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SECTION II
ORIGINAL ARTICLES

Prevalence and Risk Factors for Symptomatic Thromboembolic Events after Shoulder Arthroplasty

Stephen Lyman, PhD; Seth Sherman, MD*; Timothy I. Carter, BA*; Peter B. Bach, MD, MAPP†; Lisa A. Mandl, MD, MPH*; and Robert G. Marx, MD, MSc, FRCSC**

Deep venous thrombosis and pulmonary embolism after shoulder arthroplasty are not well described. We sought to identify the frequency of deep venous thrombosis and pulmonary embolisms in patients after shoulder arthroplasties to compare these rates with the frequency of deep venous thrombosis and pulmonary embolisms among patients who had total hip and total knee arthroplasties, and to identify associated risk factors. The New York State Department of Health Statewide Planning and Research Cooperative System database was used to identify hospital admissions of patients having shoulder, hip, or knee arthroplasties between 1985 and 2003 with or without an associated diagnostic code for deep venous thrombosis or pulmonary embolism. This resulted in a retrospective cohort of 328,301 procedures. The frequency of deep venous thrombosis was 5.0 per 1000 procedures for shoulder arthroplasties compared with 15.7 for hip arthroplasties and 26.9 for knee arthroplasties. The frequency of pulmonary embolisms was 2.3 for shoulder arthroplasties, 4.2 for hip arthroplasties, and 4.4 for knee arthroplasties. Increasing age, trauma, and cancer were risk factors for thromboembolic events after shoulder arthroplasties. Although the absolute rates of thromboembolic complications were less in patients who had shoulder arthroplasties compared with those of patients who had lower extremity procedures, a larger percentage of these complications were pulmonary embolisms. Perioperative antithrombotic prophylaxis may be beneficial to reduce the frequency of deep venous thrombosis and pulmonary embolisms among patients having shoulder arthroplasties, particularly in higher-risk groups.

Level of Evidence: Prognostic study, Level II (retrospective study). See the Guidelines for Authors for a complete description of levels of evidence.

Venous thromboembolic disease after total hip arthroplasty (THA) and total knee arthroplasty (TKA) is a common, well-studied complication of these procedures. In contrast, the frequency of deep venous thrombosis (DVT) and pulmonary embolism (PE) coincident with shoulder arthroplasty has not been well-characterized in the literature. It is important to diagnose and prevent these conditions because acute PE causes greater than 150,000 deaths per year in the United States,[8] and the frequency of shoulder arthroplasties is increasing.[1]

The incidence of thromboembolic disease after THAs and TKAs without prophylaxis ranges from 29% to 60% for DVT and 1% to 3% for fatal PEs.[5,9] Some investigators support the use of pharmacologic prophylaxis as the standard of care after THAs and TKAs.[3,7] To date, we are aware of only four case reports and one retrospective case

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From the *Hospital for Special Surgery, and the †Memorial Sloan Kettering Cancer Center, New York, NY.
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Correspondence to: Stephen Lyman, PhD, Foster Center for Clinical Outcome Research, Hospital for Special Surgery, 535 E 70th St, New York, NY 10021. Phone: 212-606-1866; Fax: 212-774-2455; E-mail: lymans@hss.edu.
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series of 10 patients with PE after shoulder arthroplasties.[11,13,16] Because of the relative lack of existing evidence, the risk factors for thrombogenic events and the potential benefits of pharmacologic prophylaxis in patients at high-risk after shoulder arthroplasties have not been described.

We wanted to determine the prevalence of and risk factors for DVT and PE after total shoulder arthroplasties and shoulder hemiarthroplasties and to compare this prevalence those of THAs and TKAs. The primary research objective is to identify predictors of DVT and PE after total shoulder arthroplasty and shoulder hemiarthroplasty. The secondary research objective is to compare the prevalence of DVT and PE in shoulder arthroplasty with the prevalence in THAs and TKAs.

MATERIALS AND METHODS

The Statewide Planning and Research Cooperative System (SPARCS) database from the New York State Department of Health, a census of all hospital discharges in the state, was used to determine the frequency of DVT and PE after major joint arthroplasties. The Statewide Planning and Research Cooperative System has data on all New York State hospital discharges from 1985 to 2003.

Patients who had THAs (ICD-9-CM procedure 81.51), TKAs (81.54), total shoulder arthroplasties (81.80), or shoulder hemiarthroplasties (81.81) performed on an inpatient basis (total joint surgeries are not done on an outpatient basis) from 1985 to 2003 were included in this study. Patient demographic and hospitalization information such as age, gender, length of stay, previous diagnosis of malignancy, and comorbidities were considered covariates for this study. Comorbidities were defined using the comorbidity scale described by Charlson et al[4] and adjusted for use with administrative data by Deyo et al.[6] This adjustment accounts for acute comorbidities that may have occurred during the admission of interest rather than being part of the preexisting comorbidity profile.

The study population consisted of 328,305 patients who had THAs, TKAs, total shoulder arthroplasties, or shoulder hemiarthroplasties from 1985 through 2003 (Table 1). These procedures were performed at 246 medical facilities by 3649 surgeons. The majority of these patients (THA, 152,461; TKA, 162,085) had lower extremity joint replacements whereas 13,759 had total shoulder arthroplasties or hemiarthroplasties. The demographics of the four surgical groups (THA, TKA, total shoulder arthroplasty, and shoulder hemiarthroplasty were similar regarding patient age and gender. Length of stay data were broken into length of stay for all years and length of stay since 2000 to reflect current practices of shorter hospitalization. Average length of stay for the entire study period was 4.7 ± 5.0 days for the patients who had total shoulder hemiarthroplasties and 8.7 ± 7.5 days for patients who had THAs. When compared with length of stay data since 2000, the average length of stay for all groups were considerably decreased, with a range of 3.1 ± 2.7 days for patients who had total shoulder arthroplasties to 5.1 ± 3.6 days for patients who had THAs. The majority of patients in the THA, TKA, and total shoulder arthroplasty groups were treated for osteoarthritis. In the shoulder hemiarthroplasty group, fractures were the most frequent reason for treatment. Rheumatoid arthritis was another common primary diagnosis, accounting for as few as 4% of patients in the THA group and as many as 10.6% of patients in the total shoulder arthroplasty group.

The outcomes of interest for this study were DVT (ICD-9-CM diagnosis 451.0–451.9, 453.8, 453.9, 997.2) and PE (415.1, 415.11) during the surgical admission. Covariates of interest included age, gender, ethnicity, orthopaedic diagnosis, comorbidities including cancer, and admission for trauma. Cancer was included as a potential covariate because previous research has indicated patients diagnosed with cancer are at increased risk for thromboembolic complications.[10] Trauma was defined as a fracture or dislocation of the involved joint (hip, knee, or shoulder).

Statistical analysis consisted of descriptive and inferential statistics. Variables were described using means, medians, minimums, maximums, and standard deviations for continuous variables and counts and percentages for categorical variables. Inferential analysis was performed using Fisher's exact test because of the small number of events for some outcome variables

TABLE 1. Study Population by Type of Joint Arthroplasty

Demographics	Total Hip Arthroplasty	Total Knee Arthroplasty	Total Shoulder Arthroplasty	Shoulder Hemiarthroplasty
Total number of patients	152,461	162,085	4931	8828
Female	90,653 (59.5%)	106,907 (66.0%)	2971 (60.3%)	6174 (69.9%)
Age (years)	66.7 ± 13.1	68.2 ± 10.1	66.4 ± 12.2	66.3 ± 14.8
Length of stay 1985–2003 (days)	8.7 ± 7.5	6.9 ± 5.0	4.7 ± 5.0	7.5 ± 8.5
Length of stay 2000–2003 (days)	5.1 ± 3.6	4.8 ± 2.9	3.1 ± 2.7	4.8 ± 5.6
Diagnosis				
Osteoarthritis	216,564 (83.8%)	154,192 (95.1%)	3629 (73.6%)	2367 (27.2%)
Rheumatoid arthritis	5969 (4.0%)	8596 (5.3%)	524 (10.6%)	598 (6.9%)
Avascular necrosis	14,125 (9.4%)	1463 (0.9%)	268 (5.4%)	582 (6.7%)
Fracture	12,106 (8.0%)	352 (0.2%)	465 (9.4%)	4341 (49.8%)
Dislocation	295 (0.2%)	66 (0.0%)	36 (0.7%)	282 (3.2%)

TABLE 2. Comparison of Arthroplasties for Risk of Thromboembolic Events

Outcome	Total Shoulder Arthroplasty Rate per 1000 (number of events)	Hemiarthroplasty Rate per 1000 (number of events)	All Shoulder Arthroplasties Rate per 1000 (number of events)	Total Hip Arthroplasty Rate per 1000 (number of events)	Total Knee Arthroplasty Rate per 1000 (number of events)
Any deep venous thrombosis	4.1 (20)	5.6 (49)	5.0 (69)	15.7* (2392)	26.9* (4365)
Pulmonary embolism	2.6 (13)	2.2 (19)	2.3 (32)	4.2* (646)	4.4* (713)
Any thromboembolic events	6.1 (30)	7.2 (64)	6.8 (94)1	19.2* (2922)	30.3* (4917)
Death from any cause	2.4† (12)	7.8 (69)	5.9 (81)	6.8 (1039)	2.1* (341)
Total number of cases	4931	8828	13,755	152,461	162,085

*p < 0.01 compared with rate for all shoulder arthroplasties; †p < 0.01 compared with rate for hemiarthroplasties

(eg, PE in shoulder arthroplasty). Skewed continuous outcome measures (eg, length of stay) were analyzed using the Kruskal-Wallis test for nonnormally distributed data with a post hoc Mann Whitney U test for pairwise comparisons.

A logistic regression model was built for multivariable analysis for any thromboembolic event (eg, DVT or PE) for each type of surgery (eg, TKA, THA, and shoulder arthroplasty). All potential independent variables were tested using simple logistic regression models. All independent variables that were predictors of the outcome in simple logistic models were considered for inclusion in the multivariable model. The most parsimonious model was one in which each independent variable was associated with the outcome, but in which no additionally measured covariates would be associated with the outcome when placed into the model.

A critical p value of 0.05 was used for all analyses. All data management and analyses were done using the SAS System for Windows® (Microsoft®, Redmond, WA) version 8.02 (SAS, Cary, NC).

RESULTS

The frequency of DVT after any shoulder arthroplasty (total shoulder arthroplasty + shoulder hemiarthroplasty = shoulder arthroplasty) was 5.0 per 1000 cases overall; the frequency of PE was 2.3 per 1000 (Table 2). The frequency of DVT or PEs after shoulder arthroplasties was less frequent ($p < 0.01$) than DVT or PE after TKAs or THAs (relative risks, 0.19–0.55). There were no differences in the risk of DVT or PE between patients who had total shoulder arthroplasties and shoulder hemiarthroplasties. However, the risk of death during the hospital admission from all causes was less ($p < 0.01$) in the patients who had total shoulder arthroplasties compared with patients who had shoulder hemiarthroplasties.

Arthroplasty for trauma (eg, fracture or dislocation), advanced age, and a previous diagnosis of malignancy all were associated with increased risk of thromboembolic events after shoulder arthroplasties and THAs (Table 3). Women were at increased risk of thromboembolic events after TKAs, but decreased risk after THAs even after controlling for other factors. The comorbidity index of Charlson et al as modified by Deyo et al was associated only with increased risk of thromboembolic events among patients with two or more comorbidities who had THAs. With the exception of the diagnosis of cancer among patients who had shoulder arthroplasties, all effect sizes were modest.

DISCUSSION

The goal of this research was to identify the frequency and risk factors for thromboembolic events after shoulder ar-

TABLE 3. Logistic Regression Model for Risk of Thromboembolic Event

Risk Factor	Shoulder Arthroplasty Odds Ratio (95% CI)	Total Knee Arthroplasty Odds Ratio (95% CI)	Total Hip Arthroplasty Odds Ratio (95% CI)
10-year increase in age	1.19 (1.02, 1.37)*	1.03 (1.00, 1.06)*	1.10 (1.07, 1.13)†
Femal gender	1.06 (0.66, 1.71)	1.07 (1.00, 1.13)*	0.87 (0.81, 0.94)†
Trauma (fracture/dislocation)	1.63 (1.07, 2,49)*	1.43 (0.89, 2.29)	1.22 (1.08, 1.38)†
Cancer	2.41 (1.20, 4.83)*	1.12 (0.95, 1.32)	1.38 (1.17, 1.62)†
No comorbidities	—‡	—‡	—‡
One comorbidity	0.81 (0.49, 1.34)	0.99 (0.93, 1.06)	1.08 (0.99, 1.18)
Two+ comorbidities	1.63 (0.75, 3.58)	0.82 (0.70, 0.97)	1.21 (1.00, 1.48)*

All variables in model listed in table are adjusted for one another; *p < 0.05; †p < 0.01; ‡Reference group.

throplasties, because little previous literature exists on a population level. Additionally, the frequency of thromboembolic events in patients who had shoulder arthroplasties was compared with the frequency of thromboembolic events in patients who had THAs and TKAs because these complications have been studied frequently and prophylaxis has been recommended for patients having these procedures.

There are limitations to using administrative databases for research. The information for each case of DVT or PE is limited to ICD-9 codes with no information regarding the location of the thrombus (fewer than 10% of DVTs were coded by upper or lower extremity) or the use of prophylaxis to prevent DVT or PE. This information also only reflects patients who are diagnosed with DVT or PE before discharge for their surgical admission. It is unknown if the patients with DVT captured in this database are symptomatic, because some hospitals routinely may do ultrasonography of all patients before discharge. The method for confirming these DVTs and PEs is unknown. Readmission for, and outpatient diagnoses of, DVT or PE are not included in these data. Also, only a sample of the patient records recorded in SPARCS are validated each year, so there is the possibility some of the patients in this study are misdiagnosed because of coding errors. Despite these limitations, this database allows for the study of this relatively rare condition. The largest previous study had five cases whereas our study evaluates 94 events, (69 DVTs and 32 PEs) after total shoulder arthroplasty or hemiarthroplasty.

Ideally patients would be distinguished by whether their operations were elective or nonelective. However, previous studies of DVT and PE after shoulder arthroplasty, THA, and TKA have not used this distinction, because the importance lies in the universe of thromboembolic events, not the subset. The multivariable model is used to elucidate this relationship. Based on the findings of the model, patients with admission for trauma (eg, nonelective cases) are more likely to have a DVT or PE.

The strengths of this study include the large sample size and virtually complete inclusion of all total joint replacements performed in New York State between 1985 and 2003. Hospitals are required by law to report to SPARCS, and therefore the data are expected to be very nearly complete. There is no reason to suspect the few cases that might be missing from the database are systematically biased toward or away from DVT or PE. These large numbers with a comparison group (patients without DVT or PE) allows for an objective quantification of the risk factors associated with DVT and PE in this population.

The incidence and risk factors for DVT and PEs after hip and knee surgeries have been described. Conversely, there is little published information regarding DVT and PEa after shoulder arthroplasties. Arcand et al[2] reported the case of a 32 year-old man with axillary vein thrombosis and nonfatal PE after elective shoulder arthroplasty. Scott[14] reported on a 24 year-old man with brachial vein thrombosis and nonfatal PE after glenohumeral joint débridement. Rockwood et al[12] reported on two cases of PE after elective shoulder arthroplasties, a fatality in a 52-year-old man who had revision total shoulder arthroplasty, and a nonfatal PE in a 36-year-old man who had a total shoulder arthroplasty. Saleem and Markel[13] reported on a fatal PE in a 68-year-old active man who had an elective shoulder arthroplasty.

Sperling and Cofield[15] reported the largest series to date on PEs after total shoulder arthroplasties or hemiarthroplasties. Four women who had shoulder hemiarthroplasties and one woman who had a total shoulder arthroplasty (mean age, 68 years) sustained nonfatal PEs confirmed by computed tomography or ventilation-perfusion scan. Time of diagnosis ranged from the day of surgery to postoperative Day 7. All four patients who had ultrasound or impedance plethysmography studies of the lower extremities had negative findings. Only one patient had ultrasonography of the upper extremity, which was negative.[15]

The frequency of patients having DVT or PE develop while hospitalized is less for patients having total shoulder arthroplasties or hemiarthroplasties than for patients having THAs or TKAs, but the length of stay also is less. Therefore, patients who have total shoulder arthroplaties or hemiarthroplasties have less time to have a DVT or PE detected while they are in the hospital. Although this study likely underestimates all frequencies of DVT and PE after these procedures, the shorter length of stay for patients having shoulder procedures may magnify their underestimation. Also, during the time of this study, the use of prophylaxis for DVT and PE was routine among patients having THAs and TKAs, but not among patients having total shoulder arthroplasties or hemiarthroplasties.

Although the frequency of DVT is approximately three to five times less among patients having total shoulder arthroplasties or hemiarthroplasties than for patients having THA or TKAs, the frequency of PE is just two times less. This may be because patients having THAs and TKAs likely have more diagnostic procedures for DVT. Also, death from any cause was greatest among arthroplasties most likely to be performed for fractures, namely shoulder hemiarthroplasties and THAs.

These data indicate a stronger relationship between patient age and risk of thromboembolic event after a total shoulder arthroplasty or hemiarthroplasty compared with a THA or a TKA. Consistent with data regarding THAs and TKAs, the risk of thromboembolic events increased among patients having shoulder arthroplaties who had concurrent shoulder fractures or a history of cancer.

Although thromboembolic disease is more common after THAs and TKAs, it also occurs after total shoulder arthroplasties and hemiarthroplasties. Actual rates are greater, as only rates for patients diagnosed with DVTs and PEs while hospitalized are reported here. Consideration for prophylactic anticoagulation should be given to patients having shoulder arthroplasties who are elderly, who have sustained fractures, who have a previous diagnosis or malignancy, and/or who have multiple comorbidities. Additional research should be conducted in a prospective fashion to determine the timing and location of thromboembolic events after shoulder arthroplasties, patients who should receive anticoagulants, and the specific interventions that could be done to decrease the risk of thromboembolic events after shoulder arthroplasties. Possible interventions might include a change from the beach chair position, less bend in the hips during the procedure, and the use of compression boots during surgery.

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