



Characterisation and outcomes of upper extremity amputations[☆]



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ABSTRACT

Background: The purpose of this study is to characterise the injuries, outcomes, and disabling conditions of the isolated, combat-related upper extremity amputees in comparison to the isolated lower extremity amputees and the general amputee population.

Methods: A retrospective study of all major extremity amputations sustained by the US military service members from 1 October 2001 to 30 July 2011 was conducted. Data from the Department of Defense Trauma Registry, the Armed Forces Health Longitudinal Technology Application, and the Physical Evaluation Board Liaison Offices were queried in order to obtain injury characteristics, demographic information, treatment characteristics, and disability outcome data.

Results: A total of 1315 service members who sustained 1631 amputations were identified; of these, 173 service members were identified as sustaining an isolated upper extremity amputation. Isolated upper extremity and isolated lower extremity amputees had similar Injury Severity Scores (21 vs. 20). There were significantly more non-battle-related upper extremity amputees than the analysed general amputation population (39% vs. 14%). Isolated upper extremity amputees had significantly greater combined disability rating (82.9% vs. 62.3%) and were more likely to receive a disability rating >80% (69% vs. 53%). No upper extremity amputees were found fit for duty; only 12 (8.3%) were allowed continuation on active duty; and significantly more upper extremity amputees were permanently retired than lower extremity amputees (82% vs. 74%). The most common non-upper extremity amputation-related disabling condition was post-traumatic stress disorder (PTSD) (17%). Upper extremity amputees were significantly more likely to have disability from PTSD, 13% vs. 8%, and loss of nerve function, 11% vs. 6%, than the general amputee population.

Discussion/conclusion: Upper extremity amputees account for 14% of all amputees during the Operation Enduring Freedom and Operation Iraqi Freedom conflicts. These amputees have significant disability and are unable to return to duty. Much of this disability is from their amputation; however, other conditions greatly contribute to their morbidity.

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Background

Extremity injury in the military during Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) has caused significant mortality and morbidity. Belmont et al. [1] found the rate of musculoskeletal injury needing evacuation from the “combat environment” to be 77%, 6% of which were extremity

amputation. Numerous studies have analysed the injury patterns and amputation rates of injured service members [1–11]. However, the current literature does not adequately address the characteristics of or impact of disability associated with upper extremity amputation on the individual service members.

Upper extremity amputations in OIF/OEF represent 14–50% of all amputations returning from the “combat environment,” causing significant long-term functional impairment and disability [5,7,12]. In an analysis of service members’ disability ratings by Cross et al. [2], upper extremity amputations were associated with the highest disability ratings. However, the injuries, outcomes, and disabling conditions of the isolated, combat-related upper extremity amputees, in comparison to the isolated lower extremity amputees and the general amputee population have not been analysed. The purpose of this study is to more closely characterise the injuries, outcomes, and disabling conditions of isolated,

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14. ABSTRACT

Background: The purpose of this study is to characterise the injuries, outcomes, and disabling conditions of the isolated, combat-related upper extremity amputees in comparison to the isolated lower extremity amputees and the general amputee population. **Methods:** A retrospective study of all major extremity amputations sustained by the US military service members from 1 October 2001 to 30 July 2011 was conducted. Data from the Department of Defense Trauma Registry, the Armed Forces Health Longitudinal Technology Application, and the Physical Evaluation Board Liaison Offices were queried in order to obtain injury characteristics, demographic information, treatment characteristics, and disability outcome data. **Results:** A total of 1315 service members who sustained 1631 amputations were identified; of these, 173 service members were identified as sustaining an isolated upper extremity amputation. Isolated upper extremity and isolated lower extremity amputees had similar Injury Severity Scores (21 vs. 20). There were significantly more non-battle-related upper extremity amputees than the analysed general amputation population (39% vs. 14%). Isolated upper extremity amputees had significantly greater combined disability rating (82.9% vs. 62.3%) and were more likely to receive a disability rating >80% (69% vs. 53%). No upper extremity amputees were found fit for duty; only 12 (8.3%) were allowed continuation on active duty; and significantly more upper extremity amputees were permanently retired than lower extremity amputees (82% vs. 74%). The most common non-upper extremity amputation-related disabling condition was post-traumatic stress disorder (PTSD) (17%). Upper extremity amputees were significantly more likely to have disability from PTSD, 13% vs. 8%, and loss of nerve function, 11% vs. 6%, than the general amputee population. **Discussion/conclusion:** Upper extremity amputees account for 14% of all amputees during the Operation Enduring Freedom and Operation Iraqi Freedom conflicts. These amputees have significant disability and are unable to return to duty. Much of this disability is from their amputation; however, other conditions greatly contribute to their morbidity.

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combat-related upper extremity amputees, in comparison to the isolated lower extremity amputees and the general amputee population.

Methods

Using a protocol approved by our Institutional Review Board, all amputations sustained by the US military service members from 1 October 2001 to 30 July 2011 were examined. Service members were from the United States Army (USA), the United States Air Force (USAF), the United States Marine Corps (USMC), and the United States Navy (USN). This query identified 1315 service members who had sustained 1631 amputations. A total of 94 amputees did not have primary, major extremity amputations (MEAs) and were excluded from further analysis. Consequently, 1221 amputees were included in our analysis. Amputation patterns were classified based on the level of their amputations. Specifically, an upper extremity amputation includes all upper extremity amputation subtypes ranging from wrist disarticulation to shoulder disarticulation, but excluding isolated digital amputations. Of these 1221 MEAs, 173 service members were identified as sustaining an upper extremity amputation without associated lower extremity amputation. This cohort was cross-referenced with the Department of Defense Trauma Registry (DoDTR, Joint Base Fort Sam Houston, TX, USA), the Armed Forces Health Longitudinal Technology Application, and each service's Physical Evaluation Liaison Office database (PEB) in order to obtain injury characteristics, demographic information, further treatment characteristics, and outcome data.

The PEB is a group of medical and military personnel who evaluate injured service members in order to assess their ability to return to duty versus being medically retired from service. If a service member is physically able to perform all or some of his or her military duties, the PEB will determine if he or she is fully fit for duty (FIT) or eligible for continuation on active duty (COAD) in a limited capacity or under a new occupational role. If a disability due to the injury, also called an unfitting condition, persists that prevents the service member from performing military duty, the PEB then determines if he or she needs to be placed on Temporarily Disabled Retired List (TDRL), Permanently Retired (PR), or should be separated with severance pay without disability pay (SWSP). The PEB uses a 75% disability rating in order to qualify a service member as being fully disabled [13]. Although the demands of combat service members are much greater than the majority of the general population, these determinations provide the relative civilian equivalent of disability and an individual's ability to return to work.

For service members who are placed on TDRL, PR, or SWSP, the unfitting conditions which preclude their return to active duty are also enumerated by the PEB. Each unfitting condition is assigned a disability rating which is reflected as a percentage. The higher the rating the more severely the condition detracts from the service member's ability to perform his or her military occupation. The

Table 1

Cohort demographics for US service members with isolated major extremity amputations.

	Upper extremity amputees	Lower extremity amputees
N	225	1007
Mean age	24	25
% Male	98%	98%
Median rank	E4	E4
% Enlisted	94%	93%
Mean ISS	21	20

Table 2

Isolated upper extremity amputation level.

Total amputations	173
Wrist disarticulation	23 (13%)
Trans-radial	82 (47%)
Elbow disarticulation	2 (1%)
Transhumeral	59 (34%)
Shoulder disarticulation	7 (4%)

separate disability ratings for each unfitting condition are combined using a specific method to yield each service member's total disability rating.

The disabling conditions identified, total disability and occupational outcome determination assigned by the PEB were then analysed. The impact of each disabling condition was determined by multiplying the average disability assigned for each condition by the frequency of each disabling condition as previously done by Cross et al. [2] Fischer's exact test was used to analyse categorical data and a Student's *t*-test was used to analyse continuous data. The *p* value was set at 0.05.

Results

There were 1003 isolated lower extremity amputees, 225 amputees with at least one upper extremity amputation, and 162 isolated unilateral upper extremity amputees identified. The cohort demographics can be seen in Table 1. There were 11 (7%) isolated bilateral upper extremity amputees. Trans-radial amputations were the most common upper extremity amputation levels (82, 47%) and elbow disarticulations were the least common (2, 1%) (Table 2). The Injury Severity Score (ISS) between the isolated upper extremity and isolated lower extremity amputees was similar (21 vs. 20, $p = 0.19$). Upper extremity amputations were most commonly caused by explosions (197, 92.1%), motor vehicle crash (98, 3.4%), and penetrating gunshot wounds (7, 3.3%). Following this trend, lower extremity amputations were most commonly caused by explosions (936, 93.3%), motor vehicle crashes (13, 1.3%), and gunshot wounds (38, 3.79%). The isolated upper extremity amputees had significantly greater combined disability scores (mean: 82.9 vs. 62.3, $p < 0.0001$) and were given higher disability determinations (69% vs. 53%, $p = 0.0004$) than the

Table 3

Return to duty physical examination board (PEB) determinations.

	Total with final PEB status	PR/PDRL ^a	TDRL ^b	COAD ^c	Fit ^d	Sep w/Sev ^e
UE amputees	145 (90%)	119 (82%)	13 (9%)	12 (8%)	0 (0%)	1 (1%)
LE amputees	733 (73%)	540 (74%)	93 (13%)	63 (9%)	16 (2%)	21 (3%)

UE, upper extremity; LE: lower extremity.

^a PR/PDRL, permanently retired, permanently disability retired list.

^b COAD, continuation on active duty.

^c TDRL, temporarily disabled retired list.

^d Fit, fit for duty.

^e Sep w/Sev, separated with severance pay, no disability benefits.

Table 4
Impact of disabling conditions among US service members sustaining an upper extremity amputation.

	Disabling condition	Frequency	Percentage (%)	Avg disability	Impact ^a
1	Upper extremity amputation	132	76.30	75	9900
2	Post-traumatic stress disorder**	30	17.34	42	1260
3	Loss of function of a major nerve***	21	12.14	30	630
4	Facial injury	15	8.62	32	480
5	Loss of hand function	18	10.40	25	450
6	Scar to an extremity	18	10.40	25	450
7	Traumatic brain injury	16	9.25	23	368
8	Degenerative arthritis/decreased joint range of motion	18	10.40	17	306
9	Muscle injury	11	6.36	25	275
10	Eye injury	7	4.05	33	231

^a Impact = average disability × frequency of disabling characteristic.

** UE amputees significantly more likely to have PTSD than the general amputee population ($p=0.0222$).

*** UE amputees significantly more likely to have loss of function of a major nerve than the general amputee population ($p=0.0297$).

isolated lower extremity amputees. The upper extremity amputees were more likely to be permanently retired than the isolated lower extremity amputees (83% vs. 74%, $p=0.026$). No upper extremity amputees were found FIT and only 12 (8.3%) were allowed COAD (Table 3). The most impactful non-upper extremity amputation-related disabling conditions for the upper extremity amputees were post-traumatic stress disorder (PTSD) (17%, impact = 1260), loss of nerve function (12%, impact = 630), and facial injuries (7%, impact = 480) (Table 4). The upper extremity amputees were also significantly more likely to have disability from PTSD ($p=0.02$) and loss of nerve function ($p=0.03$) than the general amputee population.

Discussion

Several studies have characterised injury trends, amputation characteristics, and overall disability in the military population since the beginning of OIF/OEF [1–12]. The majority of literature has focused primarily on the characteristics, treatment, and disability associated with severe lower extremity trauma and amputations. However, upper extremity amputations account for nearly one-fifth of all amputations in the amputation cohort studied and have not been well characterised. The purpose of this study is to better characterise these upper extremity amputees and their disabling characteristics in comparison to the isolated lower extremity amputees and the general amputee population. This study provides the largest analysis of upper extremity amputees, to date.

The overall upper extremity amputation rate in this cohort was 14%. This rate is lower than the previous reports regarding wartime injury patterns. Dougherty et al. [10] found the rate of upper extremity amputations to be 50% among all extremity amputations seen at Naval and Marine treatment facilities during a 1-year period. In more inclusive studies regarding military amputations, Stansbury et al. [5] and Stinner et al. [7] found the rate of upper extremity amputations to account for approximately 25% and 22%, respectively. Furthermore, this study showed similar rates of trans-radial amputations as previously reported by Stansbury et al. [5]. This study incorporated data from multiple databases designed to track injury characteristics at multiple echelons of care and treatment facilities. Consequently, we were able to capture a greater number of total amputees than previously reported. The more inclusive nature of this report may account for the lower rate of upper extremity amputations. Furthermore, this lower rate may represent changes in injury patterns over time or improvements with the protective gear donned by service members.

In previous studies characterizing wartime injuries, improvised explosive devices (IEDs) were responsible for approximately

75–78% of all injuries [4,11]. In this cohort, 92% of all upper extremity amputations compared to 93% of lower extremity amputations were caused by explosive mechanisms. Furthermore, when compared to isolated lower extremity amputees, the ISS of upper and lower extremity amputees were similar (21 vs. 20) and both upper and lower extremity amputees were predominately enlisted males in their mid-twenties. These similarities suggest injury patterns of similar overall severity in relatively equivalent populations. This allows for more valid conclusions to be made regarding the relative morbidity associated with upper versus lower extremity amputations and their overall outcomes.

The PEB assigned 119 (82%) upper extremity amputees determinations of permanent retirement, 8 (12%) were allowed to continue on active duty, and none were permitted to return to full duty. This is in contrast to prior reports that showed a return to duty rate of approximately 17–22% depending on amputation level and a return to duty rate of 18–25% depending on amputation level for isolated lower extremity amputees [7]. The increased disability rating with upper extremity amputees compared with lower extremity amputees may be secondary to increased challenge performing activities of daily living without the use of the service member's hands, and due to the reported increased difficulty with the use of upper extremity prosthetics [14–16]. There may also be a prevailing perception that lower extremity amputees have higher functional abilities as many of these individuals are able to return to a high level of function with the current lower extremity prosthetics and rehabilitation processes [16–22].

Upper extremity amputations were associated with higher disability ratings and higher rates of full disability. Isolated upper extremity amputees received a final disability rating of 83% while lower extremity amputees received a disability rating of only 62%. This is consistent with the findings of Cross et al. [2], who found that upper extremity amputations were associated with the highest percentage of disability (72%) in soldiers presenting to the PEB. Furthermore, in this study, 69% of all upper extremity amputees were considered fully disabled with an average total disability rating of 83%. This difference likely represents differences in current rehabilitative processes and greater long-term functional impairments with the current upper versus lower extremity prosthetic options.

This study further found that in those amputees with isolated upper extremity amputations, PTSD carried the second highest average total disability and disability impact scores. The profound disability that PTSD carries with amputees has been well documented in prior studies and is consistent with the findings of this study [23–25]. At the time of evaluation at the PEB, a diagnosis of PTSD was found in 13% and 17% of all upper extremity and isolated upper extremity amputees, respectively. PTSD was the second highest rated disability among all isolated upper extremity

amputees. This incidence is less than the previous reports of posttraumatic stress in civilian and military traumatic amputees [16,23,24]. This difference may be secondary to posttraumatic stress being diagnosed after the time of PEB hearing and discharge from service, and differences in baseline overall population demographics and initial injury mechanisms. Furthermore, the high incidence of PTSD could partially reflect the prominence of PTSD in upper extremity amputees compared to the general amputee population.

Although this study characterises a highly specialised cohort, the major strength of this study is its size as it is the largest cohort of upper extremity amputees that has been characterised to date. Military injury patterns can be vastly different from their civilian equivalents due to the high-energy nature of their mechanisms. However, as trauma patients frequently suffer high-energy injuries, this study can help providers counsel their patients with traumatic high-energy amputations.

The foremost limitation of this study is its retrospective nature. This severely limits this study's ability to gather long-term functional data and significant outcome data, to include functional outcome scores, following a soldier's injury and subsequent discharge from military service. The information obtained regarding this cohort is from multiple databases that inherently have a degree of reporting error, conflicting information, and missing data. Furthermore, those records of amputees with severely limited data were excluded from further analysis at the onset of data analysis. This may have selected those amputees who were less severely injured at the time of injury or excluded those who had died while in hospital.

This study utilised the ISS to compare the magnitude of a patient's injuries. This score is routinely reported by the military and allows for consistent comparison throughout the duration of the study period [26–28]. However, this score may underestimate the true severity of injuries and has the limitation of excluding the multiple extremity injuries that are common among this patient population [29–33]. Consequently, although the ISS of our cohorts were comparable, other injury scoring systems such as the New Injury Severity Score (NISS), which has been shown to more accurately characterise the severity of a patient's injuries as well as their outcomes, may have allowed for variations in our conclusions [26–29].

This study only included primary MEAs. The military has many service members who sustain finger and partial hand amputations that were not included in the scope of this study. Consequently, digital amputations were excluded and should be examined in future studies independently as these are likely to carry a large degree of disability. Lastly, the retrospective nature of this study also limits our ability to determine validated outcome scores or other functional measures for this cohort, as such information is not available in our record system. Such information would be extremely useful in future research to further define the function and outcome of these amputees.

Conclusion

Upper extremity amputees account for 14% of all amputees during OIF and OEF. These amputations are more commonly related to explosive mechanisms, a finding consistent with prior studies. While substantial progress has been made in prosthetics and rehabilitation programmes, it appears that almost all upper extremity amputees are significantly disabled and unable to return to active duty, especially when compared to lower extremity amputees. Although much of this disability appears to be related to their amputation, other conditions such as PTSD are also prevalent in this population and undoubtedly contribute to their disability profile. Upper extremity amputees clearly

have different characteristics and debilitating features than lower extremity amputees. These differences are important to consider when providing treatment for this patient population as they may require additional resources beyond standard amputee care. Overall, the unique needs of upper extremity amputees require additional investigation and characterisation of their long-term outcomes to ensure that this subset of patient receives the appropriate level of care.

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Conflict of interest statement

Author JW is an editor of the *Journal of Surgical Orthopaedic Advances and Tissue Engineering*, author JR receives a consultancy fee for a grant review board from the Congressionally Directed Medical Research Program (CDMRP), and authors DT and CK have nothing to disclose.

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