**Title:**

PRESSURE ULCER DEVELOPMENT IN TRAUMA PATIENTS WITH SUSPECTED SPINAL INJURY; THE INFLUENCE OF RISK FACTORS PRESENT IN THE EMERGENCY DEPARTMENT

**First author:**

H. W. (Wietske) Ham, MSc, RN, CEN

Senior Emergency Nurse and PhD candidate at University Medical Center, Utrecht, the Netherlands

Correspondence office

Room E 00.157

P.O. Box 855000

3508 GA

Utrecht, The Netherlands

Fax: +31 88 7555407

Phone: +31 88 7566666

Email: H.W.Ham@umcutrecht.nl

Home address

Kornedijk 18

4197 RN

Buurmalsen

Co-authors

**Secondauthor**

L. (Lisette) Schoonhoven, PhD, RN

Professor of Nursing, University of Southampton, Faculty of Health Sciences, Southampton, United Kingdom;

**Third Author**

M. (Marieke) J. Schuurmans, PhD, RN

Professor of Nursing Science at University Medical Centre Utrecht

**Last Author**

L. (Luke) P. H. Leenen, PhD, MD, FACS

Professor of Trauma at University Medical Center Utrecht

**ABSTRACT**

**Objectives**

To explore the influence of risk factors present at Emergency Department admission on pressure ulcer development in trauma patients with suspected spinal injury, admitted to the hospital for evaluation and treatment of acute traumatic injuries.

**Design**

Prospective cohort

**Study Setting**

Level one trauma center in the Netherlands

**Participants**

Adult trauma patients transported to the emergency department on a backboard, with extrication collar and headblocks and admitted to the hospital for treatment or evaluation of their injuries.

**Methods**

Between January and December 2013, 254 trauma patients were included. The following dependent variables were collected: Age, Skin color and Body Mass Index, and Time in Emergency Department, Injury Severity Score, Mean Arterial Pressure, hemoglobin level, Glasgow Coma Score, and admission ward after emergency department.

**Results**

Pressure ulcer development during admission was associated with a higher age (p 0.00, OR 1.05) and a lower Glasgow Coma Scale score (p 0.00 , OR 1.21) and higher Injury Severity Scores ( p 0.03, OR 1.05). Extra nutrition decreases the probability of PU development during admission (p 0.047, OR 0.194). Pressure ulcer development within the first 48 hours of admission was positively associated with a higher age ( p 0.010, OR 1.030) and a lower Glasgow Coma Scale score (p 0.047, OR 1.142). The proportion of patients admitted to the ICU and MC was higher in patients with PU.

**Conclusions**

The pressure ulcer risk during admission is high in patients with an increased age, lower Glasgow Coma Scale and higher Injury Severity Score in the Emergency Department. Pressure ulcer risk should be assessed in the emergency department to apply preventive interventions in time.

**INTRODUCTION**

In the international pressure ulcer (PU) guideline, 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)’ (Haesler, 2014). It is clear that a PU results from pressure, but not all patients exposed to pressure develop PUs. The tissue response on mechanical load (pressure) varies for each individual and multiple risk factors appear to play a role in PU development (Haesler, 2014). Trauma patients may have a particular risk for developing PUs too. A specific high-risk group are trauma patients with suspected spinal injury. Untill recently, in the Netherlands, all of these patients were immobilized at the scene of accident, with a backboard, cervical collar and headblocks. Immobilization ends after evaluation in the Emergency Department (ED) and continues in case of diagnosed injury. Furthermore, their injuries can lead to prolonged periods of immobility and reduced perfusion and oxygenation. Above that, they are frequently exposed to immobilizing and medical devices. Following the most recent international guideline, adult patients with devices should be considered at risk for PU development (Haesler 2014). And third, all trauma patients are admitted to a emergency department, which increases PU risk (Denby and Rowlands 2010; Dugaret et al., 2014).

The evidence to substantiate the increased PU risk in trauma patients is sparse. There are only three (older) studies that describe PUs in trauma patients (Baldwin and Ziegler 1998; Watts et al., 1998; O'Sullivan et al.', 1997). One of these was retrospective, and described a PU incidence of 0.4% in 7492 trauma patients (O'Sullivan et al., 1997) and two were prospective. The latter studies described a PU incidence of 30.6% in a small sample of 36 severe trauma patients, (Baldwin and Ziegler, 1998) and a PU prevalence of 20.3% in 148 trauma patients (Watts et al., 1998). Length of admission (Baldwin and Ziegler, 1998) and limitation in mobility (Baldwin and Ziegler, 1998; Watts et al., 1998) were described as possible risk factors for PU development in trauma patients.

A recent systematic review which focused on device related PUs that may occur in trauma patients with suspected spincal (cord) injury reviewed 13 studies. Of these, nine studies included healthy volunteers and only four studies included trauma patients. The latter described PU development specifically related to cervical collars (Ham et al., 2014). Collar-related PU incidence is described as 6.8 to 38% in two retrospective (Ackland et al., 2007; Chendrasekhar et al., 1998) and two prospective studies (Ackland et al.', 2007; Powers et al., 2006). Length of time in the collar (Ackland et al., 2007; Chendrasekhar et al., 1998; Powers et al., 2006; Molano Alvarez et al., 2004), admission to the Intensive Care Unit (ICU) and mechanical ventilation (Molano Alvarez et al., 2004) were described as significant risk factors for collar related PU.

In contrast to the paucity of studies on risk factors for PU development in trauma patients, there are multiple studies on risk factors for pressure ulcer development within other patient populations. In a systematic review, Coleman et al. (2013) included 54 studies with a wide range of study populations, variables and methodologies (Coleman et al., 2013). After evaluation of the study quality, the risk factors were described under twelve domains: ‘impaired activity/mobility’, ‘skin status’, ‘perfusion and oxygenation’, ‘nutritional status’, ‘skin moisture’, ‘body temperature’, ‘advanced age’, ‘sensory perception’, ‘hematological measures’, ‘general health status’, ‘gender’ and ‘race’ (Haesler, 2014; Coleman et al., 2013). Of these, ‘impaired activity/mobility’, ‘skin status’ (presence of pressure ulcers), and ‘perfusion and oxygenation’ are considered major risk factors (Haesler, 2014; Coleman et al., 2013).

These risk factors are applicable for a wide range of patients, but it is unclear to what extent these risk factors are applicable for the specific population of trauma patients with suspected spinal injury. ~~These trauma patients are usually relatively young. Furthermore, they are generally healthy and well-nourished prior to admission and the mean age is notably lower compared to other risk groups (elderly, chronically ill).~~ Risk factors for PU development in trauma patients with suspected spinal injury should therefore be assessed in order to identify patients vulnerable to PU development during hospital admission. We expect the PU risk to be at its highest in the acute phase; during ED stay and first days of admission. In the acute phase, injuries are recent and acute treatment is needed; this may lead to immobility and a decreased general health status. The identification of trauma patients at risk should start from admission to the ED, before hospitalization. Accordingly, appropriate preventive interventions can be applied in an early stage (Haesler, 2014). The aim of this study was to explore the influence of risk factors present at ED admission on PU development in trauma patients with suspected spinal injury, admitted to the hospital for evaluation and treatment of acute traumatic injuries.

**METHODS**

**Design, setting and participants**

Between January and December 2013, we conducted a prospective cohort study in a level one trauma center in The Netherlands. All consecutive trauma patients transported to the emergency department on a backboard, with extrication collar and headblocks, were eligible for participation. Inclusion criteria were: (1) trauma patients aged ≥ 18 years; (2) standard prehospital spinal immobilization (i.e. backboard, headblocks and extrication collar); (3) admitted to the hospital through the ED for treatment of acute traumatic injuries. Exclusion criteria were: (1) existing skin breakdown before admission; (2) severe burn wounds (>10% body region); (3) transferred from the ED to another hospital.

**Immobilization procedure**

In the ED, the backboard was removed directly after arrival in the resuscitation room, before the initial assessment (Lubbert, Schram & Leenen 2005). Trauma patients remained immobilized, with an extrication collar and headblocks and in supine position. Injury of the spine was excluded or diagnosed by radiology (Computed Tomography scans) in combination with clinical examination. In intoxicated, unconscious or sedated patients, clinical examination was postponed until patients regained consciousness. Meanwhile, the extrication collar and headblocks were replaced by a semi-rigid collar (Philadelphia® Philadelphia cervical collar co, NJ). In case of deep sedation (and thus not moving independently) and admission to the Intensive Care Unit, the cervical spine was immobilized with straps on the forehead and lateral support.

**Study outcomes**

**Pressure ulcers**

Pressure ulcer incidence comprised the number of patients that developed pressure ulcer(s) during their hospital stay. Because we expect the pressure ulcer risk to be at its highest during ED stay and first days of admission, the number of patients with ‘early’ pressure ulcer development (within 48 hours after emergency department admission) was also described. Pressure ulcers were categorised using the International Pressure Ulcer Classification System (European Pressure Ulcer Advisory Panel (EPUAP), National Pressure Ulcer Advisor Panel 2009). If redness was identified, a transparent disc was pressed onto the redness. If the skin under the transparent disk did not blanch, it was considered to be a category 1 PU (EPUAP working group ).

**Potential Risk Factors**

To explore the association of potential risk factors with pressure ulcer development, the following variables were collected: Age, Skin color and Body Mass Index (BMI), and Time in ED, Injury Severity Score (ISS), Mean Arterial Pressure (MAP), hemoglobin level, Glasgow Coma Score (GCS), and admission ward after ED. ISS is a scale to measure injury severity (Copes et al., 1988), and GCS is a scale to measure the level of consciousness (Teasdale and Jennett, 1974). All potential risk factors were based on ten out of the twelve domains as described by Coleman et al. (2015) and the international PU guidelines (Haesler, 2014; Coleman et al., 2013).

**Preventive interventions during admission**

To adjust for possible confounders, we collected data on the application of preventive interventions. Preventive interventions were: application of a Pressure Redistributing (PR) mattress, frequent repositioning in bed, and extra Nutrition. The application of preventive interventions was scored until PUs were identified. If no PUs appeared, preventive interventions were scored until discharge or death.

All hospitalized patients were on a standard PR mattress. The PrePurse screening tool was used to assess PU risk (Schoonhoven et al., 2006). Risk Scores were calculated on admission, in case of changed conditions or every week. If nurses identified pressure ulcer risk (PrePurse scores > 20) or discovered pressure ulcers, patients were placed on the appropriate dynamic air mattresses (Promatt ®, or Auto Sure Float ®). During an Intensive Care Unit stay, all patients were on a high-risk dynamic air mattress; next to pressure distributing functions, these mattresses were equipped with mechanisms to achieve various body-positions.

If patients were bed-bound, they were repositioned in bed at least every 2-4 hours per 8 hour shift. Repositioning in bed was not possible in case of hemodynamic instability, unstable fractures or increased pain due to movement of limbs. Institutional guidelines prescribed to screen all patients for malnutrition (Malnutrition Universal Screening Tool) (Stratton et al., 2004). In case of risk for malnutrition, appropriate dietary interventions were taken.

**Sample size**

We were not able to calculate the sample size, whereas this was the first prospective study on pressure ulcer development in trauma patients with suspected spinal cord injury. Estimating the sample size was challenging: trauma data revealed that 1200 trauma patients were treated yearly in the study setting, however the proportion of patients with suspected spinal injury in this group was unclear. Therefore we chose a practical method and planned a period of recruitment of 12 months.

**Data collection**

After 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 (deferred consent). After inclusion, patients were followed up until discharge from the hospital or death. If a PU was detected, the course of development was monitored. A nurse scientist, specialized and trained in PU care, collected data on a structured data collection form. Data on risk factors were collected on ED admission (day 0). Patient visits started at day one after hospital admission (at the latest within 48 hours), every two days, until PU development, discharge or death. All patient visits were planned during daily care routines, to minimize the burden for the patients. At each patient visit, a skin assessment for PU development was performed. To assess the application of frequent repositioning (at least every 2-4 hours) and extra nutrition, nursing notes were examined, combined with observations during patient visits. The use of PR mattresses was observed (‘dynamic air mattresses’ and ‘high- risk dynamic air mattresses’) during patient visits. The Medical Ethics Review Committee of the participating institute stated that the Dutch Medical Research Involving Human Subjects Acts (Wet Medisch wetenschappelijk Onderzoek-WMO) does not apply to this study and official Institutional Review Board approval is not required under the WMO (protocol number 12/161).

**Missing data**

In 33 patients, 34 values were randomly missing (1.03%) on BMI, MAP and Hb. In order to include these patients in the analysis, we performed multiple imputation in five iterations on all missing data (linear regression model). Means of the imputed variables were comparable to the original data. (Table 1)

**Analysis**

Pressure ulcer incidence was defined as a proportion: the number of patients who developed at least 1 category 1-4 pressure ulcer within the total sample. We constructed 95% confidence intervals (CIs) around proportions (Clopper-Pearson exact method)(Clopper and Pearson, 1934). Baseline characteristics were described as frequencies and percentages for categorical or dichotomous variables. As continuous data were not normally distributed, the median and the inter quartile range (first Q1, third quartile Q3) were described. The two-sided Mann-Whitney test and chi-square test were used to compare risk factors in patients with and without PUs. In order to explore the association between risk factors for PU development, multivariate analysis using logistic regression was performed (enter method). The associations between potential risk factors and PU development during admission were described. As we expect the risk to be highest during ED stay and the first days of admission, the association between potential risk factors and PU development within 48 hours was also described. There was no indication for multicollinearity between potential risk factors. The level of significance was established at p < 0.05. We used the Statistical Package for the Social Sciences (SPSS) 20.0 program for data description and analysis (Version 20.0, Armonk, NY: IBM Corp.).

**RESULTS**

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

**Baseline characteristics**

The median (Q1,Q3) age was 52 (32,65) years and 93 (36.6%) were female. 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 a mild to moderate injury (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 hospitalized for a median (Q1,Q3) of 5.0 (5,21) days. 44 patients were admitted to the Intensive Care Unit and 98 to the Medium Care Unit. The majority of the patients had a ‘pale to light brown’ skin pigmentation (n=233, 91.6%). (Table 2)

**Pressure Ulcer Incidence**

The incidence of pressure ulcer development during the period of hospital stay was 28.3% (72/254; CI 95% 22.9-34.3%). The incidence of pressure ulcer development within 48 hours after admission was 13% (33/254; CI 95% 9.1%-17.8%)

**Group Comparison**

In both patients groups (PU development during admission or PU development within 48 hours) patients with PU had a significant higher age, and a significant lower MAP, hemoglobin level and GCS score. Type of admission ward differed significantly between patients with and without PU; the proportion of patients admitted to the Intensive Care Unit and Medium Care Unit was higher in patients with PU. (Table 3)

**Multivariate logistic regression**

PU development during admission was associated with an older age (p 0.00, OR 1.05) and a lower GCS score (p < 0.01 , OR 1.21) and higher ISS score ( p = 0.03, OR 1.05). Extra nutrition significantly decreased the probability of developing PU during admission (p=0.047, OR 0.194). PU development within the first 48 hours of admission was positively associated with an older age ( p=0.01, OR 1.030) and a lower GCS score (p=0.047, OR 1.142). (Table 4)

**Discussion**

This was an explorative study on risk factors in trauma patients with suspected spinal injury. We found that patients who developed PU, had a significantly older age, and a significantly lower MAP, Hemoglobin level and GCS score in the ED. Furthermore, we found a significant difference in type of admission ward after evaluation in the ED in patients with PU. PU development during admission was positively associated with an older age, low GCS and a higher ISS in the ED. PU development within 48 hours was positively associated with older age and a low GCS in the ED.

In contrast to ISS, GCS, hemoglobin level and MAP, age is a non-influenceable risk factor, and not related to the severety of injury. Age is a known risk factor for PU development, (Haesler, 2014; Coleman et al., 2013) and apparently also significantly associated with PU development in this relatively young group of patients. ISS, GCS, hemoglobin level and MAP are risk factors that are all directly related to the patients’ condition. Type of admission ward is also obviously related to the patient’s conditions as the complexity of required care corresponds with the type of admission ward.

Trauma has a major physical and mental impact on a patient’s and their caregivers’ life. PU development during the admission will increase this impact, and can easily delay rehabilitation (Gorecki et al., 2010; Gorecki et al., 2009) Emergency nurses, trauma surgeons and emergency physicians should recognize the increased PU risk in trauma patients who have been immobilized for preventive reasons. It is of utmost importance to be aware of the increased pressure ulcer risk in the advanced aged trauma patients and trauma patients in a critical condition. Specifically, low GCS and the severity of injury should be considered in evaluating the PU risk in the ED. In our study, we evaluated the association between risk factors present at ED admission and PU development, as we expected the PU risk to be at its highest during ED stay and first days of admission. In total, 28.3% of the trauma patients developed PUs. Of these 45.8% of the patients developed PUs within 48 hours after admission and 54.2% of the trauma patients developed PUs after 48 hours of admission. All patients were immobilized with a backboard prior to emergency department admission, which increased the PU risk (Ham et al, 2014; Oomens et al., 2013; Hemmes et al., 2014). Although the backboard was removed after arrival in the resuscitation room, trauma patients remained immobilized with an extrication collar and headblocks and in supine position on a Stryker ® stretcher, until spinal injury was diagnosed or excluded. These stretchers are equipped with small and thin mattresses, which are easy manageable and designed for radiation transmission. The period of immobilization, both on the backboard and on the stretcher, increased the PU risk.

In our study, ‘extra nutrition’ decreased the probability of PU development during admission. Clearly the regular screening, nutrition assessment and the application of a nutrition plan in trauma patients have contributed to a significantly decreased probability of developing PUs. Malnutrition is a known risk factor for PU development (Haesler, 2014; Shahin et al., 2010; Brito et al., 2013; Iizaka et al., 2010; Banks et al., 2010). In general, unlike the elderly (Haesler, 2014; Shahin et al., 2010), trauma patients are most likely well- nourished prior to hospital admission, as they are relative young and healthy, but, malnutrition during admission may form a risk for trauma patients; it is likely that the nutritional needs increase due to their injuries, and their nutritional supply may be delayed due to surgical procedures or medical tests.

Emergency nurses should initiate the application of a PU prevention plan before ward admission. As Emergency nurses are involved in direct patient care day-and-night they should emphasize the importance of a timely risk assessment, and increase awareness of the PU risk in these patients.

Furthermore, we need to realize that two major preventive interventions for pressure ulcer development, namely “repositioning” and “early mobilization”, may be hindered in this patient group due to their injuries. As a consequence, regular skin assessment should be intensified to help detect pressure ulcer risk in an early phase, in order to apply alternative preventive interventions, when “repositioning” or “early mobilization” is impossible.

**Strengths and limitations**

This is the first explorative study on risk factors present in the ED and PU development in trauma patients. The actual association between risk factors present at ED admission and PU development during admission may be biased by risk factors that occurred during admission. We did not evaluate the association between risk factors that occurred during hospital admission, like fever or impaired mobility and PU development. Moreover, we limited our risk factor assessment to risk factors related to the trauma, and have not collected data on other risk factors associated with pressure ulcer occurrence, like incontinence, compromised skin status, smoking status or the patients’ medical history. Therefore it is possible that other risk factors play a role in PU development during admission.

Eligible patients were admitted to the ED day-and-night. In order to avoid selection bias, delayed informed consent was authorized and applied. A homogeneous sample was obtained by restriction; solely trauma patients who were immobilized with a backboard, extrication collar and headblocks prior to hospitalization were included. To attain realistic incidence figures, care-as-usual (risk assessment, prevention and PU care) was maintained during the study period. If patients developed a PU category 2 or more, nurses were notified to pay extra attention to pressure ulcer care.

The presence of PUs was observed by skin assessments and not extracted from patient records. Data collection by skin observations strengthens reliability and prevents under evaluation due to incomplete documentation. The reliability of data-collection was further improved, since a single data collector performed data collection; no inter-rater reliability issues arose.

Data were collected within 24 hours, and every 2 days thereafter by one data-collector. Although category 1 PUs could have been missed due to this frequency, observing once every 48 hours ensured we did not miss category 2 to 4 PUs, as these were still visible as a scab when healing. We visited all patients within the first 48 hours of their hospital stay, and most patients were seen at least twice. Therefore, the probability of detecting a PU was high.

Results of our study may however be influenced by the Hawthorn effect. Nurses were informed and aware of skin inspections for study purposes, since this took place during daily care routines. This may have increased awareness of PU risk assessment and prevention.

**Implications for practice and further research**

After evaluation in the resuscitation room of the ED, medical and nursing staff should be aware of the increased PU risk for trauma patients immobilized with a backboard, cervical collar and headblocks prior to hospital admission. Furthermore, trauma patients with an older age, a low GCS score, and high ISS score, are at risk for PU development. Preventive interventions should be initiated and applied in an early stage of admission. Nurses should recognize the fact that frequent repositioning is a challenge in trauma patients. If frequent repositioning is not possible, patients should be considered at risk and skin assessments and the prevention program should be intensified.

Future studies should focus on prevention of pressure ulcers in this specific patient group, in order to develop effective preventive interventions. Further research is needed to explore risk factors for PU development during the hospital stay.

**Conclusions**

PU risk should be assessed in the ED to apply preventive interventions in time. We explored the influence of risk factors on PU development in trauma patients with suspected spinal injury, who were immobilized with a backboard, headblocks and cervical collar prior to evaluation in the ED. The PU risk during admission is high in patients with an older age, lower GCS and higher ISS score in the ED. To prevent PU development, assessment should start in the ED, prior to hospital admission, after which preventive interventions can be applied in an early stage.

References

Ackland, H.M., Cooper, D.J., Malham, G.M. & Kossmann, T., 2007. Factors predicting cervical collar-related decubitus ulceration in major trauma patients. Spine. 15;32 (4): 423-8

Baldwin, K.M., Ziegler, S.M., 1998. Pressure ulcer risk following critical traumatic injury, Advances in Wound Care : The Journal for Prevention and Healing. 11(4), pp. 168-173.

Banks, M., Bauer, J., Graves, N., Ash, S., 2010. Malnutrition and pressure ulcer risk in adults in Australian health care facilities. Nutrition.26(9), pp. 896-901.

Brito, P.A., de Vasconcelos Generoso, S., Correia, M.I., 2013. Prevalence of pressure ulcers in hospitals in Brazil and association with nutritional status--a multicenter, cross-sectional study. Nutrition 29(4), pp. 646-649.

Chendrasekhar, A., Moorman, D.W. , Timberlake, G.A., 1998. An evaluation of the effects of semirigid cervical collars in patients with severe closed head injury. The American Surgeon. 64(7), pp. 604-606.

Clopper, C.J. , Pearson, E.S., 1934. The Use of Confidence or Fiducial Limits Illustrated in the Case of the Binomial. Biometrica. 4(26), pp. 404-413.

Coleman, S., Gorecki, C., Nelson, E.A., Closs, S.J., Defloor, T., Halfens, R., Farrin, A., Brown, J., Schoonhoven, L., Nixon, J., 2013. Patient risk factors for pressure ulcer development: systematic review. International journal of nursing studies. 50(7), pp. 974-1003.

Copes, W.S., Champion, H.R., Sacco, W.J., Lawnick, M.M., Keast, S.L., Bain, L.W., 1988. The Injury Severity Score revisited. The Journal of trauma. 28(1), pp. 69-77.

Denby, A., Rowlands, A., 2010. Stop them at the door: should a pressure ulcer prevention protocol be implemented in the emergency department?". Journal of wound, ostomy, and continence nursing. 37(1), pp. 35-38.

Dugaret, E., Videau, M.N., Faure, I., Gabinski, C., Bourdel-Marchasson, I., Salles, N., 2014. Prevalence and incidence rates of pressure ulcers in an Emergency Department. International wound journal.11(4), pp. 386-391.

EPUAP working group , PUCLAS2 Pressure Ulcer Classification. Available: <http://www.puclas.ugent.be/puclas/e/> [2012, 03/15].

European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisor Panel., 2009. Prevention and Treatment of Pressure Ulcer: Quick Reference Guide, Washington D.C.

Gorecki, C., Brown, J.M., Nelson, E.A., Briggs, M., Schoonhoven, L., Dealey, C., Defloor, T., Nixon, J., European Quality of Life Pressure Ulcer Project group, 2009. Impact of pressure ulcers on quality of life in older patients: a systematic review. Journal of the American Geriatrics Society. 57(7), pp. 1175-1183.

Gorecki, C., Lamping, D.L., Brown, J.M., Madill, A., Firth, J., Nixon, J., 2010. Development of a conceptual framework of health-related quality of life in pressure ulcers: a patient-focused approach. International journal of nursing studies. 47(12), pp. 1525-1534.

Haesler, E. (ed), 2014. National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treautment of Pressure Ulcers: Clinical Practice Guideline., Cambridge Media: Osborne Park, Western Australia.

Ham, W., Schoonhoven, L., Schuurmans, M.J., Leenen, L.P., 2014. Pressure ulcers from spinal immobilization in trauma patients: A systematic review. The journal of trauma and acute care surgery. 76( 4), pp. 1131-1141.

Hemmes, B., Brink, P.R., Poeze, M., 2014. Effects of unconsciousness during spinal immobilization on tissue-interface pressures: A randomized controlled trial comparing a standard rigid spineboard with a newly developed soft-layered long spineboard. Injury. 45 (11), pp. 1741-1746.

Iizaka, S., Okuwa, M., Sugama, J., Sanada, H., 2010. The impact of malnutrition and nutrition-related factors on the development and severity of pressure ulcers in older patients receiving home care. Clinical Nutrition. 29 (1), pp. 47-53.

Lubbert, P.H.W., Schram, M.E., Leenen, L.P.H., 2005. Is there a reason for spine board immobilization in the emergency department for patients with a potential spinal injury?. European Journal of Trauma. 31(4), pp. 375-378.

Molano Alvarez, E., Murillo Perez Mdel, A., Salobral Villegas, M.T., Dominguez Caballero, M., Cuenca Solanas, M., Garcia Fuentes, C., 2004. Pressure sores secondary to immobilization with cervical collar: a complication of acute cervical injury. Enfermeria intensiva / Sociedad Espanola de Enfermeria Intensiva y Unidades Coronarias. 15 (3), pp. 112-122.

Oomens, C.W., Zenhorst, W., Broek, M., Hemmes, B., Poeze, M., Brink, P.R., Bader, D.L., 2013. A numerical study to analyse the risk for pressure ulcer development on a spine board. Clinical biomechanics (Bristol, Avon). 28(7), pp. 736-742.

O'Sullivan, K.L., Engrav, L.H., Maier, R.V., Pilcher, S.L., Isik, F.F., Copass, M.K., 1997. "Pressure sores in the acute trauma patient: incidence and causes", The Journal of trauma, 42 (2), pp. 276-278.

Powers, J., Daniels, D., McGuire, C., Hilbish, C., 2006. The incidence of skin breakdown associated with use of cervical collars. Journal of trauma nursing : the official journal of the Society of Trauma Nurses. 13 (4), pp. 198-200.

Schoonhoven, L., Grobbee, D.E., Donders, A.R., Algra, A., Grypdonck, M.H., Bousema, M.T., Schrijvers, A.J., Buskens, E., prePURSE Study Group., 2006. Prediction of pressure ulcer development in hospitalized patients: a tool for risk assessment. Quality & safety in health care. 15 (1), pp. 65-70.

Shahin, E.S., Meijers, J.M., Schols, J.M., Tannen, A., Halfens, R.J., Dassen, T., 2010. The relationship between malnutrition parameters and pressure ulcers in hospitals and nursing homes. Nutrition. 26 (9), pp. 886-889.

Stratton, R.J., Hackston, A., Longmore, D., Dixon, R., Price, S., Stroud, M., King, C., Elia, M., 2004. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. The British journal of nutrition. 92 (5), pp. 799-808.

Teasdale, G., Jennett, B., 1974. Assessment of coma and impaired consciousness. A practical scale. Lancet. 2 (7872) pp. 81-84.

Watts, D., Abrahams, E., MacMillan, C., Sanat, J., Silver, R., VanGorder, S., Waller, M., York, D., 1998, Insult after injury: pressure ulcers in trauma patients. Orthopaedic nursing / National Association of Orthopaedic Nurses. 17 (4), pp. 84-91.

Table 1. Missing data

|  |  |  |  |
| --- | --- | --- | --- |
| Values | # missing values | Original mean values | Imputed mean values |
| BMI | 18 | 25.6 | 25.6 |
| MAP | 6 | 79.6 | 79.7 |
| Hb | 2 | 8.5 | 8.5 |
|  |  | Original numbers | Imputed nembers |
| Skin color\*\* 1-3 4-6 | 8 | 233 13 | 240 14 |

BMI: Body Mass Index; MAP: Mean Arterial Pressure Hb: Haemoglobin\*\*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. Baseline characteristics

|  |  |
| --- | --- |
|  | **Value** |
| **Patient characteristics****Age**  | Median (Q1,Q3)/ Frequency (%)52 (32, 65) |
| **BMI**  | 26.6 (22.4,27.5) |
| **Female** | 93 (36.6%) |
| **Mechanism of injury** Fall Cycle crash Car crash  Scooter Motorcycle crash Pedestrian struck Crush Assault Unknown Strangulation  | 106 (41.7%)52 (20.5%)40 (15.7 %)18 (7.1%)11 (4.3%)12 (4.7%)10 (3.9%)2 (0.8%)2 (0.8%)1 (0.4%) |
| **ISS score** Mild (0-9) Moderate (10-15) Severe (16-24) Very severe (>24) | 89 (35%)51 (20.1%)64 (25.2%)50 (19.7%) |
| **Skin type\*\*** Type 1-3  (pale to light brown skin) Type 4-6  (medium to very dark brown skin) | 233 (91.6%)13 (5.1%) |
|  |  |

Q1: first quartile, Q3: third quartile, BMI: Body Mass Index, ISS: Injury Severity Score,

\*\*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.

|  |  |  |
| --- | --- | --- |
|   | Pressure ulcer development during admission | Pressure ulcer development within 48 hours |
|  | No n=182 | Yesn=72 | Mann-Whitney U | No n=222 | Yes n=33 | Mann-Whitney U |
|  | *Mean rank score* | *Mean rank score* |
| Age  | 111.4 | 168.3 | Z¹ -5.56p 0.00 | 120.9 | 171.7 | Z -3.71p 0.00 |
| BMI  | 129.7 | 121.8 | Z -0.8p 0.42 | 127.1 | 130.4 | Z -0.22p 0.83 |
| Length in ED | 131.0 | 118.6 | Z – 1.21p 0.23 | 127.1 | 130.1 | Z -0.22 p 0.83 |
| ISS | 114.8 | 159.6 | Z -4.39p 0.00 | 125.1 | 143.9 | Z- 1.37P 0.17 |
| MAP | 135.0 | 108.6 | Z -2.58p 0.00 | 131.1 | 103.7 | Z -1.99P 0.05 |
| Hb | 139.7 | 96.7 | Z -4.21p 0.00 | 131.7 | 103.7 | Z – 2.33p 0.02 |
| GCS | 113.0 | 164.2 | Z -5.88 p 0.00 | 124.0 | 99.6 | Z-2.33p 0.02 |
|  | Non | Yes | Chi-square | Non  | Yes | Chi-square |
| Gender  *Male* *Female* | 11468 | 4725 | Chi²0.2p 0.4 | 13883 | 2310 | Chi 0.65p 0.42 |
| Skin\*\* *Light* *Dark*Admission *ICU* *MCU* *Ward* | 17391344125 | 675312219 | Chi 0.37p 0.53Chi 55.5P 0.00 | 210113355133 | 303111111 | Chi 0.93P 0.33Chi 10.05P 0.00 |

Table 3. Group comparisons

BMI: Body Mass Index; ED: Emergency Department; ISS: Injury Severity Score; MAP: Mean Arterial Pressure; Hb: Hemoglobin; GCS: Glasgow Coma Scale; ICU: Intensive Care Unit; MCU: Medium Care Unit, Ward: nursing ward \*\*Following the Fitzpatrick scale Light: Type 1-Type 3, Dark: Type 4 -Type 6

Table 4. Multivariate logistic regression (enter method)

|  |  |
| --- | --- |
|  Pressure ulcer development during admission n = 72 |  Pressure Ulcer development within 48 h n = 33 |
|  | ***P value*** | ***OR*** | ***95% CI*** | ***P value*** | ***OR*** | ***95% CI*** |
| Age | 0.00\* | 1.05 | 1.03-1.07 | 0.01\* | 1.03 | 1.01-1.06 |
| Female¹ | 0.17 | 1.74 | 0.79-3.88 | 0.25 | 1.71 | 0.69-4.21 |
| Skin color\*\*² | 0.64 | 0.71 | 0.17-2.96 | 0.28 | 0.44 | 0.10-1.97 |
| BMI | 0.66 | 0.98 | 0.91-1.06 | 0.93 | 1.00 | 0.91-1.09 |
| Length in ED | 0.41 | 1.00 | 1.00-1.01 | 0.74 | 1.00 | 1.00-1.01 |
| ISS | 0.03\* | 1.05 | 1.00-1.09 | 0.76 | 1.01 | 0.96-1.05 |
| MAP | 0.11 | 0.98 | 0.98-0.96 | 0.13 | 0.98 | 0.96-1.01 |
| Hb | 0.27 | 0.82 | 0.57-1.17 | 0.42 | 0.87 | 0.61-1.23 |
| GCS | 0.00\* | 1.21 | 1.08-1.35 | 0.01\* | 1.16 | 1.03-1.31 |
| Position change⁴ | 0.34 | 4.50 | 0.21-96.53 | 0.33 | 0.26 | 0.02-3.84 |
| Extra nutrition⁵ | 0.04\* | 0.20 | 0.04-0.94 | 0.87 | 1.13 | 0.25-5.19 |
| PR mattress⁶ | 0.68 | 0.79 | 0.26-2.37 | 0.81 | 1.17 | 0.33-4.09 |

\*\*Following the Fitzpatrick scale Light: Type 1-Type 3, Dark: Type 4 -Type 6; BMI: Body Mass Index; ED: Emergency Department; ISS: Injury Severity Score; MAP: Mean Arterial Pressure Hb: Hemoglobin; GCS: Glasgow Coma Scale; PR; Pressure Redistributing.

¹ Reference: Female ² Reference: Dark pigmentation ³ Reference: Nursing ward⁴ Reference: no position change ⁵ Reference: No extra nutrition⁶ Reference: no PR Mattress