Common Factors and Outcome in Late Upper Extremity Amputations After Military Injury

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Objectives: Much attention has been given to lower extremity amputations that occur more than 90 days after injury, but little focus has been given to analogous upper extremity amputations. The purpose of this study was to determine the reason(s) for desired amputation and the common complications after amputation for those combat wounded service members who underwent late upper extremity amputation.

Design: Retrospective case series.

Setting: Tertiary trauma center.

Patients/Participants: All US service members who sustained major extremity amputations from September 2001 to July 2011 were analyzed.

Intervention: Late (>90 days after injury) upper extremity amputations.

Main Outcome Measurements: Amputation level(s), time to amputation, age, number of operations, pre/postoperative complications, reason(s) for desiring amputation, and disability outcomes were analyzed.

Results: Seven of 218 (3.2%) upper extremity amputees had a late upper extremity amputation (>90 days from injury to amputation). The mean and median number of days from injury to amputation was 689 and 678, respectively. The most common preamputation complications were loss of wrist or finger motion (7, 100%), neurogenic pain (4, 57%), and heterotopic ossification (4, 57%). Three (43%) patients (2 persistent and 1 new onset) had neurogenic pain and 2 (29%) had heterotopic ossification after amputation. Only 57% (4 of 7) of amputees used their prostheses regularly.

Conclusions: Service members undergoing late upper extremity amputation seem to have different pre and postoperative complications than those patients undergoing late lower extremity amputations. It was common for the amputee to not wear their prostheses and to experience similar complications after amputation, albeit in a less severe form.

Key Words: late amputation, upper extremity amputation, combat related amputation

Level of Evidence: Prognostic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

There is no good formula or algorithm that can be used to determine whether a threatened upper extremity should be acutely salvaged or amputated.[1–3] Worse, there are no quality studies that attempt to define an upper extremity limb salvage in a consistent way such as the Lower Extremity Assessment Project study did for the lower extremity.[4,5]

Common doctrine has been to make every attempt to salvage upper extremities because the unique and complex function of the hand is difficult to replicate with prosthesis.[6] However, with limb salvage, there is a risk of patient dissatisfaction from continued pain or lack of function that could lead to a subsequent late amputation. Although previous work has been published to help surgeons better understand the factors that go into to late amputations for lower extremities,[7,8] no such literature exists for the upper extremity. This is despite upper extremity amputations having a greater impact on a patient's quality of life than lower extremity amputations.[9,10] In addition, upper extremity amputations make up between 18% and 50%[11–13] of all amputations sustained in combat but only about 6% of all combat-related late amputations.[14]

There have been numerous studies published examining both acute and late major amputations caused by extremity trauma during the Operation Iraqi Freedom, Operation Enduring Freedom, and Operation New Dawn conflicts.[11–13,15–18] However, there seems to be very little literature that has examined late upper extremity amputations, and it is unknown if the characteristics of those patients who undergo late amputation are similar to those who undergo late lower extremity amputations. The purpose of this study was to determine the reason(s) for desired amputation and the common complications after amputation for those combat-wounded service members who underwent late upper extremity amputation.

METHODS

This retrospective study was conducted under a protocol approved by our institutional review board. The Military

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Amputation Database (Extremity Trauma and Amputation Center of Excellence, Ft Sam Houston, TX) was queried to identify all major extremity amputations (MEAs) sustained by service members that occurred between October 1, 2001, and July 30, 2011. This database contains demographic information on all US Military amputees injured during recent military conflicts who were treated at military treatment facilities. MEA was defined as an amputation proximal to the carpals or tarsals of a limb.[12] These names were then crossreferenced within the Joint Theater Trauma Registry at the US Army Institute of Surgical Research (Ft Sam Houston, TX). This registry contains medical treatment data on service members that is obtained from the battlefield and each treatment facility where they are treated. Further information regarding the treatment of service members was obtained from the electronic medical records of each patient and the Theater Medical Data System. The Physical Evaluation Board (Ft Knox, KY) was able to provide data regarding the disability of all late upper extremity Army amputees and the amount of disability each amputee was designated. Although the military system is slightly different than disability system used by the Veterans Administration, each service members disability rating is based on the Veterans Administration Schedule for Rating Disabilities System where any rating above 75 is considered fully disabled.[19] Each disabling condition is given a rating and which is then subtracted from 100. If a service member has multiple disabling conditions, then they are subtracted separately so that 2 conditions that each carries a 50 disability rating would leave a service member with 75 disability.

RESULTS

Of the 218 upper extremity amputees, 7 (3.2%) underwent a late upper extremity amputation (defined as a primary amputation being performed greater than 12 weeks after the date of injury[4,7,20]). None of the patients who underwent late amputation had any other MEAs. The most common mechanism of injury was an explosive device (71%) and the most common type of injury sustained by the amputees was a burn (57%). One (14%) of the injuries was a nonbattle-related injury (a 50%–55% total body surface area burn sustained during a refueling accident within a combat zone). All the late upper extremity amputees had an Injury Severity Score of greater than 8 (mean 23.3, range 14–38). Six amputees (85%) had at least 3 Abbreviated Injury Scores above 0. Five (71%) amputees underwent a wrist disarticulation and 2 (29%) underwent a transradial amputation.

The median latency period between the initial injury and the amputation was 678 days with a mean of 689 days (range 96–1267 days). Five (71%) amputees had a complete nerve loss of at least the median, ulnar, or radial nerves with 1 patient sustaining a complete brachial plexus injury. Three of those amputees had an attempted nerve repair and/or graft. One patient had bilateral sural nerve grafts for attempted reconstruction of his ulnar and median nerves with partial recovery of both. Another amputee had a sural nerve graft for attempted reconstruction of his ulnar nerve without improvement. The last patient had attempted reconstruction of his brachial plexus with nerve grafts with limited success. Four amputees (57%) had attempted coverage of their wounds [3 patients had split thickness skin grafts, 1 had PriMatrix dermal repair scaffold (TEI Biosciences, Boston, MA)]. Five (71%) underwent a fasciotomy of their amputated extremity within the first 3 days of their injury. Three patients (43%) sustained a vascular injury that required reconstruction. One patient underwent a subclavian artery shunt and another an argyle shunt followed by a polytetrafluorethylene graft of their brachial artery and the last required a reverse saphenous vein graft of their ulnar artery.

The amputees underwent an average of 6.1 debridement and irrigation procedures (range 3–12) and 8.9 (range 6–14) total operations on their injured extremity before amputation. All the amputees demonstrated loss of motion in their injured extremity with 5 patients having loss of motion of their wrist, one of their digits and another with decreased motion in both his wrist and digits. Five (71%) patients stated that the reason they wanted an amputation was for improved function. Of the 5 patients (71%) whom developed neurogenic pain at some point during their treatment, 2 patients (29%) had preamputation pain that was relieved by their amputation, 1 patient developed new onset neurogenic pain after amputation, and 2 other amputees had neurogenic pain both before and after their amputations. The 2 patients who had neuropathic pain before and after their amputations both had documentation of a decrease in the severity of their neuropathic pain after amputation. It was not clear from the documentation, if this pain was solely phantom limb pain or a different type of neuropathic pain. Only 1 (14%) had a chronic infection. Table 1 lists all reported complications before amputation.

All 7 of the amputees were permanently retired from the Military or pending permanent retirement orders. The average disability rating for these amputees was 91% (range 70%–100%). The most common disabling condition listed among these amputees was posttraumatic stress disorder (4, 57%) followed by burn scars involving the face, head, or neck (3, 43%) and deep burn scars (3, 43%). All the disabling conditions for the amputees can be seen in Table 2.

All 7 of the amputees were right-hand dominant and 4 (57%) amputees sustained the amputation on their dominant hand. Three of the 7 (43%) amputees reported not using their prosthesis often or at all and all these amputees sustained amputations of their dominant hand. One of the patients who did not use their prosthesis often or at all sustained a transradial amputation, whereas the other 2 sustained wrist disarticulations. Of the 4 patients who had heterotopic ossification of their forearm as one of the reasons they elected to undergo an

TABLE 1. All Complications Reported by Late Upper Extremity Amputees Before Their Amputation

Complications Before Amputation		
Loss of wrist motion	6	86%
Neurogenic pain	4	57%
Heterotopic ossification	4	57%
Arthritis or painful joint	3	43%
Loss of digit motion	2	29%
Wound dehiscence/breakdown	2	29%
Infection	1	14%
Malunion	1	14%
Nonunion	1	14%

TABLE 2. Disability Ratings and Disabling Conditions for Each Service Member Who Underwent a Late Upper Extremity Amputation

Service Member	Final Result	Combined Disability Rating	Disabling Conditions
1	Permanently retired	70	Loss of use of the hand; degenerative arthritis
2	Permanently retired	100	Loss of use of the hand; ventral hernia; resection of large intestine; burn scars of face, head, or neck
3	Retirement orders pending at last follow-up	90	Amputation of arm below the insertion of pronator teres; complete paralysis of the median nerve; complete paralysis of the ulnar nerve
4	Permanently retired	100	Anatomical loss of both hands; burn scars of face, head, or neck; PTSD; deep burn scars
5	Permanently retired	90	Median nerve paralysis; TBI residuals; PTSD; loss of elbow supination
6	Permanently retired	100	Burn scars of face, head, or neck; PTSD; loss of use of hand; deep burn scars
7	Permanently retired	90	Amputation of arm below the insertion of pronator teres; PTSD; scapular dyskinesia; paralysis of all radicular groups of the upper extremity

PTSD, posttraumatic stress disorder. TBI, Traumatic Brain Injury.

amputation, 2 (50%) had heterotopic ossification at their amputation site after the amputation was performed. One of these patients seemed to only be bothered by the heterotopic ossification when wearing his prosthesis. However, as he did not wear his prosthesis often this heterotopic ossification was not often symptomatic. The other patient's heterotopic ossification was regarded as minor and did not interfere with the use of his prosthesis. None of the amputees who did not have heterotopic ossification before their amputation developed the condition after the amputation was performed.

DISCUSSION

This study demonstrates that few of the upper extremity amputations (7 of 218, 3.2%) that have occurred in our Military population are performed more than 90 days after the initial injury. This is almost 5-fold lower than the rate for late lower extremity amputation for combat-related injuries,[7] but similar to rates of lower extremity late amputations (3.9%) in the civilian population[21] and the number of late upper extremity amputations (3 of 100) found by Tintle et al in their recent paper looking at reoperations after upper extremity amputations.[5] The mean and median length of time between the date of injury and amputation for the late upper extremity amputees (689 and 678 days, respectively) are substantially longer than that same interval for late lower extremity military amputees.[7] Although it is unclear why this difference in interval length exists, it is likely that surgeons are more reluctant to amputate an upper extremity than a lower extremity, hoping that it will continue to improve and provide the patient with a better outcome than can be provided by an amputation and prosthesis. However, literature suggests that patients undergoing attempted limb salvage of their upper extremity may have insight into their extremity's terminal outcome after just 6 months of recovery[22] and that extremely prolonged observation after a severe upper extremity injury rarely improved limb function in patients who had replanted upper extremities.[23] Although the increased latency period between the injury and amputation may improve the amputees' ability to cope with the amputation,[24] it is poorly understood why this time difference is so large between upper and lower late amputations.[25] Late amputations also occur when the patient is relatively stable and are aimed at optimizing their function. This differs dramatically from the acute period of trauma when limbs may be amputated for preservation of life[12] and allows a patient to have more influence on the ultimate fate of his or her severely injured limb.

Although it seems that the late amputees in this study were more severely injured than similar service members who underwent late lower extremity amputations,[26] this study, like others,[5,13,20] found that explosive devices caused the majority of injuries sustained by these amputees. The complications of stiffness, nerve injury, and joint pain that were found in many of these late upper extremity amputees before their amputation may be largely attributable to these blast injuries.[19,27,28]

The most common complications encountered by the late upper extremity amputees in this study differ from those complications found in service members with severe type III open tibia fractures who went on to a late amputation. Huh et al[20] found problems with soft tissue coverage and infections to be the most common reasons why those with lower extremities underwent late amputations. Tintle et al[5] also found infection and wound complications to be common reasons for why upper extremity amputees needed to undergo a reoperation. Such complications were not commonly found in late upper extremity amputation cohort used in this study. The majority of patients in this study had a complete injury to a major nerve (5, 71%) or a severe burn (4, 57%), injuries that occurred at much lower rates in similar studies.[29] It is likely that the high number of nerve injuries found in this study contributed to the neurogenic pain that was commonly found in the late upper extremity amputees.

Heterotopic ossification was a common finding before (4, 57%) and after (2, 29%) amputation. Similarly, 2 of the 5 patients who had neurogenic pain before their amputation continued to experience neurogenic pain after the amputation was complete. These data suggest that performing a late upper extremity amputation for these conditions may not reliably resolve either problem. However, the impact of each of these conditions will depend on many factors. One of the patients seemed to be largely unaffected by the heterotopic ossification after the amputation because of how minor it was, whereas the

other patient seemed to have more severe heterotopic ossification after the amputation. Still, because that patient did not wear his prosthesis often, he remained largely asymptomatic from the condition. Similarly, it seemed that the neuropathic pain present after these amputations were performed was less severe than the neuropathic pain experienced before the procedures.

All 6 amputees who had a finalized status of disability were permanently retired. There are many factors likely lead to these patients leaving the military and there are many transradial and wrist disarticulation amputees who return to active duty. Also, it is difficult to make comparisons with other studies that have examined outcome data and return to duty rates in amputees[30,31] because of the small number of late amputees in this study. However, all the amputees in this study were severely injured and disabled, with multiple disabling conditions.

This study found that only 4 of the 7 amputees (57%) used their prosthetic arm frequently despite all of them receiving multiple prostheses. This percentage is lower than the 76% found in a previous study that looked at all unilateral upper extremity amputees from the Operation Iraqi Freedom/Operation Enduring Freedom conflicts[32] and substantially lower than the 84% found in another study looking at upper extremity amputees.[5] These differences exist despite having patient populations with very similar demographics, treatment centers, and access to prosthetic and rehabilitation centers. It is uncertain if these disparities represent an adaptation due to limited use of the extremity during the nearly 2 years, on average, that these patients were attempting limb salvage. Previous literature has also found that unilateral upper extremity amputees reject their prostheses at a rate close to 20 times higher than unilateral lower extremity amputees.[32] All 3 of the non- or rare-prosthesis users sustained amputations to their dominant hand. Still, it remains unclear whether or not the amputation of the dominant extremity has influence on prosthetic wear.[33,34]

This study contains several limitations. First, the study cohort is small; however, the cohort is all late upper extremity amputees more than 10 years of military conflict. Second, the retrospective study design has limitations in data quality and quantity to include a lack of patient-driven outcome scores. This study also only examined initial MEAs and excluded partial hand and foot amputations. These 7 amputees had severely injured upper extremities that are very rare in both military and civilian populations. It is only these types of extremity injuries that are considered for limb salvage and it would be interesting to compare the injuries and complication sustained by those patients who had successful upper extremity limb salvage to this cohort of patients. Clearly, not having such a comparative group is a limitation of this study. All these factors are important to consider when judging the external validity of this study.

CONCLUSIONS

The most common complications that led service members to undergo late amputation of the upper extremity were loss of joint motion at their wrists or digits, neurogenic pain, and heterotopic ossification. These complications seem to differ from those commonly seen with late lower extremity amputations. Further research is needed to determine the impact of late upper extremity amputation on quality of life, long-term prosthetic use, and upper extremity function.

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