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Abnormal preoperative platelet count may predict postoperative complications following shoulder arthroplasty

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Background: The purpose of this study is to investigate the association between preoperative platelet counts and postoperative complication rates within 30 days of total shoulder arthroplasty (TSA).
Methods: The American College of Surgeons National Surgical Quality Improvement database was queried for all patients who underwent TSA between 2015 and 2019. The study population was then divided into 5 groups based on their preoperative platelet count: <100k (moderate-to-severe thrombocytopenia), 100-150k (mild thrombocytopenia), 150-200k (low-normal preoperative platelet count), 200-450k (normal, reference cohort), and >450k (thrombocytosis). Postoperative complications within 30 days of the TSA were collected. Multivariate logistic regression analysis was conducted to investigate the relationship between preoperative platelet counts and postoperative complications.
Results: A total of 19,721 patients undergoing TSA between 2015 and 2019 were included in this study. One hundred fifty-five patients (0.8%) had moderate-to-severe thrombocytopenia, 982 (5.0%) had mild thrombocytopenia, 3945 (20.0%) had a low-normal preoperative platelet count, 14,386 (72.9%) had a normal preoperative platelet count, and 253 (1.3%) had thrombocytosis. An increasing rate of overall complications was observed as the severity of thrombocytopenia progressed from low-normal (6.4%) to mild thrombocytopenia (10.2%) and to moderate-to-severe thrombocytopenia (18.7%). The overall complication rate of the thrombocytosis cohort was 14.6%. In comparison to normal platelet count, low-normal thrombocytopenia, mild thrombocytopenia, moderate-to-severe thrombocytopenia, and thrombocytosis were identified by multivariate analysis as significant predictors of overall complications (odds ratios [ORs] of 1.12, 2.15, 2.43, 2.71, respectively), postoperative anemia requiring transfusion (ORs of 1.63, 3.45, 5.97, 4.21, respectively), and minor complications (ORs of 1.39, 2.64, 3.40, 3.34, respectively). Minor complications include progressive renal insufficiency, urinary tract infection, transfusions within 72 hours after surgery, pneumonia, and superficial incisional surgical site infection.
Conclusion: Increasing severity of thrombocytopenia correlated with higher overall postoperative complication rates following TSA. Interestingly, patients with thrombocytosis had the highest overall postoperative complication rates among all cohorts included in this study. Platelet counts are often the reflection of other comorbidities and a good indicator of patient's general health status. Long-term optimization of abnormal platelet counts may potentially reduce surgical complications.

Total shoulder arthroplasty (TSA) is an increasingly popular treatment for degenerative diseases of the shoulder. Since 2012, the uses of anatomic TSA and reverse TSA (RTSA) have both substantially increased, while the use of hemiarthroplasty has concomitantly decreased.[5] Additionally, the indications for RTSA have expanded to include proximal humerus fractures and revision surgery for failed open reduction and internal fixation.[17] TSA has also demonstrated favorable outcomes in elderly patients, leading to an increase in TSAs done for elderly patients with more chronic comorbidities.[3,9]

Increasing surgical volume in the elderly patient population demands better preoperative risk stratification in order to optimize

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patient outcomes and minimize adverse events. Previous studies have investigated patient demographics and comorbidities as risk factors for postoperative complications following TSA. Age, male gender, functional status, and American Society of Anesthesiologists (ASA) class 3 and 4 were all found to be risk factors for unplanned 30-day readmission.[20] Furthermore, diabetes was found to be associated with increased rates of nonhome discharge and greater lengths of stay,[23] and obesity was associated with increased risk of readmission after TSA and infection after RTSA.[2] In addition to demographics and comorbidities, preoperative testing can provide important information for risk stratification.

As part of the preoperative evaluation, routine laboratory tests are performed that include complete blood counts, metabolic panels, and coagulation studies. Previous studies have investigated the complication rates associated with abnormal hematocrit levels, elevated coagulation times, and low albumin levels.[6,18,32] However, the effect of preoperative platelet counts has not been extensively investigated. In the realm of orthopedic surgery, studies regarding platelet counts and postoperative complications have been limited to total hip (THA) and total knee arthroplasties (TKA). There are no similar studies for shoulder arthroplasty. Studies of THA and TKA indicate that both abnormally high and abnormally low preoperative platelet counts are associated with higher rates of complications for both types of surgery.[24,25]

The purpose of this study is to investigate the association between preoperative platelet counts and postoperative complication rates in patients undergoing TSA. We hypothesized that abnormally low and abnormally high preoperative platelet counts can help predict higher complication rates following TSA.

Methods

The American College of Surgeons (ACS) National Surgical Quality Improvement (NSQIP) database was queried for all patients who underwent TSA between 2015 and 2019. The NSQIP database is fully deidentified. Therefore, this study was exempt from approval by our University's Institutional Review Board. Patient data that is included in the NSQIP database is obtained from over 600 hospitals in the United States by healthcare workers through various modalities such as interviews, outpatient visits, and review of patient notes.[10] Inter-reliability disagreement rate has been quantified to be <2%.[31] In addition, the database is audited on a regular basis to ensure that patient data is accurate.[30] The NSQIP database has been utilized for many other clinical studies pertaining to general orthopedics,[4,15] as well as shoulder arthroplasty.[20,21]

Current Procedural Terminology (CPT) code 23472 was used to identify 22,542 patients who underwent TSA from 2015 to 2019. CPT code 23472 includes both RTSA and anatomic TSA. Cases were excluded for patients younger than 18 years of age, those for whom preoperative serum platelet values were not available, any cases with revision codes (CPT codes 23473 and 23474), and cases reporting preoperative fractures, neoplasms, and/or infections. The above exclusions resulted in the retention of total of 19,721 cases for our statistical analysis (Fig. 1). The study population was then stratified into 5 groups based on their preoperative platelet count: <100k (moderate-to-severe thrombocytopenia), 100-150k (mild thrombocytopenia), 150-200k (low-normal preoperative platelet count), 200-450k (normal, reference cohort), and >450k (thrombocytosis).[12]

Patient demographics included race, gender, body mass index, age, smoking status, functional status, ASA physical status classification class, and perioperative steroid use. Additional variables collected included preoperative laboratory values, preoperative comorbidities, 30-day postoperative complication data, and

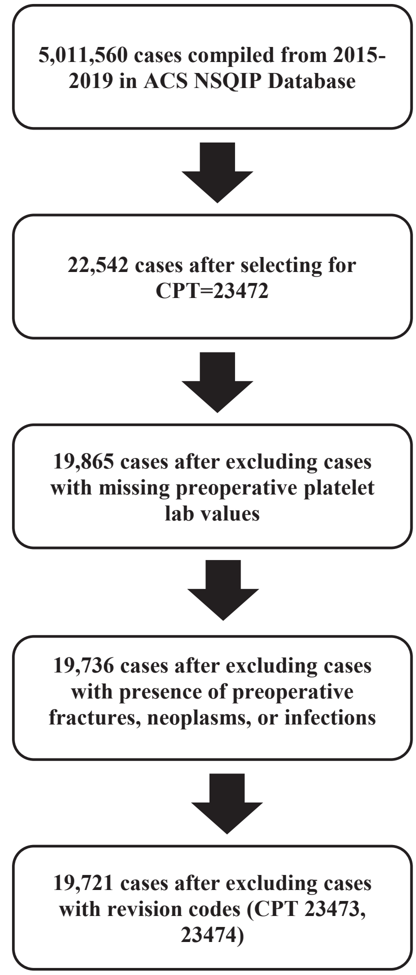

Figure 1 Case selection schematic. *ACS NSQIP*, American College of Surgeons National Surgical Quality Improvement Program; *CPT*, Current Procedural Terminology.

operative outcomes. Steroid use status was positive for patients who had routine intake of immunosuppressants or corticosteroids within 30 days before the procedure. Smoking status was positive for patients who smoked cigarettes at any point within the past year prior to the procedure. Reported usage of e-cigarettes, cigars, marijuana, or pipes did not alter a negative smoking status. Patients were classified as presenting with severe systemic disease if ASA physical status classification class was ≥3. Some notable preoperative comorbidities collected in this study include the following: non–insulin-dependent and insulin-dependent diabetes, severe chronic obstructive pulmonary disease (COPD), congestive health failure, recent unintentional weight loss, bleeding disorder, transfusion, previous sepsis, dyspnea, ascites, and disseminated cancer. Both major and minor complications that occurred within 30 days postoperatively were analyzed. Major complications included the following: cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, deep vein thrombosis requiring therapy, cerebrovascular accident, stroke, unplanned intubation, pulmonary embolism, on a ventilator >48 hours, acute renal failure, sepsis, septic shock, still admitted 30 days after the procedure, reoperation, readmission, mortality, deep incisional surgical site infection (SSI), and organ/space SSI. Minor complications included the following: progressive renal insufficiency, urinary tract infection, transfusions within 72 hours after surgery, pneumonia, and superficial incisional SSI.

Statistical analyses for this investigation were conducted using SPSS Software version 26.0 (IBM Corp., Armonk, NY, USA). Bivariate analysis was conducted to compare patient demographic characteristics, comorbidities, and surgical characteristics between cohorts. Multivariate logistic regression analysis, which was adjusted for all notably associated variables such as patient demographics, preoperative comorbidities, and operative variables, was conducted to investigate the association between preoperative platelet count and postoperative complications. Calculated odds ratios (ORs) were reported in relation to the 95% confidence interval. The level of statistical significance was set at $P < .05$.

Results

After exclusion criteria, a total of 19,721 patients undergoing TSA between 2015 and 2019 were included in this study. Among those patients, 155 (0.8%) had moderate-to-severe thrombocytopenia, 982 (5.0%) had mild thrombocytopenia, 3945 (20.0%) had a low-normal preoperative platelet count, 14,386 (72.9%) had a normal preoperative platelet count, and 253 (1.3%) had thrombocytosis (Table I).

Table I
Platelet cohorts.

Platelet cohort (platelet count)	N = 19,721 (%)
Moderate-to-severe thrombocytopenia (≤100k)	155 (0.8)
Mild thrombocytopenia (101-150k)	982 (5.0)
Low-normal (151-200k)	3945 (20.0)
Normal (200-450k)	14,386 (72.9)
Thrombocytosis (≥450k)	253 (1.3)

In comparison to the reference cohort with a normal platelet count of 200-450k, all other cohorts had a greater proportion of patients with the following comorbidities: insulin-dependent diabetes, non–insulin-dependent diabetes, partially dependent functional status, ASA classification of 3 or higher, history of severe COPD, history of bleeding disorder, and preoperative blood loss or anemia necessitating transfusion (Table II). Although the difference was not statistically significant, all other cohorts had longer mean length of stay (LOS) and mean operation time compared to the reference cohort. Compared to mild thrombocytopenia and low-normal preoperative platelet cohorts, both moderate-to-severe thrombocytopenia and thrombocytosis cohorts had higher proportion of patients with the following comorbidities: dyspnea at moderate exertion, partially dependent functional status, history of severe COPD, history of bleeding disorder, previous sepsis, and preoperative blood loss or anemia necessitating transfusion.

An increasing rate of overall complications was observed as the severity of thrombocytopenia progressed from low-normal (6.4%) to mild thrombocytopenia (10.2%) and to moderate-to-severe thrombocytopenia (18.7%) (Table III). A similar pattern was seen for major complications (4.2%, 6.5%, 7.7%), minor complications (3.1%, 5.5%, 14.2%), cardiac complications (0.3%, 0.4%, 1.9%), respiratory complications (0.9%, 1.5%, 3.2%), postoperative anemia requiring transfusion (1.9%, 3.6%, 12.9%), nonhome discharge (10.8%, 14.0%, 16.1%), and hospital readmission (2.8%, 4.7%, 5.8%). Complication rates of the thrombocytosis cohort were comparable to the moderate-to-severe thrombocytopenia cohort: overall complications (14.6% vs. 18.7%), major complications (7.9% vs. 7.7%), minor complications (8.7% vs. 14.2%), cardiac complications (0.4% vs. 1.9%), respiratory complications (0.8% vs. 0.8%), nonhome discharge (14.6% vs. 16.1%), hospital readmission (6.7% vs. 5.8%), and return to the operating room (3.2% vs. 1.3%).

After controlling for all associated patient demographics and comorbidities, adjusted multivariate logistic regression analysis showed that compared to normal preoperative platelet cohort, the low-normal preoperative platelet count cohort had a greater likelihood of developing the following complications: overall complications (OR 1.185, $P = .010$), minor complications (OR 1.385, $P < .001$), postoperative anemia requiring transfusion (OR 1.631, $P < .001$), and nonhome discharge (OR 1.281, $P < .001$) (Table IV).

In comparison to the normal platelet cohort, the mild thrombocytopenia cohort was observed to have a greater likelihood of developing the following complications: overall complications (OR 2.152, $P < .001$), major complications (OR 2.005, $P < .001$), minor complications (OR 2.636, $P < .001$), postoperative anemia requiring transfusion (OR 3.452, $P < .001$), nonhome discharge (OR 1.929, $P < .001$), hospital readmission (OR 2.043, $P < .001$), and return to the operating room (OR 2.949, $P < .001$).

In comparison to the normal platelet cohort, the moderate-to-severe thrombocytopenia cohort had a greater likelihood of developing the following complications: overall complications (OR 2.429, $P < .001$), minor complications (OR 3.400, $P < .001$), cardiac arrest/myocardial infarction (OR 4.894, $P = .013$), and postoperative anemia requiring transfusion (OR 5.956, $P < .001$).

In comparison to the normal platelet cohort, the thrombocytosis cohort also had a greater risk of developing the following complications: overall complications (OR 2.707, $P < .001$), major complications (OR 2.085, $P = .002$), minor complications (OR 3.337, $P < .001$), wound dehiscence (OR 12.110, $P = .038$), urinary tract infection (OR 3.608, $P = .004$), postoperative anemia requiring transfusion (OR 4.211, $P < .001$), nonhome discharge (OR 1.575, $P = .021$), hospital readmission (OR 2.354, $P < .001$), and return to the operating room (OR 3.504, $P = .002$).

Discussion

This study used a national database to identify thrombocytopenia and thrombocytosis as potential risk factors for overall complications and minor complications following TSA. Additionally, increasing severity of thrombocytopenia was significantly associated with increased risk of overall complications, minor complications, and postoperative anemia requiring transfusion. Moderate-to-severe thrombocytopenia was associated with significantly elevated risk of developing cardiac arrest/myocardial infarction. Mild thrombocytopenia was associated with increased risk of nonhome discharge, hospital readmission, and returning to the operating room. Thrombocytosis cohort had the highest overall postoperative complication rates among all cohorts included in this study. In addition, thrombocytosis was significantly associated with increased risk of wound dehiscence, urinary tract infection, postoperative anemia requiring transfusion, nonhome discharge, hospital readmission, and returning to the operating room. This data suggests that considering patients' preoperative platelet count has the potential to become a useful tool that may assist orthopedic surgeons in risk stratifying and managing patients accordingly before undergoing TSA.

Preoperative risk stratification has become an essential facet of TSA as it has become a popular elective treatment for degenerative diseases of the shoulder. TSA has shown to be an excellent treatment modality for elderly patients with a higher prevalence of medical complexity.[3,9] Identifying modifiable risk factors and managing those conditions prior to the surgery could not only decrease hospital LOS and hospital costs, but also can improve surgical planning and interdisciplinary communication with the goal of optimizing postsurgical outcomes.[19]

Abnormal preoperative platelet count, which includes both thrombocytopenia and thrombocytosis, is a modifiable risk factor that is associated with postoperative complications following TSA. Although thrombocytopenia may lead to adverse surgical outcomes

Table II
Comparison of patient demographics, medical comorbidities, and operative characteristics between platelet cohorts.

Outcome	Normal (200-450k)	Low-normal (151-200k)	Mild thrombocytopenia (101-150k)	Moderate-to-severe thrombocytopenia (≤100k)	Thrombocytosis (≥450k)	*P* value
Overall number	14,386	3945	982	155	253	
Age (yr)	69.00 ± 9.39	70.87 ± 9.29	71.86 ± 9.15	70.50 ± 11.24	68.53 ± 11.12	.406
BMI (kg/m^2)	31.34 ± 6.88	31.24 ± 6.67	30.85 ± 6.38	31.63 ± 8.37	29.93 ± 7.22	.325
Female, n (%)	8816 (61.3)	1616 (41.0)	352 (35.8)	84 (54.2)	207 (81.8)	**<.001**
Smoker, n (%)	1590 (11.1)	335 (8.5)	102 (10.4)	25 (16.1)	39 (15.4)	**<.001**
Race, n (%)						.219
Black or African American	712 (4.9)	162 (4.1)	39 (4.0)	6 (3.9)	11 (4.3)	
Asian	105 (0.7)	22 (0.6)	6 (0.6)	1 (0.6)	1 (0.4)	
White	12,007 (83.5)	3320 (84.2)	846 (86.2)	134 (86.5)	210 (83.0)	
American Indian or Alaska Native	66 (0.5)	11 (0.3)	2 (0.2)	0 (0.0)	3 (1.2)	
Native Hawaiian or Pacific Islander	17 (0.1)	7 (0.2)	2 (0.2)	1 (0.6)	0 (0.0)	
Unknown	1479 (10.3)	423 (10.7)	87 (8.9)	13 (8.4)	28 (11.1)	
Anesthesia, n (%)						.986
Other or none	414 (2.8)	115 (2.9)	22 (2.2)	2 (2.3)	5 (2.0)	
General	13,950 (97.0)	3825 (97.0)	958 (97.6)	153 (98.7)	248 (98.0)	
Spinal	22 (0.2)	5 (0.1)	2 (0.2)	0 (0.0)	0 (0.0)	
Diabetes, n (%)						**<.001**
Insulin-dependent	696 (4.8)	223 (5.7)	71 (7.2)	19 (12.3)	15 (5.9)	
Nondiabetic	11,848 (82.4)	3215 (81.5)	771 (78.5)	110 (71.0)	200 (79.1)	
Non–insulin-dependent	1842 (12.8)	507 (12.9)	140 (14.3)	26 (16.8)	38 (15.0)	
Dyspnea, n (%)						.065
At rest	48 (0.3)	14 (0.4)	5 (0.5)	2 (1.3)	0 (0.0)	
Moderate exertion	896 (6.2)	283 (7.2)	59 (6.0)	15 (9.7)	21 (8.3)	
None	13,442 (93.4)	3648 (92.5)	918 (93.5)	138 (89.0)	232 (91.7)	
Functional status, n (%)						**.005**
Independent	13,974 (97.1)	3845 (97.5)	943 (96.0)	145 (93.5)	241 (95.3)	
Partially dependent	293 (2.0)	59 (1.5)	28 (2.9)	9 (5.8)	8 (3.2)	
Totally dependent	12 (0.1)	4 (0.1)	2 (0.2)	0 (0.0)	1 (0.4)	
Unknown	107 (0.7)	37 (0.9)	9 (0.9)	1 (0.6)	3 (1.2)	
ASA classification, n (%)						**<.001**
1 or 2	6285 (43.7)	1505 (38.1)	283 (28.8)	38 (24.5)	97 (38.3)	
3, 4, or 5	8086 (56.2)	2435 (61.7)	699 (71.2)	116 (74.9)	156 (61.7)	
None assigned	15 (0.1)	5 (0.1)	0 (0.0)	1 (0.6)	0 (0.0)	
Use of a ventilator, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	-
History of severe COPD, n (%)	996 (6.9)	275 (7.0)	74 (7.5)	14 (9.0)	25 (9.9)	.313
Ascites, n (%)	1 (0.0)	0 (0.0)	1 (0.1)	2 (1.3)	0 (0.0)	**<.001**
History of CHF, n (%)	82 (0.6)	32 (0.8)	14 (1.4)	5 (3.2)	0 (0.0)	**<.001**
Use of hypertension medication, n (%)	9616 (66.8)	2727 (69.1)	707 (72.0)	108 (69.7)	163 (64.4)	**.001**
Disseminated cancer, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	-
Wound infection, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	-
Use of corticosteroids, n (%)	709 (4.9)	184 (4.7)	58 (5.9)	8 (5.2)	23 (9.1)	**.019**
Weight loss, n (%)	24 (0.2)	13 (0.3)	1 (0.1)	0 (0.0)	1 (0.4)	.246
Bleeding disorder, n (%)	255 (1.8)	111 (2.8)	77 (7.8)	33 (21.3)	8 (3.2)	**<.001**
Transfusion, n (%)	22 (0.2)	7 (0.2)	6 (0.6)	4 (2.6)	2 (0.8)	**<.001**
Previous sepsis, n (%)	73 (0.5)	19 (0.4)	5 (0.5)	4 (2.6)	2 (0.8)	**.035**
Length of stay (d)	1.59 ± 3.48	1.62 ± 3.83	1.91 ± 4.08	1.67 ± 8.34	1.94 ± 1.86	.060
Total operation time	107.93 ± 43.41	108.35 ± 41.76	108.66 ± 43.36	108.33 ± 54.66	114.38 ± 54.78	.189

BMI, body mass index; *ASA*, American Society of Anesthesiologists; *COPD*, chronic obstructive pulmonary disease; *CHF*, congestive heart failure.
Bold values indicate statistically significant values ($P < .05$).

due to the role of platelets in hemostasis, it may also serve as a hypothetical marker for other systematic comorbidities that may negatively impact postsurgical outcome. For instance, abnormal platelet counts are often associated with pre-existing comorbid conditions such as cardiovascular disease, chronic liver disease, and malignancy that may have deleterious effect on surgical outcomes.[28,33] On the opposite spectrum, platelets seen in thrombocytosis are known to be dysfunctional and prothrombogenic. It has been noted in the literature that even temporary reactive thrombocytosis due to anemia or infection can lead to increased risk of developing venous thromboembolism, leading to mortality.[13]

The association between abnormal platelet count and suboptimal clinical outcome has been well described in the literature.[12,34-36] Previous studies in THA and TKA concluded that both thrombocytopenia and thrombocytosis correlated with adverse postoperative outcomes.[24,25] However, the predictive value of preoperative platelet count on adverse outcomes has not been investigated for TSA. As such, the main objective of the present study is to utilize the NSQIP database to determine the association between abnormal platelet counts and adverse postoperative outcomes following TSA. In order to account for preoperative conditions that may have affected preoperative platelet count, cases with preoperative fractures, neoplasms, or infections were excluded from the statistical analysis. Cases involving both hematologic malignancies and solid tumors were also excluded.

Our analysis revealed that patients with low platelet counts tended to be male, of higher ASA, more likely diabetic, and less functionally independent compared to those with normal platelet count. This pattern is consistent with findings in the literature that low platelet count is associated with male gender, significant comorbidities, and past surgical histories.[12] Interestingly, our paper also found that those with higher platelet counts tended to be female, of lower body mass index, less functionally independent, and more likely smokers. The relationship between smoking and thrombocytosis is well described in the literature.[7,11,26] Lupia et al[22] showed that chronic smokers had higher thrombopoietin

Table III
Comparison of complication rates following shoulder arthroplasty between platelet cohorts.

Complication	Normal (200-450k)	Low-normal (151-200k)	Mild thrombocytopenia (101-150k)	Moderate-to-severe thrombocytopenia (≤100k)	Thrombocytosis (≥450k)	P value
Overall complication (%)	879 (6.1)	254 (6.4)	100 (10.2)	29 (18.7)	37 (14.6)	**<.001**
Major complication (%)	573 (4.0)	165 (4.2)	64 (6.5)	12 (7.7)	20 (7.9)	**<.001**
Minor complication (%)	418 (2.9)	123 (3.1)	54 (5.5)	22 (14.2)	22 (8.7)	**<.001**
Cardiac arrest or MI (%)	48 (0.3)	12 (0.3)	4 (0.4)	3 (1.9)	1 (0.4)	**.019**
Renal complication (%)	17 (0.1)	6 (0.2)	4 (0.4)	0 (0.0)	0 (0.0)	.181
Respiratory complication (%)	117 (0.8)	34 (0.9)	15 (1.5)	5 (3.2)	2 (0.8)	**.004**
DVT (%)	49 (0.3)	8 (0.2)	5 (0.5)	1 (0.6)	1 (0.4)	.480
Stroke/CVA (%)	9 (0.1)	6 (0.2)	1 (0.1)	0 (0.0)	0 (0.0)	.486
Sepsis or septic shock (%)	26 (0.2)	7 (0.2)	2 (0.2)	0 (0.0)	1 (0.4)	.918
Wound infection (%)	69 (0.5)	19 (0.5)	4 (0.4)	1 (0.6)	3 (1.2)	.596
Wound dehiscence (%)	5 (0.0)	3 (0.1)	0 (0.0)	0 (0.0)	1 (0.4)	.076
UTI (%)	99 (0.7)	27 (0.7)	13 (1.3)	1 (0.6)	6 (2.4)	**.006**
Postoperative transfusion (%)	229 (1.6)	73 (1.9)	35 (3.6)	20 (12.9)	15 (5.9)	**<.001**
Mortality (%)	19 (0.1)	9 (0.2)	4 (0.4)	1 (0.6)	0 (0.0)	.096
Nonhome discharge (%)	1302 (7.0)	427 (10.8)	137 (14.0)	25 (16.1)	37 (14.6)	**<.001**
Hospital readmission (%)	403 (2.8)	110 (2.8)	46 (4.7)	9 (5.8)	17 (6.7)	**<.001**
Return to the OR (%)	179 (1.2)	53 (1.3)	26 (2.6)	2 (1.3)	8 (3.2)	**<.001**

MI, myocardial infarction; *DVT*, deep vein thrombosis; *CVA*, cerebrovascular accident; *UTI*, urinary tract infection; *OR*, operating room.
Bold values indicate statistically significant values ($P < .05$).

Table IV
Association between risk of complications following shoulder arthroplasty and preoperative platelet cohort classification.

Complication	Low-normal (151-200k)	Mild thrombocytopenia (101-150k)	Moderate-to-severe thrombocytopenia (≤100k)	Thrombocytosis (≥450k)
	Odds ratio, *P* value (95% CI)	Odds ratio, *P* value (95% CI)	Odds ratio, *P* value (95% CI)	Odds ratio, *P* value (95% CI)
Overall complication	1.185, **.010** (1.041-1.350)	2.152, **<.001** (1.618-2.862)	2.429, **<.001** (1.533-3.850)	2.707, **<.001** (1.887-3.885)
Major complication	1.077, .360 (0.919-1.261)	2.005, **<.001** (1.428-2.814)	1.554, .169 (0.830-2.912)	2.085, **.002** (1.302-3.340)
Minor complication	1.385, **<.001** (1.149-1.668)	2.636, **<.001** (1.806-3.847)	3.400, **<.001** (1.947-5.937)	3.337, **<.001** (2.114-5.269)
Cardiac arrest or MI	1.084, .770 (0.632-1.857)	1.038, .960 (0.238-4.536)	4.894, **.013** (1.389-17.244)	0.901, .921 (0.115-7.068)
Renal complication	0.969, .946 (0.389-2.411)	2.873, .199 (0.574-14.379)	0.000, .996 (0.000-0.000)	0.000, .995 (0.000-0.000)
Respiratory complication	0.935, .700 (0.665-1.315)	1.622, .176 (0.805-3.268)	2.155, .147 (0.764-6.076)	1.199, .765 (0.365-3.933)
Deep vein thrombosis	0.644, .136 (0.361-1.149)	2.314, .131 (0.779-6.876)	1.731, .599 (0.224-13.398)	0.974, .980 (0.130-7.311)
Stroke/CVA	1.923, .276 (0.594-6.232)	0.000, .993 (0.000-0.000)	0.000, .996 (0.000-0.000)	0.000, .995 (0.000-0.000)
Sepsis or septic shock	0.757, .435 (0.376-1.523)	0.524, .550 (0.063-4.358)	0.000, .996 (0.000-0.000)	3.773, .084 (0.835-17.045)
Wound infection	1.298, .253 (0.830-2.031)	1.503, .505 (0.453-4.991)	1.691, .610 (0.224-12.757)	3.093, .066 (0.930-10.290)
Wound dehiscence	0.783, .763 (0.159-3.850)	0.000, .993 (0.000-0.000)	0.000, .995 (0.000-0.000)	12.110, **.038** (1.142-128.374)
Urinary tract infection	1.250, .254 (0.852-1.832)	2.213, .056 (0.980-4.997)	0.496, .527 (0.056-4.359)	3.608, **.004** (1.503-8.662)
Postoperative transfusion	1.631, **<.001** (1.267-2.098)	3.452, **<.001** (2.159-5.521)	5.965, **<.001** (3.220-11.048)	4.211, **<.001** (2.430-7.300)
Mortality	2.111, .077 (0.923-4.829)	1.770, .501 (0.336-9.329)	1.498, .754 (0.119-18.881)	2.373, .430 (0.277-20.312)
Nonhome discharge	1.281, **<.001** (1.142-1.436)	1.929, **<.001** (1.456-2.556)	1.242, .407 (0.745-2.070)	1.575, **.021** (1.071-2.316)
Hospital readmission	1.070, .479 (0.887-1.291)	2.043, **<.001** (1.381-3.020)	1.628, .182 (0.796-3.328)	2.354, **<.001** (1.522-4.219)
Return to the OR	0.985, .917 (0.749-1.297)	2.949, **<.001** (1.792-4.853)	1.274, .691 (0.386-4.209)	3.504, **.002** (1.504-6.202)

CI, confidence interval; *MI*, myocardial infarction; *CVA*, cerebrovascular accident; *OR*, operating room.
Bold values indicate statistically significant values ($P < .05$).

levels compared to nonsmokers. Our study controlled for smoking status in addition to all other statistically associated variables with the multivariate logistic regression analysis. All cohorts with abnormal platelet count in our study, whether high or low, had longer hospital LOS, as well as total operation time. The current literature shows that prolonged hospital LOS due to postsurgical complication is associated with increased cost burden from a hospital administrative perspective.[14,29] Our data suggests that measuring preoperative count can aid in predicting LOS and operative time associated with TSA, which can help reduce hospital costs.

Given the findings of our study, preoperatively addressing and controlling for factors contributing to abnormal platelet counts may limit the rate of postoperative complications after TSA. There are many etiologic mechanisms for low platelet counts, such as immune-mediated diseases, organ sequestration, and bone marrow disorders.[1] The association between abnormal platelet counts and adverse surgical outcomes identified in this paper further complements the literature findings that optimizing preoperative hematologic laboratory values may reduce surgical complications.[27,38]

There are some key limitations related to data collection and study design that warrant further investigation. One limitation is the timeframe during which data was collected in the ACS NSQIP database, which only includes surgical complications that occur within 30 days of surgery. As a direct result, this study fails to consider any long-term postoperative complications that may eventually affect a significant portion of patient population undergoing TSA. In addition, this paper does not account for potential preoperative anticoagulation, platelet transfusion, or usage of medications that may affect platelet levels as those data were not readily available in the ACS NSQIP database. Furthermore, although there is literature identifying different etiologies of abnormal platelet count,[1] our study was unable to investigate whether different etiologies of abnormal platelet count affect shoulder arthroplasty outcomes for the same reason.

The main strength of this study is its high power, which allowed the authors to detect the relationship between platelet count and postoperative complications that are relatively rare, such as postoperative anemia requiring transfusion. It has also been shown in the literature that the robustness of the NSQIP database is superior to other national databases in terms of consistency, completion of data input, and accuracy.[8,16,37] Furthermore, this study was able to adjust for many comorbidities and patient characteristics in our multivariate analysis. Finally, this study has broad implications to the preoperative screening and optimization of patients undergoing shoulder arthroplasty.

Conclusion

Our study analyzed a large national surgical database and identified abnormal preoperative platelet count, both low and high, as independent risk factors for postoperative complications after TSA. Increasing severity of thrombocytopenia correlated with higher overall postoperative complication rates. Interestingly, patients with thrombocytosis had the highest overall postoperative complication rates among all cohorts included in this study. It is imperative for healthcare providers to consider preventative treatment and optimize surgical planning to improve recovery, decrease LOS, facilitate timely functional rehabilitation, and optimize patient health and satisfaction when treating patients with hematological dysfunction.

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