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Task Force Uruzgan, Afghanistan 2006-2010: medical aspects and challenges

Rigo Hoencamp

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Task Force Uruzgan, Afghanistan 2006-2010: medical aspects and challenges

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volgens besluit van het College voor Promoties
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klokke 10.00 uur

Door:
Rigo Hoencamp
geboren te Den Haag in 1979

Promotiecommissie

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Prof. Dr. I.B. Schipper
Dr. E.C.T.H. Tan (Radboud Universitair Medisch Centrum)

He who wishes to be a surgeon, must first go to war.

(Hippocrates, ca. 460-377 B.C.)

Aan mijn ouders

Voor Fleur, Loyce en Yade

Contents

Introduction

Chapter 1. General introduction and outline of the thesis

General introduction

A good friend of our family recently gave me an article about the experiences of a nurse (close relation) during the battle of Caen (1944)[1]. Her experiences and challenges are by now almost seven decades old, but still very current. In addition to the required military tactical skills and medical competences, this fascinating in depth description of the hardships in a hospital during an armed conflict shows that (1) the mental and physical resilience of casualties and their colleagues is vital for survival, (2) military medicine has no fixed golden standards. Current practices are subject to a continuous process of adaptations, dictated by recent experiences and developments, and (3) injuries sustained in armed conflicts differ from those seen in civilian trauma. The last two items are described extensively in recent literature [2-11].
As a troop commander in the Royal Netherlands Marine Corps in Uruzgan, Afghanistan, I experienced the overwhelming power of Esprit de Corps, team spirit and learned the importance of being modest. Outside the fence, I witnessed sometimes terrible brutalities in human interaction and learned to respect the horrendous effects of an armed conflict and the human suffering it causes.

> Armed conflicts are part of our history and are likely to be part of our future.
> Civilian medicine is not similar to military medicine.

With the above statements in mind, we need to draw lessons from previous conflicts to keep the morbidity and mortality of battle casualties (BCs) as low as possible. As such, we need to develop lessons learned from the Dutch presence in Afghanistan.

Recent conflicts

In the aftermath of the terrorist attacks of September 11, 2001, the United States of America (US) initiated the so-called Global War on Terror (GWOT) and deployed military units to multiple theaters in the Middle East and Southwest Asia [12-14].
Starting as a more traditional type of warfare, with overwhelming firepower within the clear boundaries of one country, the GWOT slowly progressed into a counter-insurgency operation; an operation characterized by a blurring of the lines between war and politics, combatants and civilians. This modern type conflict is often referred to as fourth-generation warfare and is characterized by traditional armed forces being challenged by non-state related insurgents that use unconventional combinations of lethal and non-lethal tactics that are extremely complex to neutralize. One of the distinguishing features of this type of conflict is the heavy use of improvised explosive devices (IEDs), causing a typical casualty pattern [6,11]. This casualty pattern, especially the anatomical distribution of this type of battle injuries (BIs), differs drastically from previous conflicts. One of the most striking examples of the maiming effect of IEDs is the so-called dismounted complex blast injury [6]. Since 2001, over 10,000 coalition service members have been killed and over 50,000 were injured during the operations in Iraq and Afghanistan [5]. Additionally, thousands of contractors, host-nationals, foreign national security personnel and insurgents have been injured or killed.

The importance of describing the incidence and character of battle injuries, as well as their precipitating mechanisms, has been recognized since the 19th century. Since that time, many reports have been published[3]. A comprehensive and thorough evaluation of the epidemiology and characteristics of modern times battlefield injuries is vital to improve future combat casualty care, in developing protective measures, in identifying risk factors and populations at risk, and in evaluating efficiency of delivered care[15]. However, the development of reliable conclusions and recommendations requires the universal use of clear and unambiguous casualty definitions (Figure 1).

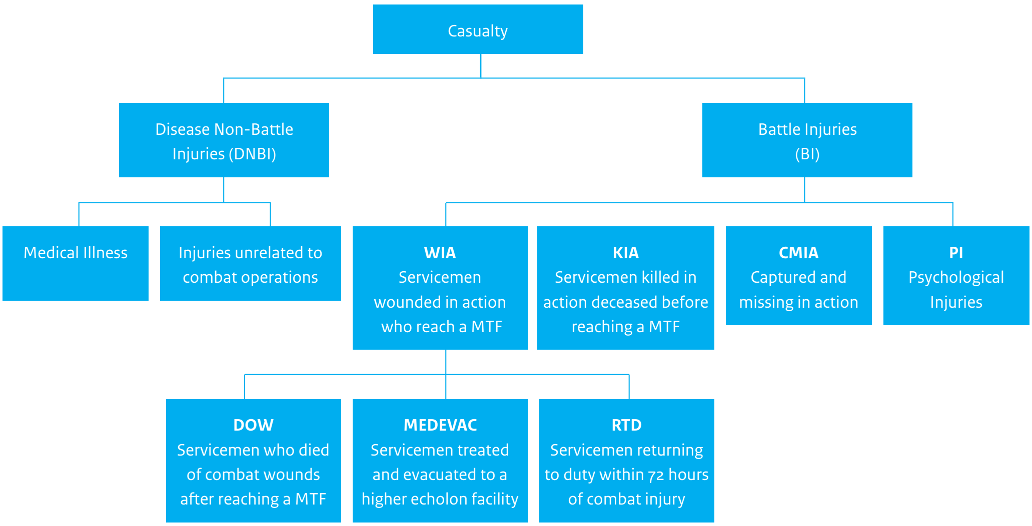

***Figure 1:** Schematic of military casualty definitions and classifications*[2]

Currently, there is very limited literature about recent Dutch participation in armed conflicts. Optimization of our military medical system is only possible with clear data and outcomes. This includes quality of care (QOC), cost-effectiveness and long term follow up of service members. Therefore a thorough evaluation of the Dutch military medical system is required.

Dutch involvement

Recently, the Dutch Armed Forces (DAF) have participated in two North Atlantic Treaty Organization (NATO) military missions: Operation Enduring Freedom and the International Security Assistance Force (ISAF) mission in Afghanistan. ISAF was authorized by United Nations Security Council resolution 1386 in December 2001[16]. The Netherlands participated in ISAF with Task Force Uruzgan (TFU), as the Netherlands were lead nation in Uruzgan province between 2006 – 2010. During that period, Dutch service members were frequently exposed to the devastating effects of IEDs[11]. The main component of TFU was located at Multi National Base Tarin Kowt (MBTK), a second base was located at Deh Rawod (Figure 2).

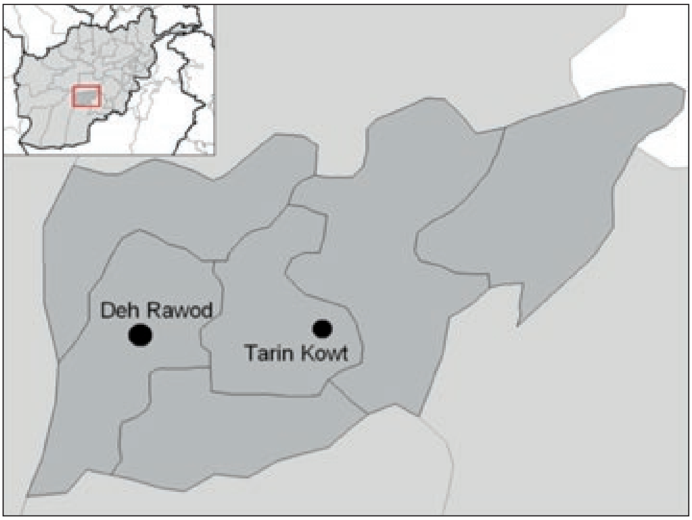

Figure 2: *Map Uruzgan, Afghanistan*

The Medical Support Organization (MSO) in Southern Afghanistan during the ISAF operations, was a multinational joint service with a wide range of capabilities, delivering care in a hostile and austere environment (e.g. enemy threat, patient's overall medical condition, evacuation timelines, availability of assets, qualifications / capabilities of medical personnel and prevailing tactical / weather conditions). The NATO Allied Joint Medical Support Doctrine (AJP-4.10)[17] is the capstone document on which the MSO is based, but it is not an unchangeable holy doctrine (Figure 3). During the deployment of the DAF to Southern Afghanistan the MSO was adapted to the local situation in Uruzgan province (Figure 4).

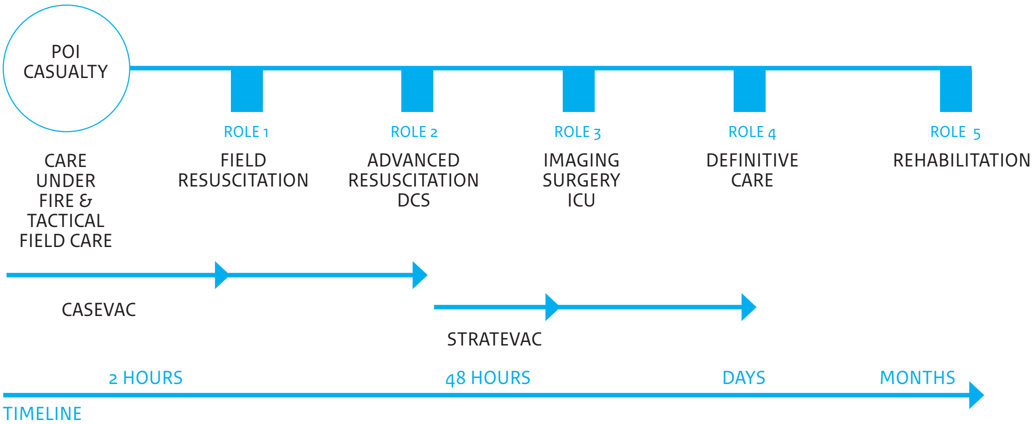

Figure 3: *Schematic overview of the treatment phases in the medical support organization in relation to time and availability of medical care*[5]

POI indicates point of injury; *DCS:* damage control surgery; *ICU:* intensive care unit.

Figure 4: Description of the medical support organization [5]

The NATO coalition forces operate with a standardized model of evacuation and (surgical) treatment phases, that can be adapted to several situations depending on different geographical and battle type related factors. This model is based on a system with progressively sophisticated levels of medical support in the chain of events when taking care of a battle casualty (BC).

Role 0 (battlefield and evacuation):

This includes Self Care and Buddy Care (SCBC). This is basic assistance that can be provided by all combatants to treat basic circulation- airway, breathing, and circulation (c-ABC) problems.

Evacuation from the point of injury

This is a critical phase where military tactics, time, information flow and communication are essential. This phase is performed by military tactical commanders, and military nurses trained according to Tactical Combat Casualty Care (TCCC) doctrine and Battlefield Advanced Trauma Life Support (BATLS) principles. The NATO 9-liner/ MIST is used as a formal document for Medical Evacuation (MEDEVAC) or Casualty Evacuation (CASEVAC). This 9-line medical evacuation message is a series of phonetic letters, numbers, and basic descriptive terminology used to transmit essential evacuation information such as location, (war) time zone, security of pick-up site, number of patients by precedence, special equipment required, patient nationality and status.

Medical Treatment Facilities (MTF)

Role 1 MTF:

This level is the first level of care in which medical professionals are situated. Care at these facilities is aimed at initial life and limb saving (mostly non-surgical) procedures. On our forward operating base in Dew Rawod there was a role 1 MTF. Care in this phase is generally performed by military nurses (AMV), general duty medical officers (AMA / GDMO) and general practitioners (GP). All of them are trained according to Battlefield Advanced Trauma Life Support (BATLS) principles. If more extensive surgical interventions are required, the patients are transported to a higher echelon.

Role 2 MTF:

At this level of care subsequent emergency resuscitation and damage control surgery is performed by military medical specialists, mainly anesthesiologists and surgeons. In addition to a Role 2 Enhanced (E), a Role 2 MTF Light Manoeuvre (LM), medical care is limited to life-and-limb saving and damage control surgery, with a short holding capacity. A Role 2 MTF should be easily accessible and in a safe area. On Multi National Base Tarin Kowt there was a Role 2E MTF with additional (e.g. intensive care unit [ICU], radiological imaging) facilities.

Secondary Evacuation

Moving the patient to a Role 3 MTF or civilian hospital (by helicopter or tactical ambulance) is called MEDEVAC or Strategic Evacuation (STRATEVAC). At these higher echelons, more specialist care is available and a longer length of hospital stay is possible. The MTFs are designed to provide theatre secondary health care within the restrictions of the Theatre Holding Policy.

Figure 4: *Continued*

Role 3 MTF:
At this level in the Medical Support Organization, there are facilities for deployed hospitalization and the elements to support it. It basically includes surgical interventions at primary surgery level, ICU, nursing beds and diagnostic support. Depending on mission characteristics it includes a mission-tailored variety of clinical specialties, focused on the provision of emergency medical care. During the Dutch operations in Uruzgan province, this task was in most cases fulfilled by the Multinational Role 3 MTF, located at Kandahar Airfield (KAF).

Role 4 MTF:
Located at the end of the evacuation and treatment chain, the Role 4 MTF provides the full spectrum of definitive medical care that could (or should) not be delivered in theatre. It includes definitive high care specialist surgical and medical procedures, reconstructive surgery and (long term) rehabilitation facilities. Role 4 care can be provided by military hospitals, but also in cooperation with the national, civilian, health care system. This combined service was provided in the Central Military Hospital and the University Medical Centre Utrecht.

Rehabilitation
This is the phase that follows after the sometimes intensive in-hospital treatment.

Evolution in Military Medicine

To overcome the gap between civilian and military medicine [3,8,18-20], many efforts have been undertaken. Frank Butler et al. introduced the Tactical Combat Casualty Care (TCCC) doctrine [21,22], which comprises a set of trauma management guidelines for use on the battlefield. The TCCC (also TC3) doctrine was first introduced in the US Special Operations community, but the conflicts in Iraq and Afghanistan have seen TCCC, or modifications (e.g. Battlefield Advanced Trauma Life Support principles), become the standard of military pre-hospital care in most NATO coalition forces. Numerous lifesaving materials, tools, protocols and courses (e.g. haemostatic dressings, tourniquet revival, massive transfusing protocol, damage control surgery courses) were developed. Apart from the direct medical effects of modern training doctrines, limiting transportation times is essential in improving survival rates of battle casualties. Improvements and modifications in dedicated rotary or fixed wing evacuation, combined with the mentioned current practices, have reduced mortality rates to far below 5% [23]. The military surgeon plays a vital role in the initial care of a wounded service member and should be ready for this demanding task in the damage control surgery phase. It is conceivable that a “young” military surgeon will deploy soon after completing civilian residency training, encountering complex combat injuries he is not familiar with, simply because they are rare in civilian trauma or are taken care of by a different type of (surgical) specialist. Regardless of (residency) subspecialisation, all Dutch military (trauma) surgeons complete their surgical training on civilian patients. To date there is no standardized (Dutch) military training program implemented, but it is gradually developing based on our recent experiences.
Military medicine is a continually evolving specialization; all efforts should be given for optimization [24]. The ongoing struggle to find a “full fit” curriculum for military medical service members might resemble the search for “the holy grail”, and the cost of such an extensive surgical training program may outweigh the

benefits. There is, however, a strong analogy with disaster medicine and surgery. Collaboration of disaster and military medicine could, therefore, potentially be useful. This may imply changes in the training that military and civilian organizations offer to military medical personnel.

Rationale and aims of this thesis

This dissertation gives a perspective on the combat casualties from a very recent theatre of war, namely Afghanistan, where the DAF were actively involved. This perspective focuses on the short and long term effects of injuries sustained by a service member, but also on the impact of these injuries and their consequences on his comrades and his social network. Despite the evolving technical capabilities of modern mechanized or automated elements (e.g. drones and robots), human "boots on the ground" will likely remain crucial in future armed conflicts. Today's civilian medicine, characterized by increasing costs, raising patient awareness and growing legal concerns, urges health care facilities and medical professionals to obtain and provide detailed insight in quality of provided care. The introduction of numerous expensive diagnostic modalities and therapeutic strategies urges individual physicians and health care facilities to evaluate efficacy and accuracy of the care delivered. This insight in quality of provided care can be used to detect shortcomings and to initiate new scientific studies. Furthermore, monitoring provided care increases transparency for physicians, hospitals and patients, and can be used to evaluate financial aspects. These analyses are difficult to conduct in military medicine and often lacking. Partially driven by the increase in welfare, value and quality of life, an increased attention for this topic is coming from military, medical, economic and political points of view. Therefore, in order to collect data and draw meaningful conclusions, also regarding QOL and cost-effectiveness, a detailed registration system of interventions on BCs should be used. This thesis recognizes, and aims to enhance, the quality of the short and long term care of service members that perform their (national) duties in the DAF.

Part 1: Incidence and epidemiology of battle casualties

The first part of the thesis consists of (1) a systematic review of the incidences and characteristics of BCs from NATO coalition forces in Iraq and Afghanistan, and (2) a cross-sectional analysis of incidence and epidemiology of casualties treated at the Dutch role 2 enhanced medical treatment facility at Multi National Base Tarin Kowt (role 2 MTF NL), Afghanistan in the period 2006-2010. **Chapter 2** is a systematic review of the prevalence and characteristics of BCs from NATO coalition forces in Iraq and Afghanistan. This chapter provides insight in demographics and opportunities to optimize quality of care of BCs. The aim of **Chapter 3** is to review the incidence and epidemiology of casualties treated at the role 2 MTF NL at Multi National Base Tarin Kowt. This assessment shows the broad spectrum of battle injuries sustained. **Chapter 4** aims to evaluate the impact of explosive devices on Dutch BCs in Southern Afghanistan, by evaluation of demographics and tactical circumstances.
As such, the objective of this part is (1) to evaluate the incidence and types of BCs in NATO coalition forces and (2) to compare these international data with the DAF and historical figures.

Part 2: Quality of care

The second part of this thesis evaluates (1) QOC in the pre-hospital phase during the military operations in Uruzgan, and (2) the in-theatre hospitalized phase. **Chapter 5** focuses on determining the impact of combat events in the direct circle (first responders) surrounding a BC. For assessment of post deployment impact, both the Post Deployment Reintegration Scale and Impact of Event Scale were used. This assessment shows the impact of combat events on first responders. The objective in **Chapter 6** is (1) to assess the medical preparedness, deployment experience, and post-deployment impact on Dutch surgeons and anesthesiologists serving in Afghanistan, and (2) to identify potential improvements on various aspects of the medical care. **Chapter 7** describes the challenges in training military surgeons in relation to current surgical resident training programs. The aim of this chapter was to compare the surgical workload at the role 2 MTF NL in Southern Afghanistan with the exposure to surgical pathology in civilian surgical training and the pre-deployment medical specialist work up program, in order to construct a possible curriculum for the future military surgeon. A second goal of this chapter was to perform a detailed assessment of the pre-hospital and damage control phase after a casualty sustained a battle or non-battle injury.

Part 3: Quality of life

The third part of this thesis focuses on the QOL of a BC, divided in (1) role of social support, (2) outcome, and (3) post deployment reintegration. **Chapter 8** focuses on the long term follow up and care consumption of the BCs of the DAF. The goal of this chapter was to assess the impact of battle injuries on BCs. **Chapter 9** describes an assessment of all care consumption of repatriated servicemen from Afghanistan. The aim of this chapter was to assess the volume and type of injuries of all repatriated Dutch service members. Furthermore, lessons learned were identified for future operations.

Chapter 10 summarizes our main conclusions and formulates recommendations for future research in military medicine.

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Part 1
Incidence and epidemiology of Battle Casualties

Chapter 2. Systematic review of the prevalence and characteristics of Battle Casualties From NATO coalition forces in Iraq and Afghanistan

Rigo Hoencamp; Eric Vermetten; Edward C.T.H. Tan; Hein Putter; Luke P.H. Leenen; Jaap F. Hamming

Injury. 2014;45:1028-1034

ABSTRACT

Background: The North Atlantic Treaty Organization (NATO) coalition forces remain heavily committed on combat operations overseas. Understanding the prevalence and characteristics of battlefield injury of coalition partners is vital to combat casualty care performance improvement. The aim of this systematic review was to evaluate the prevalence and characteristics of battle casualties from NATO coalition partners in Iraq and Afghanistan. The primary outcome was mechanism of injury and the secondary outcome anatomical distribution of wounds.

Methods: This systematic review was performed based on all cohort studies concerning prevalence and characteristics of battlefield injury of coalition forces from Iraq and Afghanistan up to December 20th 2013. Studies were rated on the level of evidence provided according to criteria by the Centre for Evidence Based Medicine in Oxford. The methodological quality of observational comparative studies was assessed by the modified Newcastle-Ottawa Scale.

Results: Eight published articles, encompassing a total of n = 19,750 battle casualties, were systematically analyzed to achieve a summated outcome. There was heterogeneity among the included studies and there were major differences in inclusion and exclusion criteria regarding the target population among the included trials, introducing bias. The overall distribution in mechanism of injury was 18% gunshot wounds, 72% explosions and other 10%. The overall anatomical distribution of wounds was head and neck 31%, truncal 27%, extremity 39% and other 3%.

Conclusions: The mechanism of injury and anatomical distribution of wounds observed in the published articles by NATO coalition partners regarding Iraq and Afghanistan differ from previous campaigns. There was a significant increase in the use of explosive mechanisms and a significant increase in the head and neck region compared with previous wars.

BACKGROUND

The Global War on Terror (GWOT) is the largest scale armed conflict for the North Atlantic Treaty Organization (NATO) in its existence. This operation, with the evolution of the conflict from traditional warfare to a counter-insurgency operation, has been confronted with many battle casualties (BCs) on the side of the allied forces, where the mechanism of injury and anatomical distribution of battle injuries (BIs) is changing [1]. The conflict is characterized by heavy use of improvised explosive devices (IEDs) causing a typical casualty pattern [2]. The study of BI and their causes is important for improving care on the battlefield and the field assistance, for developing protective measures, identifying risk factors and populations at risk and efficiency of care. In addition, due to the insurgents in the Iraq and Afghanistan wars relying extensively on irregular means of warfare, findings from the study of injured military personnel may also have implications for disaster preparedness and mass-casualty events that result from terrorism in the civilian sector [2]. It is of interest to search for published data on this subject to consider improvements in care for BCs.

A systematic review of scientific reports on BCs in NATO coalition partners has not yet been performed. From an initial read of studies in this domain it was evident that the registry before 2004 was very fragmentary and not well structured. A Joint Theatre Trauma Registry (JTTR) was established in 2004 and is a prospective standardized system of data collection, designed to encompass all the aforementioned roles of combat casualty care for United States of America (US) and Canadian troops [3]. Population of the JTTR is dependent on initial entry of casualty data into each individual medical record. The JTTR has greatly enhanced the organization of trauma care in trauma zones. Understanding the prevalence and characteristics of battlefield injury of coalition partners is vital to combat casualty care performance improvement [3]. The aim of this systematic review is to evaluate the prevalence and characteristics of BCs in NATO coalition partners. The primary outcome was mechanism of injury (MOI) and the secondary outcome anatomical distribution of wounds (AD).

METHODS

The protocol for objectives, literature search strategies, inclusion and exclusion criteria, outcome measurements, and methods of statistical analysis was prepared *a priori*, according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement [4,5] and is described in this section.

Literature search strategy

This systematic review was performed based on all cohort studies concerning prevalence and characteristics of battlefield injury of coalition forces from Iraq and Afghanistan. An electronic database search of Pubmed, Medline, Embase Science Citation Index Expanded, the Web of Science and World Wide Web search (keywords "battle, combat, casualties, wounded, war and military") was performed up to December 20th 2013. All electronic databases were searched for articles published using the medical subject headings (MeSH) or entry terms (supplement 1) "military personnel" and "military casualties". Equivalent free-text search terms, such as "military casualty", "battle casualties", "armed forces", "military medicine" and "wounds and injuries" were used in combination with "JTTR", "trauma registry" and "statistics". The reference lists from the included studies were searched to identify additional studies.

Inclusion and exclusion criteria, data extraction and outcomes of interest

Two authors (RH, ET) independently identified the studies for inclusion and exclusion, and extracted the data. The accuracy of the extracted data was further confirmed by a third author (EV). The inclusion criteria were as follows: 1. battle (combat) casualties, 2. NATO forces, 3. cohort studies, 4. Iraq or Afghanistan. Defining the population studied reaching a Medical Treatment Facility (MTF) is necessary to perform valid comparisons between wars and draw meaningful conclusions. The inclusion of Killed in Action (KIA), Died of wounds (DOW), Return to Duty within 72-hours (RTD) and Non Battle Injury (NBI) in any cohort analyzed, will affect the distribution of wounds and mechanism of injury [6]. A schematic flowchart of military casualty definitions and classifications is presented in Fig. 1. The risk of population bias in this systematic review is inevitable, due to different inclusion criteria, therefore no power analysis was performed. However, a narrative description of prevalence and characteristics of battlefield injury of coalition force was performed, to minimize possible effects of heterogeneity and cohort overlap. Clinical outcome (including Afghanistan Army and Police) would ideally be part of a comparative evaluation in this qualitative synthesis, but due to lack of follow up and clear end points in the included studies, this was not included in this systematic review.

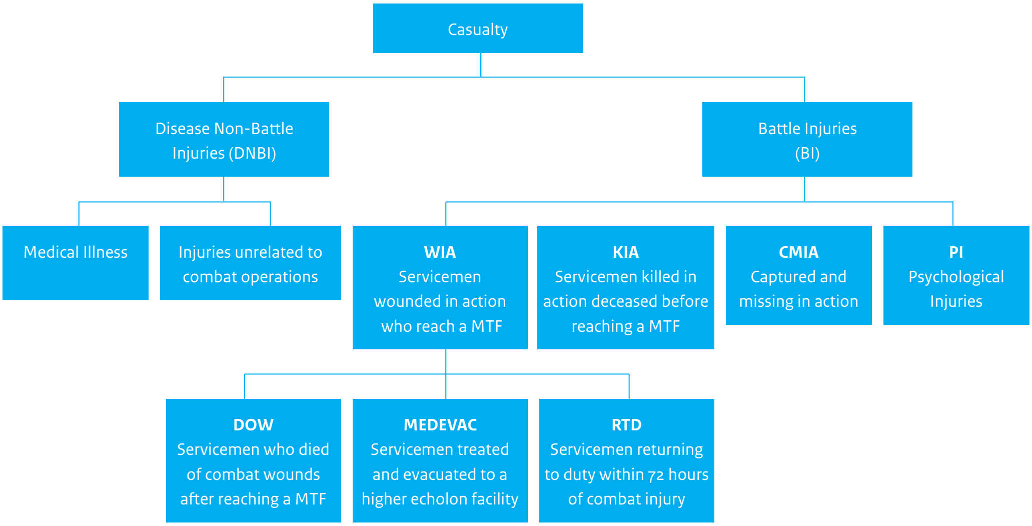

Figure 1: *Schematic of military casualty definitions and classifications*[6]

MTF indicates medical treatment facility.

Quality assessment

Studies were rated on the level of evidence provided according to criteria by the Centre for Evidence Based Medicine in Oxford. The methodological quality of observational comparative studies was assessed by the modified Newcastle-Ottawa Scale[7]. A score of 0–9 was assigned to each study. It was agreed that the lack of adequate population description or clear prevalence and characteristics of NATO coalition forces would result in the studies being classified as having a high risk of bias. The mechanism of injury and, more likely, the anatomical distribution of wounds could be different comparing the coalition forces with the Afghan National Security Forces. The major difference was usage of any kind of body protection. These cohort studies[6,8-28] are the best evidence for epidemiology and demographics of BCs of NATO coalition partners published up to December 20th 2013.

Statistical analysis

The software package SPSS 20.0, provided by Leiden University Medical Center, the Netherlands, was used for statistical analysis to achieve a combined outcome. The categorical variables were analysed by their absolute and relative frequencies in percentages. The association between two categorical variables was calculated by applying the Pearson Chi square test. In all cases, $p < 0.05$ (two-sided) was considered statistically significant.

RESULTS

The PRISMA literature search strategy and study selection are summarized in Fig. 2. Twenty two studies [6,8-28] were included for qualitative synthesis. Eight published articles [6,22-28], encompassing a total of n=19,750 BCs, were systematically analysed to achieve a summated outcome. Fourteen published articles [8-21] were excluded due to evident cohort overlap and population bias, due to non-extractable inclusion of local nationals and Afghan National Security Forces. The characteristics of the included studies [6,22-28] are shown in Table 1.
The quality assessment of the included studies is presented in the last column of Table 1 in the NOS score. Clearly the more recent studies have a higher NOS score. Due to different inclusion and exclusion criteria, data extraction and outcomes of interest, a statistical test for heterogeneity (ea. I^2 test) is not suitable to evaluate these differences. It even could be argued that the term heterogeneity is not applicable, although with a narrative description as given in this systematic review, heterogeneity is the most suitable term. There was heterogeneity among the included studies and there were major differences in inclusion and exclusion criteria regarding the target population among the included trials leading to bias. Overlap was minimized by exact identification of the research period in relation to the inclusion criteria (Fig. 3). Because of different nationalities, locations of the medical treatment facility (different casualties) and inclusion criteria, the effects of possible overlap are limited. Although the risk of overlap is clearly present, it can contribute to a good impression of the mechanism of injury and anatomical disposition of wounds.

Combined analysis of studies

Mechanism of injury

A total of seven studies [6,23-28] (totalling to a number of n=19,671 BCs) contributed to the further analysis (Table 2). Patel et al. [22] did not describe the mechanism of injury, therefore this study was excluded in this part of the analysis. There was heterogeneity among studies, which is presented in Table 2. The overall [6,23-28] distribution in mechanism of injury was GSW 18%, Explosion 72%, Other (crash fixed or rotary wing, motor vehicle accident, other accident, burns, self-inflicted within hostile action, fire of own troops and unknown) 10%. There was a significant difference ($p<0.001$) in the mechanism of injury between Zouris et al. [23], Belmont et al. [6], Lechner et al. [25] and Eastridge et al. [27] when compared with the other studies [6,23-28], however the category other/ unknown comprised 29% in the studies of Zouris et al. [23] and Lechner et al.[25], introducing a high risk of bias.

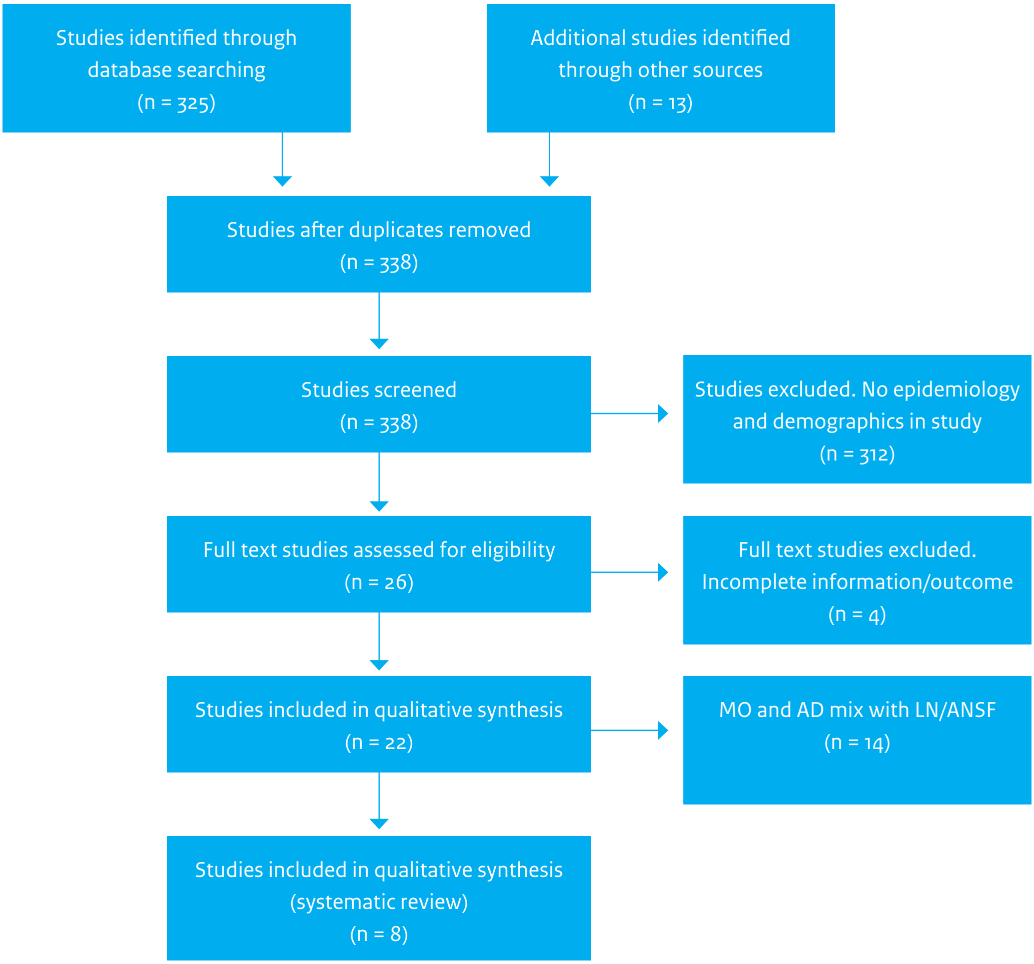

***Figure 2:** PRISMA flow chart for the systematic review*

MOI indicates mechanism of injury; *AD:* anatomical distribution; *LN:* local nationals; *ANSF*: Afghan National Security Forces.

Reference	Year	Period	Population	Operational Theatre	No. Total BC	No. NATO BC CF	Remarks
Patel et al.[22]	2004	2001MAR-2003APR	all US SM	Iraq	154	79	
Zouris et al.[23]	2006	2003MAR-2003APR	USMC + Navy	Iraq	279	279	
Owens et al.[24]	2006	2001OCT-2005JAN	all US SM	Iraq- Afghanistan	3,102	1,566	Without KIA and RTD
Belmont et al.[6]	2010	2003MAR-2004JUN	all US SM	Iraq	390	390	
Lechner et al.[25]	2010	2001OCT-2009DEC	all NATO CF SM	Iraq- Afghanistan	6,226	4,695	Only KIA
Belmont et al.[26]	2012	2005JAN-2009DEC	all US SM	Iraq- Afghanistan	7,877	7,877	Without KIA
Eastridge et al.[27]	2012	2001OCT-2011JUN	all US SM	Iraq- Afghanistan	4,596	4,596	Only Pre MTF deaths/DOW
Hoencamp et al.[28]	2013	2006AUG-2010AUG	all NATO CF SM	Afghanistan	1,101	268	
Total					**23,725**	**19,750**	

***Table 1:** Characteristics of included studies.*

SM indicates service members; *US:* United States; *USMC:* United States Marine Corps; *BC:* battle casualty; *CF:* coalition forces; *Pre MTF:* pre medical treatment facility; *QA:* quality assessment; *NOS:* Newcastle-Ottawa Scale; *RTD:* return to duty; *KIA:* killed in action; *DOW:* died of wounds; *NATO:* North Atlantic Treaty Organisation.

Anatomical distribution of wounds

A total of eight studies[6,22-28] (totalling to a number of n=18,830) contributed to the analysis (Table 3). Belmont et al.[6], Eastridge et al.[27] and Hoencamp et al.[28] included fewer BCs in the analysis of the anatomical distribution of wounds. There was heterogeneity among studies, the differences are presented in Table 3. The overall anatomical distribution of wounds was head and neck 31%, truncal (chest-abdomen) 27%, extremity 39% and other/unknown 3%. There was a significant difference ($p<0.001$) between the analyzed studies concerning the anatomical distribution of wounds. When comparing Lechner et al.[25] and Eastridge et al.[27] with the other studies, the risk of truncal wounds was significantly higher and the risk of extremity injury was significantly lower. When excluding Lechner et al.[25] and Eastridge et al.[27], the anatomical distribution of wounds was as follows; head and neck 28%, truncal (chest-abdomen) 18%, extremity 54% and other/unknown 0%. Belmont et al.[26] (3,8) and Owens et al.[24] (4,2) described a significantly ($p<0.001$) higher number of combat wounds per casualty than the other studies[6,22,23,25,27-28] (1,5).

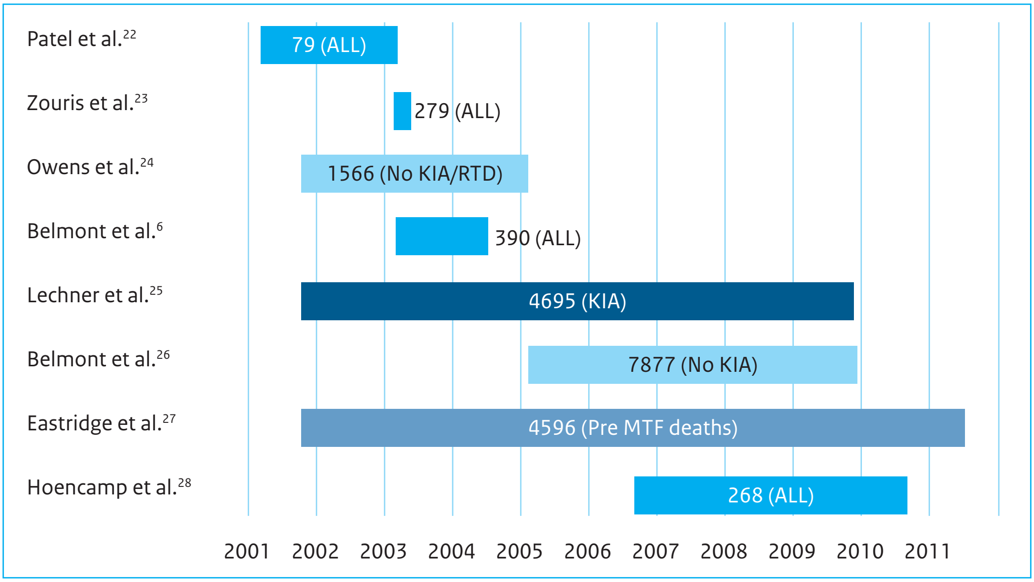

***Figure 3:** Schematic representation of the research period and the battle casualty per study.*

BC: indicates battle casualty; *RTD:* return to duty; *KIA:* killed in action; *All:* All types of battle casualties; *Pre MTF*: pre medical treatment facility.

Reference	No. BC	GSW	Explosion	Other	Remarks	p value*
Zouris et al.[23]	279	70 (25)	130 (46)	79 (29)		<0.001
Owens et al.[24]	1,566	270 (19)	1,146 (79)	150 (2)	Without RTD	.217
Belmont et al.[6]	390	35 (9)	341 (87)	14 (4)		<0.001
Lechner et al.[25]	4,695	593 (13)	3,005 (64)	1,097 (23)	KIA/DOW	<0.001
Belmont et al.[26]	7,877	1,564 (20)	5,862 (74)	451 (6)	Without KIA	.041
Eastridge et al.[27]	4,596	1,016 (22)	3,387 (74)	193 (4)	Pre MTF deaths/ DOW	<0.001
Hoencamp et al.[28]	268	40 (16)	185 (69)	43 (15)		.337
Total	**19,671**	**3,588 (18)**	**14,056 (72)**	**2,027 (10)**		

Table 2: *Mechanism of injury (%).*

BC: indicates battle casualty; *GSW*: gunshot wound; *Other*: accident, motor vehicle accident, crash, burns, unknown; *RTD*: return to duty; *KIA*: killed in action; *DOW*: died of wounds; *Pre MTF*: pre medical treatment facility; *No*: number.
*Chi-squared test

Reference	No. BC	No total wounds	Head/Neck	Truncal	Extremity	Other region	Mean	Remarks	p value*
Patel et al.[22]	79	90	17 (22)	6 (8)	49 (62)	18 (22)	1.14		<0.001
Zouris et al.[23]	279	454	84 (18.6)	59 (13.1)	311 (68.4)	0 (0)	1.6		<0.001
Owens et al.[24]	1,566	6,609	1,949 (29.4)	1,085 (16.3)	3,575 (54.1)	0 (0)	4.2		<0.001
Belmont et al.[6]	98	174	63 (36.2)	25 (14.4)	86 (49.4)	0 (0)	1.83	Without KIA/RTD	<0.001
Lechner et al.[25]	4,695	4,695	1,690 (36)	2,160 (46)	470 (10.0)	375 (8.0)	1	KIA	<0.001
Belmont et al.[26]	7,877	7,877	2,214 (28.1)	1,575 (20.0)	4,088 (51.9)	0 (0)	3.76		<0.001
Eastridge et al.[27]	976	976	0 (0)	856 (87.7)	120 (12.2)	0 (0)	1	PS Pre MTF deaths	<0.001
	3,040	3,040	1,504 (49.5)	786 (25.9)	512 (16.8)	238 (7.8)	1	NS Pre MTF deaths	<0.001
Hoencamp et al.[28]	220	323	94 (29.1)	54 (16.9)	175 (54.1)	48 (17.9)	1.5	Other/ unkwown not in statistics	<0.001
Total	**18,830**	**24,238**	**7,615 (31)**	**6,606 (27)**	**9,386 (39)**	**631 (3)#**			

***Table 3:** Anatomical distribution of wounds (%).*

RTD indicates return to duty; *Other:* accident, motor vehicle accident, crash, burns, unknown; *KIA:* killed in action; *DOW:* died of wounds; *Pre MTF:* pre medical treatment facility; *PS:* potentially survivable; *NS:* non survivable; *No:* number.
Other/ unknown not in statistics. * Chi-squared test. Not all percentages add up to 100%, because of multiple injuries per battle casualty.

DISCUSSION

This systematic review of NATO coalition forces battle casualties from the GWOT (Iraq and Afghanistan) reveals considerable difference in the mechanism of injury and anatomical distribution of wounds between the included studies. The mechanism of injury and anatomical distribution of wounds also differ significantly with reports from previous campaigns (Table 4 and 5)[6, 24]. Explosions accounted for 72% as mechanism of injury and gunshots wounds for 18% of BCs in this systematic review. Belmont et al.[6] and Owens et al.[24] compared their results from the current theatre in Iraq and Afghanistan with previous campaigns [29-32]. Explosive mechanisms of injury accounted for 35% of all recorded combat casualties in World War I [30], 65% in Vietnam[32]. During the last century of warfare, there has been an increase in the number of combat casualties resulting from explosive mechanisms of injury, including mortars, rocket-propelled grenades, landmines, and IEDs, when compared with gunshot wounds. The anatomical distribution of head and neck wounds showed a major difference with previous campaigns. The use of more effective protective equipment and body armour are a clear explanation for this shift in anatomical distribution of wounds. Surprisingly, the percentage of extremity injury did not change a lot, while with the protective measures a decrease might have been expected. Possibly these measures are not sufficiently protective against explosions. Future development of protective equipment should focus especially on the prevention of head, neck and extremity injury. Head/ neck injuries accounted for 31%, truncal 27% and extremity 39% in this systematic review. The differences in inclusion and exclusion criteria among the included studies (KIA, pre MTF deaths and RTD) caused a significant difference ($p<0.001$) when comparing head/ neck and truncal injuries. When corrected for the military lethal (KIA and pre MTF deaths casualty definitions and classifications the results (head and neck 28%, truncal (chest-abdomen) 18%, extremity 54% were comparable with the anatomical distribution of wounds of the WIA in the GWOT[6,24]. Belmont et al.[26] described the distributions of 29,624 distinct combat wounds as well as their MOI incurred by 7,877 casualties reaching a MTF. This represents 0.4% of the 1.99 million US service members deployed in the two theatres (Iraq and Afghanistan) from 2005-2009; WIA included 72-hour RTD, and only 272 or 3.45% became DOW. The rounded mechanism of injury for all WIA were 74% explosions, gunshot wounds 20%, motor vehicles accidents 3% and other 3%. DOW were more likely to have a gunshot wound (30% vs. 20%) and correspondingly somewhat less likely to have been injured by an explosive device (65% vs. 74%). The distribution of wounds was head & neck 28%, thorax 10%, abdomen 10% and extremities 52%. Belmont et al.[26] (3,8) and Owens et al.[24] (4,2) described a significant ($p<0.001$) higher number of combat wounds per casualty than the other studies (1,5). These differences could be explained by the use of different (international) definitions, and the absence of a uniform NATO wide trauma registry. Where extractable, the BC cohort in the studies included all coalition forces service members WIA, (including KIA en DOW) and RTD. Battle casualties that returned to duty, which were excluded from casualty statistical analysis in some studies, will bias the reported results to more severe injuries. Furthermore, not only the primary, but also other additional distinct BI were accounted for, potentiating an accurate data analysis. It was not possible to compare the mechanism of injury and anatomical distribution of wounds by theatre of war and year as described by Belmont et al.[26]. Coalition partners also reported poor population of data points and poor registration of pre-hospital data entered into a digital medical registration system. Therefore, in 2004, the US established the Joint Theater Trauma Registry (JTTR) as a standardized system of data collection, designed to encompass all the echelons of Medical Support Organization[33-34]. We recommend that a

Campaign	GSW	Explosion	Other
Civil war[29]	91	9	
WWI[30]	65	35	
WWII[30]	27	73	
Korea[31]	31	69	
Vietnam[32]	35	65	
Iraq and Afghanistan (Current study)	18	72	10

***Table 4:** Mechanism of injury from previous campaigns in percentage.*

GSW indicates gunshot wound; *WWI:* World War I; *WWII:* World War II.

Location	WWII[30]	Korea[32]	Vietnam[32]	Iraq and Afghanistan (Current study)
Head and neck	21	22	16	31
Truncal	22	18	23	27
Extremities	58	60	61	39
Other				1

***Table 5:** Anatomical distribution of wounds.*

WWII: indicates World War II.

uniform NATO wide system with a track and follow up system should be implemented in order to improve the quality of care at the battlefield. As shown by Therien et al.[34] the volume and quality of reporting of data was improved after the introduction of the JTTR. The severity of the BI in this review could not be scored in a consensus-derived global severity scoring system, such as the Abbreviated Injury Scale (AIS)[36] or the Injury Severity Score (ISS)[37]. Such a severity scoring system should also be part of a future NATO wide trauma registry. Eastridge et al.[27] concluded that most battlefield casualties die of their injuries before ever reaching a surgeon. As most pre-hospital deaths are classified as combat casualties with non-survivable injuries, mitigation strategies to impact outcomes in this population need to be directed toward injury prevention and improving the level of pre-hospital care. To improve the outcome of combat casualties with a potentially survivable injury, strategies must be developed to stop and treat catastrophic hemorrhage on the battlefield, optimize airway management, and decrease the time from point of injury to surgical intervention. The most substantial, although not exclusive, opportunity to improve these casualty outcomes seems to be in the pre-MTF setting. Understanding battlefield mortality is a vital component of the military trauma system. Future studies should focus on casualty deaths both before and after reaching the MTF, exploring strategies to impact and improve outcomes.

There are several limitations to this review. Retrospective cohort studies are always sensitive to bias and variable battle casualty definitions in the different studies significantly affect casualty analysis results. There were major differences in inclusion and exclusion criteria regarding the target population among the included trials leading to bias. The risk of population bias in this systematic review is inevitable, therefore no power analysis was performed, other than a narrative descriptive of prevalence and characteristics of battlefield injury of coalition force, to minimize best possible effects of heterogeneity and cohort overlap. The absence of more detailed BC information (rank, age, division) and information detailing injury severity and its subsequent evaluation compromises this current study evaluation; these data should be present in the ideal registry which is described in the work of Belmont et al.[6,26] and Champion et al.[35]. Overlap in this review was minimized by exact identification of the research period in relation to the inclusion criteria, nevertheless we realize that the risk overlap is still present. We realize using extant large databases to accrue the actual data would have been helpful in being most accurate and safer. Effective evaluation of the prevalence and characteristics of battlefield injury of coalition partners is vital to combat casualty care performance improvement. These cohort studies are the best evidence for epidemiology and demographics of BCs of NATO coalition partners published up to December 20th 2013.To the best of our knowledge the present systematic review allows for the most complete and thorough reporting of coalition forces BCs to date. Further research is necessary to develop effective protective equipment and body armour for all injuries, with special focus on head, neck and extremity injuries.

In conclusion, the mechanism of injury and anatomical distribution of wounds observed in the GWOT, differ from previous campaigns. There was a significant increase in the use of explosive mechanisms and a significant increase in the head and neck region (without KIA and DOW) compared with previous wars. We recommend that a NATO wide registry system should be implemented with a track and follow up system in order to further improve the quality of care and registration of casualties on the battlefield. Further research is necessary to develop more effective protective equipment and body armour, with special focus for head and neck and extremity protection.

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Supplemental data 1. Search Terms

Pubmed

Medical subject headings (MeSH) terms (“Military Personnel”[Mesh] OR “military personnel”[all fields] OR “military casualties”[all fields] OR “military casualty”[all fields] OR “battle casualties”[all fields]OR “battle casualty”[all fields] OR “army personnel”[all fields] OR “armed forces”[all fields] OR (theater[All Fields] AND (“war”[MeSH Terms] OR “war”[All Fields]) OR “Military Medicine”[Mesh] OR “Military Medicine”[all fields] OR “Military Medical”[all fields] OR “Military Nursing”[Mesh] OR “Military Nursing”[all fields])) AND (“JTTR”[all fields] OR “joint theater trauma registry”[all fields] OR “Tactical Combat casualty care”[all fields] OR “TCCC”[all fields] OR (“nato”[all fields] AND (“9-liner”[all fields] OR “9 liner”[all fields])) OR “trauma system”[all fields] OR “MOTR”[all fields] OR “casualty statistics”[all fields] OR “Medical Records”[Mesh] OR “Medical Records”[all fields] OR “Medical Record”[all fields] OR “clinical record”[all fields] OR “clinical records”[all fields] OR “Wounds and Injuries”[Mesh]).

Embase

(soldier/ OR military phenomena/ OR “military personnel”.mp. OR “military casualties”.mp. OR “military casualty”.mp. OR “battle casualties”.mp.OR “battle casualty”.mp. OR “army personnel”.mp. OR “armed forces”.mp. OR (theater.mp. AND (war/ OR “war”.mp.) OR military medicine/ OR “Military Medicine”.mp. OR “Military Medical”.mp. OR military nursing/ OR “Military Nursing”.mp.)) AND (“JTTR”.mp. OR “joint theater trauma registry”.mp. OR “Tactical Combat casualty care”.mp. OR “TCCC”.mp. OR (“nato”.mp. AND (“9-liner”.mp. OR “9 liner”.mp.)) OR “trauma system”.mp. OR “MOTR”.mp. OR “casualty statistics”.mp.)

Web of Science

TS= (military personnel OR military casualt* OR battle casualt* OR army personnel OR armed forces OR (theater AND war) OR military medicine OR Military Medical OR military nursing) AND TS= (JTTR OR joint theater trauma registry OR Tactical Combat casualty care OR TCCC OR (nato AND (9-liner OR 9 liner)) OR trauma system OR MOTR OR casualty statistic*).

Chapter 3. Incidence and Epidemiology of Casualties treated at the Dutch role 2 Enhanced Medical Treatment Facility at Multi National Base Tarin Kowt, Afghanistan in the period 2006-2010

Rigo Hoencamp; Floris J. Idenburg; Jaap F. Hamming; Edward C. T. H. Tan

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ABSTRACT

Background: To improve care for the injured service member, we have analyzed battle casualty patterns and mechanisms. This study is the first documented report of wounding patterns and mechanisms of battle casualties treated at the Dutch role 2 Enhanced Medical Treatment Facility at Multi National Base Tarin Kowt, Uruzgan, Afghanistan.

Methods: Participants were selected from the trauma registry at the Dutch role 2 Enhanced Medical Treatment Facility, where they fitted the criteria battle casualty and disease non battle injury between August 2006 and August 2010.

Results: The trauma registry query resulted in 2,736 casualties, of which 60% (1,635/2,736) were classified as disease non-battle casualties and 40% (1,101/2,736) as battle casualties. The battle casualties sustained 1,617 combat wounds, resulting in 1.6 wounds per battle casualty, these injuries predominately were caused by explosions (55%) and gunshots (35%). The wounding pattern was as follows: head and neck (21%), thorax (13%), abdomen (14%), upper extremity (20%) and lower extremity (33%).

Conclusions: The wounding patterns seen at the Dutch role 2 Enhanced Medical Treatment Facility at Multi National Base Tarin Kowt resemble the patterns as recorded by other coalition partners. The wounding patterns differ with previous conflicts: a greater proportion of head and neck wounds, and a lower proportion of truncal wounds.

INTRODUCTION

In the aftermath of the terrorist attacks of September 11, 2001, the United States (US) initiated the so-called Global War on Terrorism and deployed military units to multiple theaters in the Middle East and Southwest Asia[1]. Since then, over 10,000 coalition service members have been killed and over 50,000 have been injured in Iraq and Afghanistan. Also, many thousands of contractors, host-nationals, foreign national security personnel, and insurgents were injured or killed. The Iraq and Afghanistan armed conflicts have produced comparable combat-related casualties with the Vietnam and the Korea War with injury patterns differing from previous theaters of war [2]. The International Security Assistance Force (ISAF) is a North Atlantic Treaty Organization (NATO) led security mission in Afghanistan that was authorized by the United Nations Security Council in December 2001.

The importance of describing the incidence and character of battle injuries, as well as their precipitating mechanisms, has been recognized since the 19th century. Since that time, many reports have been published concerning the types of battle injuries sustained by battle (combat) casualties (BCs)[3]. From August 2006 to August 2010 The Netherlands were Lead Nation in the Uruzgan province. The main component of the Dutch Task Force Uruzgan was located near Tarin Kowt at the Multi National Base Tarin Kowt. It was composed of approximately 1,200 Dutch service members and contained its own Medical Treatment Facility (MTF). The Dutch Role 2 Enhanced MTF (Role 2 MTF NL) was located at the Multi National Base Tarin Kowt and it was intentionally small with limited capabilities beyond resuscitative/ damage control surgery and limited ICU capacity. After stabilisation, patients could be transported to higher echelons of care.

To date, the number of treated casualties at Role 2 MTF NL has not been published and more current first-hand data has not been reported[4]. Therefore trends in battle injuries and battle casualties treated in Role 2 MTF NL at Multinational Base Tarin Kowt remain unreported. The goals of this study are to determine the total medical exposure at Role 2 MTF NL, the epidemiology of BCs and to contrast our findings with other MTF of coalition partners in Afghanistan and Iraq. Ultimately, our findings in epidemiologic trends of combat injuries may provide insight to the prevention and treatment of such injuries. The 4-year workload, volume and type of injuries treated may also be useful in future planning of the training and pre-deployment requirements of the Dutch military medical forces.

METHODS

This study was conducted under a protocol reviewed and approved by the Dutch Ministry of Defense and both the Institutional Review Board and Medical Ethical Committee of Leiden, The Netherlands.
A "casualty" in customary military usage means an active duty service member lost to the theatre of operations for medical reasons. The term, therefore, includes disease (illness) and noncombat injuries (NBI), as well as combat injuries. The definition of a battle (combat) casualty is as follows [5]. A battle casualty is identified as a service member being injured as direct result of hostile action, sustained in combat or sustained going to or coming from a combat mission. For the purpose of this study we included persons killed or wounded accidentally by friendly fire directed at a hostile force or what was thought to be a hostile force. We excluded (1) self-inflicted wounds (2) wounds or death inflicted by a friendly force when the serviceman is absent without leave, or is a voluntary absentee from his or her place of duty [5]. Participants eligible in this study were selected from a general digital admission database of the ministry of Defense, which fitted the criteria battle casualty and NBI between August 2006 and August 2010. For the Dutch battle casualties a follow up period of 30 days (complication and died of wounds) was used for discharge category. We performed an inventory of that were recorded in the database of the Trauma Registry at Role 2 MTF NL. We merged the casualty demographics with information from the medical records to identify the mechanism and type of injury. After segregating the NBI, the battle casualties were divided in seven groups, namely Coalition Forces (Australian, Czech, French, Great Britain, Dutch, US), Afghan National Security Force (composed of Afghan National Army, Afghan National Police, Afghan Security Guard, Kandak Amniante Uruzgan), Local Nationals, Other (Opposing Militant Forces, Interpreters, civilian contractors and unknown). In the calculation of the anatomical distribution of wounds, we excluded the unknown cases to correct for the missing data.
At the Multi National Base Tarin Kowt there was an adjacent forward US surgical team, which contributed to a low number of US battle casualties and missing information for these specific cases of classification of the mechanism of injury and anatomical distribution of wounds.
Due to missing information in the digital database, all information was manually collected, this contributed to the long delay in reporting this important statistics. A student investigator conducted data collection and verification. The first author performed a cross check of these data. All baseline information was registered in an electronic data file. All data were analyzed using SPSS 20.0. The categorical variables were analysed by their absolute and relative frequencies in percentages. The association between two categorical variables was calculated by applying the Pearson Chi square test. In all cases, $p < 0.05$ was considered statistically significant.

RESULTS

In the studied period between August 2006 and August 2010, a total of 2,736 patients (BC 40.2% [1,101/2,736] NBI 59.8% [1,635/2,736]) were treated to the Role 2 MTF NL. The combined study population was predominantly male 95.7% (1,054/1,101), with a mean age of 24 years. The patient discharge category of battle casualties and NBI was significantly different ($p<0.0001$) in respect to discharge to home/return to unit, referral to a local hospital or Role 1/2 MTF, referral to higher medical echelons and Killed in Action (KIA)/ Died of Wounds (DOW).

Battle casualty statistics

There were a total of 1,101 battle casualties treated to Role 2 MTF NL between August 2006 and August 2010. The distribution of the battle casualties was as follows: coalition forces comprised 24.3% (268/1,101) of the battle casualties (Australian 31.7% [85/268], Czech 0.4% [1/268], French 0.4% [1/268], Great Britain 2.6% [7/268], Dutch 58.6% [157/268], US 6.3% [17/268]). The Afghan National Security Forces 32.7% (360/1101), whereas Local Nationals 40.3% (444/1,101), Opposing Militant Forces 1.5% (16/1,101), interpreters 0.5% (5/1,101), civilian contractors 0.3% (3/1,101) and unknown 0.5% (5/1,101) comprised the remaining group of battle casualties. There was a significant difference ($p<0.0001$) in discharge category of battle casualties. There was significant difference between the coalition forces BCs, Afghan National Security Forces and Local Nationals in respect to discharge to home/return to unit, referral to a local hospital or Role 1/2 MTF and direct repatriation out of theatre (Table 1). The discharge category of the coalition forces BCs was of follows; 45.9% (123/268) returned to duty, 34.7% (93/268) were referred to a role 3 MTF or repatriated directly out of theatre, 13.1% (35/268) were killed in action or died of wounds (within 30 days) and 6,3% (17/268) unknown.

Mechanism of injury

There was a significant difference ($p<0.0001$) in the mechanism of injury when coalition forces were compared with Afghan National Security Forces and Local Nationals (Table 2). Coalition forces' 69.0% (185/268) casualties were injured more often by explosive devices compared with both Afghan National Security Forces 52.8% (190/360) and Local Nationals 47.9% (213/444). Similarly, Afghan National Security Forces 42.8% (154/360) and Local Nationals 40.1% (178/444) were more often victims of gunshot wounds compared with coalition forces 14.9 (40/268). The Local Nationals were more often injured by a stabbing incident when compared with coalition forces and Afghan National Security Forces.

Anatomical distribution of wounds

A total 1,037 battle casualties sustained 1,687 wounds, resulting in 1.6 wounds per battle casualty. The anatomical distribution of wounds was calculated without the unknown (74/1,101), which resulted in 1,037/1,101 unique battle casualties. Extremity injuries were most common among all groups (Table 3) and there was a significant difference ($p<0.0001$) in anatomical distribution of wounds. The Local Nationals 15.8% (112/710) more often sustained thorax injuries compared with coalition forces 7.7% (25/323) and the Local Nationals 18.5% (131/710) more abdominal injuries compared with coalition forces 9% (29/323) and Afghan National Security Forces 10.5% (57/543).

Discharge category	BC n=/ (%)	NBI n=/ (%)	Total n=/ (%)
Home/RTU	467 (42.4)	1,136 (69.5)	1,603 (58.6)
Role 1-2 MTF	290 (26.3)	290 (17.7)	580 (21.2)
Role 3 MTF	150 (13.6)	78 (4.8)	228 (8.3)
REPAT	52 (4.7)	28 (3.4)	80 (2.9)
KIA/DOW	99 (8.9)	45 (1.7)	144 (5.3)
UNK	43 (3.9)	58 (3.5)	101 (3.7)
Total	**1,101 (40.2)**	**1,635 (59.8)**	**2,736 (100)**

Table 1: *Battle casualty and disease non battle injury discharge category.*

RTU: Return to unit; Role 1-2: Local hospital or other NATO Forward Surgical Team; *MTF:* Medical Treatment Facility: *REPAT;* direct repatriation out of theatre; *KIA/DOW;* killed in action or died of wounds; UNK; Unknown; *NBI:* Disease Non Battle Injury; *BC:* battle casualty.

Patient category	Explosion n=/ (%)	GSW n=/ (%)	Other n=/ (%)	Unk n=/ (%)	Total n=/ (%)
CF	185 (69.0)	40 (15.9)	2 (0.7)	41 (15.3)	268 (24.3)
ANSF	190 (52.8)	154 (42.8)	9 (2.5)	7 (1.9)	360 (32.7)
LN	213 (47.9)	178 (40.1)	48 (10.8)	5 (1.2)	444 (40.3)
Other	16 (55.5)	9 (31.0)	1 (3.4)	3 (10.3)	29 (1.5)
Total	**604 (54.9)**	**381(34.6)**	**60(5.4)**	**56(5.1)**	**1,101 (100)**

Table 2: *Primary mechanism of injury from battle casualties (n=1,101).*

CF: Coalition Forces; *ANSF:* Afghan National Security Forces; *LN:* Local National; *Other* (=*OMF:* opposing military forces; *CIV:* Foreign civilian employee; *TERP:* interpreter); *UNK:* Unknown; *GSW:* Gunshot Wounds.

Patient category	Head/Neck n=/ (%)	Thorax n=/ (%)	Abdomen n=/ (%)	Lower Ex n=/ (%)	Upper Ex n=/ (%)	Total wounds n=/ (*)	Unk n=	Mean wounds per BC
CF	94 (29.1)	25 (7.7)	29 (9.0)	109 (33.7)	66 (20.4)	323 (220)	48	1.5
ANSF	120 (22.1)	59 (10.9)	57 (10.5)	203 (37.4)	104 (19.2)	543 (346)	14	1.6
LN	113 (15.9)	112 (15.8)	131 (18.5)	208 (29.3)	146 (20.6)	710 (436)	8	1.6
OTHER	6 (14.6)	9 (22.0)	3 (7.3)	11 (26.8)	12 (29.2)	41 (19)	4	2.2
Total	**333 (20.5)**	**205 (12.6)**	**220 (13.6)**	**531 (32.8)**	**328 (20.3)**	**1,617 (1037)***	**74**	**1.6**

Table 3: *Anatomical distribution of wounds (n= 1,037).*

CF: Coalition Forces; ANSF: Afghan National Security Forces; *LN:* Local National; *OTHER* (=*OMF:* opposing military forces; *CIV:* Foreign civilian employee: *TERP:* interpreter; UNK: Unknown); *Lower Ex:* Lower Extremity; *Upper Ex:* Upper Extremity; *AD:* anatomical distribution; *BC:* battle casualty.
*The anatomical distribution of wounds (excluded the unknown cases), mean is calculated without the unknown cases.

DISCUSSION

From August 2006 to August 2010, 2,736 (BC 40%, NBI 60%) patients were treated at Role 2 MTF NL. Coalition forces comprised 24% of the battle casualties, Afghan National Security Forces 33% and Local Nationals 40%. Almost 70% of the coalition forces BCs was injured by explosive devices, which is significantly higher compared with both Afghan National Security Forces (53%) and Local Nationals (48%). Battle injuries are mainly caused by explosions with many patients arriving in deplorable condition and these battle casualties are often wounded on multiple anatomical body regions. The use of protective body armor and explosions are a clear explanation for this change in anatomical distribution of wounds in the coalition fores[2]. Belmont et al.[3] and Owens et al.[6] reported similar data (Table 4 and 5) and these are comparable with findings of other NATO Role 2 facilities in Afghanistan[7-9]. There is a significant increase in wounds in the head and neck region and a significant decrease in thoracic wounds compared with previous wars[10-13], which could be attributed to improvement of protective body armour in recent wars.
Eastridge et al.[14] concludes that most battlefield casualties die of their injuries before ever reaching a surgeon. As most deaths are classified as nonsurvivable, mitigation strategies to impact outcomes need to be directed toward injury prevention. To impact the outcome of battle casualties with a potentially survivable injury, strategies must be developed to mitigate hemorrhage on the battlefield, optimize airway management, and decrease the time from point of injury to surgical intervention. Clarke et al.15 suggest that severely wounded BC victims should be retrieved by dedicated pre-hospital critical care teams and triaged to the highest and/or most appropriate level of medical care available within the region. The prehospital phase seems to be the most substantial opportunity to improve the outcome of a BC[16-17].

Campaign	GSW	Explosion
Civil war[10]	91	9
WWI[11]	65	35
WWII[11]	27	73
Korea[12]	31	69
Vietnam[13]	35	65
OEF/OIF Owens et al.[6]	19	81
OEF/OIF Belmont et al.[3]	23	77
Current study*	16	69

***Table 4:** Mechanism of injury from Coalition Forces by campaign (%).*

GSW indicates gunshot wound; *WWI.* World War I; *WWII.* World War II; *OEF:* Operation Enduring Freedom; *OIF:* Operation Iraqi Freedom.
*Percentages do not add up to 100%, other/unknown cases 15%

Location	WWII[11]	Korea[12]	Vietnam[13]	OIF/OEF Owens et al.[10]	OEF/OIF Belmont et al.[3]	Current study
Head and Neck	21	21.4	16	30.0	36.2	29.1
Thorax	13.9	9.9	13.4	5.9	7.5	7.7
Abdomen	8	8.4	9.4	9.4	6.9	9
Extremities	58	60.2	61.1	54.5	49.4	54.1

Table 5: *Anatomical distribution of wounds from Coalition Forces by campaign (%).*

WWII: indicates World War II; *OEF:* Operation Enduring Freedom; *OIF:* Operation Iraqi Freedom.

Battle casualties produce a pattern of injury (mechanism of injury) that is not routinely seen in a civilian Dutch surgical practice. In an era of increasing surgical sub specialization, the deployed surgeons needs to acquire and maintain a wide range of skills from a variety of surgical specialties. Lack of knowledge and only basic civilian surgical skills on this broad spectrum of battle injuries can lead to higher morbidity and mortality of the battle casualties. This spectrum of injuries supports the recent discussion about the basic training and skills of the military surgeon[18-22]. Several Dutch military surgeons and military anaesthesiologist are employed in a level one trauma centre[23], therefore having the necessary exposure of severe polytrauma patients (ISS > 16). This civilian experience in comparable severity trauma patients may help when treating this type of patients on the Role 2 MTF NL. Recently the Definitive Surgical Trauma Care (DSTC®) course has been made mandatory before deployment for all Dutch military surgeons and the same for the Definitive Anaesthetic Trauma Course (DATC) for all Dutch military anaesthesiologists and intensivists. Both courses are in the Dutch Military Training curriculum, which not only focuses on (orthopaedic) trauma surgery, both also contains the necessary thoracic, vascular, urological, neurosurgical and paediatric surgical skills. Currently we are working on an Emergency or acute Surgery training in a high volume level one trauma centre with penetrating injuries, this being the next step in formation of a robust pre-deployment workup program for all Dutch military surgeons (depending on future deployments). Team training, not only including the surgeon and scrub nurses but also the anaesthesiologist and anaesthesia nurse, would be a further development. Further research is necessary to determine the contents of a mandatory training/ residency program for the Dutch military surgeons and anaesthesiologists[24] (unpublished data).
Retrospective cohort studies are sensitive for bias and battle casualty definitions significantly affect casualty analysis results. Clearly defining the studied population is necessary to make valid comparisons and draw meaningful conclusions between wars, as most prior casualty reports lack this clear definition. The inclusion of KIA, Return to Unit, and NBI in any analyzed cohort will affect the distribution of wounds and mechanisms of injury [3]. In this study all stabbing incidents were defined as BI in the provided database, which could have led to overestimation of battle casualties in the Local Nationals group. The severity of the injuries in this study could not be scored in a consensus-derived global severity scoring system, such as the Abbreviated Injury Scale (AIS)[25] or the Injury Severity Score (ISS)[26]. Diaz et al[27]. described a cohort from August 2006 to August 2007, in which all ISS scores were calculated based on the available information of sustained injuries. The mean ISS for BCs was 9 (standard deviation ± 9) and NBI 7. These results give a good

indication of the severity of injuries in the investigated 4-year period. A civilian situation is hard to compare with the Role 2 MTF NL, although severity of injury and exposure are comparable with a level one trauma centre in The Netherlands[23]. The results of Spijkers et al.[23] show that level one trauma center University Medical Centre Utrecht had an admission of approximately 1,000 trauma patients over two periods of two years. The mean ISS over these two periods was 11. Sturm et al.[28] reported a mean ISS of 7.2 of trauma patients treated in Trauma Centre West Holland in the period 2004 to 2006. The mean ISS (9) of the trauma patients was lower than the published ISS of the level one trauma centers in The Netherlands, but higher than the level two and three hospitals. A cross check showed that the main ISS was an underestimation of the polytrauma patients (ISS > 16). Lastly, a major limitation was the limited possibility of data verification and missing data, due to the lack of a standardized, prospective trauma registry system. Coalition partners also reported poor population of data points and poor registration of pre-hospital data entered into a digital medical registration system, leading to missing data. Therefore, the US established in 2004 the Joint Theater Trauma Registry as a standardized system of data collection, designed to encompass all the roles echelons of Medical Support Organisation[29-30]. A NATO wide medical registry would be recommended.

In conclusion, the wounding patterns seen at the Dutch role 2 MTF at Multi National Base Tarin Kowt resemble the patterns as recorded by other coalition partners. The wounding patterns differ with previous conflicts: a greater proportion of head and neck wounds, and a lower proportion of truncal wounds. The use of improvised explosive devices have become more prevalent in current military operations, which lead to relatively more head and neck and extremity injuries. The deployed surgical teams were adequately prepared[24], were exposed to severely injured patients and functioned well under high physical and mental stress in a combat theatre, with limited resources and capabilities. The prehospital phase seems to be the most substantial opportunity to improve the outcome of battle casualties.

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Chapter 4. Impact of explosive devices in modern armed conflicts: in-depth analysis of Dutch battle casualties in Southern Afghanistan

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ABSTRACT

Background: To improve care for injured service members, we have analyzed the patterns and mechanisms of all Dutch battle casualties. This study represents an in-depth analysis of all Dutch battle casualties during our participation in the ISAF mission as lead nation (2006-2010) Southern Afghanistan.

Methods: Participants were selected from the trauma registry at the Dutch role 2 Enhanced Medical Treatment Facility, where they fitted the criteria Dutch battle casualty between August 2006 and August 2010.

Results: The trauma registry query resulted in 203 Dutch battle casualties, with 1.7 wounds per battle casualty. The battle injuries were predominately caused by explosions (83%). The wounding pattern was as follows: head and neck (30%), thorax (9%), abdomen (15%), upper extremity (16%) and lower extremity (30%). The mean AIS and ISS were 3 (range 1-6) and 11 (range 1-75), the case fatality rate 9%, the percentage killed in action 16%, and the percentage died of wounds 1%.

Conclusions: Explosive devices accounted for the majority of battle casualties, a higher percentage than in previous wars. Knowledge of the type of injuries may also be valuable in treating casualties from natural disasters or mass casualty situations. An integral multinational joint approach is highly recommended to develop more effective protective equipment and body armour, with special focus on head and neck and extremity protection. Prospective registration in a standardized system of data collection, encompassing all echelons of the medical support organization should be implemented.

INTRODUCTION

The importance of understanding battle (combat) injuries, as well as their precipitating mechanisms has generally been recognized and several reports have already been published concerning the incidence and character of battle injuries sustained by battle (combat) casualties (BCs)[1-6]. Comparison is only possible using clear battle casualty definitions[6]. The Iraq and Afghanistan armed conflicts have resulted in a large number of combat-related casualties, like in the Korea and Vietnam wars, but with injury patterns differing from previous theatres of war[7]. Explosive devices are the signature threat of current military operations, and prevention of casualties and major injuries are the major concern[1,2]. The Netherlands (NL) were the lead nation in the Uruzgan province (2006-2010), deploying approximately 17,000 military service members[8], as part of the North Atlantic Treaty Organization (NATO) led International Security Assistance Force (ISAF) mission in Southern Afghanistan. The main component of the Task Force Uruzgan was located at the multi-national base Tarin Kowt (MBTK). It was composed of 1,200 Dutch service members, and possessed its own medical treatment facility (role 2 MTF NL) containing approximately 50 multinational medical service members. The role 2 MTF NL was configured with two emergency resuscitation tables, one operating room, two ICU beds and fourteen regular nursing beds (Figures 1 and 2).

Figure 1. *The Dutch role 2 Medical Treatment Facility in Uruzgan, Afghanistan, reinforced by a ballistic protection wall (Hesco-Wall).*

Figure 2. *The operation room at the Dutch role 2 Medical Treatment Facility in Uruzgan, Afghanistan.*

Hoencamp et al.[1,2,9] described the total incidence of all casualties (~75% caused by improvised explosive devices [IEDs], and at least n=157 Dutch BCs) and challenges during the treatment of casualties at the role 2 MTF NL. The Dutch government published a report describing a different number of Dutch battle casualties (n=144)[8]. This discrepancy shows the difficulty in the usage of (NATO) battle casualty definitions and registration information. Coalition partners also reported poor registration of (pre-) hospital data, leading to missing information. Therefore, the United States of America (US) established in 2004 the Joint Theater Trauma Registry (JTTR, now known as the Department of Defense Trauma Registry [DoDTR]) as a standardized system of data collection, designed to encompass all the echelons of the Medical Support Organization[10,11].

To date, an in-depth analysis of the Dutch BCs treated at role 2 MTF NL, with special emphasis on IEDs, has not been compiled, partly due to the lack of a complete and standardized trauma registry. The goal of this study was to conduct a detailed analysis of the Dutch BCs, and to lay the foundation for a (Dutch) military medical trauma registry. Ultimately, our findings in epidemiological trends of combat injuries may provide insight to the prevention and treatment of such injuries. Structural data on the type of injuries treated may also be useful in prevention, development of protective equipment and pre-deployment requirements of the Dutch armed forces.

METHODS

This study was approved by the Ministry of Defense (MOD), the Institutional Review Board and the Medical Ethics Committee of Leiden University, the Netherlands. Battle casualties were defined as service members being injured as a direct result of hostile action, sustained in combat or sustained going to or coming from a combat mission[6]. For the purpose of this study, we included individuals killed or wounded accidentally by friendly fire directed at a hostile force, or what was thought to be a hostile force (blue on blue). We excluded (1) self-inflicted wounds, (2) wounds or death inflicted by a friendly force when the serviceman was absent without leave, or was a voluntary absentee from his or her place of duty, and (3) psychological injuries. Individuals who died of wounds before receiving treatment at a MTF were deemed killed in action (KIA). Service members who survived their injury until arrival at a MTF were defined as wounded in action (WIA). The WIA group was further subdivided into service members who died of wounds (DOW) from combat injuries after reaching a MTF, those treated and returned to duty within 72 hours (RTD), and those aero medically evacuated (STRATEVAC) out of theatre. The percentage KIA was defined by the following equation[12]: %KIA = KIA / [KIA + (WIA-RTD)]×100. The percentage DOW was defined by the following equation[12]: %DOW = DOW / (WIA-RTD)×100. The case fatality rate (CFR) was defined as the percentage of fatalities among all wounded and is defined by the following equation[12]: CFR = (KIA + DOW) / (KIA + WIA)×100. The percentage per deployed service member (PPDSM) was calculated as overall score and per branch of service: PPDSM = BC/ total deployed service members (or per branch of service) ×100. Participants eligible for this study came from a general digital admission database of the MOD, and they fitted the criteria 'BC between August 2006 and August 2010'. A follow-up period of 30 days (complication and died of wounds) was used. We performed an inventory of records in the database of the trauma registry at the role 2 MTF NL and merged the Dutch battle casualty demographics with information from the medical records to identify the mechanism and type of injury. All information was collated in a specifically designed electronic database. The BCs were divided into five rank groups namely; junior enlisted (E1-E4), senior enlisted (E5-E9), warrant officers (WO1-WO2), junior officers (O1-O3) and senior officers (O4-O10). In calculating the mechanism of injury (MOI), and anatomical distribution of wounds (AD), we excluded the unknown cases to correct for missing data. Statistical analyses were performed using a software package, SPSS (Version 20, IBM Corporation, Armonk, New York). The categorical variables were analyzed by their absolute and relative frequencies in percentages. The association between two categorical variables was calculated by applying the Pearson χ^2 squared test. In all cases, $p < 0.05$ was considered statistically significant. The severity of the injuries in this study was scored in the Abbreviated Injury Scale (AIS)[13], the Injury Severity Score (ISS)[14] and expressed in mean and range.

RESULTS

Battle casualty statistics

During the study period a total of 199 Dutch battle casualties (WIA-DOW-RTD-KIA) were treated at the role 2 MTF NL (Table 1). Between August 2006 and August 2010, approximately 17,000 military service members (~15,000 Army, ~250 Navy, ~600 Marines, ~1,000 Air force and ~150 Military Police) were deployed, 25% of them multiple times (Table 2). The combined study population was predominantly male (99%, 197/199), with a mean age of 24 years. The CFR was 9.5%, the percentage KIA 16.5%, and the percentage DOW 1.1%. The distribution of BCs by branch of service was significantly different ($p<0.0001$) across all years studied with a greater absolute percentage (85.1%) of Army service members sustaining battle injuries in Afghanistan. The Army (0.9%) and Marine Corps (3.5%) demonstrated the highest overall percentage of BCs per deployed service member. When examining the distribution of BCs by rank group, significant differences ($p<0.0001$) were noted in the 72.4% (144/199) junior enlisted, 17.1% (34/199) senior enlisted, 0.5% (1/199) warrant officers, 5.5% (11/199) junior officers, 1% (1/199) senior officers, and unknown cases 2% (8/199).

Mechanism of injury and anatomical distribution of wounds

Explosions (83.9%) were the dominant mechanism of injury, being significantly higher than those caused by gunshot wounds (6.0%, ($p<0.0001$)) (Table 3), from small arms fire. Roadside IEDs accounted for the highest casualty rate per incident (CR). In nine major incidents the CR was ≥5, the “on target” roadside IEDs seemed to follow an “all or nothing pattern”. Flat bottom vehicles were struck in all high CR cases. The distribution of casualties showed a significantly higher peak in the spring and summer periods (Figure 3).

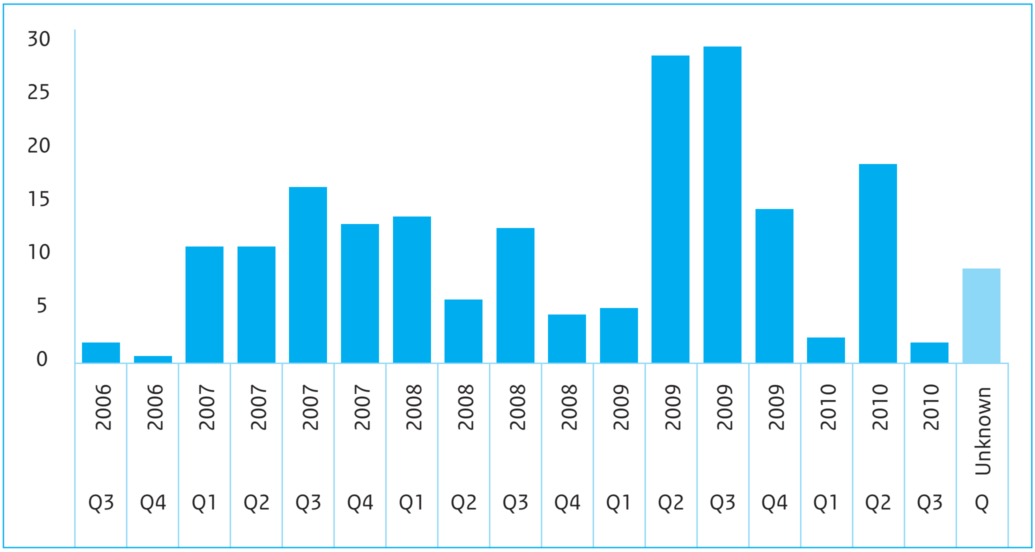

Figure 3: *Distribution of battle casualties in relation to time of year (n=199).*

Q indicates quarter of year; *Q unknown* represents the unknown case dates.
The vertical axis represents the number of battle casualties per quarter of year, the horizontal axis represents the quarters from Q3 2006 till Q3 2010, the last column represents the unknown incident dates n=9.

A total of 199 BCs sustained 308 wounds, resulting in 1.7 (calculated without the unknown cases wounds per BC (Table 4)). The anatomical distribution of wounds was calculated with the unknowns excluded in the WIA-RTD group (15/199). Head & neck, and extremity injuries were most common among all groups. Ocular injuries accounted only for 3.0% (6/199) in all BCs. There was a significant difference ($p<0.0001$) in thoracic injuries when comparing the KIA and DOW group with the WIA group. The mean AIS (body region with highest AIS score) and ISS were 3 (range 0-5) and 11 (range 1-43) in the WIA group.

Battle casualty type	Number	Percent
WIA	181	90,9
STRATEVAC	91	45.7
RTD	89	44.7
DOW	1	0.5
KIA	18	9.1
BC (WIA + KIA)	199	100
CFR	NA	9.5
Percentage KIA	NA	16.5
Percentage DOW	NA	1.1

***Table 1:** Dutch combat casualty statistics for the armed conflict in Southern Afghanistan (2006-2010).*

WIA indicates wounded in action; *STRATEVAC:* strategic aeromedical evacuation; *RTD:* Return to duty; *DOW:* died of wounds; *BC:* battle casualty; *KIA:* killed in action; *CFR:* case fatality rate; *NA:* not applicable.

Unit	Number	Percent	PPDSM
Army	131	85.1[a]	0.9[a]
Navy	0	0[a]	0[a]
Marines	21	13.6[a]	3.5[a]
Air force	2	1.3[a]	0.2[a]
Military police	0	0[a]	0[a]
Unknown unit	45	NA	NA
Total	**199**	**100**	**1.2[a]**

***Table 2:** Casualty demographics per unit (n=199).*

PPDSM indicates percentage per deployed service member; *NA:* not applicable.
[a]The percentages are calculated n=154, excluding the unknown unit (during deployment) cases (n=45).

MIO	WIA RTD N (%)	WIA STRATEVAC N (%)	KIA N (%)	Total N (%)
GSW	6 (50.0)	4 (33.3)	2 (16.7)	12(6.0)
Explosion	75 (44.9)	78 (46.7)	14 (8.4)	167 (83.9)
IED	68 (46.0)	68 (46.0)	12 (8.1)	148 (74.4)
Rocket/Grenade	4 (28.6)	9 (64.3)	1 (7.1)	14 (7.0)
Mortar	3 (60.0)	1 (20.0)	1 (20.0)	5 (2.5)
Other	8 (40.0)	10 (50.0)	2 (10.0)	20 (10.1)
Total	**89 (44.7)**	**92 (46.2)**	**18 (9.1)**	**199 (100)**

Table 3: *Primary mechanism of injury (n=199).*

MIO indicates mechanism of injury; *GSW:* Gunshot Wounds; *IED:* improvised explosive device; *Other* (=motor vehicle accident, blue on blue, musculoskeletal injuries during patrol, unknown); *N:* number; *WIA:* wounded in action; *RTD:* Return to duty; *STRATEVAC:* strategic aeromedical evacuation; *KIA:* killed in action.

AD	WIA RTD N (%)	WIA STRATEVAC N (%)	KIA N (%)	Total N (%)
Head/ neck	36 (39.5)	45 (26,8)	18 (36.8)	99 (32.1)
Thorax	5 (5.5)	11 (6.6)	8 (16.3)	24 (7.8)
Abdomen	13 (14.3)	19 (11.3)	8 (16.3)	40 (13.0)
Lower extremity	23 (25.3)	58 (34.5)	10 (20.4)	91 (29.5)
Upper extremity	14 (15.4)	35 (20.8)	5 (10.2)	54 (17.5)
Unknown	15 (100)	0 (0)	0 (0)	NA
Total wounds	**91 (29.6)**[a]	**168 (54.5)**	**49 (15.9)**	**308 (100)**[a]
Mean wounds per BC	1.2[a]	1.8	2.7	1.7[a]
AIS mean (range)	3 (0-3)	4 (1-5)	NA	3 (1-5)[b]
ISS mean (range)	3 (0-9)	11 (1-43)	NA	11 (1-43)[b]

Table 4: *Anatomical distribution of injury (n=199).*

AD indicates anatomical distribution; *BC:* battle casualty; *AIS:* Abbreviated Injury Scale; *ISS:* Injury Severity Score; *N:* number; *WIA:* wounded in action; *RTD:* Return to duty; *STRATEVAC:* strategic aeromedical evacuation; *KIA:* killed in action; *NA:* not applicable.

[a] The mean anatomical distribution of wounds is calculated on n=74 WIA RTD, excluding the unknown cases (n=15).

[b] The AIS (body region with highest AIS score) and ISS were calculated without the KIAs.

DISCUSSION

This study is the first in-depth analysis of all Dutch battle casualties from the ISAF mission to Southern Afghanistan, as contained in the trauma registry (2006-2010). Battle injuries were mainly (84%) caused by explosions with casualties often sustaining wounds to multiple anatomical body regions, this compares to reports by coalition partners[1-6,15,16]. One of the significant difficulties in comparing epidemiological casualty data from different conflicts is the variation in the used battle casualty definitions as well as difficulties in obtaining full data capture in austere combat environments. A valid comparison is only possible using strict (NATO) battle casualty definitions[6]. Collaboration of the Dutch armed forces in a validated registration system (e.g. DoDTR) or integration in the Dutch national trauma registry seem realistic opportunities. Improvements in prevention and protective equipment (body amour and vehicle protection) will only be successful if we continue to anticipate on the usage of these weapons of terror in the future by opposing militant forces. The high incidence shows the importance of a thorough understanding of the biomechanics of (improvised) explosive devices and the wounds inflicted by these devices[17-21]. Ramasamy et al.[18] described the mechanism of (improvised) explosive devices extensively; injuries from explosions are classified into four categories: primary, secondary, tertiary and quaternary blast injuries (Textbox 1). Due to the lack of a trauma registry, it was not possible to classify the Dutch BCs in these categories.

Textbox 1: Subgroups of blast injuries

Primary blast injuries are caused by the sudden increase in air pressure after an explosion. Air-containing organs (e.g. middle ear, lungs, and gastrointestinal tract) are susceptible to the effects of the blast wave. Eardrums may rupture at pressures of 2 psi, whereas pulmonary effects are seen at 70 psi. Exposure to pressures above 80 psi is associated with death in more than 50% of cases. Tissue susceptibility to the effects of primary blast is inversely related to the third power of a victim's distance from the explosion. Consequently, the presence of severe pulmonary damage is evidence of the proximity of the victim to the explosion. Secondary blast injuries occur when bomb fragments or nearby debris are energized by the explosion and cause injury by penetrating trauma. Tertiary blast injury is caused when the casualty is thrown by the explosion and collides with nearby objects. Quaternary blast injury is a miscellaneous group (e.g. thermal effects of the explosion and psychological injuries).

The nature of blast injuries has become more apparent in recent times despite occurrence in every conflict of the twentieth century. It is the multi-modal mechanism through which blast injuries are caused that drives the development of complex solutions (e.g. in-vehicle blast scenario) in order to develop evidence-based clinical management[18]. Army service members sustained the absolute highest number of BCs, the Marines the highest relative number, this can be explained by the scope of operations in these units. There was a significant increase in wounds in the head and neck region and a significant decrease in thoracic wounds compared with previous wars[22-25] which could be attributed to improvement in protective body armour in recent years. Extremities remain relatively unprotected by Dutch (NATO approved) body armour.

The thoracic injuries were associated with a higher AIS and ISS score and thus, not surprisingly, significantly more common in the KIA and DOW group. Interestingly, serious ocular and genitalia injuries have been commonly associated with IED incidents[26], however they were only sporadically seen in our series. The use of protective body armour, especially ballistic eye protection, could be an explanation for this difference in anatomical distribution of wounds. The different operational tasks and area of operations could possibly be another explanation, but beyond the scope of this study. The use sniffer dogs, also might have influenced the incidence of IEDs of mechanism of injury. Their casualty rate is approximately 25%, but they have also been very useful in detecting IEDs. A combined analysis of somatic and psychological effects of blast injuries (e.g. traumatic brain injuries) warrants further assessment. The pre-hospital phase seems to be the most important phase in the medical support organization to improve the outcome for BCs[27-30]. In Europe (and thus also in the Netherlands), the incidence of penetrating and blast trauma is low[31,32]. Medical specialist training and education for deployment to austere environments, encountering multiple injured patients with high-energy transfer fragment, projectile and blast wounds that require an assortment of damage control and definitive operative competencies should be developed, because the spectrum of injuries is unparalleled in standard civilian practice[33]. Knowledge of this type of injuries is also valuable in treating casualties from natural disasters or mass casualty situations (e.g. Boston marathon bombing). Non-Governmental and civilian organizations (e.g. political, law enforcement and commercial companies) should be part of this integration process. An integral multinational joint approach is highly recommended. The Dutch experiences in Afghanistan have shown that the insurgents adapt their methods swiftly and effectively to our operational tempo and standard operational procedures (e.g. higher explosive charges after the replacement of flat bottom vehicles with V-shaped bottom vehicles). The major threat in current armed conflicts are (roadside) IEDs. Besides protective equipment, the best forms of prevention are tactically avoiding threat (when possible and applicable), and early adaptations. The intelligence and surveillance services should provide concise information for optimal operational (battle) planning. The aspect of terror; not killing but severely wounding the coalition forces, is the key strategy of the insurgents. Static and heavy vehicle supported operations make us vulnerable for IEDs in asymmetric armed conflicts. Tactical adaptions ("out of the box solutions") are required the keep momentum and the element of surprise. Weather conditions and vegetation in relation to time of year were predictors for a higher incidence of (roadside) IEDs. This can be explained by the weather (e.g. ground conditions and rain), and vegetation changes in the spring and summer for good concealment of IEDs. In order to prevent the insurgents from succeeding in their aim of disrupting coalition forces, we should limit predictability and adapt to the local situation. Prevention of injuries from planned attacks by good mission command ("creative auftragstaktik") is only possible if good intelligence is available.

There are certain limitations to our study. First, the absence of a standardized system of data collection, and the inevitable resulting delay in reporting these statistics. Secondly, because of missing information, inaccuracy could be present in calculating the AIS and ISS in the RTD group. Thirdly, missing information could have led to an underestimation of the total number of WIA-RTD. Fourthly, retrospective cohort studies are sensitive to bias and battle casualty definitions significantly affect casualty analysis results. The inclusion of KIA and RTD in any analyzed cohort will affect the distribution of wounds and mechanisms of injury. Clearly defining the studied population is necessary to make valid comparisons and draw meaningful conclusions. The ideal registry is described in the work of Belmont et al.[34]. Although reports from previous armed conflicts have been published after the completion of combat operations by NATO coalition partners, this study represents an in-depth analysis of all Dutch battle casualties during our participation in the ISAF mission as lead nation (2006-2010).

In conclusion, the wounding patterns observed in Dutch BCs in Southern Afghanistan (2006- 2010) differed from previous NATO conflicts. Explosive devices accounted for the majority of battle casualties, a higher percentage than in previous wars. Knowledge of the management of this type of injuries may also be valuable in treating casualties from natural disasters or (terror) mass casualty situations. An integral multinational joint approach is highly recommended to develop more effective protective equipment and body armour, with special focus on head and neck and extremity protection. Prospective registration in a standardized system of data collection, encompassing all echelons of the medical support organisation should be implemented. Collaboration of the Dutch armed forces in the DoDTR or integration in the Dutch national trauma registry seem good opportunities in achieving this aim.

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Part 2
Quality of care

Chapter 5. Impact of combat events on first responders: experiences of the armed conflict in Uruzgan, Afghanistan

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Injury. In press

ABSTRACT

Introduction: Care for battle casualties demands special skills from medics, nurses and tactical commanders. To date, no inventory has been performed evaluating the first responders (medics, nurses and tactical commanders) around battle casualties.

Method: This observational cohort study was conducted amongst the first responders (n=195) who were deployed to Southern Afghanistan (2009-2010) in three Marine companies. The survey focused on four main topics: (1) participants general background, (2) exposure to combat (casualty) situations, (3) self-perceived quality of care (1 [low] to 10 [high]) in the pre-hospital phase, and (4) the effects of combat stressors on professional skills and social environment using the Post Deployment Reintegration Scale (PDRS) and the Impact of Event Scale-Revised (IES-R).

Results: 71% of the eligible Dutch tactical commanders, medics, and nurses participated in this survey. Most (14/16) medics and nurses scored their pre-deployment training as sufficient. The overall self-perceived quality of care score was above average (7.8). Most (80%) of the participants were exposed to battle casualties. There were no significant differences regarding rank, gender, age and military task using the impact of event scale and PDRS, except for a worse score on the work negative, family positive and personal positive subscales ($p<0.05$) in the PDRS for the first responders in comparison to the armed forces norm score.

Conclusion: The quality of care in the pre-hospital phase was considered adequate, symptoms of post-traumatic stress in this group was low. Active involvement of co-combatants and the social support network are essential in adaption after exposure to combat events. Further research is necessary to identity predisposing preventable high stress factors, and to compose a “waterproof” aftercare program.

BACKGROUND

Units deployed to armed conflicts are at high risk of exposure to combat events. Observations and experiences from the Dutch armed forces (DAF) deployed to Afghanistan are potentially useful for improving pre-deployment training and post-deployment care of military personnel. This exposure to combat events can be direct (as active combatant) or indirect (non-combatant). Recently, the DAF participated in two North Atlantic Treaty Organization (NATO) led military missions: Operation Enduring Freedom and the International Security Assistance Force (ISAF) mission in Afghanistan.[1-7] The Netherlands was lead nation in Uruzgan province between 2006 – 2010, deploying Task Force Uruzgan (TFU). During that period, Dutch service members were frequently exposed to high intensity combat.[1-5] The medical support organisation (MSO) in Southern Afghanistan during the ISAF operations was a multinational joint service with a wide range of capabilities, delivering care in a hostile and austere environment. The NATO Allied Joint Medical Support Doctrine (AJP-4.10) [5] is the capstone document on which the MSO is based, but it is not an unchangeable holy doctrine [9] (Figure 1). The main component of TFU was located at the Multi National Base Tarin Kowt (MBTK), a second base was located at Deh Rawod, and the MSO was adapted to this local situation in Uruzgan province (Supplemental data 1). Tactical Combat Casualty Care (TCCC) [10-12] comprises a set of trauma management guidelines customized for use on the battlefield. This doctrine was first

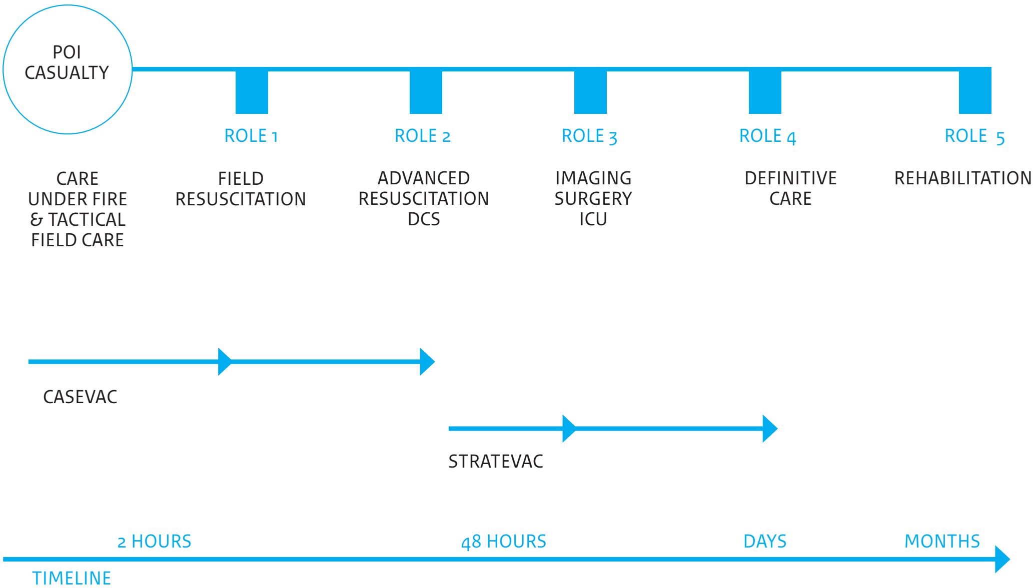

***Figure 1:** Schematic overview of the treatment phases in the medical support organization in relation to time and availability of medical care.*

POI indicates point of injury; *DCS*: damage control surgery; *ICU*: intensive care unit; *CASEVAC*: Casualty Evacuation; *STRATEVAC*: Strategic Evacuation.

introduced in the United States Special Operations community, but the conflicts in Iraq and Afghanistan have seen TCCC become the standard in most NATO coalition forces. The balance between good medicine and good tactics during a combat mission is a continuous process of situational awareness (SA) and right judgement, both by tactical commanders and medical service members. Combat medics and their tactical unit commanders have three objectives while providing care during a combat mission; (1) maximize the probability in fulfilling the unit's mission successfully, (2) provide the best possible care for the (individual) casualty, and (3) minimize additional casualties. This (instinctively contradicting) balance could cause high mental stress for these first responders. Care for battle casualties (BCs) demands special skills from the Dutch deployed service members.The pre-hospital phase seems to be the most substantial opportunity to improve the outcome of BCs, especially the first "platinum" 10 minutes after an injury. [3-13] However, there is no objective measurement to evaluate the quality of care (QoC) in the pre-hospital phase and the impact of violent incidents on the first responders or "the direct circle". To date, no systematic inventory, using structured questionnaires, has been performed evaluating "the direct circle" around battle casualties in the pre-hospital phase and the impact of pre-hospital variables on the post-deployment phase. The impact of combat stressors could be much higher than generally assumed. The primary aim of this study was to assess the medical preparedness, deployment experiences, predisposing factors for post-traumatic stress disorder (PTSD), and post-deployment impact on Dutch medics, nurses, tactical commanders and enablers serving in Afghanistan. The secondary aim was to identify possible improvements in pre-deployment training, long term post-deployment evaluation and re-integration.

MATERIALS AND METHODS

This observational cohort study was approved by the Ministry of Defense (MOD), the Institutional Review Board and the Medical Ethics Committee of Leiden University, the Netherlands. During the period studied (June 2009-August 2010), three companies of the Royal Netherlands Marine Corps (RNLMC) were deployed to MBTK in Southern Afghanistan in 4-5 month periods as part of TFU. These companies contained 10 medics, 10 nurses, 90 tactical commanders (all ranks [officers and non-commissioned officers [NCO]]), and 85 attached enablers (e.g. signal operators, specialised tactical support). These 195 service members were considered as first responders or direct circle around a BC. The tactical commanders could be nominated as on-scene commanders [OSC] during a specific task. There is no international consensus about the term medic. In this study we excluded the basic medically trained combatants (combat life savers [CLS]), but included pre-hospital trauma life support (PTLS) and special forces (SF) medics. The PTLS and SF Medic provide more advanced medical assistance, then basic medically trained combatants based on TCCC principles (respectively 6 and 12 week courses). The participants were divided into five rank groups namely; junior enlisted (E1-E4), senior enlisted (E5-E9), warrant officers (WO1-WO2), junior officers (O1-O3) and senior officers (O4-O10).

Assessment

All (195) identified participants received an online questionnaire in the last quarter of 2013 (mean ~3 years after deployment), two digital reminders and in case of no response a reminder by telephone. The first part of the questionnaire (Supplemental data 2) was based on current literature[2, 4, 5, 10, 13], and screened for validity and relevance by an expert board of Dutch military medical specialists (Delphi method). It focused on three main topics: (1) participants general background, (2) exposure to combat (casualty) situations, and (3) self-perceived QoC in the pre-hospital phase (QoC was described as the subjective judgment by the participants, and expressed in a numeric variable from 1 [low] to 10 [high]); in this study we defined a score of 7 as "average". The subgroups of the participants only answered questions applicable for their task. The second part focused on effects of combat stressors on professional skills and social environment using the Post Deployment Reintegration Scale (PDRS)[14] and the Impact of Event Scale-Revised (IES-R)[15]. The PDRS contains 36 items and is a multidimensional measure of post deployment reintegration experiences/ attitudes. It is designed to reflect a continuum of positive and negative experiences of military personnel in personal, family, and work domains. Each domain is split into a positive and negative subscale (score 0 – 5). On negative subscales higher scores indicate more negative attitudes and on positive subscales higher scores indicate more positive attitudes. Internal consistency reliability and construct validity were studied with positive outcomes for the six subscales[14]. Reference points for the separate subscales were developed by analyzing scores of 3000 Canadian service members, who had recently returned from a mission in Afghanistan[15]. The IES-R consists of a 22-item self-report measure that assesses traumatic stress. Responses are given on a 5-point scale, scoring 0 (not at all), 1, 2, 3 and 4 (extreme) and render a total score (ranging from zero to 88). The IES-R has good psychometric properties[16]. There is no specific cut-off score, in this study we used a cut-off score of 33 and above for the assessment of PTSD[16].

The basic categorical variables were expressed as mean, standard deviation (SD), and range. In all cases $p < 0.05$ was considered statistically significant using the independent sample t-test. Statistical analyses were performed using a computerized software package, SPSS (Version 20, IBM Corporation, Armonk, New York).

RESULTS

Of the 195 online distributed questionnaires (Figure 2), 10 (5%) were distributed to medics, 10 (5%) to nurses, 90 (48%) to tactical commanders, and 85 (42%) to enablers. The response rate was 71% (139/195). The 127 completed questionnaires were included in the analysis, 12 were excluded (5/12 did not leave MBTK [therefore were not regarded as the direct circle around a BC], 5/12 refused to participate in the full survey, and 2/12 did not state the reasons for non-participation). Respondent information and demographics are provided in Table 1. Most (95%) of the participants were male. Almost ninety percent of the participants were aged between 20 and 40. The mean number of deployments (duration ≥28 days) of the participants was 2 (1-8). Ninety one percent of the participants were still in active duty. None of the participants stated exposure to combat related events as reason for no longer being in service. Twenty percent have been on other missions since their deployment with TFU.

Self-perceived score of pre-deployment medical training and required skills

Most (14/16) medics and nurses scored their pre-deployment training as sufficient, 57% (4/7) of the medics stated that they felt the need for a more formal emergency department residency. Ninety percent (14/16) of the medics and nurses inserted an intravenous drip during their deployment, 90% were successful at the first attempt. Thirty one percent (5/16) of the medics and nurses applied a tourniquet during their deployment, all were successful in stopping the bleeding. Sixty nine percent (88/127) of the participants suggested a more formal medical role for the CLSs, because they are always most forward in the combat theatre and considered capable for these lifesaving duties by all participants.

Self-perceived quality of care and information transfer

The participants were asked to score the QoC, the results are presented in Table 2. The overall score of the participants was above average (7.8). Seventeen percent (22/127) of the participants were not exposed directly to BCs during their deployment, 46% (59/127) of the participants were exposed to 1-5 BCs, and 31% (40/127) to more than 5. All exposed OSCs filled out a NATO 9-liner/MIST. The NATO 9-liner/ MIST are standard documents used for the evacuation of a BC from the battle scene, containing information such as location, wartime, security of pick-up site, number of patients by precedence, special equipment required, patient nationality and status. Ninety nine (76/77) percent of the OSCs consider the 9-liner/ MIST an effective tool for medical information transfer. Only, nineteen percent (3/16) of the medics and nurses felt the need for direct contact with a medical specialist (surgeon/ anesthesiologist) at the point of injury (POI) during treatment of a BC. Seventy four (94/127) percent of the participants stated that real-time aids could contribute to a better SA for the medical personnel in the role 2 MTF.

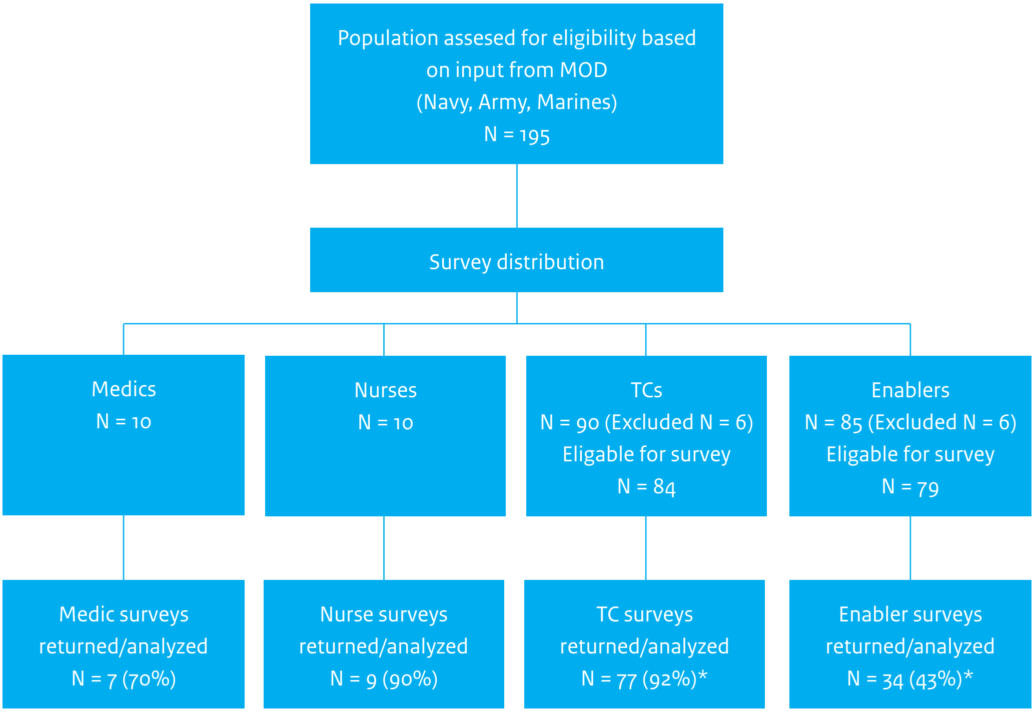

Figure 2: *CONSORT diagram for questionnaire lessons learned deployed medics, nurses, tactical commanders and enablers to Southern Afghanistan.*

TC indicates tactical commanders; *MOD:* Ministry of Defense; *N:* number.
*Calculated without the excluded cases

Characteristic	During deployment (n)	Present (n)
Mean age (range)	24 (20-53)	NA
Sex (%)		
Male	121 (95.3)	NA
Female	6 (4.7)	NA
Marital Status		
Married	52	57
Registrated partner	43	44
Relationship	18	9
Single	14	17
Children %	42	61
Active duty (%)	NA	116 (91.3)
Rank		
E1-E4	50	21
E5-E9	48	58
WO1-WO3	2	8
O1-O3	21	18
O4-O6	6	11
Mean years of active duty (SD)	11 (7.1)	13 (7.2)
Mean deployment history (range)	2 (1-8)	NA
Function		
Medic	7	NA
Nurse	9	NA
Tactical commander	77	NA
Enabler	34	NA
Total	**127**	**NA**

Table 1: *Demographics of the deployed medics, nurses, tactical commanders, and enablers (n=127).*

E1-E4 indicates junior enlisted; *E5-E9* senior enlisted; *WO1–WO3*: warrant officers; *O1–O3*: junior officers; *O4–O6*: senior officers; *SD*: standard deviation; *NA*: not applicable.

Mean QoC (SD)	Medic	Nurse	Tactical commander	Enabler	Total
Point of injury[a]	7.4 (1.6)	8.2 (1.6)	7.8 (1.7)	7.8 (1.7)	7.8 (1.6)
IC point of injury	7.4 (1.5)	8.3 (1.5)	7.9 (1.7)	7.7 (1.6)	7.9 (1.6)
Information transfer[b]	7.8 (1.6)	7.8 (1.6)	7.4 (1.7)	7.8 (1.5)	7.6 (1.5)
Crashroom[c]	8.0 (1.7)	7.7 (1.6)	7.4 (1.9)	7.7 (1.6)	7.5 (1.7)
Role 2 general[d]	8.2 (1.6)	8.2 (1.6)	7.4 (1.8)	8.2 (1.7)	7.6 (1.8)
IC Role	7.6 (1.5)	8.2 (1.5)	7.7 (1.7)	8.2 (1.8)	7.8 (1.6)

***Table 2:** Quality of care scored by the deployed medics, nurses, tactical commanders, and enablers (n=127).*

QoC indicates Quality of care; *SD*: standard deviation; *IC*: international collaboration.
[a]Subjective score on 10 point scale of quality of care at the point of injury, [b]subjective score of information transfer from point of injury to role 2/3, [c]subjective score quality of care in crashroom, [d]subjective score quality of care at the role 2/3 in general, scores are expressed as mean values (1=lowest –10=highest).

Phase	Direct circle around BCs	SCBC	Medics/ nurses	Specialist medical care	Military commanders (e.g. TRiM)	Stress management	Social support Family and relation
Pre hospital Care							
Care under Fire	+	+	-	-	-	-	-
Tactical Field Care	+	+	+	-	-	-	-
Evacuation Care	+	+	+	NA	NA	NA	NA
Initial care unit after RTB	+	NA	+	NA	+	+	NA
MTF							
Role 1	+	NA	+	-	-	-	+
Role 2	-	NA	-	+	+	-	+
Role 3	-	NA	-	+	+	-	+
Role 4	+	NA	-	+	+	-	+
Reintegration	+	NA	+	+	+	+	+

***Table 3:** A schematic overview of proposed involvement matrix in the medical support organisation*

MTF indicates medical treatment facility; *SCBC:* self-care and buddy care; *RTB:* return to base, *TRiM*: Trauma Risk Management; *NA*: not applicable.
The score was expressed in a symbol plus (+) or minus (-), in this study we defined a positive response of ≥25% as cut-off value.

Effect on professional skills and social environment

Eighty one (103/127) percent of all participants stated that prior to deployment they were given sufficient information on the nature and severity of the injuries of BCs they could face during deployment. One hundred percent of the participants described a positive influence of their deployment on their professional military skills. Team spirit ("esprit de corps") and realistic training ("train as you fight") were mostly (respectively 30% and 25%) mentioned as force multiplier. Twenty four percent (30/127) described a positive effect on their personal development, 4% (5/127) described a negative effect on their personal development. Twelve percent (15/127) described a negative influence on their social support network (relational problems, even leading to divorces), 5% (6/127) a positive effect. Twenty two percent (28/127) felt the need to meet an independent professional coach to talk about their experiences at some point after deployment, 78% (99/127) did not feel this need at any point in the post deployment phase. All participants used their direct colleagues for discussion and feedback during and/ or after deployment. Sixty five (82/127) percent of the participants suggested more involvement for the direct circle around a BC in both the rehabilitation and reintegration phase of the BC. We composed an involvement-matrix for key-players and peers in the subsequent treatment and rehabilitation stages. This overview is expressed in Table 3. Twelve (15/127) percent of the participants stated the need for a social support online network. Sixty two (80/127) percent of the participants did have a Trauma Risk Management session (TRiM)[17] directly after a BC, 39% (50/127) did have TRiM after 4-6 weeks. Seventy two (92/127) percent was positive about the mandatory (2 days) Third Location Decompression (TLD)[18,19] period in Crete. TLD refers to the initial process, undertaken by military personnel at the end of an operational deployment, whereby adjustment from military operations commences.

Post deployment

Using the IES, no significant differences regarding rank, gender, age and military task, also in assessment of the subscales (intrusion, avoidance en hyper arousal), were discovered. The mean score was 5.3 (SD 9.3), three OSCs scored above the cut off value for PTSD (respectively 38, 44 and 45). The PDRS showed a significantly different ($p<0.05$) outcome in the work negative, family positive and personal positive subscales (compared to the Canadian norm values[14]), represented in Table 4. Regarding rank, gender, age and military tasks there were no significant differences.
There were no clear war zone-related factors which influenced scores in the IES or PDRS domains. This includes the following variables: engagement in direct combat, whether there was a BC in their unit, interval between deployments, and the total number of deployments.

PDRS Score (SD)	Medics/nurses/TCs	Canadian control	P-value
WP	3.63 (0.83)	3.51 (0.77)	0.09
WN	2.29 (0.86)	3.51 (0.77)	<0.001*
FP	2.94 (0.92)	3.15 (0.98)	0.02*
FN	2.06 (0.90)	2.01 (0.94)	0.55
PP	3.04 (1.03)	3.38 (0.91)	<0.001*
PN	1.81 (0.68)	1.82 (0.83)	0.88

Table 4: *Post deployment reintegration scale by the deployed medics, nurses, tactical commanders, and enablers (n=127).*

PDRS indicates Post deployment reintegration scale; *SD:* standard deviation; *TC:* tactical commander.
The full PDRS scale has 36 items. Within each of the three domains, 6 items assess negative and 6 items assess positive aspects of reintegration; thus, there are 6 PDRS subscales (Work Positive *(WP)*, Work Negative *(WN)*, Family Positive *(FP)*, Family Negative *(FN)*, Personal Positive *(PP)*, Personal Negative *(PN)*). Each item on the scale is rated on a 5-point scale (ranging from 1= Not at all true to 5= Completely true). Scores for each of the six PDRS subscales are computed separately by creating a mean score for each.
*statistically different $p<0.05$ (independent sample t-test)

DISCUSSION

This study represents the first large-scale systematic survey using structured questionnaires evaluating the direct circle around BCs in both the pre-hospital phase and its impact on the (long term) post-deployment phase. Almost all medics and nurses scored their pre-deployment training as sufficient for dealing with severely injured BCs. Most (80%) of the participants were exposed to BCs. The QoC was generally perceived as good. Most (99%) of the OSCs described the 9-liner/MIST as an effective tool, 74% OSCs stated that real time assets could enhance the SA of medical personnel. Interestingly, only few (<5%) of the medics and nurses stated the need for direct communication with a medical specialist (e.g. surgeon or anesthesiologist). The participants gave two explanations: (1) that providing more information can be a time-consuming and distracting task for the OSC during combat situations, (2) that direct communication with a medical specialist would not have changed the outcome of the BCs. Nevertheless, good communication is beneficial in triage and therefore might have improved the outcome of a BC (e.g. direct evacuation to a role 3 MTF with neurosurgical capabilities in case of a severe head trauma). Hoencamp et al.[2] described that 75% of the surgeons and anesthesiologists had the feeling they did not receive enough information. It could be argued that with the current technical possibilities it is feasible to equip the commanding officer and his troops with one way "real time" imaging (e.g. helmet camera's, and biometric function assessment). Using this real-time imaging, it might be possible to gain SA at the POI for the medical specialist, without using precious time of the OSC during direct combat. This enhanced situational awareness may reduce stress levels for the medical specialist, due to early "active" involvement in the pre-hospital process. The cost (and weight for the combatant) of such electronic devices may outweigh the benefits, but this is beyond the scope of this study.

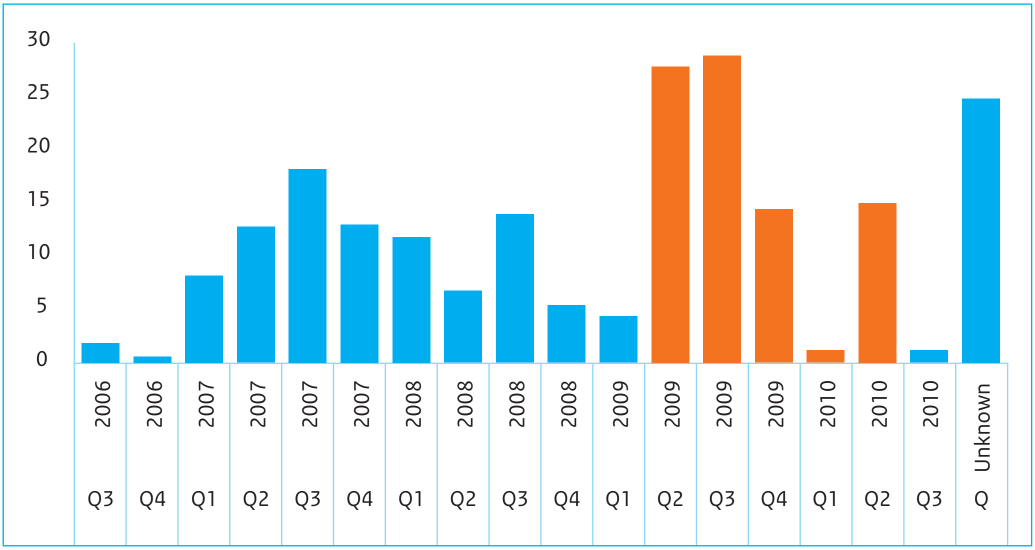

***Figure 3:** Distribution of Dutch battle casualties in relation to time of year (n=210)[5].*

Q indicates quarter of year; Q *unknown* represents the unknown case dates. Orange bar: studied period.

After the initial pre-hospital care and subsequent evacuation a (combat) unit faces a challenge; how to deal with the consequences of combat events and BCs. Currently, the focus is mainly on the acute phase after injury. The participants emphasise the need for a more hybrid approach, including first responders, indirect involved service members, family and friends to manage the effect of combat events. Only three participants were above the cut-off value from the IES-R scale for PTSD. This low overall score is interesting since they are removed from their conventional identity and social support system, and they are deprived of a sense of control and physical comforts. Yet, they must witness and immerse themselves in the often gruesome results of armed conflict. The significant worse scores on the PDRS subscales, illustrate the impact of deployments. The units were deployed in the period with the highest casualty rate of Dutch service members [5] (Figure 3), apart from the continuous high casualty rate/MTF admissions of Afghan national security forces and local nationals (~20% children) [1, 4]. Perhaps good preparation as well as unit cohesion has resulted in low incidence of combat stress-related disorders. Research demonstrated that medical personnel in military units are highly vulnerable to PTSD, and also that protective effects of unit cohesion increases as warzone stress exposure intensifies [20]. Contrary to what has been found in other studies psychological health outcomes beyond PTSD, such as psychological distress, multiple physical symptoms, fatigue and heavy drinking were not found in this study [21]. The role of co-combatants and social support network cannot be overemphasized. The proposed key player involvement-matrix could be very useful in the reintegration process. As this matrix expresses the involvement of every stakeholder after an combat event per phase. A quarter of the participants recognized the importance of "esprit de corps" and realistic training programs ("train as you fight") as force multipliers. Interestingly, the response rate in the enablers (attached units) was significantly lower compared to the OSCs and medics. This might indicate the team bonding in the combat units. This confirms the need for attention for group dynamics (e.g crew resource management and mission command or "auftragstaktik") and realistic training. The newly developed TRiM screening functioned adequately. Despite participation being obligatory, the compliance in attending TRiM was too low, and serious attempts should be installed to raise it to 100%. During the deployment of TFU, TRiM was only used by the Marine companies, following the positive results in the British Armed Forces [17]. According to the participants, TRiM was useful as a signalling and peer group stress management system. The Dutch MOD has meanwhile implemented the TRiM in the Royal Netherlands Navy. Given these results, implementation of TRiM as a stress management system in other parts of the DAF should be considered. While the majority of service members will transition from the armed conflict to home life in a seamless manner, some will struggle to find their place after leaving the sometimes hostile environment of the theatre of military operations. Being involved in an armed conflict, a mass casualty situation, a terrorist attack or a natural disaster like an earthquake, changes people. For many of those, these are life changing experiences [22-25]. This study tried to outline areas of anticipated difficulty in the reintegration experience, and to alert (mental) health practitioners to specific areas that could be problematic. The problems of reintegrating those who served in armed conflicts or were exposed to disasters will not cease. The recommendations in this study are not limited to military medicine, and might be useful in civilian and disaster medicine. Identifying predisposing factors [26] to prevent PTSD, could be very effective in combination with low impact screening tools, such as TriM. Electronic aids like "apps", might be useful as a screening or monitoring tool, in particular for mental health conditions [27]. It is a general responsibility to mobilize government agencies, create public-private partnerships, and invest our resources to mitigate the approaching veteran's health care needs, the impact on our social services, and the costs to society[28].

There are some factors that need to be taken into account. One of the limitations of this study was that we could not use explicit criteria to assess the appropriateness of care delivered on the battlefield, therefore an implicit review was used. There are two common methods used to determine "appropriateness of care": implicit review and explicit review. In implicit review, where a reviewing panel determines the "appropriateness of care" for each BC by comparing the actual process of care against his or her own knowledge and opinion of what optimal care is, versus an explicit review, involving well-defined criteria. Secondly, this is a retrospective study, with a delay (mean ~3 years) between exposure and assessment. We were interested in the long term impact of the deployment on the personnel, but could have performed multiple time point assessment to assess trajectories of the results that were presented here. Thirdly, we used the Canadian reference values for the PDRS, as Canada has a reintegration process that is similar to the Netherlands. Moreover, the life standard is comparable to the Netherlands, and recent comparative analysis demonstrated similar approaches to mental health in the deployment cycle across NATO countries [29]. Nevertheless, it would be interesting to re-validate these norm values in the DAF. Lastly, the questionnaires and cut off values used are only tools to score PTSD, and might have resulted in under- or overestimation of the post deployment impact. The PTSD rate was low compared to governmental organisations [30,31], and warrants further assessment.
This study represents the first assessment of the effects of combat events in a combined (bottom-up) approach (research on pre-deployment preparation, physical and mental health) evaluating the direct circle around battle casualties in both the pre-hospital phase and its impact on the (long term) post-deployment phase. The Wounded Warrior Recovery Project (WWRP) could be very illustrative for long term consequences of combat events[32], and collaboration in this project could be beneficial for the DAF.

In conclusion, there is no (global) golden emergency system, timeline, after care or "standard fit" in armed conflicts. Our results show that the QoC in the pre-hospital phase was considered adequate, but that further optimization is possible in the post-deployment care. The proposed key player involvement matrix could be very useful in the reintegration process. Electronic aids, like screening and post deployment (therapeutic) management tools, could facilitate in achieving this aim. The PTSD rate in the RNLMC (with attachments) deployed to Southern Afghanistan was low using the IES. Further research is necessary to identify predisposing preventable high stress factors and compositing of a "waterproof" aftercare program (e.g. fully integral TRiM) as initial warning for more specialist (mental) care.

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Supplemental data 1. Description of the medical support organisation

The NATO coalition forces operate with a standardized model of evacuation and (surgical) treatment phases, that can be adapted to several situations depending on different geographical and battle type related factors. This model is based on a system with progressively sophisticated levels of medical support in the chain of events when taking care of a battle casualty (BC).

Role 0 (battlefield and evacuation):

This includes Self Care and Buddy Care (SCBC). This is basic assistance that can be provided by all combatants to treat basic circulation- airway, breathing, and circulation (c-ABC) problems.

Evacuation from the point of injury

This is a critical phase where military tactics, time, information flow and communication are essential. This phase is performed by military tactical commanders, and military nurses trained according to Tactical Combat Casualty Care (TCCC) doctrine and Battlefield Advanced Trauma Life Support (BATLS) principles. The NATO 9-liner/ MIST is used as a formal document for Medical Evacuation (MEDEVAC) or Casualty Evacuation (CASEVAC). This 9-line medical evacuation message is a series of phonetic letters, numbers, and basic descriptive terminology used to transmit essential evacuation information such as location, (war) time zone, security of pick-up site, number of patients by precedence, special equipment required, patient nationality and status.

Medical Treatment Facilities (MTF)

Role 1 MTF:

This level is the first level of care in which medical professionals are situated. Care at these facilities is aimed at initial life and limb saving (mostly non-surgical) procedures. On our forward operating base in Dew Rawod there was a role 1 MTF. Care in this phase is generally performed by military nurses (AMV), general duty medical officers (AMA / GDMO) and general practitioners (GP). All of them are trained according to Battlefield Advanced Trauma Life Support (BATLS) principles. If more extensive surgical interventions are required, the patients are transported to a higher echelon.

Role 2 MTF:

At this level of care subsequent, emergency resuscitation and damage control surgery is performed by military medical specialists, mainly anesthesiologists and surgeons. In addition to a Role 2 Enhanced (E), a Role 2 MTF Light Manoeuvre (LM), medical care is limited to life-and-limb saving and damage control surgery, with is a short holding capacity. A Role 2 MTF should be easily accessible and in a safe area. On Multi National Base Tarin Kowt there was a Role 2E MTF with additional (e.g. intensive care unit [ICU], radiological imaging) facilities.

Supplemental data 1. continued

Secondary Evacuation
Moving the patient to a Role 3 MTF or civilian hospital (by helicopter or tactical ambulance) is called MEDEVAC or Strategic Evacuation (STRATEVAC). At these higher echelons, more specialist care is available and a longer length of hospital stay is possible. The MTFs are designed to provide theatre secondary health care within the restrictions of the Theatre Holding Policy.

Role 3 MTF:
At this level in the Medical Support Organization, there are facilities for deployed hospitalization and the elements to support it. It basically includes surgical interventions at primary surgery level, ICU, nursing beds and diagnostic support. Depending on mission characteristics it includes a mission-tailored variety of clinical specialties, focused on the provision of emergency medical care. During the Dutch operations in Uruzgan province, this task was in most cases fulfilled by the Multinational Role 3 MTF, located at Kandahar Airfield (KAF).

Role 4 MTF:
Located at the end of the evacuation and treatment chain, the Role 4 MTF provides the full spectrum of definitive medical care that could (or should) not be delivered in theatre. It includes definitive high care specialist surgical and medical procedures, reconstructive surgery and (long term) rehabilitation facilities. Role 4 care can be provided by military hospitals, but also in cooperation with the national, civilian, health care system. This combined service was provided in the Central Military Hospital and the University Medical Centre Utrecht.

Rehabilitation
This is the phase that follows after the sometimes intensive in-hospital treatment.

Supplemental data 2. Questionnaire lessons learned deployed medics, nurses, tactical commanders and enablers to Southern Afghanistan (translated from the original Dutch questionnaire)

BG = Battle Group
ETA = Estimated Time of Arrival
MIST = Mechanism of injury, Injuries, vital Signs, Treatment
SA = Situational Awareness
BC = Battle Casualty
MTF = Medical Treatment Facility
OSC = On-scene Commander
POI = Point of Injury
PDRS = Post Deployment Reintegration Scale
IES-R = Impact of Event Scale - Revised

Phase 1/2

How many Dutch battle casualties (BCs) did your unit (with you directly involved as OSC or medic/military nurse) see during the deployment?
How many BCs from attached units (ANA/ ANP/ Coalition Forces) did you and your unit see during the deployment?
This may also be an estimate.
How many times did you have to fill out a 9-liner?
How many times did you have to fill out a MIST?
How many times did your unit have to fill out a 9-liner for BCs?
How many times did your unit have to fill out a MIST for BCs?
On average, how much time did it take you to fill out a 9-liner for a BC?
    0-5 minutes, 5-10 minutes, 10-15 minutes, > 15 minutes
On average, how much time did it take you to fill out a MIST for a BC?
    0-5 minutes, 5-10 minutes, 10-15 minutes, > 15 minutes
Was the 9-liner a clear and adequate tool for passing on information?
    No, because
    Too long, Too complicated, Incomplete, Unclear, Other:
Was the MIST a clear and adequate tool for passing on information?
    No, because
    Too long, Too complicated, Incomplete, Unclear, Other:
Is it necessary to give the Combat Life Saver (CLS) a more formal role in the pre-hospital phase to improve the quality of care at the POI?
How many times did you apply an intravenous drip during your deployment?
    On average, how many attempts did you require to carry out the procedure satisfactorily?
How many times did you apply a tourniquet during your deployment?
    Did the tourniquet have an immediate effect?
Did you feel that you needed direct contact with a medical specialist (surgeon/anaesthetist) at the POI during treatment of a BC?

Supplemental data 2. continued

In your opinion, would real-time aids contribute to better and more useful information for medical personnel in, for example, the Role 2 MTF?

Which real-time aids?

Video (helmet camera), Direct radio link, One-way radio link (from POI to higher echelon), Other:

No, because?

Slow work down, Act as a distraction, Other:

In your opinion, would real-time aids contribute to better and more useful information at the POI during treatment of a BC?

Which real-time aids?

Video (helmet camera), Direct radio link, One-way radio link (from POI to higher echelon), Other:

No, because?

Not necessary, High risk of passing on incorrect information, Other:

In retrospect, which of the training courses or learning occurrences listed below were the most useful to you as the medic at the POI (the time between occurrence of the injury and departure of the helicopter)?

Not applicable to me (OSC)

Mission-specific training, Paramedical training (Defence Medical Training Institute), Unit training during work-up period, Previous personal experience, Other (civilian) training course, Colleagues' experiences, Other:

What do you feel you lacked as a medic during treatment of a BC at the POI?

Not applicable, I was OSC / Military Physician

Nothing, Sufficient personal preparation for the mission, The right scenario training (old-school unrealistic work-up path), The right equipment, The right coaching, The right communication equipment, Other:

What was your perception of international medical cooperation after an incident had occurred (1 = very poor 10 = very good)?

At POI

At Role 2

Could you now assess the quality of care/information handover during the following 4 phases (1 = very poor 10 = very good)?

Quality of care at Point of Injury

Quality of information handover from POI to Role 2 MTF (e.g. 9-liner, ETA*, MIST**, triage)

Quality of care in trauma room (the "crash room")

General quality of care at the Role 2 MTF

Did you perceive a big difference in the quality of care per BC at the POI?

In retrospect, were you given sufficient information on the nature and severity of the injuries of BCs you might have to treat?

By whom?

Direct superior in the armed forces, Previously deployed colleagues, Mission-specific training instructor, Training at the Defence Medical Training Institute, Other:

Supplemental data 2. continued

When did you become aware of this?

When I first heard that there was a NLD casualty, When I experienced it for myself, Only after the casualty had been evacuated, Only after my deployment, Other:

What is your assessment of the overall treatment and care of casualties from your unit (1 = very poor 10 = very good)?

Phase 3/4 - Social support

Please indicate in the table below in which phase the various members of personnel should be involved in the treatment and care of BCs. Some combinations are by definition not possible (such as parents in phase 1).

The phases of the medical treatment process are:

Phase 1: Pre-hospital phase. This is the phase between the BC receiving the wound at the Point of Injury (POI) and the first treatment in a higher echelon, including transport.

Phase 2: Hospital (Role 2 MTF) phase. This is treatment of the BC in a hospital.

Phase 3: First rehabilitation phase until six months after BC received the wound (could be in either Afghanistan or the Netherlands).

Phase 4: Second rehabilitation phase from six months after BC received the wound (in the Netherlands).

Colleagues (from unit)
Direct superior in armed forces
Medic / Military nurse involved at POI
Medical specialist (e.g. surgeon/ anaesthetist)
Battle Group Commander
Parents/family
Partner
Friends
Spiritual welfare officer/Chaplain
Defence Social Services Agency
Rehabilitation specialist
Colleagues network
Other

Do you think it useful for the first medic on the scene to be involved in the BC's aftercare path?
For me *personally:*
Do you think it useful for the first medic on the scene to be involved in the BC's aftercare path? For the BC:
What advice do you have for improving phase 3/4?

Phase 3/4 - Personal

Receiving social support can be both helpful and pleasant. However, not everyone finds it easy to ask for help. The idea that you have to solve all your own problems can also lead to isolation.

How would you describe yourself when asking for social/mental support from partner/family/friends.

Before deployment, During deployment after a BC in my unit

I ask for help very easily, I seldom ask for help, I almost never ask for help, I do not ask for help

Supplemental data 2. continued

Do you (or did you in the past) feel the need to be part of a social network (a kind of facebook community) for former deployed personnel, fellow sufferers and war veterans?
Have you (sometimes) felt the need to discuss your deployment experiences and the consequences thereof with an independent 'coach'?
    With who else?
    Direct superior in armed forces, Spiritual welfare officer//Chaplain, Home GP/Military physician, Defence Social Services Agency, Psychologist/ Psychiatrist, Colleagues network, Other:
Have you discussed your experiences with an independent 'coach'?
    Why?
    With who else?
    Direct superior in armed forces, Spiritual welfare officer/Chaplain, Home GP/ Military physician, Defence Social Services Agency, Psychologist/ Psychiatrist, Colleagues network, Other:

Phase 3/4 – Colleagues network

Did you have a first TRiM (Trauma Risk Management) interview 72 hours after the incident?
    If yes:
    Individually, As part of a group
What was the reason for this?
What did you think of the first TRiM interview?
Did you have a second TRiM interview 4 to 6 weeks after the incident?
    If yes:
    Individually, As a group
    What was the reason for this?
What are your thoughts on the decompression period on Crete?
    Positive, Negative, No decompression period
After the mission, did you discuss your work experiences (i.e. in the medical domain) with your colleagues?
    What stopped you from doing so?
    How has your deployment to Uruzgan affected your personal and professional lives in the Netherlands? In the area of:
    Medical skills and competences?
    Personal development?
    Your home situation?
Would you again like to be deployed in the role of medic (possibly as a secondary task) in the future?
    Not applicable, I was OSC/Signals Operator
Have you ever considered following a medical training course?
    Not applicable, I was OSC/Signals Operator/ military physician/nurse
Looking back on your deployment and the period after your deployment with BG-10/11/12 (up until today)
What experience with BG 10/11/12 did you find to be very positive?
What experience with BG 10/11/12 did you find to be very negative?
What advice would you give to your current or future colleagues when preparing for deployment as a medic (next to their military tasks)?
What question would you have like to have answered but is missing in this questionnaire?

Chapter 6. Lessons learned from Dutch deployed surgeons and anesthesiologists to Afghanistan: 2006- 2010

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ABSTRACT

Introduction: Care for battle casualties demands special skills from surgeons and anesthesiologists. The experiences of Dutch military surgeons and anesthesiologists that deployed to South Afghanistan provided an opportunity to evaluate pre-deployment training and preparation of military medical specialists.

Method: A survey was conducted amongst all surgeons and anesthesiologists (n=40) that deployed to South Afghanistan between February 2006 and November 2010. They were asked about their medical preparedness, deployment experience, and post-deployment impact.

Results: Most (35/40) participants reported high levels of preparedness prior to their deployment. All (40/40) surgeons and anesthesiologists described a positive influence of their deployment on their professional skills and 33/40 described a positive effect on their personal development. Knowledge of maxillofacial, ophthalmic, neurological, urological, gynecological, vascular and thoracic surgery scored below average. Impact on mental health and social support network was reported as negative by 11/40 participants, 24/40 reported a neutral and 5/40 a positive effect.

Conclusion: A standardized pre-deployment training program to prepare Dutch surgeons and anesthesiologists for combat surgery is currently lacking. These results emphasize the need for a standardized pre-deployment medical training, despite high levels of perceived preparedness. Also, the high mental and psychological impact on the deployed surgeons and anesthesiologists warrants further assessment.

INTRODUCTION

Since the global war on terrorism began in 2001, the toll on service members in terms of medical treatment for battle casualties (BCs) has been quite high. Over 10,000 coalition service members have been killed and over 50,000 have been injured in Iraq and Afghanistan[1]. In addition, a high number of contractors, host-nationals, foreign national security personnel, and also insurgents have been seriously wounded or were killed. Deployed surgeons and anesthesiologists delivered critical care to many of these casualties. While in the recent armed conflicts improved body armor has reduced the amount of thoraco-abdominal trauma, the proportion of extremity injuries remained high, mostly caused by explosive devices[1-3].
The medical support organization (MSO) in South Afghanistan during the International Security Assistance Force (ISAF) operations was a multinational joint service holding a wide range of capabilities, delivering care in a hostile austere environment. The Dutch role 2 Enhanced Medical Treatment Facility (role 2 MTF NL) at Multinational Base Tarin Kowt (MBTK) was comprised of approximately 50 multinational medical service members. It was configured with two emergency resuscitation tables (crash room), one operating room, two ICU beds and fourteen regular nursing beds. The role 3 MTF at Kandahar Airfield (KAF) was configured with eight emergency resuscitation tables, three operating rooms, eight ICU beds, twenty regular nursing beds, full laboratory and diagnostic services including a CT scanner. Decisions regarding care and transportation of BCs were often driven by a number of factors. These included e.g. enemy threat, mechanism of injury, patients overall medical condition, evacuation timelines, availability of assets, qualifications/capabilities of medical personnel, and prevailing tactical or weather conditions. Various difficult medical decisions were made during complex military operations and evidence to support or refute current practice was a continually evolving process[4]. Since 2008, the Definitive Surgical Trauma Care Course (DSTC[(R)]) and Definitive Anesthetic Trauma Care Course (DATC) were introduced as Dutch pre-deployment training for emergency medicine or damage control surgery. Recent discussions about the minimum required skills and mandatory courses for military medical specialists strengthen the need for international standardization[5-9]. Yet, to date, there is no standardized mandatory medical preparation for the medical specialist that is being deployed. It is important to identify potential improvements on various aspects of the medical care from the perspective of the Dutch deployed surgeons and anesthesiologists at the role 2 MTF NL at MBTK and the Role 3 MTF at KAF. The aim of this study was to assess the medical preparedness, deployment experience, and post-deployment impact of Dutch surgeons and anesthesiologists serving in Afghanistan.

MATERIALS AND METHODS

During the period studied (February 2006 – November 2010), 21 (trauma) surgeons, 2 orthopedic surgeons and 18 anesthesiologists were deployed multiple times (1-3) in 2-3 month periods to the Dutch role 2 MTF NL and/ or the role 3 at KAF. In the role 2 MTF NL the (trauma) surgeon was the sole surgical medical specialist. In higher echelons (role 3 KAF), the initial surgical responsibility is divided in two, over a general and an orthopedic surgeon. Other types of specialist surgery were also available in these higher echelons e.g. maxillofacial, ophthalmic, neurological, urological, gynecological, vascular and thoracic surgery. In the Netherlands the current practice is that both the trauma surgeon and the orthopedic surgeon focus on skeletal aspects of extremity injuries in elective and acute settings. The soft tissue and visceral trauma injuries are the primary domain of the trauma surgeon. All deploying medical specialists followed a one week pre-deployment course provided by the Dutch Ministry of Defense (MOD) with specific (non-)medical information about the Area of Operations (AOR), team introduction and basic military skills training. All Dutch surgeons and anesthesiologists that have been deployed between February 2006 and November 2010 to South Afghanistan were asked to identify self-perceived strengths and weaknesses of the MSO in our AOR in Afghanistan. They were invited to participate in a questionnaire that assessed these factors. The questionnaire was composed based on current literature[4-8] and screened for relevance by an expert board of Dutch military medical specialists. The survey was conducted in the first quarter of 2012. The questionnaire (Figure 1) contained 4 main topics: (1) participants general information, (2) medical expertise, (3) perceived quality of care (QOC) in the pre-hospital and damage control surgery phase, and (4) effects on professional skills and social environment. Quality of care was described as the subjective judgment of the Dutch deployed surgeons and anesthesiologists to our AOR. The score was expressed in a numeric variable from 1 (low) to 10 (high), in this study we defined a score of 7 as average.

This study was approved by the MOD and the Institutional Review Board of Leiden University, the Netherlands. The basic categorical variables were expressed as mean, standard deviation (SD), and range. Statistical analyses were performed through a computerized software package, using SPSS (Version 20, IBM Corporation, Armonk, New York).

***Figure 1:** Questionnaire 'lessons learned of deployed surgeons and anesthesiologists to Afghanistan' (translated from the original on-line Dutch questionnaire).*

GENERAL
Name:
Specialism : O Surgeon O Anesthesiologist
Sub specialization:
Age: O 30-40 O 40-50 O > 50
Gender: O Male O Female
Board registered medical specialist (in years): O <5 O 5-10 O 10-20 O > 20
Date (year) of M.D. degree:
Date (year) of sub specialization:
Number of deployments to Uruzgan or Kandahar:
Total number of deployments:

TRAINING AND PREPARATION
1. Did you feel professionally prepared for your task in Afghanistan?
a. Yes
b. No
Explanation:

2. What additional courses or training have you done prior to your deployment? How would you appreciate the value of that course on the scale (1low-10high)?
a. The mission oriented training
b. Professionally - course name:
c. Professionally - course name:
d. Professionally - course name:
e. Other activity, namely:
Explanation:

3. Did you have the same feeling after the mission, as referred to in Question 1?
a. Yes
b. No
If not, why not?

Figure 1: continued

DEPLOYMENT

4. For surgeons: How do you consider, in retrospect, your own training, knowledge and skills with respect to treatment of injuries from the below mentioned surgical sub specialization on the scale (1low-10high)?

Vascular surgery:
Abdominal surgery:
Soft tissue injuries:
Fractures:
Neurosurgery:
Thoracic Surgery:
Obstetrics/Gynecology:
Urology:
Plastic (reconstructive) surgery:
Maxillofacial Surgery:
Ophthalmics:
Burns:
Pediatric Surgery:
Explanation:

5. What was of most value for you during your preparation for the deployment to Southern Afghanistan?

6. How do you rate the quality of care in the following four phases on the scale (1low-10high)?

a. At the point of injury
Explanation:
b. The transfer of information from point of injury to the role 2/3 hospital (9-liner, ETA*,** MIST, triage)
* ETA = Estimated Time of Arrival
** MIST = Mechanism of injury, Injuries, Vital Signs, Treatment
Explanation:
c . The crash room (“trauma bay”)
Explanation:
d. In general, in the role 2/3
Explanation:

7. Did you receive timely and adequate information on a battle casualty (BC) from the point of injury to prepare in the crash room?

a. Always
b. Sometimes
c. Never
Explanation:

Figure 1: continued

8. Did you receive a 9-liner and MIST before the entrance of a BC?
a. Always
b. Sometimes
c. Never
Explanation:

9. Were the 9-liner and MIST good resources for information transfer from a BC?
a. Yes
b. No
Explanation:

10. What should be improved in the transfer of information after an incident/ casualty in order to provide good medical care in a Role 2/3 hospital?

PERSONAL

11. Did you feel the need for an independent "coach" (peer to peer), to talk about your experiences during the deployment?
a. Always
b. Sometimes
c. Never
Explanation:

12. Did you ever felt the need to talk with direct colleagues about your experience during the deployment?
a. Always
b. Sometimes
c. Never
Explanation:

13. Did your deployment to South Afghanistan have impact on your professional knowledge and skills, and on your personal life. What kind of influence?
In the following areas:
a. Professional skills and competencies?
b. Personal development?
c. Impact on the situation at home?

14. What would you especially recommend your colleagues if they prepare (future) deployments?

RESULTS

Participants general information

All but one (40/ 41) of the Dutch deployed surgeons (n=22) and anesthesiologists (n=18) participated in the survey; one surgeon died of disease non battle injuries during his deployment. Most (37/40) specialists were males. Three of the participants were aged between 30-40, 11/40 between 40-50, and 26/40 above 50. Two of the participants were board certified medical specialist less than five years, 8/40 between 5-10 years, 8/40 between 10-15 years, 5/40 between 15-20 years, 17/40 more than 20 years. The median number of earlier deployments of the participants was 3 (1-13). The primary sub specialization of the surgeons was as follows; 10 trauma, 9 general, 2 orthopedic and 1 vascular surgery.

Preparedness and medical expertise

Thirty five (surgeons 18/22, anesthesiologists 17/18) of the participants reported high levels of preparedness prior to their deployment. Most of the participants (surgeons 20/22 and anesthesiologists 16/18) scored their knowledge and skills as more than sufficient for the complexity of the injuries that they were exposed to during their deployment. The participants scored the quality of the pre-deployment course as 5.6 (range 1-9). Most (6/10) of the junior specialists scored the DSTC(R) or DATC as very useful (mean score >8.5) in their pre-deployment training. The same high score was given to the Polytrauma Rapid Echo/ ultrasound evaluation Program by five surgeons, and to the Battle Advanced Trauma Life Support Course by three anesthesiologists. Nine (surgeons 5/22, anesthesiologists 4/18) of the participants scored their optional residency in the United States (US), United Kingdom or South Africa as most useful during deployment. The surgeons were asked to score their self-perceived (surgical) medical expertise (table 1). Knowledge of maxillofacial, ophthalmic, neurological, urological, gynecological, vascular and thoracic surgery scored below average.

Generally perceived quality of care

The participants were asked to score the QOC at different levels of the MSO (table 2).

Surgical expertise	Mean	Minimum	Maximum	SD
Fracture surgery	8,5	5	10	1,2
Soft tissue surgery	8,2	6	10	0,9
Burn treatment	8,2	7	10	1,2
Gastro intestinal surgery	8,1	7	10	0,9
Pediatrics	7,1	4	10	1,3
Thorax surgery	6,9	4	10	1,6
Vascular surgery	6,7	4	10	1,3
Plastic (reconstructive) surgery	6,5	5	8	0,9
Urology	5,0	1	8	2,0
Neurosurgery	4,5	1	8	2,3
Obstetrics/Gynecology	4,5	1	8	2,4
Ophthalmic surgery	3,7	1	8	2,3
Maxillofacial surgery	3,5	1	7	1,9

***Table 1:** Self-perceived surgical expertise of deployed surgeons (n=22).*

SD indicates standard deviation, scores are expressed on 10 point scale as mean (1=lowest –10=highest).

Quality of care	Surgeon mean (min-max)	Anesthesiologist mean (min-max)
Point of injury[a]	6,8 (3-9)	6,1 (2-9)
Information transfer[b]	6,1 (3-9)	6,1 (3-9)
Crashroom[c]	7,7 (4-10)	7,5 (4-10)
Role 2/3 general[d]	7,4 (5-9)	7,6 (6-9)

***Table 2:** Quality of care scored by the deployed surgeons (n=22) and anesthesiologists (n=18).*

[a]Subjective score on 10 point scale of quality of care at the point of injury, [b]subjective score of information transfer from point of injury to role 2/3, [c]subjective score quality of care in crashroom, [d]subjective score quality of care at the role 2/3 in general. *Min* indicates minimum, *max*: maximum, scores are expressed as mean values (1=lowest –10=highest).

Information transfer

Nine (surgeons 5/22, anesthesiologists 4/18) of the participants felt they received enough information from the point of injury (POI), 31/40 had the feeling they did not receive enough information in most cases. The 9-liner is a standard NATO document used for a casualty evacuation from the battle scene (CASEVAC). The 9-line medical evacuation message is a series of phonetic letters, numbers, and basic descriptive terminology used to transmit medical evacuation information such as location, wartime, security of pick-up site, number of patients by precedence, special equipment required, patient nationality and status. Nine (surgeons 5/22, anesthesiologists 4/18) of the participants received the 9-liner for every BC, 31/40 did not receive these documents in every case. Thirty five (surgeons 19/22, anesthesiologists 16/18) of the participants considered the 9-liner an effective tool for medical information transfer, 5/40 were negative about the functionality of this document.

Effect on professional skills and social environment

All (40/40) surgeons and anesthesiologists described a positive influence on their professional skills. Thirty three (surgeons 19/22, anesthesiologists 14/18) of the participants described a positive effect on their personal development, 7/40 described a neutral effect on their personal development. Eleven (surgeons 6/22, anesthesiologists 5/18) of the participants described a negative influence on their social support network, 24/40 (surgeons 11/22, anesthesiologists 13/18) a neutral effect, and 5/40 (surgeons 5/22) a positive effect. Eighteen (surgeons 7/22, anesthesiologists 11/18) felt the need to meet an independent professional coach (defined here as peer to peer) to talk about their experiences at some point after deployment, 22/40 did not feel this need at any point in the post deployment phase. All participants reported that they used their direct colleagues for discussion and direct feedback during and/ or after deployment.

DISCUSSION

This study assessed the self-perceived medical preparedness, deployment experiences, and post-deployment impact on the Dutch surgeons and anesthesiologists deployed during the ISAF mission to the role 2 MTF NL and the role 3 at KAF. The surgeons scored their knowledge/ surgical skills of maxillofacial, ophthalmic, neurological, urological, gynecological, vascular and thoracic surgery as below average. The perceived quality of care provided from the POI up to the role 2/3 was scored below average and the care provided at the role 2/3 in the damage control surgery phase above average. The mental and psychological impact of the deployments on the surgeons and anesthesiologists was similar as previously described[9]. The group was heterogeneous, but overall fairly experienced: 80% had more than five year experience and were deployed several times to different military theatres. The general feeling of "lack of readiness" and need for pre-deployment courses was higher with the junior specialists, which most likely can be explained by less general specialist experience. Interestingly we could not find studies describing lack of preparedness for anesthesiologists. This could indicate that the knowledge, skills and preparedness of anesthesiologists for such deployments can be considered as acceptable or good. In the studied period the surgeons were encouraged to complete the DSTC(R) and anesthesiologists to complete the DATC before deployment. Most of the junior specialists scored the DSTC(R) or DATC as very useful in their pre-deployment training, apart from a foreign residency. A standardized mandatory "Emergency War Surgery Course" and/ or emergency surgery residency could increase the self-perceived level of medical and surgical preparedness. Although a survey[6] under US Army orthopedic surgeons showed comparable results in the self-perceived level of medical and surgical preparedness, their mandatory war surgery workup program did not significantly change the self-perceived level of medical and surgical preparedness. Ramasamy et al.[9] proposed a similar pre-deployment six week Military Operational Surgical Training (MOST) course and trainee/ residency deployment for six weeks to increase medical and surgical preparedness. Willy et al.[5] described the DUO plus model, which entails a specialization in general surgery plus a second specialization in either visceral surgery or orthopedic/trauma surgery. Our results support the recent discussion about enhancing the basic training and skills of military surgeons. In the role 2 MTF NL the surgeon was the sole surgical medical specialist, responsible for both skeletal and visceral injuries. After the pre-hospital phase, damage control surgery and damage control resuscitation are often the key objectives. Lack of knowledge and basic surgical skills on maxillofacial, ophthalmic, neurological, urological, gynecological, vascular and thoracic surgery can lead to higher morbidity and mortality rates of BCs. The participants scored the generally perceived QOC at the POI and quality of medical information transfer from the POI as below average. Thirty one of the participants had the feeling they did not receive enough information in most cases. Potentially this is an opportunity for improvement, yet we are aware that providing more information can be a time-consuming and distracting task for the on scene commander (OSC) during combat situations. It could be argued that with the current technical possibilities it is feasible to equip the commanding officer and his units with "real time" imaging, for instance via helmet camera's, and biometric function assessment, thus enhancing medical quality "on site". Using this real-time imaging, it might be possible to gain situational awareness at the POI for the medical specialist, without using precious time of the OSC during direct combat. This enhanced situational awareness may reduce stress levels for the medical specialist, due to early active involvement in the pre-hospital process. Eastridge et al.[10] concluded that most battlefield casualties die of their injuries before ever reaching a surgeon. As most deaths were classified as non-survivable, mitigation strategies to impact these outcomes need to be directed toward injury prevention. To impact the outcome of BCs with a potentially survivable injury, strategies must be developed to mitigate hemorrhage on the battlefield, optimize airway management, and decrease the time from POI to surgical intervention. Clarke et al.[4] suggested that severely wounded BC victims should be retrieved by dedicated pre-hospital critical care teams and triaged to the highest and/or most appropriate level of medical care available within the region. The pre-hospital phase is believed to be the most substantial opportunity to improve the outcome of BCs[11-12]. A vast minority of the participants experienced a negative influence on their social support network, and almost half felt the need to meet an independent professional coach to talk about their experiences at some point after deployment. The high mental and psychological impact described by the participants indicates that attention should be given to the impact deployments can have on the personal life of deployed medical specialists. Tyler et al.[9] described a similar negative influence on the social support network. They also described that 27% of the deployed medical specialists had two or more symptoms of posttraumatic stress disorder. Kearney et al.[6] reported that nearly a third of the surgeons reported low mental preparedness for deployment, many surgeons reported previous military courses or experiences as contributors to their mental readiness for deployment. Surgeons with these previous experiences rated their mental preparedness for deployment significantly higher. These findings suggest that surgeons without previous military courses or experiences may feel mentally underprepared for deployment and, therefore, may benefit from additional pre-deployment counseling or assistance. Good pre-deployment preparation could result in lower stress levels and may lead to a lower negative influence on the social support network of deployed medical specialists. We found no prior reports on the self-perceived preparedness and medical expertise of the Dutch deployed surgeons and anesthesiologists, nor on the self-perceived quality of care from the pre-hospital phase to the higher echelons in a combat environment. There are some factors that need to be taken into account. One of the limitations of this study was that we could not use explicit criteria to assess the appropriateness of care delivered on the battlefield. There are two common methods used to determine "appropriateness of care": implicit review and explicit review. In implicit review, a reviewing panel determines the "appropriateness of care" for each BC by comparing the actual process of care against his or her own knowledge and opinion of what optimal care is.

Currently, there is no standardized mandatory pre-deployment training to prepare Dutch deploying surgeons and anesthetists for war surgery. The recent obligation of the DSTC® and DATC is a sign that standardization for the Dutch military surgeons and anesthesiologists is being implemented. Further research is necessary to compose the contents of a useful mandatory training program for the Dutch military surgeons and anesthesiologists. An emergency surgery/ anesthesiology residency could be a next step in the formation of a robust pre-deployment workup program. The high mental and psychological impact on the deployed surgeons and anesthesiologists indicates that assessment of mental health of the surgeons and anesthesiologists on the short and long term is very important. Availability of flexible, low profile psychological (peer to peer) support could accommodate this. Also an assessment of the whole MSO by medical specialists, tactical commanders, medics and nurses, who have been actively involved in all phases is recommended. We wish to underscore that the conclusions of this study can be implemented without additional risk for the MSO and BCs. Further research is warranted to evaluate the impact of battle injuries in BCs in relation to the initial treatment given.

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Chapter 7. Challenges in training of military surgeons: experiences from Dutch combat operations in Southern Afghanistan

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ABSTRACT

Background: To improve care for battle casualties, we analyzed the surgical workload during the Dutch deployment to Uruzgan, Afghanistan. This surgical workload was compared with the resident surgical training and the pre-deployment medical specialist program.

Methods: Patient data were analyzed from the trauma registry (2006-2010) at the Dutch Role 2 medical treatment facility (MTF). The case logs of chief residents (n=15) from the general surgery training program in the Netherlands were used as comparison.

Results: The trauma registry query resulted in 2,736 casualties, of which 60% (1,635/2,736) were classified as disease non-battle casualties and 40% (1,101/2,736) as battle casualties. During the study period 1,427 casualties (336 pediatric cases), required 2,319 surgical procedures. Graduating chief residents did an average of 1,444 cases, including 165 laparotomies, 19 major vessel repairs, 28 amputations, and 153 fracture stabilizations during their residency. Residents had limited exposure to injuries requiring a thoracotomy, craniotomy, nephrectomy, IVC repair and external genital trauma.

Conclusions: The injuries treated at the Dutch Role 2 MTF were often severe, exposure to pediatric cases was much higher than reported in other combat hospitals in Iraq and in Afghanistan. The current civilian resident training does not foresee in the minimally required competences of a fully trained military surgeon. The recognition of military surgery as a subspecialty within general (trauma) surgery, with a formal training curriculum, in the Netherlands should be considered. The introduction of a North Atlantic Treaty Organization Military (and Disaster) Surgery standard may attribute to achieve this aim.

BACKGROUND

The battlefield casualties research working group publishes in collaboration with the Ministry of Defense (MOD) data and analyses of armed conflict related medical experiences[1-4]. The International Security Assistance Force (ISAF) is a North Atlantic Treaty Organization (NATO) led security mission in Afghanistan that was authorized by the United Nations Security Council in December 2001. The main purpose of the mission is to train the Afghan National Security Forces and assist Afghanistan in rebuilding key government institution. Since 2002, the Dutch (NL) Armed Forces have been involved in operations in Afghanistan. From August 2006 to August 2010 the Netherlands were lead nation in Uruzgan province, deploying Task Force Uruzgan (TFU). Uruzgan is located in the southern region of the country, having borders with Zabul and Kandahar to the south, Helmand to the southwest, Daykundi to the north, and Ghazni Province to the east. Uruzgan covers an area of 12,640 km^2, with approximately 400,000 inhabitants, who are mostly part of a tribal society.

The main component of TFU was located at Multi National Base Tarin Kowt (MBTK), Afghanistan. It was composed of approximately 1,200 service members and contained a Dutch role 2 Enhanced Medical Treatment Facility (role 2 MTF NL). It was comprised of approximately 50 multinational medical service members. The role 2 MTF NL was configured with two emergency resuscitation tables, one operating room, two ICU beds and fourteen regular nursing beds. Besides the primary aim of treatment of coalition forces at the role 2 MTF NL, the secondary aim was the treatment of Afghan national security forces and local nationals. In the Netherlands, the Institute of Collaboration Defense and Relation Hospitals (IDR) of the Ministry of Defence (MOD) is the central organ responsible for training and deployment of military medical specialists. The content of the pre-deployment work-up program for military surgeons, in the Netherlands (2006-2010) was composed of:

1. A short basic military skills course

2. A one week course with general information about the area of operations

3. Courses:
   a. Mandatory: Advanced Trauma Life support (ATLS®), Battlefield Advanced Trauma Life support (BATLS), Emergency Management of the Severe Burn Course (EMSB®) and Major Incident Medical Management and Support course (MIMMS®)
   b. Since 2008 mandatory: Definitive Surgical Trauma Care (DSTC®) and Polytrauma Rapid Echo/ultrasound evaluation Program (PREP)
   c. Optional clinical rotation in South Africa for acquaintance with penetrating trauma

In the above mentioned period 17 different Dutch surgeons, most of them (15) being reservists, deployed multiple times (1-3) to MBTK in 2-3 month periods to the role 2 MTF NL. Most NATO countries divide the initial surgical responsibility between a general and an orthopaedic surgeon[5-11]. In the Netherlands both the trauma surgeon and the orthopaedic surgeon focus on skeletal aspects of extremity injuries in elective and acute settings. Soft tissue and visceral trauma are the primary domain of the trauma surgeon in the Netherlands. In the role 2 MTF NL the (trauma) surgeon was the sole surgical medical specialist, treating severely injured casualties in a combat theatre with limited resources. Other types of specialist surgery were only available in higher echelons, as the key objective at a role 2 MTF is damage control surgery. After initial stabilisation, patients could be evacuated to higher echelons of care (e.g. role 3 MTF at Camp Bastion in Helmand province or at Kandahar Airfield in the province Kandahar). Battle casualties treated at the role 2 MTF NL were dominantly injured by explosions (55%) and gunshot wounds (35%)[1]. The above described (international) military setting, mechanisms of injury and surgical pathology are substantially different from those seen in civilian trauma. In Europe the incidence of penetrating and blast trauma is low[12]. In the Netherlands violence related penetrating injuries were only registered as emergency department admission in 2,519 cases and as cause of death in 92 cases (respectively 16.4/ 100,000 and 0.6/100,000 per inhabitant) in 2011[13,14]. Penetrating trauma accounts for only 5–10 % of all trauma in Europe, compared with 40–50% in the United States of America (US)[15,16]. It is possible that a newly trained military surgeon will deploy soon after completing civilian residency training, and will encounter these complex combat injuries. Regardless of (residency) subspecialisation, all Dutch military general (trauma) surgeons complete their surgical training on civilian patients, because there is no standardized military surgical training program yet. Although numerous studies have described the operative caseload and injury patterns seen in both Iraq and Afghanistan by coalition partners[1,5-11], comparing in-theatre surgical workload with caseloads completed by graduating surgical residents has only been performed by the US military[10,17-19]. The aim of our study was to compare the surgical workload at the role 2 MTF NL in South Afghanistan with the exposure of surgical pathology in civilian surgical training and the pre-deployment medical specialist work up program, in order to identify a possible curriculum modification for the future military surgeon.

METHODS

This study was approved by the MOD and the Institutional Review Board and Medical Ethical Committee of Leiden University, the Netherlands. Basic data collection and verification of the cases treated at the role 2 MTF NL between August 2006 and August 2010 was conducted using the electronic admission database. Missing information was collected from the written patient records. Patient demographics collected included age, divided into children (under 16 years old) and adults. Injuries were subsequently subdivided into two categories; battle casualty (BC) or non-battle injury (NBI). To compare the caseload of the deployed general (trauma) surgeon to caseloads encountered in residency by graduating general surgical residents, we used the electronic admission database of the role MTF NL. These cases were compared with case logs of chief residents (n=15) from the general surgery training program, provided by the national surgical committee in the Netherlands from graduation years 2010 to 2013. Statistical analyses were performed through a computerized software package, using SPSS (Version 20, IBM Corporation, Armonk, New York). The categorical variables were analysed by their absolute and relative frequencies in percentages.

RESULTS

The role 2 MTF NL admission database query in the studied period between August 2006 and August 2010, resulted in 2,736 casualties, of which 60% (1,635/2,736) were classified as disease non-battle casualties and 40% (1,101/2,736) as battle casualties. During the study period 1,427 casualties (24% [336/1,427] pediatric cases), required 2,319 surgical procedures. Sixty six per cent (1,523/2,319) of the surgical procedures were performed on casualties with battle injuries and 34% (796/2,319) on casualties with disease non-battle injuries. In the battle casualty group 80 cases were unknown and 202 required no surgical procedure. In the non-battle casualty group 182 cases were unknown and 845 required no surgical procedure. The breakdown of procedures by anatomical location, was 32% (736/2,319) extremities, 19% (430/2,319) chest-abdomen, 7% (170/2,319) head & neck and 42% (983/2,319) general surgery or debridement on any anatomical location. The full spectrum of surgery as described in table (Table 1) was present. The second and third column displays the percentage of overall surgical procedures in the deployed setting by battle or non-battle injury, and the right column displays mean number of cases completed per resident during the course of their general surgical training in elective and emergency setting (PPR, procedures per resident). The most common surgical procedures performed (by any specialty) were irrigation and debridement of wounds (40%), followed by skeletal fixation (17%) and (exploratory) laparotomy (14%). Graduating chief residents did an average of 1,444 cases during their residency (range 1,188 to 1,682). Residents did an average of 165 laparotomies (mostly in elective setting), 19 major vessel repairs, 28 amputations, and a large number of fracture stabilisation (153 PPR). Residents had limited exposure to injuries requiring a thoracotomy, craniotomy, nephrectomy, IVC repair, external genital trauma and pediatric surgery.

Procedures performed	BC No (%)	NBC No (%)	Total	PPR
Head/neck	131 (8.6)	39 (4.9)	170 (7.3)	19
Thoracotomy	20 (1.3)	2 (0.3)	22 (0.9)	NR
Chest drain	53 (3.5)	8 (1.0)	61 (2.6)	NR
DC laparotomy	121 (7.9)	4 (0.5)	125 (5.4)	165[c]
Laparotomy	69 (4.5)	113 (14.2)	182 (7.8)	[c]
Genitals	11 (0.7)	29 (3.6)	40 (1.7)	7
Major amputation	61 (4.0)	20 (2.5)	81 (3.5)	28[d]
Minor amputation finger/toe	37 (2.4)	8 (1.0)	45 (1.9)	[d]
Large arterial vessel	19 (1.2)	2 (0.3)	21 (0.9)	19
Extremity ORIF	46 (3.0)	115 (14.4)	161 (6.9)	153[e]
External fixation	113 (7.4)	95 (11.9)	208 (9.0)	[e]
MUA	0 (0)	54 (6.8)	54 (2.3)	2
Fasciotomy/escharotomy	59 (3.9)	2 (0.3)	61 (2.6)	NR
DID	633 (41.6)	187 (23.5)	820 (35.4)	NR
DIS	88 (5.8)	17 (2.1)	105 (4.5)	NR
Reconstruction/SSG	62 (4.1)	51 (6.4)	113 (4.9)	NR
Minor general surgery	0 (0)	50 (6.3)	50 (2.2)	NR
Total Procedures	**1,523 (66)**[a]	**796 (34)**[b]	**2,319 (100)**	

***Table 1:** Surgical procedures at the Dutch role 2 Medical Treatment Facility Uruzgan, Afghanistan.*

DID indicates debridement, irrigation, and dressing; *DIS:* debridement, irrigation, and splinting; *SSG:* split skin graft; *No:* number; *BC:* battle casualty; *NBC:* non battle casualty; *DC:* damage control; *ORIF:* open reduction internal fixation; *MUA:* manipulation under anaesthesia; *NR:* procedure frequency not captured by resident case log database; *PPR:* procedures per resident.

[a] Total procedures on 819 unique battle casualties, [b] Total procedures on 608 unique non battle casualties, [c] Total laparotomies, [d] Total amputations, [e] Total of operative fracture stabilisations.

DISCUSSION

This study compared the surgical workload of deployed military surgeons with cases completed by civilian surgical residents in order to identify a possible curriculum modification for the future military surgeon. Almost 2,500 surgical procedures were performed at the role 2 MTF NL in the study period (2006-2010). Sixty six per cent of the surgical procedures were performed on casualties with battle injuries and 34% on casualties with disease non-battle injuries. Pediatric cases made up 24% of all surgical cases, which is far higher than the 5% pediatric cases reported in combat hospitals in Iraq[20] and the 15% in Afghanistan[5]. Graduating chief residents did an average of almost 1,500 cases during their residency. Laparotomies and fracture stabilisation were the most performed procedures. Although residents are broadly trained, they had limited resident exposure to injuries, requiring a thoracotomy, craniotomy, nephrectomy, IVC repair, external genital trauma and pediatric (trauma) surgery. The sustained high surgical workload noted in this study (role 2 MTF NL) demonstrates that there is little opportunity to have a gradual introduction to military surgery in order to accommodate any on-deployment learning curve. Ramasamy et al.[5] described the problem sharply. Military surgeons practising in an austere environment encounter multiply injured patients with high-energy transfer fragment, projectile and blast wounds that require an assortment of damage control and definitive operative competences unparalleled in standard civilian practice. Therefore Dutch military surgeons need to be properly trained and equipped to treat the complex casualties they can be confronted with during military operations, with special emphasis on blast & penetrating injuries, damage control surgery and triage.

	Mean	Minimum	Maximum	SD
Fractures[a]	8.5	5	10	1.2
Soft tissue surgery[a]	8.2	6	10	0.9
Burn treatment[a]	8.2	7	10	1.2
Gastro intestinal surgery[a]	8.1	7	10	0.9
Pediatrics[a]	7.1	4	10	1.3
Thorax surgery[a]	6.9	4	10	1.6
Vascular surgery[a]	6.7	4	10	1.3
Plastic (reconstructive) surgery	6.5	5	8	0.9
Urology[b]	5.0	1	8	2.0
Neurosurgery[a]	4.5	1	8	2.3
Obstetrics/Gynecology[b]	4.5	1	8	2.4
Ophthalmic[b]	3.7	1	8	2.3
Maxillofacial surgery[b]	3.5	1	7	1.9

Table 2: *Self-perceived medical expertise of the deployed surgeons at the Dutch role 2 Medical Treatment Facility Uruzgan, Afghanistan**

SD indicates standard deviation, scores are expressed on 10 point scale as mean (1=lowest – 10=highest)
[a] key damage control surgery, [b] key adjuvant (damage control surgery) skills.
* submitted survey.

Parker et al.[21] and Willy et al.[6] compiled a core surgical skills list and proposed a training matrix. We used this matrixes for our proposed damage control surgery training matrix (Table 3). When the relative numbers of procedures performed in each surgical discipline are considered, it must be kept in mind that specialised medical teams (e.g. neurosurgery, maxillofacial surgery, urology and ophthalmology) were only stationed in higher echelons. Therefore, the surgical procedures at the role 2 MTF NL were all performed by a general (trauma) surgeon. After initial stabilization some casualties needed transport to higher echelons of care for definitive treatment. Patients not eligible for referral remained hospitalized in the role 2 MTF NL. From a humanitarian point of view (quality of provided care), it can be argued that a surgical team in a role 2 MTF needs to have the capabilities to perform the full spectrum of surgical procedures, beyond damage control surgery. Taking the wide spectrum of injuries in these high combat hospitals into account, we suggest the need for a broadly trained military surgeon. When this is not possible in the current stream of sub-specialisation, a paired surgeon surgical team (a senior and a junior surgeon with a different specialization) could be considered. Hoencamp et al. (submitted survey) described the self-perceived medical expertise of the general (trauma) surgeons at the role 2 MTF NL (Table 2). This illustrated the challenging task of the deployed surgeons and the discrepancies in self-perceived surgical skills and workload. At the time of their deployment most of the Dutch military surgeons were board-certified for more than five years, but only few of them had combat experience. Only few (junior) specialists had the non-formalized opportunity to do dedicated fellowships in South-Africa. The Dutch armed forces should formalize the training to optimally match the required competences of military surgeons and the curriculum of surgical residents.
Deering et al.[22] reported a decline in surgical skills during military operations. Recent Dutch experiences during the anti-piracy missions with low casualty rates and minimal surgical workload illustrate this dilemma. During NATO mission Ocean Shield and European Union mission Atalanta in the Somali Basin, the Gulf of Aden and the Arabic Sea, there was in total one appendicitis and one tendon repair in a period of 6 months (2013). In a 3 month period (2012), at the German role 3 MTF in Kunduz, Afghanistan, 27 surgical procedures were performed with 90% being NBI orthopedic trauma (personal communication ET). To prevent a decline in surgical skills short deployments should be considered during low-intensity missions with correspondingly reduced surgical workloads, especially for the junior medical specialists. We suggest a staged classification of military surgeons, with a clear differentiation between a senior, junior and trainee medical specialist for different violence spectra. By these means it is possible to match the surgeon to the deployment, with the possibility to upscale or downscale considering the casualty rate, type of injury and workload. Combat operations rarely follow a set pattern; any situation can instantly change, the staged approach does not mean concessions to the required surgical skill set. Tailor-made medical planning should be part of the initial battle planning.

Abdominal and vascular procedures	Thoracic procedures
Aortic cross-clamping during resuscitative laparotomy (thoracic or abdominal)	Thoracic access methods (including rapid emergency thoracotomy)
Simple ligation of any major vessel tear	Closure of penetrating cardiac wounds
Arterial injuries shunted/ligated + fasciotomy/coiling Venous injury ligation or repair Liver laceration packing	Lung haemorrhage control En-masse lobectomy Pulmonary tractotomy
Colonic perforation control	Non-anatomically stapled lung resection
Removal of solid organs (e.g. spleen and kidney) Bladder ruptures catheterized and drained Pancreatic bed leaks multiply drained	En-masse closure of chest wall muscles Repair or drainage of intra-thoracic oesophageal injuries Temporary (patch) closure of thoracic wounds (using an iv fluid bag)
Peritoneal soilage copiously irrigated and contained	Thoracic infection control using early appropriate antibiotics
Abdomen temporarily and/or rapidly closed Visceral compartment syndrome treated with plastic sheet or temporary vacuum packing Abdominal infection control using early appropriate antibiotics	

***Table 3:** A suggested damage control surgical skill set.*

CNS indicates central nervous system

Extremity and pelvic procedures	Head, neck and neurosurgical procedures
Unstable pelvic ring fracture-pelvic binding or external fixation / pelvic packing	Surgical control or major head and neck vessels
Junctional zone bleeding control with urinary catheter tamponade	Drainage of cervical oesophageal injuries
Articular fracture stabilisation with bridging external fixator Rapid amputation decision making and performance Fracture reduction with approximate alignment	Surgical airway management including tracheostomy Intercranial bleeding-emergent haemorrhage control Adequate early exposure via a burr hole technique
Soft tissue damage-rapid primary debridement with physiological alignment	Intracranial haematoma evacuation/limitation of contamination
Contamination minimised by high volume fluid lavage Compartment syndrome prevention-wide area Soft tissue coverage temporary dressings	CNS superficial bone/metal fragment removal CNS infection control using early antibiotic therapy fasciotomy of any compartment
Management of burn patients, escharotomy, mesh-graft	
Primary wound management with vacuum drainage packs Femoral fracture control with rapid unilateral frame external fixation or Donway splint Musculoskeletal infection control using early appropriate antibiotics	

Training solutions and continuing training

Although Hoencamp et al.[1] concluded that the deployed surgical teams functioned well under high physical and mental stress in a combat theatre, further optimization is possible. The recognition of Military surgery as a subspecialty within general (trauma) surgery, with a formal curriculum and education & research program, in the Netherlands should be considered. The contents of such a training program should contain at least: 1. essential basic military training; 2. clearly defined courses: e.g. basic courses (ATLS®, BATLS, EMSB® and MIMMS®), damage control surgery courses (e.g. DSTC®, the Emergency War Surgery Course [EWSC®], the French advance course for deployment surgery [Cours Avancé de Chirurgie en Mission Extérieure, CACHIRMEX] and the UK Definitive Surgical Trauma Skills [DSTS®]), adjuvant courses (e.g. pediatric course, neurosurgical course, obstetric course and PREP course); 3. fellowships; 4. junior specialist deployment; 5. formalized continuing training; 6. surgical team training (Crew Resource Management). Military surgery has been appropriately recognised as a subspecialty within general surgery in the United Kingdom (UK) by the Intercollegiate Surgical Curriculum Project and the Defence Medical Services have continued to fund fellowships to overseas trauma centres for military surgeons in the UK[5]. Willy et al.[6] described the German DUO plus model, which entails a specialization in general surgery plus a second specialization, either visceral surgery or trauma/orthopedic surgery. A collaboration in an international military surgical task group or with a larger NATO coalition partner would fit the Dutch Armed Forces, because apart from the medical point of view, the cost of such an extensive surgical training program may outweigh the benefits of a smaller country. There is a strong analogue with disaster medicine and surgery. Collaboration in composing a training matrix for Disaster and Military medicine could possibly be useful, but beyond the scope of this study. Historically, units of the Dutch Armed Forces work in close cooperation with operational units of several international partners (e.g. US, UK, Canada, Germany, Australia, Singapore, France and Belgium). The level of provided care and positive endorsement of these partners, may indicate the quality of care provided by the Dutch military surgeons. Such a medical cooperation could be a solution for future deployments. The recently discussed NATO curriculum by the Military Surgical Expert Team of the Committee of the Chiefs of Military Medical Services are signs of implementing standardization for the NATO military surgeon[23]. Also, the IDR is planning to present a Dutch surgical training program for military surgeons this year (2014). The obligation of the DSTC® and PREP courses are clear signs that standardization for the Dutch military surgeons is being implemented on the course side of the training matrix. An emergency surgery fellowship in a foreign level 1 trauma center with a significant exposure to penetrating trauma could be a next step in the formation of a future pre-deployment workup program. A standardized international fellowship program could improve the NATO coalition integration of the Dutch medical armed forces. To acquire and improve the skills and competences a residency deployment of 4-6 weeks with a senior colleague could be part of this training program. A downfall is the increase of the deployment rate per military surgeon. The proposed continuing program by Willy et al.[6] would perfectly fit the needs. The general plan is a 3-5 month refresher program every 5 years. If they are to preserve the acquired skills, regular practice in those disciplines in which they are not routinely engaged as part of their work will be necessary (e.g. a trauma surgeon will be required to receive training in the disciplines of thoracic, visceral and vascular surgery). To enhance experience with rare injuries live tissue training, cadaver dissections and computer simulations could serve as training tools before deployment[11].

There are certain limitations to our study. First, due to initially missing information there was a relatively long delay in reporting these statistics. Incomplete or missing medical charts may have led to an under-estimation of the performed surgical procedures. Also surgical procedures were often undefined in both the procedures performed at the role 2 MTF NL and in the resident case logs. Some specific areas of resident experience could not be assessed due to limitation of the resident case log, which fails to capture resident experience with specific injuries (or differentiation between trauma and non-trauma). Secondly, only 15 residents were assessed from civilian surgical training in the Netherlands. Additional (personal) follow up training could not be scored. Thirdly, it was not possible to assess objectively the quality of the provided care in respect to clinical outcome, morbidity and mortality. Last, the severity of injuries could not be scored in a consensus-derived global severity scoring system, such as the Abbreviated Injury Scale[24] or the Injury Severity Score[25.] Coalition partners also reported poor population description of data points and poor consistence of pre-hospital data entered into a digital medical registration system[26]. For this reason the US established in 2004 the Joint Theater Trauma Registry (JTTR) as a standardized system of data collection, designed to encompass all echelons of the Medical Support Organization. Recent experiences in Afghanistan, with Australian and Singaporean participation, go even beyond classical NATO borders.
To improve future international collaboration, the introduction of an international trauma registry could be a proactive option. This study, to our knowledge, represents the only European comparison of surgical cases seen in the current theater of combat operations to cases completed by surgical residents and pre-deployment surgical work up program.

In conclusion, during recent armed conflicts, like Afghanistan, military surgeons treated many casualties. Exposure to pediatric cases was much higher than reported in other combat hospitals in Iraq and in Afghanistan. The findings at the role 2 MTF NL show that the injuries were often severe and the required surgical procedures sometimes highly demanding. In addition the single surgeon surgical teams were exposed to the full surgical spectrum. It could be argued that the current Dutch standard, of deploying a single surgeon, should be reconsidered, especially because of increasing subspecialisation in surgical training. Considerations about individual skillsets, fatigue, stress, reducing operating times, shared decision making and quality of care contribute to the thought of deploying paired surgical teams with complimentary competences. The recognition of military surgery as a subspecialty within general (trauma) surgery, with a formal training curriculum in the Netherlands should be considered. Further research is necessary to evaluate the psychological impact of being the sole surgeon in a MTF and to assess and validate the proposed curriculum. Tailor-made medical planning should be part of the initial battle planning to effectively face the challenges. The current civilian resident training does not foresee in the minimal required competences of a fully trained military surgeon. Standardized courses, exchange/ fellowship programs, the deployment of surgical residents as part of their medical specialist training, staged classification of military surgeons and the introduction of a NATO military (and disaster) surgery standard may attribute to achieve this aim.

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Part 3
Quality of life

Chapter 8. Long-term impact of battle injuries; five year follow-up of injured Dutch servicemen in Afghanistan 2006-2010

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ABSTRACT

Background: Units deployed to armed conflicts are at high risk for exposure to combat events. Many battlefield casualties (BCs) have been reported in the recent deployment to Afghanistan. The long-term impact of these combat injuries, at their 5 year endpoint, is currently unknown. To date, no systematic inventory has been performed of an identified group of BCs in comparison to non-injured service members from the same operational theatre.

Methods: We conducted an observational cross-sectional cohort study on a selected group of Dutch BCs (n=62) that deployed to Afghanistan (2006-2010), and compared their results to two control groups of non-injured combat groups (battle exposed [n=53], and non-battle exposed [n=73]). Participants rated their impact of trauma exposure (Impact of Events, IES), post deployment reintegration (Post Deployment Reintegration Scale [PDRS]), general symptoms of distress (Symptom Checklist 90 [SCL-90]), as well as their current perceived quality of life (EuroQol-6D [EQ-6D]). Also cost effectiveness (Short From health survey [SF-36]) and care consumption were assessed (Trimbos/iMTA questionnaire).

Findings: Over 90% of BCs were still in active duty. The mean scores of all questionnaires (IES, EQ-6D, SF-36, and SCL-90) of the BC group were significantly higher than in the control groups ($p<0·05$). The PDRS showed a significantly lower ($p<0·05$) outcome in the negative subscales. The mean consumption of care was triple that of both control groups. A lower score on quality of life was related to higher levels of distress and impact of trauma exposure.

Interpretation: This study showed a clear long-term impact on a wide range of scales, that contributes to a reduced quality of life in a group of BCs. Low perceived cost effectiveness matched with high consumption of care in the BC group in comparison to the control groups. These results warrant continuous monitoring of BCs.

BACKGROUND

Military medicine covers a large area of interest, including battlefield related acute medical and surgical interventions, but also the long-term physical and psychological wellbeing of service members. Research in military medicine is essential to enable justification for new doctrines, practices and management guidelines. This field is fueled with balancing design imperatives, calls for operational sustainability, military ethics, and optimizing quality of life (QOL) for the service members in the aftermath of service. Recently, we described the short term outcome and the impact of events on the direct circle around battle casualties (BCs) of service members serving in Task Force Uruzgan (TFU), that deployed as part of the North Atlantic Treaty Organization (NATO) International Security Assistance Force (ISAF) mission in Southern Afghanistan.[1,2] Many studies report on the immediate impact on general health,[3-8] and long-term studies tend to focus solely on mental health impact[9,10] of deployments. To date, no systematic assessment has been performed evaluating the long-term follow-up of an identified group of injured service members in comparison to an equal group of non-injured service members from the same operational theatre. Awareness of and insight into the short and long-term impact of combat injuries can provide opportunities for case orientated health surveillance programs. The aim of this study was to compare the five year follow-up of QOL and health care consumption of injured service members to a comparable group of non-injured service members. Possible associations between type and severity of injury and long-term outcome of the injured service members were explored. We also tried to identify possible points of improvement in post-deployment treatment and re-integration, by identifying the predictive value of combat related factors (injury, deployment effects, danger to life) for QOL.

MATERIALS AND METHODS

Study design and participants

This observational cohort study was conducted among Dutch service members during the period 2006-2010. In these years, 12 brigades (~17,000 service members)[3] were deployed to Multinational Base Tarin Kowt (MBTK) in Southern Afghanistan, in 4-5 month periods, as part of TFU. The participants consisted of 3 groups: (1) service members that were injured in theatre, labeled as BCs, (2) non-injured active combatants from the same combat units (control group 1 [CG1]), and (3) non-injured service members, with a staff function on MBTK (control group 2 [CG2]). Battle casualties were defined as service members being injured as a direct result of hostile action, sustained in combat or sustained going to or coming from a combat mission. The BCs were selected from a general digital admission database of the Ministry of Defense (MOD), where they fitted the criteria 'BC between August 2006 and August 2010'. The following variables were used as injury specific information: mechanism of injury (MOI), anatomical distribution of wounds (AD), and Injury Severity Score (ISS). The control groups were randomly selected by an independent employee from the department of epidemiology of the MOD. The only exclusion criterion in the control groups was sustaining a battle injury. All identified service members were requested to complete an online questionnaire in the last quarter of 2013 (mean ~ five years after deployment). If necessary they received two digital reminders and two reminders by telephone. The participants were divided into five rank groups namely; junior enlisted (E1-E4), senior enlisted (E5-E9), warrant officers (WO1-WO2), junior officers (O1-O3), and senior officers (O4-O10). As socio-demographic characteristics were measured: sex, age, marital status, and educational level.

Assessment

The survey contained 5 domains: (1) the Impact of Event Scale (IES),[11] (2) the Post Deployment Reintegration Scale (PDRS),[12,13] (3) the Symptom Checklist 90 (SCL-90),[14-16] (4) Quality of Life using the EuroQol-6D (EQ-6D),[17] the 36-item Short Form health survey (SF-36),[18] and (5) the modified Trimbos/iMTA questionnaire for Costs associated with Psychiatric Illness (TIC-P).[19] All assessments were self-reported.

The IES[11] consists of a 22-item measurement that assesses traumatic stress. Responses are given on a 5-point scale, scoring 0 (not at all) to 4 (extreme), and render a total score (zero to 88), subdivided in the following subscales: intrusion (INT), avoidance (AVO), and hyper arousal (HAR).[11]

The PDRS[12] contains 36 items, and is a multidimensional measure of post deployment reintegration experiences/attitudes that is designed to reflect a continuum experience of military personnel in several domains (Work negative [WN]; Work positive [WP]; Family negative [FN]; Family positive [FP]; Personal negative [PN], and Personal positive [PP]). Each domain is split into a positive and negative subscale (score 0 – 5). On negative subscales higher scores indicate more negative attitudes, and on positive subscales higher scores indicate more positive attitudes.[13]
The SCL-90,[14-16] containing 90 questions with a 5-point rating scale (ranging from 1 [not at all] to 5 [extreme]), are used to assess physical and psychological symptoms of distress. Outcome scores are divided into nine symptom subscales: anxiety (ANX, range 10-50), agoraphobia (AGO, range 7-35), depression (DEP, range 16-80), somatization (SOM, range 12-60), insufficient thinking and handling (IN, range 9-45), distrust and interpersonal sensitivity (SEN, range 18-90), hostility (HOS, range 6-30), sleeping disorders (SLE, range 3-15), and a rest subscale (REST, range 9-45). The total score (SCL-90-TOT, range 90-450) is calculated by adding the scores of the subscales.
The EQ-6D[17] questionnaire is a concise utility index, designed to measure health-related quality of life and health preferences, using a visual analogue scale. The SF-36[18] is a survey of patient health, and is a measure of health status, commonly used in health economics as a variable in the quality-adjusted life year calculation to determine the cost-effectiveness of a health treatment. The SF-36 consists of eight scaled scores (vitality, physical functioning, bodily pain, general health, physical role functioning, emotional role functioning, social role functioning, and mental health), which are the weighted sums of the questions in their section. Each scale is directly transformed into a 0-100 scale (i.e. zero is maximum disability and 100 is no disability).
For calculating the total direct medical costs, the Trimbos/iMTA questionnaire for Costs associated with Psychiatric Illness (TiC-P)[19] was used. The scale allows to assess general utilization of medical treatment such as the number of contacts with the general practitioner and multiple other care providers (e.g. medical specialist, physical therapist, and psychologist) during the last six months, including stay or treatment in university -, psychiatric - or general hospitals. The costs were estimated using the Dutch guidelines for cost calculations in health care.[20] Reference unit prices from 2006 of the corresponding health care services were applied.[21]

Statistical analysis

In addition to demographics, we used post deployment questionnaires and, only for the BCs, information about the injury (Table 1). Continuously distributed variables were summarized by the mean value and standard deviation (SD). Absolute and relative frequencies were used to describe nominal and ordinal variables. The Kruskall Wallis test was used to identify differences in the questionnaire outcomes between the BC group and both control groups. Relations between quality of life (EQ-6D) and psychological- and physical distress, traumatic stress, and post deployment reintegration, were determined with Pearson's r correlation test. Relations in the BC group between QOL, age and ISS score were also calculated with a Pearson correlation. Due to measurement level, the relations between EQ-6D versus AD (lower & upper extremity, truncal, head & neck, and combined injuries) and rank were determined with univariate regression analyses. Statistical analyses were performed using a computerized software package, SPSS (Version 20, IBM Corporation, Armonk, New York). This study was approved by the MOD and the Institutional Review Board and the Medical Ethics Committee of Leiden University, the Netherlands.

Variables		
Demographics		
All groups		
Age	Sex	Rank
Marital status post deployment	Educational status*	Number of deployments
IES	PDRS	SCL-90
EQ-6D	SF-36	Modified TIC-P
Battle casualties		
Injury date	Mechanism of injury	AD
ISS		

Table 1: Variables analyzed.

AD inidcates anatomical distribution; *ISS:* Injury Severity Score
*Educational status was divided into three groups: low (no formal education, elementary school, lower vocational education or lower general secondary education), middle (middle general secondary education), and high (college or university).

RESULTS

All questionnaires were distributed online. Of the 965 questionnaires that were distributed (Figure 1), 165 were distributed to BCs, 400 to CG1, and 400 to CG2. Respectively, the response rate in the BC group was 38% (62/165, [of this group 53% were repatriates, 48/90], [19% returned to duty [RTD], 14/75]), 13% (53/400) in CG1, and 18% (73/400) in CG2. Almost eighty percent (149/187) of the participants was aged between 20 and 40. Ninety percent of the BCs was still in active duty, 92% of CG1, and 88% of CG2. The mean number of deployments of the participants was 3 (range 1-8). Demographics of the BC group closely matched composition of CG1. Respondents in CG2 were significantly older and higher educated than in the first two groups (see Table 2).

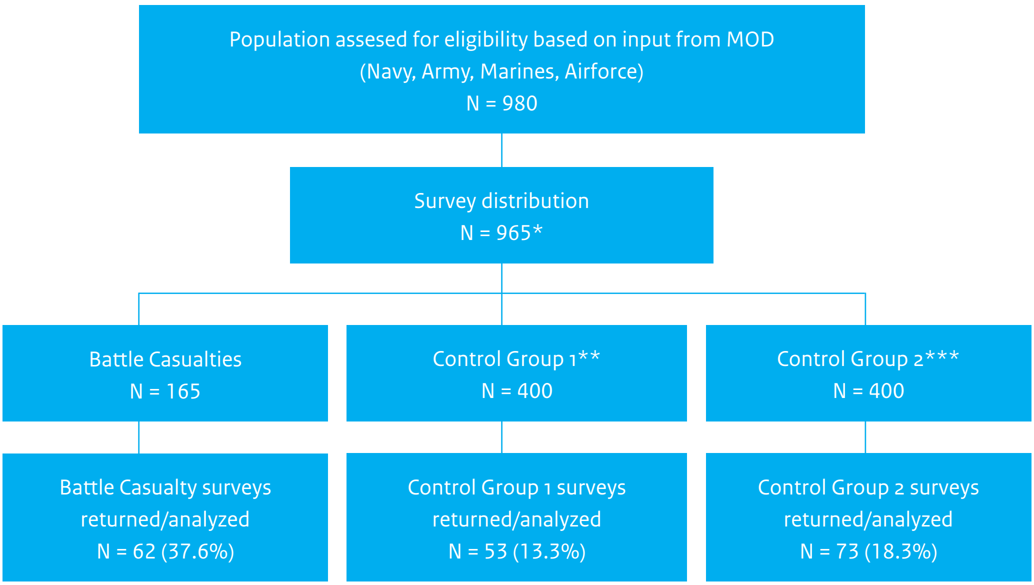

***Figure 1:** CONSORT diagram for questionnaire Dutch battle casualties and control group deployed to Southern Afghanistan.*

MOD indicates Ministry of Defense; N: number.
*The correct contact information of N=15 BCs was not traceable. **Control group 1: non injured active combatants.
***Control group 2: non injured staff or logistic service members.

The MOI was in 96·7% (60/62) explosions (80·6% [50/62] IEDs) and in 2·3% (2/62) small arms fire. The AD was as follows: 30·6% (19/62) lower extremity, 4·8% (3/62) upper extremity, 9·7% (6/62) truncal, 9·7% (6/62) head & neck, and 45·1% (28/62) combined injuries. The mean ISS was 10·4 (SD 9·8). In the sub-analysis within the BC group, there were no significant correlations between the QOL and the continuous variables ISS (r -·19; p=0·20) and age (r -·27; p=0·06), using the Pearson's test. Univariate regression turned out that rank (p=0·004) was positively associated with QOL, where MOI (p=0·20) and AD (p=0·10) were not. The care consumption in the subgroup of lower extremity injuries (single and combined) was significantly higher (p=0·03) compared to the other combat injuries. There was no significant relation (p=0·18) with QOL and care consumption.
The mean IES scores were respectively in the BC group 15·9 (SD 18·8), CG1 5·1 (SD 9·6), and CG2 3·7 (SD 7·1). Significant differences (p<0·05) between the three groups were found on the IES as well as the PDRS. This was also true for assessment of the subscales (intrusion, avoidance, and hyper arousal) (p<0·05). The PDRS also showed a significant different outcome (p<0·05) in all negative subscales, when comparing the 3 subgroups (Table 3).
The mean overall SCL-90 scores were respectively in the BC group 135·5 (SD 46·7), CG1 107·4 (SD 22·2) and CG2 107·3 (SD 25·6). The mean SCL-90 of the BC-group was significantly higher (p<0·05) than in the control groups. All SCL subscales were significantly different (p<0·05) between the BCs and the two control groups.
There were also significant differences (p<0·05) between the three groups using the EQ-6D; the mean EQ QOL scores were respectively in the BC group 77·9 (SD 17·2), CG1 86·7 (SD 12·8), and CG 2 86·0 (SD 11·7). Also on SF-36, there were significant differences (p<0·05) between the three groups in all subscales.
Significant differences (p<0·05) were also found in direct medical costs consumed over the last six months between the three groups using the modified TIC-P. Mean costs of direct medical care were respectively in the BC group € 487 (SD 1154), CG1 € 162 (SD 197), and CG2 € 166 (SD 329). The mean scores (all significantly different) of the IES, SCL-90, EQ-6D and TIC-P are presented in Figure 2.
The results of the Pearson correlation are described in Table 4, in which we analyzed the overall group and the 3 subgroups. The quality of life (EQ-6D) was negatively associated with the total scores of SCL-90 (r -·62;p<0·05) and IES (r -·48; p<0·05). A lower score on QOL was related to higher levels of distress and traumatic stress. Associations for the negative subscales of PDRS pointed out that higher QOL scores were associated with less negative attitudes on the scales WN, FN, and PN (WN= r -·18 p<0·05; FN= r -·39 p<0·05; PN= r -·23 p<0·05).

Characteristic during deployment	BC N=62	CG_1 N=53	CG_2 N=73
Age, mean (range)	25·6 (18-49)	28·1 (19-49)	37·2 (19-58)
Sex (%)			
Male	61 (98·4)	50 (94·3)	65 (89·0)
Female	1 (1·6)	3 (5·7)	8 (11·0)
Marital Status (%)			
Married/ Registered partner	20 (32·3)	27 (50·9)	43 (58·9)
Relationship	28 (45·2)	17 (32·1)	9 (12·3)
Single	14 (22·6)	9 (17·0)	21 (28·8)
Divorced	0	1 (0·2)	3 (0·4)
Widow	0	0	1 (0·1)
Active duty (%)	56 (90·3)	49 (92·4)	64 (87·7)
Rank (%)			
E1-E4	43 (69·4)	23 (4·3)	10 (13·7)
E5-E9 12	(19·0)	16 (3·0)	23 (31·5)
WO1-WO3	1 (1·6)	1 (0·2)	7 (9·6)
O1-O3	6 (9·5)	12 (2·3)	22 (30·1)
O4-O10	0	1 (0·2)	11 (15·1)
Number of deployments, mean (range)	2·5 (1-7)	2·8 (1-7)	2·9 (1-8)
Educational status (%)			
Low	1 (1·6)	1 (0·2)	4 (5·5)
Middle	58 (92·1)	43 (81·1)	44 (60·3)
High	3 (4·8)	9 (17·0)	25 (34·2)

***Table 2:** Demographics of battle casualties and both control groups.*

BC indicates battle casualty; *CG1:* control group 1; *CG2:* control group 2; *N:* number; *E1-E4:* junior enlisted; *E5-E9:* senior enlisted; *WO1–WO3:* warrant officers; *O1–O3:* junior officers; *O4–O10:* senior officers.

Variable Mean (SD)	**BC N=62**	**CG_1 N=53**	**CG_2 N=73**	**P value**
IES*	15·9 (18·8)	5·1 (9·6)	3·7 (7·1)	<0·0001ϕ
INT	6·4 (7·6)	2·5 (4·1)	1·6 (3·2)	<0·0001ϕ
AVO	4·0 (5·9)	1·5 (3·7)	0·9 (2·0)	<0·0001ϕ
HAR	5·5 (6·6)	1·1 (2·5)	1·2 (2·3)	<0·0001ϕ
PDRS**				
WP	3·7 (0·6)	3·5 (0·7)	3·5 (0·8)	0·36
WN	2·8 (1·1)	2·4 (1·1)	2·1 (0·8)	0·001ϕ
FP	3·1 (0·9)	3·0 (0·8)	3·0 (0·9)	0·95
FN	2·3 (0·9)	2·0 (0·8)	1·8 (0·8)	0·003ϕ
PP	3·3 (0·8)	3·0 (1·0)	3·2 (0·9)	0·43
PN	2·4 (1·0)	1·9 (0·9)	1·8 (0·7)	0·001ϕ
SCL-90***	135·5 (46·7)	107·4 (22.2)	107·3 (25·6)	<0·0001ϕ
ANX	14·5 (5·8)	11·2 (2.0)	11·6 (3·9)	<0·0001ϕ
AGO	9·0 (3·3)	7·5 (1.1)	7·6 (1·4)	<0·023ϕ
DEP	23·4 (8·4)	19·2 (4.7)	19·5 (6·9)	<0·005ϕ
SOM	19·1 (7·6)	14·9 (4.8)	14·6 (3·3)	<0·0001ϕ
IN	16·6 (7·1)	11·7 (3.8)	11·2 (3·2)	<0·0001ϕ
SEN	25·2 (8·4)	21·6 (5.4)	21·7 (6·0)	0·005ϕ
HOS	9·6 (4·6)	7·2 (1.7)	7·0 (1·5)	0·001ϕ
SLE	5·6 (3·0)	3·8 (1.3)	4·2 (1·9)	0·002ϕ
REST	12·4 (4·2)	10·3 (2.4)	10·0 (1·9)	<0·0001ϕ

Variable Mean (SD)	BC N=62	CG_1 N=53	CG_2 N=73	P value
EQ-6D	77·6 (17·2)	86·7 (12·8)	86·0 (11·7)	0·002ϕ
SF-36****				
PF	78·6 (22·6)	97·4 (7·9)	93·6 (15·2)	<0·0001ϕ
SF	79·7 (21·0)	93·4 (15·2)	91·2 (16·5)	<0·0001ϕ
RP	69·6 (41·9)	93·4 (19·0)	92·8 (20·1)	<0·0001ϕ
RE	73·2 (40·0)	86·8 (30·9)	92·8 (19·7)	0·004ϕ
MH	72·4 (18·3)	83·0 (13·7)	82·1·7 (14·4)	0·003ϕ
VT	61·9 (19·7)	75·7 (16·8)	72·7 (17·1)	0·001ϕ
BP	74·1 (24·7)	90·8 (13·5)	89·3 (14·9)	<0·0001ϕ
GP	67·4 (19·0)	77·0 (17·0)	74·8 (17·6)	0·02ϕ
TIC-P*****	486·8 (1153·5)	162·9 (197·3)	166·1 (328·8)	0·02ϕ

***Table 3:** Scores of IES, PDRS, SCL-90, EQ-6D and TIC-P per subgroup.*

BC indicates battle casualty; *CG1:* control group 1; *CG2:* control group 2; *SD:* standard deviation; *N*=number
ϕ significant difference (p<0.05) using the Kruskall Wallis test. *Subscales IES; *INT:* intrusion; *AVO:* avoidance; *HAR:* hyper arousal. **Subscales PDRS; *WP:* Work positive; *WN:* Work negative; *FP:* Family positive; *FN:* Family negative; *PP:* Personal positive; *PN:* Personal negative. ***Subscales SCL-90; ANX: anxiety; *AGO:* agoraphobia; *DEP:* depression; *SOM:* somatization; *IN:* insufficient thinking and handling; *SEN:* distrust and interpersonal sensitivity; *HOS:* hostility; *SLE:* sleeping disorders; *REST:* rest subscale. ****Subscales SF-36; PF: Physical functioning; *SF:* Social functioning; *RP:* Role physical; *RE:* Role emotional; *MH:* Mental health; *VT:* Vitality; *BP:* Bodily pain; *GH:* General Health.
***** Costs in euros.

Variable Correlation (r)	Overall N=188	BC N=62	CG_1 N=53	CG_2 N=73
IES*	-·48ϕ	-·56ϕ	-·38ϕ	-·13
INT	-·41ϕ	-·45ϕ	-·39ϕ	-·10
AVO	-·46ϕ	-·55ϕ	-·36ϕ	-·12
HAR	-·48ϕ	-·57ϕ	-·30ϕ	-·15
PDRS**				
WP	·19ϕ	·50ϕ	·02	·19
WN	-·18ϕ	-·11	-·07	-·20
FP	·06	·22	-·06	·01
FN	-·39ϕ	-·38ϕ	-·25	-·40ϕ
PP	-·02	·19	-·24	·03
PN	-·23ϕ	-·16	-·13	-·22
SCL-90	-·62ϕ	-·62ϕ	-·60ϕ	-·53ϕ
SF-36***				
PF	·41ϕ	·28ϕ	·44ϕ	·41ϕ
SF	·59ϕ	·51ϕ	·51ϕ	·66ϕ
RP	·47ϕ	·43ϕ	·48ϕ	·37ϕ
RE	·55ϕ	·63ϕ	·53ϕ	·28ϕ
MH	·55ϕ	·54ϕ	·51ϕ	·48ϕ
VT	·60ϕ	·55ϕ	·64ϕ	·53ϕ
BP	·51ϕ	·56ϕ	·30ϕ	·39ϕ
GH	·60ϕ	·52ϕ	·66ϕ	·59ϕ

***Table 4:** Overall and subgroup relations between quality of life, distress, traumatic stress, and post deployment reintegration.*

BC indicates battle casualty; *CG1:* control group 1; *CG2:* control group 2; *N:* number.
ϕ significant difference ($p < 0.05$) using the Pearson's r correlation test. *Subscales IES-R; *INT:* intrusion; *AVO:* avoidance; *HAR:* hyper arousal. **Subscales PDRS; *WP:* Work positive; *WN:* Work negative; *FP:* Family positive; *FN:* Family negative; *PP:* Personal positive; *PN:* Personal negative. ***Subscales SF-36; *PF:* Physical functioning; *SF:* Social functioning; *RP:* Role physical; *RE:* Role emotional; *MH:* Mental health; *VT:* Vitality; *BP:* Bodily pain; *GH:* General Health.

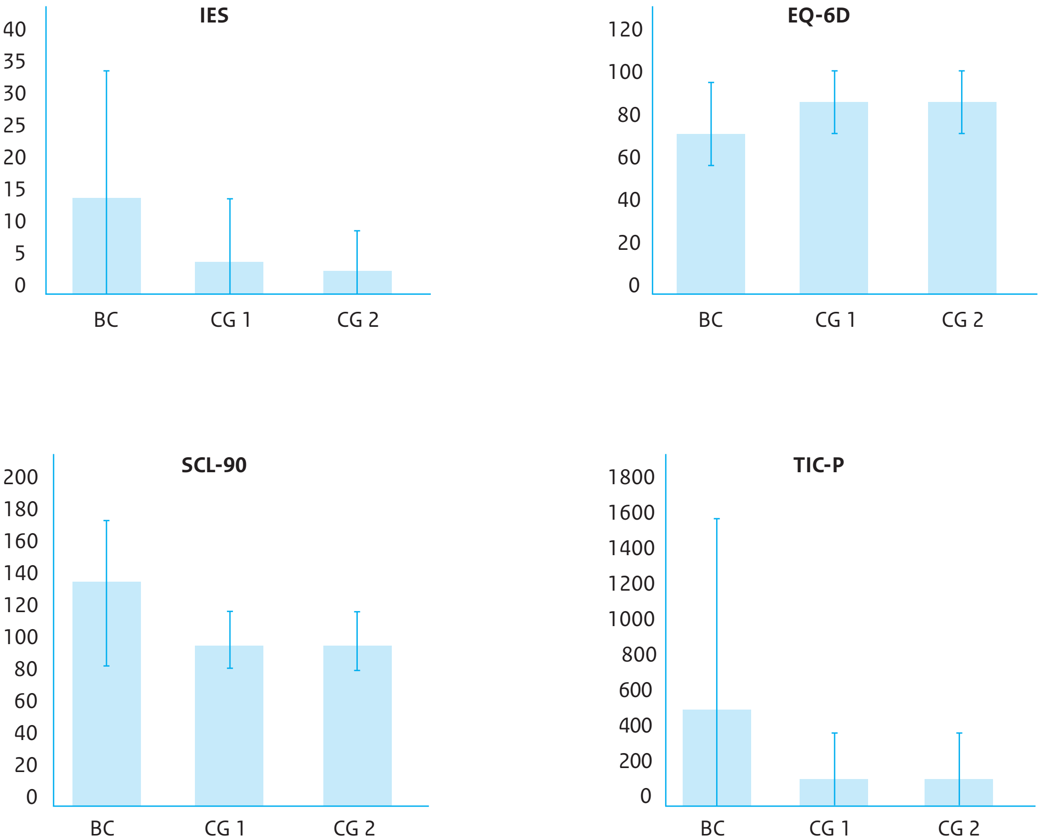

***Figure 2:** Schematic overview of mean scores of the IES SCL-90, EQ-6D and TIC-P per subgroup.*

BC indicates battle casualty; CG1: control group 1; CG2: control group 2. There was a significant difference ($p<0{\cdot}05$) using the Kruskall Wallis test in all 4 questionnaires in the 3 subgroups.

DISCUSSION

This study represents the first systematic cross-sectional survey using structured questionnaires to evaluate the long-term follow-up of (Dutch) battle casualties. Ninety percent of BCs reported to be still on active duty. The QOL of BCs showed a clear marked reduction at the five year follow-up, and traumatic stress levels differed significantly across the BC group compared with the control groups. The distress levels were significantly higher, and care consumption was three times higher in the BC group compared to the control groups. Correlational analysis showed that QOL was negatively associated with the total scores of SCL-90 and IES. A lower score on QOL was related to a worse outcome on distress, traumatic stress, and post deployment reintegration. The association of traumatic stress and distress levels with QOL provides an opportunity and advocates for continued interventions to manage these elevated stress levels, in order to further improve the QOL. Interestingly, long-term outcomes in the BC group were not associated with mechanism or type of injury. There was a significant relation in the BC group regarding rank and QOL. This relation was not significant for AD, ISS, and age (borderline non-significance). In our study, the lower ranked reported higher levels of distress, which may be related to higher exposure to combat stress. Focus on stress coping behavior in these groups may improve their QOL. Scott and colleagues[22] concluded that the most influential factors contributing to a patient's QOL depended on a patient's demographic status, socioeconomic background, and mental health. This is in line with our earlier studies in which we identified the possible protective effects of team bonding and social support network in stress coping behavior.[2] The association of lower QOL and SCL-90/IES scores could be explained by on-going effects of the initial impact (e.g. uncertainty about future, ongoing rehabilitation, and surgical treatment) after sustaining combat injury. The costs of direct medical care over the last six months, five years after sustaining combat injuries, were three times higher in the BCs compared to the control groups. Also, care consumption in the subgroup of lower extremity injuries (single and combined) was significantly higher. Including the costs of the first four years would, very likely, drastically increase the costs in the BC group. It sounds quite intuitive that combat injuries are a predictor for a lower QOL, and that assessment of the repatriated BCs, without the RTD BCs, might suggest that certain types of injury (e.g. extremity injuries) would score worse. However, when we focus on the repatriated BCs this could likely lead to eye-catching results, but with the introduction of bias.[8] In future research it could be helpful to construct one 'sum score' for the five used questionnaires to assess the correlation of QOL with demographics (age, rank, ISS, and AD). The majority of service members transition from an armed conflict to regular life in a seamless manner, but some struggle to find their place when leaving a highly violent theatre.[23] This study tried to outline areas of anticipated difficulty in the reintegration process, in order to alert (mental) health care providers to specific areas that could be problematic in treatment of BCs. Building on the influential factors of other studies,[22,23] early identification in combination with active unit involvement and proper family rehabilitation may sustain the QOL of a BC. Other research has shown that the most important supporting factor after sustaining a battle injury seems to be peer mentoring and easy access to professional help for the injured service members and their direct social support network. Identifying predisposing factors, such as severity and type of injury, in combination with effective, low impact screening tools,[23-25] could be effective as early warning system for extra mental support. In addition to early interventions in the first months after sustaining their battle injuries, we

should also aim for long-term availability of support mechanisms. Our NATO coalition partners describe the same challenges;[26-28] cross-pollination seems a good opportunity to collectively improve our aftercare programs.
One of the limitations of this study is its observational character, and although associations between study variables and outcomes were determined, these associations should not be misconstrued as a cause-and-effect relationship. Also, there are some potential confounding variables that must be acknowledged. Secondly, this is a single time point retrospective study, where ideally we would have performed multiple time point assessments to assess trajectory development of the present outcomes through time. Thirdly, the questionnaires and cut off values used are only tools, and might have resulted in under- or overestimation of the (post) deployment impact. Fourthly, the relatively low numbers could be reason for limited significant outcome in regression analysis in the BC group. Semi structured interviews could be a good instrument to exploit the BC group in depth. Self-perceived aftercare requirements per subgroup of BCs might be helpful in developing a tailor made recovery program. Interestingly, the relatively low response rate (~20%) in the RTD BCs, and the responses and interactions during our visits to the Dutch wounded service members institutions,[29,30] could indicate that many RTD BCs do not identify themselves as a BC. This is potentially fueled by the fact that most of them were not decorated with the wounded soldier cross. Although reports from previous armed conflicts have been published, this study is the first to evaluate long-term patient-based outcomes in BCs in comparison to an equal group of non-injured service members from same the combat zone.

In conclusion, the QOL, the long-term impact of events, and the current distress levels were significantly worse when comparing the BC group with the control groups. Consumption of care was, five years after the injury, still three times higher among the BCs. The results of this analysis are meant to provide novel insight into management and long-term outcomes of BCs. The association of traumatic stress and distress levels with QOL, provides a window of opportunity and advocates for sustained interventions to manage these raised stress levels, in order to further improve the QOL. Future analyses in NATO perspective could help to identify modifiable factors that, hopefully, will improve outcomes among all BCs.

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Chapter 9. Cross-sectional analysis of Dutch repatriated service members from Southern Afghanistan (2003-2014)

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ABSTRACT

Background: A systematic analysis of the complete medical support organization (MSO) of the Dutch Armed Forces regarding repatriated service members from Afghanistan has not been performed so far.

Methods: All information was collated in a specifically designed electronic database and gathered from the archive of the Central Military Hospital for all Dutch service members receiving treatment for wounds or diseases sustained in the Afghan theatre from July 2003 till January 2014.

Results: Traumatic injuries were the main cause (63%, 141/223) of repatriation, and Improvised Explosive Devices the major (67%, 60/89) mechanism of injury in the battle casualty (BC) group. The mean time between injury and medical evacuation from Afghanistan was 8 days, and this was reduced to 3.6 days in case of polytrauma casualties (ISS>15).

Conclusions: Sixty percent of all Dutch medical evacuations from Afghanistan was not directly related to combat operations. The mean time between injury and medical evacuation from Afghanistan is 8 days, which was reduced to 3.6 days in severely injured casualties. Shorter transport intervals might improve morbidity and mortality of casualties, a timeframe of 48-72 hours for receiving definitive treatment seems feasible. Further research is necessary to identify delay factors and possible improvements in the MSO.

BACKGROUND

The Dutch Armed Forces (DAF) participated in three recent missions in Afghanistan; (1) Operation Enduring Freedom 2001-2011 (OEF), deploying ~ 2,000 service members, (2) International Security Assistance Force 2002-2010 (ISAF), including four years (2006-2010) as lead nation in the province of Uruzgan, deploying ~17,000 Dutch service members (as Task Force Uruzgan [TFU]), and (3) European Police training mission 2011-2014 (EUPOL) in Kunduz, deploying ~1,500 service members. The participations in the Afghan armed conflicts were the first broad scale deployments for the DAF resulting in numerous casualties since the Korean war. All injured service members were first treated in the Dutch Role 2 Medical Treatment Facility (Role 2 MTF) or MTF in Kunduz and when required, the casualties were repatriated to the Central Military Hospital (CMH) and University Medical Center Utrecht (UMCU) in Utrecht, the Netherlands. This joint involvement is a good example of civilian and military collaboration (SDC 1). Many studies focusing on Dutch battle casualties (BCs) have been published, but the disease non-battle injuries (DNBIs) have not been covered in these studies.[1-4] These data however are essential for gaining insight into the impact of casualties on the complete medical support organization (MSO). Interestingly, there is also very limited international literature about this subject.[5-7]

A systematic analysis of the complete MSO regarding repatriated service members has not been performed so far. The primary aim of this study is to assess the volume and type of injuries of all repatriated Dutch service members. The ultimate goal is to further optimize the MSO for future military deployments.

METHODS

This study was approved by the Ministry of Defense (MOD), the Institutional Review Board and the Medical Ethics Committee of Leiden University, the Netherlands. A 'casualty' in customary military usage means an active duty service member lost to the theatre of operations for medical reasons. The term therefore includes diseases (illnesses) and non-combat/battle injuries (DNBI), as well as combat injuries. BCs were defined as service members being injured as a direct result of hostile action, sustained in combat or sustained going to or coming from a combat mission.[8] Service members who survived their injury until arrival at a MTF were defined as wounded in action (WIA).

All information was collated in a specifically designed electronic database and gathered from the archive of the CMH for all Dutch service members receiving treatment for wounds or diseases sustained in the Afghan theatre from July 2003 till January 2014.

The casualties were divided into five rank groups namely; junior enlisted (E1-E4), senior enlisted (E5-E9), warrant officers (WO1-WO2), junior officers (O1-O3), and senior officers (O4-O10). Medical evacuations included in the analyses were classified by the causes and natures of the precipitating medical conditions (based on information reported in relevant evacuation and medical encounter records). First, all medical conditions that resulted in evacuations were classified as "battle injuries" or "non-battle injuries and illnesses". Evacuations due to non-battle injuries and illnesses were sub-classified into 13 illness/injury categories based on International Classification of Diseases (ICD-9-CM) diagnostic codes reported on records of medical encounters after evacuation.[9] The categorical variables were analyzed by their absolute and relative frequencies in percentages. The association between two categorical variables was calculated by applying the Pearson χ^2 test. In all cases, $p < 0.05$ was considered statistically significant. The severity of the injuries in this study was scored according to the Abbreviated Injury Scale (AIS)[10] and the Injury Severity Score (ISS)[11], and was expressed in mean and range. Statistical analyses were performed using predictive analysis software, SPSS (Version 20, IBM Corporation, Armonk, New York).

SDC 1: *Central Military Hospital and University Medical Center Utrecht, the Netherlands.*

RESULTS

During the studied period (2003-2014) a total of 223 Dutch service members were repatriated. The vast majority was male (93%, 208/223) with a mean age of 29 years (respectively 25 and 32 years for BCs and DNBIs). Sixty percent (134/223) of all medical evacuations were DNBIs, and these service members were significantly ($p<0.05$) older than the BCs.

The distribution per unit was as follows; 74.9% (167/223) Army, 11.2% (25/223) Navy, 9.4% (21/223) Air force, 2.7% (6/223) Military Police, and 1.8% (4/223) Civilian Police. When examining the distribution of repatriates by rank group, a significant difference ($p<0.05$) was noted between the 54.3% (121/223) junior enlisted, 26.0% (58/223) senior enlisted, 2.2% (5/223) warrant officers, 7.2% (16/223) junior officers, and 7.2% (16/223) senior officers, 1.8% (4/223) civilian police and unknown cases 1.3% (3/223). The distribution of repatriates according to the NATO definitions is shown in Table 1. The difference in age, AIS, ISS, period between incident and arrival CMH, number of surgical procedures and total admission time are presented in Table 2 and 3. In Table 3 the trauma injuries (BC N=89, DNBI N=52) and polytrauma patients (ISS>15) are presented. The intensity of treatment (surgical procedures and total admission time) was significantly higher ($p<0.05$) in the BC group compared to the DNBI group. Twenty one percent (17/80) of the 80 BCs had a blast related tympanic perforation and 18% (14/80) of the BCs had signs of acoustic trauma.

Repatriation

The mean time between injury and medical evacuation from Afghanistan was 8 days, which reduced to 3.6 days in the severely injured group (ISS>15).

Sixty nine percent (153/223) of the patients were repatriated because of a surgical or orthopedic problem (Table 4). The DNBI group was defined conform the ICD-9-CM in Table 5. Sixty three percent (141/223) of the casualties were repatriated because of a traumatic injury (89 BCs and 52 DNBIs). IEDs were the main cause of injury 43% (60/141), as shown in Fig 1. Except for the three casualties repatriated for mental disorders we did not find casualties repatriated because of psychological injury (PI). These three patients were repatriated in 2005 and 2006, the beginning of the Dutch involvement in Afghanistan.

Distribution of repatriates	Frequency	Percentage
BC: WIA STRATEVAC (1 DOW)	89	39.9
DNBI: injuries not related to combat operation	52	23.3
DNBI: medical illness	82	36.8
Total	**223**	**100**

Table 1: Distribution of repatriates according to NATO definitions.

Abbreviations: *BC:* battle casualty; *WIA:* wounded in action; *STRATEVAC:* strategic evacuation; *DOW:* died of wounds; *DNBI:* disease non-battle injury.

Demographics	BC N=89 (range, SD)	DNBI N=134 (range, SD)	Total N=223 (range, SD)	P value
Age	25 (18-49, 6.3)	32 (18-59, 10.7)	29 (18-59, 9.7)	p<0.05
Highest AIS (mean)	1.53[a] (0-4, 1.3)	N/A	N/A	N/A
ISS	11.3 (1-43, 9.5)	N/A	N/A	N/A
Period between incident and arrival CMH (days)	5.5 (0-62, 8.5)	9.8 (1-132, 14.3)	8.0 (0-132, 12.4)	p<0.05
Surgical procedures (N)	4.2 (0-21, 4.6)	0.7 (0-8, 1.3)	2.1 (0-21, 3.4)	p<0.05
Total admission time (days)	19.1 (0-145, 28.5)	3.3 (0-30, 5.5)	9.7 (0-145, 20.1)	p<0.05

Table 2: Demographics of battle casualties and disease non-battle injuries.

Abbreviations: *BC:* battle casualty; *DNBI:* disease non-battle injury; *N:* number; *SD:* standard deviation; *AIS:* abbreviated injury severity score; *ISS:* injury severity score; *N/A:* not applicable; *CMH:* Central Military Hospital, Dutch Role 4.
[a] Region: extremity.

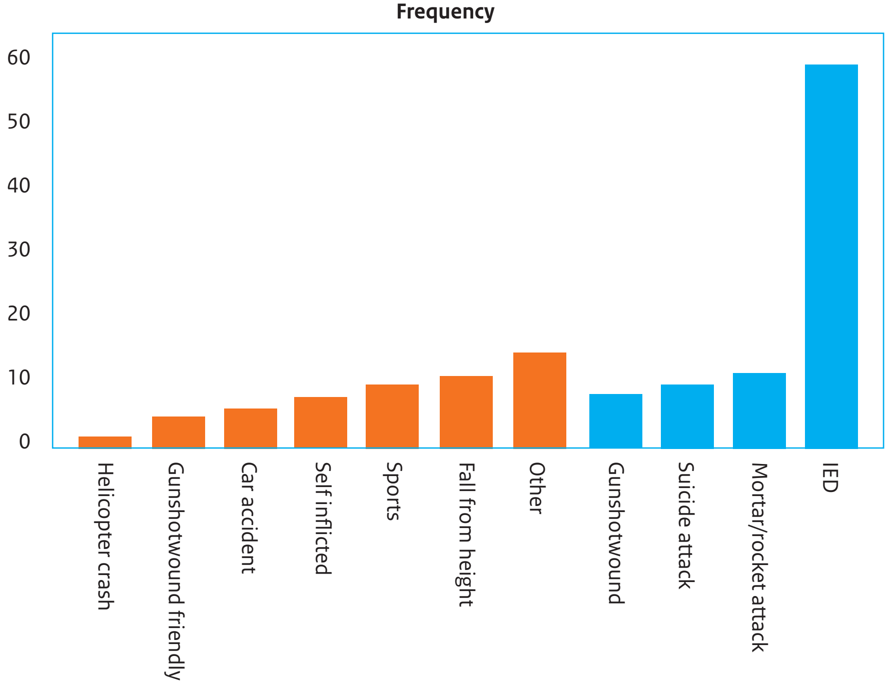

Figure 1: *Cause of injury for the Dutch repatriated casualties.*

Abbreviations: *IED:* improvised explosive device. Left (red) the non-battle injuries, right (blue) the battle injuries.

Demographics	**Trauma injury*** N=141 (range, SD)	**ISS>15** N=26 (range, SD)	**P-value**
Age	26 (18-59, 7.5)	26 (19-59, 8.8)	0.97
Highest AIS (mean)	1.56[a] (0-4, 1.2)	1.77[b] (0-5, 2.0)	0.63
ISS	8.8 (0-43, 8.5)	23.9 (16-43, 7.9)	<0.05
Period between incident and arrival CMH (days)	6.9 (0-62, 9.3)	3.6 (1-10, 2.4)	<0.05
Surgical procedures (N)	3.1 (0-21, 3.9)	6.9 (0-21, 5.7)	<0.05
Total admission time (days)	13.8 (0-145, 24.1)	35.0 (0-145, 38.8)	<0.05

Table 3: *Demographics of trauma injuries and polytrauma patients.*

Abbreviations: *SD:* standard deviation; *ISS:* injury severity score; *N:* number; *AIS:* abbreviated injury severity score; *CMH:* Central Military Hospital, Dutch Role 4.
*Trauma injury group consisted of battle casualties N=89 + injuries not related to combat operation N=52.
[a] Region: extremity; [b] Region: head and neck.

Leading specialism	Frequency	Percentage
Surgery	128	57.4
Internal medicine	17	7.6
Orthopedic surgery	27	12.1
Urology	5	2.2
Plastic surgery	3	1.3
Neurology	16	7.2
Ophthalmology	2	0.9
Cardiology	9	4.0
Psychiatry	3	1.3
Ear, nose and throat	5	2.2
Maxilla facial surgery	2	0.9
Pulmonology	5	2.2
Gynecology	1	0.4
Total	**223**	**100**

Table 4: *Repatriated Dutch service members from Afghanistan in the period 2003-2014 divided by leading specialism.*

Diagnostic category (ICD-9-CM)	Frequency	Percentage
Battle injuries*	89	39.9
Genitourinary system (580-629)	7	3.1
Endocrine, nutrition, immunity (240-279)	1	0.4
Respiratory system (460-519)	6	2.7
Circulatory system (390-459)	10	4.5
Skin and subcutaneous tissue (680-709)	1	0.4
Non-battle injuries (800-999)	52	23.3
Digestive system (520-579)	20	9.0
Nervous system (320-389)	16	7.2
Other (V01-V82)	4	1.8
Infectious and parasitic diseases (001-139)	8	3.6
Mental disorders (290-319)	3	1.3
Musculoskeletal system (710-739)	6	2.7
Total	**223**	**100**

Table 5: *Diagnostic category (ICD-9-CM) for the Dutch repatriated casualties.*

Abbreviations: *ICD-9-CM*: International Classification of Diseases, Ninth Revision, Clinical Modification.
*non specified group of battle injuries

DISCUSSION

This report is the first systematic analysis of all the repatriated casualties in Afghanistan from the DAF. Traumatic injuries were the main cause (63%, 141/223) of repatriation, and IEDs the major (67%, 60/89) mechanism of injury in the BC group. The mean time between injury and medical evacuation from Afghanistan was 8 days, and this reduced to 3.6 days in the polytrauma casualties (ISS>15). Sixty percent of all medical evacuations were DNBIs, and these service members were significantly older than the BCs. In the limited published literature currently available, the percentage DNBIs is even higher (76%-86%).[6,9] The introduction of a standard medical exam/ endurance test in the pre-deployment phase could be useful as screening tool in reduction of the DNBI casualty rate. Our efforts should aim for reduction of preventable repatriation by effective pre-deployment tests. The relatively long interval between injury and arrival in the CMH warrants further assessment. An interval between 3.6 and 8 days seems quite long compared to the generally accepted timeline for definitive care and protocols. Although there are no clearly defined timelines, the NATO Allied Joint Medical Support Doctrine AJP 4.10[12] is the capstone document on which the MSO is based, and this protocol only provides rough outlines. Nessen et al.[13] describes a rough timeframe of 48-72 hours for strategic evacuation to the next level of care and out of the combat theater (role 4 MTF) for definitive surgical care. The shortest timeframe currently is 12 hours from the point of injury to arrival in a role 4 MTF.[13] The polytrauma patients in our study arrived with a mean interval of 3.6 days. The appreciation of time in resuscitation and damage control surgery (DCS) of polytrauma patients is a general value. All our efforts should aim for reduction of transport times in the MSO, shorter transport intervals might improve morbidity and mortality of (Dutch) casualties.

There were clear and valid explanations for these relatively long transport intervals. Several factors should be taken into account, when evaluating the Dutch MSO; (1) the Dutch MSO depends on coalition partners regarding transport of (critical ill) casualties. Organizing transport for the severely injured takes time and might result in delay, (2) planned follow-up operations (second and third look) in Afghanistan. The multinational role 3 MTF at Kandahar Airfield (KAF) was mostly used for these type of surgical procedures before evacuation out of theatre. The multinational character of the personnel at the role 3 MTF at KAF and an extra “stop moment” in the medical evacuation, might have influenced the final outcome (e.g. loss of information, language barriers in transfer of information, and again delay in definitive treatment).[15]

Interestingly, 22% of the patients who were exposed to a blast event were diagnosed having a tympanic perforation. Another 18% had clear signs of acoustic trauma on audiogram. Harrison et al.[14] described comparable results. During our studied period all repatriated service members involved in a blast event were screened by an ear- nose- and throat (ENT) specialist. The high rate of ear trauma after a blast injury illustrates the need for a robust screening program. Further research is necessary to assess the consequences of blast injuries on the long term (e.g. ENT and PI impact).

There are certain limitations to our study. First, the absence of a standardized system of data collection and the inevitable resulting delay in reporting these statistics. Secondly, there were only a few psychological injuries reported in this study. It is not clear whether these PIs were repatriated without registration in the CMH or that deployed service members developed their psychological injuries (e.g. asked for medical assistance) after returning home. According to NATO definitions PIs are battle injuries, not reporting these injuries results in an underestimation of the total amount of battle injuries. Thirdly, retrospective cohort studies are sensitive to bias and battle casualty definitions significantly affect casualty analysis results. Clearly defining the studied population is necessary to make valid comparisons and draw meaningful conclusions.

In conclusion, sixty percent of all Dutch medical evacuations from Afghanistan were not directly related to combat operations, effective pre-deployment tests could be useful in reduction of preventable repatriation. The mean time between injury and medical evacuation from Afghanistan was 8 days, which was reduced to 3.6 days in severely injured casualties. The appreciation of time in resuscitation and DCS of polytrauma patients is a general value, all our effort should aim for reduction of transport times in the MSO. Shorter transport intervals might improve morbidity and mortality of casualties, a timeframe of 48-72 hours for receiving definitive treatment (in a role 4 MTF [out of theatre]) seems feasible. Further research is necessary to identify delay factors and possible improvements in the MSO.

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Discussion

Chapter 10. Summary and future perspective

Summary and future perspective

Between 2006 and 2010 Task Force Uruzgan, as part of the ISAF mission, conducted military operations in a hostile environment. This thesis describes the multifactorial influences of armed conflicts; from the direct consequences for combat casualties, to the impact they have on their comrades, medical personnel and family members.
The aim of this thesis is to evaluate quality of care (QOC) of the Dutch armed forces (DAF) and the quality of life (QOL) of injured Dutch service members. Therefore, the thesis focuses on the incidence and characteristics of battle casualties (BCs) in North Atlantic Treaty Organization (NATO) coalition forces and secondly it compares these international data with the DAF and historical data. It further focuses on (1) QOC in the pre-hospital phase during the armed conflict in Uruzgan, and (2) the initial in-hospital (in-theatre hospitalized) phase. The military surgeon plays a vital role in the initial care of wounded service members and should be ready for this demanding task. Finally, this thesis focuses on the QOL of a BC, divided in (1) the role of social support, (2) outcome, and (3) post deployment reintegration.

In **Chapter 1** the armed conflicts of the last century and the recent conflicts are addressed. It illustrates the important improvements and adaptations in body-armour and personal protective equipment, that resulted in a different anatomical distribution of wounds, and the impact that combat events have on service members. This chapter provides a perspective on combat casualties from Afghanistan. This perspective focuses on the short and long term effects of injuries sustained by service members, but also on the impact of these injuries and their consequences on their comrades and their social network.

Incidence and epidemiology of battle casualties

Part 1 evaluates the incidence and types of battle casualties of NATO coalition forces and compares these international results with the DAF. It provides insight in demographics, offers opportunities to optimize quality of care of BCs, and describes the impact of explosive devices on the DAF.

Chapter 2 is a systematic review evaluating the incidences and characteristics of battle casualties from NATO coalition partners in Iraq and Afghanistan. This review is based on all available cohort studies of battlefield injuries of coalition forces from Iraq and Afghanistan. Eight published articles, encompassing a total of 19,750 battle casualties, were systematically analysed to achieve a summated outcome. These studies were rated on the level of evidence provided, according to criteria of the Centre for Evidence Based Medicine in Oxford. The methodological quality of observational comparative studies was assessed by the modified Newcastle-Ottawa scale. There was heterogeneity between the included studies, with major differences in inclusion and exclusion criteria, introducing bias. The overall distribution in mechanisms of injury was 18% gunshot wounds, 72% explosions and 10% other. The overall anatomical distribution of wounds was head and neck 31%, truncal 27%, extremity 39% and 3% other. The mechanisms of injury and anatomical distribution of wounds observed by NATO coalition partners in Iraq and Afghanistan differ from previous campaigns. Improved explosive devices (IEDs) became the major threat in these armed conflicts. We recommend that a NATO wide registry system should be implemented with a track and follow up system in order to further improve the quality of care and registration of casualties on the battlefield. Further research is necessary to

develop more effective protective equipment and body armour, with special focus for head and neck and extremity protection.

Chapter 3 is the first documented report on wounding patterns and mechanisms of injuries of battle casualties treated at the Dutch role 2 enhanced medical treatment facility (MTF) at Multi-National Base Tarin Kowt, Uruzgan, Afghanistan. A total of 2,736 patients were admitted, of which 60 % (N = 1,635) were classified as 'disease non-battle casualties' and 40 % (N = 1,101) as 'battle casualties'. The battle casualties sustained 1,617 combat wounds, resulting in 1.6 wounds per battle casualty. These injuries were predominately caused by explosions (55 %) and gunshots (35 %). The wounding patterns were as follows: head and neck (21%), thorax (13%), abdomen (14%), upper extremity (20%), and lower extremity (33%). These figures resemble the patterns as recorded by coalition partners, but differ from previous conflicts: a greater proportion of head and neck wounds and a lower proportion of truncal wounds. The pre-hospital phase seems to be the most substantial opportunity to improve outcomes for BCs, with improvements in body armour and life & limb saving medical skills as spear points.

Chapter 4 represents an in-depth analysis of all Dutch battle casualties during our participation in the ISAF mission as lead nation (2006-2010) in Southern Afghanistan. The trauma registry query resulted in 199 Dutch battle casualties. The case fatality rate was 9.5%, the percentage killed in action was 16.5%, and the percentage died of wounds was 1.1%. The wounding patterns were as follows: head and neck (32%), thorax (8%), abdomen (13%), upper extremity (18%) and lower extremity (30%). The mean AIS and ISS were 3 and 11 in the wounded in action group. Explosive devices accounted for almost 85% of the casualties. This study shows roughly the same windows of opportunity as found in chapter 3, but also stresses the need for a prospective registration in a standardized data collection system that encompasses all echelons of the medical support organization. Collaboration of the Dutch armed forces in the US trauma registry (DoDTR) or integration in the Dutch national trauma registry seem good opportunities for achieving this aim.

Quality of Care

Part 2 evaluates (1) the self perceived QOC in the pre-hospital phase during the armed conflict in Uruzgan, and (2) the initial in-theatre hospital phase, with special emphasis on QOC in the pre-hospital phase as experienced by the "direct circle" around BCs and the psychological impact on deployed surgeons and anesthesiologists.

Chapter 5 assesses "the direct circle" around battle casualties. An online survey was conducted amongst medics, nurses, tactical commanders and enablers (n=200) deployed to Southern Afghanistan (2009-2010) in three Marine companies. Eighty seven percent of the eligible Dutch medics, nurses and tactical commanders participated in this survey. Most (14/16) medics and nurses scored their pre-deployment training as sufficient, the overall self-perceived QOC score was above average (7.8). There were no significant differences regarding rank, gender, age and military task using the impact of event scale and post deployment reintegration scale (PDRS). The only exceptions were the work negative, family positive, and personal positive subscales in the PDRS, where there was a significant difference ($p<0.05$) with the Canadian norm values. The post-traumatic stress disorder rate in the deployed Marine companies was low. Further (prospective) research is necessary to identify predisposing, but preventable high stress factors and for composition of a “waterproof” aftercare program (e.g. fully integral TRiM) as initial warning instrument for the need of more specialist (mental) health care.

Chapter 6 extends our evaluation of the medical support organization (MSO). The experiences of Dutch military surgeons and anesthesiologists that deployed to South Afghanistan provided an opportunity to evaluate pre-deployment training and preparation of our military medical specialists. An online survey was conducted amongst all surgeons and anesthesiologists (n=40) that deployed to the role 2 MTF in Uruzgan and / or the role 3 MTF at Kandahar Airfield between February 2006 and November 2010. Most (35/40) participants reported high levels of self-perceived preparedness prior to their deployment. All (40/40) surgeons and anesthesiologists described a positive influence of their deployment on their professional skills and 33/40 described a positive effect on their personal development. Knowledge of maxillofacial, ophthalmic, neurological, urological, gynecological, vascular and thoracic surgery scored below average. Impact on their mental health and social support network was reported as negative by 11/40 participants, 24/40 reported a neutral and 5/40 a positive effect. Eighteen (surgeons 7/22, anesthesiologists 11/18) felt the need to meet an independent professional coach (defined here as peer to peer) to talk about their experiences at some point after deployment, 22/40 did not feel this need at any point in the post-deployment phase. A focused pre-deployment training program to prepare Dutch surgeons and anesthesiologists for combat surgery is currently lacking. These results emphasize the need for a standardized pre-deployment medical training, despite high levels of perceived preparedness. Also, the high mental and psychological impact of their experiences on the deployed surgeons and anesthesiologists warrants further assessment.

Chapter 7 compares the surgical workload at the role 2 MTF with resident surgical training and the surgical exposure during deployment. In the studied period 1,427 casualties (including 336 pediatric cases), required 2,319 surgical procedures. Graduating chief residents did an average of 1,444 cases, including 165 laparotomies, 19 major vessel repairs, 28 amputations, and 153 fracture stabilizations during their residency. Residents had limited exposure to injuries requiring a thoracotomy, craniotomy, nephrectomy, IVC repair and repair of external genital trauma. The injuries treated at the Dutch Role 2 MTF were often severe. Exposure to pediatric cases was much higher than reported in other combat hospitals in Iraq and in Afghanistan.
The current civilian resident training does not provide in the minimally required competences of a military surgeon, because it is not focused on military deployment. In order to prepare specialists for the typical challenges of a military (medical) deployment, a specified program of training is required and a organizational structure should be introduced. The recognition of military surgery as a subspecialty within general (trauma) surgery, with a dedicated training curriculum, in the Netherlands should be considered. The introduction of a North Atlantic Treaty Organization Military and Disaster surgery standard could attribute to achieve this aim.

Quality of life

Part 3 focuses on the QOL of a BC, divided in (1) role of social support, (2) outcome, and (3) post deployment reintegration.

Chapter 8 evaluates the 5-year follow up of Dutch battle casualties. The survey contained 6 main topics: (1) participants general background, (2) the Impact of Event Scale-Revised (IES-R), (3) the Post deployment reintegration scale (PDRS), (4) the Symptom Checklist 90 (SCL-90-R), (5) Quality of Life (QOL) using the EuroQol-6D (EQ-6D) and Short form health survey (SF)-36, and (6) the modified Trimbos questionnaire for Costs associated with Psychiatric Illness (TIC-P). Thirty eight percent of the eligible BCs participated in this survey. The, significantly different ($p<0.05$), mean IES was respectively in the BC group 15.9, CG1 5.1, and CG2 3.7. The PDRS showed a significantly different ($p<0.05$) outcome in the work negative, family negative and personal negative subscale. The mean SCL-90 of the BC group was significantly higher than that in the control groups ($p<0.05$). The mean costs of direct medical consumption was respectively in the BC group € 486.80, CG1 €162.90, and CG 2 €166.10.
The QOL, the impact of events, and the distress levels were significantly different when comparing the BC group with the control groups. Care consumption was three times higher in the BCs. The results of this analysis are meant to provide novel insight into management and long-term outcomes of BCs. The association of traumatic stress and distress levels with QOL, provides an opportunity and advocates for aggressive interventions to manage these raised stress levels, in order to improve the QOL. Future analyses could help to identify modifiable factors that, hopefully, will improve outcomes among all BCs.

In **Chapter 9,** a systematic analysis of the complete MSO of the Dutch Armed Forces regarding repatriated service members from Afghanistan (July 2003-January 2014) was performed. Musculoskeletal injuries were the main cause (63%, 141/223) for repatriation, and IEDs the major (67%, 60/89) mechanism of injury in the BC group. The mean time between injury and arrival in the Netherlands was 8 days, and this was limited to 3.6 days in case of polytrauma casualties (ISS>15). Sixty percent of all medical evacuations were DNBIs, and these service members also were significantly older compared to the BCs. In our opinion the repatriation time frame was relatively long before receiving definitive treatment; 48-72 hours for arrival in a role 4 medical treatment facility (out of theatre) for definitive surgical care seems feasible. Further research is necessary to identify delay factors and possible improvements in the MSO, also the assess the relation between shorter evacuation timeframes and beneficial outcome for a BC.

Conclusions and future directions

This dissertation focuses on recent experiences in armed conflicts. Uruzgan, Afghanistan, saw four years of involvement of the Dutch Armed Forces in fighting insurgents and nation building.
Armed conflicts are part of our history. Triaging and treating wounded service members in the early days of battlefield medical care was primarily aimed at returning them to the frontline. In those days soldiers who were severely wounded had a dismal prognosis. Chances of surviving significant blood loss, penetrating torso trauma and infections were miserably low. However, in history, military medicine induced numerous practical adaptations to existing medical practices and started many innovations. Famous war surgeons like Paré[1] (1510-1590) and Larrey[2] (1766-1842) are remembered for their contributions to military medicine that

found rendition in civilian medical care. The Dutch military physician Mathijsen[3] (1805-1878) is believed to be the inventor of the Plaster of Paris. Armed conflicts are still part of today's world. Conflicts in Iraq and Afghanistan and civil wars like in Libya, Syria, Gaza and Ukraine cause human suffering on a daily basis. War has changed over centuries and wars will continue to change. Therefore, military medicine will continuously have to familiarize itself with new developments. The clouding lines between soldiers and civilians, states and non-states, and the obscuring differences between war and politics have changed the battlefields. Frontlines hardly exist any longer. When looking at numbers (without a robust trauma registry from the earlier armed conflicts), battlefield statistics have changed over the last century. The number of military casualties and the amount of civilian victims, including infants, children and women, are nowadays different (regarding ratio military/ civilian casualties). The predominant mechanisms of injury are still explosions and gunshot wounds. Better personal protective equipment is likely to be an influential factor in the changing patterns of the anatomical distribution of those injuries.

Experiences from these modern time conflicts have enormously contributed to changes in modern civilian (trauma) care. The Joint Trauma System (JTS) Clinical Practice Guidelines found their origin in military medicine[4] and are frequently implemented in customized or adjusted form in civilian protocols. The revival of the tourniquet and the use of so called massive transfusion protocols found their basis on the battlefields of Iraq and Afghanistan[5-7]. As said, military medicine needs to follow conflicts. It needs to adapt effectively to new threats and developments, like the introduction of Improvised Explosive Devices or "dirty" bombs. It needs to adjust its modus operandi constantly and swiftly. And, in recent years, military medicine did adapt, resulting in the lowest case fatality rates ever[8-12]. Military medicine covers a large area of interest, including battlefield related medical and surgical acute interventions, but also the physical and psychological wellbeing of service members during and after their deployment. Preferably there should be scientific evidence for interventions applied and consequently research in military medicine is essential. Detailed analyses can be converted into new doctrines, practices and management guidelines. However, for simple practical reasons like getting a victim's informed consent, it is difficult to do even basic prospective studies, let alone to conduct multicentre, randomised pre-hospital and clinical trials in actual areas of military operations. Many, if not all, published battlefield studies are therefore descriptive and or retrospective in nature. Hence, the obtainable levels of evidence are limited. Yet, if we want to further improve the quality of care for wounded service members, we need to find ways to overcome that gap between military and civilian medicine. Till then, we will have to learn as much as possible from recent experiences in war-zones and introduce these observations in doctrines and training courses. Knowledge of the management of war-zone injuries is also valuable in treating casualties from natural disasters or (terrorist) mass casualty situations[13]. Studying the changing anatomical distributions of war injuries might help in developing lifesaving materials and better protective equipment. To date, only a few prospective battlefield studies[14-16] (with a high level of evidence) have been conducted. The PRISMO study[17] of Eric Vermetten is a fine example of Dutch modern research, and might help us to disentangle factors of relevance in Post-Traumatic Stress Disorder. Attention for team interaction is crucial for this high stress environment. Crew resource management is more and more finding it's place in civilian and military medicine. This effective tool in teamwork should be exploited for maximal profit.

Overall, three themes are dominating this thesis: incidence and epidemiology of BCs, QOC and QOL. These three themes are the foundation for more research in the DAF. Optimizing the treatment of BCs goes beyond the MSO, early active involvement of “buddies”, tactical commanders and family after a combat incident will be beneficial for everyone. A fully integral approach in the DAF is required. Military medicine is a continually evolving process, all efforts should be exerted for optimization. The integration of prospective studies will enhance the quality of lessons learned from each armed conflict. There is a strong analogy with disaster medicine and surgery. Collaboration of disaster and military medicine could possibly be useful. If the results reported in this dissertation could help to improve the quality of the Medical Support Organization, the training of medical and non-medical personnel, and the QOL of all involved by more than one percent, we have achieved our aim.

Many questions remain unanswered and clichés are once again applicable. Two are discussed below.

Civilian medicine is not similar to military medicine

Current civilian resident training does not provide in the minimally required competences of a military surgeon. This gap will only grow due to the ongoing “super “specialization and the loss of the true general surgeon. Not many surgeons will be exposed to, and capable of dealing with, ossal, vascular and truncal injuries. We should anticipate on this development.

There are several possible solutions discussed in this thesis: standardized courses, exchange/ fellowship programs, the deployment of surgical residents as part of their medical specialist training, staged classification of military surgeons, the introduction of a NATO military (and disaster) surgery standard and the recognition of military surgery as a subspecialty within general (trauma) surgery.

The changes in the way armed conflicts are fought, brought us to fourth-generation warfare. In the coming decades the distinction between a war theater and a civilian setting might blur even more, changing into fifth generation of warfare. This implies that new skills and competences should be integrated in military and civilian medicine.

Boots on the ground

Despite the evolving technical capabilities of modern mechanized or automated elements like drones, human “boots on the ground” will likely remain crucial in future armed conflicts. Therefore our efforts to improve the quality of medical care for wounded service members should never cease. The important role of co-combatants and a strong social support network cannot be overemphasized. Their early active involvement in the rehabilitation process will be beneficial for everyone.

As a former troop commander and sportsman, I strongly believe in the power of teamspirit and teamwork. Esprit de Corps and “train as you fight” are more than force multipliers, but a way of life. Recent collective participation of wounded service members in “Mud Masters” and “The Invictus Games” strengthens this assumption. Only as a team will we be able to meet the challenges.

Qua Patet Orbis

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Chapter 11. Summary in Dutch (Nederlandse samenvatting)

Summary in Dutch (Nederlandse samenvatting)

Dit proefschrift richt zich op ervaringen van de Nederlandse krijgsmacht in Uruzgan, Afghanistan gedurende de periode 2006-2010. In het proefschrift worden, onder andere, multifactoriële invloeden rond gevechtsgewonden beschreven: van directe consequenties voor de gevechtsslachtoffers (*Battle Casualties*, BC's) tot en met de impact die deze gebeurtenissen hebben op medestrijders, medisch personeel en familieleden. De focus van dit proefschrift ligt in de eerste plaats op de incidentie en karakteristieken van BC's van de NAVO-coalitiepartners tijdens de missie in Afghanistan. Op de tweede plaats worden deze internationale data vergeleken met die van de Nederlandse krijgsmacht en met historische data. Op de derde plaats wordt de kwaliteit van zorg van de pre-hospitale-fase tijdens het gewapende conflict in Uruzgan beschreven, alsmede de initiële in-hospitale fase (hospitalisatie in het missiegebied). Tot slot, worden de korte en lange termijn effecten van verwondingen opgelopen tijdens gevechtshandelingen en de impact van deze verwondingen op de zgn. buddy's en het sociale netwerk van de gewonde militair beschreven.

Hoofdstuk 1 beschrijft gewapende conflicten uit de vorige eeuw en meer recente conflicten. Dit illustreert de belangrijke verbeteringen en aanpassingen van (voertuig)bepantsering en persoonlijke beschermingsmiddelen. Deze verbeteringen en aanpassingen hebben geresulteerd in een andere (lichaams)verdeling van verwondingen en in de impact die gevechtshandelingen hebben op het defensiepersoneel.

Incidentie en epidemiologie van gevechtsslachtoffers

Deel 1 van het proefschrift evalueert de incidentie en typering van gevechtsgewonden van de NAVO-coalitiepartners, waarna deze internationale resultaten worden vergeleken met de Nederlandse resultaten uit Uruzgan. Dit geeft inzicht in demografie, beschrijft de impact van geïmproviseerde explosieven, de zgn. bermbommen (*Improved Explosive Devices* IED's) en schets mogelijkheden om de kwaliteit van geleverde zorg voor gevechtsslachtoffers te verbeteren.

Hoofdstuk 2 is een systematisch onderzoek dat de incidentie en karakteristieken beschrijft van BC's van NAVO-coalitiepartners in Irak en Afghanistan. Deze review is gebaseerd op alle beschikbare studies over gevechtsverwondingen afkomstig van de NAVO-coalitiepartners tijdens missies in Irak en Afghanistan. Acht gepubliceerde artikelen, welke in totaal 19.750 BC's omvatten, zijn geanalyseerd. Deze studies zijn gewaardeerd op het aangegeven *level of evidence*, dit conform de criteria van het *Centre of Evidence Based Medicine* in Oxford, VK.
De methodologische kwaliteit van deze observationeel vergelijkende studies is vergeleken met de gemodificeerde Newcastle-Ottawa schaal. Er werd heterogeniteit geconstateerd tussen de geïncludeerde studies, met grote verschillen tussen inclusie en exclusie criteria.
De verdeling in letselmechanisme was als volgt: 18% schotwonden, 72% explosieven en 10% overige. De anatomische distributie van verwondingen is: hoofd en nek 31%, romp 27%, extremiteiten 39% en 3% overige. Het letselmechanisme en de anatomische distributie van verwondingen zoals geobserveerd door de NAVO-coalitiepartners is anders dan in voorgaande gevechtscampagnes. Bermbommen waren de

grootste bedreiging tijdens de meest recente gewapende conflicten.
Er wordt een NAVO-breed registratie systeem aangeraden om de registratie van verwondingen te verbeteren tijdens gewapende conflicten. Tevens is er meer onderzoek noodzakelijk om beschermende materialen te ontwikkelen, met extra aandacht voor hoofd en nekletsel.

Hoofdstuk 3 is het eerste rapport over wondpatronen en oorzakelijke mechanismen van verwonding van BC's behandeld in het Role 2 MTF op het Nederlandse Kamp Holland. Totaal werden er 2.736 patiënten opgenomen waarvan 60% (N = 1.635) werd geclassificeerd als *disease non-battle injuries* (DNBI's) en 40% (N = 1.101) als verwonding door gevechtshandelingen ofwel *battle injuries* (BI's). Er waren in totaal 1.617 gevechtsverwondingen, resulterend in 1,6 wonden per BC. De verdeling in letselmechanisme was als volgt: explosies 55% en schotwonden 35%. De anatomische distributie van verwondingen was: hoofd en nek 21%, thorax 13%, abdomen 14%, bovenste extremiteit 20% en onderste extremiteit 33%. Deze getallen zijn vergelijkbaar met resultaten van de NAVO-coalitiepartners tijdens de missie in Afghanistan, maar verschillen van die uit eerdere gewapende conflicten: een groter deel hoofd en nek verwondingen en een afgenomen deel romp verwondingen. De pre-hospitale fase blijkt de belangrijkste fase om de overlevingskans van een gevechtsgewonde te verbeteren.

Hoofdstuk 4 beschrijft een diepgaande analyse van alle Nederlandse gevechtsgewonden tijdens de participatie in de ISAF-missie (2006-2010) in zuidelijk Afghanistan. In totaal waren er 199 Nederlandse BC's. Letaliteit was 9,5% en het percentage gesneuvelden tijdens gevechtsacties (*Killed In Action*, KIA) was 16,5%. Het percentage gesneuvelden als gevolg van verwonding (*Died of Wounds*, DOW) was 1,1%. De anatomische distributie van verwondingen was als volgt: hoofd en nek 32%, thorax 8%, abdomen 13%, bovenste extremiteit 18% en onderste extremiteit 30%. In de groep gewonden tijdens gevechtsacties (*Wounded in Action*, WIA) waren de gemiddelde AIS en ISS 3 respectievelijk 11 (schematische weergave van ernst van de verwondingen). In 85% van de gevallen waren explosieven het letselmechanisme. Een integrale multinationale benadering is noodzakelijk om beschermende materialen te ontwikkelen, met name voor extremiteit-, hoofd- en nekletsel. Een prospectief registratie systeem is noodzakelijk om binnen de gehele militaire medische zorgketen de registratie van verwondingen te verbeteren. Samenwerking met het Amerikaanse registratie systeem (DoDTR) of integratie in het Nederlandse landelijke traumaregistratie systeem zijn hiervoor mogelijke oplossingen.

Kwaliteit van zorg

Deel 2 evalueert de kwaliteit van zorg, ten tijde van het gewapend conflict in Uruzgan, in de pre-hospitale-fase en die in de initiële-hospitale-fase. Er is specifieke aandacht voor kwaliteit van zorg in de pre-hospitale-fase, zoals ervaren door de 'directe cirkel' rond de gevechtsslachtoffers, en voor de psychologische impact van uitzendingen op chirurgen en anesthesisten.

Hoofdstuk 5 evalueert de 'directe cirkel' rond gevechtsgewonden. Door middel van een online vragenlijst is een enquête gehouden onder gewondenverzorgers, verpleegkundigen, tactische commandanten en ondersteunend personeel (N =200). Deze geënquêteerden waren ingezet bij drie compagnieën van het Korps Mariniers in Zuid Afghanistan (2009-2010). Zeven en tachtig procent van de in aanmerking komende gewondenverzorgers, verpleegkundigen en tactisch commandanten deed mee aan dit onderzoek. De

meeste gewondenverzorgers en verpleegkundigen gaven hun training voorafgaand aan de uitzending een voldoende score, de globale zelfwaargenomen kwaliteit van zorg was bovengemiddeld (7,8). Er was geen significant verschil tussen rang, geslacht, leeftijd en militaire taak bij gebruik making van de *impact of event scale* en de *post deployment reintegration scale*, (PDRS). De enige uitzonderingen waren de *work negative*, *family positive* en *personal positive subscales* in de PDRS, waar een significant verschil ($p<0{,}05$) werd gevonden met de Canadese normwaarden. De mate van Post Traumatische Stress Stoornis (PTSS) in de uitgezonden compagnieën van het Korps Mariniers was laag.
Verder (prospectief) onderzoek is noodzakelijk om predisponerende, maar mogelijk vermijdbare, stressfactoren te identificeren. Het blijkt wenselijk te zijn om vanaf het tijdsstip van een gevechtsverwonding een waterdicht nazorgprogramma op te zetten voor de gehele eenheid.

Hoofdstuk 6 evalueert de medisch ondersteunende organisatie (*Medical Support Organization*, MSO). Door middel van een online vragenlijst werd een enquête gehouden onder alle (N = 40) chirurgen en anesthesisten die ingezet zijn in het *Role* 2 MTF in Uruzgan en/of in het *Role* 3 MTF op Vliegbasis Khandahar (KAF) tussen februari 2006 en november 2010. De meeste deelnemers (35/40) rapporteerden een grote mate van gereedheid voor hun uitzending. Alle (40/40) chirurgen en anesthesisten beschreven een positieve invloed van de uitzending op hun professionele vaardigheden, en 33/40 beschreven een positief effect op de eigen persoonlijke ontwikkeling. Kennis van maxillofaciale, opthalmische, neurologische, urologische, gynaecologische, vasculaire en thoracale chirurgie scoorde onder de normwaarde van 7 (schaal 1-10). Bijna 50% van de chirurgen en anesthesisten hadden behoefte aan een onafhankelijke coach om, op enig moment na de uitzending, over hun ervaringen te praten. Een gericht trainingsprogramma voorafgaand aan de uitzending om Nederlandse chirurgen en anesthesiologen voor te bereiden op oorlogschirurgie ontbreekt op dit moment.

Hoofdstuk 7 beschrijft het aantal en de type operaties uitgevoerd in de *Role* 2 MTF en vergelijkt deze met het aantal en de type operaties uitgevoerd door een jonge klare chirurg. In totaal ondergingen 1.427 slachtoffers (inclusief 336 pediatrische casus) 2.319 chirurgische procedures. Jonge klare chirurgen hadden tijdens hun opleiding gemiddeld 1.444 operaties zelfstandig uitgevoerd, inclusief 165 laparotomieën, 19 grote vaatoperaties, 28 amputaties en 153 operatieve fractuur stabilisaties. Jonge klare chirurgen hadden een minimale blootstelling aan verwondingen welke een thoracotomie, craniotomie, nefrectomie of IVC herstel vereisten. Tevens was blootstelling aan kinderslachtoffers vele malen hoger dan werd gerapporteerd in andere militaire ziekenhuizen in Irak en Afghanistan.
De huidige (civiele) opleiding voorziet niet in de minimaal vereiste competenties van een militair chirurg, deze opleiding is niet toegespitst op militaire uitzendingen. De erkenning van militaire chirurgie als subspecialisme van de algemene (trauma) chirurgie in Nederland, met een duidelijk opleidingscurriculum, blijkt wenselijk. De invoering van een NAVO-standaard voor militaire en rampenchirurgie zou kunnen bijdragen dit doel te bereiken.

Kwaliteit van leven

Deel 3 legt de nadruk op de kwaliteit van leven van een BC, onderverdeeld in de rol van het thuisfront, functioneren en re-integratie na uitzending.

Hoofdstuk 8 evalueert vijf jaar *follow up* van Nederlandse gevechtsgewonden. Een online enquête omvatte vijf onderdelen, te weten: de *Impact of Event Scale-Revised* (IES-R), de *Post Deployment Reintegration Scale* (PDRS), de *Symptom Checklist 90* (SCL-90-R), *Quality of Life* (QOL) gebruik makend van de EuroQol-6D (EQ-6D) en *Short form health survey* (SF)-36, en als laatste de *modified Trimbos questionnaire for Costs associated with Psychiatric Illness* (TIC-P). Achtendertig procent van de geïdentificeerde gevechtsgewonden hebben deelgenomen aan de enquête. De significant verschillende ($p<0.05$), IES was respectievelijk in de BC groep 15.9, controle groep 1 (uitgezonden militairen met gevechtsfunctie) 5.1, en controle groep 2 (uitgezonden militairen met functie op het kamp) 3.7. De PDRS toonde een significant verschillende ($p<0.05$) uitkomst in de *work negative, family negative* en *personal negative* subschaal. De totaal score op de SCL-90 in de BC groep was significant hoger dan in de control groepen ($p<0.05$). De medische zorgconsumptie was respectievelijk in the BC groep € 486,80, controle groep 1 € 162,90, en controle groep 2 € 166,10.
De kwaliteit van leven, impact van gebeurtenissen en stresslevels waren significant hoger in de BC groep vergeleken met de controle groepen. Tevens was de zorgconsumptie driemaal hoger in de BC groep. De associatie tussen stresslevels en kwaliteit van leven, vraagt om een adequate vroege aanpak van deze verhoogde stresslevels om de kwaliteit van leven mogelijk te verbeteren. Vervolg onderzoek is noodzakelijk om beïnvloedbare factoren te destilleren, en daarmee hopelijk de uitkomsten voor de gevechtsgewonden te verbeteren.

Hoofdstuk 9 beschrijft de complete medische ondersteuning van de Nederlandse krijgsmacht met betrekking tot de uit Afghanistan gerepatrieerde militairen (juli 2003 tot januari 2014). Verwondingen aan het bewegingsapparaat waren de hoofdreden (63%, 141/223) voor repatriëring en bermbommen waren de belangrijkste oorzaak voor verwondingen (67%, 60/89) in de BC groep. De gemiddelde tijd tussen verwonding en aankomst in Nederland was acht dagen, welke gereduceerd werd naar 3,6 dagen in geval van polytrauma slachtoffers (ISS > 15). Zestig procent van alle medische evacuaties was als gevolg van DNBI's en deze groep repatrianten was significant ouder in vergelijking met de BC groep.
Het leveren van definitieve zorg duurde relatief lang. Een tijdspanne tussen 48-72 uur voor aankomst in een centraal militair hospitaal (*Role* 4 MTF) lijkt haalbaar. Verder onderzoek is noodzakelijk om te evalueren of een kortere afvoertijd ook 'ziektewinst' oplevert bij een BC.

Conclusies

Concluderend, er worden drie hoofdthema's in dit proefschrift besproken: ten eerste incidentie en epidemiologie van BC's, ten tweede de kwaliteit van zorg en ten derde de kwaliteit van leven. Deze drie thema's leggen het fundament voor meer (medisch) onderzoek binnen de Nederlandse krijgsmacht. Optimalisatie van de behandeling van gevechtsgewonden gaat verder dan de medisch ondersteunende organisatie. Vroege betrokkenheid van buddy's, familieleden, medisch personeel en tactisch commandanten is bevorderlijk voor eenieder. Een volledig geïntegreerde aanpak binnen de Defensie organisatie is noodzakelijk. Militaire Geneeskunde is een continu evoluerend proces, waarbij alle mogelijkheden moeten worden aangewend om dit proces te optimaliseren.

De integratie van prospectieve studies zal de kwaliteit van lessons learned van elk gewapend conflict verhogen. Er is een sterke overeenkomst met rampengeneeskunde en rampenchirurgie. Samenwerking van rampengeneeskunde en militaire geneeskunde kan daarom nuttig zijn. Als de resultaten omschreven in dit proefschrift kunnen bijdragen aan de verbetering van de kwaliteit van de medisch ondersteunende organisatie, de opleiding van medisch en niet-medisch personeel en de kwaliteit van leven van alle betrokkenen met meer dan een procent, dan is het doel bereikt.

Ten slotte

Veel vragen blijven onbeantwoord en clichés zijn wederom van toepassing. Twee hiervan worden hieronder bediscussieerd.

Civiele geneeskunde verschilt significant met militaire geneeskunde
De huidige civiele heelkundige opleiding voorziet niet in de benodigde competenties van een militair chirurg. Dit gat zal alleen maar blijven groeien bij voortdurende superspecialisatie. Weinig chirurgen zullen worden blootgesteld aan zowel ossaal als vasculair en thoracale verwondingen. Het is van belang dat we op deze ontwikkelingen anticiperen.

Er zijn meerdere mogelijke oplossingen beschreven in dit proefschrift: gestandaardiseerde cursussen, uitwisselingsprogramma's (o.a. fellowships), uitzending van chirurgen in opleiding (AIOS) naar conflict-gebieden als onderdeel van hun medisch specialistische opleiding, trapsgewijze classificatie van militair chirurgen, de introductie van een NAVO militair (en ramp gerelateerde) chirurgische standaard en de erkenning van militaire chirurgie als subspecialisatie binnen de algemene (trauma) chirurgie.
De veranderde wijze van vijandig optreden heeft een vierde generatie oorlogsvoering gebracht. In de komende decennia zal de scheidslijn tussen het strijdtoneel en de civiele omgeving meer en meer vervagen, wat kan leiden tot de vijfde generatie oorlogsvoering. Dit impliceert dat nieuwe vaardigheden en competenties geïntegreerd dienen te worden in militaire en civiele geneeskunde.

Boots on the ground
Ondanks de evoluerende technische mogelijkheden van moderne gemechaniseerde en geautomatiseerde elementen zoals drones, zullen *boots on the ground* een cruciaal onderdeel blijven vormen in toekomstige gewapende conflicten. Derhalve dienen de inspanningen om de kwaliteit van zorg voor gewond geraakte militairen te verbeteren nooit te stoppen. De rol van mede-combattanten en een sterk ondersteunend sociaal netwerk kan nimmer te veel benadrukt worden. Hun vroege betrokkenheid in het revalidatie proces zal heilzaam zijn voor eenieder.

Als voormalig pelotonscommandant en sportman, geloof ik heilig in de kracht van teamgeest en teamwork. *Esprit de Corps* en *train as you fight* zijn meer dan *force multipliers* en eerder een levenshouding. Recente intiatieven als collectieve deelname door gewonde buddy's aan "Mud Masters" en "The Invictus Games" versterken deze insteek. Alleen als team kunnen wij deze uitdagingen aan.

Qua Patet Orbis
(**Zo wijdt de wereld strekt**)

Appendices

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Curriculum Vitae

The author of this thesis was born on October 13th, 1979 in The Hague. In 1997 he graduated from secondary school at the ATLAS college Rijswijk. Subsequently he was admitted to the Bio-Pharmaceutical Sciences faculty of the University of Leiden. The next year, 1998, he was admitted to medical school at the University of Leiden. After graduation in 2005 he joined the Royal Netherlands Marine Corps, deploying to Afghanistan in 2009-2010. While acting as platoon commander he continued conducting (military) medical research and finalized the first year of Dutch Law at the Open University of the Netherlands.
In July 2010, he started his surgical residency at the “Medisch Centrum Haaglanden” under supervision of Dr. J.C.A. Mol van Otterloo and Dr. S.A.G. Meylaerts. In 2012 he transferred to Leiden University Medical Center (Prof. Dr. J.F. Hamming). Since July 2014 he is back in The Hague to complete his residency, focusing on vascular and trauma surgery. In 2014 he transferred from the Marine Corps to the Royal Netherlands Navy Medical Corps (R).

He was active as a semi-professional soccer player for ADO The Hague. He played for eight years in the first rugby team of the Haagsche Rugby Club and the National Netherlands Rugby team (XV and VII a-side). He is still very active in (technical) diving and all its related medical aspects.
He lives happily in The Hague with his lovely and beautiful wife Fleur and their two wonderful daughters Loyce and Yade.