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A comparison of health outcomes for combat amputee and limb salvage patients injured in Iraq and Afghanistan wars

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BACKGROUND:	Treatment of military combatants who sustain leg-threatening injuries remains one of the leading challenges for military providers. The present study provides systematic health outcome data to inform decisions on the definitive surgical treatment, namely amputation versus limb salvage, for the most serious leg injuries.
METHODS:	This was a retrospective analysis of health records for patients who sustained serious lower-extremity injuries in the Iraq and Afghanistan conflicts, 2001 to 2008. Patients had (1) amputation during the first 90 days after injury (early amputees, n = 587), (2) amputation more than 90 days after injury (late amputees, n = 84), or (3) leg-threatening injuries without amputation (limb salvage [LS], n = 117). Injury data and health outcomes were followed up to 24 months.
RESULTS:	After adjusting for group differences, early amputees and LS patients had similar rates for most physical complications. Early amputees had significantly reduced rates of psychological diagnoses (posttraumatic stress disorder, substance abuse) and received more outpatient care, particularly psychological, compared with LS patients. Late amputees had significantly higher rates of many mental and physical health diagnoses, including prolonged infections and pain issues, compared with early amputees or LS patients.
CONCLUSION:	Early amputation was associated with reduced rates of adverse health outcomes relative to late amputation or LS in the short term. Most evident was that late amputees had the poorest physical and psychological outcomes. These findings can inform health care providers of the differing clinical consequences of early amputation and LS. These results indicate the need for separate health care pathways for early and late amputees and LS patients. (<i>J Trauma Acute Care Surg.</i> 2013;75: S247–S254. Copyright © 2013 by Lippincott Williams & Wilkins)
LEVEL OF EVIDENCE:	Epidemiologic and prognostic study, level III.
KEY WORDS:	Combat amputee; limb salvage; health outcomes; Iraq/Afghanistan war.

During the Iraq and Afghanistan conflicts, thousands of US military personnel sustained lower-extremity injuries usually caused by high-energy trauma from powerful blast weaponry.^{1,2} The most severe of these injuries have been leg threatening, characterized by complex fracture patterns, extensive soft tissue damage, as well as vascular and neurologic compromise.^{3–7} For military health care providers, one of the most challenging clinical decisions remains whether to treat such injuries with early amputation or to attempt limb salvage (LS) through reconstructive surgeries.^{3–8} However, there are limited clinical outcome data for combat amputee and LS populations to inform this critical health care decision and to guide management of their rehabilitation after injury.^{3–6,9–11}

Patients who undergo amputation or LS commonly experience adverse health outcomes, including infections, thromboembolic disease, heterotopic ossification (HO), and psychological disorders.^{12–15} Previous studies indicate relatively high rates of some physical complications among combat amputees relative to nonamputees with serious extremity injuries,^{12–16} but similar or reduced rates of adverse psychological outcomes such as posttraumatic stress disorder (PTSD).¹² Most combat amputations either were traumatic or occurred within days of injury, but approximately 15% of patients had late amputations¹⁷ (>90 days after injury), apparently related to infected and/or painful limbs.^{18–21} Amputee and LS patients require prolonged medical and rehabilitation care after injury. Amputees have a well-established clinical and rehabilitation pathway through military amputee care programs (ACPs).^{12,16} By contrast, the clinical pathway for LS patients is less well-defined or studied.⁸ Most important, little systematic study has quantified the clinically documented outcomes and rehabilitation needs of combat amputees compared with a carefully identified LS comparison group (i.e., nonamputees with leg-threatening injuries).^{3–6,20–23}

The first objective of this study was to provide systematic data on physical and psychological health outcomes to inform decisions on the definitive surgical treatment for leg-threatening combat injuries. The second objective was to describe health care use by combat amputee and LS patients to improve their clinical pathways after injury. We quantified early

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adverse health outcomes and health care use by patients undergoing either amputation or LS following injuries in the Iraq or Afghanistan wars, 2001 through 2008. Clinical outcomes were compared based on the type of treatment (amputation vs. LS) and its timing (early vs. late amputation). Based on previous research,^{12–15} we hypothesized that early amputation would be associated with significantly higher rates of physical complications and similar or reduced psychological disorders compared with LS patients. Furthermore, amputees should show increased rehabilitation therapy use because of their unique access to ACPs.¹⁶ Finally, previous research suggests that late amputees may have the highest rates of adverse physical and psychological disorders.^{8,18–21}

PATIENTS AND METHODS

Data Sources

This research was approved by the Naval Health Research Center's Institutional Review Board (protocol NHRC.2007.0016).

Injury-specific data were obtained from the Expeditionary Medical Encounter Database (EMED),²⁴ including medical encounter forms capturing data primarily at Navy-Marine Corps forward treatment facilities in Iraq and Afghanistan. The EMED includes medical records of extremity injuries (e.g., fractures, soft tissue injuries) documented by patients' medical providers. Abbreviated Injury Scale (AIS) scores were assigned by EMED military clinicians²⁴ and used to calculate Injury Severity Scores (ISSs).²⁵ For 545 amputees not captured by the EMED, ISS data were obtained from the Joint Theater Trauma Registry.²⁶ Both projects employ experienced combat trauma nurses with extensive AIS coding experience, which is associated with reliable scoring.²⁷

Health outcome data from Level 4 and 5 military treatment facilities came from Standard Inpatient Data Records, Standard Ambulatory Data Records, and Health Care Service Record files via TRICARE Management Activity, including DRG International Classification of Diseases—9th Rev. (ICD-9) diagnostic codes. Records were merged from the Armed Forces Health Longitudinal Technology Application, routinely generated by credentialed providers for patient encounters at military treatment facilities and government-reimbursed private clinics.²⁸

Study Population and Patient Identification

Patients who died of wounds and those with brain or spinal injuries causing extremity paralysis were excluded. After exclusions, we identified 964 US military personnel who sustained either major extremity amputations (excluding fingers, toes) or leg-threatening injuries during the Afghanistan or Iraq wars from 2001 through 2008. Of 847 amputees identified (99% of 858 combat amputees identified by independent military counts),²⁹ we included patients with lower-extremity amputations only (n = 671). Lower-limb amputees were identified using ICD-9 codes (896, 897). We recorded unilateral or bilateral amputations and their anatomic levels, including above the knee (i.e., transfemoral or higher level including hip disarticulations) or below the knee (i.e., transtibial or lower level including ankle/foot or partial foot amputations). The timing of amputations (days after injury) is noted in Table 1. Patients treated with amputations during the first 90 days after injury were classified as early amputees (EAs). Patients who had amputations more than 90 days after injury were classified as late amputees (LAs).^{17,22} A separate group of 117 patients had leg-threatening injuries without amputation (also known as

TABLE 1. Injury Characteristics of Amputees and Limb Salvage Patients*

Injury Characteristics	Early Amputees (≤90 d After Injury)		Late Amputees** (>90 d After Injury)		Limb Salvage (No Amputation)	
	Unilateral (n = 441)	Bilateral (n = 146)	Unilateral (n = 78)	Bilateral (n = 6)	Unilateral (n = 107)	Bilateral (n = 10)
Age <25 y, %	57 ^b	64	56	4 of 6	67 ^b	7 of 10
ISS, mean/median	16 ^a /14	23/21	12 ^a /10	18/14	14/10	15/10
Mechanism of injury, blast, %	89 ^{a,b}	96	74 ^a	6 of 6	68 ^b	7 of 10
Injury location, %						
Transfemoral or above the knee	37		12		23%	4 of 10
Transtibial or below the knee	63 ^{a,b}		88 ^{a,c}		77% ^{b,c}	6 of 10
Primary LS injury type, %†						
G-A Grade IIIA fracture					8%	1 of 10
G-A Grade IIIB fracture					56%	0 of 10
G-A Grade IIIC fracture					8%	1 of 10
Major soft tissue injury					14%	1 of 10
Penetrating vascular wound					7%	4 of 10
Severe ankle or foot injury					8%	3 of 10
TBI, %	34	55	27	2 of 6	29	0 of 10
Preinjury psychological diagnosis, %	10 ^b	13	9	1 of 6	6 ^b	0 of 10

*Differences between unilateral groups ($p < 0.05$ χ^2 or Fisher's exact test as appropriate) were ^aEA versus LA, ^bEA versus LS, and ^cLA versus LS.

**Amputation times per patient were as follows (days after injury): 0, n = 523; 1 to 30, n = 58; 31 to 90, n = 6; 91 to 180, n = 10; 181 to 360, n = 26; 361 to 730, n = 41; and greater than 730, n = 7).

†Injury types identified by a military orthopedic surgeon's review of individual patient medical records from Levels 2 through 5. Fifty percent of LS patients had multiple injury types (e.g., severe foot injury and major soft tissue injury).

G-A, Gustilo-Anderson; TBI, traumatic brain injury.

limb salvage or LS) as defined later. These 671 lower limb amputees and the 117 LS patients constituted the present study samples.

Patients with leg-threatening injuries without subsequent amputation were identified as follows. First, an LS review form captured injury criteria considered as leg-threatening by previous civilian and military studies.^{7,22} LS injury criteria were one or more of the following: complex fractures (Gustilo-Anderson Grades 3C, 3B, and selected 3A) as well as vascular, major soft tissue, and/or severe foot injuries. Second, the EMED was searched to identify patients with serious lower-extremity injuries (as defined by an AIS ≥ 3 , $n = 465$). Third, one experienced military orthopedic surgeon (primary reviewer) reviewed EMED casualty records for a representative subset of these patients ($n = 200$) and completed the LS form, including specific injuries and their anatomic location (e.g., femur or tibia). The primary reviewing surgeon and a second orthopedic surgeon both reviewed a subset of 13 patients and agreed on Gustilo-Anderson classifications for 12 of 13 patients. Moreover, we found no significant differences in ISS or age between the 200 patients reviewed (mean ISS, 13.2; median ISS, 10.0; mean age, 24.8 years; median age, 22.0 years), and the remaining 265 EMED patients not reviewed (mean ISS, 14.2; median ISS, 10.0; mean age, 24.2 years; median age, 22.0 years) (p 's > 0.10 , two-tailed t test of means, after log transformation to normalize distributions, or nonparametric two-tailed Mann-Whitney U-test).

Finally, the primary reviewing surgeon judged whether injuries were leg threatening (0 = definitely not, 5 = possibly, 10 = definitely) based on either an acute threat to the extremity (e.g., dysvascular limb) or if limb amputation was a practical treatment option. This judgment also included review of the casualty record for any notations by the treating physician indicating that he or she believed amputation was a viable treatment alternative. The primary surgeon completed secondary reviews of 15 cases with an initial LS score of 5. In 13 of the 15 cases, this surgeon assigned a higher score (≥ 6), and in the other 2 cases the score was the same (5). Therefore, it seemed that the primary surgeon initially excluded marginal cases by assigning scores of less than 5. Consequently, patients who met the LS injury criteria (e.g., Grade 3B fracture) and received physician scores of 5 or greater were included in the final LS sample (unilateral, 107; bilateral, 10). The distribution of final LS scores was as follows: LS score of 5, 19 patients or 16%; LS score of 6 to 8, 46 patients or 39%; and LS score of 9 to 10, 52 patients or 44%. We compared two subsamples of LS patients; those with a score of 5 ($n = 19$ cases; median ISS, 10) and those with scores of 10 ($n = 45$ cases; median ISS, 11). We found no significant differences between groups in median ISSs or in selected critical outcomes (i.e., osteomyelitis, infections, PTSD, or p 's > 0.10).

Research Design

This was a retrospective cohort study using the previously mentioned data sources. Follow-up of outcomes continued for 24 months after injury²² or until patient medical records were no longer available in databases. Mechanisms of injury were blast, gunshot wound, or crush. ISS was calculated

as described previously. Traumatic brain injury³⁰ and post-injury complication codes (e.g., osteomyelitis, HO) were identified by EMED and amputee care clinicians.²⁴ We subsequently searched for these codes in health databases. Psychological diagnostic codes were grouped as adjustment, anxiety, mood, PTSD, substance abuse, and other psychological diagnoses. PTSD cases were defined as two or more separate health care encounters at which ICD-9 diagnostic codes of 309.81 were recorded at least 30 days after injury.³¹ Preinjury psychological records indicated whether each patient showed at least one preinjury diagnosis or not.

Health care clinic codes were extracted from the medical expense and performance reporting system, which documents specific outpatient clinic visits including physical therapy, occupational therapy, psychiatric care, orthopedics, pain clinic, as well as prosthetics and orthotics care. These codes did not specifically indicate whether visits were related to the ACP. Year of injury was categorized as 2001 through 2005 or 2006 through 2007 because it was correlated with changes in operational tempo (e.g., Iraq surge, 2007), which may have affected health outcomes.

Statistical Analyses

Percentages of patients with specific health outcomes (e.g., infections or PTSD) for the entire 24-month follow-up were calculated using the total number of patients in each group as the denominator. Percentages during specific intervals after injury (e.g., 90 days) were calculated using the average daily count of patients during that interval as the denominator. Means and medians were presented to summarize demographic variables and to indicate how the distributions might be skewed. Nonparametric significance tests identified any demographic differences. χ^2 or Fisher's exact tests were used as appropriate to compare frequency data for different samples (e.g., number of patients with PTSD).

Logistic regression analyses determined whether unilateral injury group (EA, LA, or LS) was significantly associated with health outcomes. Odds ratios (ORs) and confidence intervals were adjusted for covariates: age (<25 or ≥ 25 years), log ISS, mechanism of injury (blast or nonblast), injury year (2001–2005 or 2006–2008), injury location (above the knee or below the knee), or preinjury psychological diagnosis. Separate regressions evaluated unilateral versus bilateral amputee groups.

RESULTS

Table 1 summarizes demographic and injury characteristics. Variables showing significant differences were entered as covariates into later regression analyses.

Outcomes Follow-up

Follow-up rates were greater than 90% for all groups through 12 months. Thereafter, LAs had significantly higher follow-up rates after 18 months (LA, 95%; LS, 78%; EA, 69%) and after 24 months (LA, 83%; LS, 62%; EA, 48%) compared with the remaining groups (p 's < 0.05).

TABLE 2. Physical Complications of Amputee and Limb Salvage Patients*

Complication, %	Early Amputees (≤ 90 d After Injury)		Late Amputees (>90 d After Injury)		Limb Salvage (No Amputation)	
	Unilateral (n = 441)	Bilateral (n = 146)	Unilateral (n = 78)	Bilateral (n = 6)	Unilateral (n = 107)	Bilateral (n = 10)
Anemia	55 ^{a,b}	73	40 ^a	2 of 6	41 ^b	2 of 10
Any infection	69	73	77 ^c	5 of 6	57 ^c	5 of 10
HO	31 ^{a,b}	49	17 ^a	3 of 6	14 ^b	1 of 10
Osteomyelitis	33 ^a	33	47 ^a	2 of 6	34	2 of 10
DVT and/or PE	16	42 [†]	15	1 of 6	15	2 of 10
Cellulitis	25 ^a	30	40 ^{a,c}	1 of 6	20 ^c	1 of 10
Septicemia	10 ^a	15	4 ^a	1 of 6	9	0 of 10
Nonhealing wound	11 ^{a,b}	16	19 ^a	0 of 6	19 ^b	1 of 10
PLS	59	73	49	5 of 6	—	—

*Differences between unilateral groups ($p < 0.05$ χ^2 or Fisher's exact test) were ^aEA versus LA, ^bEA versus LS, and ^cLA versus LS.

PLS, phantom limb syndrome.

Complications

EAs had significantly increased rates of anemia, infections, and HO, relative to LS patients. The unilateral groups had similar overall rates of deep vein thrombosis/pulmonary embolism (DVT/PE), although the onset for some of these diagnoses occurred later after injury for the LS and LA groups (Fig. 1). LAs generally had higher rates of infectious complications and nonhealing wounds compared with EAs and/or LS patients (Table 2). Bilateral amputees had significantly higher rates of DVT/PE compared with unilateral amputees.

Psychological Diagnoses

The majority of patients in all groups had a psychological diagnosis but differed in rates of specific disorders (Table 3). EAs had significantly lower rates of PTSD and substance abuse compared with LS patients. LAs had significantly higher rates of 5 of the 6 psychological disorders categories compared with EA and/or LS patients and significantly more diagnoses compared with amputee groups. LAs and LS groups had similar rates of PTSD and substance abuse but significantly higher rates compared with EAs.

Health Care Use

The percentage of patients with one or more clinic visits was calculated for unilateral injury groups EA, LA, and LS (data not shown elsewhere). Amputees received significantly more care at most outpatient clinics compared with LS patients, particularly at psychiatry (EA, 88%; LA, 81%; LS, 29%; $p < 0.05$), psychology (EA, 38%; LA, 42%; LS, 22%; $p < 0.05$), occupational therapy (EA, 93%; LA, 92%; LS, 69%; $p < 0.05$), and prosthetic/orthotic clinics (EA, 91%; LA, 86%; LS, 28%; $p < 0.05$). LAs had higher use rates for the orthopedic ward and pain clinics compared with EA or LS patients (orthopedic ward: EA, 58%; LA, 85%; LS, 61%; $p < 0.05$) (pain clinic: EA, 47%; LA, 73%; LS, 49%; $p < 0.05$). The median visits to the various clinics among amputees was 2 to 3 times higher than that of LS patients (except for pain and orthopedic clinic/ward).

Outcomes by Time After Injury

Figures 1 and 2 show rates of selected health outcomes. All groups had relatively high incidence rates for osteomyelitis and DVT/PE during the first 30 days. During subsequent intervals (Days 91–180 and Days 181–270), EAs had significantly

TABLE 3. Psychological Diagnoses of Amputees and Limb Salvage Patients*

Psychological Diagnosis, %	Early Amputees (≤ 90 d After Injury)		Late Amputees (>90 d After Injury)		Limb Salvage (No Amputation)	
	Unilateral (n = 441)	Bilateral (n = 146)	Unilateral (n = 78)	Bilateral (n = 6)	Unilateral (n = 107)	Bilateral (n = 10)
Any psychological diagnosis**	71	80	78	6 of 6	74	5 of 10
PTSD†	19 ^{a,b}	20	33 ^a	1 of 6	30 ^b	3 of 10
Adjustment	37	43	47 ^c	2 of 6	32 ^c	3 of 10
Anxiety	30	33	39	1 of 6	32	2 of 10
Mood	24 ^a	27	40 ^{a,c}	0 of 6	23 ^c	1 of 10
Substance abuse	12 ^a	12	23 ^a	0 of 6	19	2 of 10
Other psychological disorders	42	53	40	4 of 6	50	4 of 10

*Differences between unilateral groups ($p < 0.05$ χ^2 or Fisher's exact test as appropriate) were ^aEA versus LA, ^bEA versus LS, and ^cLA versus LS. Other psychological disorders included pain, sleep, and cognitive disorders.

**Mean number of psychological diagnoses: EAs, 1.8; LAs, 2.6; and LS, 2.3 ($p < 0.05$).

†PTSD cases included only patients with at least two separate PTSD diagnoses.

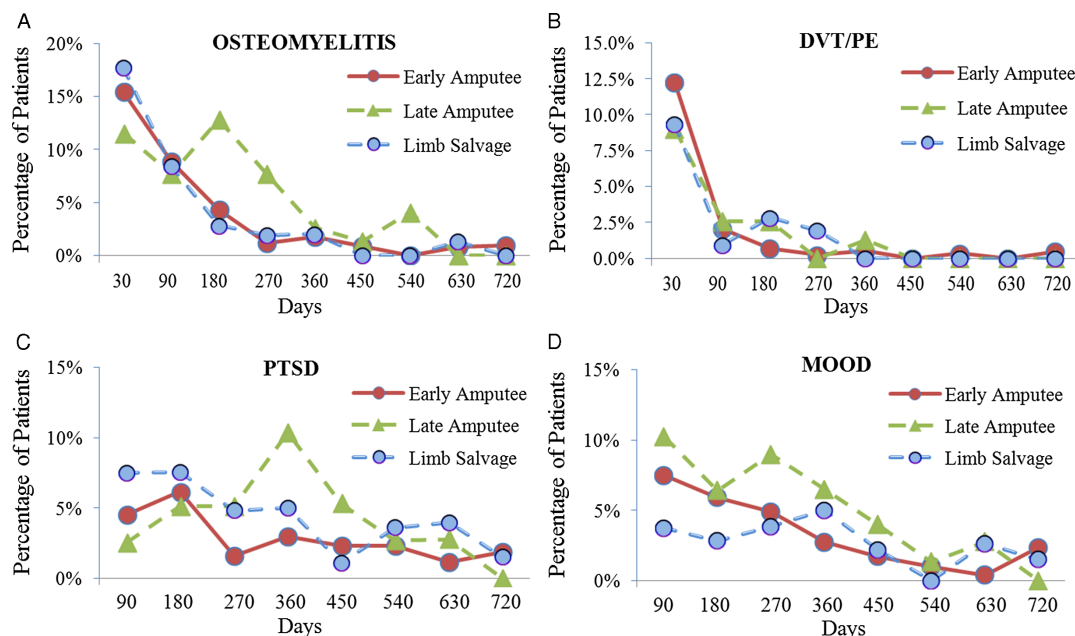


Figure 1. Incidence rates of selected health outcomes during consecutive 30-day or 90-day intervals after injury for unilateral injury groups. Data are the first or onset diagnosis for each patient (e.g., Day 90 includes 0–90 days, Day 180 includes 91–180 days, Day 270 includes 181–270 days). Statistical significance during postinjury intervals through Day 360 only (χ^2 or Fisher's exact test as appropriate). Osteomyelitis: at 180 and 270 days, EA < LA, p 's < 0.01. DVT/PE: at 180 days, EA < LA and LS, p < 0.05. PTSD: at 270 days after injury, EA < LA and LS, p 's < 0.06; 360 days after injury, EA < LA, p < 0.01. Mood: combined data through 360 days, EA < LA, p < 0.05.

lower rates of osteomyelitis compared with LAs (p 's < 0.05). During Days 91 to 180, EAs had significantly lower DVT/PE rates compared with LAs and LS patients (p < 0.05). EAs had lower PTSD rates compared with LAs or LS patients during Days 181 to 270 (marginally significant, p 's < 0.06). During Days 271 to 360 EA had significantly lower PTSD rates compared with LAs (p < 0.05). EAs had significantly lower mood disorder rates compared with LAs across the first year (p < 0.05, combined data Days 0 through 360). Given the low number of new cases during the second year, significance tests were not conducted.

For physical therapy, EA had significantly higher clinic use rates compared with LS during each 90-day interval after injury from Days 0 through 450 (p 's < 0.05). However, EAs had

significantly lower rates of physical therapy use compared with LAs during each 90-day interval between Days 271 and 720 (p 's < 0.05). All groups had similar rates of pain clinic use during the first 30 days. However, EAs had significantly lower rates compared with LAs during each interval after 30 days through 630 days (p 's < 0.05). EAs used the pain clinic significantly less compared with LS patients during Days 181 to 270 (p < 0.05).

Table 4 shows that unilateral injury group was significantly associated with certain health outcomes independent of specific covariates (e.g., ISS). EAs had increased ORs for several complications including anemia, any infection, and HO (ORs relative to LS group). By contrast, EAs had reduced ORs for PTSD and substance abuse by approximately 50%

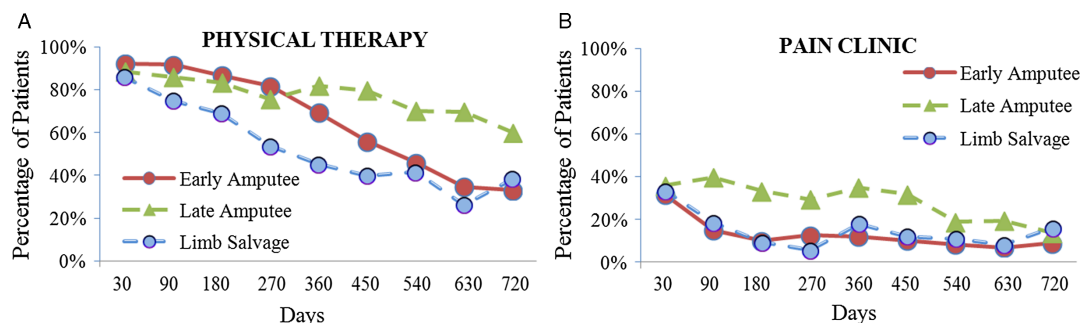


Figure 2. Prevalence rates for selected clinic use during consecutive 30-day or 90-day intervals after injury for unilateral injury groups. Data are the percentage of patients with at least one clinic visit during each interval. Statistical significance during all postinjury intervals through Day 720 (χ^2 or Fisher's exact test as appropriate). Physical therapy: at 30 through 450 days, EA > LS, p 's < 0.05. At 360 through 720 days, EA < LA, p < 0.05. Pain clinic: at 90 through 630 days, EA < LA, p < 0.05. At day 270, EA > LS, p < 0.05.

TABLE 4. Results of Logistic Regression Analyses for Unilateral Injury Groups*

Independent Variables	After Injury Outcomes Variables OR (95% Confidence Interval)						
	Anemia	Any Infection	Cellulitis	Osteomyelitis	Heterotopic Ossification	PTSD	Substance Abuse
Injury group**							
Limb salvage							
Early amputee	2.00 (1.27–3.16)	1.77 (1.13–2.79)			2.32 (1.54–3.51)	0.39 (0.24–0.63)	0.54 (0.29–0.99)
Late amputee		3.24 (1.64–6.41)	3.36 (1.63–6.89)	2.03 (1.06–3.88)			
ISS (log)	1.60 (1.16–2.20)	2.17 (1.54–3.06)	1.86 (1.26–2.73)	1.52 (1.05–2.19)	2.32 (1.26–4.28)		
Injury location (below vs. above knee)				1.49 (1.00–2.22)	2.15 (1.40–3.30)		
Age (≤ 25 vs. ≥ 25), y							0.46 (0.28–0.78)
Injury year (2001–2005 vs. 2006–2008)	1.51 (1.08–2.10)		1.48 (1.00–2.18)	1.76 (1.23–2.53)	2.98 (1.96–4.51)	2.04 (1.36–3.04)	2.09 (1.27–3.45)
Preinjury psychological diagnosis (no vs. yes)						2.62 (1.45–4.75)	4.25 (2.21–8.16)

*Reference groups for each independent variable are in italics.

**Injury group showed no significant association with postinjury deep vessel thrombosis and/or PE, anxiety, or adjustment disorders. Traumatic brain injury rates did not significantly vary among unilateral injury groups. The mechanism of injury was not a significant factor in the final models for any psychological diagnosis or PTSD. Bilateral amputees had increased odds of deep vessel thrombosis and/or PE versus unilateral amputee (ORs, 2.61; 95% confidence interval, 1.68–4.07).

relative to LS patients, and these groups had similar ORs for anxiety, adjustment, and other psychological disorders. LAs had significantly increased ORs for any infection, osteomyelitis, and cellulitis relative to LS patients. They also had increased odds of mood disorder relative to LS patients and similar odds for the other psychological categories.

DISCUSSION

This is one of the first studies to quantify and compare early adverse physical and psychological outcomes for patients treated with amputation or LS following combat injuries in the Iraq and Afghanistan conflicts. After adjusting for covariates, the type and timing of definitive surgical treatment was significantly associated with specific health outcomes and outpatient health care use. Early amputation was generally associated with similar or fewer adverse health outcomes relative to patients treated with LS or LA. Most evident was that patients treated with late amputation had relatively high rates of adverse physical and psychological outcomes.

Previous military reports emphasized the lack of clinically documented outcome data to inform definitive surgical treatment of leg-threatening injuries.^{5,6} The present study provides such treatment-specific outcomes during the first 24 months after injury, indicating apparent benefits of early amputation. For patients who sustain leg-threatening injuries that may be treated with either amputation or LS, military providers currently recommend a substantial period of reflection including clinical and family consultation before deciding on amputation or salvage.^{5,6,8,10} Based on our findings, providers may consider the apparent benefits of early amputation versus late amputation or LS in this complex clinical decision. Although this is one of the first studies comparing outcomes associated with these procedures, we found a pattern of results across physical, psychological, and health care use outcomes that indicate benefits of early amputation. While EAs showed higher rates of some complications (e.g., HO) than those of LS patients, these groups had similar overall rates for other important complications (e.g., osteomyelitis or DVT/PE). Importantly, the osteomyelitis and DVT/PE complications were shorter lasting for EAs relative to LS patients and/or LAs. LAs had substantial additional adverse health outcomes previously described.

The present results provide substantial initial support for developing distinct clinical pathways for EAs, LAs, and LS patients. EAs have a well-established pathway through the ACP.¹⁶ The present results are consistent with its efficacy, although we did not directly test the efficacy of ACPs. By contrast, an LS clinical pathway including early medical and rehabilitation care does not seem well established.^{21,32–34} The present findings may also support ACPs by further defining the unique clinical outcomes and health care needs of EAs. Providers may consider the present results to refine the clinical pathway for LS and LAs. The prolonged duration and/or relatively high rates of osteomyelitis, DVT/PE, substance abuse, and PTSD for LS patients and/or LAs suggest additional screening might help manage these outcomes. Importantly, LS patients had relatively complicated psychological recovery with PTSD and substance abuse, but they received

substantially less psychiatric care than did amputees. Although the military's goal is to provide all trauma patients with psychiatric consults,³² this finding suggests barriers to psychological care for LS patients. Consequently, psychological screening at treatment entry and subsequently at regular intervals such as annually if health status changes might be appropriate for LS patients. Screening might be integrated with primary or specialized care settings including follow-up surgeries typical of LS patients. The results also suggest early and aggressive screening for adverse physical complications, given the initially high rates of life-threatening complications such as DVT/PE among all groups. Finally, operative and postoperative care regimens (e.g., wound care management or activity restrictions) have not been well described for military patients with leg-threatening injuries, particularly for the LS population. Further research should quantify surgical and medical care for combat amputee and LS patients and evaluate their relationships with health outcomes.

The strengths of this study included a near-complete sample of combat amputees injured from 2001 through 2008²⁹ and a representative group of LS patients. Detailed casualty records were available because of advanced capabilities to capture in-theater clinical encounters, namely the EMED.^{24,26} Military databases allowed longitudinal tracking of numerous physical and psychological diagnoses at regular intervals for relatively large patient samples.²⁸

The primary study limitation was that we used a retrospective observational study comparing nonrandomized groups. Therefore, results should be interpreted with appropriate cautions for this design, especially given the serious nature of amputation versus LS decisions. However, our regression analyses adjusted for any group differences in age, service affiliation, preinjury psychological diagnoses, mechanism of injury, injury location, ISS, and/or traumatic brain injury. Most important, the significantly lower rates of adverse outcomes reported for EAs versus LAs and/or LS were independent of such group differences (e.g., age, ISS). Outcomes were followed up in the short term in military databases, and many patients left military care during the second year after injury. However, group differences reported occurred during the first year after injury when all groups had similar follow-up rates.

There was also some limitation on the description of lower limb injuries (e.g., AIS scores) for all groups. LS patients certainly were well defined by AIS scores of 3 or greater and physician identification of injuries. However, amputees likely had multiple lower limb injuries related to amputation, which unfortunately were not available because they were not systematically captured by trauma registries early in the Iraq war. For LAs in particular, it seems difficult to identify the specific injuries related to later amputation. Importantly, we carefully identified the location of the lower-limb injury (above or below the knee), which is a well-known predictor of functional outcomes.³⁵ This variable also significantly contributed to health outcomes in the present results. Future research should also analyze specific pain diagnoses that may be correlated with relatively high rates of pain clinic use among LAs. The absolute rates of some complications (e.g., HO) were lower than previous reports.¹⁵ However, amputees showed increased odds of HO relative to LS patients, which was consistent with

radiographic studies.¹⁵ Absolute rates of phantom limb syndrome, osteomyelitis, and infections were consistent with previous reports.^{36–38}

This study did not evaluate functional outcomes such as patient mobility levels and activities of daily living.

In conclusion, the type and timing of definitive surgical treatment (amputation vs. LS) was significantly associated with several adverse health outcomes in the short term. Early amputation was associated with similar or reduced physical and psychological disorders relative to successful LS. By contrast, late amputation (>90 days after injury) was significantly associated with the highest rates of physical and psychological disorders. The present study provides initial results to refine existing treatment strategies for amputees and to guide the development of treatment pathways after injury for LS patients. Further study should follow the long-term outcomes of amputee and LS populations using both military and Department of Veterans Affairs health databases.

AUTHORSHIP

T.M. is the first author, and he wrote the first draft of the manuscript; conducted literature search and review; is primarily responsible for the research design; managed all aspects of the scientific design, analysis, and interpretation of the results; and assisted the in data analysis and interpretation of the results and conclusions.

V.F.S. is the second author, and he assisted extensively on revising the introduction, method, results, and discussion sections of the manuscript. He completed all of the patient chart reviews to identify so-called LS patients. He contributed significantly to the interpretation of the literature reviewed and study results in the present study as they relate to combat extremity injuries. He has extensive experience treating combat injured patients with leg-threatening injuries at Naval Medical Center San Diego.

J.W. is the third author, and he was exclusively responsible for database analysis, extraction, and organization of all health data records for the present study. He was also primarily responsible for data analysis including logistic regressions. He also critically reviewed the manuscript and contributed to the overall research design and execution of the study.

M.R.G. is the fourth author, and he was primarily responsible for developing access to the Emergency Medical Encounter Database and the Joint Theater Trauma Registry to obtain in-theater casualty records for the present study. He also contributed to the overall scientific design of the study and critically reviewed the manuscript.

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DISCLOSURE

The authors declare no conflicts of interest.

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14. ABSTRACT Background: Treatment of military combatants who sustain leg-threatening injuries remains one of the leading challenges for military providers. The present study provides systematic health outcome data to inform decisions on the definitive surgical treatment, namely amputation versus limb salvage, for the most serious leg injuries. Methods: This was a retrospective analysis of health records for patients who sustained serious lower-extremity injuries in the Iraq and Afghanistan conflicts, 2001 to 2008. Patients had (1) amputation during the first 90 days after injury (early amputees, n = 587), (2) amputation more than 90 days after injury (late amputees, n = 84), or (3) leg-threatening injuries without amputation (limb salvage [LS], n = 117). Injury data and health outcomes were followed up to 24 months. Results: After adjusting for group differences, early amputees and LS patients had similar rates for most physical complications. Early amputees had significantly reduced rates of psychological diagnoses (posttraumatic stress disorder, substance abuse) and received more outpatient care, particularly psychological, compared with LS patients. Late amputees had significantly higher rates of many mental and physical health diagnoses, including prolonged infections and pain issues, compared with early amputees or LS patients. Conclusion: Early amputation was associated with reduced rates of adverse health outcomes relative to late amputation or LS in the short term. Most evident was that late amputees had the poorest physical and psychological outcomes. These findings can inform health care providers of the differing clinical consequences of early amputation and LS. These results indicate the need for separate health care pathways for early and late amputees and LS patients.					
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