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Comparison of military and civilian burn patients admitted to a single center during 12 years of war

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ABSTRACT

Objective: The current conflicts in Iraq and Afghanistan resulted in an increased incidence of burn injury in the military population. We sought to compare the characteristics and outcomes of this population to a civilian cohort cared for at the same burn center over the same time-period.

Methods: A retrospective review was performed to examine differences in the demographics, etiology, mortality, and functional status over a 12-year period. Descriptive analyses were performed. Logistic regression was used to calculate the likelihood of mortality.

Results: A total of 3814 patients were included in this analysis; 1069 were military casualties. When compared to civilians, military patients were younger, had a higher incidence of flame-induced burn injury, mean total body surface area burned (% TBSA), rate of inhalation injury, and lower mortality. Civilian patients presented with a higher Baux score. Although most military patients had a full functional recovery, they had a greater incidence of severe disability. In a univariate model, likelihood of mortality was higher in civilians. No difference in mortality between the two cohorts was found after adjusting for age, inhalation injury, gender, % TBSA and percent full-thickness burn.

Conclusions: Military patients exhibited improved survival and functional recovery over their civilian counterparts. However, mortality did not differ between civilian and military patients after controlling for known covariates. Further studies are needed to improve functional outcomes in civilian patients, who may not have the inherent advantages of younger age and healthier physical status found in military patients.

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1. Introduction

The current conflicts in Iraq and Afghanistan are the longest wars in the history of the United States, lasting for over 16 years to date. Thermal injury has accounted for up to 10% of combat casualties sustained during these conflicts [1]. Previous studies performed early in the conflict demonstrated a predominance of explosive mechanisms responsible for combat-related burn injuries, frequent non-combat burns [2] and a favorable mortality compared to the Vietnam conflict, which was the

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last time burns were examined in depth in a combat population [3]. The current battle in the Middle East has evolved over nearly two decades that operations have been conducted, to include advancement of explosive devices. Improvised explosive devices (IED), which range from small, homemade weapons that contain shrapnel-producing agents to large modified munitions such as howitzer rounds, have transformed modern warfare. When these devices detonate under a vehicle, an additional mechanism of severe burn injury occurs as the combustion of contents within the vehicle, such as fuel and ammunition, occur and fires within the vehicle often continue to burn for longer periods of time. This results in a different pattern of injury to the service member than those who experience IED explosions away from a vehicle [2].

The U.S. Army Institute of Surgical Research (USAISR), Fort Sam Houston, Texas, is the only Department of Defense (DoD) burn center and has cared for all seriously injured burn casualties from these conflicts who survived evacuation. The USAISR also serves as the burn center for 49 counties in south Texas, covering an area of over 80,000 square miles. Civilian burns in south Texas often include both domestic accidents and occupational injuries from oil and gas extraction, construction, manufacturing, mining, and material processing activities. Serving these 2 distinct populations affords the USAISR the opportunity to compare them with respect to clinically relevant outcomes. A study similar to this was conducted in the first few years of the conflict in the Middle East with the hypothesis that outcomes would be worse in military patients due to the prolonged time and distance of evacuation and associated traumatic injuries. The opposite was found, however, with military patients exhibiting an improved mortality before controlling for older civilian patients; this difference became insignificant when controlling for older patients. This study aimed to conduct a more comprehensive analysis, including patients admitted over a 12 year period, to evaluate whether the evolution of this conflict which included an increase in destructive power through more powerful explosive munitions, would influence the mortality and other meaningful clinical outcomes in the military population. We sought to compare the military cohort to civilians treated over the same period to progress this comparison and determine whether outcomes of a civilian population could be extrapolated to those hurt during combat operations.

2. Materials and methods

After approval from the institutional review board, a retrospective analysis was performed of all adult burn patients admitted to the USAISR between January 1, 2003 and December 31, 2014. This encompassed the period during which patients with burns sustained during active combat operations in the Middle East were received. Patients included sustained burns caused by thermal (including blast), chemical, or electrical mechanisms. Patients were excluded if they had a non-burn diagnosis, such as a skin disease. Data were collected from our institution's burn registry and included demographic information such as age at time of injury, race, etiology of burn, percent total body surface area burned (% TBSA), percent full-thickness injury, presence of inhalation injury, expected functional recovery status (estimated at the time of hospital discharge), and mortality. The recovery status definitions used are described in Table 1. Due to the inability to determine final disposition, patients transferred to another acute care facility were excluded.

Patient and injury characteristics, including mechanism of injury, presence of inhalation injury, and % TBSA, were compared. Descriptive statistical analyses were performed using the Student's t-test or Mann–Whitney U test for continuous variables and Chi-square test for categorical variables where appropriate. Logistic regression was used to calculate the likelihood of mortality with and without controlling for known risk factors for mortality, including age, inhalation injury, % TBSA and gender. Significance was set at $p < 0.05$.

3. Results

During the collection period of January 1, 2003 through December 31, 2014, a total of 3814 patients were eligible for analysis. A total of 1069 (28%) of these patients were military. 688 of the 1069 (64%) military patients experienced battle-related injuries. Table 2 shows the demographic and burn injury characteristics for each group. Military patients were younger at the time of injury compared to the civilian population (24 vs. 41 years; $p < 0.001$), and were predominantly male. Military and civilian patients experienced similar median % TBSA burned, but military patients had a higher percentage of full-thickness burn injury (7.5% vs. 3%; $p < 0.0001$). The most common etiology of burn injury in military patients was blast injury; however, civilians experienced more fire/flame, scald, chemical, and electrical burns than military patients ($p < 0.001$).

Civilian patients presented with higher median Baux scores, defined as age plus % TBSA burned (50 vs. 34.8, $p < 0.0001$), reflecting increased age, and experienced a higher mortality than their military counterparts (7.3% vs. 5.1%%).

Table 1 – Recovery status definitions.

Term	Definition
Alive, expected full recovery	Patient discharged with physical and mental capabilities intact, consistent with the pre-injury state
Alive, expected moderate recovery	Patient discharged with some degree of physical or mental disability that is the result of the injury event. The disability may be temporary
Alive, expected severe disability	Patient discharged with severe or incapacitating physical or mental impairment that was not present in the pre-injury state
Dead	Deceased; did not survive

Table 2 – Demographic and burn injury characteristics.

Variable	All (N=3814)	Military (N=1069)	Civilian (N=2745)	p-Value
Age, median (IQR), years	33 (23–49)	24 (21–29)	41 (28–53)	<0.001
Gender, male, no. (%)	3190 (83.6)	1030 (96.4)	2160 (78.7)	<0.001
Race, no. (%)				<0.001
White	1806 (47.4)	628 (58.7)	1178 (42.9)	
Black	229 (6)	98 (9.2)	131 (4.8)	
Hispanic	1232 (32.3)	77 (7.2)	1155 (42.1)	
Asian	28 (0.7)	11 (1)	17 (0.6)	
Native American	1 (0)	0 (0)	1 (0)	
Other	518 (13.6)	255 (23.9)	263 (9.6)	
Blast/explosion	816 (21.4)	637 (59.6)	179 (6.5)	<0.001
Inhalation injury, yes, no. (%)	426 (11.2)	151 (14.1)	275 (10)	<0.001
Etiology, no. (%)				<0.001
Fire/flame (including blast)	2731 (71.6)	899 (84.6)	1832 (68.5)	
Fire/flame (excluding blast)	1915 (50.2)	262 (24.6)	1653 (61.8)	
Scald	470 (12.3)	68 (6.4)	402 (15)	
Contact with hot object	114 (3)	8 (0.8)	106 (4)	
Chemical	86 (2.3)	9 (0.8)	77 (2.9)	
Electrical	179 (4.7)	30 (2.8)	149 (5.6)	
Other/unknown	158 (4.1)	49 (4.6)	109 (4.1)	
Inhalation injury only	76 (2)	6 (0.6)	70 (2.6)	
Mechanism of injury				
Thermal	3315 (86.9)	975 (91.7)	2340 (87.5)	
Chemical	86 (2.3)	9 (0.8)	77 (2.9)	
Electrical	179 (4.7)	30 (2.8)	149 (5.6)	
Baux score, median (IQR)	46 (32–63)	34.8 (27.2–50.5)	50 (32.2–67)	<0.001
Modified Baux score, median (IQR)	47 (32–66)	35.5 (27.5–53)	51 (39–69)	<0.001
% TBSA burned, median (IQR)	7 (3–16)	7 (3–20)	7 (2.6-15.5)	0.28
Percent full-thickness burn	4 (1–17)	7.5 (2–27.5)	3 (1–12)	<0.001
Expected recovery status at discharge				0.003
Alive, expected full recovery	3108 (81.5)	895 (83.7)	2213 (80.6)	
Alive, expected moderate recovery	401 (10.5)	98 (9.2)	303 (11)	
Alive, expected severe disability	49 (1.3)	21 (2)	28 (1)	
Dead	256 (6.7)	55 (5.1)	201 (7.3)	

Abbreviations: IQR, interquartile range; TBSA, total body surface area.

Military patients had a higher incidence of blast trauma, in which patients would experience larger burns, more inhalation injury and associated traumatic injuries. In addition, military patients experienced a higher incidence of inhalation injury than civilians (14.1% vs. 10%; $p < 0.001$).

Known factors associated with increased risk of mortality were examined in a univariate analysis (Table 3). Age, presence of inhalation injury, higher % TBSA, and greater percentage of full-thickness burn injury were all associated with an increased risk of mortality. Female gender and Hispanic ethnicity were also found to be univariate predictors of increased mortality. When examining the mechanism of burn injury, there was no difference in survival between thermal, chemical and electrical burns. In a univariate analysis, civilian patients exhibited a higher likelihood of mortality than military patients. However, the difference in mortality between military and civilian patients no longer existed after controlling for known covariates.

The recovery status of patients, as defined by the National Burn Registry (NBR), demonstrated that military patients were more likely to have a full recovery than their civilian counterparts, likely reflective of younger age, fewer premorbid conditions, and better overall health prior to injury (Fig. 1). However, when considering all patients who had severe disability after their injury, military patients comprised a higher percentage of this category (Table 4).

4. Discussion

This single-center, retrospective cohort study compares the characteristics of burn injury, functional outcomes, and mortality of military and civilian burned populations treated at a single center over a 12-year period during which the US was engaged in multiple combat operations in the Middle East. Military patients were younger and had a higher incidence of blast injury, yet were more likely to survive and recover fully than their civilian counterparts.

In both the military and civilian cohorts, the most significant univariate predictors of mortality were inhalation injury, % TBSA, full-thickness burn size, and female gender. Our data are consistent with previous studies [4,5] endorsing these mortality predictors. When controlling for age, presence of inhalation injury, gender, and % TBSA, the populations had statistically equivalent mortality rates.

These findings confirm and extend those of Wolf et al. [6] who demonstrated similar survival in military patients and an age-matched cohort of civilians. The study conducted by Wolf

Table 3 – Likelihood of mortality.

	OR (95% CI)	p-Value
Univariate		
Age	1.045 (1.038–1.052)	<0.001
Gender		
Male vs. female	0.573 (0.426–0.773)	<0.001
Military vs. civilian	1.457 (1.072–1.98)	0.016
Race/ethnicity		
White	0.53 (0.158–1.783)	0.305
Black	1.341 (0.798–2.254)	0.268
Hispanic	1.329 (0.999–1.767)	0.051
Asian	1.887 (0.561–6.348)	0.305
Native American	0 (0–0)	1.000
Other/unknown	0.967 (0.637–1.466)	
Blast injury	1.48 (1.114–1.966)	0.07
Etiology of burn		
Fire or flame burn (including blast)	1.148 (0.612–2.151)	0.667
Scald burn	0.291 (0.121–0.698)	0.006
Contact with hot object	0.742 (0.266–2.07)	0.569
Chemical burn	0.157 (0.02–1.239)	0.079
Electrical burn	0.707 (0.285–1.754)	0.455
Inhalation injury: yes vs. no	10.526 (8.019–13.817)	<0.001
TBSA burn	1.077 (1.07–1.084)	<0.001
Full-thickness burn	1.062 (1.054–1.07)	<0.001
Multivariate: adjusted for age, inhalation, gender, **blast,** TBSA and % full-thickness burn, military status		
Civilian vs. military	1.138 (0.583–2.221)	0.705
Gender (male vs. female)	1.424 (0.835–2.426)	0.194
Age	1.077 (1.062–1.092)	<0.001
Presence of blast injury	1.299 (0.661–2.284)	0.515
Total burn size	1.06 (1.042–1.077)	<0.001
Full thickness burn	1.026 (1.009–1.043)	0.003
Presence of inhalation injury	1.959 (1.217–3.156)	0.006

Abbreviations: OR, odds ratio; CI, confidence intervals; TBSA, total body surface area.

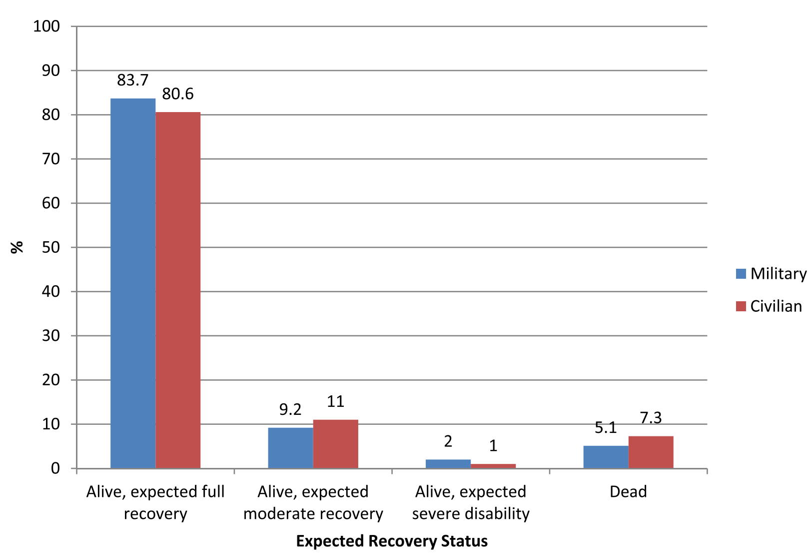

Fig. 1 – Comparison of expected recovery status.

was a fraction of the current study, including both military and civilian patients treated at the USAISR during the early years of the wars, between April 2003 and May 2005. The present study demonstrates a similar mortality to the previous study for civilian patients (7.1%) but increased mortality for military patients (5.1% in the current study vs. 3.8% in the prior study). Indeed, as the wars progressed, there was an increase in destructive power on the battlefield. Improvised explosive devices (IEDs) became more sophisticated and widespread, especially in Iraq, leading to more severe injuries.

Table 4 – Predictors of functional outcomes.

	OR (CI)	p-Value
Univariate		
Gender (male)	1.411 (1.149–1.732)	0.001
Military member	1.24 (1.028–1.495)	0.024
Age	0.967 (0.962–0.971)	<0.001
Absence of blast injury	1.289 (1.066–1.558)	0.009
% TBSA	0.936 (0.932–0.941)	<0.001
% full thickness	0.948 (0.942–0.954)	<0.001
Absence of inhalation injury	7.049 (5.752–8.638)	<0.001
Multivariate: adjusted for gender, military status, age, blast injury, inhalation injury, % TBSA, % full thickness)		
Age	0.955 (0.947–0.963)	<0.001
% TBSA	0.95 (0.94–0.961)	<0.001
% full thickness	0.988 (0.976–1)	0.056
Male gender	1.057 (0.746–1.498)	0.754
Military member	1.131 (0.759–1.686)	0.545
Absence of blast injury	0.915 (0.619–1.351)	0.654
Absence of inhalation injury	2.104 (1.518–2.916)	<0.001

In contrast to our findings, military casualties during the Vietnam conflict exhibited greatly increased survival compared to their civilian counterparts treated at this Burn Center. Thus, during 1969–1972, mortality for military patients was 6% vs. 26.5% for civilians, $p<0.001$. This was attributed to "preselection," in that military patients experienced a delay in evacuation from the combat zone to the Burn Center, "during which time the more severely injured patients with significant complications expired". Furthermore, the Burn Center adopted a "general policy to accept only the more severe burn cases within the Continental United States" [7]. On the other hand, our current evacuation strategy aims to transfer all burned military casualties as soon as possible, regardless of the severity of their injuries.

The steadily decreasing mortality observed over the course of this study in the face of battle surges and increasing number of combat casualties suggests improved care at all levels, from point of injury (POI) to critical care provided at all echelons. Interventions such as the Joint Theater Trauma System's implementation of burn resuscitation guidelines have improved outcomes [8]. POI care, to include Tactical Combat Casualty Care (TCCC), significantly contributes to the survival of severely injured military patients [9]. Prior to deployment, every service member is trained in tactical combat casualty care, which allows them to provide life-saving measures to themselves and others immediately after injury. Medics and corpsmen are trained to establish intravenous access within 15 min, which may be earlier than in the civilian population and allows for immediate initiation of resuscitation after burn injury [4]. Additionally, the Joint Trauma System's Clinical Practice Guidelines for Burn Care facilitated improved management and resuscitation across the military continuum of care. Subsequently, the overall improved survival may be a reflection of the above factors as well as the continuous performance improvement and a learning health care system that developed and resulted in progressive improvements for the burn casualty population.

In our study, the total burn size was similar between the two cohorts; however, the percentage of full-thickness burn injury was greater in the military population. In addition, the etiologies of injury differed between groups. In the current military conflict, explosions were far more common, accounting for the dominant etiology of injury and resulting in a higher percentage of full-thickness injuries in this study. This is consistent with previous literature regarding the prevalence of blast injury in these conflicts, in which an estimated 3 per 1000 soldiers deployed between 2005–2009 sustained blast injuries; this is much higher than previous conflicts [10]. The increased percentage of full-thickness injuries is likely due to the intense heat that is a result of the continued burning of vehicles, clothing, and other equipment after the initial blast/explosion [2,11]. Conversely, the civilian burned population in south Texas included a high number of work-related and industrial accidents, accounting for the higher number of electrical and chemical injuries observed in this population.

With regards to short-term outcomes, the majority of patients in both cohorts had expected full functional recoveries at the time of initial hospital discharge. During their hospitalizations, all patients admitted to the USAISR, regardless of their military or civilian status, receive intensive rehabilitation at least daily to optimize their functional recovery status at discharge. Patients will also receive additional medical and surgical procedures that may enhance their function and improve their quality of life. The resource-intensive investment in terms of rehabilitation, additional medical and surgical procedures, and long-term care needed for full recovery of burn casualties is substantial. The military cohort often was expected to recover fully, which is likely reflective of their healthy pre-injury state. However, a greater proportion of military patients survived with an expected severe disability, which can conceivably place a strain on resource required to provide long-term care for these patients. Studies such as this can aid in planning resource allocation when preparing for future conflicts.

With regards to long-term follow-up and outcomes, a comparison between the military and civilian patient populations is more difficult. Military service members are eligible to receive lifelong treatment, rehabilitation, and follow-up at the USAISR. Under our current program, civilian patients able to receive follow-up care for one year following their injury.

After the patients are no longer eligible to receive care from the USAISR, data regarding functional status and other outcomes is no longer able to be collected.

The retrospective nature of this study carries inherent limitations as does the heterogeneous nature of the groups compared. The exclusion of the few patients transferred to other acute care facilities—21 civilians (0.6%) and 2 military patients (0.2%)—means that the disability rate was underestimated.

5. Conclusion

In a non-risk adjusted analysis, military patients exhibited improved survival and expected functional recovery over civilian patients after experiencing burn injury of comparable extent. After controlling for known predictors of mortality, such as age and the presence of inhalation injury, there was no survival difference observed. Percent TBSA burned, inhalation injury, and age continue to be the dominant factors which influence survival in both populations. The low mortality of both populations and high number of patients experiencing full recovery continues to support the treatment of civilian patients in a military burn center as an essential component of combat readiness, while providing a valuable service to the citizens of south Texas. Further studies will examine how the advantages of younger age and healthier physical status found in the military population can be applied to civilian patients who may not share the same characteristics.

Disclaimer

The views expressed in this chapter are those of the authors and do not reflect the official policy or position of the U.S. Army Medical Department, Department of the Army, DoD, or the U.S. Government.

Conflict of interest

I wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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