RESEARCH ARTICLE

The Impact of Preoperative Co-morbidities on Blood Transfusion Requirements Following Reverse Total Shoulder Arthroplasty

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Received: 3 April 2024 *Accepted: 29 April 2024*

Abstract

Objectives: Reverse total shoulder arthroplasty (RTSA) continues to increase in popularity as a surgical operation in the United States. As indications for this procedure expand, more attention is needed to evaluate perioperative risk factors and patient characteristics. Postoperative anemia requiring blood transfusion (BT) is a well-documented risk factor for increased in-house mortality although little has been studied on the relationship between RTSA and postoperative BT. The purpose of this study was to identify comorbidities and patient characteristics as risk factors for BT in patient's undergoing RTSA.

Methods: Using the Nationwide Inpatient Sample (NIS) database, 59,925 RTSA patients (2016-2019) were analyzed, with 1.96% requiring postoperative BT. Demographics, comorbidities, and preoperative factors were compared between BT and non-BT groups via univariate and multivariate analyses.

Results: Overall prevalence of blood transfusion in all patients was 1.96%. Male sex (OR 1.75, $p < 0.001$), Asian ethnicity (OR 1.96, $p = 0.012$), age >80 (OR 1.51, $p < 0.001$), age >90 (OR 2.26, $p < 0.001$), CKD (OR 1.94, $p < 0.001$), and Parkinson's disease (OR 2.08, $p < 0.001$) were associated with increased BT odds. Cirrhosis exhibited the highest impact (OR 5.7, $p < 0.001$). Conversely, Caucasian ethnicity (OR 0.76, $p = 0.023$), uncomplicated DM (OR 0.73, $p = 0.002$), tobacco-related disorders (OR 0.43, $p < 0.001$), BMI >30 (OR 0.8, $p = 0.011$), and elective procedures (OR 0.16, $p < 0.001$) decreased BT odds.

Conclusion: These results were useful with identifying several risk factors that predispose to a higher risk of postoperative BT in patients undergoing RTSA including male sex, people of Asian descent, age > 80, CKD, Parkinson's disease, and cirrhosis. These findings provide clinicians with information that may be helpful with preoperative planning and perioperative management of complex patient populations.

Level of evidence: III

Keywords: Blood transfusion requirements, Nationwide inpatient sample, Preoperative co-morbidities, Reverse Total Shoulder Arthroplasty

Introduction

Revere total shoulder arthroplasty (RTSA) was initially developed as a salvage procedure for cuff tear arthropathy. More recently, it has been gaining popularity as a great procedure to treat different shoulder pathological conditions in adult populations such as degenerative glenohumeral arthritis, irreparable rotator cuff tears, and traumatic fractures.[1-3] as these indications have continued to expand, the number of procedures per year has continued to increase as well. From 2016 to 2020, 154,499 patients have undergone primary shoulder arthroplasty, of those 95,808 underwent RTSA.[3] As of 2023, the American Academy of Orthopedic Surgeons estimates that more than 53,000 shoulder replacements are performed in the U.S. each year.[4]

As the incidence of this procedure increases, so too does the rate of complications. Recent studies have shown rates

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of complications ranging from 13%–24% following RTSA.[2,5-7] In the postoperative period, patients are sometimes given blood transfusions (BT) if clinically indicated, typically performed as a resuscitation effort and to prevent postoperative anemia, which has been shown to be a predictor for in-hospital mortality following surgery.[8-10] There are studies in the literature that discuss post-op complications following RTSA, however few focus on how pre-op comorbidities affect the need for BT following surgery.[11-15] The existing studies that have explored the relationship of patient risk factors and BT have been limited by older datasets or lack an adequate sample size.[16-21]

The aim of our study was to use a high-powered database to assess for any relationship between pre-operative comorbidities and patient characteristics with rates of BT in patients undergoing rTSA. We hypothesize that risk factors that lead to lower preoperative hemoglobin (hgb) would lead to higher rates of BT.

Materials and Methods

Data Acquisition

Patient data from individuals who underwent primary reverse total shoulder arthroplasty (RTSA) in the United States between 2016 and 2019 were obtained from the Nationwide/National Inpatient Sample (NIS) database. Within this cohort, those who received blood transfusions during their hospital stay were identified. The NIS database contains a wide range of information, including patient demographics (including any accompanying comorbidities) and details related to hospital admission (such as length of stay, associated costs, and discharge specifics).

The NIS database stands as the largest publicly available, all-payer database for inpatient care within the United States, encompassing data from over 7,000,000 hospital stays. Rigorous quality assessments ensure the reliability of the data, which is cross-referenced with predetermined benchmarks. Due to its extensive size, the NIS database is invaluable for generating national and regional estimates, as well as for examining rare conditions, unconventional treatments, and specific patient groups. The version of the NIS database covering the years 2016 to 2019 categorizes conditions using the International Classification of Diseases, Tenth Revision, Clinical Modification/Procedure Coding System (ICD-10-CM/PCS).

Data Extraction

Since the information on NIS database is de-identified and publicly available, our study was exempted from the Institutional Review Board approval. All patients who underwent RTSA, were identified based on code from International Classification of Diseases (ICD-10), 10th Revision Clinical Modification Procedure (ICD-10 CMP). Various details including age, sex, ethnic background, and elective versus non-elective surgery provided in the NIS dataset were utilized for analysis of patient characteristics medical co-morbidities such as DM, chronic kidney disease, tobacco use disorder, liver cirrhosis, Parkinson's, dialysis, and previous organ transplant were recorded utilizing ICD-10 Diagnosis Code. The BT data of the sample population were obtained. A detailed comparison of all the included parameters between the various groups was made and analyzed statistically. Overall, 59925 patients underwent RTSA, during the time period between 2016 and 2019 and were included in our study from the NIS database. Among these patients, 1177 (1.96%) required a blood transfusion post-surgery.

Statistical Analysis

Statistical Analysis of the data was conducted using SPSS version 27.0 (IBM; Armonk, NY, USA). Numerical variables were examined using the T-test, while categorical variables were assessed using the Chi-square test. Fischer's exact test was applied for variables with an incidence of less than 5. Following identification of significant associations in the univariate analysis, multivariate analysis was carried out. Odds ratios and 95% confidence intervals were computed for various outcome parameters and complication events. A significance level of $p \leq 0.05$ was deemed statistically significant.

Results

Demographic Variables Associated with Blood Transfusion after RTSA

From the NIS database, we were able to compare various demographic information about patient's who underwent RTSA including sex, age, and ethnicity [Table 1]. The overall prevalence of blood transfusion in all patients was 1.96% (1177 patients, $P<0.001$). Based on univariate analysis, increased rates of blood transfusions were associated with individuals of Hispanic (P <0.029) or Asian descent (P <0.001), whereas individuals of Caucasian descent (P <0.038) were found to have decreased risk of needing BT, when compared to other ethnic groups. Individuals of African American (P = 1.000) and Native American (P = 0.564) ethnicity had non-significant findings. When comparing sex, males (P <0.001) were found to be associated with increased rates of BTs, whereas female sex (P <0.001), were associated with decreased rates of BT. When comparing patients between the ages of 60-80 years old, patients > 80 years (P <0.001) were associated with increased rates of BT. Additionally, analyzing patient ages bimodally, patients >75 (P <0.001) were found to have higher risk of requiring BTs, compared to variable young the patients < 60 years old (P <0.001) with decreased rates of blood transfusion.

Comorbidities Associated with Blood Transfusion after RTSA

Additional results of univariate analysis comparing co-morbid conditions in our data set included complicated vs uncomplicated diabetes mellitus (DM), tobacco related disorder, liver cirrhosis, chronic kidney disease (CKD), reliance of dialysis, history of organ transplant, body mass index (BMI) > 30, BMI > 50, Parkinson's disease, and then elective vs non-elective surgery [Table 2]. Again, the overall prevalence of blood transfusion in all patients was 1.96% (1177 patients, P <0.001). Among these individuals, several comorbidities were associated with increased rates of blood transfusion including liver cirrhosis (P <0.001), CKD (P<0.001), dialysis (P = 0.004), organ transplant (P = 0.035), and Parkinson's disease (p <0.001). Conversely, the comorbidities associated with lower rates of blood transfusion were tobacco related disorder (P <0.001), and BMI > 30 (P <0.001). Results of patients with a BMI > 50 were non-significant. When comparing elective vs non elective surgery, our results showed that non-elective procedures (P

<0.001) were associated with increased rates of BT. Individuals with uncomplicated DM (P <0.001) were found to have lower rates of BT compared to complicated DM (P = .299).

Table 1. Demographic Variables Associated with Blood Transfusion after RTSA (UVA)

Variable	Variable within the BT Group & Percentages (1177)	Percentage of total BT	Variable within the Non-BT Group & Percentages (58808)	Percentage of total non-BT	P value
Sex					
Male	903	80.84%	36292	61.71%	<0.001*
Female	273	24.44%	23626	40.17%	
Age					
< 60	83	7.43%	5267	8.96%	
60-70	271	24.26%	18498	31.45%	<0.001*
70-80	427	38.23%	25806	43.88%	
80-90	348	31.15%	9799	16.66%	
> 90	48	4.30%	555	0.94%	
>65	593	53.09%	40122	68.23%	<0.001*
Ethnicity					
Caucasian	975	87.29%	50942	86.62%	0.038*
African American	54	4.83%	2542	4.32%	0.564
Hispanic	68	6.09%	2665	4.53%	0.029*
Asian	21	1.88%	341	0.58%	<0.001*
Native American	***	0.36%	206	0.35%	1.000

P ≤0.05 statistically significant (in bold), (*) represents statistical significance
***- Exact number not reported due to HCUP data use agreement

Table 2. Comorbidities Associated with Blood Transfusion after RTSA (UVA)

Comorbidities	Received BT (RBT)	Percentage	Non-BT	Percentage	P value
Uncomplicated DM	117	10.47%	8657	14.72%	<0.001*
Complicated DM	***	0.36%	118	0.20%	0.299
Tobacco related disorder	71	6.36%	9644	16.40%	<0.001*
Liver cirrhosis	33	2.95%	307	0.52%	<0.001*
CKD	196	17.55%	4769	8.11%	<0.001*
Dialysis	***	0.63%	100	0.17%	0.004*
Organ transplant	***	0.63%	156	0.27%	0.035*
BMI > 30	185	16.56%	11964	20.34%	<0.001*
BMI > 50	82	7.34%	513	0.87%	0.084
Parkinson's disease	28	2.51%	690	1.17%	<0.001*
Non-elective procedure	425	38.05%	4424	7.52%	<0.001*

P ≤0.05 statistically significant (in bold), (*) represents statistical significance
***- Exact number not reported due to HCUP data use agreement

Multivariate Analysis of Variables Associated with Blood Transfusion after RTSA

Following univariate analysis, particular significant variables were selected for further multivariate analysis [Table 3]. Based on our analysis, male sex increased the odds of blood transfusion by 1.75-fold (P < 0.001). Individuals of Asian descent were significantly more likely to receive a blood transfusion (OR 1.96, p = 0.012). Patients aged >80 (OR 1.51, P < 0.001) or age > 90 (OR 2.26, P < 0.001) were at increased risk of receiving a blood transfusion. Patients with CKD had increased odds of transfusion as well (OR 1.94, P < 0.001). Parkinson's disease (OR 2.08, P < 0.001) was also at increased odds. As expected however, presence of cirrhosis had the biggest impact on the odds of blood transfusion (OR 5.7, P < 0.001). Several of our multivariate analysis variables showed significantly decreased odds of needing a BT including Caucasian ethnicity (OR 0.76, P = 0.023), DM without complications (OR 0.73, P = 0.002), tobacco related disorder (OR 0.43, P < 0.001), BMI > 30 (OR 0.8, P = 0.011), and elective procedures (OR 0.16, P < 0.001). Individuals of Hispanic ethnicity (OR 0.80, P = 0.192), age > 65 (OR 1.11, P = 0.399), undergoing dialysis (OR 1.35, P = 0.514) or have received an organ transplant (OR 1.93, P = 0.112) had non-significant odds ratios.

Table 3. Overall Variables Associated with Blood Transfusion after RTSA (MVA)

Variable	Odds Ratio	95% confidence interval	P value
Male	1.75	1.52 to 2.02	<0.001*
Asian	1.96	1.16 to 3.31	0.012*
Hispanic	0.80	0.57 to 1.12	0.192
Caucasian	0.76	0.60 to 0.96	0.023*
Age < 65	1.11	0.87 to 1.41	0.399
80-90	1.51	1.26 to 1.82	<0.001*
Age > 90	2.26	1.59 to 3.20	<0.001*
Uncomplicated DM	0.73	0.60 to 0.89	0.002*
Tobacco related disorder	0.43	0.33 to 0.54	<0.001*
BMI > 30	0.80	0.68 to 0.95	0.011*
CKD	1.94	1.64 to 2.30	<0.001*
Dialysis	1.35	0.55 to 3.30	0.514
Liver cirrhosis	5.70	3.82 to 8.51	<0.001*
Parkinson's disease	2.08	1.40 to 3.10	<0.001*
Organ Transplant	1.93	0.86 to 4.30	0.112
Elective vs non-elective surgery	0.16	0.14 to 0.18	<0.001*

P ≤0.05 statistically significant (in bold), (*) represents statistical significance

Discussion

The findings of our study provide valuable insights into the complex interplay between patient characteristics, co-morbidities, preoperative risk factors, and the need for postoperative BT following RTSA. Furthermore, demographic variables play more of a role than we realized in determining the likelihood of BT in the postoperative period.[22,23] These findings have important implications for risk assessment, preoperative optimization, and patient management strategies in the context of RTSA.

Many studies in the literature analyzing the association between risk factors and the need for postoperative BT in patients who received RTSA found that preoperative hemoglobin level is the strongest predictor of blood transfusion after shoulder surgery. Typically, the literature has found that tobacco use increased estimated surgical blood loss and BT rates.[24] But notably, our study showed tobacco-related disorders were linked to lower BT rates. This could be attributed to tobacco smoke leading to heightened platelet (PLT)-dependent thrombin level which can induce a prothrombotic state.[24] Cigarette smoking may lead to reduced intraoperative bleeding and subsequent BT requirements. Patients with a body mass index (BMI) >30 demonstrated decreased odds of requiring BT. While the exact mechanisms remain to be elucidated, it is possible that higher adipose tissue content could contribute to enhanced clotting capabilities and improved hemostasis.[25,26] Elective procedures were also strongly associated with lower transfusion rates, affirming the value of optimal preoperative planning and patient selection. Elective surgeries allow for a more comprehensive assessment of preoperative risk factors, enabling clinicians to take proactive measures to optimize hemoglobin levels and manage co-morbidities that may contribute to bleeding tendencies.[27-29]

Demographic variables also exerted a considerable influence on transfusion rates. Female sex was associated with decreased odds of BT, echoing previous research findings, indicating that hormonal factors might contribute to more favorable coagulation profiles in women.[30] Moreover, patients under the age of 65 and those of Caucasian descent exhibited lower transfusion rates, possibly reflecting better physiological reserves and genetic predispositions that promote hemostasis. Older age, particularly in the 80-90 and over 90 age groups, correlated with increased odds of BT. This aligns with the idea that physiological changes associated with aging, including decreased hemostatic capacity and increased prevalence of co-morbidities impact bleeding tendencies.[19,31] A study looking at the relationship between age and the need for blood transfusion following cardiac surgery yielded similar results. De Santo found that elderly patients underwent transfusion more often than younger patients with a 1.3-fold increase in the relative risk for transfusion.[32] The presence of cardiac disease, complicated DM, male sex, and individuals of Hispanic or Asian descent were also identified as factors associated with higher transfusion rates. These findings highlight the multifactorial nature of transfusion risk, with underlying cardiovascular conditions and inherent genetic differences potentially contributing to altered hemostasis and increased bleeding susceptibility. Complicated DM emerged as one such co-morbidity associated with increased transfusion rates. Growing evidence indicates that anemia in DM patients is a strong indicator of increased risk for diabetes-related macrovascular and microvascular complications.[33-37]

We do acknowledge several limitations in our study. Our study is a retrospective design as well as data collection from multiple centers, surgeons, and postoperative protocols. We also acknowledge the limits of the PearlDiver Database which is based on CPT and ICD-9 codes which carries the potential to limit data collection. Although we do acknowledge these limitations, our study does benefit from high predictive power given the large sample from the PearlDiver database along with our matching protocol to decrease the chance of confounding. Additionally, our outcomes were all decided before the data collection process was started, adding strength to the credibility of our results. Lastly, none of the authors matched the patients nor performed any of these surgeries which aids in minimizing any selection bias.

Conclusion

Our study is useful with identifying several risk factors that predispose to a higher risk of postoperative BT in patients undergoing RTSA including male sex, people of Asian descent, age > 80, CKD, Parkinson's disease, and cirrhosis. These findings provide clinicians with information that may be helpful with preoperative planning and perioperative management of complex patient populations. Future studies combing risk factors observed in our study and others could help to decrease need for postoperative B.[38, 39]

Acknowledgement

I would like to acknowledge the guidance and mentorship provided by the others authors. Their expertise in Orthopedics was invaluable in shaping the direction of this research and refining our methodology. Their constructive feedback and insightful suggestions played a pivotal role in elevating the overall quality of this study.

Authors Contribution:

Alexander Turner :study conception and design, data condensing & organization analysis and interpretation of results, and manuscript preparation.
Hunter B. Jones: analysis and interpretation of results, and manuscript preparation.
Philip A. Serbin: analysis and interpretation of results and manuscript preparation.
Senthil Sambandam: study conception and design, analysis and interpretation of results, and manuscript preparation.

Declaration of Conflict of Interest: The author(s) do NOT have any potential conflicts of interest for this manuscript.

Declaration of Funding: The author(s) received NO financial support for the preparation, research, authorship, and publication of this manuscript.

Declaration of Ethical Approval for Study: N/A

Not required, as the data was college from publicly available data.

Declaration of Informed Consent: I declare there is no information (names, initials, hospital identification numbers, or photographs) in the submitted manuscript that can be used to identify patients.

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