

ORIGINAL ARTICLES

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Midterm Health and Personnel Outcomes of Recent Combat Amputees

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ABSTRACT Objective: Warfighters who sustained combat amputations in Operation Enduring Freedom or Operation Iraqi Freedom (OEF/OIF) have unique challenges during rehabilitation. This study followed their outcomes. Methods: Subjects were 382 U.S. warfighters with major limb amputations after combat injury in OEF/OIF between 2001 and 2005. Outcome measures were diagnoses, treatment codes, and personnel events captured by health and personnel databases during 24 months postinjury. Results: Most patients had multiple complications generally within 30 days postinjury (e.g., infections, anemia), with important exceptions (e.g., heterotopic ossification). Lower limb amputees had 50% more complications than upper limb amputees. Two-thirds of patients had a mental health disorder (e.g., adjustment, post-traumatic stress disorder), with rates of major disorder categories between 18% and 25%. Over 80% of patients used physical and occupational therapy, prosthetic/orthotic services, and psychiatric care. Conclusions: Combat amputees had a complex set of outcomes supporting the continued need for military amputee care programs.

INTRODUCTION

The consequences of combat amputations for warfighters are among the leading challenges for military health care.¹⁻³ Traumatic limb loss involves complex physical and psychological issues⁴⁻⁶ and recent combat amputees are considered a unique patient population.^{1,2} Besides trauma care and physical rehabilitation, these challenges include minimizing the impact of amputation on work, psychosocial, and mental health outcomes. As of February 2008, there were over 700 major limb amputations among U.S. warfighters from Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF), with most younger than age 30.^{1,2,7} Approximately, 95% of these patients had amputations occur on the battlefield or within days after combat injury.⁸ There is little reported information on postinjury complications,

health care use, and mental health and work outcomes of recent combat amputees.⁹

The predominant mechanism of injury leading to combat amputations has been powerful explosive weapons, including improvised explosive devices (IEDs), rocket-propelled grenades (RPGs), mortars, and mines. These weapons cause complicated extremity injuries and comorbidities, such as open fractures, extensive damage to soft tissue, nerves, and arteries, internal bleeding, and traumatic brain injury (TBI). These wounds are often severely contaminated.^{9,10} Unfortunately there are limited data on extremity infections and other complications following battlefield injuries.¹¹

A brief report on 381 recent combat amputees injured in OEF/OIF between 2001 and 2005 summarized patient injuries other than amputation, including 45% with active infections, 39% with other bone fractures, and 41% with other soft tissue injuries.⁹ A study of 187 OEF/OIF amputees found that the blast mechanism of injury and level of amputation relative to injury increased risk for heterotopic ossification (HO), a significant complication in residual limbs.¹² Other studies had limited sample sizes.^{13,14}

Vietnam veterans reported deficits in quality of life as long as 28 years after traumatic amputation.^{15,16} The rate of service discharge among military amputees was 97% in a 1995 study.¹⁷

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However, recent estimates indicate 18% of OEF/OIF amputees returned to active duty (oral communication with Charles Scoville, manager, Army Amputee Care Program). Structured survey studies of civilians with traumatic amputations showed factors (e.g., self-efficacy) associated with improved physical and psychosocial outcome scores but overall long-term outcomes were poor.¹⁸⁻²⁰ Unfortunately, it is difficult to generalize from civilian to military populations because of differences in age, preinjury fitness, mechanisms of injury, exposure to combat environment, and access to advanced military medical care.^{1,2}

Recent studies analyzed warfighters' reports of combat injury and mental health using structured surveys administered during the year after deployment to OEF or OIF.²¹⁻²³ Combat amputees were not analyzed separately. Higher ratings of physical problems 1 month after injury increased odds of post-traumatic stress disorder (PTSD) and depression 7 months after injury.²¹ Survey instruments indicated higher rates of depression, anxiety, or PTSD following deployment in Iraq than in Afghanistan (approximately 16% vs. 11%) or before deployment to Iraq (approximately 9%).²² One study analyzed medical records of mental health diagnoses given to warfighters by providers at level 4 or 5 military care facilities after OEF/OIF. Increased Injury Severity Score (ISS) increased odds of PTSD diagnosis or any mental health diagnosis during the first 2 years following injury.²⁴

Since 2001, the U.S. military has developed a comprehensive amputee care program (ACP) designed to take advantage of the warfighters' youth and preinjury fitness, with access to a team of medical specialists.^{1,2} The ACP addresses individual needs for trauma care, physical medicine and rehabilitation, prosthetics, physical and occupational therapy (PT and OT), mental health care, and planning for discharge or return to duty. There has been little research to follow postinjury care and outcomes of OIF/OEF amputees.⁹ The present study used Department of Defense (DoD) health databases to describe postinjury care, complications, mental health diagnoses, and work outcomes of combat amputees during the first 2 years postinjury. The comprehensive sample consisted of warfighters who had combat-related amputations between 2001 and 2005, and have had 2 or more years to rehabilitate their injuries.

METHODS

Subjects

Subjects were U.S. warfighters in OEF or OIF between 2001 and 2005 who sustained a combat injury causing or leading to a major extremity amputation (i.e., excluding only fingers or toes). Searches of the Career History Archival Medical and Personnel System (CHAMPS) database,²⁵ the Amputee Care Program (ACP) database, and the Navy-Marine Corps Combat Trauma Registry Deployment Health Expeditionary Medical Encounter Database (Navy-MC CTR EMED)²⁶ identified 449 individuals with one or more major extremity amputations caused by combat-related activity through December 2005. Individuals who died of wounds were excluded. Of the 449

amputees, 382 had outcome measures available in CHAMPS, and those 382 were the subjects.

Research Design

This was a retrospective review of existing medical and personnel records approved by our institutional review board. Patients were followed for 24 months postinjury or until their medical records were no longer available in CHAMPS (usually because of military service discharge). Combat amputations typically occurred within days after battlefield injury.⁸ Injuries that occurred during OEF/OIF through December 31, 2005 were included, which allowed at least 24 months of follow-up time for the present study. Civilian studies of short-term outcomes following amputation usually extend 24 months after injury.¹⁸ Outcome measures described standard diagnosis and procedure codes for surgeries and longitudinal changes in complications, mental health diagnoses, and outpatient clinic use.

Data Sources

CHAMPS

This database obtains data from DoD Tricare Management Activity including inpatient and outpatient diagnoses by credentialed providers at military treatment facilities and government reimbursed private clinics. Personnel data came from the Defense Manpower Data Center and the Defense Enrollment Eligibility Reporting System for members of all armed services. These data have supported many epidemiological studies including mental health of warfighters.^{25,27} Specific measures include demographics, accession events, duty station, occupation, service discharge and care at levels 4 and 5 medical facilities, including *International Classification of Diseases*, Ninth Revision (ICD-9) diagnostic and complication codes, surgical procedure codes, disposition codes, medical discharge dates, and outpatient care visits, such as PT and OT, and psychiatric visits.

Amputee Care Program Database

This database contains a list of combat-related military amputees since 2001 including mechanism of injury (e.g., IED, gunshot wound [GSW]), level of amputation (e.g., above elbow), circumstances of injury and postinjury care, and whether the primary amputation occurred before treatment in the United States. This research database is shared by Walter Reed Army Medical Center, National Naval Medical Center Bethesda, Brooke Army Medical Center (BAMC), and Naval Medical Center San Diego.^{1,2}

The 2-year follow-up period in the present study does not represent the time patients participated in ACP rehabilitation. Patients complete the program at different times after injury, most well within 2 years. Virtually all patients received postinjury treatment in the ACP since this is the standard of care for recent combat amputees.^{1,2}

Navy-MC CTR EMED

This database, developed at the Naval Health Research Center (NHRC), includes data from far-forward medical care at levels 1B, 2, and 3, supplemented by data from levels 4 and 5 military medical facilities.²⁶ The Navy-MC CTR EMED and the Joint Theater Trauma Registry (JTTR) provided injury severity scores (ISS).

Anatomic Location of Amputation

The anatomic location of the amputation can be associated with risk of later outcomes.¹⁸ Given the specificity available in the databases, the following locations were included:

- (a) lower extremity—below knee, including foot amputation (BKA).
- (b) lower extremity—above knee, including through the knee and hip disarticulation (AKA).
- (c) upper extremity—below elbow, including wrist amputation (BEA).
- (d) upper extremity—above elbow, including shoulder disarticulation (AEA).

An ISS was also calculated for all patients.²⁸

Demographic and Outcome Variables

These variables were extracted from the databases:

- (1) Age, gender, service branch, marital status, pay grade, and occupational code.
- (2) Subject attrition. The discharge/retirement dates typically document subject attrition. Each amputee's outcomes data usually were available in DoD medical databases as long as the individual remained in military service. Patients sometimes received disability retirement benefits for continued care at military hospitals and their outcomes data were followed after retirement. For these individuals, the date of study attrition represented when patients left the military medical system rather than military retirement.
- (3) Complications. A list of complications developed for the Navy-MC Corps CTR was modified by a research trauma nurse and a combat casualty care physician. Complications were specific to residual limbs and general such as anemia or infections. ICD-9 codes for infections were:
 - Postoperative: 998.5b–998.59
 - Osteomyelitis: 730.0b–730.99
 - Cellulitis: 682.0b–682.99
 - Chronic infection of amputation stump: 997.62
 - Infection/inflammatory due to device: 996.6b–996.69
 - Septicemia: 038.0b–038.99.
 - ICD-9 codes for HO were: 728.10, 728.12, and 728.13.
- (4) Outpatient clinic visits for specialties including PT and OT, psychiatry, orthopedics, and the prosthetic/orthotics lab (P&O lab).

- (5) Traumatic brain injury. An ICD-9 code in the following range within 30 days of injury identified TBI.²⁹
 - 800.00–801.99 (fractures of the vault or base of the skull).
 - 803.00–804.99 (other unqualified and multiple fractures of the skull).
 - 850.00–854.10 (intracranial injury, including concussion, contusion, laceration, and hemorrhage).
- (6) Mental health diagnoses. Mental health diagnoses were indicated by an ICD-9 codes between 290 and 319, excluding 305.10 (tobacco addiction). Diagnoses were grouped as adjustment, anxiety, mood, PTSD and substance abuse disorders, and other mental health diagnoses. A diagnosis of PTSD was an ICD-9 code of 309.81 at least 30 days postinjury. Preinjury mental health diagnoses have been identified as a risk factor for development of later mental health disorders, and were also recorded.

Data Analysis

The data were analyzed by location of amputation (e.g., upper vs. lower limb) and time postinjury. Rates were calculated for the entire follow-up period (i.e., 24 months or until study attrition) and within specific intervals during follow-up such as 3 months (quarters). Individuals coded as discharged from service (i.e., their outcomes data were no longer available) were not counted after the quarter in which they were discharged. The effects of location of amputation (upper vs. lower) on outcomes such as complication rates were tested for statistical significance using χ^2 tests.

RESULTS

The sample ($n = 382$) consisted almost exclusively of men (98.4%, 376 men/6 women), and most amputees were under 30 years of age (mean = 26.0, median = 24.5) and unmarried (61%) at the time of injury. Their service affiliation was predominantly Army (70.4%) followed by Marines (24.6%), Navy (3.1%), and Air Force personnel (1.8%).

Virtually all injuries (91.4%) were caused by explosions or blasts (328 of 359 patients—23 missing), including IEDs, RPGs, mortars, or landmines. Ninety-eight percent of amputees (376 of 382) received diagnosis codes indicating amputation within 1 month of combat injury.

Anatomic Location of Amputation and Injury Severity Score

Three hundred eighty individuals had specific anatomical locations available (Table I). Lower extremity amputees outnumbered upper extremity amputees by a 3:1 ratio. Approximately 15% of the sample (59 of 380) lost more than one limb, consisting of bilateral amputees ($n = 49$) and individuals who lost an upper and a lower limb ($n = 10$).

Table I also shows ISS scores documenting that combat amputees had moderate to serious injuries (i.e., ISS 9 to 15)^{24,28} with the mean and median scores for their amputation and other injuries (e.g., TBI, fractures) between 10 and 23.

TABLE I. Anatomical Location of Amputation for Combat Amputees, 2001–2005 ($n = 382$) and Associated Injury Severity Scores (ISS)

Location	No.	%	Sublocation	No.	%	Mean ISS	Median ISS
Upper Extremity	92	24					
			Above Elbow	37	40	23.1	21
			Below Elbow	49	53	13.3	10
			Bilateral	6	7	23.8	11
Lower Extremity	278	73					
			Above Knee	93	33	18.9	17
			Below Knee	142	51	10.5	10
			Bilateral	43	15	18.4	17
Upper and Lower Extremity	10	3				23.2	21
Not Recorded	2	1				18.0	18

TABLE II. Most Common Complications for Amputee Patients

Complication	Total	%
Any Infection	219	57.3
Phantom Limb Syndrome	212	55.5
Anemia	169	44.2
Postoperative Infection	102	26.7
Osteomyelitis	84	22.0
Cellulitis	69	18.1
Heterotopic Ossification	69	18.1
Amputation Stump Complications	66	17.3
Chronic Infection of Amputation Stump	56	14.7
DVT and/or PE	51	13.4
Pneumonia	47	12.3
Infection/Inflammatory Due to Device	44	11.5
Nonhealing Wound	42	11.0
Septicemia	42	11.0

There was considerable variability between groups. Bilateral, above knee, and above elbow amputees had numerically higher severity scores than below elbow and below knee amputees.

Subject Attrition During Follow-Up

We calculated the percentage of the initial sample of 382 amputees whose outcomes data remained available during consecutive 3-month intervals (quarters). Thereafter, they were lost to follow-up, usually because of service discharge. A total of 94.5% of the sample had outcomes data available through the first 9 months postinjury, 85.3% through 12 months, 69.6% through 15 months, and 32.7% through 24 months.

Complications First Year After Injury

Ninety-four percent of the sample had at least one complication with almost 4 complications per patient (mean = 3.8). Table II shows the 14 most frequent complications, those occurring in at least 10% of the sample. Patients with at least one type of infection, phantom limb syndrome (PLS), and anemia were most common. Four specific types of infections followed. Approximately 13% of patients had deep vessel thrombosis (DVT) and/or pulmonary embolism (PE).

Table III shows the prevalence of complications categorized as infections, stump complications, and other issues. The first 30 days postinjury are critical to recovery and are presented

TABLE III. Percentage of Sample with Specific Complications in the First Year After Injury

Complication	Time Since Injury				
	Within 30 days	1–3 Months	3–6 Months	6–9 Months	9–12 Months
Infections					
Postoperative Infection	16.0	8.2	4.0	3.0	3.1
Osteomyelitis	10.5	9.0	5.6	3.9	3.7
Cellulitis	4.5	3.2	5.1	4.4	1.8
Chronic Infection	6.3	2.1	3.2	1.9	2.5
Infection/Inflammatory Due to Device	6.3	2.7	3.0	2.2	0.9
Septicemia	9.7	1.9	1.1	0.0	0.0
Stump Complications					
Phantom Limb Syndrome	25.1	25.8	19.6	11.4	8.9
Heterotopic Ossification	2.4	2.4	7.3	7.8	5.5
Amputation Stump	2.9	4.0	5.9	3.6	4.0
Nonhealing Wound	6.0	5.1	3.0	0.8	0.6
Other					
Anemia	40.3	3.7	1.3	0.0	1.2
Pneumonia	8.9	4.0	0.5	0.0	0.0

separately from the second 60 days. Subsequent intervals or quarters are 90 days. The highest rates occurred during the first 30 days postinjury for 8 of the 12 complication types and particularly for infections, even when compared with the longer intervals of 60 to 90 days thereafter. Stump complications were the exception: the rates for three of four types of stump complications increased sometime after the first 30 days. Most notable was HO, which had the lowest rate of all leading complications during the first 30 days (2.4%) and increased to the second-highest rate for 3 to 6 months (7.3%) and 6 to 9 months (7.8%) after injury. Rates for 5 of 7 infectious complications including pneumonia decreased by about one-half or more soon after the first 30 days.

Complications in Upper/Lower Extremity Amputees

Lower extremity amputees had more complications per patient (4.15) than upper extremity amputees (2.77), approximately a 50% increase among lower limb amputees. The lower and

upper groups included single and bilateral amputees. Table IV presents the lower/upper effect by specific complications. The lower to upper ratio in the far right-hand column shows the magnitude of this effect and statistical significance level, if any. All complications showed numerically increased rates in lower vs. upper extremities. Statistically significant lower/upper ratios included chronic, postoperative infections and osteomyelitis. Stump complications including HO had significantly higher rates among lower than upper limb amputees. However, the rates of pneumonia, PLS, and anemia did not significantly differ between upper and lower amputees.

Traumatic Brain Injury

One hundred eleven of 382 amputee patients (29%) had a TBI or head concussion diagnosis. Eighty-four of 382 patients (22%) had these diagnoses within 30 days of injury.

Mental Health Disorders

Almost two-thirds of amputees had at least one mental health diagnosis (Table V, left panel). Diagnoses in the major disorder

categories (adjustment, anxiety, mood, and PTSD) occurred in 18% to 25% of patients. The exception was substance abuse (6%) such as alcohol and other drugs. There were no significant differences between upper and lower extremity amputees. PTSD was the most prevalent specific diagnosis, followed by acute stress reaction and depressive disorder. Depressive disorder accounted for over three-quarters of all mood disorders diagnosed. The most prevalent other mental health diagnoses were cognitive disorder not otherwise specified, postconcussion syndrome, sleep, and pain disorders (Table V). Finally, there were 36 preinjury compared with 527 postinjury diagnoses. One-third of all preinjury diagnoses (12 of 36) showed a reoccurrence postinjury.

The onset of mental health disorders generally occurred within the first few months after injury (Table V). The onset for most disorders was two to three times more likely during the first quarter than the second quarter of follow-up. The increase in PTSD onset between the first and second quarters was biased somewhat because PTSD diagnoses by definition occur 30 days postinjury or later.

TABLE IV. Comparison of Complications in Upper and Lower Limb Amputees

Complication	Lower Extremity	Upper Extremity	Lower Extremity	Upper Extremity	Lower to Upper
	No.	No.	% of Patients	% of Patients	Ratio
Infections					
Postoperative Infection	83	17	30	18	1.62*
Osteomyelitis	73	9	26	10	2.68**
Cellulitis	55	11	20	12	1.65
Chronic Infection, Amputation Stump	52	2	19	2	8.60**
Infection/Inflammatory Due to Device	35	8	13	9	1.45
Septicemia	31	7	11	8	1.47
Stump Complications					
Phantom Limb Syndrome	157	49	56	53	1.06
Heterotopic Ossification	55	9	20	10	2.02*
Amputation Stump Complications	56	9	20	10	2.06*
Nonhealing Wound	34	6	12	7	1.88
Other					
Anemia	129	35	46	38	1.22
Pneumonia	36	11	13	12	1.08

χ^2 significance levels: * $p < 0.05$; ** $p < 0.01$. Calculations based on 278 lower extremity amputees and 92 upper extremity amputees.

TABLE V. Overall Rates of Mental Health Disorders for Combat Amputees and Rates of New Cases During the First Four Quarters Postinjury

	Total	%	Q1	Q2	Q3	Q4
Total Patients in System	382		376	372	361	326
PTSD	69	18.1	3.2%	7.2%	3.4%	2.4%
Adjustment Disorders	93	24.3	13.0%	4.6%	4.0%	3.0%
Anxiety Disorders	97	25.4	14.4%	6.0%	3.1%	0.8%
Mood Disorders	78	20.4	6.9%	6.6%	2.5%	3.5%
Substance Abuse Disorders	23	6.0	1.9%	0.8%	0.9%	1.3%
Other MH Disorders ^a	167	43.7	25.3%	7.9%	8.0%	6.2%
Cognitive Disorder NOS	42	11.0				
Postconcussion Syndrome	31	8.1				
Nonorganic Sleep Disorder	26	6.8				
Psychogenic Pain	22	5.7				

Quarterly rates may sum to exceed overall rates due to decreasing sample sizes/denominators with subject attrition. PTSD, post-traumatic stress disorder; MH, mental health.

^aOther MH disorders include: cognitive disorder not otherwise specified (NOS), postconcussion syndrome, nonorganic sleep disorders, psychogenic pain.

Outpatient Clinic Use Rates

Over two-thirds of amputees used the PT (93%), OT (89%), prosthetic/orthotic lab (P&O lab) (85%), psychiatric (83%), and orthopedic clinics (73%), at least once. Other clinics (orthopedic ward, pain management, burn unit) were used by fewer than half of the patients. Among users, the mean number of clinic visits ranked the same as use rates, ranging from 90 (PT), 35 (OT), 23 (P&O lab), 21 (psychiatric), to 3 (pain clinic) with the exception of the burn unit (44). Figure 1 shows use rates for upper and lower limb amputees during the first year for the most frequently used clinics, namely PT, OT, orthotic lab, and psychiatric clinic. Use rates for all clinics were highest during the first few months and declined thereafter. PT and P&O lab had higher use rates among lower than upper extremity amputees, particularly later in the first year after injury. In contrast, OT use rates were higher among upper than lower extremity amputees, and this trend increased after the first few months. There were no substantial differences in psychiatric clinic use between upper and lower limb amputees.

Occupation and Marital Outcomes

Nearly 40% of amputees had a promotion or increase in pay grade at some point following their injury. Only one individual received a demotion.

Before deployment, 60% (231 of 382) of subjects were not married and 36% (137 of 382) were married (14 had no marital data). Following injury, 13% (43 of 382) of amputees had some change in marital status. Of those who were previously unmarried, 15% married (35 of 231) and of those who were previously married, 6% divorced (8 of 137).

DISCUSSION

This study provides one of the first objective descriptions of health and work outcomes of OEF/OIF combat amputees using a comprehensive sample⁹ including clinically documented amputations and injury severity scores. The results showed a complex set of outcomes based on provider diagnoses of infectious complications and/or mental health disorders, most occurring within 30 to 90 days after injury. Use of outpatient clinics such as PT and OT and psychiatric care was also relatively high soon after injury. Upper and lower limb amputees differed in their risk of some physical complications and in their use of rehabilitation therapies but showed similar rates of mental health disorders. Some outcomes persisted or increased after the first 90 days, including complications of residual limbs (PLS, HO) and PTSD. The complex nature of the combat amputee outcomes described in this study supports

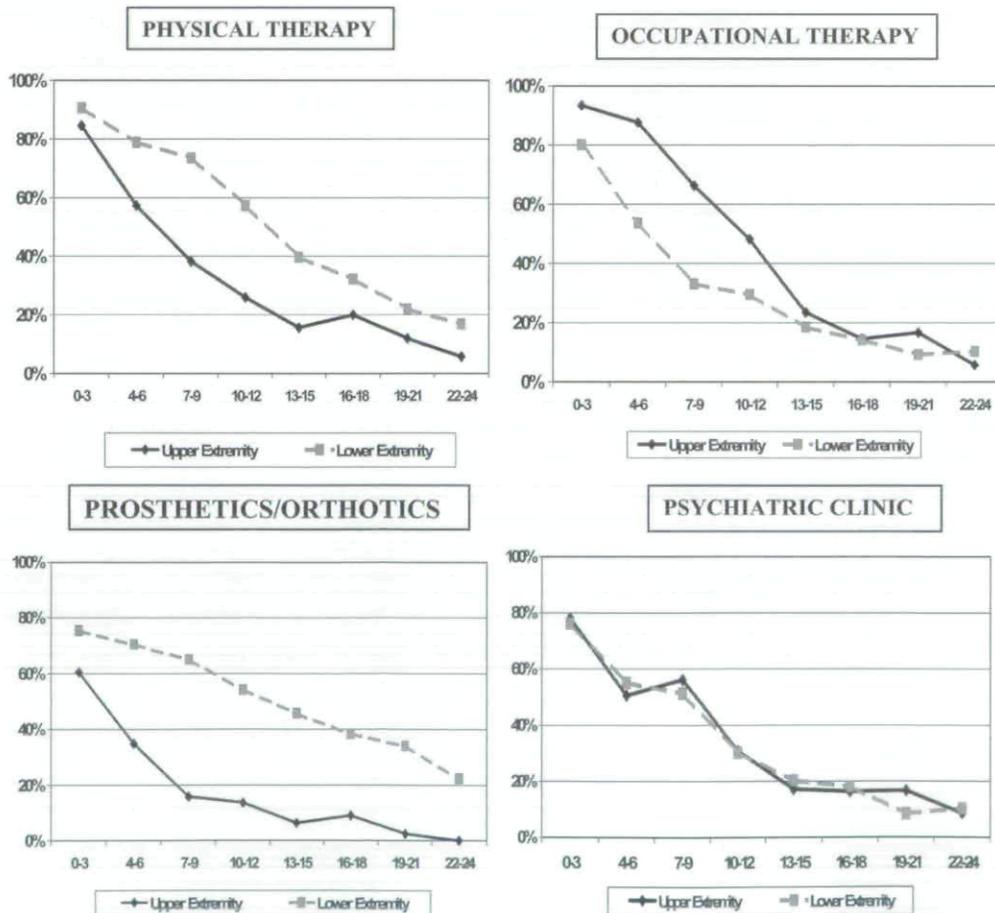


FIGURE 1. Clinic use rates among amputees during consecutive 3-month intervals (quarters) during follow-up.

the relevance and continued need for ACPs at military treatment facilities.

Previous studies of OEF/OIF casualties focused on wounding patterns, with sparse data on complications.^{10,12,30,31} In the present study, infections, such as cellulitis and osteomyelitis, ranked among the most common complications. The osteomyelitis rate was 22% for amputees, slightly higher than 15% in a previous study of OIF/OEF orthopedic patients.³² Both studies found higher rates among lower than upper extremity cases.³² Overall, 57% of combat amputees had at least one type of infection, slightly higher than the 45% in the only previous study.⁹ Infection rates for moderate to serious extremity injuries among civilians have ranged from 25% to 50%.^{11,31} The rates of other complications among amputees are consistent with previous reports³³ (e.g., PLS). The increase in HO rate after the first few months is also consistent with previous studies.³⁴ HO can interfere with prosthetic use by combat amputees.¹² Civilian limb salvage patients had a higher risk of additional surgeries, complications, and rehospitalizations than amputees,¹⁸ but these results may differ for combat amputee vs. limb salvage patients.

The rate of mental health diagnoses among amputees was 66%, slightly higher than 58% previously reported among warfighters with moderate to serious battle injuries (ISS > 9).^{24,28} Anxiety and adjustment disorders showed the highest rates, with new cases occurring relatively soon postinjury. Nearly half of combat amputees had other mental health diagnoses including cognitive, postconcussion, pain and sleep disorders, which also had high rates of new cases early postinjury. This latter finding may be caused by the transient effects of blast injury, and further study can determine whether these other disorders persist more than a few months postinjury. The PTSD diagnosis rate of 18.1% was lower than the rates of anxiety, adjustment, and mood disorders among combat amputees, and also relative to PTSD rates reported in survey studies.²² Surveys indicated overall rates of PTSD between 11% and 20%, and PTSD risk increased as much as three times among those who reported being wounded.²² It is difficult to generalize from survey studies to those using provider diagnoses.^{27,35} Surveys are anonymous and healthcare diagnoses are not. Combat amputees received programmed medical and peer support through the ACP, which might have mitigated mental health issues.^{1,2} Further study can determine whether risk of the above-mentioned mental health outcomes among combat amputees differs from warfighters with polytrauma or minor injuries.

Combat amputees used several outpatient clinic specialties at relatively high rates, particularly soon after injury. Lower limb amputees used PT and P&O services at higher rates than did upper limb amputees, especially later in the first year after injury. Upper limb amputees had higher OT rates than lower limb amputees, also later in the first year. These differences are expected for lower or upper limb amputees, respectively.^{1,2,36} Providers might consider the benefits

of encouraging PT and OT use, as appropriate, later in the first year after injury.

The rate of psychiatric clinic use soon after injury (approximately 80% of amputees) coincides with a high rate of mental health diagnoses during the first 3 to 6 months. Surveys showed that 23% to 40% of OIF/OEF warfighters who screened positive for mental health disorders sought professional help.²² Psychological disorders can persist or their onset might be delayed long after combat injury.^{37,38} Only one-third of amputees were using the psychiatric clinic 1 year after injury, suggesting the need for long-term mental health surveillance. Use of the pain management clinic appeared low considering prolonged recovery with pain is characteristic of severe combat injuries.^{1,2} Pain management is routinely conducted by physical medicine and rehabilitation physicians in the ACP. Therefore, these patients typically receive pain management care as appropriate, most without visiting the pain management clinic.

The strengths of this study are a comprehensive sample of OEF/OIF combat amputees injured between 2001 and 2005 and use of objective DoD health and personnel databases of standard medical procedure and diagnosis codes made by credentialed providers to document patient care. The sample size of 382 represents virtually all major combat amputees between 2001 and 2005.⁸ Many findings are consistent with previous literature (e.g., rates of PLS, HO, infections, osteomyelitis, and PT/OT use).^{9,11,24,31-34}

The study limitations included a relatively short follow-up period because of patient discharge from military service. Almost 90% of the sample remained available for 1 year postinjury. However, study attrition was 50% by the middle of the second year, reducing effective sample size. Importantly, the essential results for physical complications, mental health disorders, and clinic use occurred within the first year postinjury. The high rates of diagnoses and treatments during the first few months after injury might be increased by intensive patient evaluation by clinicians. The ACP ensures that combat amputees receive proactive multidisciplinary care, including trauma, PT and OT, and psychiatric review following injury.^{1,2,9} Another limitation might be under-reporting of some diagnoses by providers such as DVT/PE in 13% of combat amputees vs. 22% in a previous report.³⁹ However, in the present study DVT/PE ranked among the most common complications. The TBI rate for combat amputees was 22% vs. 59% among OEF/OIF warfighters who suffered blast injuries.⁴⁰ However, approximately 75% of the present patients were lower extremity amputees, possibly explaining their low TBI rate.

The present approach may be relevant for evaluation of the ACP, with appropriate comparison groups. Program descriptions call for a range of outcome measures to evaluate ACP effectiveness.^{1,2} Objective health care diagnoses can be obtained from research databases longitudinally for large samples without imposing on patients. This could help validate self-reported mental health information and document surgeries, medications, and complications.

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REFERENCES

- Pasquina PF, Bryant PR, Huang ME, Roberts TL, Nelson VS, Flood KM: Advances in amputee care. *Arch Phys Med Rehabil* 2006; 87(3, Suppl 1): S34-43.
- Gajewski D, Granville R: The United States Armed Forces Amputee Patient Care Program. *J Am Acad Orthop Surg* 2006; 14(10, Suppl): S183-7.
- Masini BD, Waterman SM, Wenke JC, Owens BD, Hsu JR, Ficke JR: Resource utilization and disability outcome assessment of combat casualties from Operation Iraqi Freedom and Operation Enduring Freedom. *J Orthop Trauma* 2009; 23: 261-6.
- Gunawardena NS: Functional outcomes of unilateral lower limb amputee soldiers in two districts of Sri Lanka. *Mil Med* 2006; 171(4): 283-7.
- McCarthy ML, MacKenzie EJ, Edwin D, et al: Psychological distress associated with severe lower-limb injury. *J Bone Joint Surg Am* 2003; 85A(9): 1689-97.
- Rybarczyk B, Szymanski L, Nicholas JJ: Limb amputation. In: *Handbook of Rehabilitation Psychology*, pp 29-38. Edited by Frank RG, Elliot TR. Washington, DC, American Psychological Association, 2000.
- Fischer H: CRS report for Congress: Operation Iraqi Freedom and Operation Enduring Freedom. Knowledge Services Group, the Library of Congress. Available at <http://www.fas.org/spp/crs/natsec/RS22452.pdf>; accessed July 28, 2008.
- Stansbury LG, Lalliss SJ, Branstetter JG, Bagg MR, Holcomb JB: Amputations in U.S. military personnel in the current conflicts in Afghanistan and Iraq. *J Orthop Trauma* 2008; 22: 43-6.
- Potter BK, Scoville CR: Amputation is not isolated: an overview of the U.S. Army Amputee Care Program and associated amputee injuries. *J Am Acad Orthop Surg* 2006; 14: S188-90.
- Covey D, Aaron RK, Born CT, et al: Orthopedic war injuries: combat casualty to definitive treatment: a current review of clinical advances, basic science and research opportunities. *Instr Course Lect* 2008; 57: 65-86.
- Murray CK, Hsu JR, Solomkin JS, et al: Prevention and management of infections associated with combat related extremity injuries: Clinical Practice Guidelines Consensus Conference. *J Trauma Inj Infect Crit Care* 2008; 64(3, Suppl): S239-51.
- Potter BK, Burns TC, Lacap AP, Granville RR, Gajewski DA: Heterotopic ossification following traumatic and combat-related amputations: prevalence risk factors and preliminary results of excision. *J Bone Joint Surg Am* 2007; 89-A(3): 476-86.
- Lin DL, Kirk KL, Murphy KP, McHale KA, Doukas W: Evaluation of orthopedic injuries in Operation Enduring Freedom. *J Orthop Trauma* 2004; 18(8): S48-53.
- Anderson RC, Frisch M, Farber GL, Hayda RA: Definitive treatment of combat casualties at military medical centers. *J Am Acad Orthop Surg* 2006; 14: S24-31.
- Dougherty PJ: Long-term follow-up of unilateral transfemoral amputees from the Vietnam War. *J Trauma* 2003; 54: 718-23.
- Dougherty PJ: Transtibial amputees from the Vietnam War: 28-year follow-up. *J Bone Joint Surg Am* 2001; 83: 383-9.
- Kisbaugh D, Dillingham TR, Howard RS, Sinnot MW, Belandes PS: Amputee soldiers and their return to active duty. *Mil Med* 1995; 160: 82-4.
- Bosse MJ, MacKenzie EJ, Kellam JF, et al: An analysis of outcome of reconstruction or amputation of leg-threatening injuries. *N Engl J Med* 2002; 347: 1924-31.
- MacKenzie EJ, Bosse MJ, Pollak AN, et al: Long-term persistence of disability following severe lower-limb trauma: results of a seven-year follow-up. *J Bone Joint Surg Am* 2005; 87A(8): 1801-9.
- Pezzin LE, Dillingham TR, MacKenzie EJ: Rehabilitation and the long-term outcomes of persons with trauma-related amputations. *Arch Phys Med Rehabil* 2000; 81: 292-300.
- Grieger TA, Cozza SJ, Ursano RJ, et al: Posttraumatic stress disorder and depression in battle-injured soldiers. *Am J Psychol* 2006; 163: 1777-83.
- Hoge CW, Castro CA, Messer SC, McGurk D, Cotting DI, Koffman RL: Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. *N Engl J Med* 2004; 351(1): 13-22.
- Hoge CW, McGurk D, Thomas JL, Cox AL, Engel CC, Castro CA: Mild traumatic brain injury in US soldiers returning from Iraq. *N Engl J Med* 2008; 358: 453-63.
- MacGregor AJ, Corson KS, Shaffer RS, et al: Psychological correlates of battle and nonbattle injury among Operation Iraqi Freedom veterans. *Mil Med* 2009; 174: 224-31.
- Gunderson E, Garland CF, Miller MR, Gorham ED: Career History Archival Medical and Personnel System. *Mil Med* 2005; 170(2): 172-5.
- Galarneau MR, Hancock WC, Konoske P, et al: The Navy-Marine Corps Combat Trauma Registry. *Mil Med* 2006; 171(8): 691-7.
- Larson GE, Highfill-McRoy RM, Booth-Kewley S: Psychiatric diagnoses in historic and contemporary military cohorts: combat deployment and the healthy warrior effect. *Am J Epidemiol* 2008; 167(11): 1269-76.
- Copes WS, Champion HR, Sacco WJ, Lawnick MM, Keast SL, Bain LW: The injury severity score revisited. *J Trauma* 1998; 28: 69-77.
- Centers for Disease Control and Prevention: Traumatic brain injury in the United States: a report to Congress. Available at http://www.cdc.gov/ncipc/tbi/tbi_congress/05_references_appendix.pdf; accessed October 15, 2008.
- Zouris JM, Walker JG, Dye JL, Galarneau MR: Wounding patterns for US Marines and sailors during Operation Iraqi Freedom, major combat phase. *Mil Med* 2006; 171(3): 246-52.
- Hospenthal DR, Murray CK, Andersen RC, et al: Guidelines for prevention of infection after combat related injuries. *J Trauma Inj Infect Crit Care* 2008; 64: S211-20.
- Yun HC, Branstetter JG, Murray CK: Osteomyelitis and military personnel wounded in Iraq and Afghanistan. *J Trauma Inj Infect Crit Care* 2008; 64: S163-8.
- Ketz AK: Pain management in the traumatic amputee. *Crit Care Nurs Clin North Am* 2008; 20: 51-7.
- Balboni TA, Gobeze R, Mamon HJ: Heterotopic ossification: pathophysiology, clinical features, and the role of radiotherapy for prophylaxis. *Inter J Radiat Oncol Biol Phys* 2006; 65: 1289-1299.
- Toomey R: Invited commentary: how healthy is the "healthy warrior"? *Am J Epidemiol* 2008; 167(11): 1277-80.
- Smurr LM, Gulick K, Yoncosek K, Ganz O: Managing the upper extremity amputee: a protocol for success. *J Hand Ther* 2008; 21: 160-76.
- Starr AJ, Smith WR, Frawley WH, et al: Symptoms of posttraumatic stress disorder after orthopedic trauma. *J Bone Joint Surg Am* 2004; 86A(6): 1115-21.
- Dohrenwend BP, Turner JB, Turse NA, Adams BG, Koenen KC, Marshall R: The psychological risks of Vietnam for US veterans: now revisited with new data and methods. *Science* 2006; 313: 979-82.
- Franklin A, Pasquina PF, Luu V, Scoville C, Doukas W: The incidence of deep venous thrombosis and pulmonary embolism in the combat amputee. *Arch Phys Med Rehabil* 2006; 87: E30.
- Okie S: Traumatic brain injury in the war zone. *N Engl J Med* 2005; 352: 2043-7.

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