JSES Open Access 3 (2019) 183–188

Contents lists available at ScienceDirect

JSES Open Access

journal homepage: www.elsevier.com/locate/jses

Risk factors for venous thromboembolism in total shoulder arthroplasty

Brandon E. Lung, MD [a], Shrey Kanjiya, MD [b], Michael Bisogno, MD, MBA [b], David E. Komatsu, PhD [b], Edward D. Wang, MD [b,*]

[a] School of Medicine, Stony Brook University, Stony Brook, NY, USA
[b] Department of Orthopaedics, Stony Brook University, Stony Brook, NY, USA

ARTICLE INFO

Keywords:
Shoulder arthroplasty
venous thromboembolism
pulmonary embolism
deep vein thrombosis
complications
discharge destination

Level of evidence: Level III, Cross-Sectional Design, Prognosis Study

Background: Although venous thromboembolism (VTE) has been studied in lower-extremity arthroplasty, there are few guidelines regarding established risk factors for VTE in total shoulder arthroplasty (TSA). With literature suggesting the VTE rate may be as high as 13%, VTE prevention and risk factors should be considered in preoperative planning.

Methods: All TSAs from 2011 through 2016 were queried from the National Surgical Quality Improvement Program database. Age, sex, body mass index, American Society of Anesthesiologists class, ethnicity, functional status, comorbidities, discharge destination, surgical indication, length of stay, and operative time were compared between patients with and without 30-day postoperative VTE. Pearson χ^2 and *t* tests were used to assess baseline categorical and continuous variables, respectively. Multivariate logistic regression analysis was conducted to determine associated independent risk factors for VTE.

Results: The analysis included 13,299 patients; VTE developed in 83 patients (0.62%). Patients with VTE were older (72 years vs. 69 years) and had a longer hospital stay (3.5 days vs. 1.9 days). Compared with patients with no VTE, patients with VTE were more likely to undergo TSA for proximal humeral fractures, to be discharged to a rehabilitative center, to have a preoperative albumin level lower than 3.5 g/dL, to undergo non-elective surgery, to have an American Society of Anesthesiologists class of 3 or greater, to have a surgical-site infection develop, and ultimately to need a shoulder reoperation (all $P < .05$). Multivariate logistic regression analysis revealed that hypoalbuminemia (albumin level < 3.5 g/dL), an increased length of stay, and African American ethnicity were independent risk factors for VTE development.

Conclusion: Patients with hypoalbuminemia, an increased length of stay, and African American ethnicity are at an increased risk of VTE after shoulder arthroplasty. A high index of suspicion is warranted for elderly patients with fractures who may need preoperative medical optimization.

Although venous thromboembolism (VTE) has been extensively studied in lower-extremity arthroplasty, there are few guidelines regarding prophylaxis and established risk factors for VTE in total shoulder arthroplasty (TSA). As health care economics shifts to outcome-based bundled-payment models, it is important for providers to understand not only the risks associated with medical comorbidities but also factors that may affect postoperative patient satisfaction, independence, and discharge disposition.[26] Although the role of demographic characteristics and comorbidities regarding pulmonary embolism (PE) and deep vein thrombosis (DVT) in TSA is unclear, it is important for surgeons to understand the magnitude of risk, potential long-term complications, and current prevention methods for VTE.[30] Whereas absolute rates of VTE in TSA may be lower compared with hip and knee arthroplasty, high-risk TSA patients may benefit from perioperative antithrombotic prophylaxis as a higher percentage of VTE complications are found to be PE compared with lower-extremity arthroplasty.[25] Currently, VTE prophylaxis guidelines for TSA are not well established, and previous American Academy of Orthopaedic Surgeons guidelines have been extrapolated from lower-extremity data because of a lack of consensus on TSA risk factors.[14,33]

This retrospective study was exempt from approval by our university's institutional review board because all patient data were fully deidentified and made publicly available as a Health Insurance Portability Accountability Act–compliant data set.

* Corresponding author: Edward D. Wang, MD, Department of Orthopaedics, Stony Brook University Hospital, HSC T-18, Room 080, Stony Brook, NY 11794-8181, USA.

E-mail address: Edward.wang@sbumed.org (E.D. Wang).

https://doi.org/10.1016/j.jses.2019.07.003

With the expanded surgical indications and increased number of insured patients under the Affordable Care Act, the prevalence of TSA patients with medical comorbidities and risk factors for VTE, including smoking and vascular diseases, is higher.[11] In the United States, 1-year costs for VTE can be as high as $33,000, with an additional $11,700 resulting from complications associated with post-thrombotic syndrome, including paresthesia, pain, and ulceration.[31] As Medicaid services begin to establish pay-for-performance payment models and Medicare's Bundled Payments for Care Improvement model becomes relevant for TSA providers, it is important for surgeons to achieve proper optimization of high-risk patients via an interdisciplinary team-based approach.[24] The majority of VTE events in the literature have been shown to occur between the first operative day and postoperative day 4, but diagnosis as late as 3 months is possible.[33] With the Centers for Medicare & Medicaid Services and Hospital Readmissions Reduction Program penalizing postoperative readmissions, it is important for surgeons to not only consider VTE prophylaxis in high-risk patients but also communicate with patients regarding the inherent risks and benefits as they pertain to patient expectations.

Previous studies have suggested that patients with comorbidities including prior VTE, advanced age, critical care hospitalization, diabetes, heart disease, malignancy, lung disease, renal disease, obesity, pregnancy, and blood disorders are thought to have an increased risk of VTE.[12,15,33] In addition, modifiable factors such as mobility, smoking, prolonged operative time, patient positioning, intramedullary instrumentation, and alcohol use have been implicated in the increased risk of VTE in TSA patients.[12,14,33,42] However, these preoperative factors are not consistently associated with an increased risk of VTE in the literature, as numerous studies have failed to show notable associations between VTE and malignancy, increasing age, prior VTE, reduced mobility, blood disorders, and obesity.[14,21,38,40] Past guidelines from the National Institute for Health and Care Excellence regarding postoperative low-molecular-weight heparin have been revised because of a lack of established risk factors, and the 2010 American Academy of Orthopaedic Surgeons guidelines only recognized a history of VTE as a reliable risk factor.[2,5,9,22] In fact, a survey of members of the British Elbow and Shoulder Society found that 58% of surgeons do not use any form of VTE prophylaxis in upper-extremity surgery as a consensus has yet to be reached.[13]

Overall, because of the silent nature, immediate onset, and potential morbidity and death from VTE, surgeons should become aware of the importance of prevention rather than treatment in high-risk patients undergoing TSA.[42] As TSA becomes a more popular option for various shoulder pathologies, there is a need for surgeons to consider demographic characteristics, medical history, and underlying diagnostic factors such as trauma as risk factors for VTE.[43] In fact, over 50% of shoulder surgery patients with VTE are readmitted, and those patients with PE are susceptible to further complications including cerebrovascular accidents, mechanical ventilation, and myocardial infarction.[43] With VTE rates as high as 13% and acute PE accounting for over 150,000 deaths in the United States per year, there is a need to identify patient factors, such as nutrition status, ethnicity, length of stay, and comorbidities, that surgeons can use preoperatively to prepare for VTE prevention.[25] However, the benefits of prophylactic anticoagulation must be weighed carefully on an individual basis against the risks of delayed wound healing, bleeding, and adverse drug reactions.

Methods

All TSAs from 2011 through 2016 were queried from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database, which includes 30-day outcomes from more than 480 academic and private hospitals throughout the United States.[3] The clinical data are obtained by trained health care reviewers who review patients' 30-day postoperative progress notes, outpatient visits, and direct interviews, which are audited and have been reported to have an interobserver disagreement rate of 1.56%.[35] From 2011 through 2016, 274 collected variables, including patient demographic characteristics, laboratory values, medical comorbidities, postoperative complications, and discharge status, were identified for surgical patients.

The study population consisted of all adults (aged $\geq$ 18 years) undergoing anatomic or reverse TSA as identified by Current Procedural Terminology code 23472 from January 1, 2011, to December 31, 2016. The primary outcome was a composite VTE variable, which included patients receiving diagnoses of either DVT requiring therapy or PE. Patients in whom DVT was diagnosed met the NSQIP criteria of having a new diagnosis of superficial or deep thrombosis within 30 days of principal surgery confirmed by a duplex scan, venogram, computed tomography (CT) scan, or other definitive imaging modality. These patients must also have been treated with either anticoagulation therapy (not including aspirin), a vena cava filter, vena cava clipping, or a thrombectomy or must have refused treatment when treatment was warranted.[28] Patients in whom PE was diagnosed met the NSQIP criteria of having a new diagnosis of a pulmonary artery blood clot within 30 days of principal surgery confirmed by a CT examination, transesophageal echocardiography, pulmonary arteriogram, CT angiogram, autopsy, or high-probability ventilation-perfusion scan.[28]

Baseline demographic data and other patient characteristics—including age, sex, ethnicity, inpatient status, transfer status, anesthesia type, elective surgery status, operative time, body mass index (BMI), obesity, diabetes, smoking, functional independence, medical comorbidities, steroid use, albumin level, and American Society of Anesthesiologists (ASA) classification—were compared between patients with and without a diagnosis of VTE. Patient medical comorbidities included a history of chronic obstructive pulmonary disease (COPD), ascites, congestive heart failure (CHF), hypertension requiring medication, renal failure, cancer, weight loss, and bleeding disorders. Primary preoperative surgical indications for TSA, including osteoarthritis, cuff arthropathy, fracture, and revision, were compared between the VTE and non-VTE groups. Outcome variables besides VTE, including return to the operating room, length of stay, readmission, discharge destination, and surgical-site infection (SSI), were recorded. Discharge destination was dichotomized into routine (home) and non-routine, which included rehabilitation and other care facilities. Hypoalbuminemia was defined as a preoperative serum albumin level of less than 3.5 g/dL within 90 days of the principal procedure.[6]

Categorical patient demographic variables were compared using the Pearson χ^2 test to assess baseline characteristics between patients with and without VTE. Because of the large sample size, a normal distribution of the data was assumed. All predictor variables were included in the multivariate binary logistic regression analysis with VTE as the dependent dichotomous variable to determine baseline patient variables that are independent risk factors for VTE events. The Hosmer-Lemeshow goodness-of-fit test was appropriately assessed, and adjusted odds ratios (ORs) were evaluated as a measure of the effect size for each variable. Statistical analysis, with $P < .05$ deemed statistically significant, was performed using SPSS software (version 23.0; IBM, Armonk, NY, USA).

Results

From 2011 through 2016, a total of 13,299 patients who underwent TSAs were included in the study, including 83 patients (0.62%) in whom VTE developed (Table I). Compared with patients with no VTE, patients with VTE were more likely to be older (71.4

Table I
Patient demographic characteristics and parameters in patients with and without VTE occurrence

Parameter	All patients, n	No VTE	VTE	*P* value
n (%)	13,299 (100)	13,216 (99.38)	83 (0.62)	
Age, mean ± SD, yr		69.2 ± 9.7	71.4 ± 12.6	.038*
% female		43.70	55.70	.15
BMI, mean ± SD		31.1 ± 6.8	31.5 ± 7	.55
Ethnicity, %				.27
White	10,928	99.40	0.60	
African American	610	99	1	
Hispanic	478	100	0	
American Indian or Alaskan	53	100	0	
Asian	85	100	0	
Inpatient status, %				.07
Inpatient	12,519	99.30	0.70	
Outpatient	780	99.90	0.10	
Origin status, %				.51
Transferred from home or nursing home	13,229	99.40	0.60	
Transferred from acute care facility	68	100	0	
Elective status, %				.008*
Elective	13,239	99.40	0.60	
Emergency or not elective	60	96.7	3.30	
Anesthesia type, %				.91
General	12,777	99.40	0.60	
Regional	511	99.40	0.60	
Functional health status and activities of daily, % living				.42
Independent	12,868	99.40	0.60	
Not independent	347	99.70	0.30	
ASA class, %				.09
1	237	99.20	0.80	
2	5839	99.60	0.40	
3	6840	99.20	0.80	
4	368	99.50	0.50	
5	1	100	0	
ASA class ≥ 3, %				.028*
No	6077	99.50	0.50	
Yes	7208	99.20	0.80	
Preoperative surgical indication, %				.013*
Osteoarthritis	9259	99.50	0.50	
Cuff arthropathy	1054	99	1	
Fracture	834	98.80	1.20	
Revision	386	99.50	0.50	
Operative time, mean ± SD, min		112 ± 45.5	116 ± 47.3	.4

VTE, venous thromboembolism; *SD*, standard deviation; *BMI*, body mass index; *ASA*, American Society of Anesthesiologists.
* Statistically significant ($P < .05$).

years vs. 69.2 years), to undergo non-elective surgery (3.3% vs. 0.6%), to have an ASA class of 3 or greater (0.8% vs. 0.5%), and to undergo TSA for proximal humeral fractures (1.2% vs. 0.5%) (all $P < .05$, Table I). Among demographic characteristics and provider-related characteristics of patients with and without VTE, sex, BMI, ethnicity, inpatient status, and admission origin did not differ significantly between groups. In terms of procedural measures, the anesthesia type and operative time were not significantly different between groups (Table I).

Preoperative medical comorbidities were compared between the 2 groups, and only hypoalbuminemia (albumin level < 3.5 g/dL) was significantly different between VTE and non-VTE patients (1.3% vs. 0.5%, $P = .01$) (Table II). Other medical comorbidities including obesity, diabetes, smoking, COPD, ascites, CHF, hypertension, renal failure, dialysis, disseminated cancer, steroid use, recent weight loss, and bleeding disorders were not significantly different between the 2 cohorts. Among recorded 30-day postoperative complications and measurements, VTE patients had a longer hospital stay (3.5 days vs. 1.9 days, $P < .01$) and were more likely to have been discharged to a rehabilitative center (1.4% vs. 0.5%, $P < .01$), to have an SSI develop (5.3% vs. 0.65%, $P < .01$), and ultimately to need a shoulder reoperation (4.3% vs. 0.6%, $P < .01$) and readmission (8.5% vs. 0.4%, $P < .01$) (Table III). Other recorded complications such as bleeding requiring a transfusion and a hospital stay greater than 30 days were not significantly different between groups.

On multivariate logistic regression analysis, patients with hypoalbuminemia were more likely to have a VTE occurrence than patients with normal preoperative albumin levels (OR, 2.30; 95% confidence interval [CI], 1.23-6.03; $P = .03$) (Table IV). Patients with a longer length of stay were also more likely to have a VTE occurrence than patients who were discharged sooner (OR, 1.09; 95% CI, 1.02-1.17; $P = .01$). Compared with white patients, African American patients were more likely to experience a VTE occurrence (OR, 3.26; 95% CI, 1.08-9.82; $P = .04$). Other predictor variables including operative time, functional independence with activities of daily living, BMI, ASA class, obesity, elective surgery, inpatient status, sex, cancer, and bleeding disorders were not independently associated with VTE events.

Discussion

As the indications for TSA expand, surgeons can expect a greater management of medical comorbidities in arthroplasty patients. Identifying modifiable patient risk factors and performing preoperative risk stratification can help guide interdisciplinary surgical planning and physician-patient communication on improving TSA outcomes while reducing hospital costs.[24] Patients who are

Table II
Medical comorbidities in patients with and without VTE occurrence

Parameter	All patients, %	No VTE, %	VTE, %	*P* value
Obesity	57.20	99.30	0.70	.57
Diabetes	17.30	99.40	0.60	.91
Smoking	10.60	99.60	0.40	.32
COPD	6.60	99.20	0.80	.51
Ascites	<0.01	100	0	.91
CHF	0.40	100	0	.56
Hypertension	66.80	99.40	0.60	.57
Renal failure	<0.01	100	0	.86
Dialysis	0.40	100	0	.61
Disseminated cancer	0.20	100	0	.68
Steroid use	5	99.30	0.70	.67
>10% weight loss in past 6 mo	0.20	100	0	.68
Bleeding disorder	2.80	98.60	1.40	.07
Hypoalbuminemia (albumin level < 3.5 g/dL)	7.90	98.70	1.30	.014*

VTE, venous thromboembolism; *COPD*, chronic obstructive pulmonary disease; *CHF*, congestive heart failure.
* Statistically significant ($P < .05$).

considered to be in a hypercoagulable state often present with numerous pre-existing comorbidities that must be addressed prior to surgery, and because of the low overall incidence of VTE in TSA, it is difficult for surgeons to identify potential risk factors. There are few guidelines on VTE prophylaxis, and in a survey of 99 American Shoulder and Elbow Surgeons members, only 37 reported using chemical prophylaxis.[14]

When baseline demographic characteristics were compared, VTE patients were more likely to present as older, non-elective trauma patients with numerous medical comorbidities as reflected in their greater likelihood of having an ASA class of 3 or greater. The older age of VTE patients in this study is consistent with previous studies that found increasing age to contribute to not only increased physiological coagulopathy but also increased venous stasis and intimal injury due to loss of muscle tone and age-related degeneration.[30,33] Although Day et al[14] found no correlation of advanced age with VTE, it is important to be especially cautious in older patients as acute PE causes greater than 150,000 deaths in the United States per year and many of these older patients are unable to recover fully to prior levels of functional independence.[5,9,25] Previous studies have found fracture patients to be at an increased risk of VTE as the increased physiological stress, bleeding, inflammation, and traumatic endothelial injury contribute to inherent hypercoagulability.[13] These trauma patients are often bed bound, dehydrated, and malnourished, which further contribute to an increased VTE risk. However, anticoagulation in trauma patients must be carefully considered as the risks of bleeding, infection, and death are increased.[10,29]

Table III
Thirty-day complications in patients with and without VTE occurrence

Parameter	All patients	No VTE	VTE	*P* value
Length of stay, mean, d		1.9	3.5	<.01*
Discharge destination, %				<.01*
Home	88.40	99.50	0.50	
Acute care or rehabilitation	11.60	98.60	1.40	
Surgical-site infection, %				<.01*
No	99.60	99.40	0.60	
Yes	0.40	94.70	5.30	
Bleeding requiring transfusion, %	0.20	100	0	.66
Reoperation, %				<.01*
No	98.80	99.40	0.60	
Yes	1.20	95.70	4.30	
Readmission, %				<.01*
No	97	99.60	0.40	
Yes	3	91.50	8.50	
Still in hospital > 30 d, %	<0.01	100	0	.94

VTE, venous thromboembolism.
* Statistically significant ($P < .05$).

Although trauma and age are not modifiable factors, contributors to ASA class 3 and 4 can be better controlled preoperatively by the health care team.[24] Team-based multidisciplinary approaches, including the Perioperative Surgical Home model, have been established to help high-risk patients with personalized perioperative medical care and optimization, with goals to increase patient satisfaction and safety. In our study, patients with VTE were more likely to be malnourished as reflected in their preoperative albumin levels. Albumin levels lower than 3.5 g/dL are regularly used in the orthopedic literature to suggest malnutrition and have further been shown to increase the risk of anemia, an extended length of stay, and death.[17] Malnutrition may contribute to dysregulated clotting cascades, and further research is needed to determine whether preoperative or postoperative nutritional supplementation may result in fewer overall complications and a lower cost per stay.[23] In fact, in our multivariate logistic regression analysis, hypoalbuminemia was an independent risk factor for VTE events. Hypoalbuminemia has been shown to increase clotting and the risk of stroke, often leaving patients with decreased functional independence.[1] In TSA patients, gain in function and mobility are quality-of-life indices discussed during surgical planning. Malnutrition and medical optimization are important topics that should be addressed between the surgeon and patient. Although Bohl et al[6] found no association between VTE and malnutrition, health care providers should be aware of malnutrition as a relatively modifiable risk factor whether through preoperative or postoperative nutrition.

Patients with VTE were also more likely to experience other postoperative complications including an increased length of stay, discharge to a rehabilitative center, SSI, shoulder reoperation, and readmission. In our multivariate regression, increased length of stay was an independent risk factor for the development of a VTE occurrence, and this finding is consistent with the results of prior studies as the thrombosis risk increases with reduced mobility with longer hospital stays.[27,43] Although the longer stay may be a result of an increased need for monitored recovery, pneumatic compression devices, prompt rehabilitation, and foot and ankle exercises are being advocated as part of a multimodal approach in patients who may be unable to receive chemical anticoagulation.[34] Communication about the risks of VTE with a prolonged hospital stay is necessary between the surgeon, patient, physical therapist, and nurses in taking preventive measures. Patients with VTE were more likely to be discharged to a rehabilitative care facility instead of home, which suggests that these patients with likely poorer mobility, functional independence, and recovery are at greater risk of VTE events.

Table IV
Multivariate logistic regression analysis of patient predictors of VTE occurrence within 30 days of surgery

Predictor of VTE occurrence	OR	95% CI		*P* value
		Lower	Upper	
Age	1.016	0.972	1.061	.49
Sex	0.94	0.43	2.05	.88
Ethnicity compared with white				
African American	3.26	1.083	9.82	.036*
Hispanic	<0.01	<0.01		.99
American Indian or Alaskan	<0.01	<0.01		.99
Asian	<0.01	<0.01		.99
Inpatient status	6.20×10^6	0		.99
Origin status	2.30×10^6	0		.99
Anesthesia type	7.20×10^6	0		.99
Obesity	0.72	0.24	2.2	.56
BMI	1.02	0.95	1.09	.63
Smoking	3.88	0.49	30.56	.2
Diabetes	1.12	0.43	2.88	.83
CHF	9.20×10^6	0		.99
COPD	0.66	0.19	2.27	.51
Functional health independence	<0.01	0		.99
Cancer	1.40×10^7	0		.99
Bleeding disorder	1.08	0.14	8.36	.94
Hypoalbuminemia	2.34	1.23	6.03	.04*
Not elective or emergency	2.22	0.27	18.44	.46
ASA class ≥ 3	1.29	0.59	2.79	.51
Length of stay	1.09	1.02	1.69	.012*

VTE, venous thromboembolism; *OR*, odds ratio; *CI*, confidence interval; *BMI*, body mass index; *CHF*, congestive heart failure; *COPD*, chronic obstructive pulmonary disease; *ASA*, American Society of Anesthesiologists.
* Statistically significant ($P < .05$).

The role of SSIs in VTE has been elucidated in the colorectal surgery literature, but the association is unclear in orthopedic surgery. Infections have been shown to increase inflammation, interleukin 6 levels, and thrombin generation, thus causing vessel wall clotting activation and venous thrombosis.[39] To our knowledge, there has been no previous association of SSI and VTE in shoulder surgery. Furthermore, patients with VTE were more likely to also undergo unplanned shoulder reoperations and readmissions. In our study, shoulder reoperations were performed for a variety of indications, including prosthetic loosening, dislocation, infection, fracture, and pain. Prior studies have found that adverse events, including VTE and readmission, occur mainly within 7 days of surgery, which is important to consider as Medicare and the Comprehensive Care for Joint Replacement model aim to tie reimbursement bundles to hospital quality metrics.[19,42]

In our multivariate regression analysis, African American ethnicity compared with white ethnicity was an independent risk factor for VTE occurrence. Although not specific to surgery, African Americans have been shown to have not only the highest standardized incidence of idiopathic and secondary VTE compared with other racial groups but also a greater proportion of VTE events diagnosed as PE.[41] There have been no prior studies on ethnic disparities as they relate to TSA, but Goodman et al[18] have shown that disparities in total knee arthroplasty are still relatively unknown with a lack of robust data. In fact, prior studies have shown that African American patients not only have worse postoperative complications and functional outcomes but also report poorer satisfaction after total knee arthroplasty.[7,8] Rates of non–infection-related total knee arthroplasty complications are highest among African American patients, and our study further suggests additional research is needed to address ethnic disparities in shoulder surgery.[20]

Although we analyzed patient demographic characteristics, comorbidities, and complications associated with VTE, many risk factors found in prior studies were not found to be risk factors for VTE in our study. For example, inpatient status, sex, anesthesia type, obesity, smoking, malignancy, operative time, CHF, COPD, anemia, and independent functional status were not associated with VTE occurrence as loosely suggested in previous literature.[12,14,15,33,36,38] However, even in recent studies, these risk factors and pre-existing conditions have not been replicated, with statistical significance often not having been met.[21,40] Many suggested mechanisms of VTE in TSA relate to procedural technique, including axillary vein damage during humeral manipulation, direct pressure from retractors, embolic showering through intramedullary reaming, lower-extremity venous stasis from beach-chair positioning, increased dissection, and prolonged operative time.[4,25,32,37,42] Despite the uncertainty of patient- or surgical-related causal effects for VTE, risk stratification for VTE should be performed in all TSA patients. Although the decision to use anticoagulants must be weighed against the risks of bleeding and infection, a multimodal approach in which all patients receive mechanical prophylaxis through early mobility, rehabilitation, or compression devices is generally applicable to most TSA patients.

Despite the large number of patients in this study, there are limitations in using the NSQIP database. Rates of complications, such as VTE, are limited to 30-day follow-up, whereas some VTE events are known to occur as late as 12 weeks postoperatively. The database has no information on patient use of mechanical prophylaxis or anticoagulation, such as unfractionated or low-molecular-weight heparin.[28] Many risk factors such as VTE history, family history, and use of tamoxifen or contraceptive pills are known to be risk factors for VTE but are not identified in the database. DVT and PE events identified in the NSQIP database by definition had to be confirmed by some form of imaging modality, which is not routinely ordered unless patients are symptomatic. However, many cases of thrombosis, whether upper or lower extremity, occur without symptoms, and the database is not able to capture these patients. Furthermore, the use of Current Procedural Terminology code 23472 was not able to differentiate anatomic from reverse TSA, but prior studies have found similar complication rates between the 2 procedures.[16]

Conclusion

There are few guidelines regarding prophylaxis and established risk factors for VTE in TSA patients. Patients with hypoalbuminemia, an increased length of stay, and African American ethnicity are at an increased risk of VTE after TSA, and a high index of suspicion is warranted for elderly patients with fractures who may need preoperative medical optimization. Identification of modifiable patient risk factors and preoperative risk stratification can help guide interdisciplinary surgical planning and physician-patient communication on improving outcomes while reducing hospital costs.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

1. Alvarez-Perez FJ, Castelo-Branco M, Alvarez-Sabin J. Albumin level and stroke. Potential association between lower albumin level and cardioembolic aetiology. Int J Neurosci 2011;121:25–32. https://doi.org/10.3109/00207454.2010.523134.
2. American Academy of Orthopaedic Surgeons. Preventing venous thromboembolic disease in patients undergoing elective hip and knee arthroplasty: evidence-based guideline and evidence report. Available at: https://www.aaos.

org/research/guidelines/VTE/VTE_full_guideline.pdf. Accessed February 20, 2019.
3. Anthony CA, Westermann RW, Gao Y, Pugely AJ, Wolf BR, Hettrich CM. What are risk factors for 30-day morbidity and transfusion in total shoulder arthroplasty? A review of 1922 cases. Clin Orthop Relat Res 2015;473:2099–105. https://doi.org/10.1007/s11999-014-4107-7.
4. Arcand M, Burkhead WZ Jr, Zeman C. Pulmonary embolism caused by thrombosis of the axillary vein after shoulder arthroplasty. J Shoulder Elbow Surg 1997;6:486–90.
5. Arcelus JI, Kudrna JC, Caprini JA. Venous thromboembolism following major orthopedic surgery: what is the risk after discharge? Orthopedics 2006;9:506–16.
6. Bohl DD, Shen MR, Hannon CP, Fillingham YA, Darrith B, Della Valle CJ. Serum albumin predicts survival and postoperative course following surgery for geriatric hip fracture. J Bone Joint Surg Am 2017;99:2110–8. https://doi.org/10.2106/JBJS.16.01620.
7. Bourne RB, Chesworth B, Davis A, Mahomed N, Charron K. Comparing patient outcomes after THA and TKA: is there a difference? Clin Orthop Relat Res 2010;468:542–6. https://doi.org/10.1007/s11999-009-1046-9.
8. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clin Orthop Relat Res 2010;468:57–63. https://doi.org/10.1007/s11999-009-1119-9.
9. Caprini JA. Risk assessment as a guide for the prevention of the many faces of venous thromboembolism. Am J Surg 2010;199(Suppl):S3–10. https://doi.org/10.1016/j.amjsurg.2009.10.006.
10. Colwell CW Jr. Managing thromboembolic risk in hip and knee arthroplasty: state of the art. Orthopedics 2003;26(Suppl):s231–6.
11. Dailey EA, Cizik A, Kasten J, Chapman JR, Lee MJ. Risk factors for readmission of orthopaedic surgical patients. J Bone Joint Surg Am 2013;95:1012–9. https://doi.org/10.2106/JBJS.K.01569.
12. Damodar D, Vakharia R, Vakharia A, Sheu J, Donnally CJ III, Levy JC, et al. A higher altitude is an independent risk factor for venous thromboembolisms following total shoulder arthroplasty. J Orthop 2018;15:1017–21. https://doi.org/10.1016/j.jor.2018.09.003.
13. Dattani R, Smith CD, Patel VR. The venous thromboembolic complications of shoulder and elbow surgery: a systematic review. Bone Joint J 2013;95-B:70–4. https://doi.org/10.1302/0301-620X.95B1.29854.
14. Day JS, Ramsey ML, Lau E, Williams GR. Risk of venous thromboembolism after shoulder arthroplasty in the Medicare population. J Shoulder Elbow Surg 2015;24:98–105. https://doi.org/10.1016/j.jse.2014.09.025.
15. Esmon CT. Basic mechanisms and pathogenesis of venous thrombosis. Blood Rev 2009;23:225–9. https://doi.org/10.1016/j.blre.2009.07.002.
16. Flurin PH, Roche CP, Wright TW, Marczuk Y, Zuckerman JD. A comparison and correlation of clinical outcome metrics in anatomic and reverse total shoulder arthroplasty. Bull Hosp Jt Dis (2013) 2015;73(Suppl 1):S118–23.
17. Garcia GH, Fu MC, Dines DM, Craig EV, Gulotta LV. Malnutrition: a marker for increased complications, mortality, and length of stay after total shoulder arthroplasty. J Shoulder Elbow Surg 2016;25:193–200. https://doi.org/10.1016/j.jse.2015.07.034.
18. Goodman SM, Parks ML, McHugh K, Fields K, Smethurst R, Figgie MP, et al. Disparities in outcomes for African Americans and whites undergoing total knee arthroplasty: a systematic literature review. J Rheumatol 2016;43:765–70. https://doi.org/10.3899/jrheum.150950.
19. Health Care Payment Learning & Action Network. Medicare announcement. Available at: https://hcp-lan.org/2016/03/important-medicare-announcement/; 2016, accessed April 18, 2019.
20. Ibrahim SA, Stone RA, Han X, Cohen P, Fine MJ, Henderson WG, et al. Racial/ethnic differences in surgical outcomes in veterans following knee or hip arthroplasty. Arthritis Rheum 2005;52:3143–51. https://doi.org/10.1002/art.21304.
21. Imberti D, Ivaldo N, Murena L, Paladini P, Castagna A, Barillari G, et al. Venous thromboembolism in patients undergoing shoulder surgery: findings from the RECOS Registry. Thromb Res 2014;134:273–7. https://doi.org/10.1016/j.thromres.2014.05.014.
22. Jameson SS, James P, Howcroft DW, Serrano-Pedraza I, Rangan A, Reed MR, et al. Venous thromboembolic events are rare after shoulder surgery: analysis of a national database. J Shoulder Elbow Surg 2011;20:764–70. https://doi.org/10.1016/j.jse.2010.11.034.
23. Lawson R, Doshi M, Barton J, Cobden I. The effect of unselected post-operative nutritional supplementation on nutritional status and clinical outcome of orthopaedic patients. Clin Nutr 2003;22:39–46.
24. Lovy AJ, Keswani A, Beck C, Dowdell JE, Parsons BO. Risk factors for and timing of adverse events after total shoulder arthroplasty. J Shoulder Elbow Surg 2017;26:1003–10. https://doi.org/10.1016/j.jse.2016.10.019.
25. Lyman S, Sherman S, Carter TI, Bach PB, Mandl LA, Marx RG. Prevalence and risk factors for symptomatic thromboembolic events after shoulder arthroplasty. Clin Orthop Relat Res 2006;448:152–6. https://doi.org/10.1097/01.blo.0000194679.87258.6e.
26. Matsen FA III, Li N, Gao H, Yuan S, Russ SM, Sampson PD. Factors affecting length of stay, readmission, and revision after shoulder arthroplasty: a population-based study. J Bone Joint Surg Am 2015;97:1255–63. https://doi.org/10.2106/JBJS.N.01107.
27. Noskin GA, Rubin RJ, Schentag JJ, Kluytmans J, Hedblom EC, Smulders M, et al. The burden of Staphylococcus aureus infections on hospitals in the United States: an analysis of the 2000 and 2001 Nationwide Inpatient Sample Database. Arch Intern Med 2005;165:1756–61. https://doi.org/10.1001/archinte.165.15.1756.
28. Pannucci CJ, Shanks A, Moote MJ, Bahl V, Cederna PS, Naughton NN, et al. Identifying patients at high risk for venous thromboembolism requiring treatment after outpatient surgery. Ann Surg 2012;255:1093–9. https://doi.org/10.1097/SLA.0b013e3182519ccf.
29. Parvizi J, Ghanem E, Joshi A, Sharkey PF, Hozack WJ, Rothman RH. Does "excessive" anticoagulation predispose to periprosthetic infection? J Arthroplasty 2007;22(Suppl 2):24–8. https://doi.org/10.1016/j.arth.2007.03.007.
30. Rapp CM, Shields EJ, Wiater BP, Wiater JM. Venous thromboembolism after shoulder arthoplasty and arthroscopy. J Am Acad Orthop Surg 2019;27:265–74. https://doi.org/10.5435/JAAOS-D-17-00763.
31. Ruppert A, Steinle T, Lees M. Economic burden of venous thromboembolism: a systematic review. J Med Econ 2011;14:65–74. https://doi.org/10.3111/13696998.2010.546465.
32. Saleem A, Markel DC. Fatal pulmonary embolus after shoulder arthroplasty. J Arthroplasty 2001;16:400–3.
33. Saleh HE, Pennings AL, ElMaraghy AW. Venous thromboembolism after shoulder arthroplasty: a systematic review. J Shoulder Elbow Surg 2013;22:1440–8. https://doi.org/10.1016/j.jse.2013.05.013.
34. Salvati EA, Sharrock NE, Westrich G, Potter HG, Valle AG, Sculco TP. The 2007 ABJS Nicolas Andry Award: three decades of clinical, basic, and applied research on thromboembolic disease after THA: rationale and clinical results of a multimodal prophylaxis protocol. Clin Orthop Relat Res 2007;459:246–54. https://doi.org/10.1097/BLO.0b013e31805b7681.
35. Shiloach M, Frencher SK Jr, Steeger JE, Rowell KS, Bartzokis K, Tomeh MG, et al. Toward robust information: data quality and interrater reliability in the American College of Surgeons National Surgical Quality Improvement Program. J Am Coll Surg 2010;210:6–16. https://doi.org/10.1016/j.jamcollsurg.2009.09.031.
36. Singh JA, Sperling JW, Cofield RH. Cardiopulmonary complications after primary shoulder arthroplasty: a cohort study. Semin Arthritis Rheum 2012;41:689–97. https://doi.org/10.1016/j.semarthrit.2011.09.003.
37. Sperling JW, Cofield RH. Pulmonary embolism following shoulder arthroplasty. J Bone Joint Surg Am 2002;84:1939–41. https://doi.org/10.2106/00004623-200211000-00005.
38. Tashjian RZ, Lilly DT, Isaacson AM, Georgopoulos CE, Bettwieser SP, Burks RT, et al. Incidence of and risk factors for symptomatic venous thromboembolism after shoulder arthroplasty. Am J Orthop (Belle Mead NJ) 2016;45:E379–85.
39. Tichelaar YI, Kluin-Nelemans HJ, Meijer K. Infections and inflammatory diseases as risk factors for venous thrombosis. A systematic review. Thromb Haemost 2012;107:827–37. https://doi.org/10.1160/TH11-09-0611.
40. Wagner ER, Houdek MT, Schleck C, Harmsen WS, Sanchez-Sotelo J, Cofield R, et al. Increasing body mass index is associated with worse outcomes after shoulder arthroplasty. J Bone Joint Surg Am 2017;99:929–37. https://doi.org/10.2106/JBJS.15.00255.
41. White RH, Keenan CR. Effects of race and ethnicity on the incidence of venous thromboembolism. Thromb Res 2009;123(Suppl 4):S11–7. https://doi.org/10.1016/S0049-3848(09)70136-7.
42. Willis AA, Warren RF, Craig EV, Adler RS, Cordasco FA, Lyman S, et al. Deep vein thrombosis after reconstructive shoulder arthroplasty: a prospective observational study. J Shoulder Elbow Surg 2009;18:100–6. https://doi.org/10.1016/j.jse.2008.07.011.
43. Young BL, Menendez ME, Baker DK, Ponce BA. Factors associated with in-hospital pulmonary embolism after shoulder arthroplasty. J Shoulder Elbow Surg 2015;24:e271–8. https://doi.org/10.1016/j.jse.2015.04.002.