EDITOR'S CHOICE

Postoperative Psychiatric Outcomes After Upper-Extremity Amputations

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Purpose Upper-extremity amputations alter patient form and, in cases of proximal amputation, may diminish overall function. Psychological outcomes following these procedures have been evaluated primarily on a single-institution basis. This study aimed to evaluate the incidence of psychiatric conditions following upper-extremity amputation on a population-wide basis.

Methods The TriNetX database was queried for all patients treated for upper-extremity amputations between January 1, 2010, and December 31, 2022. Preoperative and date-of-surgery diagnoses were collected to identify conditions preceding amputation. The 3-year incidence of mental health conditions was evaluated based on International Classification of Diseases codes. Chi-squared analyses were used to evaluate incidence between amputation levels. Odds ratios were used to compare outcome rates relative to the general population, as well as against that of the general, upper extremity surgical population.

Results A total of 25,091 patients underwent 25,415 amputations during our period of analysis. This group consisted of 23,416 transmetacarpal or digital amputations, 956 transforearm or wrist disarticulations, and 1,043 transhumerus or shoulder disarticulations. Traumatic etiologies were the most common across all levels. Increases in the rate of depression, general anxiety disorder, psychosis, mood disorders, alcohol or opioid abuse, post-traumatic stress disorder, and suicidality were observed in amputations at and proximal to the wrist compared to those isolated within the hand. Except for general anxiety disorder, the incidence of all psychiatric outcomes was higher relative to the general population. Compared to patients undergoing nonamputation upper extremity surgical procedures, matched analyses revealed increased odds of psychiatric illness at all amputation levels proximal to the phalanges.

Conclusions Approximately one in six patients who undergo an upper extremity amputation develop a psychiatric condition within 3 years, at an increased rate compared to the general population. Patients with more proximal amputations face a greater burden of psychiatric illness compared to those with more distal amputations. *(J Hand Surg Am. 2025;■(■):■−■. Copyright © 2025 by the American Society for Surgery of the Hand. All rights are reserved, including those for text and data mining, AI training, and similar technologies.)*

Type of study/level of evidence Prognosis IIc.

Key words Amputation, depression, post-traumatic stress disorder, psychiatric outcomes, upper extremity.

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Amputations of the upper extremity constitute challenging injuries to manage and can negatively affect patients' functional and occupational status as well their activities of daily living.[1] Psychological recovery following upper extremity injury is increasingly recognized as an important factor in improving patient-reported outcomes and functional recovery.[2] In fact, one meta-analysis suggested that psychosocial factors may be more predictive of disability than the degree of upper extremity impairment.[3]

Patients with upper extremity amputations are often young men.[2,4,5] In many instances, they have limited prior contact with the health care system, and the surgeon managing their injury represents a single point of long-term follow-up.[4,6] Therefore, it is important for upper extremity surgeons to recognize psychiatric comorbidities, facilitate appropriate referrals, and coordinate treatment. However, the true incidence of psychiatric illness after upper extremity amputation is incompletely understood as current knowledge is largely based on military populations and small studies from single institutions.[2,4]

This study used a large, multicenter database to better understand the incidence of psychiatric illness after upper extremity amputation.

MATERIALS AND METHODS

This study was a retrospective analysis using the TriNetX database. TriNetX is a multinational, multiinstitutional database that collects deidentified, aggregated data from 94 distinct health care organizations and includes information from over 110 million patients. Deidentification is performed using the standard defined in Section 164.514(a) of the Health Insurance Portability and Accountability Act Privacy Rule. The TriNetX database was queried on September 15, 2024. As the information reported in the database is aggregated and deidentified, it was exempt from institutional review board approval.

Data were collected from all patients who underwent upper extremity amputations between January 1, 2010 and December 31, 2022, with data extending for a mean of 604 days after surgery. A total of 77% of patients within the study were followed for a minimum of 6 months after surgery with 50% reaching a minimum of 5 years of follow-up. Patients <18 years of age and those aged ≥ 90 years were excluded. No restrictions were placed on the duration of preoperative enrollment in the TriNetX database.

Of the 94 hospital systems involved in the study, 41 were nonacademic centers, and 53 were academic institutions. Patients were enrolled from a broad geographic distribution, with 25% from the Northeastern United States, 19% from the Midwest, 41% from the South, 14% from the West. The percentage of patients from an unknown geographic location was $<1\%$. Amputations were identified using Current Procedural Terminology (CPT) codes, including shoulder disarticulations (CPT 23920, 23921), transhumeral amputations (CPT 24900, 24920, 24925, and 24930), forearm amputation (CPT 25900, 25905, 25907, and 25909), wrist disarticulations (CPT 25920, 25922, and 25924), transmetacarpal amputations (CPT 25927, 25929, 25915, and 26910), and digital amputations (CPT 26951 and 26952).

Using these criteria, we identified 25,091 patients who underwent a total of 25,415 upper extremity amputations. These were evaluated as a whole and stratified by amputation location. The incidence of a series of new psychiatric diagnoses established in the postoperative setting was assessed using International Classification of Diseases (ICD)-10 codes and, in cases where the primary amputation occurred prior to October 1, 2015, converted ICD-9 codes. Patients with psychiatric diagnoses on record that preceded amputation were not featured as part of our outcomes. Outcome measures evaluated included: F32 (depressive episode), F43.1 (post-traumatic stress disorder), F41.1 (generalized anxiety disorder), F11.1 (opioid abuse), F10 (alcohol-related disorders), F34 (persistent mood [affective] disorders), F39 (unspecified mood [affective] disorder), or F29 (unspecified psychosis not because of a substance or known physiological condition).

Preoperative diagnoses recorded from the date-of-surgery to within 1 month prior to amputation were collected to identify the conditions and pathologies associated with amputation. These diagnoses were grouped into categories reflecting trauma, infection, neoplasm, and vascular conditions. Traumatic etiologies included ICD-10 groupings S40−S49 (injuries to the shoulder and upper arm), S50−S59 (injuries to the elbow and forearm), and S60−S69 (injuries to the wrist and fingers). Infections incorporated ICD-10 diagnoses M65.1 (infective tenosynovitis), M86 (osteomyelitis), M72.6 (necrotizing fasciitis), and M00−M02 (infectious arthropathies). Neoplastic sources were evaluated using ICD-10 codes C40−C41 (malignant neoplasms of bone and articular cartilage) and C45−C49 (malignant neoplasms of the mesothelial and soft tissue). Finally, vascular conditions were assessed using ICD-10 codes I73.1 (thromboangiitis obliterans), I73.01 (Raynaud's syndrome with gangrene), and I70.26 (atherosclerosis of native arteries of extremities with gangrene).

TABLE 1. General Demographics of Patients With Upper Extremity Amputations and Stratified by Amputation Location

Demographic Variables	Digital or Metacarpal Amputations (N = 23,132)	Forearm or Wrist Amputations (N = 949)	Shoulder or Humerus Amputations (N = 1,043)	All Upper Extremity Amputations (N = 25,091)
Age (y) (SD)	49 (18)	47 (17)	49 (18)	49 (18)
Biological sex				
Males (%)	17,958 (77)	651 (68)	699 (67)	19,074 (76)
Females (%)	4,860 (21)	288 (30)	325 (31)	5,388 (21)
Unknown (%)	598 (3)	17 (2)	19 (2)	629 (3)
Ethnicity				
Not Hispanic or Latino (%)	16,370 (70)	678 (71)	725 (70)	17,546 (70)
Unknown (%)	3,752 (16)	140 (15)	160 (15)	4,018 (16)
Hispanic or Latino (%)	3,294 (14)	138 (14)	158 (15)	3,527 (14)
Race				
White (%)	16,461 (70)	626 (65)	739 (71)	17,620 (70)
Black or African American (%)	2,815 (12)	163 (17)	124 (12)	3,036 (12)
Unknown (%)	2,586 (11)	95 (10)	109 (10)	2,763 (11)
Other race (%)	955 (4)	40 (4)	41 (4)	1,025 (4)
Asian (%)	382 (2)	20 (2)	21 (2)	416 (2)
Native Hawaiian or other (%)	76 (<1)	<10* (1)	<10* (1)	149 (<1)
American Indian or Alaskan (%)	141 (<1)	<10* (1)	<10* (1)	82 (<1)

*TriNetX values <10 are rounded to 10 to preserve anonymity.

To assess the clinical applicability of our findings, we conducted two analyses to compare outcomes in our upper extremity amputation cohort with those in two separate, broad samples. First, we assessed the incidence of each psychiatric outcome in patients undergoing upper extremity amputation and compared them to the general population of individuals who had not undergone an upper extremity amputation and who were enrolled in the TriNetX database between January 1, 2010, and December 31, 2022. In addition, we performed a separate, propensity score-matched analysis controlling for demographic variables to compare patients undergoing upper extremity amputation with those undergoing nonamputation upper extremity procedures, including those involving the shoulder (CPTs 23000−23929), humerus and elbow (CPTs 23930−24999), forearm and wrist (CPTs 25000−25999), and hand and digits (CPTs 26010−26989).

Chi-squared tests were used to compare the raw incidence of each psychiatric outcome between proximal amputations (eg, shoulder disarticulations/transhumeral and forearm/wrist amputations) and distal amputations (eg, transmetacarpal/digital amputations). Differences in psychiatric outcomes between amputation cohorts and control groups were evaluated using odds ratios (ORs) with 95% confidence intervals (CIs). Logistic regression for age, biological sex, ethnicity, and race was performed to facilitate propensity score-matched analyses using one-to-one propensity score matching, which was then used to assess overall psychiatric outcomes between different amputation levels and individuals undergoing nonamputation upper extremity procedures. Statistical significance was set at $P < .05$ for all analyses.

RESULTS

Demographics and perioperative-associated diagnoses of upper extremity amputation

We collected data from 25,091 patients who underwent 25,415 amputations. These included 23,132 digital or metacarpal amputations, 949 amputations at the forearm or wrist, and 1,043 amputations at either the humerus or shoulder (Table 1). The average age of patients undergoing any form of amputation was 49 years. Men comprised 76% of the overall cohort, women made up 21%, and sex was unknown for 3%.

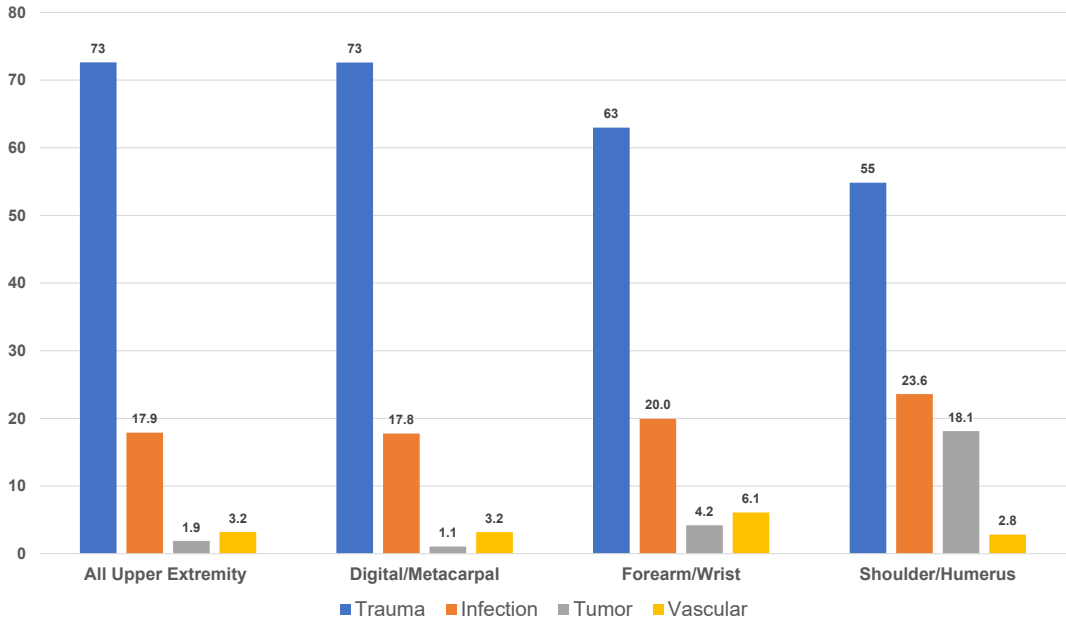

FIGURE 1: Associated diagnoses present in patients undergoing upper extremity amputation. All diagnoses were present between 1 month prior to surgery up until the day of surgery. Diagnoses are grouped broadly into either traumatic, infectious, neoplastic, or vascular etiologies. Data are illustrated as they present across all amputations and stratified by amputation level.

Ethnic demographics were relatively consistent across each amputation location. Patients identifying as White comprised 70% of the overall cohort, Black or African American patients comprised 12%, and 11% of the overall population were of unknown race. Other racial demographics comprised less than 4% of the overall population.

Preoperative and date-of-surgery diagnoses were collected as a proxy to identify the underlying pathologies leading to upper extremity amputation (Fig. 1). Across all amputation levels, trauma was the leading associated diagnosis by a wide margin. Infectious etiologies were the second most common associated diagnoses in each group, remaining relatively consistent between 17.8% to 23.6% across amputation levels. Vascular etiologies were the third most common associated diagnosis in digital/metacarpal and forearm/wrist amputation cohorts. However, diagnoses linked to underlying neoplastic disease were significantly more common in patients undergoing shoulder or transhumeral disarticulations, with 18.1% of these patients carrying these associated diagnoses compared to 3.2% and 6.1% in the digital/hand and forearm/wrist cohorts, respectively.

Psychiatric outcomes relative to the general population

To establish a baseline for the incidence of psychiatric outcomes and assess their clinical significance, we queried the database for the incidence of depression, general anxiety disorder (GAD), psychosis, mood disorders, alcohol or opioid abuse, post-traumatic stress disorder (PTSD), and suicidal ideation/attempts following all upper extremity amputations. These findings were compared with baseline incidence data from the general population (Table 2). To establish this baseline, we queried TriNetX for all patients with data between January 1, 2010, and December 31, 2022, who had not received upper extremity amputations.

We found significantly increased odds for depression, psychosis, mood disorders, alcohol and opioid abuse, PTSD, suicidality, and the aggregate of psychiatric outcomes when compared to the general population. Values ranged from 1.60 for suicidal ideation/attempts (95% CI, 1.42−1.79) to 4.14 for opioid abuse (95% CI, 3.68−4.66). No statistically significant difference in the incidence of GAD was observed (OR, 0.98; 95% CI, 0.90−1.08).

Psychiatric outcomes after amputation relative to general upper extremity procedures

The incidence of depression, GAD, psychosis, mood disorders, alcohol or opioid abuse, PTSD, and suicidal ideation/attempts was evaluated based on amputation level and compared to that of patients undergoing nonamputation, upper extremity surgical procedures (Table 3). Depression, GAD, psychosis, alcohol abuse, opioid abuse, PTSD, suicidal ideation/

TABLE 2. Incidence of Psychiatric Outcomes Relative to the General Population

Variable	Incidence Across All Amputations (25,091)	Incidence in the General Population (112,139,410)	Odds Ratio (95% CI)
Depression	10.8%	6.2%	**2.19 (2.10−2.28)**
Generalized anxiety disorder	1.9%	2.2%	0.98 (0.90−1.08)
Psychosis	0.7%	0.4%	**2.03 (1.75−2.35)**
Mood disorder	1.8%	1.2%	**1.77 (1.61−1.94)**
Alcohol abuse	3.6%	2.0%	**2.22 (2.08−2.38)**
Opioid abuse	1.1%	0.3%	**4.14 (3.68−4.66)**
Posttraumatic stress disorder	2.5%	0.8%	**3.81 (3.52−4.13)**
Suicidal ideation or suicide attempt	1.2%	0.9%	**1.60 (1.42−1.79)**
All psychiatric outcomes	15.9%	9.7%	**2.17 (2.10−2.24)**

Bolded values are statistically significant.

attempts, and overall psychiatric outcomes were increased in the proximal levels of amputation relative to that of the general upper extremity procedural cohort. However, with regard to digital or metacarpal amputations, only psychosis, alcohol and opioid abuse, PTSD, and suicidal ideation were increased relative to the general procedural cohort. Rates of depression, mood disorders, GAD, and overall psychiatric diagnoses were decreased in patients undergoing amputations limited to the digits or metacarpals.

When evaluating the incidence between amputation levels, no statistically significant difference was seen in the incidence of any psychiatric outcome between amputations at the forearm or wrist versus those at the shoulder or humerus. However, relative to digital or metacarpal amputations, more proximal levels of amputation displayed universally elevated incidences of adverse outcomes.

Matched psychiatric outcomes relative to the general upper extremity procedural population

Given the potential for demographic variables to confound our results, we performed separate matched analyses to compare the incidence of overall psychiatric outcomes between patients undergoing upper extremity amputation and those undergoing nonamputation upper extremity surgical procedures (Fig. 2). Propensity score-matched analyses were used to account for differences in demographics, specifically age, sex, race, and ethnicity. We found statistically significant increases in the rates of psychiatric outcomes associated with shoulder disarticulations, transhumeral amputations, wrist disarticulations, and transmetacarpal amputations, with ORs ranging from 1.55 to 2.11 ($P < .05$). However, no statistically significant difference was observed in psychiatric outcomes between patients undergoing digital amputations and those in the general upper extremity surgical population.

DISCUSSION

In this study, we evaluated psychiatric outcomes in a sample of 25,091 patients undergoing upper extremity amputations across a 12-year period. Previous studies evaluating the mental health of patients undergoing upper extremity amputation have been limited to retrospective analyses of single institutions or military personnel. Our study provides an analysis of the largest sample of patients undergoing any form of upper extremity amputation to date.

We observed higher rates of psychiatric disease following upper extremity amputation compared to the incidence of psychiatric pathology in the general population. Additionally, patients undergoing amputations proximal to the digits exhibited increased rates of psychiatric conditions compared to those undergoing nonamputation upper extremity procedures. Previously, Beleckas et al[7] reported high rates of depression and anxiety in patients with upper extremity pathology. In their single-institution study, they evaluated 3,315 patients using Patient-Reported Outcomes Measurement Information System data and found a high prevalence of anxiety and depression in patients seeking care for routine upper extremity conditions (eg, de Quervain tenosynovitis, Dupuytren disease, and carpal tunnel syndrome). In our study, we similarly found that patients in the general upper extremity procedural population had a significant

TABLE 3. Three-year Incidence of Psychiatric Diagnoses Following Upper-Extremity Amputation Compared to Other Nonamputation Upper-Extremity Procedures

Variable	Digital or Metacarpal Amputation (N = 23,416)	Forearm or Wrist Amputation (N = 956)	Shoulder or Humerus Amputation (N = 1,043)	All Nonamputation Upper Extremity Procedures (N = 1,181,819)
Depression	**10.7%**	**18.5%**†	**18.7%**†	11.5%
Generalized anxiety disorder	**1.9%**	2.8%†	2.7%†	3.2%
Psychosis	**0.7%**	**1.2%**†	**1.0%**†	0.5%
Mood disorder	**1.9%**	2.6%†	2.3%†	2.1%
Alcohol abuse	**3.7%**	**4.9%**†	**5.1%**†	3.1%
Opioid abuse	**1.1%**	**2.6%**†	**2.3%**†	0.7%
Posttraumatic stress disorder	**2.4%**	**5.3%**†	**5.9%**†	1.6%
Suicidal ideation or suicide attempt	**1.2%**	**1.9%**†	**2.4%**†	1.0%
All psychiatric outcomes	**15.9%**	**25.7%**†	**25.7%**†	16.4%

Bolded values indicate statistically significant differences relative to nonamputation upper- extremity procedures ($P < .05$).

†Values with statistically significant differences relative to the digital/metacarpal group ($P < .05$). No statistically significant differences were observed in the incidence of psychiatric outcomes between the forearm or wrist amputation cohort and the shoulder or humerus amputation cohort

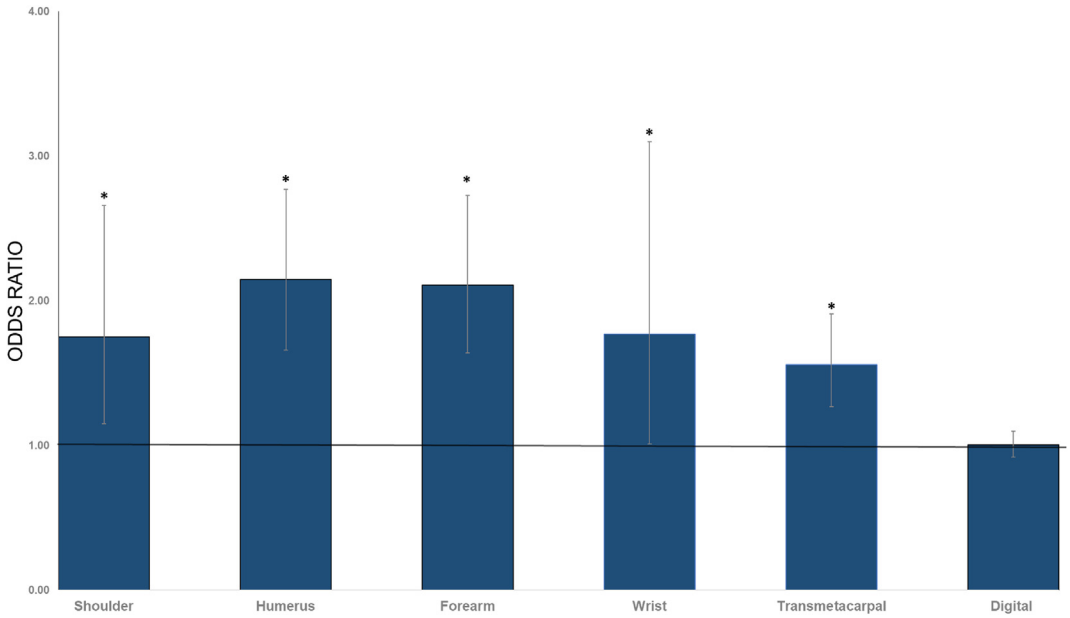

FIGURE 2: Three-year matched psychiatric outcomes following upper extremity amputation compared to nonamputation upper extremity procedures. Asterisks indicate $P < .05$.

burden of psychiatric disease, with an overall incidence of 16.4%. Although distal amputation levels exhibited similar overall rates of psychiatric disease to other upper extremity procedures, both shoulder/humerus and forearm/wrist amputations showed significantly higher incidences. This effect was consistent across matched analyses. We believe our findings underscore the importance of surgeons maintaining a high baseline suspicion for psychiatric disease in patients undergoing upper extremity amputations, particularly those with more proximal injuries, and suggest increased screening and referrals for these patients.

Within 3 years of upper extremity amputation, we found that 10.7% to 18.7% of patients in our cohort were diagnosed with depression, whereas 2.4% to 5.9% received a diagnosis of PTSD. In comparison, 11.5% and 1.6% of patients undergoing nonamputation upper

extremity procedures had diagnoses of depression and PTSD, respectively. Relative to the general population, patients who underwent upper extremity amputation had ORs of 2.19 and 3.81 for depression and PTSD, respectively. In the Military Extremity Trauma Amputation/Limb Salvage (METALS) study, Mitchell et al[8] evaluated a series of 155 individuals who underwent amputation or limb salvage procedures after upper extremity trauma. Through a series of interviews, they found that 36.4% of patients who had undergone upper extremity amputation screened positive for depression, and 21.2% provided questionnaire answers suggestive of PTSD. In a civilian study, Cohen-Tanugi et al[4] performed a single-institution study between 2016 and 2019 in which 39 patients with traumatic upper extremity amputations were screened using the Center for Epidemiologic Studies Depression Scale and the Primary Care PTSD Screen. They found that 51% of their cohort screened positive for depression at a mean time of 6.5 months after surgery and 69% screened for PTSD on average 10 months after surgery. These results highlight a discordance between the formal diagnosis of both depression and PTSD compared to symptomatic manifestations of both conditions, emphasizing the importance of a high clinical awareness for the mental health of patients undergoing upper extremity amputation.

The development of substance use disorders following orthopedic trauma has been of particular interest in the literature.[9–11] Consequently, we assessed the development of both opioid and alcohol dependence in the aftermath of upper extremity amputations. In our analysis, the incidence of opioid and alcohol abuse ranged from 1.1% to 2.6% and 3.7% to 5.1%, respectively, across all amputation levels. Relative to the general population, we found ORs of 2.22 (95% CI, 2.08−2.38) for alcohol abuse and 4.14 (95% CI, 3.68−4.66) for opioid abuse. In a comparable, ICD-based study that included 92 veterans with upper extremity amputations, 6% developed substance use disorders within 1 year of their index procedure.[12] In another study encompassing 236 patients across seven prosthetic rehabilitation centers in the United States, screening revealed concern for alcohol abuse in 39% of patients with upper extremity amputations. Similarly, 12% of patients in that study provided answers concerning for prescription drug abuse and 7% for illicit substance abuse.[13] Another ICD-based study incorporating the Expeditionary Medical Encounter Database evaluated a total of 131 traumatic upper extremity amputations.[14] They found an 18% prevalence of substance use disorders in above-elbow amputations compared to a 20% prevalence in patients with below-elbow amputations. Our study also found a comparatively high incidence of substance use disorders in this population. Given the operative risks associated with substance use, as well as their deleterious long-term sequelae, patients should be counseled appropriately and a low threshold for psychiatric referral should be maintained.

Our study has limitations, many of which are intrinsic to any database-driven, retrospective analysis. We lack patient-specific outcome measures that could further characterize the burden of disease imposed by upper extremity amputation. Moreover, the incidence of all psychiatric outcomes we evaluated relied on accurate diagnostic coding and, more broadly, access to care. As psychiatric care has historically been underused because of systemic barriers and societal biases, our reported incidences likely underrepresent the true burden of psychiatric disease following upper extremity amputations. This may be supported by the higher incidences of depression and PTSD observed in studies reliant on screening rather than formal diagnostic metrics. For approximately 48% of the patients in our study, the diagnosis leading to amputation marked their first contact with a formalized health care setting. In such cases, it is not possible to determine whether they experienced psychiatric conditions prior to the amputation and could potentially result in a falsely elevated incidence of our outcomes.

Nonetheless, our findings highlight the substantial mental health burden experienced by many patients undergoing upper extremity amputations. This study underscores the importance of a multifaceted approach to the care of patients undergoing life-altering procedures. Given the often dramatic impact of upper extremity amputations on both patient form and function, prompt psychiatric referral may be necessary to optimize long-term outcomes after these surgeries. Multidisciplinary care that addresses both the somatic and psychological aspects of recovery may help optimize outcomes and mitigate the risks associated with psychiatric conditions.

CONFLICTS OF INTEREST

No benefits in any form have been received or will be received related directly to this article.

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