

ORIGINAL ARTICLE

Hospital-acquired pressure ulcers in spinal cord injured patients: time to occur, time until closure and risk factors

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Study design: Prospective observational cohort study.

Objectives: To describe time to occur and time until closure of hospital-acquired pressure ulcers (HAPUs) in patients with spinal cord injury (SCI).

Setting: Specialised SCI acute care and rehabilitation clinic in Switzerland.

Methods: Daily registration of the presence and severity of HAPUs in a consecutive sample of SCI patients during their entire in-patient stay.

Results: Out of 185 observed SCI patients, 55 patients (29.7%) developed at least one HAPU. Within the first 30 days after admission, 50% of all HAPUs occurred. Less severe HAPUs occurred earlier than severe HAPUs. The occurrence of HAPUs was significantly associated with reason of admission ($P < 0.01$), and was highest in first rehabilitation (51.4%) and orthopaedic surgery patients (41.4%). The incidences of first HAPU in these groups were 1.04 and 2.31 per patient-year, respectively. Patients in first rehabilitation or readmitted because of pressure ulcer (PU) showed an initial lower risk for HAPUs in the Kaplan–Meier curve compared with patients readmitted for other reasons. Cox regression analysis revealed an association between longer time since SCI and time until occurrence ($P = 0.01$). Closure of the HAPUs during hospitalisation was observed in 37 patients (67.3%) after 38.9 days on average. No significant associations were found between patient characteristics and time until closure.

Conclusion: The dynamics of HAPUs varied according to admission reason and time since lesion. However, ongoing awareness to prevent HAPUs is needed in all patients with SCI.

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INTRODUCTION

A frequent occurrence of pressure ulcers (PUs) during hospitalisation of patients with a spinal cord injury (SCI) has been reported in the literature, varying from 36 to 49.2% in recent publications.^{1–3} Although many in-patient prevention concepts have been developed, being admitted to a hospital or rehabilitation centre is still a risk factor for hospital-acquired pressure ulcers (HAPUs).⁴ HAPUs are associated with high hospital costs because of prolonged hospital stay⁵ and need for additional materials and nursing time.⁶ Being discharged from the rehabilitation hospital without wound closure is associated with reduced functional outcomes⁷ and an increased risk of complications in patients with SCI.⁸ Therefore, reducing the occurrence and shortening the time until closure of PUs is important to reduce patient's burden and health-care costs.

In a cohort study in eight Dutch rehabilitation centres, 36.5% participants obtained a HAPU during the acute rehabilitation phase and 39.4% participants during functional rehabilitation.^{1,3} However, studies in non-SCI patients showed that HAPUs occurred relatively early after admission, varying from 6.2% within 2 days of admission⁹ to 12.4% within 7 days on admission to an intensive care unit.¹⁰ On average, less severe HAPUs occurred earlier than severe HAPUs on

intensive care units.¹¹ Events, such as a surgery, are known to enhance the risk of HAPUs in all and especially in SCI patients.^{12–14}

Complete healing of a PU is difficult to determine because molecular and cellular processes of healing continue for months after the epithelial covering. Therefore, measuring the closure of a PU is a more pragmatic approach. Closure of a PU has been defined as complete epithelialisation, with a thin, unstable and translucent skin without a fully restored epidermal integrity and stability.¹⁵ There are only few descriptive data on time until closure of HAPUs in SCI patients.¹⁶ Information from other populations is only marginally applicable, as healing of PUs in SCI patients takes more time because of physiological changes in the wound-healing cascade.¹⁷

The aim of this study is (1) to analyse the time between admission and occurrence of HAPUs in SCI patients in a specialised acute care and rehabilitation clinic for SCI and (2) to analyse the time until closure of these HAPUs.

MATERIALS AND METHODS

Research design

Information on the presence of PU was collected prospectively from daily observations, and registered information on risk factors was collected retrospectively from medical files. Data on occurrence, localisation and risk factors

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of PU have been reported in a previous article in this journal using the same database.² In addition, the current paper contributes a longitudinal perspective, analysing time until occurrence and time until closure of PU.

Patients

Data for this study were collected from a consecutive sample of patients with SCI admitted for in-patient treatment to the Swiss Paraplegic Centre, Nottwil, Switzerland, between September 2009 and February 2010. Included were all patients who were at least 18 years old and had an SCI classified as American Spinal Injury Association Impairment Scale (AIS) A–D. No exclusion criteria were applied. All HAPUs were treated conservatively in line with the house interne concept. The main principles of this concept include, firstly, pressure

relief adapted to the location of the PU and the personal situation of the patient. This may include bed rest, special pressure relief mattress and repositioning protocol. Secondly, according to the wound assessment URGE principles (U = Wundumgebung, R = Wundrand, G = Wundgrund, E = Exsudat),^{18,19} nurses and rehab physician initiate the local wound therapy following the TIME concept (T = tissue removal, I = infection control, M = moisture management, E = edge protection).²⁰ An individual risk assessment is made including patient's characteristics, comorbidities such as diabetes, peripheral arterial occlusive disease, infections and incontinence, local factors such as contamination and moisture, nutrition status with blood examination by a dietician and psychosocial status. In case of severe HAPU (grade 3 or more, recurrent or a nonhealing grade 2) with a potential indication of surgery, the in-house plastic surgeon was consulted.

Procedure

Patients were examined for the presence of PU every 12 h during their entire hospitalisation.

Instruments

Only PUs that occurred during admission were considered. The presence and severity of HAPUs were recorded using a documentation sheet and later entered into an access database. HAPUs were graded according to the EPUAP (European Pressure Ulcer Advisory Panel) classification.²¹ Patient characteristics such as gender, age at admission, AIS score, level of injury, time since onset of the lesion, aetiology of injury and reason for admission were retrieved from medical files.

Analysis

Time until occurrence of HAPU was defined as the number of days from admission to the first observation of the first or second HAPU. Time until closure was defined as the number of days from the first observation of the HAPU until assessment of grade 0 with complete epithelialisation was assessed for the first time.¹⁵ Locations were grouped into foot (toe, heel, forefoot, ankle), lower extremity (legs), sitting area (sacrum/coccyx, ischium, trochanter, genitals, groin) and other (back, head etcetera). Reason for admission was categorised into first rehabilitation, readmission for treatment of PU and readmission for other reasons.

Nonparametric tests were applied to test for the associations between patient characteristics and the occurrence of HAPU (χ^2 and Fisher's exact test) and time until occurrence of HAPU (Mann–Whitney and Kruskal–Wallis test). Length of stay with and without HAPU and the occurrence of HAPU per patient-months and patient-years were described. Time until occurrence of HAPU according to reason for admission group is presented in a box plot. Time until occurrence of HAPU by admission reason and categories of time since lesion (0–5, 6–25, 26 or more years) is displayed in Kaplan–Meier plots. Cox regression analysis was performed to identify independent determinants of time until occurrence of HAPU, including all variables that are bivariate significantly associated with time until occurrence of HAPU in the analysis.

Time until closure or until discharge without closure of HAPU according to the EPUAP classification is displayed in a box plot and potential determinants for discharge without closure were tested using χ^2 and Fisher's exact test. The significance level was set at 5%. All analyses were performed with SPSS version 21 (IBM Corp., Armonk, NY, USA).

The study protocol was approved by the local ethical committee of Lucerne (registration number 11095).

RESULTS

A total of 185 patients were included in the study and observed during their entire hospitalisation. Their characteristics are displayed in Table 1. Of this group, 55 patients (29.7%) developed one or more HAPUs. The severity of HAPU was grade 1 in 17 (30.9%), grade 2 in 32 (58.2%) and grade 3 in 6 patients (10.9%). Out of the 55 patients who developed HAPUs, 27 patients developed second HAPU, and in 25 patients at a different location. Most secondary HAPU occurred in patients admitted for first rehabilitation (Supplementary Table 1).

Table 1 Baseline characteristics of the study population and the subgroup of patients with HAPUs

Characteristic	All patients N = 185		With HAPU N = 55		Test P-value ^a
	N	%	N	%	
Gender					
Female	50	27.0	13	26.0	0.314
Male	135	73.0	42	31.1	
Age at admission (years)					
18–35	46	24.9	9	19.6	0.234
36–50	58	31.4	19	32.8	
51–65	60	32.4	18	30.0	
66 or above	21	11.4	9	41.9	
Time since lesion (years)					
0	34	18.4	16	47.1	0.002
1–5	38	20.5	7	18.4	
6–25	65	35.1	12	18.5	
26 or above	48	25.9	20	41.7	
Aetiology					
Traumatic	130	70.3	39	30.0	0.525
Nontraumatic	55	29.7	16	29.1	
Lesion level					
Paraplegia	108	58.4	29	26.6	0.197
Tetraplegia	77	41.6	26	34.2	
AIS injury severity					
A	121	65.4	41	33.9	0.069
B–D	64	34.6	14	21.9	
PU at admission					
No	126	69.1	32	25.4	0.060
Yes	59	31.9	23	39	
Reason for admission					
First rehabilitation	35	18.9	18	51.4	0.006
Readmission for PU	25	13.5	8	32.0	
Orthopaedic surgery	29	15.7	12	41.4	
Urologic surgery	29	15.7	2	6.9	
Re-rehabilitation	32	17.3	8	25.0	
Other readmissions	35	18.9	7	20.0	

Abbreviations: AIS, American Spinal Injury Association Impairment Scale; HAPU, hospital-acquired pressure ulcer; PU, pressure ulcer.
^aComparison of patients with and without HAPU; Fisher's exact test for 2 × 2 tables and χ^2 test otherwise.

Table 2 Occurrence of a first HAPU classified by admission reason

Reason for admission	All patients (N = 185)		Patients with HAPU (N = 55)		HAPU (per patient- years)
	N	Mean LOS	N	Mean LOS	
Readmission for PU	25	91.7	8	132.8	1.273
First rehabilitation	35	181.1	18	218.4	1.036
Re-rehabilitation	32	50.4	8	90	1.811
Orthopaedic surgery	29	65.5	12	108.2	2.308
Urologic surgery	29	13.4	2	14	1.881
Other	35	44.1	7	75.1	1.655

Abbreviations: HAPU, hospital-acquired pressure ulcer; LOS, length of stay (in days); PU, pressure ulcer.

The occurrence of HAPU was associated with reason for admission, time since lesion (Table 1) and length of stay (all: $P < 0.01$). HAPUs were most frequently seen in patients admitted for first rehabilitation (51.5%), orthopaedic surgery (41.4%) and treatment of pre-existing PU (32.0%). Expressed in patient-years, the incidence of HAPU was highest in orthopaedic patients (2.31 HAPUs per person-years; Table 2).

As an unexpected occurrence of third-grade HAPU was found, documentation sheets were checked in detail. Furthermore, location of HAPU, diagnosis, laboratory and treatment context of these patients were retrieved from the medical files, but no pattern was found. All six patients were multimorbid with varying comorbidities and one thing common in all was that they were treated with antibiotics for > 24 h because of acute or chronic infection or surgery. In three patients, this was facilitated with a rise of infection parameters at the time of occurrence.

Time until occurrence of HAPU

Within 30 days after admission, 50% of all first HAPUs occurred. The median time from admission until occurrence for grade 1, 2 and 3 HAPUs was 19, 31 and 62 days, respectively (Table 3). In comparison, patients admitted for PU or first rehabilitation showed a lower occurrence of HAPU during the first weeks of hospitalisation than patients who were readmitted for other reasons (Table 3 and Figures 1 and 2). In orthopaedic patients, HAPU occurred in 25% within 24 h post surgery and in 66.7% within 5 days post surgery.

No significant association between reason for admission and time until occurrence of HAPU was found using Cox regression analysis; however, time since lesion was significantly associated with occurrence of HAPU (Table 4). Different survival curves were found for the three groups of time since lesion, showing a higher risk to suffer from a HAPU within the first days after admission and for patients having a lesion for several years since lesion for example (Figure 3).

The mean time between occurrence of the first and the second HAPU was 40 days (s.d. 26.6 days). Of the 27 second HAPUs, 14 occurred before closure of the first HAPU. The mean and median time from admission until occurrence of a second HAPU was 87.6 and 72 days, respectively (Supplementary Table 1).

Time until closure of a HAPU

Of all HAPUs, 37 (67.3%) closed completely during hospital stay. The majority of the patients without closed wounds (15 patients, 83%) were discharged to their homes. The median time until closure during hospital stay was 31 days (interquartile range 20–62 days;

Table 3 Time until occurrence of the first HAPU (days)

	N	Median	IQR	Min-max	P-value ^a
All patients with HAPU	55	30	8–74	1–186	
<i>Gender</i>					
Female	13	32	11–77	2–138	0.736
Male	42	28	7–71	1–186	
<i>Age at admission (years)</i>					
18–35	9	67	12–77	4–174	0.135
36–50	19	8	9–45	1–186	
51–65	18	44.5	18–77	6–149	
66 or above	9	24	19–70	3–129	
<i>Time since lesion (years)</i>					
0	16	73.7	38–126	18–186	< 0.001
1–5	7	49	31–69	18–103	
6–25	12	7	3–19	1–58	
26 or more	20	15	5.5–67.5	2–149	
<i>Aetiology</i>					
Traumatic	39	32	11.5–74	1–186	0.317
Nontraumatic	16	14	4.5–77	2–129	
<i>Lesion level</i>					
Paraplegia	29	30	8–84	1–174	0.423
Tetraplegia	26	23.8	8–59	2–186	
<i>AIS injury severity</i>					
A	41	27.0	8–71	2–138	0.643
B–D	14	39.5	10–84	1–186	
<i>Reason for admission</i>					
First rehabilitation	18	70.5	46–123	2–186	< 0.001
Readmission for PU	8	69	24.5–93.5	6–149	
Re-rehabilitation	8	7	5–11	3–43	
Orthop./urol. surgery	14	14.5	4–32	2–77	
Other readmissions	7	10	3.5–32	1–91	
<i>Localisation</i>					
Sitting area	24	24	5–62	1–149	0.277
Lower extremity	6	33	10–61	1–149	
Foot	20	54	11–97	4–186	
Other	5	18	12–24	10–70	
<i>PU at admission</i>					
No	32	27	8–70	1–186	0.707
Yes	23	42	8–82	2–149	
<i>Grade of first HAPU</i>					
1	17	19	8–49	1–138	0.187
2	32	31	7–77	2–186	
3	6	62	42–83	10–149	

Abbreviations: AIS, American Spinal Injury Association Impairment Scale; IQR, interquartile range; HAPU, hospital-acquired pressure ulcer; Min-max, minimum-maximum; Orthop./urol., orthopaedic/urologic; PU, pressure ulcer.

^aMann-Whitney and Kruskal-Wallis test.

Supplementary Table 2). The median time until closure for grade 1, 2 and 3 HAPUs was 25, 34 and 39 days, respectively. The longest time until closure was found in patients admitted for first rehabilitation (median: 64 days, interquartile range 30–72 days).

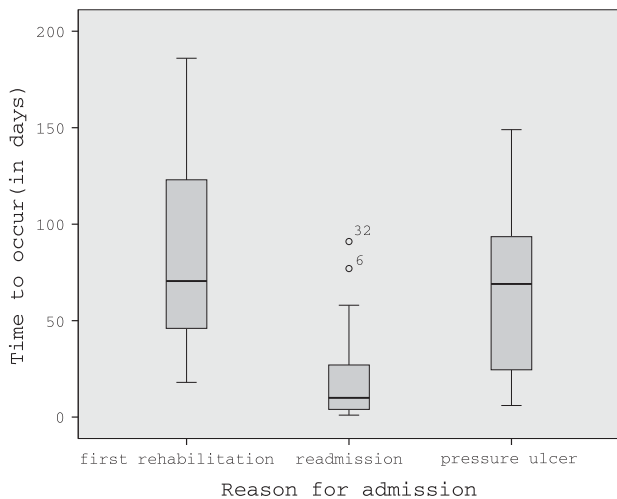


Figure 1 Time until occurrence of HAPU per admission reason. A full color version of this figure is available at the *Spinal Cord* journal online.

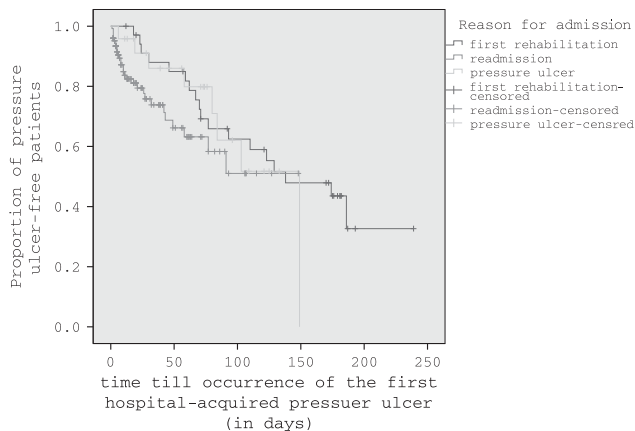


Figure 2 Survival curve for time until occurrence of HAPU by reason for admission ($N=185$). A full color version of this figure is available at the *Spinal Cord* journal online.

None of the tested characteristics were associated with being discharged with or without closure of the HAPU (Table 5). Reasons for incomplete closure as retrieved from medical files varied from a slow healing progress due to co-morbidities (including diabetes, psychiatric disorders and malignant diseases with poor prognosis) or death. There was a wide range of time until discharge of patients discharged with nonclosed wounds (Figure 4).

DISCUSSION

Based on high-quality observational data, we observed that nearly 30% of all SCI patients developed a HAPU during hospitalisation, in which 50% occurred during the first 30 days of admission. There was a wide range of time until occurrence of a HAPU, with different Kaplan–Meier curves for groups of time since lesion and reason for admission.

This high occurrence rate suggest that not all PUs can be avoided, as it has been concluded by the NPUAP (National Pressure Ulcer Advisory Panel) in 2014.²¹ Several studies have tried to give an overview about the circumstances when HAPUs occur^{1,3} by doing retrospective analysis over periods of 3 months or divide occurrences in different rehabilitation phases. By knowing and confirming the

Table 4 Cox regression for time until occurrence of HAPU ($N=185$, 55 events)

Characteristic	Odds ratio	95% CI	Wald	P-value
Time since lesion (years)	1.04	1.01–1.06	8.07	0.005
<i>Reason for admission</i>				
First rehab (reference)	—			
Readmission for PU	2.03	0.91–4.54	2.97	0.085
Readmission for other reasons	2.29	0.78–6.72	2.27	0.132

Abbreviations: CI, confidence interval; HAPU, hospital-acquired pressure ulcer; PU, pressure ulcer; rehab, rehabilitation.
 $R^2=0.07$, likelihood ratio test: test statistic = 13.91, $P=0.03$.

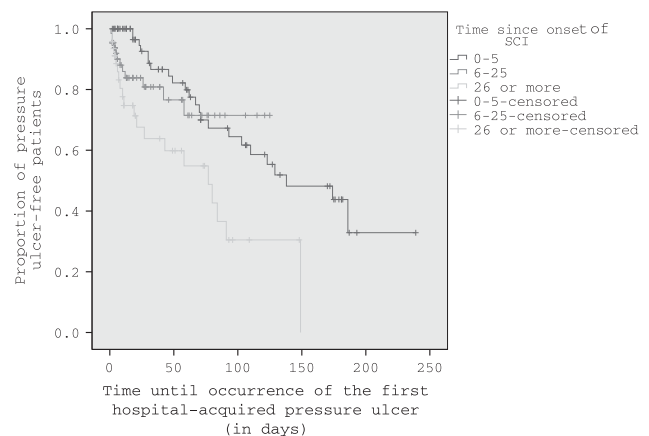


Figure 3 Survival curve for time until occurrence of HAPU by time since lesion. A full color version of this figure is available at the *Spinal Cord* journal online.

influence of length of stay,^{4,5} our daily-based observations put perspective about the influence of time on the development of HAPU.

Time until occurrence

Of all PUs, 50% occurred during the first 30 days after admission. Early development of PU after hospitalisation is well known in non-SCI cohort studies,^{9,10} reporting similar or even less time until occurrence. In our SCI population, earlier PU development was mainly seen in patients readmitted for surgery, re-rehabilitation or acute care, leading to a significant association of admission reason with time until occurrence ($P<0.001$, Table 3).

Surgery (>4 h) is a risk factor for HAPU in SCI^{12,13} and an indicator of the presence of secondary health conditions.^{12,22} Focussing on highest occurrence per patient-years, our orthopaedic SCI patients had more HAPUs in the immediate postoperative period than non-SCI patients (25% versus 5%)¹⁴ and a similar rates after 5 days of surgery (66.7% versus 58%).¹⁴ Even though surgery is of influence, not all patterns can be explained; for example, low incidences in patients admitted for deep PUs that were almost all surgically closed. Regarding our small sample size of surgical patients, further research on HAPU after surgery in SCI is recommended.

The influence of prevention and therapeutic concepts may also explain the different time dynamics found for HAPU in first rehabilitants and patients admitted for PU treatment. Immobilisation post surgery/lesion and slow mobilisation in cumulative steps afterwards, in combination with more self-responsibility before discharge and in later phases of rehabilitation, may lead to different patterns of

Table 5 Determinants of discharge without closure of the first HAPU (N = 55)

	N	Discharge without closure (%)	Test statistic ^a	P-value
All patients with HAPU	55	32.7		
Gender				
Female	13	38.5		0.426
Male	42	31.0		
Age at admission (years)				
18–35	9	55.6	6.34	0.096
36–50	19	21.0		
51–65	18	44.4		
66 or above	9	11.1		
Time since injury (years)				
0	16	31.3	0.12	0.989
1–5	7	28.6		
6–25	12	33.3		
26 or more	20	35.0		
Aetiology				
Traumatic	39	31.3		0.572
Nontraumatic	16	33.3		
Lesion level				
Paraplegia	29	27.6		0.284
Tetraplegia	26	38.5		
AIS injury severity				
A	41	21.4		0.241
B–D	14	36.6		
Reason for admission				
First rehabilitation	18	33.3	3.66	0.454
Readmission for PU	8	25.0		
Re-rehabilitation	8	12.5		
Orthop./urol. surgery	14	35.7		
Other readmissions	7	57.1		
Localisation				
Sitting area	24	29.9	0.988	0.804
Lower extremity	6	33.3		
Foot	20	40.0		
Other	5	20.0		
PU at admission				
No	32	28.1		0.285
Yes	23	39.1		
Grade of first HAPU^b				
1	17	29.4	3.52	0.171
2	32	28.1		
3	6	66.7		

Abbreviations: AIS, American Spinal Injury Association Impairment Scale; HAPU, hospital-acquired pressure ulcer; Orthop./urol., orthopaedic/urologic; PU, pressure ulcer.
^aThe χ^2 or Fisher's exact test.

HAPU development. Detailed analyses of risk factors and treatment concepts for comparison are still missing.²³

In our sample, higher proportions of HAPUs were observed within the first year after lesion and 26 years post lesion. Our survival curves also stress a higher risk during hospitalisation for patients with longer time since lesion. The significant, positive association with time

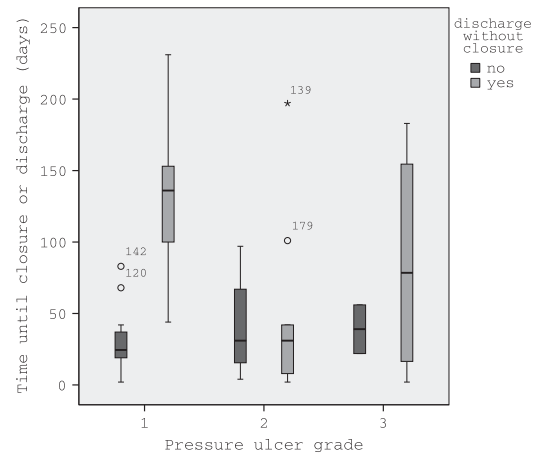


Figure 4 Time from occurrence until closure or discharge. A full colour version of this figure is available at the *Spinal Cord* journal online.

since injury ($P=0.005$) is corresponding with results found in literature.^{11,15,22}

Time until closure

The therapeutic goal and principles of treatment usually lead to healing of a PU ulcer during hospitalisation. The rehabilitation team and patients decided for conservative treatment of all HAPUs, even though plastic surgery was easily accessible. Reasons to omit surgical treatment varied from a bad health condition to the patient's wish not to be operated or to go home with a nonhealed wound grade 2 or 3. Comparing time until closure in our study with the literature,^{16,23,24} our median time was lower (69²⁴ and 49²³) in comparison with 31 days in our study). However, these comparisons are hampered by several reasons such as different patient characteristics, physiological changes in SCI patient,¹⁷ changes in treatment protocols over time and pre-existing wounds. The closure time was 2–97 days, underlining the difficulties to predict it based on severity grade. Using size measurement,¹⁶ wound closure can be analysed more carefully.

Discussing our results, we have to consider that 32.7% of our patients were discharged without complete closure of their HAPU. Some patients can be discharged when the original rehabilitation goals like a planned surgery or treatment of an infection or pain are accomplished and closure before discharge is not always needed. Because of economic pressure, the problem of unclosed pressure ulcers at discharge is increasingly reported.^{8,25} In our population as an example of the Swiss health-care system, the proportion of patients with open HAPU (32.7%) was lower at the time of discharge than in other populations (50%, 54.1%).^{8,25} Economic and politic factors, ethical considerations, vision of the institution and caregivers in the Swiss health-care system influence this rate, allowing patients an ongoing in-house treatment until closure.^{7,22} Although occurrence of PU is often discussed as an indicator of worse outcome and discharge destination,^{4,7} closure of HAPU did not change the discharge destination in our population.

Clinical relevance

Knowledge about different time dynamics in occurrence of HAPU might lead to a reduction of HAPU in in-patient rehabilitation. Increased awareness and active prevention of HAPU are needed in the early phase of admission as we observed high occurrences especially in the first weeks of hospitalisation in readmitted patients. With the

permanent risk in patients admitted for PU and first rehabilitation, repeated risk assessments or adapting awareness should be considered to evaluate changing risk factors during hospitalisation.

Strength and weakness

The advantage of this study is that it is based on careful clinical observations. However, the size of the patient group led to relatively small subgroups and results have to be interpreted with care. Secondly, as only basic patient characteristics without comorbidities were documented, important risk factors for occurrence and prolonged healing such as diabetes or peripheral arterial occlusive disease could not be analysed retrospectively.^{12,14} We recommend to analyse the presence of these contributing factors at the time of occurrence in future prospective studies. Thirdly, the results on time until closure only partially represent the reality because of missing observations of closure after discharge. High rates of skin worsening (51%) after discharge are known,²⁵ and hence we recommend an ongoing observation after discharge.

CONCLUSION

The dynamics in time until occurrence of HAPU varied according to admission reason and time since lesion. A constant awareness of the patient and caregivers is needed in all patient groups to prevent HAPU. The time until closure is difficult to predict because of wide time ranges and unclosed wounds at discharge. Further research including daily size measurement and risk factors might optimise prognosis, comparability and therefore judgement of quality of care.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Supplementary Information accompanies this paper on the Spinal Cord website (<http://www.nature.com/sc>)