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Spinal immobilization in patients after blunt trauma: a retrospective observational study, 2008-2012

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LIST OF ABBREVIATIONS

EMS	Emergency Medical Service
EPR	Electronic Patient Record
GCS	Glascow Coma scale
HET	High Energy Trauma
ICP	Intracranial pressure
MOI	Mechanism of Injury
NPA	National Protocol Ambulance care
NRS	Numeric Rating Scale
OST	On-scene time
SCI	Spinal Cord Injury
TBI	Traumatic Brain Injury
TC	Trauma Center
VRGZ	Safety Region Gelderland Zuid
WHO	World Health Organization

DUTCH SUMMARY

Inleiding: Uitwendige immobilisatie van het wervelkolom wordt door het ambulancepersoneel toegepast bij verdenking van wervelletsel. Immobilisatie kan leiden tot ongewenste (levensbedreigende) neveneffecten, zoals verhoogde hersendruk, ademhalingsproblemen, iatrogene pijn en onrust.

Doel: Inzicht geven in verschillende karakteristieken van de groep patiënten die zijn geïmmobiliseerd na stomp trauma.

Onderzoeksvragen:

- Wat zijn de karakteristieken (patiënten karakteristieken, letsels, meetwaarden, interventies, methode van immobilisatie, negatieve effecten, tijdsintervallen en ziekenhuis bestemming) van patiënten na stomp trauma met immobilisatie van het wervelkolom?
- Zijn er opmerkelijke verandering te zien over de jaren?

Methode: Retrospectief observationele studie in de periode van 2008 tot en met 2012 van geïmmobiliseerde patiënten (≥ 18 jaar). Beschrijvende statistiek werd gebruikt om de data te presenteren. Vergelijken van groepen werd gedaan met de Chi kwadraat toets of de onafhankelijke t-test.

Resultaten: Er werden 1.087 patiënten geanalyseerd waarvan 37,2% klachten van het wervelkolom aangaven en 5,7% symptomen van ruggenmergbeschadiging hadden. Er werden 46,7% van de patiënten volledig geïmmobiliseerd, zonder pijn aan het wervelkolom, maar met afleidend letsel. Partiële immobilisatie werd in 16% gedocumenteerd. Belangrijkste redenen: ademhalingsproblemen, niet passende halskraag, fracturen aan sleutelbeen of onderkaak en onrust. Bij patiënten met intracraniële drukverhoging werd niet gedacht aan het verwijderen van de halskraag (p=0,286). Gerapporteerde negatieve effecten: misselijkheid of braken (7,1%), pijn (0,1%), kortademigheid (0,3%) en onrust (0,3%).

Conclusie / Aanbeveling: Het onnodig immobiliseren komt zeer zelden voor, maar partiële immobilisatie regelmatig. Naleving van de richtlijn bij vermoeden traumatisch hersenletsel ontbreekt, en de definitie van afleidende letsel blijft onduidelijk. Het vaststellen en monitoren van ruggenmergbeschadiging gebeurt inconsequent en een gevalideerd meetinstrument ontbreekt. Er moet een duidelijke definitie van afleidende letsel komen om onnodige immobilisatie te voorkomen. Tot slot kan het rapporteren door ambulanceverpleegkundigen completer en vollediger.

Trefwoorden: Stomp trauma, prehospital, spinale immobilisatie

ENGLISH ABSTRACT

Background: Patients after blunt trauma are being spinal immobilized by ambulance staff if they meet the high risk criteria for spinal column injury. Spinal immobilization is not a benign procedure and can result in different (life threatening) adverse effects.

Objective: To provide insight into the characteristics of pre-hospital spinal immobilized patients after blunt trauma and to determine is ambulance staff is compliant in following the current guidelines of spinal immobilization. .

Research questions:

- What are the characteristics of spinal immobilized patients after blunt trauma and how was emergency care by ambulance staff provided, in terms of eight different variables?
- Are there measurable changes in characteristics over the years?

Study Method: Pre-hospital electronic patient records (≥ 18 years) were retrospectively collected from 2008 through 2012. Descriptive statistics were used to present data, chi-square and independent t- test describing differences in variables.

Results: A total of 1082 patients were analyzed, of which 37,2% had suspicion of spinal column injuries and 5,7% showed symptoms of spinal cord injury. In the population 46,8% received spinal immobilization, but without neck/back pain. Partial immobilization was documented in 16%. Main reasons were: breathing problems, inappropriate fitting collar, clavicle or jaw fractures and combativeness of the patient. No difference in application of a rigid collar in patients with or without high intracranial pressure (p=0,286). Reported adverse effects: vomiting or nausea (7,1%), pain (0,1%), shortness of breath (0,3%) and agitation (0,3%).

Conclusion / Recommendation: Unnecessary spinal immobilization is rare, but partial immobilization is coded frequently. Adherence to the spinal immobilization guideline in traumatic brain injury is lacking, and the definition of distracting injury remains unclear. Progression in time of spinal cord injury cannot be tested by ambulance staff. Finally, documentation by ambulance nurses must be more complete.

Keywords: Blunt trauma, prehospital, spinal immobilization

INTRODUCTION

Patients after blunt trauma with spinal column injuries, such as spinal fractures or dislocations, are at risk of developing Spinal Cord Injury (SCI) due to physical movement or manipulation[1-6]. SCI is defined as a traumatic injury to the spinal cord that results in permanent loss of motor and/or sensory functions[7]. In an European cohort (n=250,584), 13,2% of all severely injured patients after blunt trauma had spinal column injury and 1,8% sustained a SCI[8,9].

In the 1960's, spinal immobilization emerged to limit physical movement of the spinal column[10,11]. Full spinal immobilization consists of the use of a rigid cervical collar, a backboard with straps and supportive head blocks[12,13]. Spinal immobilization is associated with severe adverse effects and causes aspiration, serious breathing problems, increased intracranial pressure (ICP), delirium, dysphagia, pressure ulcers, iatrogenic pain or discomfort[14-36]. Furthermore, the rigid cervical collar could cause deterioration of SCI[37-42]. Full spinal immobilization causes a delay in transportation time to the hospital, which can negatively influences the outcome in patients with SCI[43]. However, the described adverse effects are reported in hospital based research or studies with healthy volunteers and it remain unknown which adverse effects occur within the pre-hospital phase.

Before the Dutch immobilization guidelines changed in 2006 all patients were routinely pre-hospital immobilized, based on the mechanism of injury e.g. high velocity traffic collisions or falls from height. Because of the known adverse effects and low incidence of spinal column injury, new criteria for spinal immobilization were implemented in Dutch National Protocol Ambulance care (NPA) in 2006. These criteria aim to immobilize only the patients who are most at risk of spinal column injury[12,13]. High risk criteria of spinal column injuries for patients after blunt trauma are: neck/back pain or tenderness, altered level of consciousness, neurological deficit, evidence of intoxication and painful distracting injury. As well, the criteria indicate not to apply a rigid collar in patients with signs of Traumatic Brain Injury (TBI). If the new guidelines resulted in appropriated immobilization of patients at risk, is unknown.

PROBLEM STATEMENT

Spinal immobilization is uncomfortable for the patient, can result in pre-hospital time delay, has adverse effects and other factors that influences patients outcome negatively. Current knowledge is mainly hospital based and lacks a full pre-hospital description of the spinal immobilized patient. Furthermore, the compliance of the immobilization guidelines are not known.

AIM OF THE STUDY

The purpose of the study is to provide insight into the characteristics of pre-hospital spinal immobilized patients after blunt trauma and to analyze whether this group is changing over time. Finally, we want to determine whether the ambulance staff is compliant in following the current guidelines of spinal immobilization.

RESEARCH QUESTIONS

1. What are the characteristics of spinal immobilized patients after blunt trauma and how was emergency care by ambulance staff provided, in terms of the following the variables:
   patient characteristics, injury characteristics, physiological measurements, emergency interventions, methods of spinal immobilization, adverse effects, time-intervals and differences in transport destination?
2. Are there changes in the characteristics over the study time period (2008-2012)?

METHODS

Study design

The study method was a retrospective chart review. The aim of this descriptive research was to observe, describe and document aspects of a situation as it naturally occurs, making this design appropriate to answer the research questions, as well as having the advantage of being time and cost effective[44]. This research method did not require an approval of the Medical Ethical Review Committee on Research in Humans. We selected data for the time period between January 2008 and December 2012.

Population and setting

This study was conducted in the Netherlands, within the region of Nijmegen. This is an urban and rural region with approximately 530,000 inhabitants. Pre-hospital emergency care in this region is provided by the Emergency Medical Service (EMS) of the safety region Gelderland-Zuid (VRGZ). The ambulances are, as throughout the Netherlands, staffed with two EMS professionals: ambulance nurses, who are legally authorized to treat patients according to the NPA and ambulance drivers who are trained in driving under emergency response conditions, and to assist the ambulance nurse with medical and nursing procedures[45].

Study population

We selected patients with the suspicion of spinal injury, who received a high priority of the ambulance dispatch centre. For these patients the ambulance must be on site within 15 minutes after the emergency call (A1 urgency). Further inclusion criteria for the patients were: ≥ 18 years of age; received full or partial external immobilization; transport destination to either Radboud University (level 1 Trauma Centre) or Canisius Wilhelmina Hospital (level two Trauma Centre). We excluded patients transported inter-hospital or by helicopter.

Data collection

Patient data files were obtained from the Electronic Patient Records (EPR) of the EMS VRGZ. The EPR was completed by the ambulance nurse and consisted of structured (coded) and unstructured (free text notes) data. Coded fields obliged to fill in existed of the following categories: name, date of birth, gender, address data, insurance policy, administered medication, time intervals and hospital destination. Remaining coded data and free text notes were documented in the EPR on personal preferences of the ambulance nurses.

Data from the EPR was provided to the researcher in a Microsoft Excel spread sheet, without any reducible patient identifiers, by the medical manager of VRGZ. Agreements with respect to confidentiality and storage of the data were made with the medical manager of VRGZ. The Microsoft Excel spread sheet consisted of 1086 patient cases. Each patient case had 88 different coded variables of which 25 met the research questions, and five different free text fields.

Variables and measurements

Patient characteristics

The patient characteristics were divided into gender, age, type of accident and alcohol use.

Injury characteristics

Injury characteristics were divided into three categories, spinal column injuries, spinal cord injuries and associated injuries. Spinal column injury and SCI were existing variables in the coded data file and coded if signs of symptoms were recognized by the ambulance nurse. In associated injuries two variables were defined conceptually. Signs of increased ICP, defined as: evidence for head trauma, a sluggish or non-reactive pupil combined and altered level of consciousness (GCS < 14)[13]. Suspicion of cranial bleeding consisted of the coded data from intracranial injury and subarachnoid hemorrhage.

Physiological measurements

The level of pain experienced by the patient was operationalized with the Numeric Rating Scale (NRS)[46]. This scale is an 11-point scale, with a score between 1-3 indicating mild pain; between 4-6 moderate pain; and between 7-10 severe pain. Consciousness was measured with the GCS and categorized into three groups: severe (GCS 3–8); moderate (GCS 9–12); and mild (GCS 13–14).

Emergency interventions

Emergency interventions included interventions in management airway, oxygen supplementation, ventilation (bag-valve mask or laryngeal tube) and the administration of medication.

Adherence to the spinal immobilization protocol

Adherence to the spinal immobilization protocol is measured by analysing the reasons for full and partial immobilization. Full spinal immobilization defined as: application of a rigid collar, backboard with straps and supportive head blocks. In partial immobilization patients only received a rigid collar or only backboard with straps. Full spinal immobilization is indicated in patients after blunt trauma with: neck/back pain or tenderness, altered level of consciousness, neurological deficit, evidence of intoxication, painful distracting injury and communication difficulties due to extremes of age, language barriers or intellectual disabilities[47]. Partial immobilization, by means of removal of the rigid collar, is only indicated in patients with with signs of increased ICP or combativeness/resistance of the patient[13]. Immobilization only based on a mechanism of trauma forceful enough to cause spinal injury, is referred as High Energy Trauma (HET). Immobilization only based on HET was done without any complaints or symptoms of injury to the spinal column, distracting injuries, altered level on consciousness or communication problems.

Adverse effect

The adverse effects analysed were: vomiting or nausea, shortness of breath, pain or discomfort and resistance or combativeness.

Time intervals

Time intervals were classified as: on-scene time (OST); transportation time to the hospital; dispatch to hospital time; and two additional cut off times (< 45 and < 60 minutes from dispatch to hospital)[12,13].

Destination to hospital

We selected two hospitals in the city of Nijmegen, a level 1 and a level 2 TC. In the Netherlands Level 1 TCs are designated to provide the highest level of trauma care. Both hospitals are approximately 3 kilometers apart.

Data analysis

Coded data

The coded variables from the Excel sheet consisted of one of more individual items. These items were screened on relevance and deleted if necessary. Syntaxes have been made to record all of the procedures and information was documented in a codebook.

Free text fields

In the Excel spread sheet there were five different free text fields. Manifest content analysis was used to analyze these free text notes[48]. This quantitative research method was focused on counting the frequency of the following reported pre-defined characteristics: alcohol use, symptoms of high intracranial pressure, nausea or emesis, adverse effects and method of spinal immobilization.

Coded categorical data were presented in absolute numbers and percentages; for continuous variables, we reported the mean and standard deviation (SD). A boxplot was used to show the age distribution between males and females.

Differences in frequencies of variables between level 1 and 2 TC were analyzed by Chi-square-tests, differences in mean scores with the independent t-test. Differences in mean age over the five years study period was calculated with one-way analysis of variance and differences over time in categorical variables by chi-square.

P values of ≤ 0.05 were considered as significant for all tests. IBM SPSS statistics version 20.0 was used to analyze the data.

RESULTS

Between January 2008 and December 2012, 1089 patients were spinal immobilized after blunt trauma and 654 admitted to a Level 1 TC and 428 to a Level 2 TC.

Patient characteristics

Coded data:

Patients in this study had a mean age of 43 years (SD ± 18,3) and 59,4% (n=643) were male (table 1). Patients of 65 years and older represented 14% (n=151) of the total study population, with the oldest patient being 93 years old. The use of alcohol was coded in 1,3% (n=14) of the cases. In 69,6% (n=756) of all cases, the type of accident was missing. The other data (remaining 30%) showed that road traffic accidents were the leading cause of injury (19,4%, n=211).

Free text notes:

Alcohol use was documented in 11,6% (n=126) of the cases.

From coded and free text data there were no significant changes of characteristics over time.

Injury characteristics

Coded data:

Suspected spinal column injuries were coded in 37,2% (n=404) of all cases. From the study sample 5,7% (n=62) of the patients showed symptoms of SCI. From associated injuries, head injuries were reported in 33,7% (n=365); thoracic injuries 13,5% (n=146); abdominal injuries 3,7% (n=40); pelvic injuries 2,1% (n=23); hip injuries 1,2% (n=13); and extremity injuries 8,9% (n=97).

Free text notes:

Signs of increased ICP were document in 6,9% (n=75).

Number of spinal column injuries showed a significant decrease over the 5 year study period (p=0,001) as well as abdominal injuries (0,023).

Physiological measurements

Coded data:

Severe loss of consciousness was coded in 5,6% (n=61) at arrival of the ambulance and moderate loss of consciousness in 6,1% (n=66) of all cases (table 2). There were 36 scores missing and the remaining 919 patients did have an GCS of 14 or 15. Data on pain was absent in 71,2% (n=770) of the patients after arrival of the ambulance on-scene. A second assessment of pain, at arrival ED, was missing in 93,2% (n=1008). The pain intensity at arrival of the ambulance was divided in 18,5% (n=201) reported no pain; 2,2% (n=24) mild pain; 3,4% (n=37) moderate pain; and 5,0% (n=54) severe pain. There is a significant decline in documentation of the NRS scores over the 5-year study period, from 55,1% in 2008 to 17,3% in 2012 (p=0,000).

Free text notes:

N/A

Emergency interventions

Coded data:

Techniques that were used to open or to clear the airway, administered oxygen and assisted breathing are reported in Table 3, whereby oxygen administration was coded in 5,8% (n=63). The other techniques varied between 0,2% (manually opening airway and bag-mask ventilation) and 0,6% (oropharyngeal airway).

Analgetics were given to 23,7% (n=256) of the patients through single drug treatment using Fentanyl, Ketamine, Nitrous oxide/oxygen mixture, Paracetamol. Drug combinations consisted of Ketamine and Fentanyl (1,6%, n=17); Paracetamol and Fentanyl (2,0%, n=22); or nitrous oxide/oxygen mixture and Fentanyl (0,2%, n=2). A significant increase of Fentanyl (p=0,035) and metoclopramide (0,010) administration is documented over the years.

Free text notes:

N/A

Adherence to the spinal immobilization protocol

Coded data:

Table 4 shows that full spinal immobilization was coded in 74,8% (n=809). In most cases of partial immobilization (n=106) the ambulance staff did not applied the rigid collar. The number of patients only immobilized by backboard decreased over the years (p=0,000).

Free text notes:

In the study population 26,4% (n=286) of the patients did complain of neck/back pain or tenderness. About half of patients (46,8%, n=506) received spinal immobilization, although they did not complain of neck/back pain. The combination of trauma mechanism and other (non-spinal) injuries was the reason for spinal immobilization. Partial immobilization was explained in 2,2% (n=24). Main reasons for partial immobilization were: breathing problems, not appropriate fitting rigid collar, clavicle or jaw fractures and combativeness or resistance of the patient. Immobilization only based on HET, without any other complaints of the patients, was reported in 1,7% of the cases (n=18). Immobilization because of difficulties in examining the cervical spinal region was recorded in 21,1% of the cases (n=228). The main reasons for the inability to examine the cervical region were identified as: language barriers;

alcohol/drugs use; and impaired consciousness. Finally, there was no difference in application of a rigid collar between groups with or without signs of high ICP (p=0,286)

Adverse effects

Coded data:

Vomiting or nausea was coded in 0,9% (n=10) of all cases. Other adverse effects could not be entered.

Free text notes:

Documentation of vomiting or nausea was documented in 7,1% (n=77). Half of the patients that experienced nausea or vomiting (50,6%, n= 39) received an anti-emetic drug (Metoclopramide). In 4,5% (n=45) of cases the antiemetic drugs were prophylactically administered. Seven remarks (0,6%) were made on adverse effects due to the rigid collar. These remarks can be summarized as: pain (0,1%, n=1); shortness of breath (0,3%, n=3); and agitation (0,3%, n=3).

The documentation of adverse effects is minimal and there is no increase over the years notable.

Time-intervals

Coded data:

The mean OST was 0:25:33 (hours:minutes:seconds), SD ± 0:10:22 (n=1055). In 45,0% (n=488) of all cases the ambulance reached the hospital within 45 minutes, and in 80,2% (n=871) the hospital was reached within 60 minutes.

Free text notes:

N/A

Destination hospital

Coded data:

Patients with suspicion of spinal injuries were relatively more often transported to the Level 2 TC (44,4%, n=190), rather than the Level 1 TC (32,4%, n=212), p < 0,00 (Table 8). There is also a non-significance difference in patients presenting with pain in the cervical spinal region and subsequent admission to a Level 2 hospital (p= 0,06). No difference was found in transporting patients with suspicion of SCI to a Level 1 or Level 2 hospital (p=0,890). (Severe) Head trauma was significantly related with admission to a Level 1 TC (p < 0,00). Only six patients (0,6%) with signs of increase ICP were admitted to the ED of a Level 2 hospital. Related to this, patients with decreased consciousness were significantly more often admitted to the Level 1 TC (p< 0,00).

Free text notes

N/A

DISCUSSION

In our data we demonstrated that 37,2% (n=404) of the patients were directly suspected of spinal column injury and 5,7% (n=62) showed symptoms of SCI. Very few adverse effects (0,6%) associated with spinal immobilization have been reported. Deviation from full spinal immobilization was found to be 16% (173/1082). Full spinal immobilization only based on HET occurs in 1,7%. Characteristics that differ over time were: number of spinal column injuries (p=0,001); number of abdominal injuries (p=0,023); decline of NRS (0,000); administration of Fentanyl (p=0,035) and Metoclopramide (p=0,010); and decline in application of rigid collar (backboard only) (p=0,000).

The adherence of prehospital spinal immobilization protocol is of great importance in order to immobilize only patients with a high risk of spinal column injury. Unnecessary immobilization (over immobilization) can increase the adverse effects and other factors that influences patients outcome negatively, whereas under immobilization can increase the risk of SCI. Domeier et al.[49] demonstrated in a large prospective study, that 12% of the patients received pre-hospital spinal immobilization when this was not required. In our study the over immobilization is low, 1,7%. Maybe the actual number of over immobilized patients is higher because the criterion of distracting injury is not well defined in the Dutch NPA. We found that 46,7% of the spinal immobilized patients did not have neck/ back pain, altered level of consciousness, neurological deficit or evidence of intoxication but had distracting injuries. Subjectivity of the criterion causes possibly a high number of unnecessarily spinal immobilized patients. Distracting injury is defined by the Dutch NPA as: long bone fractures, visceral injury requiring surgical consultation, large laceration, degloving or crush injury, large burns and any other injury producing acute functional impairment[13]. Domeier et al. defined distracting injury simply as: suspected extremity fracture proximal to the wrist or ankle. Lastly, we could not demonstrate an adherence of the PHTLS guideline were removal of the rigid collar is advised in cases of high intracranial pressure. We think that further reduction of unnecessary immobilization is warranted by clarifying and improving the pre-hospital immobilization guidelines.

Previous research provided us with scientific knowledge of adverse effects due to spinal immobilization. Kwan et al.[50] found that 55% of healthy volunteers complained of moderate to severe pain due to spinal immobilization within 30 minutes. Bauer and Kowalski[25] demonstrated in healthy volunteers a restrictive respiration after spinal immobilization. From the free text notes we did not find large numbers of documented adverse effects due to spinal immobilization. It is not clear why adverse effects are not documented by ambulance staff. A possible explanation could be that the pre-hospital time is too short for the occurrence of adverse effects. Another explanation is that pre-hospital data is not complete and adequately documented. Documentation by ambulance staff is, in a sense, a criterion for appropriate care and important to trauma research[51-53]. The World Health Organization (WHO) states that there is a need for pre-hospital generated knowledge that establish the effectiveness of interventions[54]. We found that on a number of coded variables data was not consistent or missing.

LIMITATIONS

This study, the first with a pre-hospital overview of characteristics of spinal immobilized patients after blunt trauma, knows different limitations. Data is obtained from one of the 25 EMS organizations and might not be representative of spinal immobilized patients nationwide. However, we think that the results are of interest for other ambulance services because we included both rural and urban areas and used a large study sample.

Another limitation is that a relevant amount of the coded data was missing at random because it was obliged to fill in by ambulance staff. Gaps in EMS documentation have been previously reported[55,56]. Because we studied coded data and perform free text analysis we tried to minimize information bias.

A potential limitation is that SCI is not well defined and ambulance nurses could have used subjective criteria to code SCI and therefore it can be over or underestimated.

CONCLUSION / RECOMMENDATION

This study give us more in-depth information concerning the characteristics of patients that received spinal immobilization. The results indicate that unnecessary immobilization is rare. Still, there can be made some improvements. Adherence to the spinal immobilization guideline in TBI is lacking, and definition of distracting injury remains unclear. Signs of SCI cannot be tested by ambulance staff, so progression in time is not noticeable. A validated pre-hospital instrument in measuring SCI should be developed to evaluate changes in spinal immobilization guidelines. Finally, attention should be given to the completeness en reliability of data registry and the culture within the ambulance services in contributing to scientific research. Management and staff of the Dutch ambulance services must be encouraged so that their digital records can contribute to future experimental research into the effectiveness and value of external spinal immobilization.

CONFLICT OF INTEREST

The authors of this article declare that they have no personal or financial interests with people and/or parties who can affect the study results.

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APPENDICES

Figure 1, Age distribution

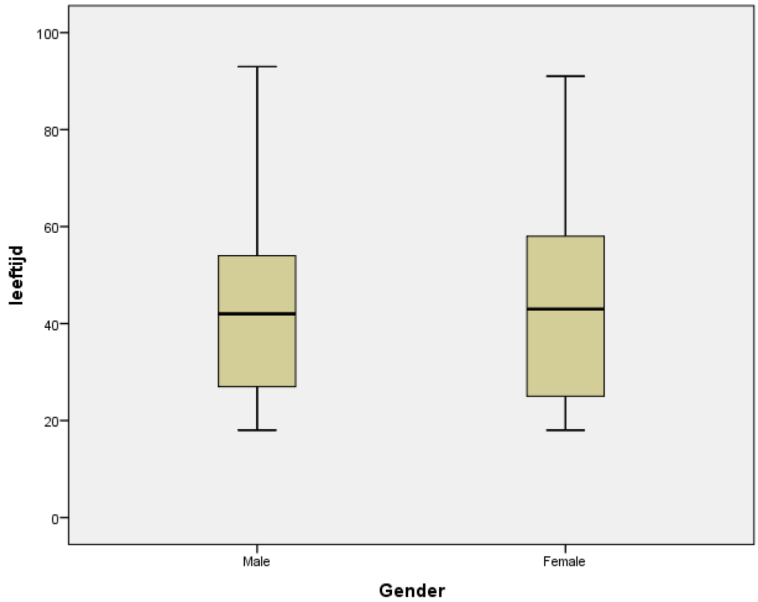

Table 1, Patient characteristics[1, 2, 3, 4]

	Total n=1082	2008 n=234	2009 n=219	2010 n=204	2011 n=211	2012 n=214	P value
Gender, % (n)							
Female	40,6 (439)	35,5 (83)	39,7 (87)	42,6 (87)	40,3 (85)	45,3 (97)	0,290
Male	59,4 (643)	64,5 (151)	60,3 (132)	57,4 (117)	59,7 (126)	55,7 (117)	0,290
Missing	0	0	0	0	0	0	
Age							
Years , mean (SD)	43,1 (18,3)	41,4 (17,0)	42,9 (17,9)	45,4 (19,3)	43,1 (18,8)	43,01 (18,5)	0.265
Maximum age	93	88	84	91	93	91	
≥ 65 year, % (n)	14,0 (151)	9,8 (23)	12,8 (28)	19,1 (39)	14,7 (31)	14,0 (30)	0,084
Missing	0	0	0	0	0	0	
Alcohol use, % (n)							
Coded data	1,3 (14)	3,4 (8)	1,4 (3)	0,5 (1)	0,9 (2)	0 (0)	
Free text notes	11,6 (126)	11,5 (27)	14,1 (31)	10,8 (22)	10,4 (22)	11,2 (24)	0,766
Type of accident, % (n)							
Traffic	19,3 (209)	22,6 (53)	16,9 (37)	20,6 (42)	18,0 (38)	18,2 (39)	0,541
Home	6,1 (66)	6,0 (14)	6,8 (15)	6,9 (14)	5,2 (11)	5,6 (12)	0,937
Sports	1,6 (17)	2,1 (5)	1,8 (4)	1,0 (2)	1,4 (3)	1,4 (3)	
Work	2,6 (28)	2,1 (5)	3,2 (7)	1,5 (3)	2,8 (6)	3,3 (7)	
Other	0,7 (8)	1,7 (4)	0,5 (1)	1,0 (2)	0 (0)	0,5 (1)	
Missing	*69,7 (754)*	*65,4 (153)*	*70,8 (155)*	*69,1 (141)*	*72,5 (153)*	*71,0 (152)*	

[1] When not specifically indicated, data must be interpreted as coded data.
[2] p-value for differences between groups was calculated with Chi-square for categorical data
[3] p-value for categorical data is not calculated by Chi square if the expected value in any category is less than 5
[4] p-value for continuous data is calculated by independent t-test

Table 2, Injury characteristics and physiological measurements [1, 2, 3, 4]

% (n)	**Total n=1082**	**2008 n=234**	**2009 n=219**	**2010 n=204**	**2011 n=211**	**2012 n=214**	**P value**
Spinal column injuries	37,2 (402)	46,2 (108)	42,0 (92)	33,3 (68)	29,4 (62)	33,6 (72)	0,001*
Suspicion of SCI	5,7 (62)	2,6 (6)	7,3 (16)	7,8 (16)	7,1 (15)	4,2 (9)	0,069
Associated injuries							
Head	33,7 (365)	32,5 (76)	34,2 (75)	36,8 (75)	29,4 (62)	36,0 (77)	0,509
Signs of increased ICP, free text notes	6,9 (75)	6,4 (15)	7,8 (17)	4,4 (9)	6,6 (14)	9,3 (20)	0,366
Suspicion cranial bleeding	3,5 (38)	2,6 (6)	4,1 (9)	2,9 (6)	2,8 (6)	5,1 (11)	0,557
Fractured jaw	0,7 (8)	0,0 (0)	1,8 (4)	1,0 (2)	0,5 (1)	0,5 (1)	
Thoracic	13,5 (146)	17,1 (40)	13,2 (29)	10,3 (21)	17,5 (37)	8,9 (19)	0,023*
Abdominal	3,7 (40)	2,6 (6)	2,7 (6)	3,4 (7)	5,2 (11)	4,6 (10)	
Pelvic	2,1 (23)	3,0 (7)	1,8 (4)	2,9 (6)	2,4 (5)	0,5 (1)	
Hip	1,2 (13)	1,3 (3)	2,3 (5)	0,5 (1)	0,9 (2)	0,9 (2)	
Upper extremities	5,5 (59)	12 (28)	7,8 (17)	1,0 (2)	0,4 (4)	0,7 (8)	
Lower extremities	3,5 (38)	6,8 (16)	4,1 (9)	4,4 (9)	0,9 (2)	0,9 (2)	
GCS at arrival ambulance							
3-8	5,6 (61)	7,7 (18)	7,3 (16)	2,5 (5)	5,2 (11)	5,1 (11)	0,132
9-13	6,1 (66)	6,4 (15)	4,1 (9)	7,8 (16)	5,2 (11)	7,0 (15)	0,519
14-15	84,9 (919)	82,9 (194)	86,3 (189)	87,3 (178)	87,2 (184)	81,3 (174)	0,289
Missing	3,3 (36)	3,0 (7)	2,3 (5)	2,5 (5)	2,4 (5)	6,5 (14)	
Report on pain, % (n)							
At arrival ambulance	28,8 (312)	55,1 (129)	32,9 (72)	18,6 (38)	17,1 (36)	17,3 (37)	0,000*
Missing	71,2 (770)	44,9 (105)	67,1 (147)	81,4 (166)	82,9 (175)	82,7 (177)	
At arrival ED	6,8 (74)	17,9 (42)	5,5 (12)	4,4 (9)	2,8 (6)	2,3 (5)	0,000*
Missing	93,2 (1008)	82,1 (192)	94,5 (207	95,6 (195)	97,2 (205)	97,7 (209)	
NRS scores, n at arrival ambulance (n at arrival ED)							
NRS 0	200 (37)	101 (27)	60 (7)	15 (1)	15 (2)	9 (0)	
NRS 1 -3 (mild pain)	24 (18)	5 (5)	2 (3)	6 (4)	5 (3)	6 (3)	
NRS 4 - 6 (moderate pain)	37 (15)	10 (8)	2 (1)	9 (4)	8(1)	8 (1)	
NRS 7 -10 (severe pain)	50 (4)	13 (2)	7 (1)	8 (0)	8 (0)	14 (1)	

[1] When not specifically indicated, data must be interpreted as structured data.
[2] There may be more several interventions per patient performed.
[3] p-value for differences between groups was calculated with Chi-square for categorical data
[4] p-value for categorical data is not calculated by Chi square if the expected value in any category is less than 5

Table 3, Emergency interventions[1,2, 3, 4]

% (n)	**Total n=1082**	**2008 n=234**	**2009 n=219**	**2010 n=204**	**2011 n=211**	**2012 n=214**	**P value**
Respiratory interventions							
Manually opening airway	0,2 (2)	0 (0)	0,9 (2)	0 (0)	0 (0)	0(0)	
Oropharyngeal airway	0,6 (6)	0 (0)	1,8 (4)	0,5 (1)	0 (0)	0,5 (1)	
Suction	0,5 (5)	0,4 (1)	0,9 (2)	1,0 (2)	0 (0)	0 (0)	
Oxygen	5,8 (63)	12,4 (29)	10,0 (22)	4,4 (9)	0,9 (2)	0,5 (1)	
Bag-mask ventilation	0,2 (2)	0 (0)	0,9 (2)	0 (0)	0 (0)	0 (0)	
Endotracheal intubation	0,4 (4)	0,4 (1)	0,9 (2)	0,5 (1)	0 (0)	0 (0)	
Administered medication							
Fentanyl	21,9 (237)	17,1 (40)	17,4 (38)	25 (51)	26,5 (56)	24,3 (52)	0,035*
Esketamine	3,5 (38)	1,3 (3)	3,7 (8)	4,4 (9)	4,7 (10)	3,7 (8)	
Nitrous oxide/oxygen mixture	0,2 (2)	0,9 (2)	0 (0)	0 (0)	0 (0)	0 (0)	
Paracetamol	1,8 (20)	0 (0)	0 (0)	1,0 (2)	2,4 (5)	6,1 (13)	
Metoclopramide	7,7 (83)	6,0 (14)	4,1 (9)	11,8 (24)	6,2 (13)	10,7 (23)	0,010*

[1] When not specifically indicated, data must be interpreted as structured data.
[2] There may be more several interventions per patient performed.
[3] p-value for differences between groups was calculated with Chi-square for categorical data
[4] p-value for categorical data is not calculated by Chi square if the expected value in any category is less than 5

Table 4, Adherence to the spinal immobilization protocol[1,2, 3]

% (n)	Total n=1082	2008 n=234	2009 n=219	2010 n=204	2011 n=211	2012 n=214	P value
Criteria for spinal immobilization, free text notes							
Neck/back pain or tenderness	26,4 (286)	25,6 (60)	26,8 (59)	26,5(54)	25,9 (55)	28,2 (61)	0,968
No neck/back pain, but distracting injuries[4]	46,8 (506)	49,1 (115)	43,6 (96)	45,1 (92)	50,5 (107)	44,9 (97)	0,556
Patient unresponsive	5,3 (57)	6,4 (15)	5,0 (11)	3,4 (7)	5,2 (11)	6,0 (13)	0,681
Inability to examine cervical region[5]	21,1 (228)	18,8 (44)	24,1 (53)	24,5 (50)	18,4 (39)	19,4 (42)	0,332
Missing	0,5 (5)	0 (0)	0,5 (1)	0,5 (1)	0 (0)	1,4 (3)	
Partial immobilization							
Rigid collar only	67	16	14	6	15	16	0,307
Backboard only	106	28	38	12	16	12	0,000*
Partial immobilization, Free text							
Rigid collar only	0,5 (5)	0,4 (1)	0,9 (2)	0,5 (1)	0,0 (0)	0,5 (1)	
Backboard only	1,7 (18)	2,1 (5)	0,9 (2)	1,0 (2)	1,4 (3)	2,8 (6)	
Manual fixation only	0,1 (1)	0,0 (0)	0,0 (0)	0,0 (0)	0,5 (1)	0,0 (0)	
Reasons partial immobilization, Rigid collar only, Free text							
Seated immobilization because of breathing problems	0,2 (2)	0,4 (1)	0,5 (1)	0,0 (0)	0,0 (0)	0,0 (0)	
Lateral position	0,1 (1)	0,0 (0)	0,0 (0)	0,0 (0)	0,5 (1)	0,0 (0)	
No clear documentation	0,1 (2)	0,0 (0)	0,5 (1)	0,5 (1)	0,0 (0)	0,0 (0)	
Reasons partial immobilization, backboard only, Free text							
Combativeness/resistance due to head trauma	0,2 (2)	0,4 (1)	0,0 (0)	0,0 (0)	0,0 (0)	0,5 (1)	
Pain from clavicle or jaw fracture	0,6 (7)	0,9 (2)	0,0 (0)	1,0 (2)	0,5 (1)	0,9 (2)	
Pain sternum	0,1 (1)	0,4 (1)	0,0 (0)	0,0 (0)	0,0 (0)	0,0 (0)	
Severe ear injury	0,1 (1)	0,0 (0)	0,5 (1)	0,0 (0)	0,0 (0)	0,0 (0)	
Presence of a motor suit or thick clothing	0,1 (1)	0,4 (1)	0,0 (0)	0,0 (0)	0,0 (0)	0,0 (0)	
Rigid collar did not fit	0,3 (3)	0,0 (0)	0,5 (1)	0,0 (0)	0,5 (1)	0,5 (1)	
No pain in cervical region	0,1 (1)	0,0 (0)	0,0 (0)	0,0 (0)	0,0 (0)	0,5 (1)	
No clear documentation	0,2 (2)	0,0 (0)	0,0 (0)	0,0 (0)	0,5 (1)	0,5 (1)	
Full immobilization only on HET	1,7 (18)	3,0 (7)	1,8 (4)	0,0 (0)	2,4 (5)	0,9 (2)	

[1] When not specifically indicated, data must be interpreted as structured data.
[2] p-value for differences between groups was calculated with Chi-square for categorical data
[3] p-value for categorical data is not calculated by Chi square if the expected value in any category is less than 5
[4] Any other injury with the exception of abrasions
[5] Main reasons for the inability to examine the cervical region were: language barriers, alcohol/drugs use and impaired consciousness.

Table 5, Partial immobilization (no rigid collar) in patients with signs of increased ICP

n	No rigid collar	Rigid collar	P[1]
Signs high ICP, coded data			0,286
Sluggish or non-reactive pupil	10	65	
Equal and reactive pupils	96	815	

[1] p-value for differences between groups was calculated with Chi-square for categorical data

Table 6, Adverse effects

% (n)	Total n=1082	2008 n=234	2009 n=219	2010 n=204	2011 n=211	2012 n=214	P value[1, 2]
Vomiting or nausea							
Coded data	0,9 (10)	0,9 (2)	0,5 (1)	1,5 (3)	1,4 (3)	0,5 (1)	
Free text notes	7,1 (77)	6,4 (15)	5,0 (11)	10,8 (22)	4,7 (10)	8,8 (19)	0,072
Other, from free text notes							
Pain, free text notes	0,1 (1)	0,4 (1)	0,0 (0)	0,0 (0)	0,0 (0)	0,0 (0)	
Shortness of breath	0,3 (3)	0,0 (0)	0,5 (1)	0,0 (0)	0,5 (1)	0,5 (1)	
Agitation/combativeness	0,3 (3)	0,0 (0)	0,5 (1)	0,0 (0)	0,0 (0)	0,9 (2)	

[1] p-value for differences between groups was calculated with Chi-square for categorical data
[2] p-value for categorical data is not calculated by Chi square if the expected value in any category is less than 5

Table 7, Time intervals , hh:mm:ss

	2008	2009	2010	2011	2012	
On-scene time (OST	**n=230**	**n=208**	**n=201**	**n= 208**	**n=208**	**Total n=1055**
OST, mean (SD)	0:25:33 (0:09:39)	0:26:55 (0:09:47)	0:26:57 (0:13:35)	0:23:42 (0:08:12)	0:24:42 (0:09:50)	0:25:35 (0:10:22)
Transportation time (TrT)	**n=227**	**n=212**	**n=192**	**n=198**	**n=205**	**Total n=1034**
TrT, mean (SD)	0:14:19 (0:07:50)	0:14:56 (0:08:58)	0:15:10 (0:09:15)	0:13:57 (0:07:15)	0:13:52 (0:07:50)	0:14:24 (0:08:14)
Dispatch to hospital time (DtHT)	**n=234**	**n=212**	**n=204**	**n=210**	**n=214**	**Total n=1080**
DtH, mean (SD)	0:49:00 (0:13:00)	0:50:00 (0:15:00)	0:50:00 (0:18:00)	0:47:00 (0:14:00)	0:48:00 (0:19:00)	0:49:13 (0:16:25)
Cut off times DtHT						
≤ 45 minutes, % (n)	42,7% (100)	42,7 (94)	46,1 (94)	48,1 (102)	45,4 (98)	45,0 (488)
≤ 60 minutes, % (n)	81,2 (190)	78,2 (172)	73,5 (150)	84,9 (180)	82,9 (179)	80,2 (871)

Table 8, Destination hospital

	Level 1 TC Nijmegen n= 654	Level 2 TC Nijmegen n=428	Total N=1082	P
Injuries, % (n)				
Head	37,0 (242)	28,7 (123)	365	0,000*
Spinal injuries	32,4 (212)	44,4 (190)	402	0,000*
Suspicion of SCI	5,7 (37)	5,8 (25)	62	0,890
Thoracic	14,7 (96)	11,7 (50)	146	0,158
Abdominal	4,6 (30)	2,3 (10)	40	0,055
Pelvic	12,8 (84)	11,2 (48)	132	0,423
Signs of increased ICP[4], free text notes	10,6 (69)	1,4 (6)	75	0,000*
Spinal region, free text notes				0,06
Neck/back pain	21,6 (141)	33,9 (145)	286	
No neck/back pain	43,4 (284)	51,6 (221)	505	
Missing	35,0 (229)	14,5 (62)		
GCS at arrival				0,000*
3-8	9 (59)	0,5 (2)	61	
9-13	5,5 (36)	0,9 (4)	40	
14-15	81,7 (534)	96 (411)	945	
Missing	3,8 (25)	2,6 (11)	36	
Age distribution				0,684
18-64 year	86,4 (565)	85,5 (366)	931	
> 64	13,6 (89)	14,5 (62)	151	

[1] Data from free text analysis is indicated explicitly, when not indicated it can be interpreted as coded data.
[2] Categorical data is compared by Chi-square

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