{4,10} First neurological assessment had to be made within 40 days after the initial injury (initial phase). In patients in whom chronic-phase (≥ 12 months) follow-up measurements were not recorded, the 6- to 12-month follow-up measurements were used for analysis.

Patients with a severe cognitive impairment, peripheral nerve lesion, incomplete database record, polyneuropathy or cranio-cerebral injury were not included in the study. Patients with a possible cauda equina syndrome were excluded from the analysis as the cauda equina has been associated with a favourable prognosis.¹¹ Therefore, injuries at and below the neurological level T12 were grouped and excluded from the analysis. Frequent causes of polyneuropathy were excluded by recording the history of patients.

Neurological outcomes

Neurological examinations were conducted according to ASIA standards.¹² All paraplegic patients with completely

conducted first-phase examinations (≤ 40 days after injury), that is, the lower extremity motor score (LEMS) and ASIA impairment scale, were included for the analysis. To assess the pinprick and light touch scores in paraplegic patients, dermatomes T2–S4–5 were assessed. The maximum score of the sensory scores in these dermatomes T2–S4–5 is 80 points. Spinal cord injuries were divided into complete (ASIA impairment scale A) and incomplete (ASIA impairment scale B, C and D) lesions. The neurological level of injury (NLI) and AIS grade were determined on the basis of the ASIA sensory and motor scores. The initial phase, chronic phase and difference between initial and chronic phases were assessed for the pinprick scores, light touch scores and LEMS in each patient.

Functional outcomes

The Spinal Cord Independence Measure (SCIM) is an instrument that focuses on performing everyday tasks, and captures the disability and impact of disability on the patient's overall medical condition and comfort.¹³ The SCIM-II¹⁴ consists of three main categories, namely, (1) self-care, (2) respiration and sphincter management and (3) mobility. The chronic-phase total SCIM-II scores were assessed in each patient.

Statistics

Descriptive statistics on age, gender and AIS were used to provide general information of the study population. Subanalysis on complete/incomplete SCI, gender (χ^2 analysis or Fisher's exact test as appropriate) and age (student's *t*-test) was performed to identify possible differences between ASCIS and tSCI patients.

The mean pinprick scores, light touch scores and LEMS were calculated for the initial phase, chronic phase and for the difference between initial and chronic phase. The median SCIM-II scores were calculated for the chronic phase. Differences in pinprick scores, light touch scores, LEMS and total SCIM-II scores between ASCIS patients and tSCI patients were calculated using Student's *t*-tests and Wilcoxon signed-rank tests, respectively.

To assess the variables that give rise to the prediction of functional outcome or total SCIM-II score, a multiple linear regression analysis was used to explain the total SCIM-II variability. The predictor variables included the initial-phase complete or incomplete SCI, aetiology, age at injury and gender. This analysis was performed to assess the role of the predictor aetiology (ASCIS or tSCI) and was not performed to identify the most suitable model for explaining total SCIM-II variability.

The differences were considered statistically significant at $P < 0.05$. Data were analysed using SPSS software (version 16.0, SPSS, Chicago, IL, USA).

Results

Among the 461 paraplegic patients within the database, 376 (82%) met the study criteria. One-year-follow-up SCIM-II measurements and ASIA motor and sensory scores were available in 93 (25%) patients (see Figure 1). The mean age at

Figure 1 Flowchart of patients in the Hamburg database with subjects eligible and included for analysis. Period of inclusion: January 2000–July 2009. ASIA, American Spinal Injury Association; AIS, ASIA impairment scale; FU, follow-up; SCI, spinal cord injury.

the time of injury in ASCIS patients was 60 years (range: 41–73) and in tSCI patients was 34 years (range: 14–80). The mean interval from the onset of the paraplegia to admission was 18 and 13 days ($P > 0.05$) and the mean length of stay was 145- and 144 days ($P > 0.05$) in ASCIS and tSCI patients, respectively. The mean chronic-phase assessments in ASCIS and tSCI patients were 643 and 1226 days after injury ($P < 0.05$), respectively. In total, 40% of ASCIS patients and 82% of tSCI patients were male. The male–female ratio in ASCIS and tSCI patients was 0.7 and 4.6, respectively. Initial-phase AIS grades in ASCIS patients were A ($n = 10$, 50%), B ($n = 2$, 10%) and C ($n = 8$, 40%). In tSCI patients, the initial-phase AIS grades were A ($n = 61$, 83.6%), B ($n = 7$, 9.6%), C ($n = 3$, 4.1%) and D ($n = 2$, 2.7%). Sub-analysis showed differences between ASCIS patients and tSCI patients for age ($P < 0.0001$), complete SCI ($P < 0.01$) and gender ($P < 0.0001$). In addition, the mean age of female subjects in the study population was higher ($P < 0.05$) than the mean age of male subjects, 48 years and 36 years, respectively (See Table 1).

In total, 24 (6%) SCI patients were identified to have ASCIS. Of these 24 ASCIS patients, 12 (50%) had 6- to <12-months follow-up and 8 (33%) had ≥12-months follow-up SCIM-II measurements and ASIA motor and sensory scores. The origin of ASCIS was idiopathic ($n = 7$), aortic dissections ($n = 6$), aortic aneurysm repair ($n = 3$), embolism ($n = 3$) and arteriovenous fistulae ($n = 1$).

In total, 352 (94%) SCI patients were identified as tSCI patients. Of these 352 tSCI patients, 14 (4%) had 6- to <12-months follow-up and 59 (17%) had ≥12-months follow-up SCIM-II measurements and ASIA motor and sensory scores.

As the number of subjects with a complete SCI (ASIA impairment scale A) was not equally distributed among

Table 1 Demographic data of 93 patients

Characteristics	ASCIS	tSCI
Subjects (no.)	20	73
Age, years, mean $\pm$ s.d.	60 $\pm$ 9	34 $\pm$ 15
Male, n (%)	8 (40%)	60 (82%)
AIS, n (%)		
A	10 (50%)	61 (83.6%)
B	2 (10%)	7 (9.6%)
C	8 (40%)	3 (4.1%)
D	0 (0%)	2 (2.7%)
Neurological level of injury, n (%)		
Th2	1 (5%)	1 (1.4%)
Th3	0	2 (2.7%)
Th4	2 (10%)	13 (17.8%)
Th5	2 (10%)	11 (15.1%)
Th6	0	8 (11.0%)
Th7	2 (10%)	1 (1.4%)
Th8	1 (5%)	7 (9.6%)
Th9	3 (15%)	11 (15.1%)
Th10	5 (25%)	12 (16.4%)
Th11	4 (20%)	7 (9.6%)

Abbreviations: AIS, ASIA impairment scale; ASCIS, acute spinal cord ischemia syndrome; tSCI, traumatic spinal cord injury.

ASCIS and tSCI, the outcome data of SCIM-II scores and ASIA motor and sensory scores were stratified in the data processing according to complete (ASIA impairment scale A) and incomplete SCI (AIS B, C and D). In the complete SCI group ($n = 71$), 10 subjects had ASCIS and 71 subjects had tSCI. In the incomplete SCI group ($n = 22$), 10 subjects had ASCIS and 12 had tSCI.

Subanalysis in the complete and incomplete SCI group demonstrated a higher mean age in ASCIS patients, 58 and 61 years, respectively, compared with tSCI patients, 34 and 33 years, respectively ($P < 0.0001$). More ASCIS patients were female ($P < 0.05$) compared with tSCI patients in both the complete and incomplete SCI group.

Neurological outcome

Complete SCI. The LEMS and pinprick scores differed significantly between ASCIS and tSCI patients. The mean score in ASCIS patients was 0.8 (95% CI, -0.6 to 2.2) and 0.03 (95% CI, -0.03 to 0.1) in tSCI patients. The mean pinprick scores in ASCIS patients and tSCI patients were 37.9 (95% CI, 23.3 – 52.5) and 27.3 (95% CI, 24.1 – 30.4), respectively. However, after 12 months, no differences were identified in ASIA motor and sensory scores (See Table 2).

Incomplete SCI. No differences were identified in the motor and sensory scores between ASCIS and tSCI patients during the initial and chronic phase (See Table 2).

Functional outcome

The median SCIM-II scores were significantly higher ($P < 0.05$) in tSCI patients compared with ASCIS patients in both complete and incomplete SCI subjects (Table 2).

Using the linear regression analysis, we were able to predict 31.4% (adjusted R^2 of 0.314) of the variability in

Table 2 The motor, sensory and SCIM II scores in 20 ASCIS patients compared with 73 tSCI patients

ASIA scores	Maximal score	Complete SCI				P-values	Incomplete SCI				P-values
		ASCIS (n = 10)		tSCI (n = 61)			ASCIS (n = 10)		tSCI (n = 12)		
		Mean	95% CI	Mean	95% CI		Mean	95% CI	Mean	95% CI	
<i>Initial phase</i>											
LEMS	50	0.8	−0.6–2.2	0.03	−0.03–0.1	0.003	10.8	5.3–16.3	11.4	1.4–21.4	0.911
Light-touch	80	35.7	23.8–47.6	27.6	24.4–30.7	0.070	50.9	41.8–60.0	51.3	41.2–61.3	0.956
Pin-prick	80	37.9	33.3–52.5	27.3	24.1–30.4	0.025	49.3	40.2–58.4	46.9	36.6–57.2	0.710
<i>Chronic phase</i>											
LEMS	50	3.1	−0.1–6.3	2.3	0.5–4.1	0.728	23.6	14.4–32.8	30.3	19.9–40.6	0.307
Light-touch	80	41.1	26.0–56.2	31.7	27.9–35.4	0.081	56.1	47.1–65.1	59.0	52.4–65.6	0.559
Pin-prick	80	39.5	25.1–53.9	29.9	26.4–33.5	0.061	54.5	45.6–63.4	57.5	50.5–64.5	0.554
<i>Improvement</i>											
LEMS		2.3	0.1–4.5	2.3	0.5–4.1	0.987	12.8	5.2–20.4	18.4	7.7–29.2	0.374
Light-touch		5.4	−2.2–13	4.1	1.5–6.7	0.707	5.2	1.4–9.0	7.8	1.3–14.2	0.484
Pin-prick		1.6	−1.3–4.5	2.6	0.9–4.3	0.634	5.2	1.4–9.0	10.6	4.6–16.5	0.124
		Median	Percentiles (25–75%)	Median	Percentiles (25–75%)	P-values	Median	Percentiles (25–75%)	Median	Percentiles (25–75%)	P-values
Total SCIM II	100	54	38–64.5	64	55–68.5	0.036	63.5	40–73	73	69.5–81	0.030

Abbreviations: ASCIS; acute spinal cord ischemia syndrome; CI, confidence interval; LEMS; lower extremity motor score; SCIM-II, Spinal Cord Independence Measure II; tSCI; traumatic spinal cord injury.

The numbers in bold indicate significant differences.

total SCIM-II scores. Using the enter method, the following model emerged ($F_{4, 137} = 17.122$, $P < 0.0001$). All predictor variables were significant in this model, except for the aetiology (Table 3). In other words, the diagnosis of ASCIS or tSCI was not a significant predictor for the variability in total SCIM-II scores after 12 months post injury.

Discussion

In this study, we identified that the neurological outcome was independent of the diagnosis ASCIS or tSCI. In the regression analysis, the variable aetiology (ASCIS or tSCI) is not a significant predictor for the variability in total SCIM-II scores after 12 months.

Although we found a slightly higher initial phase LEMS in ASCIS patients compared with tSCI patients in the complete SCI group, this difference is not of clinical relevance. In addition, higher initial phase pinprick scores were found in ASCIS patients. Iseli *et al.*⁵ identified higher pinprick scores in tSCI patients ($n = 39$) compared with ASCIS patients ($n = 28$). The study, however, provided no data about the NLI. As paraplegic and tetraplegic patients were compared, the initial NLI could have influenced the pinprick scores in favour of tSCI patients. In addition, 10 of the 28 ASCIS patients were lost to follow-up after 6 months. Although the authors state that the initial complete-incomplete ratio was similar ($P > 0.05$), the study did not explain to what extent this nonsignificant ratio was influenced by the lost-to-follow-up patients.⁵ A lack of stratification for the AIS in the study⁵ could have influenced the neurological outcome.⁸ Our data showed no differences in motor and sensory scores

Table 3 Regression results for predicting total SCIM II score after 12 months

Predictor variable	β	P-values
Age at injury	-0.403	≤ 0.0001
Female gender	-0.233	0.002
Incomplete SCI	0.361	≤ 0.0001
Aetiology ^a	0.049	0.572

Abbreviations: SCI, spinal cord injury; SCIM-II; Spinal Cord Independence Measure II.

^aAetiology of the spinal cord injury was traumatic or ischemic.

after 12 months. It seems, therefore, that these initial-phase differences are of minimal clinical relevance.

The ASCIS patients in our study were older compared with tSCI patients. This supports the suggestion that patients with non-traumatic SCI have a higher average age.^{5,15} We further identified that neurological outcome is independent of and functional outcome is dependent on age. The motor and sensory scores were not different after 12 months, although ASCIS patients were significantly older. Furlan *et al.*¹⁶ also identified that the potential of neurological outcome is not negatively influenced by older age in tSCI patients. Both older and younger patients with tSCI improved neurologically within the first year after injury; however, older age was associated with greater disability, as assessed using FIM.¹⁶ We assume that the ageing patient has more comorbidity, less functional reserves and/or learning abilities, which could imply less efficiency in the rehabilitation process and thus less functional recovery.

Considering the functional outcome, our model explained 31.4% of the variability in the total SCIM-II score. The

regression analysis showed a poor fit; however, the purpose of this study was not to identify the most suitable model, but to check the role of the predictor ASCIS or tSCI. In this model, we included the variable complete/incomplete SCI, as this is a strong covariate for functional outcome.⁸ The predictor variable gender was included, as this is believed to be a predictor for functional outcome.⁴ In our study, the female gender indeed was identified to be an independent predictor of poor functional outcome in patients with ASCIS. However, in this study female subjects were significantly older than male subjects and age could therefore have caused this negative effect of the female gender. The age of the patients furthermore was included in our model, as older age is believed to be a negative predictor.^{16,17}

The results in our study confirm the suggestion^{5,18} that these two patient groups with pathophysiologically different causes for a SCI have a similar neurological outcome. We identified two studies that compared the neurological outcome between ASCIS and tSCI patients. Catz *et al.*¹⁸ assessed the neurological recovery and how this recovery was affected by age, gender, NLI, decade of admission to rehabilitation and initial Frankel grade following non-traumatic spinal cord lesions. The study identified that the odds of recovery following tSCI were not significantly different from those of vascular lesions. Although the study¹⁸ confirmed the results of our study with regard to neurological outcome, comparisons were difficult to make as the neurological examinations were not conducted according to ASIA standards. The other study⁵ compared the prognostic factors and functional recovery between patients with either ischaemia or tSCI and concluded that the neurological deficits and rate of recovery were comparable in ASCIS and tSCI patients. The study⁵ used a stepwise multiple regression analysis for the prediction of ambulatory capacity. Of the variables (age, electrophysiological recordings and ASIA motor and sensory scores), the best prediction of outcome of ambulatory capacity was achieved by the combination of the total motor score and tibial somatosensory evoked potentials. The study, however, did not address aetiology as a predictor in the regression analysis.⁵

Our study limited the study population to paraplegic patients, as ASCIS occurs mostly in the midthoracic spinal cord.^{2,3} For instance, Salvador de la Barrera *et al.*¹⁹ had 35 paraplegic subjects in their study population of 36 ASCIS patients. Another study⁴ had 79% of the NLI located in the thoracic or lumbosacral region. Steeves *et al.*⁸ further suggested that the baseline NLI is a very strong covariate on the neurological or functional outcome. As the incidence of tetraplegic ASCIS patients is probably low and we wanted to reduce the heterogeneity of comparing tetraplegics with paraplegics, we choose to limit our study population to paraplegic patients.

Our results should be interpreted in the context of specific study limitations. First, we used a time frame of 0–40 days after the initial SCI as the initial phase. Scivoletto *et al.*¹⁷ identified that a longer time from lesion to admission did influence the neurological recovery negatively because of the ceiling effect. The interval in their study, however, had a mean of 56.9 days.¹⁷ In our study, all examinations were

within the first 40 days and no differences were identified between ASCIS and tSCI patients. The mean chronic-phase assessments, however, differed significantly. Although the variation in time points was not analysed in this study, the effect on neurological and functional outcomes is believed to be minimal.²⁰ Second, the small patient numbers in this study limit the reliability of our results. Third, it has been suggested that patients with an ischaemic myelopathy of idiopathic origin have a more favourable outcome.⁴ In this study, the idiopathic cause for ASCIS still made up 35%. Although the seven subjects had an extensive diagnostic workup, these patients were diagnosed with ASCIS simply by exclusion of other disorders.¹⁰ However, in 7–36% of ASCIS patients, the cause for the spinal cord infarction remains undefined.⁴

Conclusion

In this study, the neurological outcome according to the ASIA standards appeared to be independent of the diagnosis ASCIS or tSCI. Furthermore, our results suggest that the diagnosis of ASCIS or tSCI is not a significant predictor for functional outcome according to the total SCIM-II scores after 12 months.

Conflict of interest

The authors declare no conflict of interest.

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