Combat Wounds in Operation Iraqi Freedom and Operation Enduring Freedom

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Background: There have been no large cohort reports detailing the wounding patterns and mechanisms in the current conflicts in Iraq and Afghanistan.

Methods: The Joint Theater Trauma Registry was queried for all US service members receiving treatment for wounds (International Classification of Diseases-9th Rev. codes 800–960) sustained in Operation Iraqi Freedom and Operation Enduring Freedom from October 2001 through January 2005. Returned-to-duty and nonbattle injuries were excluded from final analysis.

Results: This query resulted in 3,102 casualties, of which 31% were classified as nonbattle injuries and 18% were returned-to-duty within 72 hours. A total of 1,566 combatants sustained 6,609 combat wounds. The locations of these wounds were as follows: head (8%), eyes (6%), ears (3%), face (10%), neck (3%), thorax (6%), abdomen (11%), and extremity (54%). The proportion of head and neck wounds is higher ($p < 0.0001$) than the proportion experienced in World War II, Korea, and Vietnam wars (16%–21%). The proportion of thoracic wounds is a decrease ($p < 0.0001$) from World War II and Vietnam (13%). The proportion of gunshot wounds was 18%, whereas the proportion sustained from explosions was 78%.

Conclusions: The wounding patterns currently seen in Iraq and Afghanistan resemble the patterns from previous conflicts, with some notable exceptions: a greater proportion of head and neck wounds, and a lower proportion of thoracic wounds. An explosive mechanism accounted for 78% of injuries, which is the highest proportion seen in any large-scale conflict.

Key Words: Military, Combat, Wound, Explosive.

J Trauma. 2008;64:295–299.

The US military is currently engaged in prolonged conflicts on two fronts, Iraq and Afghanistan. These operations, Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), are the largest scale armed conflicts since the Vietnam War. The few existing reports that have been published on the epidemiology of combat wounds in the current conflicts have been from individual medical centers, despite a global delivery of care.[1–9] The intent of this study was to analyze a centralized casualty database to describe the distribution of wounds and mechanisms of injury during the current conflicts and compare these data with available data from previous US wars.

METHODS

The Joint Theater Trauma Registry (JTTR) is a database of medical treatment information on patients from a theater of combat operations treated at US military medical facilities. There are multiple levels of care from which information is obtained, starting at the point-of-entry, progressing through ascending levels of care, and terminating at a military medical treatment facility in the United States. This database is being continually updated with information returning from areas where combatants are deployed. This database contains data extracted from patients' hard-copy medical charts.

The JTTR was queried for all US service members receiving treatment for wounds (International Classification of Diseases-9th Rev. [ICD-9] codes 800–960) sustained in OIF and OEF from October 2001 through January 2005. Non-American and civilian patients were excluded. Care was taken to eliminate the multiple counting of injuries at different levels of care by performing counts of distinct patients within each ICD-9 code. This query does not include combatants killed-in-action (KIA) but does include those that died-of-wounds (DOW). Combatants classified as return-to-duty (RTD) were excluded from in depth analysis to be consistent with casualty reporting from previous wars. In addition, combatants sustaining nonbattle injuries (NBI) were also excluded. The definition of a battle injury is as follows[10]:

> Any casualty incurred as the direct result of hostile action sustained in combat or sustained going to or from a combat mission. Included are persons killed or wounded accidentally by friendly fire directed at a hostile force or what was thought to be a hostile force. However, the following injuries are not battle casualties: (1) self-inflicted wounds (except in unusual cases); and (2) wounds or death inflicted by a friendly force while the soldier is absent without leave, dropped from the rolls, or is a voluntary absentee from his or her place of duty.

Submitted for publication May 16, 2006.
Accepted for publication July 31, 2006.

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The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of Defense or United States government. The authors are employees of the US government.

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DOI: 10.1097/TA.0b013e318163b875

Therefore, this query effectively approximates the wounded-in-action category, which is comprised of DOW, wounded combatants treated and released within 72 hours (RTD), and those treated and evacuated.[11]

The query results were analyzed by each specific ICD-9 code and compiled by region and type of injury. The particular body regions were demarcated according to criteria established by Churchill.[12] The head and neck region included all wounds of the head, face, cervical spine, and neck superior to the clavicles. The thorax included all chest and thoracic spine wounds. The abdomen included the lumbar spine, abdomen, pelvis, and external genitalia. The upper extremity included the clavicle and scapula. The lower extremity did not include the pelvis, but started at the proximal femur. These data were compared with published results from previous US conflicts for comparison. Reports from Grenada,[13] Operation Desert Storm,[14] and Somalia[15] have not been included in this analysis because of the limited number of casualties and time-frame of these conflicts. In addition, regional wounding patterns were compared with an estimate of projected body surface area as established by Burns and Zuckerman.[16] Statistical analysis was performed using SAS (Cary, NC). The statistical test used was a Z-test to determine differences in the regional wounding patterns between conflicts. Significance was set at $p < 0.00001$.

RESULTS

This query resulted in 3,102 casualties. There were 977 combatants sustaining 3,295 wounds (3.4 wounds per casualty) classified as NBI. Also, 559 combatants were treated for 1,571 wounds (2.8 wounds per casualty) and were returned-to-duty within 72 hours. These two cohorts were excluded from the remainder of this analysis. A total of 1,566 combatants sustained 6,609 combat wounds (4.2 wounds per casualty) as the direct result of hostile enemy action. There were a total of 54 combatants (3.4%) classified as DOW. Of these 1,566 combatants, 1,517 were male, 41 were female, and 8 did not have gender information available. The average age was 26.0 years (range 18–57). Army personnel accounted for 1,189 wounded combatants, Marines for 326, Navy for 38, and Air Force for 13. The median military rank was enlisted grade E-4. Enlisted and noncommissioned officer personnel accounted for 1,463 of the wounded combatants, commissioned officers for 93, warrant officers for 7, and 3 had no rank information available.

Wound Distribution

Of these 6,609 wounds, 1,949 (29.4%) were in the head and neck region, 376 (5.6%) were in the thoracic region, 709 (10.7%) were in the abdominal region, and 3,575 (54.1%) were in the extremities. Further analysis within the head and neck region revealed the following breakdown: 635 face wounds (33%), 509 head wounds (26%), 207 neck wounds (11%), 380 eye wounds (19%), 175 ear wounds (9%), and 43 unspecified wounds (2%). A complete breakdown of the wounds is in Table 1.

Table 1 Wound Distribution by Region

Region	Wounds	Percent
Head	509	8
Eyes	380	6
Face	635	10
Ears	175	3
Neck	207	3
Thorax	376	6
Abdomen	709	11
Extremity	3,575	54
Total	6,609	100

Table 2 Distribution of Wounds by Body Region (Percentage)

	Body Surface Area[16]	WWII[17]	Korea[18]	Vietnam[19]	OIF or OEF
Head and neck	12	21.0[a]	21.4[a]	16.0[b]	30.0[c]
Thorax	16	13.9[a]	9.9[b]	13.4[a]	5.9[c]
Abdomen	11	8.0[a]	8.4[b]	9.4[c]	9.4[c]
Extremities	61	58.0[a]	60.2[b]	61.1[b]	54.5[c]

Different letters within the same row represent significant differences of regional wound proportions between wars, $p < 0.00001$.

WWII indicates World War II.

A comparison of these data with reports from previous wars is contained in Table 2.[16–19] Because there are no reports from previous conflicts that detail a complete breakdown within the head and neck region, we used our compiled head and neck data for comparison. This analysis shows a significant increase in the head and neck region and a significant decrease in thoracic wounds compared with previous wars.

Mechanism of Injury

The 1,566 wounded combatants were analyzed for the reported mechanism of injury. Of these combatants, 1,452 were wounded by one of seven mechanisms that composed greater than 1% of the modes of injury: gunshot wound, improvised explosive device (IED), landmine, mortar or shrapnel, bomb, grenade, and motor vehicle collision (Table 2).[16–19] The 114 other combatants sustained 1 of the following 14 mechanisms: aggravated range of motion, trauma from blunt object, burn, environmental, flying debris, helicopter crash, machinery or equipment, plane crash, fall from height, knife or sharp object, unidentified object, unknown, none, or other. The IED, landmine, mortar or shrapnel, bomb, and grenade were summed into a category called "explosion" for comparison to previous conflicts. The mechanism of injury was fairly constant when analyzed throughout each body region (Table 3). The head and neck region, however, did have a higher proportion of explosion injuries and fewer bullet wounds.

The mechanism of injury was compared with previous wars and results tabulated in Table 4. During the past 150 years, there has been a generalized trend toward a greater

Table 3 Mechanism of Injury of All Wounded Combatants

	Number	Percent
GSW	270	19
MVC	36	2
Explosion	1,146	79
IED	558	38
Landmine	41	2
Mortar	281	19
Bomb	33	2
Grenade	233	16

MVC indicates motor vehicle collision; GSW, gunshot wound.

Table 4 Mechanism of Injury Within Regions (Percentage)

	GSW	Explosion	MVC
Head and neck	8	88	4
Thorax	19	78	3
Abdomen	17	81	2
Extremity	17	81	2

MVC indicates motor vehicle collision; GSW, gunshot wound.

Table 5 Mechanism of Injury From Previous US Wars (Percentage)

	GSW	Explosion
Civil war[20]	91	9
WWI[12]	65	35
WWII[12]	27	73
Korea[18]	31	69
Vietnam[19]	35	65
OIF or OEF	19	81

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

percentage of casualties being wounded by explosions than by bullets. Excluding the experience of Operation Desert Storm (Gulf War I), which along with Operation Just Cause (Grenada) and Somalia, are not comparable with the current conflict in terms of length of time and number of casualties sustained, the current conflict represents the lowest proportion of wounds resulting from bullet or ballistic trauma (Table 5).[12,18–20]

DISCUSSION

The current US armed conflicts of OIF and OEF are the largest since Vietnam. Since the combat began in late 2001, reports of wounding patterns have been written from the perspective of individual medical centers[1–9] despite a global delivery of care.[21] A descriptive analysis of wounding patterns is crucial for the assessment of the military medical system needs and the effectiveness of protective equipment.

We provide a descriptive analysis of wounding patterns associated with the current US armed conflicts and compare these results with those of previous conflicts. The JTTR was used to obtain injury information on all wounded US service members in theaters of operation who were cared for in the Department of Defense health care system. The regional distribution of wounds was similar to the pattern described in previous conflicts, with a few exceptions. The percentage of extremity wounds in this study was 54%. These values are very close to the 58% reported for World War II.[17] Other published reports from OIF report extremity wounding percentages of 60% and 68% obtained in smaller subsets of this study's population.[4,6] All of these reported wounding patterns approximate the estimate of body surface area proposed by Burns and Zuckerman,[16] with which 61% of wounds would be sustained by the extremities if exposure of surface area were the only factor involved.

However, the pattern of wounding is more complex than simply an expression of body surface area. The wide-scale, compliant use of body armor by US combatants began in Operation Desert Storm, which saw a reduction in thoracic injuries to 5% from the 13% seen in Vietnam. The percentage of thoracic wounds in the present study, 6%, is consistent with the pattern seen in Operation Desert Storm, as body armor use has continued.

Our percentage of head and neck wounds of 29% is the highest reported percentage for this region. Nearly 50% of the head and neck wounds were caused by IEDs, which was the highest percentage for any region. Facial wounds accounted for 61% of the head and neck region wounds. Despite improved individual and vehicular armor in a mounted urban combat environment, the face is one of the few remaining exposed regions and could account for this high rate of explosive injuries in this region. It is also possible that the improvements in body armor and the rapid medical evacuation system have saved casualties that would have been KIAs in previous conflicts. This difference is probably multifactorial and deserves further investigation.

Montgomery et al. reported a 4-month period of casualties received at Walter Reed Army Medical Center.[6] They cared for 119 patients with 184 injuries with a breakdown similar to those reported above with a few exceptions: head and neck—16%, thorax—14%, abdomen—11%, upper extremity—20%, and lower extremity—40%. The mechanism profile of these injuries was different from our results: 39% bullet, 34% blunt, and 31% explosion. The inclusion of 34 NBI among the 119 in this analysis might account for the higher rate of blunt trauma injuries. Despite this, more wounds from bullets than from explosions were noted in this analysis. This example highlights the sampling bias that is associated with casualty data collection at a single center during a short period of time; small cohorts of patients from these centers are not representative of theater casualties as a whole. The 4-month time period covered by this report also coincides with the ground offensive in Iraq, before the conflict developed into counter-insurgency warfare. This may also explain the differences in the mechanisms of injury.

Johnson et al. reported the 2-month experience at Landstuhl Regional Medical Center in Germany during the offensive phase of OIF.[4] This hospital served at the sole level 4 facility through which the majority of patients were routed. They evaluated 1,236 evacuated combatants, including 256 battle casualties with the following breakdown of wound location: head and neck—13%, chest or abdomen—11%, isolated lower extremity—31%, combined lower extremity or other location—22%, isolated upper extremity—16%, and other—7%. The reported mechanism of injury for this cohort was explosion in 48%, bullet in 30%, and blunt trauma in 21%. This breakdown is closer to our profile than that reported by Montgomery et al.; Landstuhl Regional Medical Center is the one echelon of care closer to the battlefield and their patient profile would be expected to resemble ours more than Walter Reed's. We found that more injuries were caused by explosions than bullets and this difference may be explained by the period of data query.

A recent report from a forward surgical team in OEF analyzed the wounding location for 224 battle injuries.[8] We noted a similar percentage of extremity wounds (58%), but a lower proportion of head and face wounds (17%) than this current analysis. However, the authors did not provide an explanation of their region definitions. A possible explanation of this difference in head and face wounds is the theater evacuation policies, which divert casualties with head and facial trauma to hospitals with known neurosurgical and facial trauma capabilities. Although this and other reports from small forwards units[1–3,7–9] are helpful, they cannot be used for comparison with previous US wars because of their small sample size and regional bias.

The JTTR database attempts to abstract the medical data on every American military casualty cared for in US military facilities. The data in this report represents approximately 27% of the estimated 11,352 casualties during the timeframe studied.[22] Although these data do not present a complete casualty analysis, they constitute the largest report to date.

Definitions significantly affect the results of casualty analysis.[11] It is imperative to delineate the population studied to allow for comparison as some previous casualty reports have not been clearly defined. The inclusion of KIAs, RTDs, and NBIs in any cohort analyzed will effect the distribution of wounds and mechanism of injury. For example, the inclusion of KIAs in the cohort analyzed may result in an increase in the number of head and chest wounds seen. We included DOWs and excluded RTDs and NBIs in our population studied. Inclusion of only the primary or dominant wound (as well as the means of determining this entity) can also easily skew the data. We included all wounds without determining the primary or dominant wound. The reporting of wounds from previous wars is potentially biased toward more severe injuries, with contusions, closed fractures, sprains, and minor lacerations being overlooked. We included all wounds classified according to ICD-9 in our analysis.

Although reports from previous armed conflicts have been published after the cessation of combat in the involved theater, this study offers a descriptive analysis of wounding patterns and mechanisms seen thus far in an ongoing conflict. The overall pattern mimics body surface area and is similar to the experience in previous wars, with a majority of wounds occurring in the extremities. We did find a higher proportion of head and neck wounds and a lower proportion of thoracic wounds than previous conflicts. Also, we found a greater proportion of explosion injuries than previously reported. This information and thoughtful review of these data are important for optimal medical planning, training, research, and resource allocations. Continued analysis of wounding patterns, wounding mechanisms, and outcomes will aid in adjustments of these programs to meet changing needs and validate efficacy of programs when they are altered. Collection of combat casualty data, at a level similar to the highest civilian standards, allows for concurrent analysis and provides means for improving patient care.

ACKNOWLEDGMENTS

We thank the following individuals for their assistance: Steve Markelz, Barbara Lucas, Heather Gooden, and Jing Jing Wang, MS.

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