Quality management for trauma patients in the emergency department

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Kwaliteits management voor de behandeling van trauma patiënten op de afdeling Spoedeisende Hulp

(met een samenvatting in het Nederlands)

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Introduction and outline of this thesis

Trauma is a surgical disease demanding surgical leadership

CHARLES L SCUDDER,
PRESIDENT OF THE AMERICAN COLLEGE OF SURGEONS,
COMMITTEE ON TRAUMA (1922)

Introduction

From the late 1960s to the beginning of the 1970s, awareness of the importance of a system of trauma care arose in the United States of America. In 1966 traumatic injury or death was described as the most neglected disease of modern society by the National Research Council and the Academy of Sciences [1]. With this document the magnitude of the problem in number and total costs was brought to the attention of the professionals. The document described recommendations for the prevention of traumatic injury but also advised to improve the trauma care system (development of emergency medical services, emergency departments, trauma registries, regionalization, etc). The information and suggestions in this document were used by the Committee on Trauma of the American College of Surgeons to compose their vision on the improvement of trauma care in a document entitled "Optimal Hospital Resources for Care of the Injured Patient" (1976) [2]. The recommendations from the original document in 1966 had been taken into a proposal for guidelines for the care of the injured patients in hospitals but also proposed Regional and State Trauma Systems. The latter included an Inclusive Trauma system, based upon multiple hospitals with different levels of complexity of care. With this report came the awareness that the organization of trauma care is not the responsibility of an individual hospital but of a complete region. Optimal resources should be explained as the best facilities for a specific trauma patient at a specific place and time. This did not explicitly mean that every trauma patient should be treated in a top level trauma care facility. It aimed at providing a dense network of adequate and safe care throughout the country. For an adequate and safe network a combination of a well organized regional and national trauma system and hospitals with different levels of care was deemed essential. Most regional systems were organized around a regional trauma center that could dispose of most resources, professionals and equipment (level I trauma care facility) to handle complex trauma cases. Level II hospitals were also supposed to provide initial definitive trauma care for less complex patients, although their resources may not be as extensive as in a level I facility. Hospitals with a level III assignment should be able to resuscitate patients and arrange for possible transfer to a hospital with more extensive facilities. Resources in personnel and equipment are limited in level III hospitals.

Coincidentally the document about Optimal Resources appeared in the same year that Dr. Jim Styner, an American orthopaedic surgeon, crashed with his plane and found that medical support for him and his family was far below the standard that he expected and needed. His concept of acute trauma treatment was developed into the Advanced Trauma Life Support (ATLS®) and was presented in 1985 by the Committee on Trauma of the American College of Surgeons. In just a few years these guidelines would spread around the world as the universal approach in the primary assessment of trauma patients.

The 1976-document was likewise developed into a guideline for the establishment of trauma organizations and was later renamed “Resources for optimal care of the injured patients”, with the latest version appearing in 2006. A specific “Trauma Performance Improvement Reference Manual” was published in 2002.

Meanwhile in 1982 in The Netherlands the Dutch Association of Trauma Surgery (Nederlandse Vereniging voor Traumatologie, NVT) was established. The discussion about optimal resources and organization resulted in the presentation of a vision document: the Manifest of Dutch Trauma Care in 1987 [3]. This document, like the American documents, focused on regional organization and the possible delivery of specialized trauma care 24 hours a day, 7 days a week with differentiated levels of care in every region according to the availability of resources in equipment, professional experts and severity of the traumatic injury. In The Netherlands, a country with a population of 16 million people, trauma was and still is responsible for an estimated 130,000 emergency department visits per year [4]. This has resulted in approximately 21000 hospital admissions per year nation wide in the past decade of which 10-15% were polytraumatized. It took, however, more then ten years after the publication of the manifest to finally appoint ten level I trauma centers as the coordinating hospitals in ten geographically orientated trauma regions, covering the whole country [5]. In this model, which still functions today, each level I trauma centre has a role as a primary or secondary referral centre for its region with a geographical connection with several regional level II and level III hospitals. This level classification -as in the United States- is based on the complexity and number of patients that can be handled in a specific hospital. Complex patients require extensive resources in facilities, equipment and experienced specialists. For this reason emergency trauma care in Level I facilities is generally provided by teams (consisting of a resident in surgery, anesthesiology, neurology and radiology together with two emergency department nurses and radiology technicians). In smaller level III hospitals primary assessment might be done by a single (junior) doctor. By the time regionalization had found its place, ATLS had also reached The Netherlands and provided a solid base for cooperation in top level centers between different professionals in the primary care of multiple-injured patients. ATLS further developed into the standard of care for all personnel involved in trauma care in- and outside hospitals (emergency physician, surgical resident, emergency medical services, etc).

We are now more then twenty years after the original Dutch trauma manifest was delivered, ATLS was introduced and ten years after the formal appointment of the trauma centers. It is a good moment to assess the quality of some aspects of acute trauma care in The Netherlands in an attempt to evaluate the efforts in organization and finance and estimate the effects of all these investments.

In this thesis research is described in an attempt to answer the following questions:

> Will video registration of trauma team procedures in the emergency department allow us to efficiently and precisely evaluate the overall team performance in a level I trauma centre with emphasis on organization, mutual communication and compliance with accepted (ATLS) protocols?

Patients with a high energy trauma are routinely immobilized by paramedics for reasons of transport. It has become a habit to leave these patients immobilized in the emergency department on these so called "spine boards". Immobilizing devices are only removed after radiologic confirmation of a normal spinal column has been obtained. Prolonged immobilization could lead to the development of pressure ulcers and might not be necessary to prevent clinical aggravation of symptoms in case of spinal column lesions.

> Is there a difference in subjective comfort of several types of immobilizing devices and does this comply with objective pressure measurements?

> Does early spine board removal from trauma patients in the emergency department lead to any adverse effects compared to prolonged immobilization until radiological clearance of the spinal column?

With the introduction of regional trauma systems it is daily practice that trauma patients are primarily assessed in one hospital and later transferred to another hospital. This could either be for clinical reasons (special expertise needed) or logistic reasons (operation or intensive care capacity availability). In most cases patients are transferred to a hospital with a higher level of care (level I facility).

Should interhospital transferred polytrauma patients again be examined and treated by a multidisciplinary trauma team in the emergency department of the receiving hospital to optimize the treatment?

The majority of patients that visit an emergency department are victims of a low energy trauma (fall, bicycle accident, sports injury). Quality assessment is as essential for these patients as it is for multiple injured patients. Multidisciplinary team interaction is not the issue for these patients, but the results of radiological examinations sometimes are misinterpreted which can lead to a delay in diagnosis and treatment.

Is the existing safety net for interpretation of radiological examinations in the emergency department sufficient to prevent delayed diagnosis or any damage to the patient?

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2

Video registration of trauma team performance in the Emergency Department:

the results of a two-year analysis in a level 1-trauma center

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Abstract

Trauma teams responsible for the first response to multiple-trauma patients upon arrival in a hospital consist of medical specialists or resident physicians. We hypothesized that 24-hour video registration in the trauma room would allow for precise evaluation of team functioning and deviations from (ATLS®) protocols.

Patients and methods

We analyzed all video registrations of trauma patients who visited the emergency room of a level 1-trauma center in the Netherlands between September 1, 2000 and September 1, 2002. Analysis was performed with a score list based on ATLS® protocol.

Results

From a total of 1256 trauma room presentations we found a total of 387 video registrations suitable for analysis. The majority of patients had an ISS lower then 17 (264 patients), whereas 123 patients were classified as polytrauma (ISS>=17). Errors in team organization (omission of prehospital report, no evident leadership, unorganized resuscitation, not working according to protocol and no continued supervision of the patient) lead to significantly more deviations in the treatment then when team organization was uncomplicated.

Conclusion

Video registration of diagnostic and therapeutic procedures by a multidisciplinary trauma team facilitates an accurate analysis of possible deviations from protocol. In addition to identifying technical errors, the role of the team leader can clearly be analyzed and related to team actions. Registration strongly depends on availability of video tapes, timely started registration and hardware functioning. The results from this study were used to develop a training program for trauma teams in our hospital that specifically focuses on the team leader's functioning.

Introduction

Acute trauma care puts a large burden on human and financial resources in hospitals. Therefore, just as with all forms of medical care, the quality of its performance needs to be evaluated continuously. In the Netherlands, there are ten Level 1-trauma centers that provide care for multiple trauma patients. A multidisciplinary team available around the clock performs the first assessment of these patients. Medical staff provides care according to the guidelines of the American College of Surgeons (Advanced Trauma Life Support, ATLS®) (adopted by the Dutch Trauma Society with minor modifications for medical staff); nurses follow guidelines as taught in the Trauma Nursing Core Course (TNCC®) [1]. Quality appraisal of these high cost facilities and teams is indispensable for future training and optimization of care. A supervisor who is present at the scene and can intervene if needed can evaluate the effect of medical treatment, but the presence of a supervisor may influence the trauma team's performance. Furthermore, a supervisor is not always present – especially during the night shift. Evaluating trauma teams in action through use of video registration has been used previously; it can take place at any hour of the day and occur unobtrusively, without influencing the team's actions. However, these studies have either been performed in the USA or Australia, or have only analyzed a limited number of patients [2][3][4][5].

In this study, we aimed to analyze team functioning with respect to usage of the ATLS guidelines. We hypothesized that continuous availability of video registration in the trauma room would be feasible and would allow us to efficiently and precisely evaluate the team's functioning and any deviations from (ATLS) protocols. We believed that video registration of our trauma team's procedures would also enable us to compare our results with literature. We also used the video registrations to test our hypothesis that inadequate team leadership and unorganized resuscitation influence the number of protocol violations during primary treatment of trauma patients. Additionally, we analyzed the effect of Injury Severity Score (ISS) and arrival time on the number of deviations from the protocol. Finally, we tried to develop lessons from the registration period to use in future trauma team training.

Material and methods

During a two-year period (September 1, 2000-September 1, 2002), we attempted to register all diagnostic and therapeutic procedures in trauma patients brought into the hospital after the ambulance post (Centrale Post Ambulance – CPA) radioed in their arrival. At our hospital, senior residents from the departments of surgery, anesthesiology and neurology work in cooperation with an ER physician, ER nurses and radiology technicians, who round out the trauma team. The neurology physician is responsible for neurological examination and evaluation of the patient and decides, in cooperation with the other team members, which priority must be given to diagnosis and treatment of neurological disorders (i.e., epidural hematoma, spinal cord injury). In addition, a radiology resident is on-site and can be paged by the trauma team. Trauma team procedures are based on ATLS® protocols. The team is, therefore, lead by an ATLS-certified surgical resident; the anesthesiology resident is also always ATLS-certified. The emergency receiving area is equipped for multidisciplinary resuscitation, and allows for simultaneous X-ray production (on the condition that team members wear lead gowns). Indications for when the CPA is required to radio in patients were agreed upon in the protocol of the Trauma Care Network for Central Netherlands (Traumazorgnetwerk Midden Nederland) and National Dispatch Room and Ambulance Protocol (Landelijk Protocol Ambulancezorg) [6][7]. Apart from the well-known "golden hour" in trauma resuscitation, there are no generally accepted specific time criteria. Other studies have used a time limit of 2 minutes for concluding the primary survey, and 10 minutes to finish the secondary survey [8][9]. We aimed at 7 minutes for completion of the primary survey, including intubation and/or tube thoracostomy, as well as a Focused Assessment with Sonography in Trauma (FAST). Moreover, we aimed for having a definitive treatment plan and a completed secondary survey after 20 minutes and having the patient leave the trauma resuscitation area for the next step in treatment or diagnostic evaluation within 30 minutes.

Video registration

Video footage was recorded by an analogue video system with integrated picture and sound recording capabilities that could be controlled from the trauma receiving area. As previously described by Hoyt et al., we agreed with the hospitals' legal department that video registration was to be used only for quality control purposes [3]. As long as the patients remained anonymous, informed consent did not need to be obtained. Videotapes were consequently coded by a system separate from the hospital's patient database and were erased after evaluation.

The surgical resident on duty was responsible for starting the video registration as soon as he or she arrived and for filing and processing the videotapes. If the surgical resident was detained or absent, the ER physician or a nurse started the registration. After the patient had left the trauma room, the videotape was removed from the recorder and given to the supervising consultant surgeon on call at the next staff meeting (the following morning during the week, or the following Monday on weekends).

Data analysis

The attending surgeon on call reviewed the registration using a video recorder and a standardized score sheet (Table 1). Registrations that were not reviewed by the surgeon because he/she was unavailable were assessed by one of the study investigators. All reviewers were instructed on how to evaluate the videotape with the help of a standardized score sheet that was developed by one of the authors (LL) based on ATLS guidelines. Possible errors with regard to team organization and communication and to errors in medical treatment were also evaluated. Actions performed by medical staff were scored quantitatively (time noted in minutes from arrival) and qualitatively, based upon timeliness, adequacy and duration of action. All actions performed outside the hospital before arrival in the emergency room that took at least one minute were noted (-1.00 minutes). For this reason, some mean and median times contain negative values and therefore cannot be used for statistical analysis.

The Handbook for Trauma Performance Improvement Review System was used to assign the qualitative score [10]. If no errors were made, the session was regarded as good. Deviations from protocol were viewed as errors that varied in seriousness from 0 (no discomfort or detriment to the patient) to 5 (serious permanent injury to the patient/death) (Table 2). Error types are in no way related to statistical type 1 and 2 errors, nor related to any false positive or negative predictive value. Errors are based on ATLS training. For some patients, for example, it might be a type 1 error to commit a rectal examination because the patient has an insufficient airway that should be treated first, while for another patient it may be a type 1 error to omit a rectal examination because there is suspicion of a pelvic ring fracture with possible urethral lesion. Inter-rater reliability in this evaluation method was not measured because the evaluation is based upon the objective scoring and registration of ATLS items and not the interpretation or judgment of a specific person's actions and, we believe, therefore less susceptible for inter-rater variability.

Statistical analyses

Data were statistically analyzed using Microsoft Access and Statistical Package for the Social Sciences (SPSS) version 14.0 (SPSS Inc., Chicago, IL, USA). Independent samples t-test was used to examine mean differences between groups. Normally distributed values were presented as mean with standard deviation; non-normally distributed data were expressed as medians with ranges as appropriate. Values were considered significant at the $p < 0.05$

Table 1 Score form

Date		Date review	
ED number		Reviewer	
ED arrival time	ED departure time	Tape number	
Name surgery		Name emergency physician	
anaesthesiology		nurses	
neurology		Injuries	
radiology			

			YES/NO	TIME	ADEQUATE	EXCELLENT	TYPE 0	TYPE 1	TYPE 2	TYPE 3
ORGANIZATION/COMMUNICATION										
Team arrival	Complete team before arrival patient									
Team communication	Prehospital report									
	Swift consultation of specialists									
	Warning next treatment station									
Team leadership	Evident teamleader									
	Efficient teamleader									
	Resuscitation in the correct order									
	Working according to protocol									
	Patient always under supervision									
Protective measurements	Protective apron									
	Optical protection									
	Mouth mask									
	Gloves									
	Radiology apron									
Patient transfer to trauma room trolley										
MEDICAL TREATMENT										
Primary survey										
Airway	Airway assessment									
	Adequate intervention									
	Rapid sequence induction									
	Intubation									
Spine Control	Semi rigid cervical collar.									
	Headblocks									
Breathing	Breathing assessment									
	Oxygen administration									
	Pulse oxymeter									
	Chest tube									
	Needle thoracocentesis									
Circulation	Circulation assessment									
	IV access I									
	IV access II									
	Fluid management									
	Withdrawal of blood samples									
	EKG monitoring									
	Ordering of blood products									
	Arrival of blood products									
Neurological evaluation	Disability assessment									
	GCS scored									
	Neurological exam									
Back examination	Log roll									
Hypothermia prevention	Temperature measurement									
	Temp < 36 C									
	Level One infusion system used									
	Warmed infusion									
	Warm blankets									
	Warm lamps									
Urinary catheter	Introduction of catheter									
	Sterile technique									
	Rectal examination									
End of primary survey										
Radiology	X-chest	indicated								
		performed								
		reviewed								
	X-pelvis	indicated								
		performed								
		reviewed								
	X-C spine	indicated								
		performed								
		reviewed								
	FAST ultrasound	indicated								
		performed								
		duration								
	CT scan	indicated								
		performed								
Overall judgement										
Feedback										
Remarks										

Results

Inclusion of patients

During the study period, 1256 patients meeting the criteria were treated in the Emergency Department. Attempts to record team performances were made in 417 cases, of which 387 were suitable for analysis (Table 3). In all other cases (n= 839) injuries turned out not to require multidisciplinary team treatment, the video registration was stopped early or was erased. Additional reasons for not recording team activities were defective or absent videotapes, faulty equipment (during a 12-week period). In 30 cases there was an insufficient or improper recording. These missed evaluations were not related to a specific time of day or trauma team action. The type of registration did not allow us to retrospectively compare all registered patients with those who were not properly recorded. From the 387 videos that were analyzed, the majority (253 registrations) concerned actions between 8 AM and 8 PM. Injury Severity Score (AIS-ISS) which ranged from 0 – 36 (median 10) was calculated from the trauma evaluation sheet. The attending physician filled in the sheet immediately after resuscitation was performed. Although ISS did not vary in regard to arrival time (p=0.89), significantly more deviations from protocol took place during daytime registrations (n=253, mean number of type 2 or more serious errors=2.93) than after 8 PM (n=134, mean number of type 2 or more serious errors 2.50, 95% CI 0.10-0.78, p=0.01).

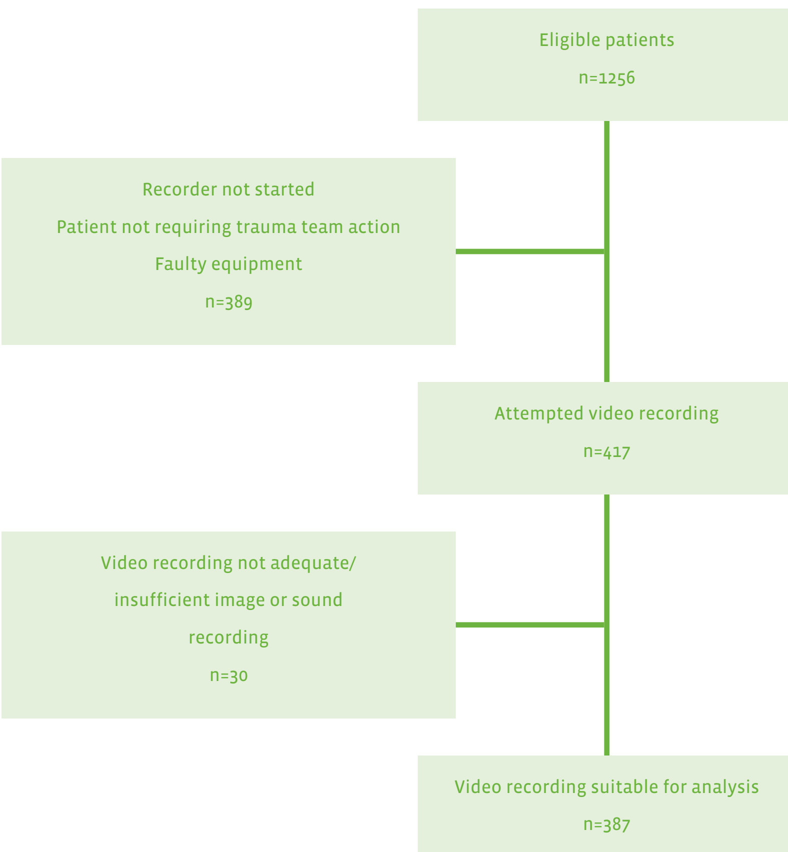
Time observations

Table 4 shows the average time (in minutes) that expired from arrival before each ATLS item on the scoring list was performed. Items that were not scored by the reviewers (patient temperature below 36° Celsius, use of heat lamps, team reviewed imaging) or that did not show added value were omitted. For example, the assessment of airway, breathing, circulation or disability was scored at exactly the same time as finishing the primary survey. The qualitative score for rapid sequence induction replaced judgment of adequacy of airway management intervention. Times for chest X ray were identical to the times for X-pelvis and C-spine examination, so we omitted these as well. It was also very difficult to judge the timeliness of consulting other specialists and ordering blood, so we refrained from showing those items in the results. The majority of patients (n=359, 92,8%) was adequately immobilized with semi rigid cervical collar and head blocks when reaching the hospital. Nearly all patients (n=376, 97,2%) had at least one intravenous access on arrival; 126 (32,6%) of them arrived in the emergency department with a second intravenous line up and running. The complete primary survey was finished within the first five minutes after arrival (mean=5.07

Table 2 **Classification of errors according to "Manual for Trauma Performance Improvement" ordered by seriousness of the consequences for the patient [10]**

Type of error	Consequences for patient	Discomfort for patient
0	none	none
1	minor	momentary, passing
2	moderately serious	considerable
3	serious	serious no permanent damage
4	very serious	very serious limited permanent injury or handicap
5	death or amputation	very serious very serious permanent injury

Table 3 **Flow chart inclusion video recording trauma patients**



minutes, SD=3.36 minutes), comprised of determining secure airway, breathing, circulation, disability and exposure, followed by protection from hypothermia (the ABCDE's). If appropriate, the first action that followed was the performance of rapid sequence induction to secure the patients' airway with an orotracheal tube (53 patients, mean=5.32 minutes, SD=11.33 minutes). Sixty patients were already intubated in the pre-hospital phase (15.5%). Radiological examination started at an average of 6.77 minutes with a chest X-ray, preceded by needle thoracocentesis in cases of tension pneumothorax (mean=6.44 minutes, SD=6.15 minutes). Insertion of a chest tube followed at an average of 13.47 minutes (SD=9.76 minutes). If abdominal ultrasound (FAST) was indicated, this was performed within an average of 15.26 minutes (SD=9.54 minutes). Patients left the trauma room after a little more than half an hour (mean=32.95 minutes, SD=14.06 minutes). The last part of their stay was, in general, used for completing the secondary survey (logroll, mean=22.38 minutes, SD=12.91 minutes) and inserting indwelling urinary (mean=24.07 minutes, SD=10.37 minutes) and gastric (mean=18.90 minutes, SD=7.43 minutes) catheters.

Quality appraisal in organization

Video registration analysis showed quite clearly that some items were not performed according to protocol (Table 5a). This applied to tasks completed by the team as a whole and to actions of individual team members. The assessment began with the arrival time of the trauma team. We expected the team to be available from at least one minute before arrival of the patient. This happened in 352 cases (range: -24.00 - -1.00 minutes). In 40 cases, the team was incomplete when the patient arrived (29 times a surgeon was missing, 13 times an anesthesiologist, 3 times a neurologist). Team members were not always adequately protected (not wearing gloves and radiological apron in 2 cases, no protective mouth mask or optical protection with 299 patients). Pre-hospital report was given by EMS personnel in 368 registrations and judged as type 0 error in 12 patients and type 1 error in 7 patients. In 50 cases, resuscitation in the correct order, effective leadership, evident leader and/or following ATLS protocol were insufficient (25% were type-1 errors). Remarkable was the number of errors in attending to the patient: errors were committed with 86 patients (24 type-0, 59 type-1, 3 type-2 errors).

Statistical analysis showed that errors in team organization also lead to a significant increase in errors (>type-1) in the overall patient treatment (Table 5b). Adequacy of pre-hospital report (p=0.01), evident leadership (p=0.01), continued supervision of the patient (p=0.00), efficient leadership (p=0.08), resuscitation in the correct order (p=0.02) and working according to the ATLS protocol (p=0.00) were individually related to

Table 4 **Timing of ATLS items (primary survey, secondary survey, procedures and imaging)**

Time to...	N	Mean Time After Arrival (minutes)*	SEM	Median*	SD	Min	Max
Primary survey							
cervical collar application	359	-0.25	0.26	-1	4.85	-1	59
intravenous access no I	376	-0.22	0.22	-1	4.24	-1	49
head blocks application	350	-0.09	0.26	-1	4.87	-1	59
oxygen application	361	-0.27	0.23	-1	4.37	-1	63
GCS score	377	1.46	0.13	1	2.61	0	30
pulsoxymeter application	358	2.86	0.1	3	1.80	-1	14
rhytm monitoring	332	3.28	0.14	3	2.58	0	28
intravenous access no II	236	3.50	0.45	-1	6.85	-1	35
hypothermia prevention	366	4.73	0.23	4	4.33	-1	59
finish primary survey (ABCD assessment)	360	5.07	0.18	4	3.36	0	37
rapid sequence induction	113	5.32	1.07	-1	11.33	-1	59
needle thoracocentesis	9	6.44	2.05	7	6.15	-1	16
finish neurological exam	296	8.32	0.46	6	8.00	0	66
Procedures							
blood samples withdrawal	342	8.37	0.23	7.5	4.31	-1	35
chest tube insertion	30	13.47	1.78	12	9.76	-1	36
gastric tube	10	18.90	2.35	19	7.43	5	30
rectal exam	147	19.95	1.04	17	12.58	2	61
logroll	189	22.38	0.94	20	12.91	1	61
urinary catheter	86	24.07	1.12	24	10.37	-1	59
Radiology							
chest X ray	359	6.77	0.19	6	3.54	0	22
start FAST ultrasound	195	15.26	0.68	14	9.54	2	75
transfer to CT scan	315	15.62	0.4	14	7.01	4	44
total trauma room time	387	32.95	0.71	31	14.06	3	111

* Values -1 symbolizes application pre-hospital

a lower total number of deviations. Errors in team arrival time (p=0.27) or wearing protective clothing (p=0.15) did not influence the number of errors made.

Quality appraisal for medical treatment

Table 5c shows deviations in medical treatment from the ATLS protocol. Although most actions were performed at the right moment and in the right way, we also found 641 deviations from protocol. These errors did not have serious consequences, but in 26 other cases, type-2 and type-3 errors were found. An example of a type-1 error is not performing logroll even though the observer judged it necessary. An example of a type-2 error is when a patient fell off the stretcher during transfer from the EMS stretcher to the trauma room trolley. A type-3 error is not establishing a first or second intravenous access in a hemodynamically instable patient. The overall rating for the team performance was good in 71.2% of the patients.

Discussion

In general, the video registration allowed us to very precisely define any shortcomings in the trauma team's functioning. Not only were we able to analyze in detail which items were performed, but we were also able to explore some relationships between errors in team organization and errors in medical treatment. The figures about the higher number of errors during daytime then during nightly hours cannot be explained as such. One possibility is that daytime supervision is easier at hand and those extra supervisors might have impaired communication resulting in a higher number of errors.

In general it is difficult to judge trauma team actions objectively because an official universal scoring system does not exist. Video registration, however, allows for a continuous and unbiased documentation of the timing and performance of both individual and team actions and enables evaluation and correction of those errors. Hoyt et al. describes one of the largest series of video analysis, as they routinely register approximately 750 trauma resuscitations yearly [3]. This large number makes it nearly impossible to review all registrations, inescapably leading to a selection of the videos reviewed. In that study, Hoyt uses a short form to judge team effort for total trauma resuscitation time, forward progression in treatment plan and completing goals based on appropriate management priorities. In a three-month period, they saw time to definitive care decrease from an average of 74 minutes to 61.

Table 5a **Quality appraisal for separate ATLS items, organization**

Organization	Performed according to protocol	Deviations from protocol Type 0	Type 1	Type 2	Type 3
Team arrival					
complete team before arrival patient	347	8	30	2	
team communication					
prehospital report	368	12	7		
swift consultation of specialists					
warning next treatment station					
Team leadership					
evident teamleader	331	33	23		
efficient teamleader	332	44	11		
resuscitation in the correct order	334	41	12		
working according to protocol	345	34	8		
patient always under supervision	294	29	61	3	
Protective measurements					
protective apron	82	305			
optical protection	88	299			
mouth mask	88	299			
gloves	385	2			
radiology apron	385	2			
Patient transfer to trauma room trolley	373	3	8	3	

Table 5b **Influence of errors in team organization on team treatment**

	Number of patients with errors type 2 or more in the item mentioned below	Number of deviations in total treatment	p-value
prehospital report	7	4.3	0.008
	380	2.7	
evident teamleader	23	3.5	0.01
	362	2.7	
efficient teamleader	11	4.0	0.08
	372	2.7	
resuscitation in the correct order	12	4.4	0.02
	371	2.7	
working according to protocol	9	4.7	<0.001
	378	2.7	
patient always under supervision	62	3.1	0.01
	312	2.5	

Most other authors use timing of separate items in the resuscitation phase for quality assessment. However, the amount of time allowed for items is different in each study. For example, both Hoff et al. and Townsend et al. believe that the primary survey should be finished within 2 minutes [8][9]. Lowe et al. and Ritchie et al. allow a limit of 3 minutes to complete the first survey, while Santora describes a scoring system in which finishing the primary survey within ten minutes is sufficient [2][11][12]. Hoff, Lowe and Townsend state that ten minutes is the limit for secondary survey. In our study, primary survey is completed on average within five minutes, but rapid sequence induction takes place within 1 minute after clearing the primary survey. Timing for adjunct procedures in our study is comparable to others or faster. The total trauma room time in this study is much shorter than most studies (Townsend=97.5 minutes; van Olden=48 minutes, Lowe=24 minutes) [13].

Another way to assess quality is through use of the Liverpool scoring form, which is specifically designed for observing and assessing trauma team (leader) performance. This form, also based on scoring ATLS items, is used by Ritchie et al. and Sugrue et al. and shows consistent scores in different studies [2][4]. On the Liverpool form, no points are awarded for items that might correctly be omitted and consequences for patients are also not taken into account.

Other authors focus more specifically on the influence ATLS training has had on patient care to refute the statement made by Vestrup et al. that ATLS has only lead to an increased number of rectal examinations but not to fewer missed diagnoses or improved patient outcomes [14]. Van Olden et al. did not use ATLS items to create a score sheet, but simply compared treatment in 31 pre-ATLS trauma resuscitations with 32 post-ATLS registrations [15]. They confirm that while the number of rectal examinations and total resuscitation time have increased since ATLS was developed (mainly by a longer prehospital resuscitation phase), this was related to a better survival in the first hour for post-ATLS patients and a lower preventable death rate compared to MTOS+ dataset.

To our knowledge, no other authors have previously used the scoring system of the Trauma Performance Improvement Reference Manual for quality appraisal and to assess trauma team performance. This scoring system allowed us to qualitatively and quantitatively judge separate actions during trauma resuscitation. Both procedures and team members could be assessed within the same system, allowing us to analyze every video for the full ATLS item list and to correlate team leader performance and resuscitation in the correct order to individual errors. It showed us that inadequate leadership was related to a higher number of protocol violations.

Table 5c **Quality appraisal for separate ATLS items, organization**

Medical treatment	Performed according to protocol	Prehospital	No indication according to protocol	Deviations from protocol Type 0	Type 1	Type 2	Type 3
Primary survey							
Airway							
airway assessment	359		28				
adequate intervention							
rapid sequence induction	116	62	266	5			
intubation							
Spine Control							
semi rigid cervical collar.	343	328	20	10	12	2	
headblocks	369	302		1	14	3	
Breathing							
breathing assessment	358		29				
oxygen administration	357	258	6	1	20	3	
pulse oxymeter	366			1	19	1	
chest tube	26	3	356	1	2	2	
needle thoracocentesis	6	2	377	3	1		
Circulation							
circulation assessment	353		24				
IV access I	348	314	18	7	12	1	1
IV access II	226	126	150	6	1	3	1
fluid management							
withdrawal of blood samples	331		20	2	34		
EKG monitoring	332		55				
ordering of blood products							
arrival of blood products							
Neurological evaluation							
disability assessment	343		44				
GCS scored	377		10				
neurological exam	307		12	1	61	6	
back examnination	Log roll	195		3	1	185	3
Hypothermia prevention							
temperature measurement	21		366				
temp < 36 C							
level One infusion system used	24		363				
warmed infusion	8		379				
warm blankets	366		21				
warm lamps							

Medical treatment	Performed according to protocol	Prehospital	No indication according to protocol	Deviations from protocol Type 0	Type 1	Type 2	Type 3
Urinary catheter							
introduction of catheter	88						
sterile technique							
rectal examination	150		17	7	213		
end of primary survey	360		27				
Secondary Survey							
Radiology							
X-chest							
indicated	357						
performed	359						
reviewed							
X-pelvis							
indicated	291						
performed	285						
reviewed							
X-C spine							
indicated	326		61				
performed	316						
reviewed							
FAST ultrasound							
indicated	194						
performed	195						
duration							
CT scan							
indicated	113						
performed	7						
overall judgement	288			94	4	1	

This study demonstrates the efficacy and applicability of a video surveillance system for routine continuous registration of trauma team actions. It facilitates an exact analysis of actions that may have potentially harmful consequences. These specific items can then be addressed during future training. We have used this video analysis to implement a feedback system and trauma team training.

Study limitations

The fact that the treatment of two-thirds of patients who met the criteria for video registrations was not filmed, or was missing or unusable, may seem high. However, other studies have also reported equally high numbers of unusable registrations [2][12][16]. Examples of reasons stated in those studies for treatments not being registered were that usable videotapes were not stocked or that the recording was started too late. These are issues we also encountered in this study.

Perspective

Video registration of trauma team actions is feasible in a Level-1 trauma center in the Netherlands. It allows comparison of findings from previous studies from other authors. In addition to the precise evaluation of deviations from protocols, it also allows specific items to be selected for future training. Furthermore, video registration helps to maintain quality appraisal during night when no supervisor is on site.

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3

Tissue-interface pressures on three different support surfaces for trauma patients

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Abstract

The purpose of this study was to evaluate and compare tissue-interface pressures on three different support surfaces for trauma patients. The support surfaces were a semi soft overlay mattress, a vacuum mattress and a spineboard. Tissue-interface pressures were measured in a standardized way between the scapulae, the sacrum, the heels and the different support surfaces in twenty healthy volunteers. Appreciation of comfort of the support surface was assessed using a 10-point visual analogue scale.
High and potentially ischaemic interface pressures were found on all three support surfaces, with the highest pressures (exceeding 170 mmHg) measured on the spineboard. The spineboard got the worst comfort score. It was also noted that no support was given to the normal lumbar lordosis by the spineboard. There is a need for new support surfaces for trauma patients, that reduce interface pressures and are comfortable.

Introduction

In The Netherlands, polytrauma patients are often transferred on a spine board, as required by protocol, for spinal immobilization during transportation. Originally, the spine board was developed as an extrication device, for which reason it has to be rigid and light. Its use as a transportation device is good for the paramedics but not for the patient. In many emergency departments, patients may not be lifted from the spine board before the presence of spinal injury has been ruled out on clinical and radiological grounds. This means that these patients generally spend a significant period on the spine board, as is illustrated in a study by Lerner and Moscati [1]. They found that the total time a trauma patient spent on a spine board (including the period of transportation) averaged 63 minutes. When patients required radiological evaluation before removal from the backboard, the total spine board time averaged three hours.

Patients with supposed critical injury often enter a cascade of prolonged immobilization in a supine position during transport and in the emergency room, often followed by immobilization on the OR table and eventually during ICU stay. A known risk of this immobilization is the development of pressure ulcers, with reported incidences in trauma patients up to 31% [2,3]. Few studies have addressed the discomfort and potential harmful consequences of the use of spine boards. Although it is supposed and generally advocated that a spinal fracture is best treated by rigid immobilization on a fl at surface, this can be questioned, and it may be argued that this way of immobilization may have harmful consequences. Moreover, the use of the rigid spine board is supposed to lead to the development of pressure ulcers in critically injured patients, because the hard surface produces high interface pressures between the skin and spine board.

In many European countries, alternative methods are used for the transportation of trauma patients, for example the vacuum mattress. The purpose of our study was to evaluate tissue-interface pressures on the spine board as well as on alternative transportation devices, e.g. a semi soft emergency department mattress and a vacuum mattress.

Material and methods

We prospectively collected data from 20 healthy volunteers, who were not experiencing any pain at the time of the study, and did not have a history of chronic back pain. The study group consisted of 7 men and 13 women, with an average age of 40 years (range 20-56). The subjects average Body Mass Index (BMI) was 24 (range 20-27). The three different surfaces were tested by all volunteers, lying in a supine position for a period of fi ve minutes on each surface. Devices were tested in a fixed order for all subjects: 1) the standard semi soft overlay mattress, which has a 5 cm thick foam core (Etesmi / JW Koch; Tilburg, The Netherlands) that is in use in our Emergency Department; 2) a vacuum mattress (Ambu®, Germa AB; Kristianstad, Sweden); 3) a spine board (Ferno-Washington, Inc.; Wilmington, Ohio, USA).

During the measurements, subjects were allowed to wear their normal clothing, but no shoes. The vacuum mattress was folded comfortably around the body before applying negative pressure, as if it were used for transportation. At the end of each five-minute period, subjects were asked to assess the tested surface for comfort on a 10-point visual analogue scale. Tissue-interface pressures were measured with the X SENSOR X2-6912 pressure-mapping device (XSENSOR Technology Corporation; Calgary, Canada). This system consists of a thin, easily foldable full body pressure- mapping pad, equipped with 6912 capacitive sensors. This pad was placed between the subject and the support surface, without folds. Placing pressure on the sensors results in the generation of a voltage difference, which increases linearly with the amount of pressure. Connection of the pad to a laptop computer with special XSENSOR software (version 4.0), allowed real-time pressure registration. Peakpressures (in mmHg) measured at the scapulae, the sacrum and the heels were noted and compared for the three different surfaces.

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, version 11.0.1. Peak-pressures were compared using a Paired-Samples T test. Differences were regarded significant if $p<0.05$.

Results

The mean peak interface pressures on the three different surfaces are presented in Table 1.

Table 1 **Mean peak interface pressure by contact site and support surface**

Contact site	ER-overlay mattress	Vacuum mattress	Spineboard
	mean (± S.D.)	mean (± S.D.)	mean (± S.D.)
scapulae	89.9 (± 35.8)	131.6 (± 50.9)	176.6 (± 3.6)
sacrum	118.0 (± 28.4)	165.6 (± 29.0)	174.9 (± 15.8)
heels	147.3 (± 22.0)	123.3 (± 45.2)	153.0 (± 16.1)

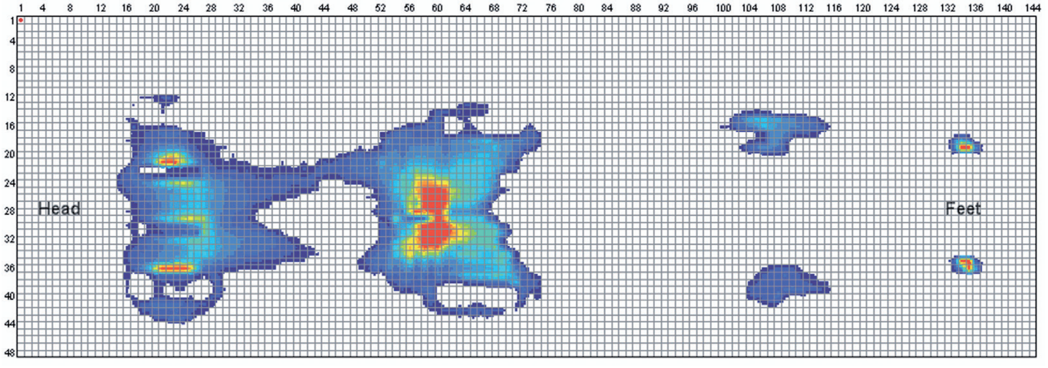
For all three contact sites, the interface pressures measured on the spineboard were highest. Our standard overlay mattress compared favourably to both the vacuum mattress and the spineboard for interface pressures measured at the scapulae and the sacrum. These differences were highly significant. At the heels, the pressures on the overlay mattress were comparable to those on the spineboard and significantly higher than those on the vacuum mattress. At the sacrum, the pressures on the vacuum mattress and spineboard did not differ significantly.

A striking, but expected finding was that the spineboard did not give any support to the normally lordotic lumbar spine, as is illustrated in Figure 1.

The volunteers appreciated the overlay mattress with a mean comfort score of 7.0 (±0.8), the vacuum mattress with a mean score of 6.6 (±1.3) and the spineboard with a mean score of 4.6 (±1.2). When considering these comfort scores, the difference in appreciation for the overlay mattress and the vacuum mattress was not significant.

Appreciations for the overlay mattress and the vacuum mattress were both significantly better when compared with the spineboard.

Figure 1 Contact sites on spineboard, without support of lumbar lordosis



Discussion

The results of our study confirm that high and potentially "ischaemic" pressures between the surface and the skin were reached on all of the three tested support surfaces at all three exposed contact sites.

To put these interface pressures in perspective, we must consider that maximum pressures that are measured on a good quality hospital mattress vary between 30 and 60 mmHg [4]. High interface pressures on the spine board have previously been reported. Lovell and Evans found mean pressures in the sacrum area up to high as 147 mmHg and they were able to reduce this to 115 mmHg by padding the surface [5]. It is therefore remarkable that during the past decade, in which the pressure ulcer problem gained attention, the layout of the spineboard was not changed. In the same study, interface pressures dramatically reduced to 37 mmHg by using a vacuum stretcher. This finding could however not be reproduced in our study. The extent of the pressure ulcer problem in critically injured patients, with an incidence figure up to 30.6%, is illustrated by several studies [2,3]. In the study by Watts et al., 20% of trauma patients who were hospitalized more than 2 days developed at least one area of skin breakdown. In almost 50% of the cases, positional pressure was the most common cause for pressure ulcers. One of the weaknesses of interface pressure measurements as these were performed is the interpretation of the outcome. It is uncertain whether pressures measured at the skin actually reflect the pressures that are present in the underlying tissues, the place where the ischaemic damage originates [6]. The good subjective appreciation for the vacuum mattress is remarkable, considering the fact that interface pressures at the shoulders and the sacrum are significantly higher than those on the ER overlay mattress are.

Conclusions

Given the high, potentially harmful pressures found on three different and frequently used support surfaces for trauma patients and the related unsatisfactory subjective comfort scores for two of them, there is a task for industrial designers to develop new, safe and more comfortable surfaces for the transportation of trauma patients. If there is no useful alternative, the time spent on a spineboard should be kept as short as possible.

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4

Is there a reason for spine board immobilization in the emergency department for patients with a potential spinal injury?

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Abstract

Background

Currently, after trauma most patients are transported to the hospital fully immobilized on a spine board. They are kept restrained to the board until full clinical and radiologic examination of the spinal column is completed. This protocol has potential detrimental effects, e.g., the development of pressure sores, and is very uncomfortable for the conscious patient. Early removal of the spine board, however, bears the chance of additional injury due to insufficient restraint of the spinal column.

Patients and Methods

In this retrospective cohort study, a period (1999) in which policy advised prolonged spine board immobilization was compared to a period (2000) in which the patient was removed from the spine board immediately upon arrival in the emergency department. A cervical collar and in-line manual stabilization of the head were maintained throughout. The authors examined possible detrimental effects of early removal of the spine board on neurologic deficits. All patients with proven spinal trauma were included in the study; in the first period 107 patients were seen, in the second, 90. The levels of the fractures in the first group were 29 cervical, 33 thoracic, and 45 lumbar; the second group had 36 cervical, 22 thoracic and 32 lumbar fracturedislocations. There were ten and 13 patients from each group, respectively, with neurologic deficit upon arrival. Patients were evaluated neurologically upon arrival and again after removal of the spine board.

Results

In both groups no detrimental changes were noted. Moreover, no adverse effects of early removal of the spine board were found.
Conclusion: Despite methodological limitations of the study it is concluded that there is no reason for prolonged immobilization of trauma patients on a long spine board after the emergency department is reached.

Introduction

High-energy trauma can lead to spinal injuries. Since the examination of the spine in trauma patients can be difficult in the prehospital setting, most patients are transported to the hospital after full spinal immobilization using a spine board [1–4]. Leaving a patient on the spine board has some potential advantages during transport to and within the hospital and during physical examination and radiologic investigation, but there is no evidence that prolonged immobilization of a patient on a spine board during his/her stay in the emergency department has a beneficial influence on clinical outcome [5–8]. Risks of prolonged placement on a spine board are pressure sores on the sacrum and occiput and neurologic damage due to restlessness in patients with spinal fractures [9, 10]. Prolonged immobilization interferes with the quality of radiologic imaging and may also compromise respiratory status [11]. Although there has been a change of protocol in the latest version of the ATLS® (Advanced Trauma Life Support) student manual to recommend spine board removal during secondary survey and log-rolling manoeuvre instead of after completion of the radiologic examination or "when patient's condition permits", there is no scientific evidence, to our knowledge, to support any specific moment of spine board removal [12, 13].

A change in our hospital protocol for spine board removal gave us the opportunity to investigate any adverse effects of early spine board removal. We performed a retrospective analysis of our clinical observations before and after this change in protocol, with a specific interest in neurologic changes.

Patients and Methods

All patients who underwent clinical treatment in the University Medical Center Utrecht (UMC Utrecht) for a proven traumatic spinal fracture between January 1, 1999 and December 31, 2000 were selected from the hospital database. The UMC Utrecht is a level 1 trauma center in the heavily urbanized zone of the Netherlands, receiving approximately 13,000 trauma patients annually, of whom roughly 250 have an Injury Severity Score of > 18. We excluded all patients with pathologic fractures from either primary tumors or metastatic tumor deposits and osteoporotic spinal fractures defined by both trauma mechanism (low energy) and radiologic aspects of the fracture. Almost all patients were admitted to the emergency department immobilized according to ATLS standards on a spine board with cervical spine protection – semirigid cervical collar – and head blocks. Until the end of December 1999, the standard protocol in the emergency room of our hospital prescribed leaving the patient on the spine board until the primary survey including examination by a neurologist and radiologic examination were completed. This protocol was changed in January 2000, when we began removing patients immediately from the spine board upon arrival in the emergency department and placing them on a soft-padded emergency department trolley (Etesmi, JW Koch, Tilburg, the Netherlands), unless there was an indication for urgent emergency surgery. This trolley can be used for in-hospital transport and its movable mattress is also compatible with CT scanning. After the board had been removed, the cervical spine was protected by either using head blocks and semirigid cervical collar or by

Table 1 **Patient data and trauma mechanism per year**

Year	1999	2000
Male/Female	57/50	53/37
Age (years), median (range)	36 (10-90)	41 (15-89)
Fall from height	60	47
Car accident	25	22
(Motor)cycle accident	18	15
Hit by falling object	2	4
Other/unknown	2	2

Table 2 **Level of spinal fracture, number of patients**

Year	1999	2000
Total	107	90
Cervical	29	36
Thoracic	33	22
Lumbar	45	32
Fracture also in other level	13	8

manual in-line immobilization of the head, neck and spinal column until primary survey and/or radiologic examination had excluded spinal lesion. These patients were also immediately examined by a neurologist after removal of the spine board. The neurologic status of each patient was documented by a neurologist again after definitive treatment. Neurologic status was described as testing the performance of cranial nerves, main peripheral neurologic reflexes, and motor function and sensibility.

We manually reviewed all medical records of the selected patients. From the 234 records that were found in our database with the aforementioned inclusion criteria, eleven patients turned out not to have had spinal fractures after all. From 26 others (seven patients in 1999 and 19 patients in 2000), medical records were incomplete, so they were not included in this analysis.

All demographic data were noted down (e.g., age, sex, type of accident, date of trauma). Diagnosis and results of the neurologic examination were also recorded.

Results

From the group of patients seen in 1999, 107 met our criteria and were labeled as group A (proven traumatic spinal injury with late removal of spine board). In 2000, 90 patients were selected and labeled as group B (spinal injuries and immediate spine board removal).

Group A (1999)

Of the 107 included patients (50 women, 57 men, median age 36 years, range 10–90 years), ten had a spinal fracture in combination with neurologic symptoms. The remaining 97 patients had a spinal fracture without neurologic sequels. Most patients had spinal injuries resulting from a fall from a height of › 1 m (60 patients, see Table 1) or a car accident (25 patients). Most lesions were at the lumbar level (45 patients). The number of patients with cervical (29 patients) and thoracic (33 patients) spine fractures were almost equal. 13 patients had fractures on more than one level (Table 2). None of the patients showed any deterioration of neurologic signs during their stay in the emergency department, neither before nor after removal of the spine board.

Group B (2000)

In this group, 90 patients were treated for a traumatic spinal injury. Of these patients (37 women, 53 men, median age 41 years, range 15–89 years), 13 had a spinal fracture with neurologic deficit. The other 77 patients showed no neurologic symptoms. In this group, the majority of fractures were of the cervical spine (36 patients), followed by fractures of the lumbar (32 patients) and the thoracic spine (22 patients). As was determined in 1999, the main cause of spinal fractures was a fall from height (47 patients). Car accidents caused spinal fractures in 22 patients (Table 1). No changes in neurologic state, both during and after removal of the spine board, were observed.

Discussion

There seem to be conflicting ideas on the subject of spine board removal. Our study retrospectively analyzed the effects of a change in the protocol of spine board immobilization on neurologic outcome in trauma patients with a spinal fracture. We concluded that there is no difference between patients who are left on the board until after primary survey and those immediately removed from the board upon arrival. Only one other study has compared two immobilization policies with respect to neurologic outcome. Hauswald et al. Conducted a 5-year retrospective study and found no differences between 120 prehospital nonimmobilized trauma patients in Malaysia and 334 immobilized trauma patients in New Mexico, USA [14]. This study may have a selection bias, since the more severely injured people in Malaysia might not have reached the emergency department, but it shows no adverse effects of not immobilizing.

The benefits (in experimental settings) of adequate immobilization of trauma patients – who by definition always have a potential spinal injury – during automotive transport in terms of prevented lateral motion are undisputed [7, 15, 16]. The clinical relevance of these experiments in healthy volunteers, however, has never been prospectively tested in trauma victims.

Supporting the idea that patients should be removed from the spine board as quickly as possible is substantial evidence that prolonged immobilization on a spine board has potentially negative consequences and may lead to major discomfort for the patient. Various studies have cited the development of pressure sores, inadequate spinal support (in case of dislocated spinal fractures), pain and discomfort, compromised respiratory status, and poor quality of radiologic imaging in patients left on spine boards for longer periods of time [9–11, 17]. The authors of the Cochrane Review on spinal immobilization could not find any articles that met their inclusion criteria and conclude that the effect of spinal immobilization on mortality, neurologic injury, and spinal stability remains uncertain. The possibility that immobilization may increase mortality and morbidity cannot be excluded, and randomized trials are needed [18]. Some people prefer the use of the spine board for in-hospital transfers as well [19]. We believe that transfer to other departments or for radiologic investigation can be safely carried out with the described soft-padded emergency department trolley and movable mattress.

At some point in the treatment of a trauma patient the spine board has to be removed. We have not found a reason to delay removing the patient from the spine board after his/her arrival in the emergency department. Based on the results of this investigation and the evidence found in literature, we now transfer all trauma patients onto a padded trolley upon arrival in the emergency department. They are then protected with a semirigid cervical collar and head blocks or with manual "in-line" immobilization.

Research considerations

This study suffers from the disadvantages of a retrospective analysis. For example, we do not have any information on total time that patients were immobilized, as that was not recorded. We did not compare X-ray quality, nor did we focus on respiratory impairment. In addition, we have very limited data on the development of decubitus ulcers. Future studies might include a prospective evaluation of these items as well.

Conclusion

In our hospital, no neurologic deterioration was seen in trauma patients with proven spinal fracture(s) as a result of early removal from a spine board in the emergency department. Based on these retrospective findings, we conclude that there is no general reason for prolonged immobilization on a spine board for trauma patients, after transport to the emergency department is completed.

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5

Early interhospital referral of polytraumatized patients: almost one third of patients are incompletely assessed initially

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ACCEPTED FOR ORAL PRESENTATION ESTES 2010, BRUSSELS

Abstract

Introduction

Trauma patients who arrive in a level I trauma care facility after inter-hospital referral for special (mostly neuro-) surgical competencies are sometimes admitted directly through specialized intensive care units. In these cases, the standard multidisciplinary assessment in the Emergency Department (ED) according to ATLS guidelines is regularly bypassed, increasing the risk of incomplete assessment of injuries. Therefore, our "on call trauma team" consistently coordinates the assessment of all transferred polytraumatized patients in the ED. In this study we analyzed the number of newly found injuries in referred polytrauma patients and the clinical consequences of those injuries (i.e., extra treatment, damage to the patient, or death). We also analyzed possible risk factors for missing injuries. Methods. Retrospective study of 154 trauma patients with ISS>16 who were transferred to our level I hospital within 48 hours after the original trauma. These patients were transferred from regional hospitals because of capacity issues or problems that could not be treated in that hospital. All patients transferred between January 1998 and December 2002 were considered "new" trauma patients to our hospital and were treated as such by the trauma team in the ED. The list of injuries from the referring hospital was compared to the list of injuries and treatment that was concluded in our hospital to define any new diagnosis and its impact on the patient. For the risk analysis, we tested several items for significant influence on missing injuries.

Results

From the study population of 154 patients, 44 patients were found to have an unsuspected injury (88 injuries). Musculoskeletal injuries accounted for the largest number of newly found injuries, followed by pulmonary and neurological injuries. Consequences of newly diagnosed injuries were generally limited in terms of (operative) treatments, although some potentially life-threatening injuries were found that had not been discovered by the referring center (e.g., tension pneumothorax, disruption of subclavian artery, splenic rupture). No deaths or permanent damage to the patients seems to have been caused by overlooked lesions. Extra treatment was operative in 5 patients; for most other patients only extra consultation immobilization was required.

Conclusion

Interdisciplinary hospital transfer of polytraumatized patients to a level I facility contains the risk of incomplete injury assessment because referring hospitals assume that a complete assessment will be carried out again at arrival. Transferred patients with multiple injuries therefore should consistently be admitted through the ED and receive a new, full standard "primary" assessment by the multidisciplinary trauma team.

Introduction

In the Netherlands, patients with multiple traumas are cared for in centralized, specific level I trauma centers [1]. The country has been divided into ten trauma regions, each with their own regional level I facility. Nevertheless, a considerable number of multiple trauma patients is presented in general or rural hospitals (level II or level III trauma care facilities), where standard imaging studies are performed and basic treatment is started and sometimes completed with simple lifesaving interventions. Currently, most Dutch hospitals follow ATLS (Advanced Trauma Life Support®) guidelines for conducting primary care. When the treatment of injuries exceeds the competences of local hospital staff, patients are transferred to the regional level I facility for specialized surgical care. Patients also might be referred from another level I facility when specialized intensive care facilities are unavailable. These types of transfers routinely take place shortly after the initial assessment is concluded, or at least within 24 hours after trauma. Frequently, these transfers are preceded only by primary assessment of trauma patients and a brief interdisciplinary consultation between specialists who are not specialized in trauma surgery (e.g., anesthesiologists, neurosurgeons, maxillofacial surgeons, hepatobiliary surgeons).

Although many articles describe algorithms and criteria for transfer of patients, there are no guidelines for admitting secondarily transferred patients to level I trauma care facilities [2]. Literature shows that many injuries are initially missed in multiple trauma patients who are primarily treated in a level I trauma facility. However, there is little evidence of how transferred patients should be treated to limit this risk [3][4][5]. Price and Lambert both described a series of patients who were transferred to a Regional Neurosurgical Unit and illustrated that the initial assessment in the primary hospital was incomplete and that major injuries had been missed by the referral hospital [6][7]. However, they did not register whether missed injuries would have been prevented by repeated screening in the emergency department.

In our level I facility, the multidisciplinary team that responds to a trauma call is also involved in screening and treating every trauma patient referred from another hospital. All referred patients are brought to the attention of a trauma surgeon who coordinates presenting the patient to the trauma team in the emergency department before he/she is admitted to a specialized unit or operation theater.

As this routine requires an extra effort from the always limited resources in the Emergency Department (ED), we wanted to compare the policy of having a trauma surgeon coordinate presentation and standardized repeated screening according to ATLS guidelines to not performing any extra screening than had been performed in the primary hospital to examine whether our practice had added value. We therefore analyzed the number of newly found injuries in multiple trauma patients referred to the hospital and the clinical consequences in terms of changes or additions in treatment, and nuisance and transient or permanent damage to the patient. We also tried to define risk indicators for missed injuries.

Patients and methods

Patients for this study were identified through our hospital's prospective trauma registry. We retrospectively analyzed the medical files of all adult and pediatric multiple trauma patients who were secondarily transferred within 48 hours after the accident to our level I trauma care facility (University Medical Centre Utrecht, The Netherlands) from another Dutch hospital between January 1998 and December 2002. Only patients with an Injury Severity Score (ISS) > 16 who had been admitted to the hospital through the ED and who had a letter of referral in their medical file were included in this study. Without exception, all eligible patients had undergone a renewed standard examination (following ATLS guidelines) by the multidisciplinary trauma team upon arrival in the emergency department. During admission, any examination data were judged according to our own standards and, if deemed inappropriate, new X-rays, Focussed Assessment Sonograph Trauma (FAST) examinations or computed tomography scans (CT scans) were performed.

Clinical data were collected from both the letter of referral from the primary hospital and specialist as well as from our hospital's own medical records, medical correspondence, radiology reports and operation reports. From these data we distilled a list of newly found diagnoses, which we defined as the difference between the diagnoses listed by the referring hospital and the list of diagnoses from our hospital. In some cases diagnoses from the referring hospital were abandoned after careful investigation in our hospital, but because this might have been the primary reason for transfer we did not use this data in our analysis. We excluded skin bruises and scratches from the list as they do not represent a major health problem when missed and are seldom described in detail. We further registered data concerning age, gender, type of accident (blunt or penetrating), involvement of drugs, alcohol or psychiatric medication, referral data (e.g., reason for transfer if noted, time of day of transfer, urgency of transfer, trauma level/profile of referring hospital), Glasgow Coma Score (GCS), ISS, treatment, admitting unit (including admission to the operating room or the intensive care unit), and specialty of referring and admitting physicians. Clinical consequences were registered by adjustments in treatment: operative or non-operative.

Statistical analysis

All data were gathered in a Microsoft Excel database. Statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS) version 14.0 (SPSS Inc., Chicago, IL, USA). Risk indicators or risk factors were analyzed by performing Chi-square tests and Independent t-tests to examine differences in prevalence of a risk factor in the group with a missed diagnosis and in the group without a missed diagnosis. This analysis was done for age, gender, intoxication with drugs or alcohol, time of trauma, time of arrival, urgency of transfer, type of accident, GCS, ISS, admission through OR or ICU, speciality of referring and admitting consultant and trauma level of the referring hospital. Differences were considered significant at $p<0.05$.

Results

Baseline data

A total of 154 patients met the inclusion criteria for this study. Two-thirds of the sample were male (104 male, 50 female patients). Age ranged from 1-93 years (mean=40.5 years, SD±21.5). The majority of patients was transferred after a blunt trauma (148 blunt, 6 patients penetrating trauma). In most cases, these patients were transferred with complex musculoskeletal injuries (48%, e.g., pelvic ring fractures, multiple fractures, grade II-III open fractures of long bones) or neurological injuries that might need surgical intervention (26%).

Mean ISS was 25 (range 17-75, SD±10.3). Eighty-eight patients had a maximal Glasgow Coma Score of 15; mean GCS was 12 (range 3-15, SD±4.5). Involvement of either alcohol, drugs or psychiatric behavior was described in 27 patients (18 alcohol, 5 psychiatry, 4 drugs). See Table 1.

Table 1 **Patient factors**

Age mean yrs (range)	40.5 (range 1-93)
Male / female	104 / 50
ISS mean (range)*	20 (range 17-75)
GCS mean (range)	12 (range 3-15)
Blunt / penetrating trauma	148 / 6
involvement of	n
alcohol	18
psychiatric medication abuse	5
drugs	4

* only patients with ISS>16 included.

Table 2 **Reason for referral**

	n
surgical expertise	74
neurosurgical expertise	40
unspecified	36
pediatric surg expertise	2
military	1
hematological expertise (Creveld)	1

Table 3 **Characteristics of referral centres**

Referring specialists	
Surgery	107
Neurology	35
Neurosurgery	5
Orthopedics	4
level assignment of referring hospital	
level I *	8
level II **	60
level III ***	86
Time of arrival in referring hospital	
12PM-8AM	25
8AM-4PM	70
4PM-12PM	59

* level I = university/trauma hospital

** level II = general hospital

*** level III = smaller hospital with limited resources

Referral pattern (hospital/urgency)

Patients were referred from 41 different hospitals around the country (distance range: 4-160 kilometers) and generally arrived within 8 hours after the accident (120 patients). Twenty-seven patients were transferred with a delay of more than 8 hours, but within 24 hours. Four patients were transferred between 24 and 48 hours after the trauma. Mean referral time was 412 minutes (range 75-2865 minutes, SD ± 393 minutes). While most patients were seen in the primary hospital during daytime hours (00:00-08:00: 25 patients; 08:01-16:00: 70 patients; 16:01-23:59: 59 patients), the majority arrived in our trauma center during evening hours (00:00-08:00: 30 patients; 08:01-16:00: 45 patients; 16:01-23:59: 79 patients). The number of referred patients ranged from 1-18 patients per hospital. Most patients came from level III hospitals (i.e., rural hospitals, 86 patients) or level II institutions (i.e., larger general hospitals, 60 patients) and were transferred because the (suspected) injuries went beyond the competences of the available staff (trauma expertise: 74 patients; neurosurgical expertise: 40 patients). In another 40 patients, unspecified capacity problems were mentioned as reason for transfer. The eight patients transported from other level I trauma centers generally needed (pediatric) intensive care or emergency operating room facilities. One military patient was transferred because our hospital cares for military personnel; another patient was specifically referred because of hematological expertise in von Willebrand's disease. See table 2 for the complete list of reasons for referral.

Surgeons were responsible for the largest group of the referrals (109 patients), followed by the neurologist (36 patients), neurosurgeon (6 patients) and orthopedic surgeon (3 patients); see table 3. After the multidisciplinary team performed a new survey in the Emergency Department, patients were admitted by nine different specialists. Most patients were admitted to the surgical department (86 patients), followed by the department of neurosurgery (28 patients), the departments of orthopedic surgery and neurology (both 11 patients) and anesthesiology (responsible for our Neurosurgical Intensive Care, 9 patients). The other departments (pediatric surgery, pediatric neurology, cardiology, maxillofacial surgery and plastic surgery) each admitted between one and three patients. Thirty-eight patients were not admitted to a ward or ICU but were immediately directed to the operating room for an acute surgical intervention. Two patients with penetrating trauma were urgently admitted to the OR, three patients with blunt abdominal trauma were operated on and nine patients received either a craniotomy for decompression or intracranial pressure monitor. Sixty patients were admitted to the Intensive Care either immediately after multidisciplinary assessment in the Emergency Department or after emergency surgery. Twenty-seven patients died in the hospital. See Table 4.

Table 4 **Characteristics of receiving hospital**

Admitting specialists	
Surgery	87
Neurology	11
Neurosurgery	28
Orthopedics	11
Anaesthesiogy (Neuro IC)	9
Paediatric Surgery	4
Plastic Surgery	2
Cardiology	1
Maxillo Facial Surgery	1
ICU/OR admittance from ED	
urgent ICU admittance	60
urgent OR admittance	38
Time of arrival in receiving hospital	
12PM-8AM	30
8AM-4PM	45
4PM-12PM	79

Registration of newly diagnosed injuries

A total of 85 new diagnoses in 44 patients were confirmed after being screened upon arrival in our hospital. The largest group of new diagnoses concerned missed musculoskeletal injuries, which accounted for almost 65% of the newly found injuries. In ten patients, an extremity fracture was identified: 4 scapula fractures, 4 clavicle fractures, 1 patella fracture and one Galeazzi type forearm fracture. Other new diagnoses included rib fractures (N=9), extra spinal fractures (N=10), pelvic ring lesions (N=6), maxillofacial fractures (6 patients) and establishing a different level of spinal fracture than previously suspected (N=2). The second largest group of missed diagnoses were neurological injuries. In sixteen patients, a new neurological diagnosis was confirmed or a more severe injury was found. Pulmonary problems were less frequent; in 4 patients, a hemothorax was added to the list of diagnoses; one of those patients had a tension hematopneumothorax. An additional four patients had an unnoticed pneumothorax and an equal number of patients were diagnosed with pulmonary contusion. In five patients, an unnoticed skin wound was found that needed treatment. Other diagnoses such as contusions and skin wounds, contusio cordis and subclavian artery disruption were found in 9 cases. In one patient, an unsuspected rupture of the spleen was found during an exploratory laparotomy for a liver rupture and unexplained unstable hemodynamics; the same diagnosis was added in four other patients after CT investigation alone, without their undergoing exploratory surgery.

Consequences of newly diagnosed injuries (Table 5)

All but five newly found lesions were treated non-operatively. No extra treatment was proposed for the five other patients as the treatment protocol for the already known injuries overlapped with the treatment for the newly found lesion. A diagnosis of hemo- or pneumothorax was treated with chest tubes. Extra consultation was requested in cases of extended brain injury and consultation and immobilization was requested for musculoskeletal injuries. Almost all patients suffered only from nuisance or temporary aggravation because of delayed treatment. No cases were found of fatal overlooked injuries, late diagnosed extremity compartment syndromes or persistent damage for the patient.

Table 5 **Consequences of missed diagnosis**

Extra diagnosis	Consequences total (n)	non operative (n)	Operative (n)	no extra treatment* (n)
Musculoskeletal				
extremity fractures	10	10		
extra spinal fractures	10	10		
rib fractures	9	8		1
CMF fracture**	6	5	1	
pelvic ring injuries	6	4		2
different level of spinal fracture	2			2
Neurological injuries				
(intra)cranial injury	16	14	2	
Pulmonary				
hemothorax	4	3	1	
pneumothorax	4	4		
pulmonary contusion	4	4		
Other				
wounds/contusions	7	7		
abdominal bleeding	5	5		
contusio cordis	1	1		
vascular injury	1		1	

* no extra treatment, because adjacent/existing injury treatment overlaps with new diagnosis

** CMF = cranio maxillo facial

Risk factors

Of the data included in the risk factor analysis, only Glasgow coma scale was significantly different between groups. GCS was significantly lower in patients with missed injuries (mean=10.2, SD±5.0) than in patients with no missed injuries (mean=12.4, SD±4.1, p=0.01). Patients with a missed injury were found to have a higher mean ISS score (mean ISS=27.5, SD±12.0) than patients in whom no injuries had been overlooked (mean ISS=24.2, SD±9.4, p=0.07). No differences were found in the presence of other risk factors like urgency of referral, referring specialisms, time of day, emergency operation or any other risk factor.

Discussion

We found that renewed multidisciplinary assessment according to ATLS guidelines of 154 referred trauma patients in the ED resulted in 85 new injury diagnoses in 44 patients. In contrast to the substantial number of extra diagnoses found, consequences for extra treatment modalities that had not already been initiated were relatively small. Most extra fractures were found in a region where immobilization already had been planned for an adjacent injury or in a part of the body where no extra treatment was needed (e.g., scapular fracture, clavicle fracture). However, a number of injuries could have led to life threatening situations if not treated adequately (e.g., pneumothorax, progression of cerebral edema, expansion of cerebral hematoma, hemorrhagic shock from subclavian artery disruption). Fortunately, no fatal consequences of missed injuries were determined. Because this study did not comprise an analysis of all patients that were not referred and their possible complications we do not know if patients were “wrongly” not transferred to a larger facility. However it seems from this analysis that referring centers know their own limits and therefore adequately apply two important rules of ATLS: “do no further harm” and “get help”. In a situation where a patient is brought to a general or rural hospital, an extensive analysis of all injuries during initial assessment of a patient is not desired and patients are transferred to a hospital with appropriate facilities as soon as their medical condition allows. For the receiving hospital, it is important to take into account this limited assessment. However, this does not mean that time-consuming diagnostic procedures should be carried out in patients with an already known serious acute intracranial problem. Upon arrival in the level I facility, a quick primary survey is conducted as if the patient had primarily been presented.

The relationship between missed diagnosis and a low coma scale found in our study is conform previous findings [8]. This is very likely related to the fact that patient history often is difficult to obtain and because the treatment for severe brain injuries is constantly under time pressure. This is an important finding because most patients who are candidates for transfer to a specialized unit are patients with a brain injury that the primary hospital staff believed to be isolated.

The effect of ISS on missed injuries is partly attributed to be an effect modifier, because extra (brain) injuries will increase the ISS. However, previous studies have shown that multiple injuries are a risk factor for missed diagnosis [9][10][11].

In theory, transferred polytrauma patients could be undergo the ATLS screening in specialized (neurosurgical) intensive care units as well as in an ED. In this study we demonstrate, however, that some patients need urgent operative treatment before transfer to a specialized unit. Some patients might have injuries unrelated to their neurological problem (e.g., extra spinal fractures, clavicle, radius and scapula fractures) that might hinder patients in their rehabilitation when not adequately diagnosed. We believe this study illustrates that most referring hospitals expect the receiving hospital to do their homework and to re-screen patients. The level of a suspected spinal injury can be different from the one that was originally diagnosed after additional imaging studies. Letters of referral often only mention one or two of the most important diagnoses. It would seem that referring hospitals assume that careful examination will be carried out again.

One of the weak points of our study is that we only examined consequences of missed diagnosis in terms of extra treatments and damage to the patient. In this retrospective study it is very difficult to determine what damage was explicitly caused by the missed or delayed diagnoses. The high number of deceased people is very likely caused by the severity of the trauma, but that could only be confirmed by autopsy studies. Ideally, consequences in survivors should be measured in terms of differences in quality of life. The retrospective design of this study and the small number of patients make it impossible to carry out a formal quality of life analysis. In one patient, we presume that a splenic rupture overlooked in the presence of a liver rupture might have been partly responsible for irreversible shock and subsequent death. No other evidence of major consequences or prevented consequences of overseen lesions could be found.

There are only very few studies concerning morbidity of missed or overseen injuries in transferred polytrauma patients [12]. Most articles focus on neurosurgical patients and mention the presence of maltreated skeletal injuries, but never report specific numbers of injuries [6][7]. The development of regionalized trauma care has caused an increase in the past years in patients being transferred to more specialized hospitals [13][14]. Further regionalization and the availability of air ambulance, however, might lead to a situation in which the most severely injured patients will be directly presented to the level I facility for primary care.

Conclusion

Repeated multidisciplinary screening of every referred multiple trauma patient in the ED has extra value in terms of discovering previously undiagnosed injuries. Although the clinical consequences for extra treatment seem moderate, this study shows that primary assessment of referred patients frequently is incomplete and inexact, and patients with a lowered Glasgow Coma Scale are particularly at risk. We therefore conclude that a multidisciplinary assessment should take place upon arrival in a referral center in order to obtain a complete picture of all injuries.

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6

Difficulties in interpretation of acute knee injury: an audit of combined clinical and radiological assessment in a level 1 trauma center

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Introduction

The limited reliability of radiological examinations in an Emergency Department (ED) is a well-known risk factor for delay in treatment and medico-legal claims. The majority of these mistakes results from radiological misinterpretation, ranging from 2.4-8.9% of all ED X-rays [1]. Radiological misinterpretation rates (MIR) have been suggested as a possible quality assurance tool for emergency physicians [2][3][4]. Methods to reduce MIR include supervision from a consulting trauma specialist, 24-hour availability of a senior radiologist (possibly by teleradiology) and specific radiological training for emergency medicine staff. In most Dutch hospitals, X-rays taken by the ED are reviewed by a radiologist on the first workday after the patient has been seen as standard practice. As another safety precaution, final radiological reports and preliminary written reports attached to the radiology order are delivered immediately.

Almost all patients who visit our emergency department with an acute knee injury and hemarthrosis or inability to walk undergo standard knee X-rays after clinical examination in the Emergency Department. Despite the above-mentioned measures to prevent radiological misinterpretations, we had the impression that a high number of missed fractures of either proximal tibia or fibula slipped through our safety measures compared to the number of missed fractures in other regions of the body. We know from previous studies that the injured knee joint is notorious for its difficult clinical and radiological assessment [5]. This is partly caused by the many possible soft tissue injuries around the knee (e.g., menisceal tears, cruciate and collateral ligament injuries) and partly by the special concave form of the joint surface of the proximal tibia which easily hides impressions or split fractures [6][7][8].

Most studies on radiological misinterpretation have focused uniquely on retrospectively reviewing imaging material. Feedback about clinical errors in diagnosis was based on the chance that a complaint was filed or a deviation in treatment was notified to the supervising specialist [9]. To date, no other study has used a prospective registration database to completely evaluate all errors in diagnoses that lead to a delay in treatment or at least result in the patient following an “abnormal” road to diagnosis.

In this study we investigated how and when (avulsion) fractures of the proximal tibia and fibula were diagnosed, either at primary assessment in the ED (‘normal’) or delayed. We also investigated the practical consequences for the patient, i.e., delay in treatment. Finally we tried to identify risk factors for delayed diagnosis of a fracture of the proximal tibia or fibula.

Methods

Database

Our level I trauma center (University Medical Centre Groningen) manages a prospective database for trauma-registration built on the "International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) [10]". The diagnoses in the medical files of all patients who visited the Emergency Department are registered in this database. We retrospectively analyzed this database to search for all patients who visited our hospital between January 1, 2002 and December 31, 2005 and were treated for one of the diagnoses mentioned in Table 1.

Study population

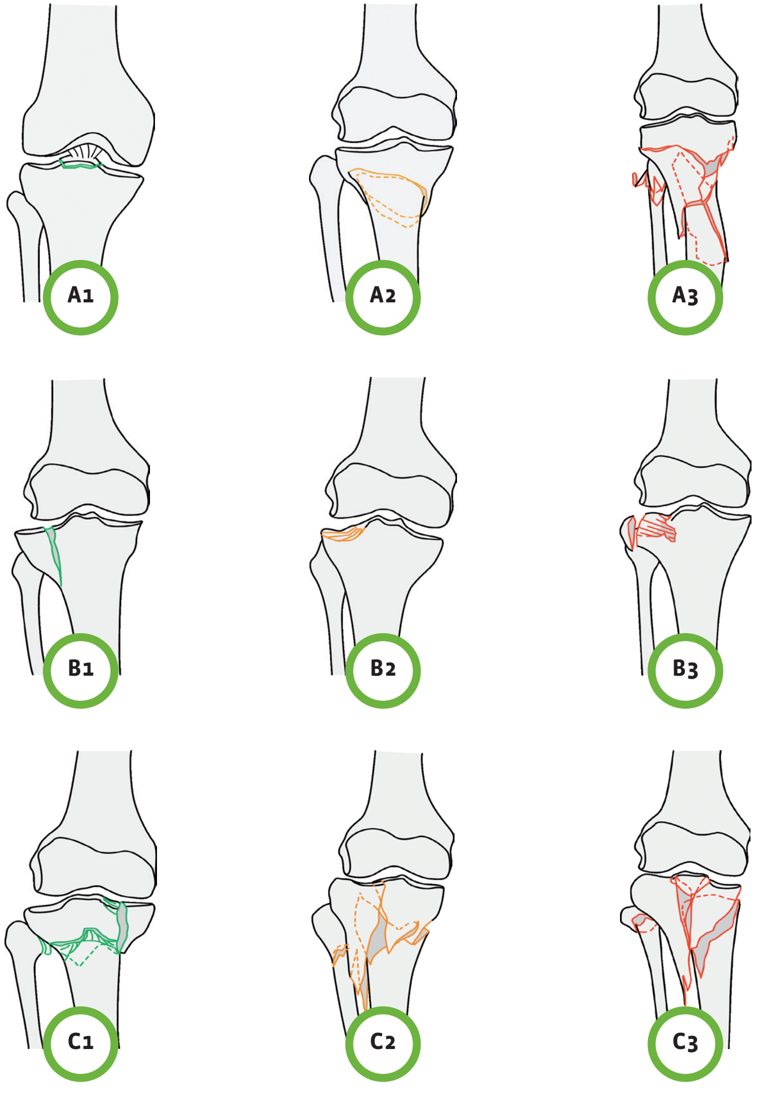
We only included adult patients with (avulsion) fractures of the proximal one-third of the tibia or fibula. Patients younger than 18 years were excluded from the study to avoid the discussion of missed epiphyseal line injuries. We also excluded patients with isolated distal femoral fractures and patellar fractures as those types of fractures do not pose the same problem in radiological misinterpretation [3]. All medical files were reviewed for remarks concerning: the treatment of primarily diagnosed proximal tibial fractures; proximal fibular fractures as a sign of combined osseous and ligament knee injury; delayed diagnosed tibial fractures; and any alarm symptoms for possible delayed diagnoses of fractures in the proximal tibia (e.g., prolonged period of treatment and period of pain, no clear explanation for complaints). Time between ED visit and final diagnosis and time between ED visit and final treatment of patients were used as parameters for determining patient consequences.

We included the official reports of MRI, CT and conventional radiographs in our reviews. If there was any suspicion of a missed fracture from this information (e.g., inconsistency in treatment or diagnosis between ED and further treatment and possible operation), one of the authors reviewed all X-rays (PL). All patients with proximal tibia or fibula fractures subsequently were included in the study. Patients with bilateral fractures were registered as two separate patients, as the chance to miss a fracture on one side is independent of the presence of a fracture on the contra lateral side. Fractures were classified according to the AO-OTA classification [11] [Figure 1]. All avulsion fractures of the proximal one-third of the tibia or fibula were classified as type A1 fractures, as were typical Segond lesions (avulsions of lateral tibia plateau symptomatic for ligamentous injury or intra-articular lesion) and bony anterior cruciate ligament avulsions of the intercondylar eminence.

Table 1 **List of ED diagnosis in the hospital database used for registration of acute injuries in and around the knee**

proximal tibia fractures
medial and lateral collateral ligamentous injuries
anterior cruciate ligament injuries
injuries of the proximal tibiofibular joint
medial and/or lateral menisceal lesions
(osteo)chondral lesions
patellofemoral luxations
knee dislocations/luxations

Figure 1



We further noted demographic data concerning age, gender, type of injury, time of arrival at ED, possible intoxications (alcohol, drugs), emergency operations (laparotomy, intubation), presence of single or multiple injuries and experience of the medical person who examined the knee (categorized as 0-3 years, 3-6, and >6 years of experience) as possible risk factors.

Data storage

All data were stored in an SPSS database (SPSS 14.0, SPSS Inc, Illinois, USA). Chi-square tests and Independent sample t-tests were used to compare means. Results were concerned significant if $p<0.05$.

Results

Fracture classification and demographic data

During the study period, 935 adult patients were registered in the database with one of the diagnoses listed in table 1. A total of 127 patients were found to have 129 fractures of the proximal tibia or fibula (71 men, 56 women; 2 patients suffered from a bilateral fracture). Age ranged from 18-93 years (mean=43 yrs ±17.9). Most patients had an isolated knee injury (90 patients) frequently caused by a traffic accident (75 cases). Twenty-seven patients sustained a rotational or valgus trauma while practicing a sport; the remaining group was injured due to a fall. When viewed according to the AO-OTA classification, fractures were almost equally divided between all types: 38 fractures were of AO type A (of which 32 patients with an intra articular avulsion fracture, type A1, including 9 typical Segond lesions), 52 patients suffered from a type B fracture, and 39 patients were diagnosed with a type C fracture. Most patients were treated operatively (91 patients); there was a higher rate of operative interventions in patients with a type B or type C fracture (type A: 19 operations, type B: 42 patients, type C: 30 patients). See table 2.

Missed diagnosis

In three patients, a fracture that was initially missed by the ED was found when the X-ray was reviewed the next workday. These patients were called back for additional imaging studies which confirmed the fracture. Two of them were operated upon.

In three other patients, the diagnosis was primarily missed by the ED and was also missed during revision the following day. Imaging studies were repeated because the patient reported continued complaints. Two of these patients were polytraumatized and complained of knee injuries after discharge from the Intensive Care Unit.

Table 2 **Demographic data**

	Total	**Age mean (range) years**	**M/F**	**Fracture Type**								
				A1	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**
Correct												
total correct diagnoses	110	44.3 (18-93)	61 / 49	24	5	1	8	11	22	14	13	12
Missed												
diagnosis at radiology conference	3	49.7 (27-66)	0 / 3	1					2			
additional imaging after clinical symtoms	3	38.7 (24-54)	3 / 0				1	1	1			
diagnosis in final radiological report, primarily not recognized by surgeon	6	24.2 (20-50)	5 / 1	1			3	1	1			
fracture never diagnosed	7	34.1 (18-66)	3 / 4	6				1				
Total missed diagnosis	**19**	**35 (18-66)**	**11 / 8**	**8**			**4**	**3**	**4**			
Total group	**129**	**44.3 (18-93)**	**72 / 57**	**32**	**5**	**1**	**12**	**14**	**26**	**14**	**13**	**12**

1) if the fracture was never diagnosed, time for delay was not calculated

Table 3 **Risk Factors**

Diagnosis	**Total**	**AO/OTA type fracture**	**Trauma mechanism**	**Mono / Polytrauma**
		Type A / Type B / Type C	**rotational / fall / traffic**	
Correct				
total correct diagnoses	110	30 / 41 / 39	16 / 25 / 79	75 / 35
Missed				
diagnosis at radiology conference	3	1 / 2 / 0	1 / 1 / 1	2 / 1
additional imaging after clinical symtoms	3	0 / 3 / 0	1 / 0 / 2	1 / 2
diagnosis in final radiological report, primarily not recognized by surgeon	6	1 / 5 / 0	4 / 1 / 1	5 / 1
fracture never diagnosed	7	6 / 1 / 0	5 / 0 / 2	7 / 0
total missed diagnosis	**19**	**8 / 11 / 0**	**11 / 2 / 6**	**15 / 4**
Total group	**129**	**38 / 52 / 39**	**27 / 27 / 75**	**90 / 39**

Delay mean (range)[1]	Treatment	Trauma mechanism
Range	Conservative/ ORIF/Arthroscopic	Rotational / fall / traffic
0	28 / 75 / 7	16 / 25 / 79
1.7 (1-3)	1 / 2 / 0	1 / 1 /
11 (5-14)	0 / 2 / 1	1 / 0 / 2
57.3 (7-150)	4 / 1 / 1	4 / 1 / 1
1)	5 / 0 / 2	5 / 0 / 2
24.7 (1-150)	**10 / 5 / 4**	**11 / 2 / 6**
2.2(0-150)	**38 / 80 / 11**	**27 / 27 / 75**

Experience level physician	Time of the day	Alcohol / drugs related	Ventilated/emergency operation
<3 / 3-6 / >6 years	0AM - 8AM / 8AM - 5PM / 5PM - 12PM	yes/no	yes/no
81 / 23 / 6	16 / 61 / 33	10 / 100	14 / 96
3 / 0 / 0	0 / 3 / 0	0	0
2 / 1 / 0	0 / 2 / 1	0	0
4 / 2 / 0	0 / 4 / 2	0	0
7 / 0 / 0	0 / 3 / 4	0	0
16 / 3 / 0	**0 / 12 / 7**	**0**	**0**
96 / 27 / 6	**16 / 73 / 40**	**10 / 119**	**14 / 115**

They were operated on with a 2-week delay. The third patient had a normal X-ray during the ED visit, but was found to have a type B2 fracture after repeated imaging one week later; the patient was later operated on.
The diagnosis in six patients was missed by the ED as well as by staff in the meeting the next day, but the (suspicion of the) presence of a fracture was noted in the final radiological report. In one of these patients, this concerned an avulsion of the lateral tibia plateau indicating ligamentous injury. However, the information that there was a suspected fracture never reached the treating physician. In four patients, the injury was treated in the same way as a fracture based on clinical information (i.e., cast immobilization to reduce pain added with diagnostic arthroscopy) and in one of these patients the final diagnosis was made after five months. In the other two patients, the miscommunication resulted in a delay of up to six weeks. Treatment was operative in both patients (1 patient underwent an arthroscopically-assisted osteosynthesis and 1 patient had an open reduction and internal fixation).
A remaining group of seven patients had a fracture that was not diagnosed until our review of the X-rays and clinical data fo this study. The percentage of ligamentous avulsions in this group was high (57 %, 4 out of seven patients). All these patients had been treated as having a ligamentous injury (i.e., immobilization and later physiotherapy). Three patients had diagnostic arthroscopy for inventory of associated soft tissue injuries. Delay in diagnosis ranged from 1-150 days (mean 24.7 days, SD± 43.5 days).

Risk factors

Table 3 shows an analysis of possible risk indicators for a missed proximal tibia or fibula fracture. In the group with a delayed diagnosis, a relatively high number of type A and type B fractures were seen compared to the normal group. (100% type A and B compared to 65% in the normal group) ($p=0.007$). In the group with correctly diagnosed fractures, the majority of fractures was caused by a traffic accident; those patients were more often diagnosed with a type C fracture.

We did not find a significant effect of the doctors' experience level on the risk to miss a fracture. Most patients (approximately 70%) were seen by medical personnel with less than 3 years of experience. Twenty-one percent of the patients were seen by a senior resident from (trauma) surgery, while 7% (8 patients) were physically examined by a supervising specialist. Most patients in the group with missed fractures were also seen by relatively inexperienced medical staff: 81% was seen by a junior doctor (<3 years of experience), four patients (19%) were seen by a senior surgical resident and none was seen by a consulting specialist.

Most patients were examined by these doctors during office hours (8AM-5PM); 52% of patients in the whole group and even more (63%) of the patients in the delayed group (difference not significant). Approximately 30% of patient investigations was done in the evening (in both groups) and a minority during the night (15% in the whole group vs 0% in the missed diagnosis group). Well-known risk indicators for overlooking fractures in poly traumatized patients (i.e., intoxication with alcohol or drugs, mechanical ventilation at arrival or emergency operation) were not found to be significant predictors of a delayed diagnosis, and were often present in the correct diagnosis group (alcohol/drugs 10 patients vs 0 in the missed diagnosis group; ventilation or operation 14 patients vs 0 in the abnormal group; $p<0,001$).

Discussion

This study demonstrates that bony injuries of the proximal tibia and fibula are easily overlooked or misinterpreted during routine physical examination and both primary and secondary assessment of standard X-rays of the knee. In almost fifteen percent of patients that entered through our emergency department, complete and correct diagnosis was delayed. Delay in treatment ranged from 1 to 42 days after trauma; delay in diagnosis in some cases was as long as five months (from the time MRI imaging was performed) and in some cases may even be infinite as some fractures were only diagnosed during this research. Although the treatment those patients received was the same as what would have been prescribed if the fracture had been properly diagnosed, it is clear that radiological misinterpretation led to a missed diagnosis and should be prevented.

Well-known risk factors for a delayed or missed diagnosis did not seem to explain the delay in diagnosis in our study.[12][13][14]. Most patients with bone lesions had a simple trauma mechanism and were seen during daytime hours. Intoxication with alcohol or drugs or mechanical ventilation also did not seem to contribute to the risk of a delayed diagnosis.

We started this investigation because we suspected that proximal tibia fractures in our hospital were over-represented in the group of trauma patients with a delayed diagnosis. In this retrospective analysis many additional radiological abnormalities were found, but the clinical impact overall was limited. We were surprised by the fact that the implementation of a meeting between radiologists and surgeons in which patients are discussed, which is required by insurance companies in the Netherlands as part of standard care for each patient, only filtered out 3 of 19 patients with

a radiological abnormality [15]. In our academic setting this meeting was sometimes chaired by a staff radiologist, but at other times also chaired by radiology residents. Eng et al. showed that faculty radiologists are more accurate in interpreting ED radiographs than radiology residents. They also showed that original films facilitated a higher accuracy than high-resolution digital monitors [16]. Although our meeting was based on plain radiographs in the first time period included in the study, we began using a digital Picture Archiving and Communication System (PACS) for reviewing X-rays in 2004. Digital images are viewed in a specially designed room with high-resolution beamers projecting images on a wide movie screen. Nevertheless this setup was never tested for accuracy of interpretation of ED X-rays. It is remarkable that six patients had deviations on X-rays that were described in the final radiological report but went unnoticed during the morning briefing.
In the past the radiologist's judgment during the morning briefing was not used as a basis for the final report. Final radiological reports could be written by another staff member. An unsigned hard copy was delivered to the surgical outpatient's administration department and was added to the patient's medical file without being reviewed by surgical staff. During the final stage of this study, procedure changed. Radiological reports were then reviewed by a supervising radiologist, who used voice-recognition software during the morning briefing to directly create the final report, which was added to the patient's file.

In general, the emergency department is not the optimal place to conduct a thorough analysis of minor injuries or illnesses; but gives medical staff an opportunity to screen for potentially life-threatening injuries and injuries that might need urgent (surgical) treatment or admission to the hospital. From this perspective, it is remarkable that 80% of patients is seen by a junior resident. The fact that inexperienced doctors run the most challenging department in the hospital was noted in 2004 by the Dutch Health Authority, which lead to the mandate that a more experienced doctor be continuously available [17]. Several authors, however, have questioned if more senior ED doctors would have fewer difficulties in adequately assessing X-rays. They found that doctors with several months' more experience or even several years' experience were no better in assessing X-rays and stated that more formal training in X-ray assessment is needed for improvement. [18][4]. Gratton et al. believe that the only way to keep misinterpretation rates low is when a senior staff member reviews every case before discharge from the emergency department. For this reason, we are planning in the near future to have a supervising trauma surgeon permanently stationed in the emergency department to physically control and examine all trauma patients Medical personnel treating any patient in the outpatient department at any time should be aware of the limitations of the findings during an ED visit and of the assessment of imaging studies in particular.

This study largely relies on the accuracy of the hospital trauma registration database. As this database exists for almost 25 years and has been maintained by the same person since 1994, we think it is very reliable in both its completeness and correctness. Diagnoses are first filed after the Emergency Department visit, but can be later adjusted after treatment ends (sometimes after several years). Unfortunately, our method of physically reviewing all files to zoom in on incongruent medical histories is not comparable to re-examining all patients clinically or performing a CT scan (gold standard). In this study risk indicators were mainly used to compare groups and to rule out the presence of any effect modifiers. The numbers are too small to perform a formal logistic regression analysis for all possible risk indicators.

Conclusion

Despite standard back up or supervising mechanisms, 15% of acute knee injuries seen in the ED were misinterpreted radiologically. Misinterpreted ligamentous avulsions represented approximately one-third of the group of missed injuries. Delay in operative treatment for missed fractures ranged from 1-42 days (7 patients); longer delays in diagnosis of up to 150 days were found, but these did not lead to extra morbidity for the patient. We could not define specific risk indicators, although a remarkably high percentage of patients was seen by relatively inexperienced doctors. The most important lesson could be that a seemingly normal X-ray in an ED patient with a traumatic knee injury does not rule out a fracture.

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7

Discussion, historic overview and integration

Introduction

Quality of care knows many definitions. Over the years different approaches and drivers of quality have been seen. From the early years of quality management in the Japanese automobile industry, to the famous Plan-Do-Act quality circle, to quality evaluation based on outcome and expected results, performance indicators and process quality, the discussion on quality matters gradually changed to quality of life and quality adjusted life years as a measure of performance. For the individual care professional it is a major effort to keep up with the current thinking on the subject, let alone to have an opinion on how to evaluate his or her own quality of care and in the meantime being squeezed between departmental, institutional and national quality management efforts.

The scope of this thesis was to assess the true quality of acute trauma care in the Emergency Department. A very basic down to earth approach has been taken in the belief that when in the evaluation of care certain problems are revealed these should be taken care of by the persons who address the problems. This precludes system wide changes, however makes evaluating the work on the floor rewarding and credible because real change can be achieved bottom up, eventually changing the system in the end.

Tools used in this thesis were analyses and testing of basic technical equipment to retrospectively auditing or studying medical files and to reviewing continuous video footage of multidisciplinary team interaction. In the end it led to improvement of training and team performance, through video evaluation, patient satisfaction, because of earlier removal of painful equipment like back boards and transfer protocols for polytrauma patients, as well as pitfalls in the radiological interpretation of diagnostics after acute knee injury.

In this discussion I want to summarize the various aspects and short history of quality initiatives, with specific emphasis on quality management for the trauma patient.

Historic overview

United States

In the past fifty years, enormous changes have been made in trauma care in the USA. In the 1960's, it was a challenge to bring attention to the relevance of trauma and the treatment of trauma patients [1]. At that time, specific education in how to treat traumatic injuries was not really given. Apart from the prevention of traffic accidents (and the corresponding decrease in traumatic injuries), the focus in health care was on the development of local, regional and national health care systems [2].

In the late seventies and early eighties, the American College of Surgeons (ACS) Committee on Trauma started to investigate quality control through an external review and verification program for specialized centers of acute care in the United States. Later (approximately 1992), this review program was extended to include the ACS program Consultation for Trauma Systems [3]. In a span of 25 years, the organization had developed into a well-organized system with its own quality assessment system. However, a worldwide change in attitude towards health care providers pushed quality control into the spotlight [4].

The focus on quality control increased dramatically after the document "To Err is Human, Building a Safer Healthcare System" in 1999 [5]. Two years later, the vision document "Crossing the quality chasm: a new health system for the 21st century" spurred the World Health Assembly (WHO) to appoint an international working group in 2002 whose goal was to organize a campaign for the safety of health care systems [6]. This initiative crowned in 2004 with the start of an international alliance for safer health care [7], signifying change of focus from quality of care to patient safety. In 2006, all these new developments led to the document Model Trauma System Planning and Evaluation in the USA [8][9]. Originating from the conditions observed by the Health Resources and Services Administration (HRSA), medical professionals mutually inspected and judged each others' work.

The Netherlands

In the Netherlands as well, the conditions for the transport and treatment of trauma victims has clearly improved since the late sixties and seventies. A nationwide network of general practitioners and (helicopter) emergency medical services was built for the extramural care for the trauma patient [10]. Currently eleven level-one trauma centers –in addition to their central role in examining and treating trauma patients - coordinate the primary assessment and treatment of these patients for their respective region [11].

The in 2007 published report from EMGO/NIVEL "Onbedoelde schade in Nederlandse ziekenhuizen" revealed shocking facts and figures. The potential avoidable mortality was estimated to be 1700 deaths annually [12]. Apart from mortality, the cost for collateral damage was roughly estimated at 167 million Euro for the year 2004. These publications sparked attention for the issue of health care quality in the Netherlands.

Why was there such a reluctance on the part of hospitals to cooperate with these programs? The fact is that doctors do their best, but still things can go wrong. Despite this individual effort mishaps are apparent. There is a famous example of a Boeing 747 captain who flew his crew into disaster when even the youngest cockpit member knew that they were not allowed to take off from Tenerife airport. The pilot's pride, assumed experience in these difficult situations and strong hierarchical constructions s prevented him from listening to a subordinate team member [13]. This story is viewed with awe in operation rooms. However, the parallel between the pilot's behavior and one's own is not always drawn by all medical staff. The fear of being confronted with one's own possible failures or even denying that failures could be made are two serious threats to the quality assessment culture.

The risk of death due to medical failure in the United States is in absolute numbers equal to the number of deaths by traffic accidents or breast cancer! The fact stands that these medical failures are potentially avoidable and could be prevented by better organization and quality control systems. Modern society demands visible and measurable quality in health care, including trauma care.

Of course there has always been juridical ground for hospitals to show their quality, but this was primarily based upon classic ways of quality control such as certification for management organization, certification for medical equipment and professional licenses and diplomas for health care workers (Kwaliteitswet Zorginstellingen en de Wet BIG (Beroepen in de Individuele Gezondheidszorg)). This way of quality management however does not correlate with individual quality or competence.

Medical competence, as measured in terms of patient outcome, was normally only checked by morbidity and mortality conferences. Mutual inspections routinely consisted of quantitative data, e.g., number of operations performed, quality of medical education given to residents and - in the Dutch situation - participation in the National Surgery Complication Database (Landelijke Heelkunde Complicatie Registratie, LHCR). Although this last item is a good start in quality assessment, it is based on voluntary registration and therefore depends largely on completeness of follow-up and inclusion of complications in the outpatient department [14]. Veen et al. clearly pointed out that system variables clearly influence the results of this evaluation [15]. On the other hand when a solid analysis of complications is done, this can lead to an evaluation and adjustment of protocols with improved results [16]. In the field of gastrointestinal (GI) surgery, the Dutch Surgical Colorectal Audit (DSCA) was recently added. In the long run, individual specialists and hospitals will be able to be compared, but currently the data is only presented anonymously per hospital and can be used for benchmarking results. Presently the content and meanings of these data are without any consequences [www.dsca.nl].

In the past years, commercial sources have published lists ranking Dutch hospitals and specialists. Although coming from an unexpected angle, this is a beginning in publishing quality indicators and an attempt to visualize quality [17][18]. The origin and processing of these data however is not scientifically watertight: data from performance indicators are combined with patient satisfaction scores or ratings from healthcare professional. In general these popular quality analyses have had more interest from the public then formal investigations like the Dutch Health Care Performance Report 2008 [19]. From this analysis of the National Institute for Public Health and the Environment it became clear that Dutch Healthcare is easy accessible, but the quality of care does not excel at an international level. The final conclusions of this report are that coordination and cooperation in health care and patient safety score relatively low. The efficiency of health care in the Netherlands is not optimal and quality is not a driving force in the health care market.

Current systems to assess quality

Outcome indicators

Patient mortality could be used as a quality parameter (in-hospital, 30-day mortality) [20]. The difficulty, however, is that trauma patients' survival is determined by multiple factors. An important example of this is how the survival rate of victims of traffic accidents has changed in the Netherlands. This figure reached an all-time low in 2008 (726 deaths/year) [21]. Specific effects of improved emergency services outside the hospital (helicopter medical teams) or inside the hospital (multidisciplinary trauma teams) could not be identified. Other factors that could have had an effect on this number are preventive measurements (e.g., adjustments to road design, decrease in maximum speed limit, mandatory use of seat belts) and mechanical protection (e.g., improved car safety, addition of air bags). An additional difficulty in using patient mortality to measure quality is the fact that polytrauma patients are by definition injured in multiple body areas, making them difficult to compare with each other. Only when a comparative outcome study in two cohorts was done with a twenty years interval Nijboer et al could determine that survivors have a better quality of life [22]. This study underlines an important problem in registration and quality control: multi-factor processes cannot be adequately described by one single outcome parameter like survival or mortality rate.

Performance indicators

Part of this problem can be solved by dividing the health care process in pieces and measuring process indicators for small parts of the total process. These indicators are used by the Dutch inspector of health care as "performance indicators" (prestatie indicatoren) but subsequently in the official report they are referred to as quality indicators, which wrongly gives the impression that they really say anything about the quality of care that was given [23]. The parameters that are used are the result of a more or less voluntarily selected set of structure, process and outcome indicators through all medical disciplines. By measuring each piece separately, however, total quality cannot be assessed as each piece only describes a part of the total process; there is no correction for all other factors in the process.

Financial benchmarking

Another solution might be to compare financial consumption per doctor, per diagnosis or per hospital. Introduced as a system to control costs, this could easily be used to benchmark quality of care [24]. Although this system is loved by managers and political planners, I believe it is simply a lever to force medical professionals into a specific treatment protocol with fixed costs that does not really measure quality [25]. A possible consequence of this could be that patients who might present a risk of costing more then the average will be banned from hospitals because they will negatively influence quality statistics [26]. Clearly, this creates the risk of a conflict of interest developing between medical professionals and hospital managers. It seems that the Dutch minister of health care would like to give hospital boards a much stronger voice over finances and quality in near future. He has stated that "if a conflict does arise between financial and medical interests that medical professionals will have to continue providing adequate medical care", but there will come a day when quality will be sacrificed for hospital managers' financial bottom line.

Modern quality assessment and patient safety, PIPS

The more modern forms of quality control emphasize the importance of a continuous multidisciplinary effort to measure, evaluate and improve the health care process. In many American hospitals this combined Performance Improvement and Patient Safety (PIPS) approach is a fixed item in the quality assessment system [8]. In the Netherlands, this push for patient safety is clearly noticeable in all new quality organizations that are formed. The idea of prioritizing patient safety has also been adopted by umbrella organizations in the Dutch Health care system (e.g., Nederlandse Federatie van Universitair Medisch Centrums, Nederlandse Vereniging van Ziekenhuizen, Orde van Medisch Specialisten, Verpleegkundigen en Verzorgenden Nederland, Landelijk Expertise instituut voor de Verpleging en Verzorging). Regrettably, the first goal - to establish a Safety Management System (Veiligheid Management Systeem, VMS) in all Dutch hospitals before January 1 2008 - was not met, but a new deadline of 2012 has been set. Moreover the value of the Safety Management System for quality management has not yet been evaluated. Fact is that quality management that is coordinated by healthcare professionals is more effective then when instituted by a manager or policy-maker [27]. In contrast to the several initiatives with proven results in organizing trauma care, only few of the items of the Dutch Healthcare Safety Management System have been tested for their influence in quality improvement [28].

Problems in quality management

Registration numbness and quality exhaustion

In the past few years, quality and safety in health care have been in the media's spotlight. Organizations practically stumble over each other to keep up with quality assessments, accreditations and safety management systems. In the second half of 2009, the quality of the surgical partnership of the Martini Ziekenhuis Groningen was checked six different times, each time by different organizations.

Quality inspection General Surgery
Quality and level inspection Emergency Department
Educational inspection General Surgery
Educational inspection Vascular Surgery
NIAZ hospital accreditation (Nederlands Instituut voor Accreditatie in de Zorg)
Inspector of Health care performance indicators

Both managers and medical professionals have been overwhelmed by the surge in number of quality assessments. Despite evidence that care can and should be better organized in Dutch hospitals, many specialists doubt if the actual developments and a progressively burdensome administration will really improve quality. The demand for quality control comes from so many different parties, some of which seem to require identical information. There is a risk that this demand will draw attention and resources away from clinical issues.

Individual quality

Finally, there is one unsolved problem in quality assessment: the quality of the individual health care professional. In the past years, quality criteria have been formulated for almost all organizations, equipment and procedures common in health care. For surgeons, until now it was sufficient to demonstrate that one had obtained the appropriate qualifications. In the absence of well defined and validated outcome indicators criteria to assess and certify individual quality are diligently being sought for. These certification demands will doubtfully allow for a more transparent quality but will also undoubtedly change the content of the surgical profession. Specializing and certifying in trauma care only on quantitative conditions might lead to demotivated doctors who are left without an elective operation program and who are condemned to long on-call shifts [29].

A conscious choice regarding the content of trauma surgeon's daily practice should be made, defining the competencies, and evaluating the results and if necessary adjust competencies or activities. Selection of clinicians should be on the base of quality and not on the base of time spent. Real individual quality assessment such as described in this thesis might be used to underline the importance of and promote the recognition of trauma surgeons in the Netherlands.

Future directions

My prediction for the near future is that only health care providers that can show their quality through size and numbers will be allowed to offer patient care. It is of the utmost importance that medical specialists adopt this problem and make it their own. Quality in health care is a personal and individual responsibility for every healthcare professional towards every individual patient. For a doctor it is daily practice to treat patients according to the best available evidence, measure outcome and evaluate (Plan-Do-Check-Act). This is why doctors should be leading in quality management. Quality management in trauma care can not been done by managers or policy makers.

The studies in this thesis show examples of ways to assess real quality in the process of caring for trauma patients. The integration of these quality assessment processes into daily practice is a task in itself for the medical specialist. The busy schedule of a medical professional must therefore be supported by a strong electronic registration system or digital medical file to warrant immediate and integral registration of the health care process, eventual complications and actions taken. That – apart from this software and IT developments - a change in quality and patient safety culture still is necessary for the greater part of the specialists, is unmistakable.

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8

Summary

During the past twenty five years, trauma care in the Netherlands has been organized into a well coordinated trauma network with eleven regional level 1 facilities and several level II and level III hospitals scattered around the country. Although the process of how this network came into existence has been largely documented, there is no evidence that this organization has indeed lead to an improvement in quality. When examined more closely, it is unclear how quality in trauma health care should be reported. When the research for this thesis started, most quality assessment focussed on processes and examining whether those processes lead to better quality of care. Optimal treatment of traumatic injuries should lead to improved care for the patient. In this thesis, I try to answer various research questions.

> Will video registration of trauma team procedures in the emergency department allow us to efficiently and precisely evaluate the overall team performance in a level I trauma center with emphasis on organization, mutual communication and compliance to accepted (ATLS®) protocols?

In chapter two, I discuss how the footage of 387 trauma team procedures in the shock room of the emergency department was analyzed. Video footage was analyzed using an ATLS®-based scoring list for quality appraisal. The ATLS philosophy provides guidelines for individual doctors for the assessment , resuscitation and treatment of patients with multiple injuries independent of the available in-hospital resources. The ABCDE logic has created a universal language on a local, national and international level. However, the multidisciplinary team approach is not part of ATLS routine. No specific rules exist on how to evaluate the team process and, as such, this is difficult to judge. This chapter describes the evaluation of the multidisciplinary treatment of polytrauma victims based on an ATLS item list. Qualitative judgment was based on the performance improvement manual [1]. I found that errors in team organization (e.g., omission of prehospital report, no evident leadership, unorganized resuscitation, not working according to protocol and no continued supervision of the patient) correlate with significantly more deviations in the treatment then when team organization was smooth. Therefore, I conclude that an accurate analysis of possible deviations from protocol can be facilitated with the use of video registration of diagnostic and therapeutic procedures by a multidisciplinary trauma team. In addition to being able to identify technical errors, the team leader's role can clearly be analyzed and related to team actions. However, registration strongly depends on availability of video tapes, timely start of registration and hardware functioning.

Is there a difference in subjective comfort of several types of immobilizing devices and does this comply with objective pressure measurements?

In chapter three, an evaluation of tissue-interface pressures on three different support surfaces for trauma patients is described. The support surfaces were a semi-soft overlay mattress, a vacuum mattress and a spineboard. Tissue-interface pressures between the scapulae, the sacrum, the heels and the different support surfaces in twenty healthy volunteers. How well volunteers appreciated comfort of the support surface was assessed using a 10-point visual analogue scale. High and potentially ischaemic interface pressures were found with all three support surfaces, with the highest pressures (exceeding 170 mmHg) measured on the spineboard. The traditionally used spineboard was judged to have the lowest comfort score. There is a need for new, comfortable support surfaces for trauma patients that reduce interface pressures.

Does early spine board removal from trauma patients in the emergency department lead to any adverse effects compared to prolonged immobilization until radiological clearance of the spinal column?

In chapter four, I concluded that prolonged immobilization of trauma patients on traditional spineboards might provide a high risk for developing pressure ulcers. For this reason, we changed protocol to remove immobilizing boards from underneath the trauma patients early. Originally introduced as a transport mechanism for unskilled personnel to extricate patients from wreckage after (motor vehicle) accidents, immobilizing boards quickly became viewed as a safe tool to treat and immobilize patients with (potential) spinal injuries. Indeed, many studies in healthy subjects showed significant reduction in spinal column movements without any proven relationship to clinical symptoms. However, no clinical study has shown a beneficial effect of in-hospital immobilization on spine boards. In chapter four, I describe a retrospective analysis of early spine board removal upon arrival in the emergency department compared to a historic group of patients with prolonged immobilization until radiological clearance of the spinal column. No detrimental changes were reported in either group. Moreover, no adverse effects of early removal of the spine board were found.

Should polytrauma patients transferred between hospitals be examined and treated by a multidisciplinary trauma team in the emergency department of the receiving hospital to optimize the treatment?

Chapter five presents the results of a retrospective study to analyze the risk of missing an injury in poly-traumatized patients who were referred to a level I trauma centre from another hospital within 48 hours of the accident. The main goal of this study was to evaluate if previously unsuspected injuries with potential medical consequences were discovered during multidisciplinary trauma team assessment in transferred patients. In the Dutch trauma system, the optimal place for an injured person to be primarily assessed seems to be a local hospital. Secondary transfer to a higher level trauma care facility can be arranged if indicated. Few guidelines exist for whether to repeat primary assessment on these referred patients upon arrival in a trauma center. This study showed that repeated multidisciplinary screening of every referred polytraumatized patient in the ED has extra value in terms of newly diagnosed injuries. While the clinical consequences seem moderate in terms of extra treatment, this study shows that primary assessment of referred patients frequently is incomplete and inexact, especially in patients with a lowered Glasgow Coma Scale. We therefore conclude that a multidisciplinary assessment has to be conducted upon arrival in a referral center in order to obtain a complete picture of all injuries.

Is the existing safety net for interpretation of radiological examinations in the emergency department sufficient to prevent delayed diagnosis or any damage to the patient?

Chapter six describes the quality assessment of our hospital's internal safety net for recognizing bony lesions of the proximal tibia and fibula (AO-OTA 41 A-C fractures). This was done by analyzing several safety measures in the emergency department that aim at preventing missed diagnosis after standard clinical evaluation followed by conventional X-ray imaging of the knee. Remarkably, standard back-up or supervising mechanisms failed to determine 15% of the bony injuries to the proximal tibia and fibula in patients with an acute knee injury in the ED (including avulsion fractures and Segond lesions). Delay in treatment ranged from 1-42 days; longer delays in diagnosis of up to 150 days were found, but these did not lead to extra morbidity for the patient. We could not define specific risk indicators. The most important lesson could be that a seemingly normal X-ray in a patient with a traumatic knee injury does not rule out a fracture.

Reference

1 Performance Improvement Subcommittee of the American College of Surgeons Committe on Trauma. Trauma Performance Improvement Reference Manual 2002:49.

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Samenvatting in het Nederlands

Gedurende de afgelopen 25 jaar is de traumazorg in Nederland georganiseerd in een goed gecoördineerd trauma netwerk met elf regionale level I (hoogste niveau) faciliteiten en meerdere level II en level III ziekenhuizen verspreid door het land. Hoewel het proces waardoor dit trauma netwerk tot stand kwam duidelijk is gedocumenteerd, is het moeilijk om bewijs te verzamelen dat deze organisatie inderdaad heft geleid tot een verbetering van de kwaliteit. Het is namelijk eigenlijk onduidelijk hoe kwaliteit in trauma zorg moet worden gerapporteerd en gestuurd. Optimale zorg voor patiënten met traumatische letsels zou moeten leiden tot het meten van een verbeterde zorg voor de patiënt, maar hoe is dit te meten? In dit proefschrift heb ik getracht aan de hand van een aantal vragen dit dilemma te beantwoorden.

> Zal video registratie van trauma team procedures zorgen voor een efficiënte en precieze evaluatie van de overall team prestatie in een level I trauma centrum, daar waar het gaat om organisatie, wederzijdse communicatie en het volgen van geaccepteerde (atls®) protocollen?

In hoofdstuk twee analyseer ik 387 video registraties van trauma team procedures volgens ATLS® richtlijnen. De introductie van de ATLS filosofie zorgde voor richtlijnen voor individuele artsen voor het beoordelen, in leven houden en behandelen van patiënten met meerdere verwondingen, nagenoeg onafhankelijk van de beschikbaarheid van middelen ter plaatse. Het ABCDE stramien van de ATLS heeft een universele taal gecreëerd voor behandelaars van trauma patiënten op een lokaal, nationaal en internationaal niveau. De multidisciplinaire team benadering zoals die in de meeste grotere ziekenhuizen wordt gehanteerd is echter geen onderdeel van ATLS routine. Daarnaast bestaan er geen specifieke afspraken om het team proces te evalueren. Met een door ons ontworpen scorelijst van ATLS items en procedures konden de multidisciplinaire teams beoordeeld worden. Afwijkingen van het protocol werden onderverdeeld in 2 groepen:

- geen afwijkingen
- wel afwijkingen
    - mild, zonder consequenties voor de patiënt
    - serieus, voorbijgaande consequenties voor de patiënt
    - serieus, tijdelijke schade voor de patiënt
    - blijvende schade voor de patiënt (niet waargenomen in de studie)

In de analyse werd vastgesteld dat problemen in de team organisatie (het achterwege laten van een overdracht van prehospitale gegevens, onduidelijk leiderschap, ongeorganiseerde resuscitatie, het alleen laten van de patiënt zonder supervisie en het niet houden aan protocollen) correleerde met significant meer afwijkingen dan wanneer de team samenwerking wel goed verliep. Uit dit onderzoek concludeerden we dat video dus gebruikt kan worden voor registratie en beoordeling van team procedures. De beoordeling van videobeelden is uiteraard sterk afhankelijk van het optimaal functioneren van de apparatuur en het tijdig starten van de opname.

Is er een verschil in comfort tussen diverse types immobiliserende hulpmiddelenen is dit te correleren aan objectieve metingen?

In hoofdstuk 3 wordt de evaluatie van weefseldruk metingen op drie verschillende ondergronden van immobiliserende hulpmiddelen voor traumapatiënten ("spine boards") beschreven. Deze hulpmiddelen waren een semi-zachte matras, een vacuum matras en een kunststof spineboard. Weefsel interface drukken tussen schouderbladen, stuit, hielen en de diverse ondergronden werden gemeten bij 20 gezonde vrijwilligers. De subjectieve beoordeling van de diverse ondergronden werd bij de proefpersonen gemeten met behulp van een visueel analoge schaal. Hoge en potentieel tot ischemie leidende drukken werden gevonden bij alle drie de hulpmiddelen (de hoogste druk, > 170mmHg bij het spine board). Dit traditioneel gebruikte spineboard scoorde tevens het laagste op comfort. Aan de hand van dit onderzoek werd duidelijk dat er behoefte is aan nieuwe comfortabele immobilisatie middelen voor trauma patiënten die de weefsel drukken reduceren. Daarnaast zou kunnen worden overwogen of er mogelijkheden zijn om patiënten minder lang op deze boards te immobiliseren.

Heeft het vroegtijdig verwijderen van het spine board bij traumapatiënten op de Spoedeisende Hulp negatieve effecten vergeleken met langdurige immobilisatie totdat de wervelkolom radiologisch is vrij gegeven?

In bovenstaand hoofdstuk heb ik beschreven dat immobilisatie op spineboards kan leiden tot hoge lokale weefsel-interface drukken. Dit was een van de redenen om het protocol te veranderen naar vroegtijdig verwijderen van het spineboard. Het spineboard is namelijk ontworpen als transport hulpmiddel voor ongeschoold personeel om bijvoorbeeld slachtoffers mee uit een (auto) wrak te halen. Al snel is de wervelplank daarna verworden tot het ideale middel om patiënten met (potentieel) letsel van de wervelkolom te behandelen en te immobiliseren. Inderdaad is in veel studies met gezonde vrijwilligers vastgesteld dat vastbinden op een plank zorgt voor minder bewegingen van de wervelkolom, echter zonder enige relatie met klinische symptomen! Ook is er geen bewijs voor het nut van het gebruik van de wervelplank in het ziekenhuis. In hoofdstuk 4 beschrijf ik een retrospectieve analyse van vroegtijdige wervelplank verwijdering in vergelijking met een historische patiëntengroep waarbij de wervelplank pas werd verwijderd na röntgenologische beoordeling van de wervelkolom. In geen van beide groepen werd een klinisch relevante verandering van de symptomen opgemerkt. Beter nog, het vroegtijdig verwijderen van de wervelplank had geen enkel nadelig effect.

> Moeten polytrauma patiënten die worden overgeplaatst naar een ander ziekenhuis opnieuw onderzocht en behandeld worden door een multidisciplinair trauma team op de Spoedeisende Hulp van het ontvangende ziekenhuis?

Hoofdstuk 5 beschrijft de resultaten van een retrospectieve studie waarmee het risico werd geanalyseerd om een letsel of aandoening te missen bij polytrauma patiënten die worden overgeplaatst naar een level I ziekenhuis binnen 48 uur na een ongeval Het belangrijkste doel van deze studie was om uit te vinden of tevoren onvermoede letsels met mogelijke medische consequenties werden ontdekt tijdens multidisciplinaire trauma team herbeoordeling in het ontvangende ziekenhuis. In het Nederlandse trauma systeem is de optimale plaats voor een gewonde soms primaire opvang en behandeling in een lokaal (niveau II of III) ziekenhuis. Zo nodig kan dan op indicatie een overplaatsing naar een centrum van een hoger niveau worden gerealiseerd. Er bestaan geen richtlijnen of bij deze overplaatsing een hernieuwd onderzoek in het ontvangende ziekenhuis hoort. In deze studie wordt aangetoond dat hernieuwde multidisciplinaire screening van elke overgeplaatste trauma patiënt op de afdeling Spoedeisende Hulp zeker meerwaarde heeft in termen van extra gevonden diagnoses (88 extra diagnoses bij 44 van de 154 patienten). Hoewel de klinische consequenties van deze extra diagnoses soms beperkt zijn, werden ook enkele levensbedreigende nieuwe diagnoses aangetoond. Het onderzoek toont vooral ook aan dat de primaire opvang en behandeling bij overgeplaatste patiënten vaak incompleet en onnauwkeurig is, vooral bij patiënten met een verlaagde Glasgow Coma Score. De conclusie kan dan ook niet anders luiden dan dat multidisciplinaire beoordeling van overgeplaatste polytrauma patiënten opnieuw moet plaats vinden in het ontvangende ziekenhuis om een compleet beeld te krijgen van alle letsels.

Is het bestaande vangnet voor de beoordeling van röntgen onderzoeken op de afdeling Spoedeisende Hulp voldoende om een vertraagde diagnose en eventuele schade aan patiënten te voorkomen?

Hoofdstuk zes beschrijft een analyse van de kwaliteit van de beoordeling van patiënten met een acuut knieletsel op basis van standaard lichamelijk onderzoek en conventionele rontgen foto. Specifiek werd gezocht naar in eerste instantie niet herkende ossale (bot) afwijkingen aan de proximale tibia (scheenbeen) of fibula (kuitbeen), volgens de kwalificatie van de AO-OTA: 41 A-C fracturen. Opmerkelijk genoeg werden ossale letsels rondom de knie in 15% van de gevallen niet herkend tijdens het bezoek aan de Spoedeisende Hulp (inclusief avulsie fracturen en zogenaamde Segond letsels). Bij drie patiënten werd tijdens de dagelijkse controle van Spoedeisende Hulp dossiers alsnog de fractuur herkend. Bij anderen duurde het diagnosticeren tot 150 dagen na het ongeval, maar dit heeft hoogst waarschijnlijk niet tot extra morbiditeit voor patiënten geleid. Vertraging in de behandeling varieerde van 1-42 dagen. Wij konden geen specifieke risico factoren vaststellen voor het niet adequaat beoordelen van een knieletsel op de Spoedeisende Hulp. De belangrijkste les zou kunnen zijn dat een ogenschijnlijk normale röntgen foto van de knie bij een patiënt met acute knieklachten een traumatisch letsel niet uitsluit.

Toekomst

Mijn voorspelling voor de nabije toekomst is dat alleen zorgaanbieders die hun kwaliteit in maat en getal kunnen laten zien toestemming krijgen om patiënten te behandelen. Het is van het hoogste belang dat medisch specialisten dit probleem onder ogen zien en zich dit probleem eigen maken. Kwaliteit in de gezondheidszorg is een persoonlijke en individuele verantwoordelijkheid voor elke zorg professional tegenover elke individuele patiënt. Voor een dokter is het dagelijkse praktijk om patiënten te behandelen volgens de best beschikbare kennis, uitkomst te meten en deze te evalueren (Plan-Do-Check-Act). Dat is ook de reden waarom dokters leidend moeten zijn in kwaliteits management, dit kan niet worden bedacht door beleidsmakers of managers.

De onderzoeken in dit proefschrift zijn voorbeelden van manieren om de werkelijke kwaliteit in het proces van zorg voor trauma patiënten vast te stellen. De integratie van deze kwaliteits evaluatie met de dagelijkse praktijk is een uitdaging op zichzelf voor de medische professional. Het drukke tijdschema van medisch personeel moet derhalve ondersteund worden door een sterk digitaal registratie systeem of elektronisch patiënten dossier om onmiddellijke en integrale registratie van het gezondheidszorg proces met eventuele complicaties en daaropvolgende acties te waarborgen. Dat er –naast deze ontwikkelingen in software en informatie technologie- een omslag in kwaliteits en patientveiligheids cultuur moet komen bij het grootste deel van de medisch specialisten valt echter niet te betwisten!

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The author of this thesis was born on April 5th 1966 in the village of Muiderberg as the youngest of four children and only son. After graduating from secondary school, he spent a year in France, which was very advantageous for his later career and also greatly improved his skiing and rock climbing skills. During his first year at university, he studied law at the University of Amsterdam before starting medicine a year later (1985) at the same university. While studying in Amsterdam, he also participated in competitive rowing at the Amsterdam Student Rowing Club "Nereus". Rowing competition culminated in victories in several high profile contests, but more importantly, the teammates from that 1984 freshmen's eight would become close friends forever.

Before starting his first 3 years of surgical training in Nieuwegein (under dr. T.J. Bast and dr P.M.N.Y.H. Go) he crossed the Atlantic Ocean in a sailboat! That was the experience of a lifetime that prepared him well for the six years of residency to follow.

For the second part of his surgical training (under Prof.dr T.J.M.V. van Vroonhoven and Prof.dr. I.H.M. Borel Rinkes), he moved to the University Medical Center in Utrecht. This is where the research presented in this thesis started. He subsequently participated in a fellowship for Trauma Surgery in Groningen (under Prof. dr.H.J.ten Duis). To his disappointment, the Helicopter Emergency Medical Services training was no longer part of the fellowship by the time the author had moved to Groningen. The trauma fellowship, however, did include a three-month period in Curacao, the Netherlands Antilles.

He is currently working as a surgeon at the Martini Hospital in Groningen, a large teaching hospital. He is a teacher at ATLS and AO courses and member of the Patient Safety Committee of the Dutch Surgery Association. His primary interest is being a good surgeon for his patients. This, together with the responsibilities for his family, has undoubtedly influenced the pace at which the writing of this thesis progressed.

He is married to Addy Verberkmoes, a cardiologist who also works at the Martini Hospital. They have three children Tijn (7), Naut (5) and Mirre (2). His recent sporting achievements include finishing the Amsterdam Marathon in 2008 .