Characterization of Extremity Wounds in Operation Iraqi Freedom and Operation Enduring Freedom

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Objectives: Extremity wounds and fractures traditionally comprise the majority of traumatic injuries in US armed conflicts. Little has been published regarding the extremity wounding patterns and fracture distribution in the current conflicts in Iraq and Afghanistan. The intent of this study was to describe the distribution of extremity fractures during this current conflict.

Design: Descriptive epidemiologic study.

Methods: The Joint Theater Trauma Registry was queried for all US service members receiving treatment for wounds (ICD-9 codes 800–960) sustained in Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) from October 2001 through January 2005. Returned-to-duty and nonbattle injuries were excluded. Wounds were classified according to region and type. Extremity wounds were analyzed in detail and compared to published results from previous conflicts.

Results: A total of 1281 soldiers sustained 3575 extremity combat wounds. Fifty-three percent of these were penetrating soft-tissue wounds and 26% were fractures. Of the 915 fractures, 758 (82%) were open fractures. The 915 fractures were evenly distributed between the upper (461, 50%) and lower extremities (454, 50%). The most common fracture in the upper extremity was in the hand (36%) and in the lower extremity was the tibia and fibula (48%). Explosive munitions accounted for 75% of the mechanisms of injury.

Conclusions: The burden of wounds sustained in OIF/OEF is extremity injuries, specifically soft-tissue wounds and fractures. These results are similar to the reported casualties from previous wars.

Key Words: combat, wounds, battle, extremity, fractures

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Extremity injuries comprised 58% to 88% of combat wounds in previous US armed conflicts.[1–7] A significant proportion (23–39%) of these extremity wounds are fractures, most of which are open injuries.[2,3,5–8] These complex open fractures are associated with a high infection and complication rate and can be associated with prolonged hospital course.[3,4,9] The goal of this study was to analyze the extremity wounding patterns in the current US armed conflicts and to compare them to previous 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 Army medical treatment facilities. There are multiple levels of care from which information is obtained, starting at the point of entry, progressing through the echelons of care, and terminating at a military medical treatment facility in the United States. This database is being continually updated with information returning from these deployed areas. This database contains data extracted from patients' hard-copy medical charts.

The JTTR was queried for all US service members receiving treatment for wounds (ICD-9 codes 800–960) sustained in Operation Iraqi Freedom and Operation Enduring Freedom from October 2001 through January 2005. Non-US and civilian patients were excluded. This query included soldiers killed in action (KIA) and those that died of wounds (DOW); however, these subgroups were not analyzed separately. Soldiers who were classified as return-to-duty (RTD; by definition discharged from medical care within 72 hours after admission) were excluded from this study as well as soldiers who sustained nonbattle injuries (NBI).

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.[10] 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 to published results from previous US conflicts for comparison.

RESULTS

A total of 1566 soldiers sustained 6609 combat wounds as the direct result of hostile enemy action. Of these, 1281 soldiers sustained 3575 extremity wounds (54%). This relative proportion is consistent with previous wars (Table 1). Of these soldiers, 1234 were male, 39 were female, and 8 did not have

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TABLE 1. Extremity Wounds as Percent of All Wounds

Extremity	WWII[1]	Korea[6]	Vietnam[2]	Desert Storm[7]	Operation Iraqi Freedom/Operation Enduring Freedom
Upper	23	29	27	23	28
Lower	35	36	34	48	26
Total	58	65	61	71	54

gender information available. The average age was 26.0 years (range, 18 to 57). Army personnel accounted for 973 wounded soldiers, Marines for 264, Navy for 32, and Air Force for 12. The median military rank was enlisted grade E-4. Enlisted and noncommissioned officer personnel accounted for 1200 of the wounded soldiers, commissioned officers for 72, warrant officers for 7, and 2 had no rank information available.

An analysis of the types of extremity wounds revealed 53% of these were penetrating soft-tissue wounds and 26% were fractures. The remainder of wound types each composed less than 5% of the total (Table 2). Of the 915 fractures, 758 (82%) were open fractures. The proportion of extremity wounds composed of fractures is consistent with reports from previous conflicts (Table 3).

The 3575 extremity wounds were evenly distributed between the upper (1838, 51%) and lower extremities (1737, 49%). The 915 fractures were also evenly distributed between the upper (461, 50%) and lower extremities (454, 50%). The most common fracture in the upper extremity was in the hand (36%) and in the lower extremity was the tibia and fibula (48%). A complete breakdown of the fracture distribution is in Table 4. The 915 fractures were evenly distributed between the upper (461, 50%) and lower extremities (454, 50%).

The mechanism of injury for the 1281 soldiers were as follows: improvised explosive device (IED) in 36%, gunshot wound (GSW) in 16%, grenade [including rocket-propelled grenade (RPG)] in 16%, mortar in 9%, shrapnel in 8%, landmine in 2%, bomb in 2%, and motor vehicle accident in 2%. The following mechanisms of injury accounted for 1% or less of the total: burn, blunt trauma, flying debris, helicopter crash, machinery/equipment, fall, knife, aggravated range of motion, unknown, and other.

TABLE 2. Types of Extremity Wounds

Wound	Number	Percent
Abrasion	50	1
Amputation	129	4
Burn	162	5
Contusion	50	1
Dislocation	24	1
Fracture	915	26
Nerve	144	4
Soft tissue	1881	53
Sprain	24	1
Vascular	166	5

TABLE 3. Fractures as Proportion of All Extremity Wounds

Conflict	Percent
Korea[6]	23
Vietnam[2]	27
Just Cause[5]	33
Desert Storm[7]	39
Operation Iraqi Freedom/Operation Enduring Freedom	26

DISCUSSION

The current US armed conflicts of Operation Iraqi Freedom (Iraq, 2003–present) and Operation Enduring Freedom (Afghanistan, 2001–present) are the largest since the Vietnam War (Vietnam, 1961–75). Since the combat began in late 2001, reports of extremity injuries have been written from the perspective of individual medical centers,[11,12] despite a delivery of care that spans five levels of facilities and three continents.

This study found that a large proportion (26%) of extremity wounds were fractures. Although there are limited published reports on fracture distribution from combat wounds, there is some data on open fracture distribution from one World War II (Europe/Pacific, 1941–1945) campaign,[1] Operation Desert Storm (Iraq, 1991),[7] and Operation Just Cause (Panama, 1989).[13] In comparison to these wars, the current conflicts are experiencing a greater proportion of upper extremity fractures. The relative distributions within the upper and lower extremities are consistent with these previous reports (Table 5).

The 82% rate of open fracture in the current study is similar to the 83% experienced in Operation Desert Storm.[7] This finding supports the many reports detailing the high percentage of fractures experienced in recent military conflicts.[3–5,7–9] The infection and complication rate in these open fractures has been reported between 0% and 60%. Lambert et al reported three of five open fractures becoming infected in a series of recent US Naval casualties.[9] Mabry et al reported that 4 of 11 open long bone fractures became infected in casualties of warfare in Somalia.[4] However, Lin et al recently reported no infections in 14 open fractures treated.[12]

TABLE 4. Distribution of Fractures in Operation Iraqi Freedom/Operation Enduring Freedom

Fracture	Closed	Open	Total	Percent Open
Clavicle	6	7	13	53
Scapula	4	28	32	87
Humerus	16	106	122	86
Forearm	23	107	130	82
Hand	20	144	164	87
Total upper	69	392	461	85
Femur	16	107	123	86
Leg	45	173	218	79
Foot	27	86	113	76
Total lower	88	366	454	80
Total	157	758	915	82

TABLE 5. Comparison of Open Fracture Distribution to Previous Wars

	World War II[1]		Desert Storm[7]		Just Cause[13]		Operation Iraqi Freedom/Operation Enduring Freedom	
Fracture	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Shoulder	—	—	—	—	3	7	35	5
Humerus	545	23	5	8	4	9	106	14
Forearm	428	18	6	9	6	14	107	14
Hand	—	—	10	15	6	14	144	19
Total upper	973	40	21	32	19	43	392	52
Femur	668	28	5	8	6	14	107	14
Leg	775	32	22	33	12	27	173	23
Foot	—	—	18	27	7	16	86	11
Total lower	1443	60	45	68	25	57	366	48
Total	2416	100	66	100	44	100	758	100

The prevalence of complications in this population stresses the importance of prospective monitoring of these patients' outcomes. The large volume of musculoskeletal trauma currently being seen in this armed conflict emphasizes the importance of these outcomes endeavors. To date, the orthopaedic experience from the current conflicts reported in the literature is limited to reports from deployed units[14–21] or from individual medical centers.[11,12,22] Unfortunately, these reports detail the injuries on relatively small cohorts and therefore are susceptible to selection bias.

Lin et al reported on the Walter Reed experience with casualties during the first 14 months of Operation Enduring Freedom.[12] They treated 52 patients, of whom 29 had sustained 49 fractures. Fourteen (29%) of these fractures were open. The most common location for fractures in the upper extremity was hand (11/21). The most common location in the lower extremity was the foot (7/15). There were only two tibial fractures in this group evaluated. It is difficult to draw any conclusions regarding injury patterns based upon the small cohort that this represents.

Johnson et al reported the experience at Landstuhl Regional Medical Center in Germany during the first 2 months of Operation Iraqi Freedom.[11] They evaluated 256 battle casualties of which 68% sustained an extremity injury. The reported mechanism of injury for this cohort was explosive in 48%, GSW in 30%, and blunt trauma in 21%. The difference in wounding mechanism can be partially explained by the nature of warfare during the first 2 months of this conflict. This was the offensive phase of the war in Iraq, as opposed to the current counter-insurgency campaign. Soldiers from the latter are well represented in our cohort and this emphasizes the high rate of explosive mechanisms in this group.

Due to the casualties receiving care at multiple echelons and medical facilities, reports from individual facilities may not accurately reflect the entire population of casualties. Although reports from small cohorts are helpful, large-scale analyses using the JTTR have been called for to better evaluate injury patterns.[23,24] The JTTR database attempts to obtain medical treatment information on all American military casualties cared for in US military facilities; however, this report represents approximately 30% of casualties during this timeframe. While this analysis is not comprehensive, it is the largest report to date. The only previous report of casualties in Iraq utilizing a data registry includes 279 Navy and Marine personnel.[25]

The cohort size in the current study is its greatest strength. A potential weakness of this study is the possibility of coding errors; however, this criticism can be made regarding any large trauma database. Another potential weakness of this study is the absence of follow-up data on these soldiers. Although both time and labor intensive, outcomes data on our injured soldiers is needed and work in this area is ongoing.

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 extremity wounds seen thus far in an ongoing conflict. The current theaters of U.S. military operations appear to be experiencing wounding patterns similar to previous conflicts. Extremity injuries compose a large proportion of combat wounds; many of these wounds are open fractures. These results reemphasize the importance of orthopaedic care for wounded soldiers.

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REFERENCES

1. Beebe GW, DeBakey ME. Location of hits and wounds. In: *Battle Casualties*. Springfield, IL: Charles C. Thomas, 1952:165–205.
2. Hardaway RM. Viet Nam wound analysis. *J Trauma*. 1978;18:635–643.
3. Islinger RB, Kuklo TR, McHale KA. A review of orthopaedic injuries in three recent U.S. military conflicts. *Mil Med*. 2000;165:463–465.
4. Mabry RL, Holcomb JB, Baker AM, et al. United States Army Rangers in Somalia: an analysis of combat casualties on an urban battlefield. *J Trauma*. 2000;49:515–528.
5. McBride JT, Hunt MM, Hannon JP, et al. Institute Report #468: Report and Medical Analyses of Personnel Injury from Operation "Just Cause." San Francisco: Letterman Army Institute of Research; 1991.
6. 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.

7. Uhorchak JM, Rodkey WG, Hunt MM, et al. *Institute Report #469: Casualty Data Assessment Team Operation Desert Storm*. San Francisco: Letterman Army Institute of Research; 1992.
8. Hansen MO, Polly DW, McHale KA, et al. A prospective evaluation of orthopaedic patients evacuated from Operations Desert Shield and Desert Storm: the Walter Reed experience. *Mil Med*. 1994;159: 376–380.
9. Lambert EW, Simpson RB, Marzouk A, et al. Orthopaedic injuries among survivors of USS Cole attack. *J Orthop Trauma*. 2003;6: 436–441.
10. Beebe GW, DeBakey ME. Death from wounding. In: *Battle Casualties*. Springfield, IL: Charles C. Thomas, 1952:74–147.
11. Johnson BA, Carmack D, Neary M, et al. Operation Iraqi Freedom: the Landstuhl Regional Medical Center experience. *J Foot Ankle Surg*. 2005; 44:177–183.
12. Lin DL, Kirk KL, Murphy KP, et al. Evaluation of orthopaedic injuries in Operation Enduring Freedom. *J Orthop Trauma*. 2004;18:300–305.
13. Jacob E. Erpelding JM, Murphy KP. A retrospective analysis of open fractures sustained by U.S. military personnel during Operation Just Cause. *Mil Med*. 1992;157:552–556.
14. 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.
15. 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.
16. Cho JM, Jatoi I, Alarcon AS, et al. Operation Iraqi Freedom: surgical experience of the 212th Mobile Army Surgical Hospital. *Mil Med*. 2005; 170:268–272.
17. Marshall TJ. Combat casualty care: the Alpha Surgical Company experience during Operation Iraqi Freedom. *Mil Med*. 2005;170:469–472.
18. Patel TH, Wenner KA, Price SA, et al. A U.S. Army Forward Surgical Team's experience in Operation Iraqi Freedom. *J Trauma*. 2004;57:201–207.
19. Peoples GE, Gerlinger T, Craig R, et al. 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.
20. Place RJ, Rush RM, 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.
21. Rush RM, Stockmaster NR, Stinger HK, et al. Supporting the Global War on Terror: a tale of two campaigns featuring the 250th Forward Surgical Team (Airborne). *Am J Surg*. 2005;189:564–570.
22. Montgomery SP, Swiecki CW, Shriver CD. The evaluation of casualties from Operation Iraqi Freedom on return to the continental United States from March to June 2003. *J Am Coll Surg*. 2005;201:7–12.
23. Beekley AC. United States military surgical response to modern large-scale conflicts: the ongoing evolution of a trauma system. *Surg Clin North Am*. 2006;86:689–709.
24. Holcomb JB. The 2004 Fitts Lecture: current perspective on combat casualty care. *J Trauma*. 2005;59:990–1002.
25. Zouris JM, Walker GJ, Dye J, et al. Wounding patterns for U.S. Marines and sailors during Operation Iraqi Freedom, major combat phase. *Mil Med*. 2006;171:246–252.

