

RESEARCH ARTICLE

Which Pre-Operative, Modifiable Risk Factors are Most Predictive of Complications in orthopedic Upper Extremity Surgery?

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Received: 10 April 2022

Accepted: 16 December 2023

Abstract

Objectives: Identification of modifiable comorbid conditions in the preoperative period is important in optimizing outcomes. We evaluate the association between such risk factors and postoperative outcomes after upper extremity surgery using a national database.

Methods: The National Surgical Quality Improvement Program (NSQIP) 2006-2016 database was used to identify patients undergoing an upper extremity principle surgical procedure using CPT codes. Modifiable risk factors were defined as smoking status, use of alcohol, obesity, recent loss of >10% body weight, malnutrition, and anemia. Outcomes included discharge destination, major complications, bleeding complications, unplanned re-operation, sepsis, and prolonged length of stay. Chi square and multivariable logistic regressions were used to identify significant predictors of outcomes. Significance was defined as $P < 0.01$.

Results: After applying exclusion criteria, 53,780 patients were included in the final analysis. Preoperative malnutrition was significantly associated with non-routine discharge (OR=4.75), major complications (OR=7.27), bleeding complications (OR=7.43), unplanned re-operation (OR=2.44), sepsis (OR=10.22), and prolonged length of stay (OR=5.27). Anemia was associated with non-routine discharge (OR=2.67), bleeding complications (OR=13.27), and prolonged length of stay (OR=3.26). In patients who had a weight loss of greater than 10%, there was an increase of non-routine discharge (OR=2.77), major complications (OR=2.93), and sepsis (OR=3.7). Smoking, alcohol use, and obesity were not associated with these complications.

Conclusion: Behavioral risk factors (smoking, alcohol use, and obesity) were not associated with increased complication rates. Malnutrition, weight loss, and anemia were associated with an increase in postoperative complication rates in patients undergoing upper limb orthopaedic procedures and should be addressed prior to surgery, suggesting nutrition labs should be part of the initial blood work.

Level of evidence: III

Keywords: Modifiable, NSQIP, Orthopaedic, Postoperative complications, Risk factors, Upper extremity surgery

Introduction

Upper extremity fractures account for approximately two million emergency department visits annually¹ and have an annual incidence of 68 fractures per 10,000 persons.² Over the past several decades, operative treatment of such fractures has increased substantially, along with the potential for surgical morbidity.³ Awareness of perioperative modifiable

patient conditions and development of programs to improve patient outcomes have been the subject of recent research in the surgical literature.⁴ This offers the advantages of a proactive, preventative approach rather than retrospective treatment.

Previous research has shown that complication rates after orthopaedic surgery are increased by various modifiable

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risk factors.⁵ One study of primary joint arthroplasty showed that uncontrolled diabetes, smoking, obesity, and poor dental health were associated with early revisions.⁶ Other studies have demonstrated that the presence of modifiable comorbidities is associated with poorer outcomes and increased costs.⁷⁻⁹ Unfortunately, such risk factors are not uncommon. Admitted patients are commonly undernourished, with hospitalization often worsening this malnutrition.^{10,11} Malnutrition is highly associated with cardiopulmonary complications, longer length of stay, and mortality. Thus nutritional support is recommended even for well-nourished patients.^{10,12,13}

The current evidence shows that improvement of patients' postoperative outcomes may be achieved by modifying their preoperative status. While many of the aforementioned studies investigate outcomes with modifiable risk factors in the lower extremity, to date, there are limited data describing the effects of these risk factors in orthopaedic procedures of the upper extremity. The purpose of this study is to determine the relationship between different modifiable preoperative risk factors and morbidity after upper extremity surgery.

Materials and Methods

Data Set

We used patient data obtained by the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) public use file (PUF). NSQIP is a validated, risk-adjusted, outcomes-based national database used for the improvement of surgical care.¹⁴ A trained reviewer collects data from the preoperative period through the 30-day postoperative period. The database includes over 100 variables, including pre-operative risk factors, intraoperative data, and morbidity and mortality outcomes for 30 days postoperatively.¹⁵

Online tutorials document specific methodological considerations to understand prior to analysis.^{16,17} Specific Current Procedural Terminology (CPT) codes are used to extract the appropriate data on surgical procedures.

Patient Selection

The NSQIP 2006-2016 dataset was queried for all adults who had upper extremity surgery as a principle procedure performed by an orthopaedic surgeon using 297 CPT codes. Procedures performed by a non-orthopaedic surgeon or patients that were missing demographic data were excluded. This study was exempt from Institutional Review Board (IRB) approval, as it does not qualify as human subjects research. There were no sources of funding for this study.

Definitions and Outcomes

The primary goal of this study was to determine the rate of complications based on pre-operative modifiable factors. Six modifiable risk factors were selected: smoking status, use of alcohol, obesity, recent loss of >10% body weight, malnutrition, and anemia. Malnutrition was defined as a pre-operative albumin level of <3.5, anemia was defined as a pre-operative hematocrit level of <39%, and obesity was defined as BMI>30. The outcomes of interest included discharge destination, major complications, bleeding complications, unplanned re-

operation, sepsis, and prolonged length of stay. Non-routine discharge was defined as discharge to a location other than the patient's home (such as skilled care, acute care, rehabilitation facilities), prolonged length of stay was defined as >95th percentile in the study population (four days), and alcohol use was defined as self-reported drinking >two ounces of hard liquor, > two 12 oz. cans of beer, or > two 6 oz. glasses of wine per day in the two weeks prior to admission. Major complications were defined as presence of deep surgical site infection, sepsis, ventilator dependence \geq 48 hours, re-intubation, acute renal failure, deep vein thrombosis, pulmonary embolism, myocardial infarction, cardiac arrest, or cerebrovascular accident.

Statistical Analysis

Analyses were performed with the NSQIP 2006-2016 dataset. Chi Square tests were utilized to determine modifiable risk factors that were significantly associated with increased comorbidities and complications after upper extremity surgery. Significant and demographic variables were used in the binary logistic regression analysis. Significance was defined as $P<0.01$. Data management and statistical analysis were performed using Statistical Package for Social Science (SPSS) (International Business Machines, Corp., Armonk, NY), version 23.

Results

Demographics

A total of 82, 214 patients underwent upper extremity surgery during the study period. There were 64,886 surgeries performed by orthopaedic surgeons and of those, cases with missing age, gender, and race were excluded, resulting in 53,780 cases remaining for the final analysis.

The majority of patients were age 41 to 60 (37.8%), female (53.3%), and Caucasian (81.5%) [Table 1].

Of the patients selected, 0.2% of patients had recent weight loss of greater than 10%, 21.6% were current smokers, 30.5% have obesity, 3.5% have malnutrition, 16.5% have anemia, and 0.6% use alcohol [Table 1, Figure 1].

Modifiable Risk Factors

After adjusting for demographics and clinical covariates, our analysis showed that malnutrition increased the likelihood of non-routine discharge (OR= 4.75), major complications (OR=7.27), bleeding complications (OR=7.43), unplanned re-operation (OR=2.44), prolonged length of stay (OR=5.27), and sepsis (OR=10.22) [Table 2; Table 3].

There was an increased likelihood of non-routine discharge (OR=2.67), bleeding complications (OR=13.27), and prolonged length of stay (OR=3.26) in patients who had anemia pre-operatively. In patients who underwent a weight loss of greater than 10%, there was an increase of non-routine discharge (OR= 2.77), major complications (OR = 2.93), and sepsis (OR= 3.70). Smoking, alcohol use, and obesity were not significantly associated with any of the postoperative complications [Table 2; Table 3].

Table 1. Demographic Data	
Variable	Frequency
Age	
18-40	15954 (29.7%)
41-60	20338 (37.8%)
61-80	14954 (27.8%)
>80	2534 (4.7%)
Female	28683 (53.3%)
Race	
Caucasian	43856 (81.5%)
African American	4678 (8.7%)
Hispanic	2896 (5.4%)
Other	2350 (4.4%)
Recent Weight Loss >10%	117 (0.2%)
Current Smoker	11606 (21.6%)
Obesity	16411 (30.5%)
Malnutrition	1903 (3.5%)
Anemia	8889 (16.5%)
Alcohol Use	315 (0.6%)

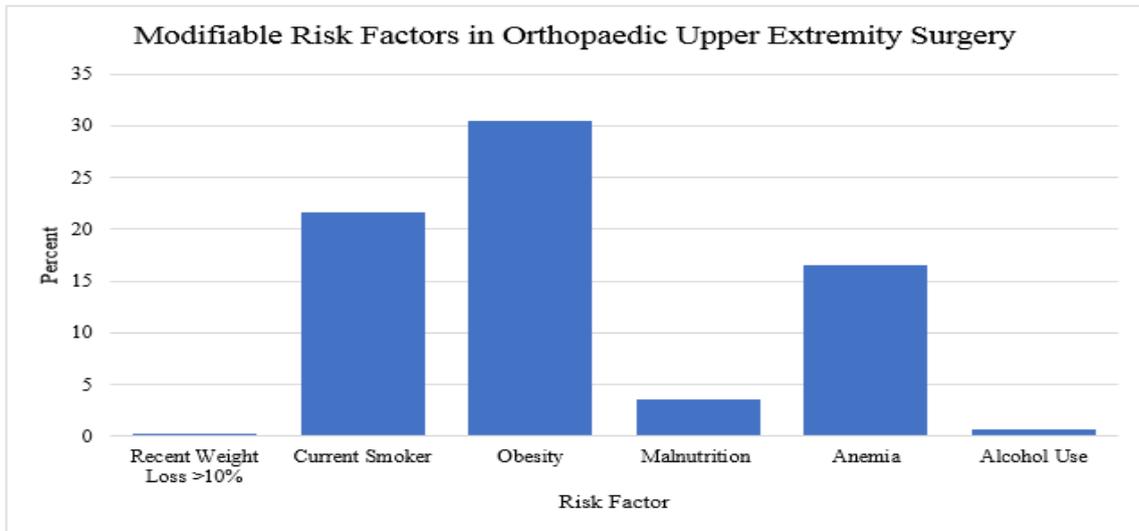


Figure 1. Prevalence of modifiable risk factors in orthopaedic upper extremity surgery

Table 2. Predictors of Adverse Events in Patients Undergoing Orthopaedic Surgery of the Upper Extremity			
	Non-Home Discharge Destination	Major Complication	Bleeding Complication
	OR ^a (95% CI ^b)	OR ^a (95% CI ^b)	OR ^a (95% CI ^b)
Age			
18-40	Ref ^c	Ref ^c	Ref ^c
41-60	1.49 (0.98-2.26)	0.74 (0.47-1.14)	1.51 (0.83-2.74)
61-80	5.32 (3.61-7.85)*	1.03 (0.66-1.59)	2.96 (1.68-5.22)*
>80	17.56 (11.71-26.34)*	0.94 (0.52-1.7)	4.47 (2.43-8.24)*
Female	0.62 (0.49-0.78)*	0.31 (0.19-0.5)*	0.09 (0.04-0.21)*
Race			
Caucasian	Ref ^c	Ref ^c	Ref ^c

Table 2. Continued

African American	1.3 (0.99-1.71)	1.41 (0.93-2.14)	1.34 (0.89-2.01)
Hispanic	0.59 (0.39-0.88)*	0.79 (0.41-1.51)	0.6 (0.3-1.18)
Other	0.77 (0.49-1.23)	1.15 (0.5-2.66)	0.66 (0.27-1.63)
Recent Weight Loss >10%	2.77 (1.47-5.23)*	2.93 (1.26-6.85)*	2.53 (1.15-5.57)
Current Smoker		1.43 (1.03-1.98)	
Obesity		1.27 (0.94-1.7)	
Malnutrition	4.75 (4.06-5.55)*	7.27 (5.69-9.29)*	7.43 (5.49-10.06)*
Anemia	2.67 (2.15-3.31)*	1.79 (1.07-3.01)	13.27 (5.82-30.28)*
Alcohol Use	-	-	

aOdds ratio, bConfidence interval, cReference, *Significance, defined as P<0.01

Table 3. Predictors of Adverse Events in Patients Undergoing Orthopaedic Surgery of the Upper Extremity

	Unplanned Re-Operation OR ^b (95% CI ^c)	Prolonged LOS ^a OR ^b (95% CI ^c)	Sepsis OR ^b (95% CI ^c)
Age			
18-40	Ref ^d	Ref ^d	Ref ^d
41-60	2.47 (0.71-8.64)	1.44 (0.84-2.46)	0.49 (0.29-0.83)*
61-80	3.8 (1.08-13.42)	2.39 (1.4-4.07)*	0.52 (0.3-0.9)
>80	1.34 (0.2-8.79)	5.17 (2.77-9.65)*	0.33 (0.13-0.81)
Female	0.51 (0.21-1.24)	0.38 (0.23-0.62)*	0.2 (0.08-0.46)*
Race			
Caucasian	Ref ^d	Ref ^d	Ref ^d
African American	1.54 (0.58-4.13)	1.61 (0.99-2.61)	1.74 (1.03-2.93)
Hispanic	0.63 (0.19-2.08)	0.46 (0.27-0.8)	1.13 (0.48-2.65)
Other	3.3 (0.73-14.79)	1.81 (0.67-4.94)	1.85 (0.73-4.7)
Recent Weight Loss >10%		1.93 (0.51-7.24)	3.7 (1.38-9.9)*
Current Smoker	1.79 (0.88-3.63)	1.31 (0.89-1.92)	1.4 (0.91-2.16)
Obesity	-	1.06 (0.78-1.45)	
Malnutrition	2.44 (1.22-4.89)*	5.27 (3.88-7.14)*	10.22 (6.64-15.74)*
Anemia	1.07 (0.41-2.81)	3.26 (2.04-5.22)*	2.3 (0.94-5.62)
Alcohol Use	0.89 (0.26-3.07)	1 (0.54-1.86)	

aLength of Stay >95th percentile, bOdds ratio, cConfidence interval, dReference, *Significance, defined as P<0.01

Discussion

Minimizing preoperative risk factors is a primary goal of surgical planning. Certain variables are known to affect surgical outcomes, such as age, race, cancer status, and genetic diseases, cannot be changed or modified in the perioperative period. Some conditions are more amenable to change, however, and should become a target of physician-patient collaboration prior to surgery. Our data demonstrated that malnutrition, recent weight loss, and anemia are three modifiable risk factors that are associated with postoperative complications when undergoing orthopaedic upper extremity surgery. Interestingly, while malnutrition and anemia were positively associated with increasing postoperative complication, behavioral risks including smoking, alcohol use, weight loss, and obesity, were not associated with increased complication rates in

upper extremity surgery.

Previous studies have shown variable effects of these risk factors. In primary and revision arthroplasty, malnutrition has been associated with increased length of stay, but the extent of effect on other adverse outcomes is debatable.¹⁸ It has also been shown to increase the rates of surgical site infections by over 200% in various orthopaedic surgeries.¹⁹ Similarly, anemia has been shown to increase postoperative complications in total joint arthroplasty²⁰ but a meta-analysis on the effects of anemia across multiple studies determined that it was unclear whether anemia was an independent risk factor or a just a marker for underlying disease.²¹ In a prospective cohort study investigating smoking and surgical site infections, Maksimović et al.²² found that smokers did not have an increased risk, while a separate meta-analysis found that smoking lead to increased

rates of infections, morbidity, and pulmonary complications.²³ Obesity increased complication rates consistently in tibial shaft fracture surgeries,²⁴ while alcohol reduces osseous turnover and leads to skeletal demineralization and increased complication rates after orthopaedic surgeries.^{25,26}

Of the patients included in our study, 16.5% of patients had anemia, 3.5% of patients had malnutrition, and only 0.2% of patients experienced recent weight loss. While recent weight loss demonstrated a positive increase in complications rates, results must be interpreted with caution due to the low number of cases with this condition. A larger number of patients had anemia and malnutrition. These risk factors may serve as targets for intervention prior to operative management in the elective setting, involving both physician and patient action. There are well-established methods to address these comorbidities, such as diet modification, enteral nutrition, normalization of hematocrit, blood transfusions, or other hematologic interventions. These interventions, however, must be investigated prospectively and are not specifically addressed in our study.

This study has several important limitations. Analysis is limited by the accuracy and completeness of the data provided in the NSQIP database. Not all procedures at a given institution are included in the database, thus there is a disproportionate contribution of surgeries to NSQIP, mainly from large academic hospitals.²⁷ The database does not include any data for the severity of complications or for surgical indications, such as nonunion. Furthermore, our sample had a high percentage of Caucasians compared to other races, which may introduce a selection bias. Another source of selection bias may be our inclusion of cases with any upper extremity surgery, which range from irrigation and debridement to operative fixation and amputation. However, we believe there is no systemic difference in the distribution of modifiable risk factors by type of procedure, and any minor discrepancies are unlikely to affect our conclusions. Finally, the sample size for patients that use alcohol and had recent weight loss was small and definitive conclusions on their effect on complication rates cannot be drawn.

Despite the limitations of our analysis, our study highlights the relationship between modifiable risk factors and complication rates in upper extremity surgeries. Many

studies have focused on medications and other risk factors that affect postoperative complications but fail to study how patients can modify behavior to lower complication rates. A randomized prospective study is needed to demonstrate the effectiveness of modifying different risk factors and determine to which degree each risk factor plays in certain postoperative outcomes.

Conclusion

We present a study to determine the relationship between preoperative modifiable risk factors and postoperative complication rates. Interestingly, the behavioral risk factors in this analysis (smoking, alcohol use, and obesity) were not associated with complication rate. Malnutrition, recent weight loss, and anemia are three potentially modifiable risk factors that should be addressed prior to surgery in order to mitigate postoperative complications and reduce healthcare costs, increase hospital profitability, and limit readmissions in today's healthcare environment. Awareness of these associations may lead to prospective studies that determine the effectiveness of modifying certain risk factors.

Acknowledgement

Not applicable

Conflict of interest: Author Michael M. Vosbikian, M.D. receives honorarium for content authorship from The Journal of Bone and Joint Surgery and is an editorial board member for ePlasty. The authors do not have any other potential conflicts of interest with respect to this manuscript.

Funding: None

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