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ORIGINAL ARTICLE

Pressure ulcers in trauma patients with suspected spine injury: a prospective cohort study with emphasis on device-related pressure ulcers

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Key words
Device-related pressure ulcers; Incidence; Suspected spinal injury; Trauma patients

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Abstract

Of all patients in a hospital environment, trauma patients may be particularly at risk for developing (device-related) pressure ulcers (PUs), because of their traumatic injuries, immobility, and exposure to immobilizing and medical devices. Studies on device-related PUs are scarce. With this study, the incidence and characteristics of PUs and the proportion of PUs that are related to devices in adult trauma patients with suspected spinal injury were described. From January–December 2013, 254 trauma patients were visited every 2 days for skin assessment. The overall incidence of PUs was 28·3% (n = 72/254 patients). The incidence of device-related PUs was 20·1% (n = 51), and 13% (n = 33) developed solely device-related PUs. We observed 145 PUs in total of which 60·7% were related to devices (88/145). Device-related PUs were detected 16 different locations on the front and back of the body. These results show that the incidence of PUs and the proportion of device-related PUs is very high in trauma patients.

Introduction

Although knowledge and awareness of pressure ulcer (PU) development has improved over the last few decades, PUs are still a threat to hospitalised patients. In 2013, the prevalence of PUs in all types of health care institutions in the Netherlands was the highest in general hospitals (8·7%) (1), indicating that hospitals are a high-risk environment. PUs cause pain and affect physical, social, psychological and financial aspects of health-related quality of life (1–3).

In the new international guidelines, a PU is defined as 'localized injury to the skin and/or underlying tissue, usually over a bony prominence, resulting from sustained pressure (including pressure associated with shear). A number of contributing or confounding factors are also associated with PUs, of which impaired mobility is a major factor' (4,5).

This definition emphasises the major role of immobility in PU development. Immobility exposes people to pressure and shear forces on one body location for prolonged periods of time. Therefore, of all patients in a hospital environment, trauma

Key Messages

- the incidence of pressure ulcers (PUs) and the proportion of device-related PUs is very high in trauma patients
- we conducted a prospective cohort study on PU incidence and characteristics and the proportion of PUs that are related to devices in trauma patients with suspected spinal injury
- incidence of PUs was 28·3%; in total, 145 PUs were found in 72 patients
- the proportion of PUs related to devices accounted for 60·7% and ranged from category 1–3; the proportion of PUs that were not related to devices accounted for 39·3% and ranged from category 1–4

- non-device-related PUs were detected at 6 different regions, solely at the back of the body; device-related PUs were detected at 16 different regions on the back and front of the body

patients with suspected spinal injuries may have a particular risk for developing PUs. They are intentionally immobile from the scene of accident onward to prevent inadvertent injury to the spinal cord. Immobilisation is achieved with a backboard, extrication collar and headblocks (6). Immobilization ends after spinal injury is ruled out but continues in case of a diagnosed injury. Besides spinal injury, further injuries can lead to extended periods of immobilisation.

Next to immobility, trauma patients are likely to be exposed to other risk factors for PU development. Their injuries may lead to decreased sensation; direct tissue damage; decreased dermal perfusion because of hypovolemic shock; altered nutrition; and surgical interventions. All of these conditions are known to increase PU risk (4,5,7).

The fact that trauma patients are frequently exposed to immobilising and medical devices may also play a role in their increased PU risk. Immobilising devices are used as prevention (extrication collar) or treatment (casts, external fixation), and medical devices are used to monitor or manage the patients condition (endotracheal tubes, oxygen masks, nasogastric tubes, urinary tubes or restraints). It is known that adult patients with medical devices should be considered at risk for PU development (4,8).

PU incidence in trauma patients has been reported as 30·6%, but the studied sample was small ($n = 36$), and the results are dated (9). In a systematic review, the application of immobilising devices (cervical collars, backboards, vacuum mattresses) has shown to increase PU risk in several studies, but most studies included healthy volunteers (10). There are only two prospective studies that focused solely on PU incidence from cervical collars in trauma patients. Powers *et al.* reported an incidence of 6·8% in 484 trauma patients from semi-rigid collars (11), and Molano *et al.* found an incidence of 23·9% in 94 trauma patients from extrication collars (12). Furthermore, severe injuries, length of admission and limitation in mobility are described as possible risk factors for PU development in trauma patients (11,12).

In summary, trauma patients may be a vulnerable patient group for PU development. Furthermore, it is unclear which proportion of the PUs in trauma patients is related to devices. In this study, we describe the incidence and characteristics of PUs, and the proportion of PUs that are related to devices, in adult trauma patients with suspected spinal injuries admitted to the hospital for the treatment of acute traumatic injuries.

Methods

Design and setting

Between January and December 2013, a prospective observational cohort study was conducted in a trauma centre in the Netherlands. This is a level one trauma centre, providing the highest level of trauma care.

Participants

All consecutive trauma patients transported to the emergency department on a backboard, with extrication collar and headblocks, were eligible for participation. Inclusion criteria were (i) trauma patients aged ≥ 18 years; (ii) standard pre-hospital spinal immobilisation (i.e. backboard, headblocks and extrication collar); and (iii) admitted to the hospital through the emergency department for treatment of acute traumatic injuries. Exclusion criteria were (i) existing skin breakdown before admission; (ii) severe burn wounds (10% body region); and (iii) transferred from the emergency department to another hospital.

Standard procedures for a suspected spinal cord injury

The backboard should be used as an extrication and transportation device only and was therefore directly removed after arrival in the crash room in the emergency department, before the initial assessment (13). Trauma patients remained immobilised, with an extrication collar and headblocks, in the supine position until injury of the cervical spine was excluded or diagnosed. Cervical spine injuries were excluded by radiology [computed tomography (CT) scans] in combination with clinical examinations. If radiology excluded the injury, but a clinical examination was impossible (in case of intoxicated, unconscious or sedated patients), cervical spine injury could not be excluded. In these patients, the clinical examination was postponed, and the extrication collar and headblocks were replaced by a semi-rigid collar (Philadelphia®, Philadelphia Cervical Collar Co, Thorofare, NJ). If patients were deeply sedated and admitted to the intensive care unit (ICU), the cervical spine was immobilised with straps on the forehead and lateral support, which was replaced with a Philadelphia® collar once patients regained consciousness. In case of diagnosed cervical injury, patients were further immobilised with a halo brace or Philadelphia® collar or underwent surgery, as indicated.

Preventive interventions during admission

All hospitalised patients were on a standard pressure distributing mattress. If nurses identified PU risk or discovered PUs, patients were placed on the appropriate dynamic air mattresses (Promatt®, Joerns, Houten, The Netherlands or Plexus Auto Sure Float®, Scan Mobility LTD, Lancashire, UK). During an ICU stay, all patients were on a Totall Care SpO2RT® ICU bed (Hill-Rom, Chicaco, IL, USA) along with pressure distributing functions, these mattresses were equipped with mechanisms to achieve various body positions.

If patients were bed-bound, they were repositioned in bed for at least every 2–4 hours. Repositioning in bed was not possible in case of haemodynamic instability, instable fractures or increased pain because of the movement of limbs. Institutional guidelines prescribed the screening of all patients for malnutrition (Malnutrition Universal Screening Tool) (14). In case of risk of malnutrition, appropriate dietary interventions were taken.

Consent and data collection

After a primary survey in the emergency department, eligible trauma patients or their legal representatives were informed

with written and verbal information. Informed consent was requested within 48 hours after admission (delayed consent). After inclusion, patients were followed up until discharge from the hospital or death. The 'transparent disc method' was used to distinguish between blanchable and non-blanchable redness (i.e., Category 1 PUs). This method consists of pressing a transparent disc on the red skin. If the skin under the transparent disk does not blanch, it is considered to be a Category 1 PU (15). If a PU was detected, the course of development was monitored. A nurse scientist, specialised and trained in PU care, collected data on a structured data collection form. Data collection started within 24 hours after emergency department admission. If patients were admitted on Wednesday or Saturday, data collection started within 48 hours. Thereafter, patients were visited every 2 days. All patient visits were planned during daily care routines. In case of uncertainty concerning categorisation of the PUs, the nurse scientist consulted an expert. To reach consensus in categorising the injury, photographs and clinical descriptions were used and discussed during the consult. If patients were lost to follow-up after inclusion, they were excluded from analysis. The Medical Ethics Review Committee of participating institute stated that the Dutch Medical Research Involving Human Subjects Acts (Wet Medisch-Wetenschappelijk Onderzoek) does not apply to this study and official approval by the Institutional Review Board is not required (protocol number 12/161).

Outcomes

The main study outcomes were the incidence and characteristics of PUs. In order to differentiate between PUs related to devices and PUs not related to devices, PUs that were *not* related to devices were defined as 'pressure ulcers' and PUs that *were* related to devices were defined as 'device-related pressure ulcers'. PUs were defined as 'device-related' if the nurse scientist identified a visible relation to devices. PU incidence comprised the number of patients that developed PU(s) during the study period. Characteristics comprised the severity, location (anatomical site), time to development and (where applicable) relation to (medical or immobilising) device. If patients developed PUs, follow-up was continued, and the highest PU category was used to describe the severity (according to the International Pressure Ulcer Classification System) (7). Types of immobilising devices included cervical collars, casts, splints, external fixation or HALO frames. Types of medical devices were endotracheal tubes, oxygen masks, nasogastric tubes, urinary tubes, thromboembolic stockings, linen savers (cotton-woven blankets used as repositioning aids or mattress protectors) or restraints.

Baseline characteristics

Baseline characteristics were collected from medical records (mechanism of injury, gender, age, body mass index, injury severity score, length of stay in the emergency department and hospital and type of ward) and observations (skin pigmentation). Injury Severity Score (ISS) between 0 and 9 were considered mild injuries, between 10 and 15 were moderate, 16–24 severe and >24 very severe injuries (16). Skin pigmentation was determined using the Fitzpatrick scale for skin type (17). At admission, PU risk was calculated with the Braden Scale. The total Braden Scale scores were used as an indicator for PU risk (range 6–23), and scores >18 indicated no risk (18).

Sample size

Because this is the first prospective study on PU development in trauma patients with suspected spinal cord injury, we were unable to calculate the sample size. Estimation of the sample size was challenging. Historical trauma data revealed that 1200 trauma patients are treated each year in the study setting, but the proportion of patients with suspected spinal injuries in this group was unclear. Therefore, we chose a pragmatic approach and planned a period of recruitment of 12 months.

Statistical methods

PU incidence was defined as a proportion: the number of patients who developed at least one (device-related) category 1–4 PU within the total sample. We constructed 95% confidence intervals (CIs) around proportions (Clopper-Pearson exact method).

The PU severity, location and relationship with devices were described and presented as frequencies and percentages. Time to PU development was defined as the number of days between emergency department admission and the first observation of a PU. Missing data (1·5%) were not replaced or imputed. Baseline characteristics were described as means, standard deviations (SDs) and ranges for continuous variables and frequencies and percentages for categorical or dichotomous variables. When data were not normally distributed, the median and the interquartile range (first Q1, third quartile Q3) were described. We used SPSS 20.0 to describe our outcomes and variables (Version 20.0, IBM Corp., Armonk, NY).

Results

During the study in 2013, 623 trauma patients were admitted to the emergency department with suspected spinal injuries. Of these, 244 were discharged from the emergency department, 10 died in the emergency department and 22 patients were discharged before consent. The eligibility of 347 was assessed. Based on the exclusion criteria, 21 were excluded, and 36 refused participation. Finally, 290 patients were recruited for the study, and 36 patients were lost to follow-up. Ultimately, 254 trauma patients were included for analysis (Figure 1).

Baseline characteristics

The median (Q, Q3) age was 52 (32, 65) years. and 161 (63·4%) were male. Mechanisms of injury were mainly falls ($n = 106$, 41·7%), followed by cycle crashes ($n = 52$, 20·5%) and car crashes ($n = 40$, 15·7%). In our sample, 140 patients suffered from mild to moderate injuries (35% ISS 0–9 and 20·1% ISS 10–15). 114 patients were severely to very severely injured (25·2% ISS 16–24 and 19·7% ISS >24). Median time (Q1, Q3) in the emergency department was 213 (152, 278) minutes, and patients were hospitalised for a median (Q1, Q3) of 5·0 (5, 21) days. Forty-four patients were admitted to the ICU for a median

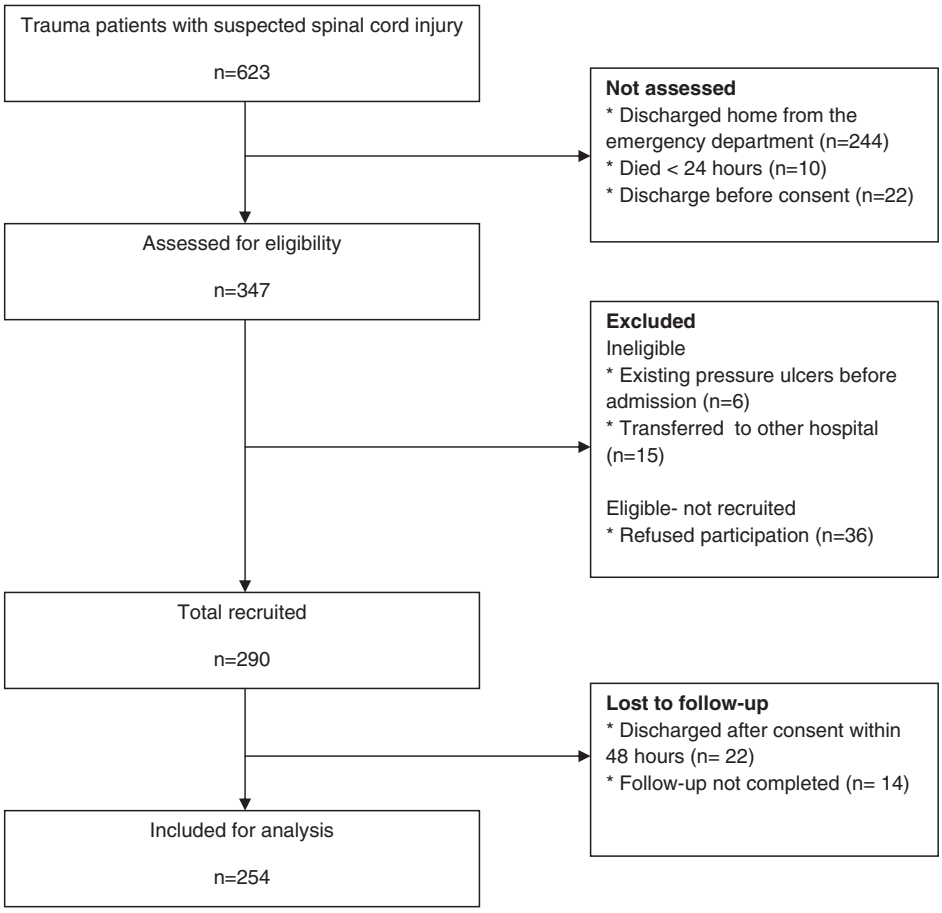

Figure 1 Flowchart inclusion.

(Q1, Q3) of 4·5 (2, 9) days and 98 to the medium care unit for a median (Q1, Q3) of 2·0 (1, 4) days. The majority of the patients had a pale to light brown skin pigmentation ($n = 233$, 91·6%). The mean (SD) Braden Scale score during admission was 15·9 (4·6) (Table 1).

Pressure ulcers

Incidence and characteristics

The overall incidence of PUs was 28·3% ($n = 72$, 95% CI 22·8–34·3%). The majority of the PUs were observed within the first week of admission ($n = 63$, 87·5%). The incidence of patients with solely device-related PUs was 13% ($n = 33$, 95% CI 9·1–17·8%); these developed within a median (Q1,Q3) of 2 days (1,3) (Table 2). In total, 72 patients developed 145 PUs. Of these, 39·3% (57/145, 95% CI, 31·3–47·8%) were not related to devices; 16 (28.1%) were category 1, 17 (29.8%) category 2, 12 (21.1%) category 3 and 12 (21.1%) category 4. Two Category 4 PUs were located on the occiput and developed in and around an existing wound area. 60.7% of the PU (88/145, 95% CI 52.2–68.7%) were related to devices. There were no Category 4 PUs related to devices; 28 (31.8%) were category 1, 47 (53.4%) were category 2 and 13 (14.8%) were category 3. The majority (55·7%) of device-related PUs were related to *immobilising* devices (49/88, 95% CI 44·7–66·3%), primarily the cervical collar (48/88). Of the device-related PUs, 44·3% (39/88, CI 33·7–55·3%) were related to *medical* devices, which were mainly restraints (19/88) and linen savers (6/88) (Table 3).

Locations

The PUs that were not related to devices were detected at six different locations and located on the back of the body, mainly on the buttocks (42·1%) and heels (33·4%). The device-related PUs were detected in 16 different regions on the front and back of the body. These PUs were mainly located on the chin (18·2%), back (14·8%), elbows (14·8%) and occiput (10·2%) (Figure 2).

Discussion

Discussion of results

It is clear that trauma patients have a high risk of developing PUs. The overall PU incidence in our study sample is very high, 28·3%. This is in line with findings from 1998, describing a PU incidence of 30·6% (9). PU incidence rates in acute care settings from January 2000 to 2013 varied between 2·8% and 9% (Category 1–4) (4). These are notably lower incidences compared to our outcomes and indicate that within the acute care setting, trauma patients are more vulnerable to PU development.

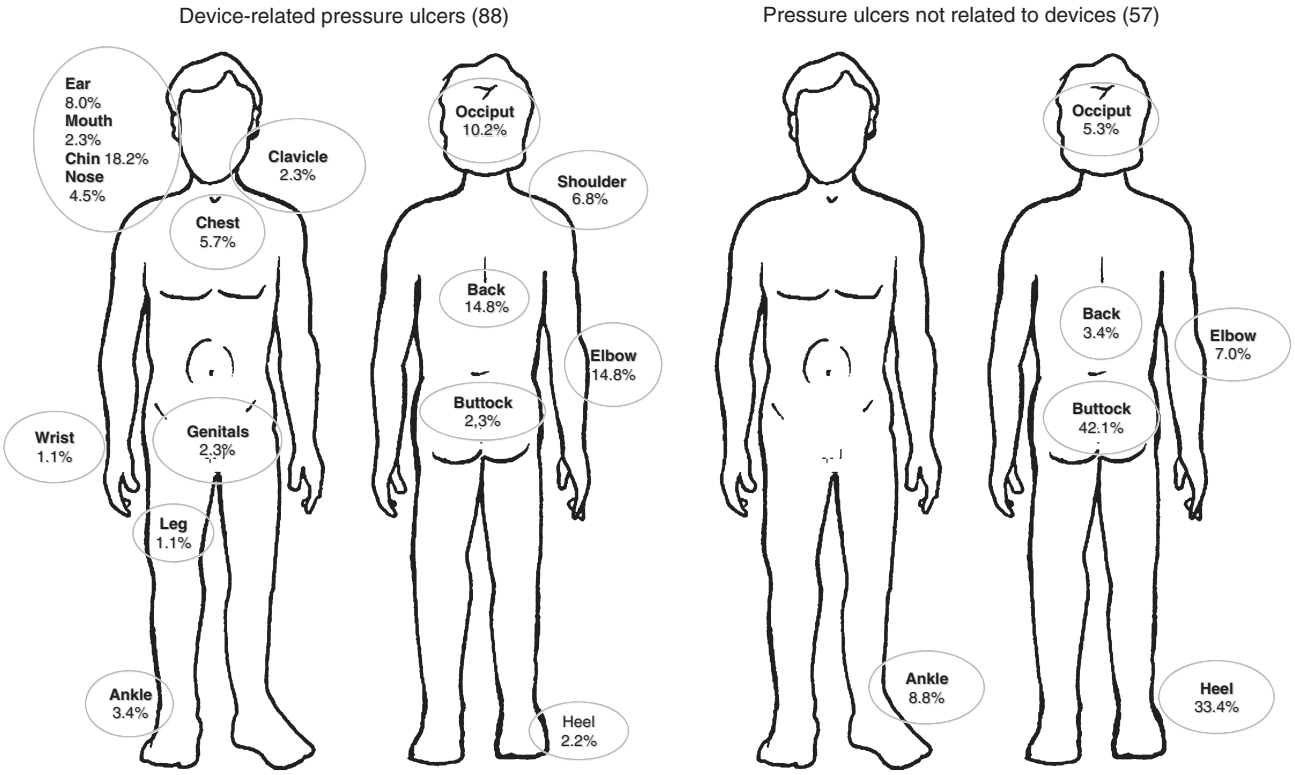

Figure 2 Pressure ulcer locations.

Undeniably, the application of devices generated high risk for PU development in our sample of trauma patients. Of the found Pus, 60·7% are related to devices. Furthermore, in 13% of our trauma patients, the PUs were solely related to devices. The exact figures are difficult to compare as studies on device-related PUs in trauma patients are scarce. In a prevalence study with 2079 hospitalised patients in intensive care, medical, surgical and step-down units, Black *et al.* found a device-related PU prevalence of 1·3% and a device-related PU proportion of 34·5% (8). Considering these findings, our results may indicate that trauma patients who were immobilised because of suspected spinal cord injuries prior to hospitalisation are more vulnerable to device-related PU development.

The international PU guideline describes device-related PUs as a 'pressure ulcer that results from the use of devices designed and applied for diagnostic or therapeutic purposes. The resultant PU generally closely conforms to the pattern or shape of the device'(4). We found that device-related PUs were mainly located on the back and front of the body. This was contrary to non-device-related PUs, which were solely located on the back of the body. The majority of the device-related PUs in our study corresponded to the pattern or shape of the device. However, we found PUs on the elbows, not following the pattern of shape of a device. These PUs were likely indirectly related to medical devices, wrist restraints. Most of these (indirectly) device-related PUs were Category 2 or 3. The wrist restraints prevented movement in agitated and confused patients. Although movement of the wrists was restricted, the urge to move remained in most of these patients. The urge to move while in wrist restraints exposed elbows to pressure and shearing forces, which led to 'derived' device-related PUs.

Contrary to our results, two studies on device-related PUs in hospitalised patients found Category 4 PUs (8,19). We did not find any Category 4 device-related PU; in fact, the majority of the device-related PUs were superficial, Category 1 or 2. The fact that most device-related PUs were not a Category 3 or 4 PU may be explained by the adherence to preventive protocols. First, in our study, sedated ICU patients with suspected cervical spine injuries were not immobilised with a Philadelphia® collar but with straps and lateral head supports. These high-risk patients were, therefore, not exposed to pressure from the collar while sedated. The Philadelphia® collar was applied only after the sedation had stopped. This procedure literally minimised the time in the collar and, thus, the risk of PU development. Second, standard PU prevention protocols were applied. These protocols prescribed daily skin care and application of cotton stockings underneath the Philadelphia® collar for moisture absorption in order to optimise skin condition. If redness or PUs occurred, the standard procedure was to adjust the collar where possible to relieve pressure. These nursing protocols decreased the risk of PU development.

Despite these preventive measures, we did find superficial device-related PU, which implies that the PU risk was not completely overcome. One explanation may be the fact that microclimate plays an important role in the development of superficial PUs. In (skin-covering) devices like collars, restraints and linen savers, the skin underneath may become moist and warm, which influences the microclimate (4,8).

Table 1 Baseline characteristics

	Value
Patient characteristics	Median (Q1, Q3)/frequency (%)
Age	52 (32, 65)
BMI*	26·6 (22·4, 27·5)
Male	161 (63·4%)
Mechanism of injury	
Fall	106 (41·7%)
Cycle crash	52 (20·5%)
Car crash	40 (15·7 %)
Scooter	18 (7·1%)
Pedestrian struck	12 (4·7%)
Motorcycle crash	11 (4·3%)
Crush	10 (3·9%)
Assault	2 (0·8%)
Unknown	2 (0·8%)
Strangulation	1 (0·4%)
ISS score	
Mild (0–9)	89 (35%)
Moderate (10–15)	51 (20·1%)
Severe (16–24)	64 (25·2%)
Very severe (>24)	50 (19·7%)
Skin type†‡	
Type 1–3 (Pale to light brown skin)	233 (91·6%)
Type 4–6 (Medium to very dark brown skin)	13 (5·1%)
Admission information	
Total LOS (days)	5·0 (5, 21)
LOS ED (minutes)	213 (152, 278)
LOS ICU (days) ($n=44$)	4·5 (2, 9)
LOS MCU (days) ($n=98$)	2·0 (1, 4)
LOS Ward (days) ($n=245$)	4·0 (2, 9)
Braden scale	Mean (SD)
Total scores	15·9 (4·6)

BMI, body mass index; ED, Emergency Department; ICU, intensive care unit; ISS, Injury Severity Score, LOS, length of stay; MCU, medium care unit; Q1, first quartile; Q3, third quartile; SD, standard deviation.
*$n=18$ missing.
†$n=8$ missing.
‡Following the Fitzpatrick scale Type 1: Very white skin, Type 2: White skin, Type 3: Cream white skin; Type 4: Brown skin; Type 5: Dark brown skin; Type 6: Black skin.

Table 2 Pressure ulcer characteristics

Pressure ulcers	Values	95% Confidence interval†
Incidence*(%)		
Overall pressure ulcers	28·3% (72/254)	22·8–34·3%
Device-related pressure ulcers	20·1% (51/254)	15·3–25·5%
Device-related Pressure ulcers only	13% (33/254)	9·1–17·8%
First observation of pressure ulcers		
Days (mean)	3 (1, 5)	
Within first week	63 (87·5%)	
Within second week	8 (11·1%)	
Third week or further	1 (1·4%)	
First observation of device-related pressure ulcers		
Days (median, Q1,Q3)	2 (1, 3)	
Within first week	32 (97%)	
Within second week	1 (3%)	
Third week or further	0	

Q1, first quartile; Q3, third quartile.
*Incidence: % patients.
†Clopper-Pearson exact method.

This enhances superficial PU development. Another explanation is the fact that devices may produce more shear forces, likely combined with friction, than pressure forces, leading to superficial PUs. This highlights the ongoing debate on whether high shear forces may primarily cause superficial ulcers while high-pressure forces may cause deeper ulcers (4). Frequent repositioning should be applied to inactive or immobile patients at risk in order to relieve pressure (20–22). This may be difficult to apply in trauma patients because of spinal injuries, bone fractures or haemodynamic instability (23) and may be complicated for several reasons. First, it may be prohibited because of specific injuries or treatment. Pain or fear to move as a result of the injuries may hinder repositioning. Second, in case of a (possible) spinal injury, straight alignment of the spine should be maintained. In these circumstances, patients are turned as a single unit while maintaining the straight alignment of the spine by a minimum of four trained caretakers, the logroll procedure (6). After logrolling, the patient is immediately placed back into the supine position; as a result, pressure relief will be achieved for a short period of time only. Moreover, the risk of causing neurological damage to the spine while logrolling might deter caretakers from performing the logroll procedure on a frequent basis.

Most of the PUs in our study developed during the first days of admission. A logical explanation for the early PU development may be the severity of illness during the first days of admission, which is typical for trauma patients who are admitted as a result of traumatic injury. The severity of illness interacts with surgical interventions, malnutrition, ICU admission and immobility, which are all known risk factors for PU development (4,5). Another explanation for early PU development is the impact of pre-hospital immobilisation with a backboard. As skin observation started after hospital admission and not in the emergency department, the exact relationship between immobilisation and early PU development remains unclear. However, the fact that PUs were already seen on day 1 after admission may imply a causal relationship. Moreover, backboards are known to produce high interface pressures (10,24,25), which may be sufficient for causing tissue damage in severely injured patients because of a decreased tissue tolerance (4,5). A final explanation for early PU development is the emergency department stay, which may increase PU risk. After arrival in the emergency department, patients were left in extrication collars and headblocks in the supine position until the (cervical) spine was cleared. Patients were in the emergency department for a median of 213 minutes, on a stretcher (Stryker®, Amsterdam, The Netherlands) with small and thin mattresses. These trolleys are designed for easy transportation and radiation transmission and not to prevent PU development.

Table 3 Proportion of device-related pressure ulcers

Values		95% Confidence interval*
Total number of pressure ulcers	145	
Proportion pressure ulcers	57/145 (39·3%)	31·3–47·8%
Proportion device-related pressure ulcers		
Immobilizing devices	88/145 (60·7%)	52·2–68·7%
Medical Devices	49/88 (55·7%)	44·7–66·3%
	39/88 (44·3%)	33·7–55·3%

	Pressure ulcer categories				
	Total	1	2	3	4
Immobilizing devices (49)					
Cervical collar	48	20	27	1	–
HALO-vest	1	–	1	–	–
Medical devices (39)					
Urinary tubes	3	–	2	1	–
Endotracheal tubes	2	1	1	–	–
Nasogastric tubes	3	–	1	2	–
Cooling mattress	2	2	–	–	–
Restrains (wrist/ankles)	19	1	11	7	–
Oxygen tube	1	1	–	–	–
Linen saver	6	1	3	2	–
Endotracheal tube fixation	3	3	–	–	–

*Clopper-Pearson exact method.

Strengths and limitations

This is the first observational study on PU development in trauma patients with a focus on PUs related to medical or immobilising devices. PUs were observed by skin assessments during admission and not from documentation in patient records. This enhances the reliability of data collection and prevents the under-estimation of the problem because of incomplete registration. Furthermore, a single data collector performed data collection. This strengthened the reliability of data collection because no inter-rater reliability issues arose. Furthermore, expert consultation was used to reach consensus in PU classification.

Eligible patients were admitted to the emergency department 24/7. In order to avoid incomplete sampling, delayed informed consent was authorised and applied. We strived to obtain a homogeneous sample by restricting the population and including solely trauma patients who were immobilised prior to hospitalisation. To achieve realistic incidence figures, care-as-usual (risk assessment, prevention and PU care) was maintained during the study period. If patients developed a PU of Category 2 or more, nurses were notified to pay extra attention to PU care.

A possible limitation, however, may be the frequency of data collection. To assure both feasibility and continuity, data was collected within 24 hours and every 2 days thereafter by one data collector. Although Category 1 PUs could have been missed because of this frequency, observing once every 48 hours ensured we did not miss the more severe PUs where the skin is broken (Category 2 and above) as these would still have been visible as a scab when healing. Furthermore, our data showed that the majority of PUs developed during the first days of hospital admission. As we visited all patients within the first 48 hours of their hospital stay, and most patients were seen at least twice, the probability of detecting the PU was high.

Results of our study may further be influenced by the Hawthorn effect. Nurses were present during data collection as this took place during daily care routines. Therefore, they were informed about the study purposes and were aware of skin inspections. This may have increased awareness of PU risk assessment and prevention.

This was a single-centre study; a multi-centre study would have increased generalisability.

Conclusion

In conclusion, the incidence of PUs and device-related PUs in trauma patients who were immobilised because of suspected spinal injuries prior to hospital admission is high. Device-related PUs accounted for the majority of the PUs found and were located at various locations on the back and front of the body. PU risk appeared to be substantial in trauma patients. In order to prevent PU development in these high-risk patients, future research should focus on predictive risk factors for PU development and the application of effective and feasible preventive interventions.

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Author contribution

WH, LS, MS and LL contributed substantially to the design, analysis and interpretation of data of the work. WH wrote the manuscript and LS, LL and MS reviewed it critically for important intellectual content and gave final approval of the version to be published. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

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