"Cervical Collar Related Pressure Ulcers (CRPU) in Trauma Patients in Intensive Care: Assessment and Prevention of Risks"

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Samenvatting

Achtergrond

De reden dat traumapatiënten (TP) een nekkraag (NK) dragen, is immobilisatie van de cervicale wervelkolom (CWK). Het ontstaan van nekkraag gerelateerde decubitus (NKGD) is één van de meest voorkomende complicaties bij het dragen van een NK. TP die opgenomen zijn op een Intensive Care Unit (ICU) hebben een verhoogde kans op NKGD, omdat veel risicofactoren (RF) voor NKGD aanwezig zijn in deze groep. Wij onderzochten de prevalentie van NKDG, RF en de relatie met preventieve interventies. Het conceptuele raamwerk van Defloor (1999) werd gebruikt om de RF te onderbouwen en organiseren in de vier concepten: Drukkrachten, schuifkrachten weefseltolerantie voor druk en zuurstof.

Methoden

De methode van onderzoek was een combinatie van beschrijvend retrospectief en een retrospectieve case-control. Alle volwassen TP die langer dan 24 uur een NK droegen en opgenomen waren op de ICU in 2006 en 2008 werden geïdentificeerd en gescreend voor inclusie. Datacollectie was retrospectief en bestond uit demografische kenmerken, RF en preventieve interventies.

Resultaten

Van de 231 opgenomen TP, werden 149 dossiers beoordeeld voor inclusie. Van 88 dossirs werd data verzameld. Drie TP (3,4%) ontwikkelden NKGD, op het achterhoofd en kin. Eerste registratie van NKGD was op dag 12, 32 en 36 van opname. Minimaal één RF werd gedocumenteerd bij TP, met en zonder NKGD. De lengte in een NK bleek langer bij TP met NKGD (40, 36 en 35 dagen) ten opzichte van een gemiddelde van 4,6 dagen voor de totale groep. Data was niet toereikend om een statistisch verband aan te tonen tussen RF, NKDG en preventieve interventies.

Conclusie

De prevalentie van NKGD is laag in deze steekproef. Ondanks ontbreken van statistische analyse, onderschrijven de resultaten van deze studie het belang van structurele preventieve zorg om RF te kunnen reduceren. Theoretische onderbouwing zou een belangrijke rol moeten spelen in toekomstig onderzoek om de effectiviteit van preventieve interventies te testen.

Sleutelwoorden: Nekkraag; Decubitus; traumapatiënten; risicofactoren; preventieve interventies; intensive care unit.

Abstract

Background

Trauma patients (TP) wear a cervical collar (C-collar) to immobilize the cervical spine (C-spine). Development of collar related pressure ulcers (CRPU) is one of the known complications of immobilizing the C-spine. Because risk factors (RF) for the development of CRPU are highly represented in TP admitted to the Intensive Care Unit (ICU), this group of patients are at high risk for developing CRPU. We assessed the prevalence of CRPU, RF and the relationship with preventive interventions. The conceptual framework of DeFloor (1999) was used to explain and organize RF into four concepts: pressure forces, shearing forces, tissue tolerance for pressure and tissue tolerance for oxygen.

Methods

A descriptive retrospective design was combined with a retrospective case control design. All adult TP wearing a C-collar for > 24 hours, admitted to the ICU in 2006 and 2008, were identified and screened for inclusion. Data were retrospective collected, including patient characteristics, RF and preventive interventions.

Results

From the 231 TP admitted in the study period, 149 charts were reviewed for inclusion and data was collected for 88 TP Three TP (3.4 %) developed CRPU, located at the occiput and chin. CRPU occurred on day 12, 32 and 36 of admission. In all TP, with or without CRPU, one or more RF were identified. The length in a C-collar appeared to be longer in TP with CRPU (40, 36 and 35 days) versus a mean of 4.6 days for the total group. We were not able to demonstrate a statistical relationship between RF, CRPU and preventive interventions because of insufficient data.

Conclusions

CRPU in TP within this data set is low. Despite the inability of statistical analysis, descriptive results of this study emphasize the importance of structural preventive care based on reduction of RF. Future research should be guided by a theoretical construction to formulate RF and the effect of preventive interventions.

Key words: cervical collar; pressure ulcers; trauma patients; risk factors; preventive interventions; intensive care unit.

1. Introduction

1.1 Background

Figures derived from the National Trauma Data Bank sample described 608,000 trauma incidents and 150,000 hospital admissions in 2006 in the United States of America (USA), caused by motor vehicle accident, fall, cut, struck, and firearm [1]. 'Trauma' is defined as "injuries to human tissue and organs, resulting from energy imparted from the environment caused by any form of energy from beyond the tolerance level of the human body" [2].

Trauma patients (TP) who require medical help are assessed, treated and evaluated by paramedics and emergency care staff, following the guidelines of the Advanced Trauma Life Support (Acker et al., 2004). These guidelines prescribe to prioritize assessment of the cervical spine (C-spine) because C-spine trauma is an immediate threat to life. Movement of the C-spine can cause or worsen neurological damage [3]. Application of a cervical collar (C-collar) prevents movement. At the scene of the accident, paramedics will apply a rigid C-collar (Stiffneck ®). After assessment in-hospital, this rigid C-collar is replaced with a semi-rigid C-collar (Miami-J®, Philadelphia®, or Aspen®), depending on the hospital policy. In practice, TP wear this C-collar until C-spine trauma is excluded.

Although C-collar application is essential and life-saving, immobilizing the C-spine is not without risks. Immobility in general is a major risk factor for developing Pressure Ulcers (PU) [4]. PU are a major problem in health care and increase medical costs, workload and admission periods, as well as physical and psychosocial burden [5]. In a Cochrane review, Kwan, Bunn & Roberts (2001) [6] found an increased risk of PU for TP immobilized with a C-collar. The term collar related pressure ulcers (CRPU) is used to delineate the type of PU that is caused by the application of a C-collar. The term PU is used to refer to the generic type of PU.

1.2 Literature review

Risk factors for PU and CRPU

Risk factors (RF) for PU development in Intensive Care Unit (ICU) patients and (CR)PU in TP have been investigated intesively [7, 8 9-12], resulting in a broad range of varying (sometimes conflicting) RF and should therefore be carefully interpreted. Study results depend on which RF were included in the study, and variations in ICU policy, methodology, data collection, analysis, PU definitions, staging systems and risk assessmen tools [7, 8]. These variation lead to incomparable results. Therefore, research findings are difficult to integrate or generalize to other fields. This broad range of incomparable RF can be prevented by incorporating a theoretical rationale[13, 14].

1.3 Conceptual framework

A combination of theory and research enhances theory development, generalizability of results, and provides an organizing structure and rationale [13-15]. This research project aims for CRPU in the most vulnerable group of TP: the severely injured TP admitted to the ICU. Previous research shows that ICU admission and mechanical ventilation are associated with the development CRPU [9]. In this study, application of a theoretical framework explains and organizes RF for CRPU in TP. Three theoretical models for PU development are described in literature [16-18]. From these, the conceptual framework of Defloor (1999) was selected because of the described concepts have a solid empirical base, clear description and compatibility to the nursing domain.

Definition of concepts and interrelationship

The conceptual scheme of Defloor (1999) enholds four concepts (see figure 1), namely, compressive (or pressure) forces, shearing forces, tissue tolerance for oxygen (TTO) and tissue tolerance for pressure (TTP). PU are caused by compressive and shearing forces. Compressive force is a constantly exerted force, while shearing forces are exerted parallel to the tissue. Shearing forces can only be generated when compressive forces are present. The combination of these forces is particularly damaging. Intensity and duration of both forces determine the development of PU. Tissue tolerance however, is defined as an intermediating factor, and is different for each individual patient. Tissue tolerance beholds several factors that influence the TTP and TTO. Factors for TTP determine if the compressive forces will be sufficient to develop the PU. TTO behold factors that influence oxygen needs and the oxygen supply of the tissue. When oxygen supply matches the tissue need for oxygen, PU are unlikely to occur. This balance can be disturbed when oxygen supply is not sufficient or when oxygen needs increase [18]. Tissue Tolerance is influenced by severity of illness, which makes this model highly applicable to ICU patients.

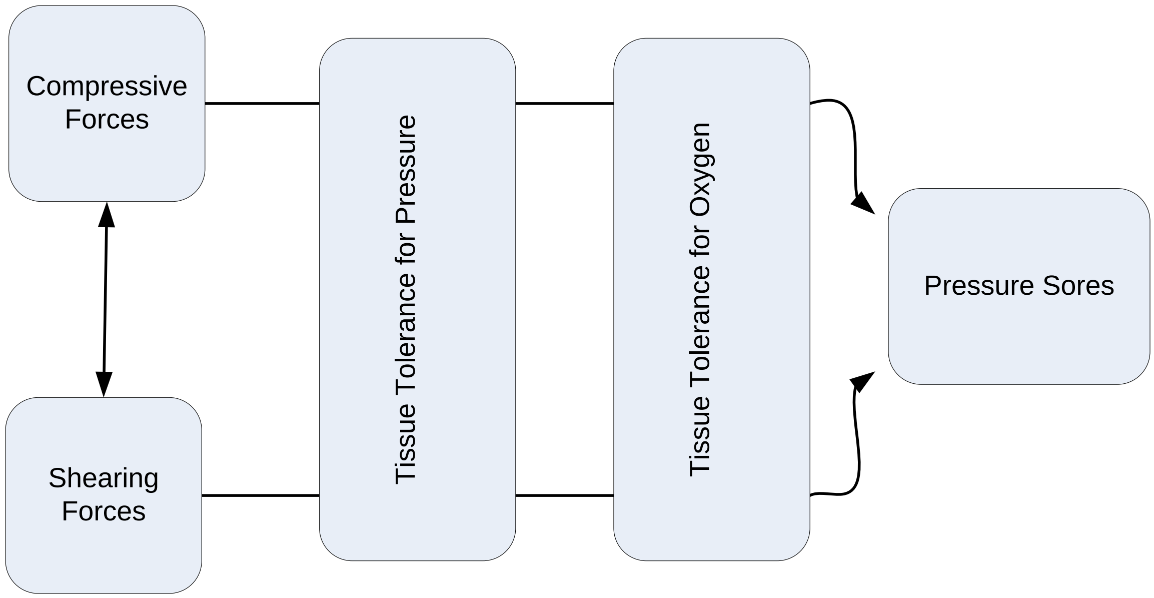


Figure 1: The conceptual model of Defloor (1999)

RF described in literature can be grouped into the four concepts of conceptual framework of Defloor (1999): compressive (or pressure) and shearing forces, TTO and TTP. Compressive and shearing forces include immobility, length of stay, body weight and skin moisture [7, 8, 18-21]. Compressive forces specific for CRPU are type of C-collar and duration of application [9-12]. The tissue tolerance is influenced by the severity of illness [7, 8, 18, 21]. TTO-supplies decrease in case of impaired circulation, poor nutritional state and impaired oxygen supply, the use of tobacco and edema [7, 8, 18-21]. TTO-needs increase by high body or environmental temperature, and anemia [7, 8, 18, 20]. TTP decreases by age over 65 years, disturbed sensory peception, dehydration, and low body weight [7, 8, 18, 19].

Preventive interventions for PU and CRPU

In order to recognize TP at risk for CRPU, caregivers should be aware of RF for CRPU. Although nurses are not solely responsible for prevention of CRPU, they tend to have the most frequent physical contacts with TP in the ICU. Regular assessment and documentation by nurses is essential to monitor RF and evaluate preventive care. The National Pressure Ulcer Advisory Panel (NPUAP) and the European Pressure Ulcer Advisory Panel (EPUAP) developed evidence-based guidelines for prevention of PU. These guidelines recommend implementing a structured risk assessment policy, regular assessment of the skin, skin care by moisturizing, assessment and optimizing the nutritional status, regular repositioning, and the use of support surfaces to relieve pressure to prevent PU. All interventions should be documented and evaluated [22]. No evidence was found concerning the frequency of applying the interventions. Therefore frequencies are generally described as ‘regular’, indicating that frequencies are adapted to the individual needs, clinical traditions or expert opinion. Similar preventive interventions for CRPU are described. Pressure from the C-collar can be relieved by minimizing the time in C-collar by optimizing the diagnostic process an applying a semi-rigid C-collar, and occipital pressure relieving cushions. Next to that, regular assessment and care of skin underneath the C-collar were described [9, 11, 23-25]. None of the preventive interventions for PU and CRPU were systematically tested, but hospital guideline implementation leads to an increase of PU incidence [26].

1.4 Problem statement

TP admitted to the ICU wearing a C-collar for protective and therapeutic purposes are at risk for developing CRPU. It is unclear if the results of previous research, concerning RF for CRPU in TP, and PU in ICU patients, can be applied to the above described population. Next to that, it remains unclear if preventive interventions reduce the development of CRPU in TP.

Furthermore, none of the reviewed studies used a theoretical framework as a rationale and organizing structure for RF.

1.5 Purpose

The purpose of this research project is to identify risk factors for CRPU in trauma patients admitted to the ICU wearing a C-collar until C-spine trauma is excluded or as part of the treatment for their C-spine injuries. Defloor’s (1999) theoretical model is used to organize and explain these risk factors. The use of a theoretical framework is a new approach in the study of RF for developing CRPU. Additionally, outcomes of this study provide a direction in determining plausible nursing interventions.

1.6 Research questions

1. What are the prevalence, location and stages of CRPU in TP admitted to the ICU wearing a C-collar before and after implementation of preventive interventions?
2. What is the relationship between risk factors and preventive interventions with CRPU in TP admitted on the ICU wearing a C-collar ?
3. What is the association/relationship between preventive interventions and the prevalence of CRPU in TP admitted to the ICU?

2. Methods

2.1 Design

In order to answer these research questions, a combined approach was used. For the first two research questions a descriptive retrospective design was applied to examine and describe the presence and relationship [13] between CRPU and RF. Secondly a retrospective case control design was applied to compare the two groups before and after implementation of three preventive interventions [13] to examine the relationship of CRPU with preventive interventions.

2.2 Setting and population

The target population were severely injured TP with C-collar, in need for intensive care. The assessable population were adult TP of a Level one trauma center in a city in the USA, admitted to the surgical trauma intensive care unit (STICU) wearing a C-collar. In 2007, two preventive nursing interventions were implemented. These interventions behold optimizing the diagnostic procedure to exclude C-spine trauma to remove the C-collar within 24 hours, and application of an occipital foam donut to relieve pressure for TP wearing a C-collar.

Selection criteria

Inclusion

- Adult trauma patients
- Wearing a C-collar during admission on the STICU

Exclusion

- Existing skin breakdown before admission on STICU, to prevent an overestimation of prevalence of CRPU
- Severe burn wounds, that is, burning wounds in more than 10 % of total body surface or in the neck. Burn wound influence the fluid balance and skin condition and form a confounding factor for developing CRPU.
- Discharge the day after STICU admission (< 24 hours).

Sample

A convenience sample was used to select eligible TP. For convenience sample the most effortlessly available patients are used as study objects [13]. The sample consisted of 231 TP admitted to the STICU in 2006 and 2008. Charts were retrospectively screened for in- and exclusion criteria and enrolled in the study if eligible by the student investigator and A. Galer (preceptor and trauma coordinator) after Institutional Review Board (IRB) approval was obtained. The procedure for identifying eligible charts was written by the student investigator in consultation with the trauma coordinator.

2.3 Ethical consideration and privacy

Because of the retrospective nature of this study no harm, disadvantage or discomfort was caused for participants. Therefore, ethical review was not necessary. The IRB of Elmhurst Hospital Center, Mount Sinai Center and Pace University approved this study and the staff of the STICU was involved in designing the research methods and set-up. Anonymity was established by anonym coding and securing the data and agreements were made about storage, analysis, reporting and publishing data.

2.4 Data collection

Data collection procedure

Previous research demonstrates that PU in TP develop in 8-12.5 days [23, 24, 27] and CRPU develop after 3 days of ICU admission for 83.6 % of the TP [9]. Data (RF, CRPU categories and patient characteristics) were collected the first 14 days of admission with a data collection tool. The content of this tool was based on the theoretical framework of Defloor (1999) and the opinion of an PU-expert for ICU patients. Data were obtained by two investigators in March and April 2010 and collected from two periods in the past, one year (2006) before and one year after the implementation of the interventions (2008), on a standardized electronically scannable data collection sheet. The lapse of time between those two periods of data collection assured the interventions to be implemented properly, preventing information bias. Data were obtained from paper as well as electronic records. Two electronic records were used, namely Healthmedics ®, containing Emergency Department admission notes from 2008 and Quadramed ®, containing hospital admission information. Data were collected until C-collar removal or until discharge from STICU. When TP were admitted for more than 14 days, collection of RF discontinued, but charts were further screened for development of CRPU, to ensure unbiased prevalence figures.

Interrater reliability

In order to assess consensus between the two investigators, interrater reliability was calculated, using three statistical techniques. Independently collected data of ten TP were used to compute Kappa for nominal data and Pearson's correlation coefficient for the ratio data [28, 29], with a significance level $\alpha < 0.05$. Kappa varied between 0.6-1.00, and Pearson's correlation was 0.731-1.00, indicating a moderate to very good agreement and relationship. The percentage of agreement was calculated for ten items from the data collection tool, because n was low, varying from 1-3. All had a percentage of 100%, for one item it was 90%. Kappa and Pearson's correlation were not significant for three items. The causes for disagreement between these items were clarified.

2.5 Variables

Demographic variables

Demographic variables were collected to describe sample characteristics to generalize the results to other populations with comparative characteristics [13] and determine whether the two groups before and after implementation of the interventions are homogeneous and thus comparable. These variables were age, gender, race, mechanism of injury, Injury Severity Score (ISS), Revised Trauma Score (RTS), and type of injuries.

Risk factors

A total of 25 risk factors were studied, applicable to the population under study, all based on the previously reviewed studies for (CR)PU in trauma patients, PU in trauma patients [10-12, 27, 30, 31], PU in ICU patients [7, 8, 19-21] and placed within the concepts of the conceptual framework of Defloor (1999). Not all identified RF could be studied, because of the data collection was retrospective.

Compressive forces and Shearing forces

Nine RF related to duration and intensity of compressive forces were studied: type of C-collar and duration of application, length of stay (LOS), Body Mass Index (BMI) of > 27 indicating overweight, number of surgical interventions during admission, Glasgow Coma Score (GCS) of < 8 indicating impaired consciousness and decreased mobility [32], history of diabetes mellitus, multiple sclerosis, spinal cord injury, para or tetraplegia, and Ramsay scores of > 3, indicating deep sedation level and low cooperation [33].

Tissue Tolerance

Severity of illness is related to tissue tolerance. High severity of illness was operationalized by collecting data concerning four RF namely Acute Physiology And Chronic Health Evaluation (APACHE) scores of > 25, indicating >55% death rate [34], Revised Trauma Score (RTS) of ≤ 11 [35], Injury Severity Scores (ISS) of ≥ 15 [36], indicating high severity of injuries and (the duration of) mechanical ventilation.

Tissue tolerance for oxygen

Five RF related to TTO were studied. Oxygen supply to tissue can be decreased by tobacco use, administration of inotropics, medical history of atherosclerosis. Impaired circulation during admission was operationalized by a low hemoglobin level indicating anemia and a Mean Arterial Pressure (MAP) of < 60 mmHg. Oxygen needs increase with high body temperature (> 101 Fahrenheit), indicating fever.

Tissue tolerance for pressure

Seven RF related to TTP were studied. These are Body Mass Index (BMI) < 18,5, indicating underweight, age > 65 years, negative fluidbalance indicating dehydration, long term administration of corticosteroids, and days without nutrition indicating malnutricion. Level of decreased sensory perception was operationalized by administration of analgetics during STICU admission. Seven critical events (see Appendix 1) were added, to operationalize the severity of illness. The events were defined in collaboration with ICU staff and a PU expert. All seven critical evens behold RF influencing Tissue Tolerance.

Collar Related Pressure Ulcers

CRPU were documented following the guidelines of the NPUAP [37], describing categories and the location of PU. The NPUAP defines four categories of PU, adding categories: deep tissue injury and one unstageable. Next to that, date of first registration was collected.

Preventive Interventions

TP admitted to the STICU were assessed to identify risk for development of PU using the Braden Scale. The institution in which this study was conducted, a structural program to prevent PU development is applied to all TP admitted to the STICU. This program beholds a regular assessment of PU risk calculating the Braden scale score. The Braden scale is composed of six subscales (sensory perception, activity, mobility, moisture, friction and nutrition) and uses nursing observations to predict the risk for PU development on a 6-23 scale [38]. Other parts of the preventive program were assessment and optimizing nutritional state and skin condition, and turning and repositioning the immobile patient every two hours. Every TP was placed on a pressure relieving mattress. Braden Scale scores at the day of admission were collected. Next to that, data of the two implemented interventions (spinal clearance < 24 hour, occipital foam donut) to prevent CRPU were collected.

2.6 Data analysis

Data were analyzed after proceeding it into a suitable data base, using the program Statistical Package for the Social Sciences (SPSS), with a significance level of α 0.05. Continuous and categorical data were transformed RF with a binary score, representing either presence or absence of RF. Some continuous data were converted to categories representing cut-off values, based on literature.

Descriptive statistics

In order to describe characteristics of the sample, descriptive statistics were calculated. For continues data, means and standard deviations and for categorical data frequencies and percentages were calculated. From this description of sample characteristics, it can be determined whether this is representive for the population.

Prevalence figures

Prevalence figures were calculated to define a set of TP from the total population of TP, admitted to the STICU, who developed CRPU at a certain point of time. These figures are expressed as a percentage [5].

Compare means

The students' T-test for independent groups was used to calculate mean population differences in the patient groups before and after implementation of interventions (2006 and 2008), for continuous data. The Chi Square test was used to calculate differences between patient groups for categorical data.

3. Results

3.1 Recruitment

The sample was incomplete because not all charts were reviewed for inclusion. Not all included charts were used for data collection because of time restriction of the research project. 231 TP were admitted to the STICU in the year 2006 and 2008. Of these TP, 107 patients met the inclusion criteria, and 82 charts still need to be reviewed for inclusion in the sample. From the group with 107 TP, data of 88 TP was collected, 44 charts from 2006 and 44 charts from 2008, and 19 charts are pending for data collection (see Appendix 2).

3.2 Description of the study population

Mean age of the sample was 43.7 years (Standard deviation SD 19.6) and 70 (80%) TP were male. Baseline characteristics are outlined in table 1. Most TP were Hispanic or White (n=42, n=38). The major part of trauma was caused by fall (32%) and pedestrian struck (24%). Mean Braden scale score for the total sample was 15.1 (SD2.9) indicating a low risk for PU. 11 TP (12%) had a Braden scale score of < 13, indicating a high to very high risk for PU, see table 2. No significant difference was found for the baseline characteristics, comparing 2006 with 2008, except for injuries of extremities (12 versus 4, p = 0.03). The mean ISS, APACHE and RTS scores indicate a prediction of high survival rates at the day of admission and the mean GCS score of 11.8 (SD3.7) indicates moderate brain injury at admission.

3.3 Risk factors

Compressive and shearing forces

RF related to compressive and shearing forces are presented in table 3 and 4. All TP were exposed to the compressive force of a rigid C-collar. For 18 TP the rigid C collar was replaced for a semi-rigid C-collar, when long term treatment was to be expected. No significant difference between 2006 and 2008 was found, except for the medical history (5 versus 10, p=0.05). More TP were deep sedated on day 1-4 (Ramsay scores > 4) in 2008 (28 versus 36), approaching significance with p=0.06. Although not significant, (p=0.08) 14 TP in 2008 had a BMI of > 28 compared with 8 TP in 2006. Significant differences in Ramsay scores >4 are outlined in table 4, for day 1,2,3,4 of admission, indicating deeper sedation in 2008 in the first 4 days of admission, compared with 2006.

Tissue Tolerance

Tissue tolerance is influenced by the severity of illness. RF are presented in table 4 and 5. Significant difference in number of ventilated TP for 2006 and 2008 was found (27 versus 36, p=0.03) , although mean days of ventilation were lower in 2008. Next to that, a significant difference in RTS scores < 11 was found (11 versus 23, p= 0.03). No differences were found in hemoglobin (HB) levels between groups, but the percentage of TP with low HB was high, 41%-100% in the first 14 days of STICU admission. Of all TP with at least one registration MAP < 60 mmHg during 24 hours, mean MAP (in 24 hours) was never < 60 mmHg (except for day 14). For the major part of TP with high body temperature, the number of mean values (per 24 hour) > 101 F were drastically reduced (see table 4).

Recorded events are outlined in table 6. The major part of events were episodes of fever during the first week of admission. The first two days of admission, low MAP was a RF for 15 TP.

Tissue tolerance for oxygen and pressure

Documented RF that may influence the TTO and TTP are outlined in table 4 and 5. If TP had an episode of fever during a day, most of the time the average temperature was not over 101 F, indicating no fever. Next to that, the average MAP was never below 60 mmHg, although during the day incidences of MAP < 60 mmHg occurred. A high percentage of TP had a low hemoglobin level in the first 4 days of admission (46.6%- 65.7%). If the TP was still admitted on day 7 and 14, hemoglobin was low for almost every TP.

3.4 Prevalence, location and stages of CRPU

The prevalence of CRPU was 3/88 (3.4%). CRPU was first documented at day 12, 26 and 32. One patient was admitted in 2006 (Case A), and two in 2008 (Case B + C). Case C developed CRPU in the first two weeks of admission in which data of RF were collected. Case A and B developed CRPU after 3 and 4 weeks of admission. During this period, data collection concerning RF was terminated after day 14 of admission. All CRPU cases were admitted to the STICU because of multi trauma due to pedestrian stuck. Length of stay was 35, 36 and 40 days and C-collars were applied until discharge. Case B and C had the rigid C collar replaced for a Miami ® C collar and an Aspen ® C collar. All the three cases were mechanically ventilated for an extended period of time and underwent 3 or more surgical interventions during STICU admission. Data concerning RF and patient characteristics are delineated in table 8.

All cases had two or more records of critical evens during the first two weeks of admission. Recorded critical events for case A were fever during 2 weeks and in the first two days a MAP of < 60 mmHg. For Case B recorded critical events were low MAP in the first two days of admission, day 3-7 of admission one episode of low saturation (<90%), 3 episodes of fever and two episodes of low MAP. The second week of admission, this TP had two episodes of low saturation, SLED for 2 days and 3 episodes of fever. For Case C critical events were an episode of arrhythmia, three episodes of fever from day 3-7 and three episodes of fever during day 8-14.

3.5 Preventive interventions

Preventive interventions are outlined in table 7. Unless implementation of optimized diagnostic process to minimize the time in C-collar, C-Spine clearance within 24 hours is not significantly different between 2006 and 2008 (p=0.14).

4. Discussion

4.1 Results

It is clear that CRPU in TP admitted to the STICU, are not a major problem in this institution, since the prevalence of CRPU is only 3.4 percent, for TP admitted > 24 hours. Purpose of this study was to identify RF for TP, admitted to the ICU. By identifying these RF and studying the implemented preventive interventions on the outcome of CRPU, this study should provide a direction in determining plausible preventive interventions. It was not possible to answer all the research questions about establishing a relationship for two reasons. First, the data set was incomplete; we were not able to review the complete sample. Second, the collected data was not suitable for statistical analysis, because of the small number of CRPU (n=3) and it was clear that there was no relationship between RF collected in the first 2 weeks of admission and development of CRPU on day 32 and 36 of admission. For that reason, the results of this study were descriptive.

Only three TP developed CRPU during admission, located at the occiput and chin. CRPU occurred on day 12, 26 and 32, which was late compared to the study results of [23, 24, 27] describing a first registration of (CR)PU in TP after 3 - 12.5 days. All RF represented in these TP were similar to the RF found for TP without CRPU. Nevertheless, considering registered ISS, RTS, GCS and APACHE scores, only case A was critically ill at admission. This case developed CRPU after 26 days; the other cases developed CRPU after 12 and 36 days. The only RF that differed from the TP without CRPU was length in C-collar (35 and 40 days). TP without CRPU were in the C-collar for a maximum of 9 days.

Risk factors

Compressive and shearing forces

Compressive and shearing forces were excerted by the C-collar and LOS. Data concerning the type of C-collar was incomplete, because of poor registration in the charts. Mean LOS was 8.8 (SD 9.9) days, and during this stay TP were in the C-collar for 4.6 (SD 7.6) days. Previous research shows that TP were longer in the C-collar, namely for 8.8, 10.3 and 10.8 days [9-11]. This may imply that this RF was less represented in this study sample. The number of TP with a medical history influencing compressing forces and the number of sedated TP was (almost) significantly higher in 2008 compared to 2006 (p=0.05, p=0.06), indicating that TP from 2008 were exposed to more RF.

Tissue tolerance

Data shows a low presence of RF representing tissue tolerance. On one hand, this is caused by the characteristics of the patients under study. TP in this sample are young (mean 43.7 years) and healthy considering the absence of medical history, and a good nutritional state (mean BMI 26.8). On the other hand, TP admitted to the STICU are critically ill, but data shows that fever, hemodynamic and oxygenation disorders were dealt with efficiently by applying rapid nursing and medical intervention for stabilization (table 4). Significant differences were found concerning number of ventilated TP, RTS cores <11 and Ramsay scores >3, which may indicate more critically ill TP in 2008. Although we found two cases with CRPU in 2008, and one in 2006, no conclusions can be drawn, because of the incomplete dataset.

Preventive interventions

In 2007, two interventions were implemented for the prevention of CRPU, namely C-spine clearance within 24 hours of STICU admission and application of a foam donut. Ham, Van Os-Medendorp, Witten, Gerkes & Leenen (2009) conclude that early C-spine clearance reduces probability of development of CRPU [39]. In 2006, 11 TP were cleared within 24 hours, compared with 19 in 2008, but no significant difference was found. Relieving pressure by applying foam donut in the occipital area was applied to all TP admitted in 2008. McInnes, Bell-Syer, Dumville, Legood, & Cullum (2008) reviewed the effectiveness of pressure relieving support surfaces and concluded that this intervention might decrease the incidence of PU [40]. Unfortunately, data in this study was not sufficient to determine if these two interventions were related with a decrease of CRPU. Allthough we were not able to determine a statisitcal relationship, common sense and results from previous studies imply that these preventive interventions may be an explanation of the overall low prevalence figures of CRPU.

4.2 Strength and Limitations

Strengths

One strong aspect of this study is the use of the conceptual framework of Defloor (1999). The framework was used as an organizing structure and as a theoretical rationale for the studied risk factors [14, 41]. This enhances the comprehensiveness of study results. Conceptual models provide a broad presentation of understanding the phenomenon [13], therefore research findings placed within this framework are more meaningful and generalizable. To collect the data, a data collection tool was developed. Variables were build on research findings and the conceptual framework of Defloor (1999), which enhanced content validity. Next to that, content of the data collection tool was discussed and reviewed by a PU-expert. Data collection was done by two independent researchers. By designing an instruction form for data collection and calculating

Kappa and Pearson's correlation inter-rater consensus could be established and information bias prevented.

Limitations

A limitation of this study is the incomplete data set, which is a major threat to information bias. Unless this limitation, all steps within this study i.e. background, introduction, methodology, data collection, results discussion and conclusions were chronologically presented in this article because of educational value of this thesis (as part of the requirements for the Master in Nursing Science at the University Utrecht). The sample size is small and TP could not be randomly assigned. Next to that, TP in 2008 appeared more severely ill than 2006. These are threats to selection bias. Because of differences between TP in 2006 and 2008, external influences could not be excluded [13]. The sample is not representative for the total population of critically ill TP, because readmitted TP from the ward to the STICU were excluded. The retrospective design of this study implies limitations and will lead to information bias. First, not all RF within the theoretical framework of Defloor (1999) were registered in the patient charts: Environmental temperature, edema and maceration of the skin underneath the C-collar. The use of tobacco was not consistent registered, resulting in a high amount of missing data. Next to that, if the TP was not mechanically ventilated and the condition was stable, not all vital signs were registered or laboratory test were done. It was not possible to calculate APACHE scores, because of missing data. This may have resulted in a misleading high APACHE scores, indicating high severity of illness for the reviewed TP. It is not possible to confirm that preventive interventions were done systematically and uniform. Turning the ICU patient is often considered difficult and potentially problematic, and instructions are not always followed [26, 42]. Although prevalence of CRPU is low, prevalence figures would probably be lower if TP admitted for less than 24 hours would not have been excluded for this study. Cautiousness has to be taken into account when generalizing these results to other settings.

4.3 Implications for the future

Implications for further research

Future research should first of all be aimed on completing the data collection of the total sample. If the found results and conclusions are the same as for the incomplete sample, it would be desirable to confirm the results in a multi centered study in order to achieve a bigger sample size and increase generalizibility [13]. The design should be prospective to decrease the probability for information bias and to collect more risk factors within the conceptual framework of Defloor (1999). This would also create a possibility to test the conceptual framework of Defloor (1999), by comparing research results with the conceptual framework based hypotheses [13]. Secondly, an effect study to evaluate the effect of implemented interventions would be valuable to determine the merit of preventive interventions.

Implication for practice

In practice, medical staff should be aware of possible risk factors. Regular assessment of the skin and nutritional state might be helpful to prevent the development of CRPU. Next to that, preventive interventions should be implemented. C-spine clearance protocols should be optimized to decrease the time in a C-collar and rigid C-collars should be replaced for semi-rigid C-collars when long-term treatment is indicated.

5. Conclusion

In conclusion, prevalence of CRPU in TP within this incomplete data set is very low, 3.4 %. One TP developed CRPU on the chin before the implementation of preventive interventions and two TP developed occipital CRPU after the implementation. Although we were not able to determine a statistical relationship between RF, preventive interventions and the prevalence of CRPU, the descriptive data shows an overall low presence of RF. Nurses were trained to provide, evaluate and document preventive care. Although no statistical conclusions could be drawn, the descriptive results of this study emphasize the importance of structural preventive care based on reduction of RF.

Table 1 Baseline Characteristics

Characteristics		Total sample	2006	2008	P value[1]
Gender	Male n (%)	70(80)	37(42)	33(38)	0.29
Race	n (%)				
Asian/Pacific	*n=3 missing*	7(8)	4(9)	3(7)	0.72
Black		5(6)	1(2)	4(10)	
Hispanic		37(42)	20(47)	17(40)	
Other		3(3)	2(5)	1(2)	
White		33(38)	16(37)	17(40)	
Type of Injuries	n (%)				
Head/Neck		75(85)	38(86)	37(84)	0.76
Face		15(17)	9(20)	6(14)	0.40
Chest		22(25)	10(23)	12(27)	0.62
Abdomen		22(25)	13(30)	9(20)	0.33
Extremities		16(18)	12(27)	4(9)	0.03*
External		52(59)	27(61)	25(57)	0.67
# systems	n (%)				
injured		42(48)	21(48)	21(48)	0.13
1		27(31)	11(25)	16(36)	
2		14(16)	9(20)	5(11)	
3		3(3)	3(7)	0	
4					
Mechanism	n (%)				
PES		21(24)	13(30)	8(18)	0.21
FLL		28(32)	14(32)	14(32)	-
CRH		0	0	0	-
GSW		3(3)	2(5)	1(2)	0.56
SW		2(2)	0	2(5)	0.15
ASS		13(15)	4(9)	9(20)	0.13
MVA		14(16)	6(14)	8(18)	0.56
MCC		2(2)	1(2)	1(2)	-
Other		3(3)	3(7)	0	0.08
Age (years)	Mean (SD)	43.7(19.6)	11.3(17.0)	10.7(22.1)	0.67
BMI	Mean (SD)	26.8(5.2)	26.4(3.0)	27.1(6.1)	0.50
ISS	Mean (SD) *n=3 missing*	13.5(9.1)	12.5(7.9)	14.6(10.0)	0.29
RTS	Mean (SD)	11.4(1.8)	11.6(1.7)	10.7(2.0)	0.12
GCS	Mean (SD)	11.8(3.7)	12.2(3.9)	11.3(4.0)	0.30
Braden score	Mean (SD) *n=4 missing*	15.1(2.9)	15.5(2.5)	14.8(3.1)	0.29
APACHE	Mean (SD) *n=36 missing*	13.7(6.6)	12.9(6.2)	14.5(7.1)	0.38

PES= Pedestrian Struck; FLL=Fall; CRH=Crush; GSW= Gunshot Wound; SW= Stab Wound; ASS= Assault; MVA= Motor Vehicle Accident; MCC = Motor Car Crash; BMI= Body Mass Index; ISS= Injury Severity Scale; RTS= Revised Trauma Score; GCS= Gascow Coma Scale; APACHE= Acute Physiology And Chronic Health Evaluation.
*=Significant p-value

[1] P-Value for differences between groups calculated with independent T-Test for continuous data and Chi-squared for categorical data

Table 2 Braden scale score at admission

n=88	n (%)
No risk (>18)	7 (8)
Low risk (15-18)	40 (46)
Moderate risk (13-14)	26 (30)
High risk (10-12)	10 (11)
Very High risk (≤ 9)	1 (1)
Missing	4 (4.5)

Table 3 Risk factors related to Compressive and Shearing forces

Risk factor		Total	2006	2008	P-value[2]
LOS (days)	mean (SD)	8.8(9.9)	8.0(1.6)	9.7(1.4)	0.43
LICC (days)	mean (SD) *n=25 missing*	4.6(7.6)	5.3(7.1)	3,9(8.1)	0.52
BMI > 27	n (%) *n=4 missing*	22(26)	8(19)	14(33)	0.08
Sedation					
Yes	n (%)	64(73)	28(63)	36 (82)	0.06
Days	mean (SD)	4.3 (5.1)	4.9 (6.14)	3.7 (4.10)	0.32
Surgical interventions	n (%)				
0		51(58)	31(70)	20(45)	0.10
1		30(34)	9(20)	21(48)	
2		2(2)	1(2)	1(2)	
3		2(2)	1(2)	1(2)	
4		1(1)	0	1(2)	
6		1(1)	1(2)	0	
Mattress type	n (%)				-
DFS2		88(100)	44(100)	44(100)	
DFS3		4(5)	2(5)	2(5)	
GCS ≤ 8	n (%)	21(24)	9(20)	12(27)	0.45
Medical history[3]	n (%) *n=2 missing*	15(17)	5(11)	10(2)	0.05*
Type of C collar[4]	n *n=77 missing*				
Miami®		2	0	2	
Philadelphia®		6	5	1	0.22
Aspen®		1	0	1	
Discharge with C collar	n (%) yes	18	10	8	0.78

LOS= Length of stay; LICC= Length in C-Collar; DSF2= Dynamic Flotation System 2; DFS3= Dynamic Flotation System 3

*=Significant p-value

[2] P-Value for differences between groups calculated with independent T-Test for continuous data and Chi-squared for categorical data

[3] Medical history of atherosclerosis, diabetes mellitus, neuropathy, spinal chord injury, para- or tetraplegia

[4] All TP´s were admitted with a rigid C collar. Treatment of C-spine injury and inability to rule out C-spine injury were indications for a semi rigid C collar. Timing and type were decided by the neurosurgeon.

Table 4 Risk factors per day for 2006 (A) and 2008 (B)

	Day 1 n(A)=44 n(B)=44		Day2 n(A)=41 n(B)=37		Day3 n(2006)=31 n(2008)=25		Day4 n(2006)=19 n(2008)=16		Day7 n(2006)=8 n(2008)=7		Day14 n(2006)=3 n(2008)=2	
Compressive and shearing forces												
Risk Factor												
Ramsay	**	^^	**	^^	**	^^	**	^^	**	^^	**	^^
A n(%)	4 (9)	3 (7)	2 (5)	0 (0)	1 (3)	0 (0)	1 (5)	0	0	0	0	0
B n(%)	21 (48)	15 (34)	15 (41)	12 (32)	9 (36)	7 (28)	6 (38)	4 (25)	1 (14)	1 (14)	1 (50)	0 (0)
P value[5]	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.02*	0.22	0.17	0.17	-	-
GCS	**	^^	**	^^	**	^^	**	^^	**	^^	**	^^
A n(%)	24 (55)	19 (43)	22 (54)	14 (34)	12 (39)	10 (32)	10 (52)	6 (32)	3 (38)	3 (38)	1 (33)	1 (33)
B n(%)	32 (73)	21 (48)	26 (70)	17 (46)	13 (52)	12 (48)	10 (63)	8 (50)	3 (43)	3 (43)	2 (100)	2 (100)
P value	0.08	0.58	0.09	0.24	0.37	0.27	0.45	0.22	0.00	0.61	-	-
Tissue Tolerance for Oxygen												
Risk Factor												
BT	**	^^	**	^^	**	^^	**	^^	**	^^	**	^^
A n(%)	8 (18)	1 (6)	10 (24)	0 (0)	8 (26)	0 (0)	3 (16)	2 (11)	4 (50)	1 (13)	2 (67)	1 (33)
B n(%)	5 (11)	2 (5)	9 (24)	1 (3)	11 (44)	2 (8)	6 (38)	1 (6)	1 (14)	0 (0)	1 (50)	0 (0)
P value	0.46	0.50	0.99	0.29	0.15	0.11	0.14	-	0.05*	0.33	-	-
HB		^^		^^		^^		^^		^^		^^
A n(%)		18 (41)		27 (66)		18 (58)		11 (57)		7 (88)		3 (100)
B n(%)		23 (52)		26 (70)		20 (80)		12 (75)		7 (100)		1 (50)
P value		0.44		0.91		-		0.39		-		-
MAP	**	^^	**	^^	**	^^	**	^^	**	^^	**	^^
A n(%)	3 (7)	0 (0)	1 (2)	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)	1 (13)	0 (0)	3 (100)	3 (100)
B n(%)	9 (20)	0 (0)	8 (22)	0 (0)	4 (16)	0 (0)	2 (13)	0 (0)	1 (14)	0 (0)	1 (50)	1 (50)
P value	0.06	-	0.08	-	0.10	-	0.11	-	-	-	-	-

[5] P-Value for differences between groups was Chi-squared for categorical data

Tissue Tolerance for Pressure
Risk Factor

FB	^^	^^	^^	^^	^^	^^
A n(%)	8 (18)	14 (34)	8 (26)	6 (31)	5 (63)	1 (33)
B n(%)	12 (27)	7 (19)	5 (20)	6 (38)	5 (71)	0 (0)
P value	0.06	0.16	0.62	0.97	0.90	0.60

BT= Body Temperature ; HB= Hemoglobin level; FB= Fluid balance
*=Significant p-value

****** Number of TP with at least one measure of a **value/score** indicating risk in 24 hours
^^ Number of TP with a ***mean*** **value/score** indicating risk during 24 hours

Value/scores indicating risk:

1. Body temperature > 101 Fahrenheit
2. Hemoglobin level ♀< 12gm/dl, ♂< 14 gm/dl
3. Fluid Balance < 0 cc
4. Ramsay ≤ 4
5. Glascow Coma Scale ≤ 8
6. Mean Arterial Pressure ≤ 60 mmHg

Table 5 Risk factors related to Tissue Tolerance

Risk factor		Total	2006	2008	P-value[6]
	Tissue Tolerance				
Mechanical ventilation					
Yes	n (%)	63(72)	27(61)	36(82)	0.03*
Days	mean (SD)	4.59 (6.0)	5.11 (0.9)	4.15 (5.82)	
APACHE 40%-85%	n (%) *n=36 missing*	12(23)	4(15)	8 (30)	0.58
RTS ≤ 11	n (%) *n=3 missing*	34(40)	11(26)	23(53)	0.03*
ISS ≥ 15	n (%) *n=3 missing*	29 (34)	12(29)	17(40)	0.14
	Tissue Tolerance for Oxygen				
Medication[7]	n (%)	6(7)	3(7)	3(7)	0.55
Inotropics					
Yes	n (%)	4(5)	1(2)	3(7)	0.31
Days	mean (SD)	2,25 (0.96)	1	2.76 (0.58)	
Smoker					
Yes	n *n=59 missing*	17	12	5	0.16
	Tissue Tolerance for Pressure				
Age > 65	n (%)	15(17)	6(13)	9(20)	0.40
Days without nutrition	mean (SD)	2.28 (1.6)	2.14 (1.5)	2.43 (1.7)	0.42
Analgetics					
Yes	n (%)	28	11	17	0.21
Days	mean (SD)	1.24 (0.6)	1.58 (0.9)	1.00	
BMI< 18,5	n (%) *n=4 missing*	4(5)	3(7)	1(2)	0.08

[6] P-Value for differences between groups calculated with independent T-Test for continuous data and Chi-squared for categorical data

[7] Chronically use of beta-blockers or corticosteroids

Table 6 Critical Events

Events	Day 1-2 (n=88) n(%)	Day 3-7 (n=56) n (%)	Day 8-14 (n=7) n (%)
CPR	1(1)	0	0
SAT <90%	4(5)	9(16)	1(14)
SLED	0	0	1(14)
Aritmia	0	1(2)	0
Fever	23(26)	23(41)	5(71)
MAP <60 mmHg	15(17)	7(12)	1(14)
ICP	7(8)	5(9)	0

CPR=CardioPulmonary Resuscitation; SAT= oxygen saturation ; SLED= Sustaine Low-Efficiency Dialysis; MAP= Mean Arterial Pressure; ICP= Intra Cranial Pressure

Table 7 Preventive interventions for CRPU

Intervention		2006	2008	P-value[8]
C spine clearance < 24 h	n (%)	11(25)	19(43)	0.14
Occipital foam Donut	n (%)	0	44 (100)	

[8] P-value for differences between groups was calculated using Chi-square test for categorial data

Table 8 Cases with CRPU

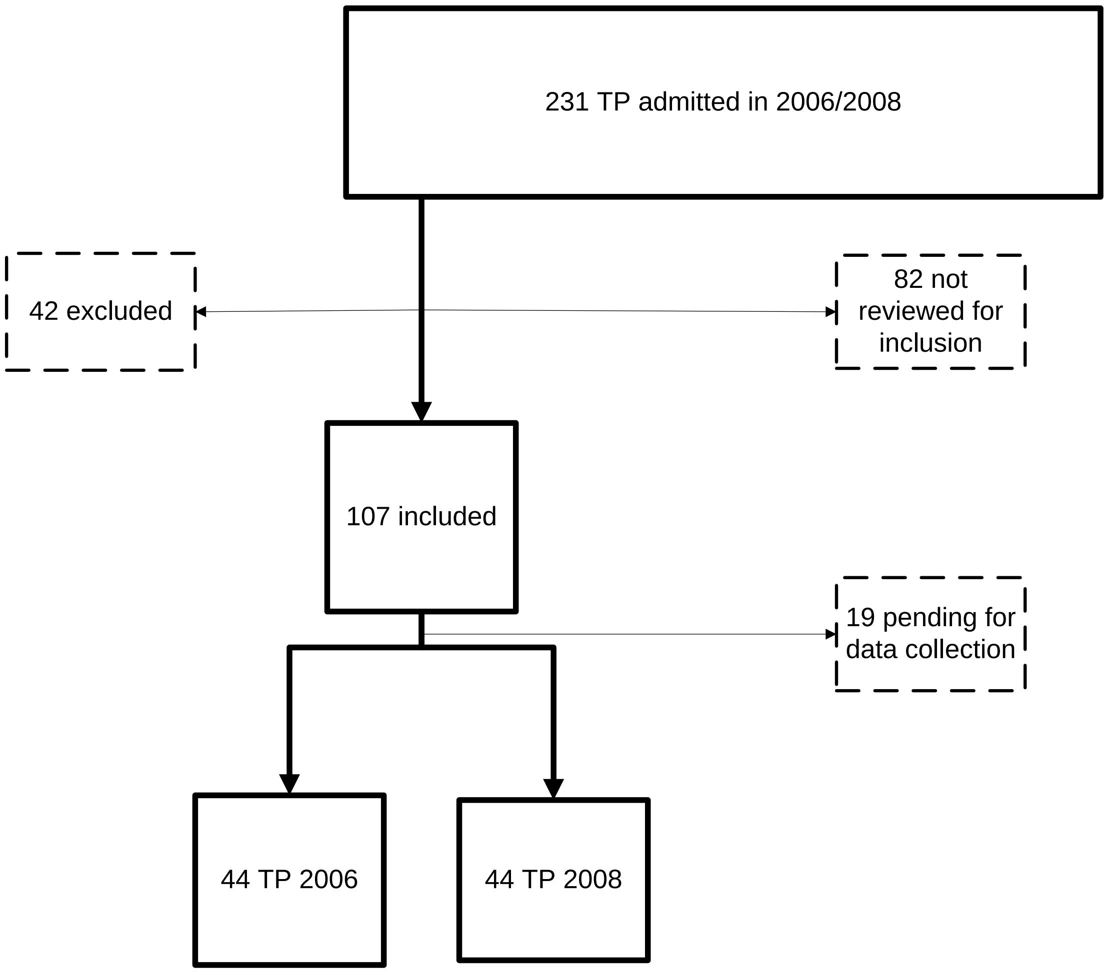
	Case A 2006	**Case B 2008**	**Case C 2008**
Patient characteristics			
Gender	Male	Male	Male
Race	Hispanic	White	White
Type of Injuries	Head/Neck, Abdomen, Extremities	Head/Neck, Extremities	Head/Neck, Chest, External
Injured systems	3	2	3
Mechanism of Injury	Pedestrian struck	Pedestrian struck	Pedestrian struck
Age (years)	20	89	62
BMI	37	25	38
ISS score	8	13	14
RTS score	8	12	11
GCS score	6	15	14
Braden score	11	17	10
APACHE score	21	-	21
First registration CRPU (day)	26	32	12
Highest category of CRPU	3	4	4
Location CRPU	Chin	Occiput	Occiput
Risk factors			
LOS (days)	40	36	35
LICC (days)	40	36	35
Medical history	No	No	No
Chr. Medication	No	No	No
# Surgical Interventions	6	4	3
Mechanical ventilation	Yes	Yes	Yes
Days	15	34	13
Sedation	Yes	Yes	Yes
Days	15	22	13
Type of	Unknown	Miami ®	Aspen ®

Semi-rigid C-collar

Appendix 1 Critical events

1. Cardiopulmonary Resuscitation (CPR), a cardiac or pulmonary arrest requiring medical interventions
2. Sustained Low-Efficiency Dialysis (SLED), a slow, continuous form of dialysis
3. Oxygen saturation of 90 % requiring medical therapy or nursing interventions
4. Fever, an episode of a body temperature of > 101 Fahrenheit, requiring medical therapy or nursing interventions
5. Arrhythmia, an episode of an abnormal rate of muscle contractions in the heart for which medical treatment was indicated
6. Mean Arterial Pressure (MAP) < 60 mmHg for more than 2 times per 24 hours, for which medical treatment was indicated
7. Intra Cranial Pressure (ICP) probe, inserted into one of the lateral ventricles or the brain parenchyma.

Appendix 2 Recruitment



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