

## ORIGINAL ARTICLE

# Occurrence and predictors of pressure ulcers during primary in-patient spinal cord injury rehabilitation

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**Study design:** Multicenter prospective cohort study.

**Objectives:** To determine the occurrence and predictors for pressure ulcers in patients with spinal cord injury (SCI) during primary in-patient rehabilitation.

**Setting:** Eight Dutch rehabilitation centres with specialized SCI units.

**Methods:** The occurrence, location and stage of pressure ulcers were registered between admission and start of functional rehabilitation (called acute rehabilitation phase) and between start of functional rehabilitation and discharge. Possible risk factors for the occurrence of pressure ulcers during functional rehabilitation (personal and lesion characteristics, complications and functional independence) were measured at the start of functional rehabilitation and were entered as predictors in univariate and multivariate logistic regression analysis with pressure ulcers during functional rehabilitation as the dependent variable.

**Results:** Data for 193 patients (86%) were available. The occurrence of pressure ulcers, including stage 1, was 36.5% during acute rehabilitation phase and 39.4% during functional rehabilitation. Most pressure ulcers were located at the sacrum (43%), followed by heel (19%) and ischium (15%). The significant risk factors for pressure ulcers during functional rehabilitation were motor completeness of the lesion, tetraplegia, pressure ulcer during acute rehabilitation phase, pneumonia and/or pulmonary disease, low score on the Functional Independence Measure (FIM) self-care, continence, transfers, locomotion and total FIM motor score. Having had a pressure ulcer during acute rehabilitation phase was the strongest risk factor.

**Conclusion:** The occurrence of pressure ulcers was comparable with other studies. A few significant risk factors were found, of which having had a pressure ulcer during acute rehabilitation phase being the strongest predictor.

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**Keywords:** spinal cord injury; pressure ulcer; incidence; predictors; risk factor; risk assessment scales

## Introduction

Pressure ulcers frequently occur in patients with spinal cord injury (SCI). During acute care or rehabilitation, 34% of the patients develop at least one pressure ulcer.<sup>1</sup> Prevention of pressure ulcers during rehabilitation shortens the stay in a rehabilitation centre and increases the chance of returning home after rehabilitation.<sup>2</sup>

More than 200 risk factors for pressure ulcers have been described in the SCI literature,<sup>3</sup> ranging from severity of SCI, nutritional status, physical status and medication use to

socioeconomic and psychological status. Although several different risk assessment scales for pressure ulcers exist, scales such as the Norton,<sup>4</sup> Braden,<sup>5</sup> Waterlow<sup>6</sup> and CBO<sup>7</sup> were not developed to be used for SCI patients. Although these scales are often applied for this patient group, they probably do not provide an optimum identification of SCI patients at risk for pressure ulcers. They might miss important risk factors and might contain risk factors that are irrelevant for this group. Only the Spinal Cord Injury Pressure Ulcer Scale (SCIPUS) was specifically developed for SCI patients.<sup>8</sup> There are two versions, the SCIPUS for the chronic phase and SCIPUS-A, for the initial hospitalization.<sup>9</sup> The predictive value of these scales is, however, unclear.<sup>10</sup>

A recent review found no studies on risk factors for pressure ulcers during the initial rehabilitation phase in a

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homogeneous SCI population.<sup>11</sup> Two rehabilitation studies were identified in this review, but both studies included patients in initial rehabilitation as well as re-hospitalized patients. The occurrence and risk factors for pressure ulcers during initial in-patient rehabilitation of SCI patients is therefore still unclear. The aim of this study was to determine the occurrence and risk factors for pressure ulcers in a selected cohort of recently injured SCI patients during in-patient rehabilitation.

## Materials and methods

### Patients

For this study, data from the Dutch multicenter prospective cohort study 'Restoration of mobility in spinal cord injury rehabilitation' was used.<sup>12</sup> This cohort study included persons with SCI who were admitted for initial rehabilitation after SCI to one of the eight SCI-specialized rehabilitation centres in The Netherlands. The inclusion criteria were as follows: recent SCI, age between 18 and 65 years, ASIA A–D and being at least in part wheelchair-dependent. Persons with a progressive disease, psychiatric disorders or insufficient knowledge of the Dutch language were excluded.

### Procedure

The period in the rehabilitation centre was divided into two periods. The period between admission to the centre and start of functional rehabilitation is called acute rehabilitation phase. The period of functional rehabilitation started when a patient could sit in a wheelchair for 3–4 h. This period ended at final discharge from the rehabilitation centre. Measurements were performed at the start of functional rehabilitation and at discharge. At each measurement, patients were seen by a rehabilitation physician for an interview and a physical examination. A trained local research assistant performed physical tests and administered a questionnaire.

### Measures

At both time points the presence, location and stage of the pressure ulcer were registered. Pressure ulcers were defined using the EPUAP classification.<sup>1</sup> The period of bed rest due to pressure ulcers was also recorded. All factors that were included in pressure ulcer risk assessment scales and that were available in our database were examined. Level and completeness of SCI were determined using the ASIA classification. For completeness of the lesion, we compared motor complete (ASIA AB) with motor incomplete (ASIA CD), because these two groups show the greatest difference in functionality. Spine fractures at onset of the SCI and cause of the SCI were noted. Patients were asked questions on smoking and alcohol use before onset of the SCI and at start of functional rehabilitation. Sports participation before SCI was also noted. Furthermore, the presence of cardiovascular disease or pulmonary disease were noted. Complications present or that had occurred during the period before the measurement (acute or functional rehabilitation) were registered: autonomic dysreflexia, oedema, spasticity, heterotopic ossification and pneumonia. The blood pressure was

measured while the patient was sitting. The resulting blood pressure was divided into three groups, hypotension <120/70 mm Hg, normotension and hypertension >140/90 mm Hg. The body mass index was assessed and scores were divided in three groups:<sup>6</sup> <20 kg m<sup>-2</sup>, 20 kg m<sup>-2</sup> until 24.9 and >24.9 kg m<sup>-2</sup>. Finally, the Functional Independence Measure (FIM) was used to measure physical and cognitive functioning.

### Analysis

The occurrence of pressure ulcers was calculated separately for the acute rehabilitation phase and for the functional rehabilitation phase, and both including and excluding stage 1 ulcers. Possible risk factors for the occurrence of stages 2–4 pressure ulcers during functional rehabilitation (the dependent variable) were analysed using logistic regression analysis. All analyses were repeated including stage 1 ulcers, but the results were similar and we only report the results of analyses excluding stage 1 ulcers. First, all possible risk factors were entered one by one as predictors in univariate logistic regression analyses. The significant predictors ( $\alpha < 0.10$ ) were then entered in multivariate logistic regression analyses, using a backward selection procedure. Three multivariate logistic regression analyses were performed (one without FIM scores, one with the FIM total motor score and one with the 4 FIM subscale scores for locomotion, self-care, continence and transfers) because the variables level and completeness of lesion, the FIM subscale scores and the FIM motor score were strongly correlated with each other.

## Results

A total of 225 patients were included, for 193 (85.7%) patients measurements were performed at the start of functional rehabilitation and at discharge. The reasons for drop-out are described elsewhere.<sup>13</sup> The characteristics of the 193 patients are summarized in Table 1.

The median duration of acute rehabilitation phase was 35 days (range 25–61 days). The median duration of functional rehabilitation phase was 191 days (range 132–290 days).

### Occurrence of pressure ulcers

Pressure ulcers, including stage 1, occurred in 36.5% of all patients during acute rehabilitation phase and in 39.4% during functional rehabilitation. Excluding stage 1, the occurrence of pressure ulcers was 30.6 and 31.1%, respectively.

Seventy-six patients had a total of 126 pressure ulcers during functional rehabilitation (Table 2). Most pressure ulcers were located at the sacrum, with a much lower percentage in the heel and ischium. The most frequent stages were stages 1 and 2, stage 4 ulcers were rare. There was no clear association between stage of the ulcer and its location. Of all 76 persons with pressure ulcers during functional rehabilitation, 43 (57%) patients were kept under bed rest due to these pressure ulcers, with a median duration of 14 days (range 1–180 days) bed rest (Table 3).

**Table 1** Characteristics of 193 patients with spinal cord injury at the start of functional rehabilitation

Characteristics	n	%
<b>Gender</b>		
Male	143	74.1
Female	50	25.9
<b>Age</b>		
Years mean	40.4	s.d. 14.1
<b>Cause SCI</b>		
Traumatic	143	74.1
Myeluminfarct/bleeding	11	5.7
Myelitis	8	4.1
Benign tumour	5	2.6
Iatrogene	7	3.6
Other non-traumatic	19	9.8
<b>ASIA</b>		
A	93	48.2
B	43	22.3
C	40	20.7
D	16	8.3
Unknown	1	0.5
<b>Level of lesion</b>		
Tetraplegia	72	37.3
Paraplegia	121	62.7
<b>Spine fracture</b>		
Yes	128	66.3
No	64	33.2
Unknown	1	0.5
<b>BMI</b>		
<20 kg m <sup>-2</sup>	48	24.9
20–24.9 kg m <sup>-2</sup>	82	42.5
>24.9 kg m <sup>-2</sup>	51	26.4
Unknown	12	6.2

Abbreviations: BMI, body mass index; SCI, spinal cord injury.

**Table 2** Pressure ulcers during functional rehabilitation

Stage→	1	2	3	4	Total (%)
<b>Location ↓</b>					
Heel	7	10	5	2	24 (19)
Ankle	0	3	7	1	11 (9)
Trochanter	3	2	0	0	5 (4)
Ischium	10	8	1	0	19 (15)
Sacrum	20	25	6	3	54 (43)
Other	1	7	3	2	13 (10)
Total (%)	41 (33)	55 (44)	22 (17)	8 (6)	126

**Table 3** Bed rest due to pressure ulcers during functional rehabilitation

Days	Patients	Percentage
0	33	43.4
1–10	20	26.3
11–20	7	9.2
21–30	8	10.5
>30	8	10.5

#### Risk factors

Of all predictors for occurrence of pressure ulcers, the following were significantly associated with the occurrence of pressure ulcers: complete SCI, pressure ulcer during acute

rehabilitation phase, pneumonia and/or pulmonary disease during acute rehabilitation phase, and low scores on the FIM subscales self-care, continence, transfers, locomotion and total FIM motor score (Table 4). The other predictors tested showed no significant relationship with the occurrence of pressure ulcers.

The results of the multivariate logistic regression analyses are shown in Table 5. Physical disability and having a pressure ulcer during acute rehabilitation phase were risk factors in all three models. In the model without FIM scores, patients with motor complete lesions had a 2.3 times higher risk for pressure ulcers. Patients who had a pulmonary condition during acute rehabilitation phase had a 2.5 times higher risk for pressure ulcers. Patients who had a pressure ulcer during acute rehabilitation phase had a 5.1 times higher risk for pressure ulcer during functional rehabilitation. The model with the total FIM motor score instead of level and completeness of SCI showed a slightly better prediction. The model with the FIM subscale scores did not result in better prediction when compared with the model with the FIM motor score. In both models with the FIM scores, only having tetraplegia and having had pressure ulcers during acute rehabilitation phase were significant risk factors of the occurrence of pressure ulcers during functional rehabilitation.

## Discussion

### Occurrence of pressure ulcers

In our study the occurrence of pressure ulcers including stage 1 was 36.5% during acute rehabilitation phase and 39.4% during functional rehabilitation. The last group consists of patients with new pressure ulcers and patients with ulcers at locations that do not interfere with functional rehabilitation. Salzberg<sup>9</sup> studied traumatic SCI patients during initial hospitalization and found 49% of the patients developing a pressure ulcer including stage 1. In a study on patients with non-traumatic SCI,<sup>14</sup> 2% developed pressure ulcers during in-patient rehabilitation against 38% in a study on patients with traumatic SCI,<sup>15</sup> both studies included stage 1. Most of our patients (74%) had a traumatic SCI and we excluded patients with walking ability, and therefore a high percentage of our study population had a motor complete SCI. Therefore, the occurrence of pressure ulcer in our study does not seem particularly high.

### Location, stages and bed rest caused by pressure ulcers

Pressure ulcers were most often located at the sacrum (43%), followed by the heel (19%) and ischium (15%). The sacrum was often mentioned in previous studies (39–52%),<sup>8,16</sup> just as the ischium (8–59%)<sup>8,16</sup> and heel (13–31%).<sup>8,14,16</sup>

The relative frequencies of pressure ulcer stages vary across different studies. In our study group, most patients had stage 1 or 2. This was also found by Garber *et al.*<sup>17</sup> and Chen *et al.*<sup>16</sup> Salzberg and Byrne,<sup>8</sup> however, found that most patients had stage 3 or 4 ulcers, but this was a population of chronic SCI patients living in the community. New *et al.*<sup>14</sup> studied an initial and a readmission group, in both groups many

**Table 4** Risk factors for pressure ulcers in SCI patients, outcome of the univariate logistic regression analyses

Variable	Number of patients	Pressure ulcers, %	Odds ratio	95% Confidence interval	P-value
<b>Gender</b>					
Male	143	30.1	1.2	0.6–2.4	0.606
Female	50	34.0			
<b>Cause SCI</b>					
Non-traumatic	50	30.0	1.1	0.5–2.2	0.847
Traumatic	143	31.5			
<b>Level of lesion</b>					
Paraplegia	121	26.4	1.8	1.0–3.3	0.072
Tetraplegia	72	38.9			
<b>Complete SCI</b>					
Incomplete	56	19.6	2.3	1.1–4.9	0.028
Complete	136	36.0			
<b>Pressure ulcer during acute rehabilitation</b>					
No	134	19.4	5.6	2.9–11.0	0.000
Yes	59	57.6			
<b>Pulmonary disease/infection</b>					
No	156	26.3	2.9	1.4–6.2	0.004
Yes	37	51.4			
<b>Oedema</b>					
No	138	32.6	0.8	0.4–1.6	0.566
Yes	53	28.3			
<b>Urinary tract infection</b>					
No	100	32.0	0.9	0.5–1.7	0.777
Yes	93	30.1			
<b>Heterotopic ossification</b>					
Yes	16	18.8	0.5	0.1–1.8	0.274
No	177	32.2			
<b>Spine fracture</b>					
No	64	26.6	1.4	0.7–2.7	0.323
Yes	128	33.6			
<b>Cardiovascular disease</b>					
No	169	32.0	0.7	0.3–1.9	0.493
Yes	24	25.0			
<b>Smoking<sup>a</sup></b>					
No	106	27.4	1.5	0.8–2.7	0.218
Yes	87	35.6			
<b>Sports before lesion</b>					
No	125	31.2	1.0	0.54–1.95	0.930
Yes	66	31.6			
<b>Alcohol use<sup>a</sup></b>					
No	45	28.9	1.1	1.6–2.4	0.716
Yes	148	31.8			
<b>Hypertension &gt; 140/90 mm Hg</b>					
No	173	31.8	0.7	0.2–2.1	0.536
Yes	20	25.0			
<b>Hypotension &lt; 120/70 mm Hg</b>					
No	72	26.4	1.4	0.8–2.7	0.278
Yes	121	33.9			
<b>BMI (kg m<sup>-2</sup>)</b>					
< 20	48	35.4	1.8	0.7–4.3	0.196

**Table 4** Continued

Variable	Number of patients	Pressure ulcers, %	Odds ratio	95% Confidence interval	P-value
20–24.9	82	28.0	1.3	0.6–2.8	0.565
> 24.9	51	23.5	Ref	Ref	Ref
	<i>Number of patients</i>	<i>Mean value</i>			
<b>Age</b>					
No ulcer	133	40.6	1.00	0.98–1.02	0.865
Pressure ulcer	60	41.0			
<b>Spasticity</b>					
No ulcer	133	2.48	0.93	0.82–1.05	0.263
Pressure ulcer	60	2.03			
<b>FIM self-care</b>					
No ulcer	130	23.9	0.93	0.90–0.97	0.000
Pressure ulcer	59	17.6			
<b>FIM continence</b>					
No ulcer	130	5.5	0.82	0.73–0.92	0.000
Pressure ulcer	59	3.5			
<b>FIM transfers</b>					
No ulcer	130	8.1	0.88	0.82–0.95	0.000
Pressure ulcer	59	4.6			
<b>FIM locomotion</b>					
No ulcer	130	6.8	0.78	0.66–0.91	0.003
Pressure ulcer	59	5.9			
<b>FIM motor score</b>					
No ulcer	130	44.3	0.96	0.94–0.98	0.000
Pressure ulcer	59	31.6			
<b>FIM cognition</b>					
No ulcer	130	34.6	0.96	0.79–1.16	0.681
Pressure ulcer	59	34.5			

Abbreviations: BMI, body mass index; FIM, Functional Independence Measure; SCI, spinal cord injury.

The italicized values are significant at  $P < 0.05$ .

<sup>a</sup>Before the lesion or during acute rehabilitation phase.

patients had stages 2 and 3 pressure ulcers. More than half of our patients with pressure ulcers did take bed rest for the pressure ulcers. This was also found in a group of non-traumatic SCI patients.<sup>14</sup>

#### Risk factors and risk assessment scales

All factors used in current pressure ulcer risk assessment scales are shown in Table 6. In this table, it is also indicated whether a factor was available in our database and, if so, whether this factor showed a significant association with the occurrence of pressure ulcers in our study. All these risk scales include an indicator of physical disability, such as mobility or activity level. This factor, either expressed by level and completeness of the lesion or by the FIM, was a strong predictor of pressure ulcers in our study and in most other studies.<sup>8,17,18</sup> One study<sup>14</sup> found no significant correlation between pressure ulcers and completeness of the lesion in the initial rehabilitation group in contrast to

**Table 5** Multivariate logistic (backward) regression models

Variable	Odds ratio	95% Confidence interval	P-value	Percentage correct predicted	Nagelkerke R <sup>2</sup>
<i>Model without FIM motor score</i>				68.8	24
Pressure ulcer during acute rehabilitation	5.1	2.5–10.1	0.000		
Completeness of lesion	2.3	1.0–5.2	0.044		
Pulmonary condition	2.5	1.1–5.7	0.024		
<i>Model with FIM motor score</i>				76.1	30
Pressure ulcer during acute rehabilitation	5.6	2.7–11.9	0.000		
Level of lesion	2.5	1.0–9.1	0.042		
FIM motor score	0.95	0.9–1.0	0.000		
<i>Model with FIM scale scores</i>				75	31
Pressure ulcer during acute rehabilitation	6.2	2.9–13.3	0.000		
Level of lesion	5.0	1.4–10	0.013		
FIM self-care	0.91	0.86–0.97	0.020		
FIM locomotion	0.82	0.7–1.0	0.068		

Abbreviation: FIM, Functional Independence Measure.

**Table 6** Pressure ulcer risk assessment scales

Variable	Norton	Braden	Waterlow	CBO	SCIPUS	SCIPUS-A	Dutch multicenter study
General physical condition	*						
Mental/cognitive state	*			*	*		–
Activity level	*	*			*	*	+
Mobility level	*	*	*	*	*	*	+
Neurological deficit			*	*			+
Complete SCI					*		+
Tetra/paraplegia						*	+
Nutrition status		*	*	*			
Food intake				*			
Fluid intake							
Sensory perception		*					
Incontinence	*		*	*	*	*	+
Moisture		*			*	*	
Friction and shear		*					–
Body mass index			*				–
Gender			*				–
Age			*	*	*		–
Skin type			*				–
Anti-inflammatory medication or steroid use			*				
Medication				*			
Major surgery or trauma			*				– #
Diabetes mellitus			*	*	*		
Pulmonary disease			*		*	*	+
Cardiac disease or abnormal ECG			*		*		–
Renal disease			*		*		
Autonomic dysreflexia, spasticity					*		–
Body temperature				*			
Serum albumin					*	*	
Serum creatinine						*	
Haematocrit			*		*		
Smoking			*		*		–
Stay in nursing home/hospital					*		NA

\*, factor in the scale; +, significant risk factor in our study; –, no significant risk factor in our study; ECG, electrocardiogram; NA, not applicable; SCI, spinal cord injury; #, spine fracture and traumatic SCI were not significant.

the readmission group. In their non-traumatic SCI patients<sup>14</sup> no significant relation was found with the FIM motor score.

Mental/cognitive state is only included in the Norton scale. Our study, however, showed very high scores on the FIM cognition scale. It is possible that a neuropsychological test would reveal cognitive impairment as a risk factor for pressure ulcers.

Our results were comparable with other studies<sup>17,18</sup> regarding the finding that patients who have had previous pressure ulcers had a high risk for future pressure ulcers. This factor is not in any risk scale.

In other studies or risk scales, medical conditions sometimes are taken as a group and sometimes are specified. We found pulmonary disease and/or pneumonia during acute

rehabilitation phase as risk factor for pressure ulcers. One study during the initial hospitalization also found this association.<sup>9</sup> Two studies found a significant association between infections and pressure ulcers,<sup>8,14</sup> without specifying which infections were studied. In one of the studies,<sup>14</sup> the relation was only found in the initial rehabilitation group, not in the readmission group. There seems to be a relation between pulmonary diseases, pneumonia and pressure ulcers. The pathology is not known, but certainly needs further study. Patients with tetraplegia more often have pulmonary problems that might lead to a lower physical condition and more bed rest, which all can contribute to an increased risk for pressure ulcers.

In many risk assessment scales, the nutrition status or intake of food and fluids is a factor. We did not have these data but studied the body mass index, which was not significantly associated with pressure ulcers.

Many risk assessment scales contain the factors age and gender, which were not significant risk factors in our study, and in other studies contradictory results were found.<sup>8,14,19</sup>

Incontinence is found in many risk assessment scales and was related to pressure ulcers in our study and Salzbergs studies.<sup>8,9</sup>

In the Waterlow and CBO scale, the use of medication is a risk factor. SCI patients almost always use medication, for example, to regulate defecation. Therefore, we could not analyse the use of medication as a predictor of pressure ulcers.

Blood albumine and haematocrit are often used to estimate the risk for developing pressure ulcers. Correlations in the literature are inconsistent.<sup>8,9,14</sup> We did not have laboratory data in our database.

Although smoking or alcohol use are often seen as risk factors for pressure ulcers, we did not find a significant relationship with pressure ulcers. In previous studies, inconsistent relations for smoking<sup>3,8,9,14,19</sup> and no relation with alcohol use was found.<sup>8,19</sup>

Many risk factors for pressure ulcer development are described in literature and in risk assessment scales. However, we only found a few significant risk factors in our SCI population. Most of the pressure ulcer risk assessment scales contain factors that are not specific for SCI patients. The SCIPUS-A scale is developed for SCI patient during initial hospitalization. This scale had the most correspondence with our significant risk factors and therefore is the most useful during primary in-patient SCI rehabilitation. Our strongest risk factor, having had a pressure ulcer during acute rehabilitation phase, was in no risk assessment scale. It has to be a factor of attention, specially because it is an efficient predictor. Furthermore, other personal and behavioural characteristics associated with pressure ulcer development<sup>19</sup> need further research.

#### Limitations

Our study was conducted within a homogeneous SCI population admitted to SCI-specialized rehabilitation centres for initial in-patient rehabilitation. As we used an existing database, we could not analyse several of the risk factors

included in risk assessment scales or that were reported in the literature, such as the skin and body temperature, skin condition, nutrition status, blood albumin, creatinine, haematocrit and vitamins. Nor could we examine behavioural characteristics.

We had no information on possible risk factors immediately after the onset of SCI, similar to the period in spinal board and the period of admission in the acute care hospital. It would have also been useful to analyse these data.

Another possible limitation was the selection bias in the Dutch multicenter study. Although the subjects were representative of the whole group of in-patient SCI patients with respect to age and gender, there were more patients with a complete lesion and tetraplegia included when compared with the excluded group and the drop-out patients.<sup>12</sup> In addition, there was a positive selection as patients who were deceased were excluded, and also a negative selection bias because patients who became community walkers during in-patient rehabilitation were excluded from the study.

#### Conclusion

The occurrence of pressure ulcers including stage 1 was 36.5% during acute rehabilitation phase and 39.4% during functional rehabilitation, excluding stage 1 it is 30.6 and 31.1%, respectively. The significant risk factors for pressure ulcers during functional rehabilitation are motor completeness of the lesion, tetraplegia, pressure ulcer during acute rehabilitation phase, pneumonia and/or pulmonary disease during acute rehabilitation phase, and low physical independence. Having had pressure ulcers during acute rehabilitation phase was found to be the strongest risk factor.

#### Conflict of interest

The authors declare no conflict of interest.

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