Author: Hoencamp, Rigo
Title: Task force Uruzgan, Afghanistan 2006-2010 : medical aspects and challenges
Issue Date: 2015-03-31

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.

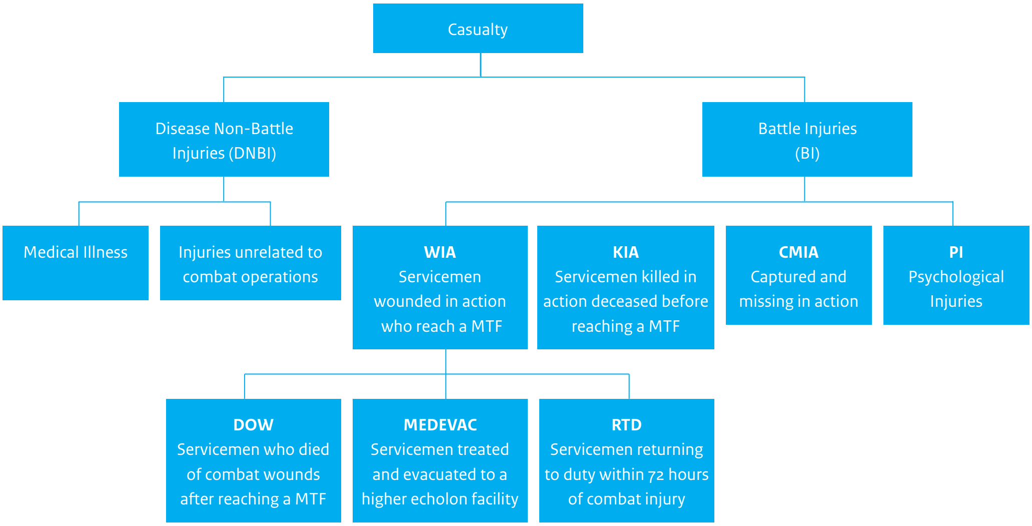

Figure 1: Schematic of military casualty definitions and classifications [6]

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.

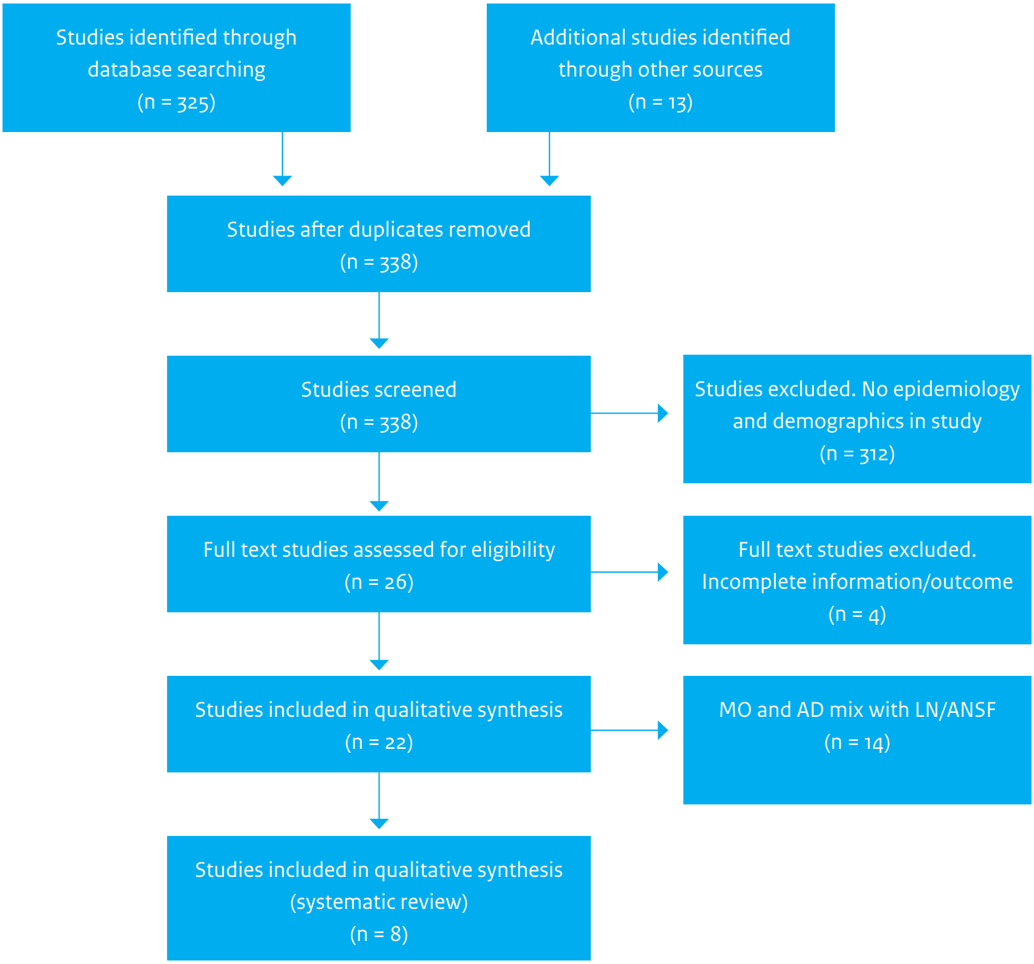

Figure 2: *PRISMA flow chart for the systematic review*

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).

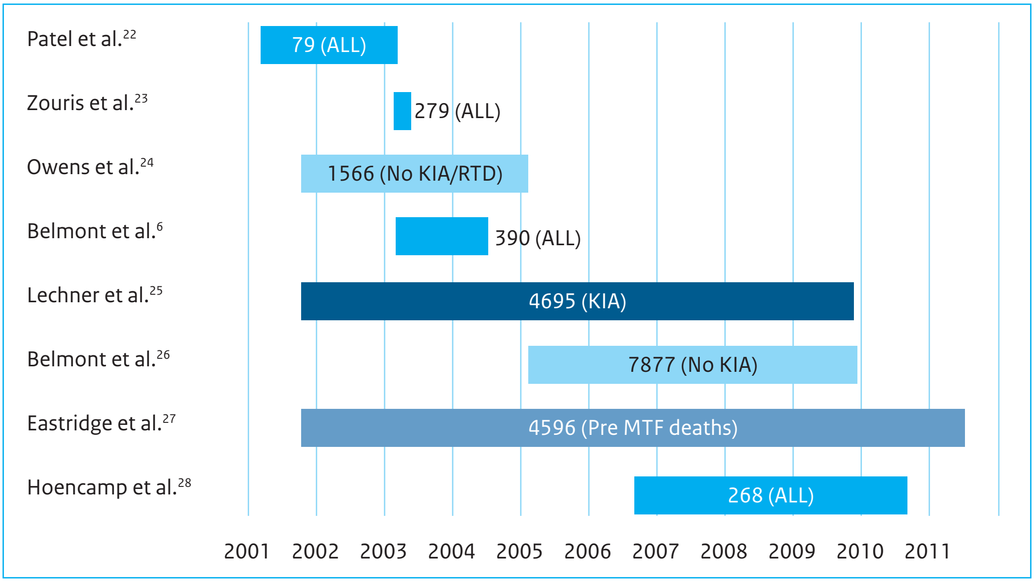

***Figure 3:** Schematic representation of the research period and the battle casualty per study.*

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.

REFERENCES

1. Beekley AC, Watts DM. Combat trauma experience with the United States Army 102nd Forward Surgical Team in Afghanistan. Am J Surg. 2004;187:652-654.
2. Gawande A. Casualties of war--military care for the wounded from Iraq and Afghanistan. N Engl J Med. 2004;351:2471-2475.
3. Therien SP, Nesbitt ME, Duran-Stanton AM, Gerhardt RT. Prehospital medical documentation in the Joint Theater Trauma Registry: a retrospective study. J Trauma. 2011;71:S103-S108.
4. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Int J Surg. 2010; 8:336-341.
5. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA. 2000;19: 2008–2012.
6. Belmont PJ, Goodman GP, Zacchilli M, Posner M, Evans C, Owens BD. Incidence and Epidemiology of Combat Injuries Sustained During "The Surge" Portion of Operation Iraqi Freedom by a US Army Brigade Combat Team. J Trauma. 2010;68:204-210.
7. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp.
8. Beitler AL, Wortmann GW, Hofmann LJ, Goff JM, Jr. Operation Enduring Freedom: the 48th Combat Support Hospital in Afghanistan. Mil Med. 2006;171:189-193.
9. Bilski TR, Baker BC, Grove JR et al. Battlefield casualties treated at Camp Rhino, Afghanistan: lessons learned. J Trauma. 2003;54:814-821.
10. Chambers LW, Rhee P, Balzei- N et al. Initial experience of US Marine Corps forward resuscitative surgical system during Operation Iraqi Freedom. Arch Surg. 2005;140:26-32.
11. Chambers LW, Green DJ, Gillingham BL et al. The experience of the US Marine Corps' Surgical Shock Trauma Platoon with 417 operative combat casualties during a 12 month period of operation Iraqi Freedom. J Trauma. 2006;60:1155-1161.
12. Cho JM, Jatoi I, Alarcon AS, Morton TM, King BT, Hermann JM. Operation Iraqi Freedom: surgical experience of the 212th Mobile Army Surgical Hospital. Mil Med. 2005;170:268-272.
13. Marshall TJ, Jr. Combat casualty care: the Alpha Surgical Company experience during Operation Iraqi Freedom. Mil Med. 2005;170:469-472.
14. Navarro SR, Abadia de Barbara AH, Gutierrez OC, Bartolome CE, Lam DM, Gilsanz RF. Gunshot and improvised explosive casualties: a report from the Spanish Role 2 medical facility in Herat, Afghanistan. Mil Med. 2012;177:326-332.
15. Nessen SC, Cronk DR, Edens J et al. US Army two-surgeon teams operating in remote Afghanistan--an evaluation of split-based Forward Surgical Team operations. J Trauma. 2009;66:S37-S47.
16. Peoples GE, Gerlinger T, Craig R, Burlingame B. Combat casualties in Afghanistan cared for by a single Forward Surgical Team during the initial phases of Operation Enduring Freedom. Mil Med. 2005;170:462-468.
17. Place RJ, Rush RM, Jr., Arrington ED. Forward surgical team (FST) workload in a special operations environment: the 250th FST in Operation ENDURING FREEDOM. Curr Surg. 2003;60:418-422.

18. Shen-Gunther J, Ellison R, Kuhens C, Roach CJ, Jarrard S. Operation Enduring Freedom: trends in combat casualty care by forward surgical teams deployed to Afghanistan. Mil Med. 2011;176:67-78.
19. Walker GJ, Zouris J, Galarneau MF, Dye J. Descriptive summary of patients seen at the surgical companies during Operation Iraqi Freedom-1. Mil Med. 2007;172:1-5.
20. Willy C, Voelker HU, Steinmann R, Engelhardt M. Patterns of injury in a combat environment. Chirurg. 2008;79:66-76.
21. Ramasamy A, Harrisson S, Lasrado I, Stewart MPM. A review of casualties during the Iraqi insurgency 2006 - A British field hospital experience. Injury. 2009;40:493-497.
22. Patel TH, Wenner KA, Price SA, Weber MA, Leveridge A, McAtee SJ. A U.S. Army Forward Surgical Team's experience in Operation Iraqi Freedom. J Trauma. 2004;57:201-207.
23. Zouris JM, Walker GJ, Dye J, Galarneau M. Wounding patterns for U.S. Marines and sailors during Operation Iraqi Freedom, major combat phase. Mil Med. 2006;171:246-252.
24. Owens BD, Kragh JF, Jr., Wenke JC, Macaitis J, Wade CE, Holcomb JB. Combat wounds in operation Iraqi Freedom and operation Enduring Freedom. J Trauma. 2008;64:295-299.
25. Lechner R, Achatz G, Hauer T, Palm HG, Lieber A, Willy C. Patterns and causes of injuries in a contemporary combat environment. Unfallchirurg. 2010;113:106-113.
26. Belmont PJ, Jr., McCriskin BJ, Sieg RN, Burks R, Schoenfeld AJ. Combat wounds in Iraq and Afghanistan from 2005 to 2009. J Trauma. 2012;73:3-12.
27. Eastridge BJ, Mabry RL, Seguin P et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. J. Trauma.2012;73:S431-S437.
28. Hoencamp R, Idenburg FJ, Hamming JF, Tan, ECTH. 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. World J Surg. 2014;38(7):1713-8. DOI:10.1007/s00268-014-2462-x.
29. Bellamy RF, Zajtchuk R. Assessing the effectiveness of conventional weapons. In Zajtchuk R, ed. Textbook of Military Medicine, Part I:Warfare, Weaponry, and the Casualty, Vol. 5, Conventional Warfare: Ballistic, Blast, and Burn Injuries. Washington, DC: Office of the Surgeon General, Department of the Army, United States of America; 1991:53– 82.
30. Beebe GW, DeBakey ME. Death from wounding. In: Battle Casualties. Springfield, IL: Charles C. Thomas; 1952:74 –147.
31. Reister FA. Battle Casualties and Medical Statistics: U.S. Army Experience in the Korean War. Washington, DC: The Surgeon General, Department of the Army; 1973.
32. Hardaway RM. Viet Nam wound analysis. J Trauma. 1978;18:635– 643.
33. United States Army Institute Of Surgical Research: Joint Trauma System. Available at: http://www.usaisr.amedd.army.mil/joint_truama_system.html.
34. Therien SP, Nesbitt ME, Duran-Stanton AM, Gerhardt RT. Prehospital medical documentation in the Joint Theater Trauma Registry: a retrospective study. J Trauma. 2011;71:S103-S108.
35. Champion HR, Bellamy RF, Roberts P et al. A profile of combat injury. J Trauma. 2003;54:S13–S19.
36. The Abbreviated Injury Scale (AIS)–1985 Revision. American Association for Automotive Medicine, Des Plaines, IL 60018.
37. Baker, S.P.; B. O'Neill, W. Haddon Jr., W.B. Long. "The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care". J Trauma. 1974;14:187–196.

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*).