Pressure ulcers, indentation marks and pain from cervical spine immobilization with extrication collars and headblocks: an observational study

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**Abstract**

**Objectives**

To describe the occurrence and severity of pressure ulcers, indentation marks and pain from the extrication collar combined with headblocks. Furthermore, the influence of time, injury severity and patient characteristics on the development of pressure ulcers, indentation marks and pain was explored.

**Design**

Observational

**Study Setting**

Level one trauma center in the Netherlands

**Participants**

Adult trauma patients admitted to the Emergency Department in an extrication collar combined with headblocks.

**Methods**

Between January and December 2013, 342 patients were included. Study outcomes were incidence and severity of pressure ulcers, indentation marks and pain. The following dependent variables were collected: time in the cervical collar and headblocks, Glasgow Coma Scale, Mean Arterial Pressure, hemoglobin, Injury Severity Score, gender, age, and Body Mass Index.

**Results**

75.4% of the patients developed a category 1 and 2.9% a category 2 pressure ulcer. Indentation marks were observed in 221 (64.6%) patients; 96 (28.1%) had severe indentation marks. Pressure ulcers and indentation marks were observed most frequently at the back, shoulders and chest. 63.2% experienced pain, of which, 38.5% experienced severe pain. Pain was mainly located at the occiput. ~~BMI was significantly different between patients with and without indentation marks (z -1.9, p 0.05).~~ Female patients experienced significantly more pain (NRS >3) compared to male patients (OR=2.14, 95% CI 1.21 - 3.80) ~~(Chi 8.2, p 0.004).~~ None of the investigated variables significantly increased the probability of developing PUs or indentation marks. ~~Being a female significantly increased the likelihood of experiencing pain with 114% (OR 2.14, p 0.009), compared to being male.~~

**Conclusions**

The high incidence of category 1 pressure ulcers and severe indentation marks indicate an increased risk for pressure ulcer development and may well lead to more severe PU lesions. Pain due to the application of the extrication collar and headblocks may lead to undesirable movement (in order to relieve the pressure) or to bias clinical examination of the cervical spine. It is necessary to revise the current practice of cervical spine immobilization.

**Keywords**

Trauma patient; extrication collar; headblocks; pressure ulcers; indentation marks; pain; risk factors

**Introduction**

**Background**

Injury from trauma is a major cause of mortality and morbidity. In Europe, almost 40 million trauma patients are treated in a hospital for injuries each year. Of these, 5.7 million are admitted to the hospital for severe injuries - more than 112 000 people per day.1 Before hospital admission, trauma patients are admitted to the Emergency Department (ED). Over 60 countries worldwide use the Advanced Trauma Life Support to assess and evaluate trauma patients in the ED. The program prescribes to immobilize patients with appropriate immobilization devices in case of suspected spine injury. An extrication backboard and an extrication collar, often combined with headblocks, are utilized for prehospital immobilization.2 The backboard should be removed as soon as possible after patient presentation in the ED. 2-4 The extrication collar and headblocks immobilize the cervical spine. Immobilization with an extrication collar combined with headblocks should be continued without backboard, but by straight alignment of the spine and supine body position.

The extrication collar and headblocks are applied to protect the *possible* injured spine in the acute phase and will be applied temporary until injury is diagnosed or excluded. Although the (possible) injured spine is protected, the application of immobilizing devices may increase risk for pressure ulcer (PU) development and pain. 5 In order to immobilize, the extrication collar and headblocks will produce succinct pressure on the skin and underlying tissues, and it is well known that PUs result from sustained pressure (including pressure associated with shear). 6

In practice, ED nurses noticed profound indentation marks from the extrication collar and headblocks after removal. These indentation marks demonstrate the extreme discomfort related to the collar and headblocks. They are caused by pressure and may therefore be an early sign of PU development. However, they have not been described systematically before.

Depending on the severity, PUs are known to cause pain and affect physical, social, psychological and financial aspects of health-related quality of life.7-9 Although the application of the extrication collar and headblocks is temporary, if patients do have cervical injury and need further treatment with a long-term collar, they could be extra vulnerable for future PU development. Furthermore, the pressure from the extrication collar and headblocks, combined with the supine body position, may cause pain. It is well possible that pain and discomfort from immobilizing devices may lead to undesirable movement of the head and spine, in order to relieve the pain.

There are no studies on pain and PU development from extrication collars combined with headblocks in trauma patients. 5 The purpose of this study was to prospectively describe the occurrence and severity of PUs, indentation marks and pain from the extrication collar combined with headblocks. Furthermore we explored the influence of time, injury severity and patient characteristics on the presence of PUs, indentation marks and pain in trauma patients with suspected spine injury, admitted to the ED for evaluation and treatment.

**Methods**

**Design, setting**

From January to December 2013, we conducted an observational study in a level one trauma center in the Netherlands.

**Participants**

All consecutive trauma patients aged ≥ 18 years admitted to the ED with standard spinal immobilization were eligible for the study. The backboard was removed before the initial assessment in the trauma room, leaving the patient in extrication collar and headblocks in supine position. Patients with existing skin breakdown, severe burn wounds (>10% body region), and patients who were transferred from the ED to another hospital or from another hospital to our ED were excluded.

**Dependent variables**

Main study outcomes were the incidence and severity of PUs, indentation marks and pain.

PUs were categorized according to the four categories of the International Pressure Ulcer Classification System. 10 (Table 1) 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. 11 Indentation marks were defined as: ‘mild’ or ‘severe’. ‘Mild’ indentation represents indentation marks without a bordering skin reaction (example 1) and ‘severe’ indentation (example 2) represents indentation marks with bordering skin reaction (tumor and/or rubor). Pain was measured with the Numeric Rating Scale (NRS) (0-10). Pain was considered mild when a patient scored 1-3 points, moderate in 4-6 points and severe in 7-10 points.

**Independent variables**

To explore the influence on the development of PUs, indentation marks and pain, the following variables were collected: time in the cervical collar and headblocks, Glasgow Coma Scale (GCS), Mean Arterial Pressure (MAP), hemoglobin level (HB), Injury Severity Scores (ISS), gender, age, and Body Mass Index (BMI). ‘Time in the cervical collar and headblocks’ was measured from ED admission to removal, in minutes. These variables are based on risk factors as described in the international PU guidelines from 2009. 10

**Data collection**

Patients were selected for the study by senior nursing staff after primary assessment in the trauma room. Trained ED nurses collected data just before and just after removal or replacement of the extrication collar and headblocks. Data were recorded on a structured data collection form. Nurses assessed skin areas exposed to pressure from the extrication collar and headblocks as described in literature: chin, occiput, clavicles, back, chest and ears.5 Pain scores were measured just before removal or replacement of the extrication collar and headblocks. Patients were asked to rate pain specifically related to skin areas exposed to pressure of the extrication collar and headblocks. Pain was not measured in patients with limited cognition (Glasgow Coma scale score <14, or intoxication) or patients who were incapable to rate pain numerically. After removal of the extrication collar and headblocks, time of removal was documented, and skin areas exposed to pressure from the extrication collar and headblocks were assessed for PUs. If skin assessment was not possible in specific areas it was documented. If redness, PUs or indentation marks were present, the skin was photographed. All photographs were examined for presence and severity of indentation marks by the first author (WH). Data on potential risk factors and baseline characteristics (mechanism of injury, age, gender, and ISS) were collected from medical records (WH).

**Bias**

To minimize information bias, ED nurses were trained to identify and categorize PUs from photographs prior to this study. 12 During the study, the trained ED nurses used a handout with descriptions and illustrations of PU wounds corresponding to the PU categories during data collection. ED nurses were trained to use the transparent disc method. During the study, inter-rater reliability was assessed. The principal investigator (WH) and seven different ED nurses independently observed pressure areas. Observations from WH were considered as a reference. Kappa for these observations was high: 0.85 (p<0.001), however, due to the acute nature and often out-of-hours care for trauma patients, only 7 nurses were evaluated.

**Sample size**

No sample size was calculated prior to the study; whereas this was the first study on pressure ulcers, indentation marks, and pain from extrication collars and headblocks. Historical trauma data showed that 1200 trauma patients were treated each year in the study setting. Unfortunately the proportion of patients with suspected spinal injury was unclear. Therefore we chose the pragmatic approach and planned a period of recruitments of 12 months.

**Missing data**

In 51 patients, 59 (1.7%; 59/3361) values were missing ~~at random~~ on BMI (n=21), MAP (n=13), HB (n=18), ISS (n=5), “time in collar’ (n=1) and GCS (n=1). As there were no obvious reasons for the missing values, they were assumed to be missing at random and we performed multiple imputations with the fully conditional specification method 13 (five iterations) on all variables. The resultant pooled data were used for data analysis.

**Data analysis**

The Statistical Package for the Social Sciences (SPSS) 20.0 program for data analysis was used (Version 20.0, Armonk, NY: IBM Corp.) As data were not normally distributed, continuous variables were described with medians and Quartiles (Q1, Q3); categorical or dichotomous variables were described with frequencies and percentages. Incidence figures were described as proportions and defined as percentage of patients with PU, indentation marks or pain; if patients had multiple PUs or indentation marks, we described the most severe lesion or mark. We constructed 95% confidence intervals (CIs) around proportions (Clopper-Pearson exact method). 14

The two-sided Mann-Whitney test and chi-square test were used to compare risk factors in patients with and without PUs, indentation marks and pain. The SPSS program calculates the tests for all iterations, however calculates solely mean ranks for the pooled data. The Mann Whitney U-test, z values and p values were therefore calculated by hand, using the exact same formulas that were applied by the SPSS program on the five iterations. Logistic regression (enter method) was used to explore the association of time, injury severity and patients’ characteristics with the development of PUs, indentation marks and pain. We used the “enter-method”: all variables were entered simultaneous. We chose this analysis because this is an explorative study with a small set of independent variables. Pain was considered present at a pain score of NRS >3; only these scores were used for analysis. The level of significance was established at p < 0.05 for all tests.

**Ethical considerations**

The Medical Ethics Review Committee of UMC Utrecht stated that the Dutch Medical Research Involving Human Subjects Acts (WMO) does not apply to this study and official IRB approval is not required under the WMO (protocol number 12/161). Informed consent for the use of data was required. After primary survey at the ED, eligible trauma patients or their legal representatives were given written and verbal information. Informed consent was asked at the ED or within 48 hours after admission (delayed consent). Where photographs were taken patients were portrayed unrecognizably.

**Results**

**Included patients**

In 2013, 623 trauma patients were admitted to the ED with suspected spinal injury; in 57 patients the extrication collar and headblocks were removed directly after arrival in the trauma room and 566 eligible patients remained. Of these, ten patients died within 24 hours without informed consent, 51 refused study participation, six patients were excluded and 13 patients were transferred to another hospital before removal of the extrication collar and headblocks. 144 patients were missed for observation either because their extrication collar and headblocks were removed outside the ED (OR, ICU or Medium Care Unit; n=52) or because the ED was so busy that patient care had to be prioritized over data collection (n=92). Finally, 342 trauma patients were included. (Figure 1)

**Baseline characteristics**

144 (42.1%) were female and the median age was 45 years. Mechanisms of injury were mainly falls (n=124, 36.3%), followed by car crashes (n=100, 29.2%) and cycle crashes (n=56, 16.4%). The majority of included trauma patients had an ISS score between 0-9 (235, 68.7%) and 10-15 (45, 13.2%) indicating minor and moderate injury. 38 (11.1%) and 24 (7.0%) patients had severe (16-24) to very severe (>24) injuries, respectively. Median time in the extrication collar and headblocks was 117 minutes. (Table 2)

**Pressure ulcers and indentation marks**

78.4% (95%CI: 73.6-82.6%) of the patients had PUs after removal or replacement of the extrication collar and headblocks in ED. 258 (75.4%) trauma patients had at least one category 1 lesion as most severe PU, and 10 (2.9%) had at least one category 2 lesion as most severe, with a mean of 2.5 lesions per patients (682/268). (Table 2) Category 1 PUs were mainly located at the chest (19.6%), back (16.1%) and the shoulders (12.6-16.9%). Category 2 PUs were located at the back and shoulders. In 221 patients (64.6%, 95%CI: 59.3-69.7%) indentation marks were identified. All indentation marks followed the pattern of the extrication collar. In 96 (28.1%) trauma patients, we observed at least one severe indentation mark, with a mean of 1.9 marks per patient (428/221). (Table 3) Mild indentation marks were mainly located at the chest (15.5%), back (10.7%) and shoulders (13.5%). Severe indentation marks were mainly located at the back (14.6%). Skin inspection was not possible for occiput (96 times), back (71 times) and chin (2 times), due to wounds or the inability to move.

**Pain**

182 patients (63.2%, 95% CI: 57.3-68.8%) experienced pain (NRS >3). 48 (16.7%) experienced mild pain (NRS 1-3), 71 (24.6%) moderate pain (NRS 4-6) and 111(38.5%) severe pain (NRS 7-10). Pain occurred most frequently at the occiput (160 times). (Table 3) In 288/342 (84%) patients, pain scores were rated. Eight patients were not capable to describe their pain on a numeric scale, seven patients were missed and in 39 patients it was impossible to rate their pain due to impaired cognition.

**Influence of time, injury severity and patient characteristics**

BMI was the most significantly different risk factor between patients with and without indentation marks (z -1.9, p 0.05). Female patients experienced significantly more pain (NRS >3) compared to male patients (Chi 8.2, p 0.004). (Table 4) None of the investigated variables significantly increased the probability of developing PUs or indentation marks. Being a female significantly increased the likelihood of experiencing pain with an OR of 2.14 (p 0.009, 95% CI 1.21 – 3.80), compared to being male. (Table 5)

**Discussion**

This is the first study on PUs, indentation marks and pain from the extrication collar and headblocks, in real trauma patients. We found very high incidence figures of PUs (78.4%), indentation marks (64.6%), and pain (63.2%).

The incidence of category 1 PUs was very high in our sample. Although category 1 is reversible in most patients, it indicates an increased risk for PU development, and may develop into a more severe PU. 6,15,16 In our study, 2.9% already had a category 2 PU.

The increased PU risk in our sample may also be demonstrated by indentation marks. This is the first study in which skin deformation from pressure (indentation marks) in humans was described. These indentation marks were most severe at the back and shoulders. Although pressure came from the extrication collar and headblocks, the indentation marks clearly followed the pattern of the extrication collar. Padding from the extrication collar was easily displaced in these locations, and the stiff material of the collar indented the skin on the back and shoulders. Results from laboratory and animal studies indicate that deformations of the tissue (in our study caused by the stiff material of the extrication collar) may play a role in cell damage.17 The severe indentation marks (including tumor and rubor), may be an inflammatory reaction and thus a first sign of tissue damage. Especially in case of injury and long-term collar treatment, this may lead to more severe PUs.

Severe pain (NRS 7-10) was experienced in 38.5 % of the examined patients. Although scientific evidence is lacking, practice shows that severe pain from pressure leads to agitation and the urge to move, in order to relieve the pressure. We need to realize that high pain scores hinder the main purpose of the extrication collar and headblocks, which is immobilization. This is potentially harmful, whereas in case of cervical injury, the consequences of movement may be fatal. Furthermore, pain can bias in the clinical evaluation of the C-spine, which results in prolonged immobilization.

Pain occurred most frequently at the occiput. This can be explained by the fact that trauma patients remain in supine position, while in extrication collars and headblocks. This position increases the mechanical load on the occiput. The increased mechanical load on the occiput could lead to PU development on the occiput, however, in our study, most of the PUs were located on the back and shoulders. This is deviant from literature while severe occipital PUs from cervical collars are described as a complication of collar use. 18-21 The inspection of the occipital area is a challenge, which may explain the relatively small numbers of occipital PUs in our study. The inability to turn, hair, wounds, dirt or stains hinder proper inspection. Occipital PUs may therefore be detected in a later but worsened stadium. 21

None of the investigated variables were significantly associated with the development of PUs or indentation marks. However, increased age may play a role in PU development (OR 1.01, p 0.09), and BMI in the development of indentation marks (OR 1.04, p 0.06). Age is a known risk factor for PU development, 6, 22 and BMI may increase the probability to develop indentation marks as adipose tissue may be more sensitive to indentation.22 A bigger sample size would have decreased the risk for a type 2 error, and thus increased the possibility of finding significant variables associated with PU development or indentation marks.

We did find gender (female) to be significantly associated with pain from the extrication collar and headblocks. This may be explained by the fact that there might be sex-related differences in pain experience. Four studies including healthy volunteers and one study with surgical patients reported significantly higher pain ratings in females compared to males. 23-27 Another explanation may be found in the fact that female and male skulls feature morphological differences. 28, 29 Although the extrication collar comes in different sizes, and although anatomical differences between adults and children are considered, no differences in gender are considered in the design. If the design of the cervical collar has actually been based on male features, pain could also be associated with a poor collar-fit.

The application of cervical collars in trauma patients with suspected spinal injury is currently under debate, because of the possible complications. Next to PU development and pain, cervical collars may increase intracranial pressure, and complicate airway management. 30-34

Holla 35 recommends applying the headblocks without the extrication collar (while strapped to a backboard). In his study, the extrication collar did not provide significantly more immobilization compared to immobilization with headblocks alone. Generalization of these results into ED practice is difficult; the study had a small sample size, and participants were strapped to a backboard, which is used for extrication and transportation only (and directly removed in the ED). 2-4

Trauma patients with suspected spinal cord injury should be protected adequately, but we need to reconsider the current practice and used materials. Therefore we strongly recommend seeking safe alternatives to immobilize trauma patient with suspected cervical spine injury. We need to cooperate with industrial designers to develop alternative collars or devices for cervical immobilization, considering different body morphologies. The alternative devices should provide sufficient immobilization, but this should go hand-in-hand with comfort and feasibility. Furthermore, we should minimize time in the extrication collar. This can be achieved by prioritizing clinical clearance and facilitation of timely radiologic imaging and assessment.

Limitations

There are some limitations that should be addressed. This was an explorative study providing evidence on occurrence and severity of PUs, pain and indentation marks, and the influence of risk factors. The results on the influence of risk factors should be interpreted with caution. Although literature and practice may underpin our findings, the significance of risk factors and their corresponding p-values can also be caused by chance, due to multiple testing.

There may also be a risk for selection bias: a large proportion of eligible trauma patients (n=144) were not included in this study. And although the baseline characteristics (age, mechanism of injury and gender) of this group were comparable to the included patients, 52 of the missed patients were critically ill. These patients were hospitalized and transferred to the ward (ICU, Medium Care Unit) or OR, before removal of the extrication collar and headblocks, due to their needs for immediate treatment. Critically ill patients are at higher risk for PU development, while their condition may lead to poor perfusion, bad skin status and immobility, which are known risk factors for PU development.6,10,36 Therefore, our current study results may underestimate the problem compared to the true clinical picture.

This large proportion of missed patients underlines the fact that research in the population of trauma patients in the ED is challenging. Trauma care is acute, not predictable and is provided day-and-night. Therefore, we selected the most pragmatic approach of data collection; by trained ED nurses. Although data collection by multiple individuals enhances the risk for observer bias, training minimized this bias. 12

The pain scores from the extrication collars and headblocks might be biased by other distracting injuries. To minimize this bias we asked alert and awake patients specifically for pain related to the extrication collar and headblocks. Although the influence of distracting injuries is difficult to eliminate in this patient category, we did not find a correlation between pain scores and ISS score. In practice, we observed that pain immediately disappeared, once the extrication collar and headblocks were removed.

There was a risk for information bias, whereas the reliability of the method used for distinction between blanchable redness and non-blanchable redness (i.e. category 1 PU) is ambiguous. Currently there are two methods: the ‘transparent disc method’ and the ‘finger-method’. The methods comprise pressing a transparent disc or finger on the reddened skin to see if it blanches. The literature is not conclusive about which method is the most reliable. Vanderwee et al. found high agreements between the two methods, but slightly more sensitivity for the ‘transparent disc method’. 37 Kottner et al. 38 reported a higher possibility of detecting a non-blanchable redness with the ‘finger-method’, compared to the ‘transparent disc method’, however accuracy of the methods was not studied. In order to increase reliability of the data collection we intentionally chose one of the two methods and considered the ‘transparent disc method’ as most reliable. All ED nurses were trained to apply the latter method.

A last issue is the reliability of distinguishing between category 1 and blanchable redness on skin with indentation marks. The bordering skin reaction (tumor, rubor) from the indentation marks may influence pressure distribution from the disc on the skin or lead to misinterpretation of redness. Unfortunately, there are no studies on diagnostic reliability of category 1 and indented skin.

In summary, we found a high incidence of category 1 PUs and severe indentation marks and high pain scores from the application of the extrication collar and headblocks. Time, injury severity and patient characteristics were not associated with PUs, and indentation marks, however being female was significantly associated with pain from the extrication collar and headblocks. Cervical immobilization for preventive reasons can be lifesaving, but it is necessary to revise the current practice of cervical spine immobilization in the ED in terms of procedures and material use in order to decrease PU risk and pain.

References

1. EuroSafe, Injuries in the European Union, Report on injury statistics 2008-2010, Amsterdam, 2013 Retrieved from http://ec.europa.eu/health/data\_collection/docs/idb\_report\_2013\_en.pdf

2. 'American College of Surgeons Committee on Trauma'. *Advanced Trauma Life Support for doctors, 8th edition.* Chicago: Amer College of Surgeons; 2008.

3. Vickery D. The use of the spinal board after the pre-hospital phase of trauma management*. Emerg Med J* 2001;18(1):51-4.

4. Lubbert PHW, Schram ME, Leenen LPH. Is there a reason for spine board immobilization in the emergency department for patients with a potential spinal injury?*. Eur J Trauma* 2005;31(4):375-8.

5. Ham W, Schoonhoven L, Schuurmans MJ, Leenen LP. Pressure ulcers from spinal immobilization in trauma patients: A systematic review*. J Trauma Acute Care Surg* 2014; 76(4):1131-41.

6. 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. Emilie Haesler (Ed.) Cambridge Media: Osborne Park, Western Australia; 2014.

7. Gorecki C, Lamping DL, Brown JM, Madill A, Firth J, Nixon J. Development of a conceptual framework of health-related quality of life in pressure ulcers: a patient-focused approach*. Int J Nurs Stud* 2010; 47(12):1525-34.

8. Gorecki C, Brown JM, Nelson EA, Briggs M, Schoonhoven L, Dealey C, et al. Impact of pressure ulcers on quality of life in older patients: a systematic review*. J Am Geriatr Soc* 2009; 57(7):15-83.

9. Halfens RJG, Nie van NC, Meijers JMM, Meesterberends E, Neyens JCL, Rondas AALM, et al. *Landelijke Prevalentiemeting Zorgproblemen; Rapportage resultaten 2013.* ; report 2013.

10. European Pressure Ulcer Advisory Panel, National Pressure Ulcer Advisor Panel. *Prevention and Treatment of Pressure Ulcer: Quick Reference Guide.* Washington D.C.: National Pressure Ulcer Advisory Panel; 2009. Retrieved from http://www.npuap.org/wp-content/uploads/2012/02/Final\_Quick\_Prevention\_for\_web\_2010.pdf

11. PUCLAS2 Pressure Ulcer Classification. Retrieved from <http://www.puclas.ugent.be/puclas/e/>.

12. Ham WH, Schoonhoven L, Schuurmans MJ, Veugelers R, Leenen LP. Pressure Ulcer Education Improves Interrater Reliability, Identification, and Classification Skills by Emergency Nurses and Physicians*. J Emerg Nurs* 2014; 23:41-53.

13. Buuren van S. Multiple imputation of discrete and continuous data by fully conditional specification*. Stat Methods Med Res* 2007; Jun;16(3):219-42.13.

14. Clopper CJ, Pearson ES. The Use of Confidence or Fiducial Limits Illustrated in the Case of the Binomial*. Biometrica* 1934; 4(26):404-13.

15. Halfens RJ, Bours GJ, Van Ast W. Relevance of the diagnosis 'stage 1 pressure ulcer': an empirical study of the clinical course of stage 1 ulcers in acute care and long-term care hospital populations*. J Clin Nurs* 2001; 10(6):748-57.

16. Nixon J, Cranny G, Bond S. Skin alterations of intact skin and risk factors associated with pressure ulcer development in surgical patients: a cohort study*. Int J Nurs Stud* 2007; 44(5):655-63.

17. Oomens CW, Bader DL, Loerakker S, Baaijens F. Pressure induced deep tissue injury explained*. Ann Biomed Eng* 2015; Feb:43(2):297-305.

18. Tafti AA, Sajadi S, Rafiei H. Pressure ulcer stage IV caused by cervical collar in patients with multiple trauma in intensive care unit*:* Letter to the editor. *Int Wound J* 2013; 19.

19. Murphy KM, Musiak H. Patient with occipital pressure ulcer requiring continued cervical collar use*. J Wound Ostomy Continence Nurs* 1997; 24(1):58-60.

20. Jacobson TM, Tescher AN, Miers AG, Downer L. Improving practice: efforts to reduce occipital pressure ulcers*. J Nurs Care Qual* 2008; 23(3):283-8.

21. Molano Álvarez E, Murillo Pérez M, Salobral Villegas M, Domínguez Caballero M, Cuenca Solanas M, García Fuentes C. Pressure scores secondary to immobilization with cervical collar: a complication of acute cervical injury [Spanish]*. Enferm Intensiva* 2004;15(3):112-22.

22. Coleman S, Nixon J, Keen J, Wilson L, McGinnis E, Dealey C, et al. A new pressure ulcer conceptual framework*. J Adv Nurs* 2014; 70(10):2222-34.

23. Etherton J, Lawson M, Graham R. Individual and gender differences in subjective and objective indices of pain: gender, fear of pain, pain catastrophizing and cardiovascular reactivity*. Appl Psychophysiol Biofeedback* 2014; 39(2):89-97.

24. Paulson PE, Minoshima S, Morrow TJ, Casey KL. Gender differences in pain perception and patterns of cerebral activation during noxious heat stimulation in humans*. Pain* 1998; 76(1-2):223-9.

25. Frot M, Feine JS, Bushnell MC. Sex differences in pain perception and anxiety. A psychophysical study with topical capsaicin*. Pain* 2004; 108(3):230-6.

26. Feine JS, Bushnell MC, Miron D, Duncan GH. Sex differences in the perception of noxious heat stimuli*. Pain* 1991;44(3):255-62.

27. Morin C, Lund JP, Villarroel T, Clokie CM, Feine JS. Differences between the sexes in post-surgical pain*. Pain* 2000; 85(1-2):79-85.

28. Stevenson JC, Mahoney ER, Walker PL, Everson PM. Technical note: prediction of sex based on five skull traits using decision analysis (CHAID)*. Am J Phys Anthropol* 2009;139(3):434-41.

29. Walker PL. Sexing skulls using discriminant function analysis of visually assessed traits*. Am J Phys Anthropol* 2008;136(1):39-50.

30. Sundstrom T, Asbjornsen H, Habiba S, Sunde GA, Wester K. Prehospital use of cervical collars in trauma patients: a critical review*. J Neurotrauma* 2014; 31(6):531-40.

31. Manoach S, Paladino L. Manual in-line stabilization for acute airway management of suspected cervical spine injury: historical review and current questions*. Ann Emerg Med* 2007; Sep;50(3):236-45.

32. Crosby ET. Airway management in adults after cervical spine trauma*. Anesthesiology* 2006; Jun;104(6):1293-318.

33. Ham HW, Schoonhoven LL, Galer AA, Shortridge-Baggett LL. Cervical collar-related pressure ulcers in trauma patients in intensive care unit*. J Trauma Nurs* 2014; 21(3):94-102.

34. Sparke A, Voss S, Benger J. The measurement of tissue interface pressures and changes in jugular venous parameters associated with cervical immobilisation devices: a systematic review*. Scand J Trauma Resusc Emerg Med* 2013; 21:81-91.

35. Holla M. Value of a rigid collar in addition to head blocks: a proof of principle study*. Emerg Med J* 2012; 29(2):104-7.

36. VanGilder C, Amlung S, Harrison P, Meyer S. Results of the 2008-2009 International Pressure Ulcer Prevalence Survey and a 3-year, acute care, unit-specific analysis*. Ostomy Wound Manage* 2009; 55(11):39-45.

37. Vanderwee K, Grypdonck MH, De Bacquer D, Defloor T. The reliability of two observation methods of nonblanchable erythema, Grade 1 pressure ulcer*. Appl Nurs Res* 2006; Aug;19(3):156-62.

38. Kottner J, Dassen T, Lahmann N. Comparison of two skin examination methods for grade 1 pressure ulcers*. J Clin Nurs* 2009; 18(17):2464-9.

Table 1 Pressure ulcer classification

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| International NPUAP- EPUAP Pressure Ulcer Classification System, 2009  1 |
| Category/Stage I: Non-blanchable redness of intact skin Intact skin with non-blanchable redness of a localized area usually over a bony prominence. Discoloration of the skin, warmth, edema, hardness or pain may also be present. Darkly pigmented skin may not have visible blanching. Further description: The area may be painful, firm, soft, warmer or cooler as compared to adjacent tissue. Category/Stage I may be difficult to detect in individuals with dark skin tones. May indicate “at risk” persons. Category/Stage II: Partial thickness skin loss or blister Partial thickness loss of dermis presenting as a shallow open ulcer with a red pink wound bed, without slough. May also present as an intact or open/ruptured serum- filled or sero-sanginous filled blister. Further description: Presents as a shiny or dry shallow ulcer without slough or bruising. This category/stage should not be used to describe skin tears, tape burns, incontinence associated dermatitis, maceration or excoriation. Category/Stage III: Full thickness skin loss (fat visible) Full thickness tissue loss. Subcutaneous fat may be visible but bone, tendon or muscle are not exposed. Some slough may be present. May include undermining and tunneling.Further description: The depth of a Category/Stage III pressure ulcer varies by anatomical location. The bridge of the nose, ear, occiput and malleolus do not have (adipose) subcutaneous tissue and Category/Stage III ulcers can be shallow. In contrast, areas of significant adiposity can develop extremely deep Category/Stage III pressure ulcers. Bone/tendon is not visible or directly palpable. Category/Stage IV: Full thickness tissue loss (muscle/bone visible) Full thickness tissue loss with exposed bone, tendon or muscle. Slough or eschar may be present. Often include undermining and tunneling. Further description: The depth of a Category/Stage IV pressure ulcer varies by anatomical location. The bridge of the nose, ear, occiput and malleolus do not have (adipose) subcutaneous tissue and these ulcers can be shallow. Category/Stage IV ulcers can extend into muscle and/or supporting structures (e.g., fascia, tendon or joint capsule) making osteomyelitis or osteitis likely to occur. Exposed bone/muscle is visible or directly palpable.  |

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

Table 2 Baseline characteristics

|  |  |
| --- | --- |
| **Patient characteristics** | **Value** |
|  | *Median (Quartiles)* |
| **Age**  | 45 (27, 61) |
|  |  |
| **Time in extrication collar and headblocks (minutes)****Female** | 117 (93, 153) *Frequency (Percentage)*144 (42.1%) |
| **Mechanism of injury** Fall Car crash Cycle crash Scooter  Motorcycle crash  Pedestrian struck  Assault Crush  Strangulation unknown | 124 (36.3%)100 (29.2 %)56 (16.4%)18 (5.3%)15 (4.4%)10 (2.9%)8 (2.3%)7 (2.0%)1 (0.3%)3 (0.9%) |
| **ISS** 0-9 10-15 16-24 >24 | 235 (68.7%)45 (13.2%)38 (11.1%)24 (7.0%) |

ISS: Injury Severity Score

|  |  |  |  |
| --- | --- | --- | --- |
| **Total n (%)****Exact 95% CI (%)** | **Pressure Ulcers**268/342(78.4)73.6-82.6 | **Indentation marks**221/342(64.6)59.3-69.7 | **Pain > NRS 3\***182/288 (63.2)57.3-68.8 |
| **n (%)** | **Blanchable redness** | **Category 1** | **Category 2** | **Mild** | **Severe** | **No** | **Mild** | **Moderate** | **Severe** |
| 49/342(14.3) | 258/342(75.4) | 10/342(2.9) | 125/342(36.5) | 96/342(28.1) | 58/288(20.1) | 48/288(16.7) | 71/288(24.7) | 111/288(38.5) |

Table 3 Incidences

\* NRS: Numeric Rating Scale scores; 1-3=Mild; 4-6=Moderate, 7-10=Severe. CI: Confidence Interval

Table 4 Group comparisons¹

|  |  |  |  |
| --- | --- | --- | --- |
|  | Indentation | Pain | Pressure Ulcers |
|  | No n=121 | Yesn=221 | Mann-Whitney U | No n=106 | Yes n=182 | Mann-Whitney U | Non=74 | Yesn=268 | Mann-Whitney U |
|  | *Median (Quartiles)* | *Median (Quartiles)* | *Median (Quartiles)* |
| GCS*missing*  | 15 (15,15) | 15(15,15)*n=1* | **Z**¹**-0.9****p 0.4** | 15 (15, 15)*n=1* | 15 (15, 15) | **Z -0.7****p 0.5** | 15 (15, 15) | 15 (15, 15)*n=1* | **Z -1.2****p 0.2** |
| ISS *missing* | 4 (1,11)*n=3* | 2 (1,10)*n=2* | **Z -1.5****p 0.1** | 4 (1, 10) | 2 (1, 10)*n=4* | **Z -0.9****p 0.4** | 2 (1,10)*n=4* | 3 (1,11)*n=1* | **Z -0.1****p 0.9** |
| BMI*missing* | 24.3 (21.7, 26.8)*n=8* | 24.7 (22.5, 28.7)*n=13* | **Z -1.9****p 0.05** | 24.6 (22.5, 27.6)*n=9* | 24.8 (22.5, 28.5)*n=8* | **Z -0.7** **p 0.5** | 24.5 (22.3, 27.8)*n=6* | 24.6 (22.2, 28.4)*n=15* | **Z -0.5****p 0.7** |
| Age*missing* | 43 (27, 62) | 46 (28, 60) |  **Z -0.4****p 0.7** | 44 (25.8, 60.3) | 42 (27, 60) | **Z-0.3****p 0.8** | 41 (23.8, 57.3) | 46 (28.3, 61) | **Z-1.6****p 0.1** |
| MAP*missing* | 80 (70,90)*n=6* | 82 (73,91)*n=7* | **Z -0.8****p 0.4** | 81 (73, 93)*n=5* | 83.5 (73.3, 90)*n=6* | **Z -0.03****p 0.97** | 84 (74, 90)*n=3* | 81 (72, 91)*n=10* | **Z-0.2****p 0.8** |
| HB*missing* | 8.8 (8, 9.4)*n=10* | 8.8 (8.1, 9.4)*n=8* |  **Z -0.9** **p 0.4** | 8.9 (8.1, 9.5)*n=8* | 8.7 (8.0, 9.3)*n=8* | **Z-1.6** **p 0.1** | 8.7 (7.9, 9.3)*n=6* | 8.8 (8.1, 9.4)*n=12* |  **Z-1.0****p 0.3** |
| Time in collar*missing* | 120 (94, 159) | 117 (92, 148.8)*n=1* | **Z -0.6** **p 0.5** | 114 (85.8, 146.3) | 117 (92.5, 155)*n=1* | **Z-1.0****p 0.3** | 126 (92, 181.5)*n=1* | 117 (92.3, 149.8) | **Z-1.1****p 0.3** |
|  | *n (%)* |  | Chi-square | *n (%)* |  | Chi-square | *n (%)* |  | Chi-square |
| Gender  *Male* *Female* | 72 (59.5)49 (40.5) | 126 (57.0)95 (43) | **Chi**²**0.2****p 0.7****CC³ 0.11****p 0.74** | 72 (67.9)34 (32.1) | 92 (50.5)90 (49.5) | **Chi 8.2****p 0.004****CC 7.6****p 0.006** | 38 (51.4)36 (48.6) | 160 (59.7)108 (40.3) | **Chi 1.7****p 0.2****CC 1.3****p 0.2** |

¹Medians and Quartiles calculated from original data ² Z Statistic, ³ Pearson Chi-square, ⁴ Continuity Correction

 GCS: Glasgow Coma Scale; ISS: Injury Severity Score; BMI: Body Mass Index; MAP: Mean Arterial Pressure HB: Haemoglobin.

Table 5 Logistic regression (Enter method)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Pressure Ulcers | Indentation marks | Pain > NRS 3 |
|  |  **OR** |  **95% CI** |  **p-value** |  **OR** |  **95% CI** |  **p-value** |  **OR** |  **95% CI** |  **p-value** |
| GCS | 1.06 | 0.93-1.22 | 0.39 | 0.94 | 0.81-1.09 | 0.38 | 0.96 | 0.67-1.39 | 0.83 |
| ISS | 1.00 | 0.99-1.04 | 0.91 | 0.99 | 0.96-1.01 | 0.27 | 0.99 | 0.96-1.03 | 0.70 |
| Age | 1.01 | 1.00-1.03 | 0.09 | 1.00 | 0.99-1.02 | 0.61 | 0.46 | 0.98-1.01 | 0.52 |
| Female\*\* | 0.78 | 0.46-1.43 | 0.43 | 1.19 | 0.71-2.01 | 0.50 | 2.14 | 1.21-3.80 | 0.009\* |
| BMI | 1.00 | 0.95-1.06 | 0.92 | 1.05 | 1.00-1.10 | 0.06 | 1.05 | 0.99-1.11 | 0.11 |
| MAP | 0.99 | 0.97-1.01 | 0.26 | 0.99 | 0.98-1.01 | 0.59 | 0.99 | 0.98-1.02 | 0.94 |
| HB | 1.16 | 0.81-1.67 | 0.41 | 1.15 | 0.86-1.53 | 0.36 | 1.03 | 0.75-1.42 | 0.96 |
| Time in collar | 1.00 | 0.99-1.00 | 0.12 | 0.99 | 0.99-1.00 | 0.31 | 1.00 | 0.99-1.00 | 0.93 |

\* p ≤ 0.05

\*\* Male = reference category

OR: Odds Ratio; CI: Confidence Interval; GCS: Glasgow Coma Scale; ISS: Injury Severity Score; BMI: Body Mass Index; MAP: Mean Arterial Pressure; HB: Haemoglobin.

