Risk factors for venous thromboembolism in total shoulder arthroplasty

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Background: Although venous thromboembolism (VTE) has been extensively 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 χ² 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, and 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.

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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. 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. 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. Currently, VTE prophylaxis guidelines for TSA are not well established, and new American Academy of Orthopaedic Surgeons guidelines have been extrapolated from lower-extremity data because of a lack of consensus on TSA risk factors.

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.

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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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{25} 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.\textsuperscript{15} 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.\textsuperscript{12,35,13} 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{15,9,22} 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{44} 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.\textsuperscript{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.\textsuperscript{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%.\textsuperscript{23} 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.\textsuperscript{25} 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.\textsuperscript{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.\textsuperscript{9}

Categorical patient demographic variables were compared using the Pearson $\chi^2$ 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
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 (9.9% vs. 9.0%, \( P < .01 \)), 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 I**

| Parameter                               | All patients, n | No VTE | VTE | \( P \) value |
|-----------------------------------------|-----------------|--------|-----|--------------|
| n (%)                                   | 13,299 (100)    | 13,216 (99.38) | 83 (0.62) | .038*        |
| Age, mean ± SD, yr                      | 69.2 ± 9.7      | 71.4 ± 12.6 | .15          |
| % female                                | 43.70           | 55.70 | .15          |
| BMI, mean ± SD                          | 31.1 ± 6.8      | 31.5 ± 7 | .55          |
| Ethnicity, %                            |                 |        |               |
| White                                   | 10,928          | 99.40  | 0.60 | .27          |
| African American                        | 610             | 99     | 1   | .91          |
| Hispanic                                | 478             | 100    | 0   | .42          |
| American Indian or Alaskan              | 53              | 100    | 0   | .42          |
| Asian                                   | 85              | 100    | 0   | .42          |
| Inpatient status, %                     |                 |        | .07 |               |
| Inpatient                               | 12,519          | 99.30  | 0.70 | .51          |
| Outpatient                              | 780             | 99.90  | 0.10 | .51          |
| Origin status, %                        |                 |        | .51 |               |
| Transferred from home or nursing home   | 13,229          | 99.40  | 0.60 | .51          |
| Transferred from acute care facility    | 68              | 100    | 0   | .51          |
| Elective status, %                      |                 |        | .008* |               |
| Elective                                | 13,239          | 99.40  | 0.60 | .51          |
| Emergency or not elective               | 60              | 96.7   | 3.30 | .51          |
| Anesthesia type, %                      |                 |        | .91 |               |
| General                                 | 12,777          | 99.40  | 0.60 | .91          |
| Regional                                | 511             | 99.40  | 0.60 | .91          |
| Functional health status and activities of daily, % |     |        | .42       |
| Independent                             | 12,868          | 99.40  | 0.60 | .42          |
| Not independent                         | 347             | 99.70  | 0.30 | .42          |
| ASA class, %                            |                 |        | .09 |               |
| 1                                       | 237             | 99.20  | 0.80 | .09          |
| 2                                       | 5839            | 99.60  | 0.40 | .09          |
| 3                                       | 6840            | 99.20  | 0.80 | .09          |
| 4                                       | 368             | 99.50  | 0.50 | .09          |
| 5                                       | 1               | 100    | 0   | .09          |
| ASA class \( \geq 3 \), %              |                 |        | .028* |               |
| No                                      | 6077            | 99.50  | 0.50 | .028*        |
| Yes                                     | 7208            | 99.20  | 0.80 | .028*        |
| Preoperative surgical indication, %     |                 |        | .013* |               |
| Osteoarthritis                          | 9259            | 99.50  | 0.50 | .013*        |
| Cuff arthropathy                        | 1054            | 99     | 1   | .013*        |
| Fracture                                | 834             | 98.80  | 1.20 | .013*        |
| Revision                                | 386             | 99.50  | 0.50 | .013*        |
| 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 (\( P < .05 \)).
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.30,31 Although Day et al14 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.30,31 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.30,29

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.30 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.32 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.31,33 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 al34 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.

| 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   | 16.60          | 99.60     | 0.40   | .32     |
| COPD      | 6.60           | 99.20     | 0.80   | .51     |
| Aspirin   | <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).

| Parameter | All patients, % | No VTE, % | VTE, % | P value |
|-----------|----------------|-----------|--------|---------|
| Length of stay, mean, d | 3.5 | 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).

Table II
Medical comorbidities in patients with and without VTE occurrence

Table III
Thirty-day complications in patients with and without VTE occurrence
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.\textsuperscript{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.\textsuperscript{11,12,42}

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.\textsuperscript{10} There have been no prior studies on ethnic disparities as they relate to TSA, but Goodman et al\textsuperscript{10} 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.\textsuperscript{10} Rates of non–injection–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.\textsuperscript{10}

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.\textsuperscript{2,14,15,33,36,38} However, even in recent studies, these risk factors and pre-existing conditions have not been replicated, with statistical significance often not having been met.\textsuperscript{2,14,40} 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 intra-medullary reaming, lower-extremity venous stasis from beach-chair positioning, increased dissection, and prolonged operative time.\textsuperscript{2,4,5,32,37,46} 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.\textsuperscript{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.\textsuperscript{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

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