Full length article

The risk of deep vein thrombosis in total joint patients compared to orthopaedic trauma patients: Need for new prevention guidelines

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ABSTRACT

Background: The development of Deep Vein Thrombosis (DVT) is a major concern following orthopaedic surgery. No study has yet to compare the rate and risk factors for DVT between total joint and orthopaedic trauma patients. To evaluate if DVT prophylaxis for trauma should differ from total joints, we explored the rate and risk factors for DVT between both cohorts.

Methods: Using a CPT code search from 2005 to 2013 in the ACS-NSQIP database, 150,657 orthopaedic total joint patients and 44,594 orthopaedic trauma patients were identified. DVT complications, patient demographics, preoperative comorbidities, and surgical characteristics were collected for each patient. A chi-squared test was used to compare the risk factors for DVT between orthopaedic trauma and total joint patients. A multivariable logistic regression model was built to adjust for comorbidities for each cohort.

Results: The rate of DVT diagnosis in the total joint population was 0.8% (N = 1186) and 0.98% (N = 432) in the orthopaedic trauma population (p = 0.57). After controlling for individual comorbidities, dyspnea, peripheral vascular disease, and renal failure were significant risk factors for DVT in total joint patients (p < 0.05), whereas age, ascites and steroid use were significant risk factors for DVT in orthopaedic trauma patients (p < 0.05).

Conclusions: Historically, the risks for DVT in total joints have been emphasized, yet based on our results, the incidence of DVT is the same for orthopaedic trauma. However, the risk factors varied. It is therefore important to consider specialty-specific DVT prophylaxis for orthopaedic trauma patients in order to improve care and reduce postoperative complications.

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1. Introduction

Venous thromboembolism (VTE), including deep vein thrombosis (DVT) and pulmonary embolism (PE), remains a major concern following orthopaedic surgery, particularly since such disease is a leading cause of perioperative morbidity and mortality.¹ Amongst patients hospitalized in the United States, it is the direct cause of death in more than 100,000 patients and a contributing factor of mortality in another 100,000 each year.^{2,3} Several patient safety initiatives, such as the Agency for Healthcare Research and Quality Patient Safety Indicators, American Public Health Association's Coalition to Prevent Deep Vein Thrombosis, and the US Surgeon General's Workshop on Deep

Vein Thrombosis have aimed to improve detection and prevention of VTE.^{4–6}

To our knowledge, no study has yet to compare the risk factors for DVT between total joint and orthopaedic trauma patients. The purpose of this article is to identify the risk factors for DVT in trauma patients and compare to total joint patients through the use of prospective multicenter data in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. By evaluating the risk factors for DVT in each cohort, our study seeks to explore whether DVT prophylaxis guidelines for total joint patients can be applied to trauma surgery patients. As our health system transitions to bundle payments, it is essential for orthopaedic trauma surgeons to identify those patients most likely to experience thromboembolic complications in order to develop a cost effective DVT prevention program, specifically targeting those patients most at risk.

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2. Methods

Patients undergoing orthopaedic procedures from 2005–2013 were identified in the ACS-NSQIP database using a Current Procedural Terminology (CPT) code search. Among these patients, a second CPT code search using only orthopaedic trauma “hip/pelvis” and “lower extremity (LE)” injury CPT codes was conducted to identify patients undergoing pelvis and LE orthopaedic trauma procedures. A similar CPT code search of total joint procedures established patients undergoing primary and revision total hip arthroplasty and primary and revision total knee arthroplasty. We chose to focus on lower extremity surgeries because they have previously been documented to have a higher incidence of DVT.⁷ Additionally, and more specifically, lower extremity and hip/pelvis orthopaedic trauma patients have also been documented to have a higher incidence of DVT than upper extremity orthopaedic trauma patients.⁸ Therefore we believe these patients would be most in need of new prophylaxis guidelines.

The development of a deep vein thrombosis (DVT) within 30-days following surgery was recorded for each patient. Patients with missing data were not included in the analysis. The ACS-NSQIP database we used encompasses over 300 variables including preoperative risk factors, intraoperative variable, and 30-day postoperative mortality and morbidity outcomes. After a careful literature review, we selected variables we believe to be most relevant to the development of DVT.^{9–15} Patient demographics (ASA Class, body mass index [BMI], sex, alcohol use, functional status and smoking status), preoperative comorbidities (ascites, bleeding disorder, ventilator use, diabetes, disseminated cancer, dyspnea, history of congestive heart failure [CHF], history of chronic obstructive pulmonary disorder [COPD], history of myocardial infarction [MI], dialysis, renal failure, use of steroids, preoperative sepsis, pneumonia, hypertension requiring medication, bleeding disorder, radiotherapy, peripheral vascular disease,

and weight loss in the last 6 months), as well as operative characteristics (surgical duration, type of surgery for total joint patients, prior operation in last 30 days) were collected for each patient. Bivariate analyses using the chi-squared test and Wilcoxon-Mann-Whitney test were performed to compare risk factors between those who developed a DVT and those who did not for both the orthopaedic trauma and total joint cohorts. Statistical significance was set at $\alpha=0.05$.

A multivariate logistic regression was then conducted to determine the predictive risk factors for DVT development in orthopaedic trauma and in total joint patients.

3. Results

A total of 195,251 patients who underwent orthopaedic procedures were identified from 2005–2013 in the ACS-NSQIP database. Of these patients, 44,594 (22.8%) were orthopaedic trauma patients with pelvis and/or LE injuries and 150,657 (77.2%) were orthopaedic total joint patients. Of the total joint patients, 84,659 (56.2%) patients underwent primary total knee arthroplasty (TKA), 53,290 (35.4%) total hip arthroplasty (THA) and the remaining 12,708 patients (8.4%) underwent revision surgery.

As shown in Table 1, the incidence of DVT within 30 postoperative days for the total joint population [0.8% (n = 1186)] and for the orthopaedic trauma population [0.98% (N = 437)] did not significantly differ between the two groups ($p=0.57$). For orthopaedic trauma patients, those who developed a DVT within 30-days following surgery had a significantly higher median age than those who did not: 80.0 (IQR: 69.0–87.0) years versus 77.0 (IQR: 59.0–86.0) years respectively ($p<0.01$). A greater BMI ($p=0.017$) and Caucasian race ($p<0.01$) was also significantly associated with a higher rate of DVT development for orthopaedic trauma patients. Total joint patients who developed a DVT were also significantly older ($p<0.01$), had a greater median BMI

Table 1
Selected demographics for DVT for Trauma vs. Total Joint Patients.

Characteristic	Orthopaedic Trauma (n = 44,594)		p	Total Joint (n = 150,657)		p
	DVT (n = 437, 0.98%)	No DVT (n = 44157, 99.0%)		DVT (n = 1186, 0.80%)	NO DVT (n = 149471, 99.2%)	
Age (median, IQR)	80.0 (69.0–87.0)	77.0 (59.0–86.0)	<0.01	66.0 (59.0–74.0)	68.0 (60.0–76.0)	<0.01
Gender (n,%)			0.260			0.310
Male	141 (32.3%)	15429 (35.0%)		493 (41.57%)	60098 (40.2%)	
Female	296 (67.7%)	28699 (65.0%)		687 (57.9%)	89134 (59.6%)	
Race (n,%)			<0.01			<0.01
White	356 (81.5%)	32286 (73.1%)		914 (77.1%)	120265 (80.5%)	
Black	24 (5.5%)	2316 (5.2%)		113 (9.5%)	9819 (6.6%)	
Other	57 (13.0%)	9555 (21.6%)		159 (13.4%)	19387 (13.0%)	
Functional Status			<0.01			<0.01
Independent	310 (70.9%)	33491 (75.8%)		1133 (95.5%)	144062 (96.4%)	
Partially dependent	96 (22.0%)	8498 (19.2%)		38 (3.20%)	4340 (2.90%)	
Dependent	28 (6.4%)	1761 (4.0%)		7 (0.60%)	262 (0.2%)	
Unknown	3 (0.70%)	407 (0.92%)				
BMI (median, IQR)	25.2 (21.5–29.2)	24.7 (20.6–29.2)	0.017	31.2 (27.4–35.8)	30.6 (26.6–35.5)	<0.01
Smoke (n,%)	57 (13.0%)	7318 (16.0%)	0.056	115 (9.70%)	15922 (10.7%)	0.310
Alcohol use (n,%)	7 (1.6%)	751 (1.7%)	0.999	8 (0.70%)	1369 (0.92%)	0.320
ASA score (n,%)			<0.01			<0.01
1	14 (3.2%)	3074 (7.0%)		21 (1.77%)	4274 (2.86%)	
2	88 (20.1%)	12138 (27.5%)		540 (45.5%)	76949 (51.5%)	
3	242 (55.4%)	22775 (51.6%)		588 (49.6%)	65065 (43.5%)	
4	93 (21.3%)	6170 (14.0%)		34 (2.87%)	3013 (2.02%)	
5	0 (0.0%)	0 (0.0%)		0 (0.0%)	9 (0.01%)	

Bold values are significant ($p < 0.05$).

($p=0.01$), and were Caucasian ($p<0.01$). Additionally, higher ASA scores for both orthopaedic trauma ($p<0.01$) and total joint patients ($p=0.018$) were significantly associated with an increased risk of DVT development.

As shown in Table 2, the incidence of DVT significantly differed based on preoperative comorbidities and operative characteristics. For the trauma cohort, the rate of DVT was significantly higher if the patient had ascites ($p<0.01$), a history of dyspnea ($p=0.034$), a history of hypertension requiring medication ($p<0.01$), preoperative renal failure ($p<0.01$), preoperative steroid use ($p=0.048$), a bleeding disorder ($p=0.05$), or had preoperative sepsis ($p=0.01$). Previous operations in the past 30 days ($p<0.01$) and use of a ventilator ($p<0.01$) also increased the rate of DVT in trauma patients. For the total joint cohort, a history of dyspnea ($p=0.020$), ascites ($p=0.045$), a history of hypertension requiring medication ($p=0.01$), bleeding disorders ($p=0.01$), and preoperative sepsis ($p<0.01$) presented with a higher rate of DVT 30-days post-operation.

After controlling for all individual patient factors, the risk factors associated with DVT development differed between total joint and orthopaedic trauma patients as demonstrated in Table 3. Age was found to be a significant risk factor for DVT for orthopaedic trauma patients (OR: 1.02, 95% CI: 1.00–1.03, $p=0.01$) whereas it was not a significant risk factor for total joint patients ($p=0.083$). Unlike a total joint patient, a trauma patient with ascites was 5.14 times (95% CI: 1.04–35.4, $p=0.04$) more likely to develop a DVT. Steroid use was also found to be a significant predictor of DVT in trauma patients but not in total joint patients. A history of peripheral vascular disease was associated with a significant 3.30 increased risk of DVT for total joint patients (95% CI: 1.13–9.55, $p=0.03$) whereas it was not shown to be a risk factor for trauma patients. Dyspnea at rest increased the risk of DVT by 4.25 times (95% CI: 1.05–17.2, $p=0.043$) and renal failure increased the risk by 12.3 times (95% CI: 1.4–107.4, $p=0.024$) for total joint patients. For trauma patients, renal failure was shown to increase the risk of DVT by 2.46 times and was not found to be significant ($p=0.12$). Additionally, an operation in the 30-days prior to surgery was found to be a significant risk factor for both cohorts, increasing the

risk of DVT by 5.23 times (95% CI: 1.83–15.0, $p=0.002$) for total joint patients and 3.93 times (95% CI: 2.10–7.33, $p<0.01$) for trauma patients.

4. Discussion

Our study, based on multicenter prospective data of over 195,000 patients, is the first to compare the incidence and risk factors for DVT in orthopaedic trauma and total joint populations. The incidence for DVT in the first 30 days after surgery for trauma and joint patients was comparable, measuring 0.98% and 0.8% respectively. Nonetheless, risk factors for DVT differed between the groups in several important categories. Increased age, steroid use and preoperative ascites were independent risk factors for DVT in the trauma group but did not significantly influence outcomes in the total joint group. Likewise, patient comorbidities such as dyspnea at rest, renal failure and peripheral vascular disease increased the incidence of thromboembolic events in total joint patients but did not play a significant role in the trauma patient cohort.

DVT after surgery is costly from both a social and economic standpoint. DVT increases length of hospital stay, medical costs and overall mortality.^{16,17} For these reasons, much attention has been paid to developing strategies to prevent thromboembolic events. Perhaps the greatest strides in forming standardized guidelines for chemoprophylaxis have come in the area of total joint arthroplasty.¹⁸ Guidelines from the American Academy of Orthopaedic Surgeons (AAOS) and the American College of Chest Physicians (ACCP) have led to lower incidence of clinically significant DVTs in joint replacement patients.^{19,20} This success has led many to apply these recommendations to orthopaedic patients as a whole. Our results suggest that risk factors for DVT in total joint patients differ from those of trauma patients.

The use of chemoprophylaxis in the setting of multi-injured trauma patients is not without dangers and limitations. Chemical DVT prophylaxis may be contraindicated in patients with brain or spinal cord injury over concern for hemorrhage. Patients requiring multiple successive procedures or those who are coagulopathic

Table 2
Preoperative Comorbidities and Operative Characteristics for DVT for Trauma vs. Total Joint Patients.

Characteristic	Orthopaedic Trauma (n = 44,594)			Total Joint (n = 150,657)		
	DVT (n = 437, 0.98%)	No DVT (n = 44157, 99.0%)	p	DVT (n = 1186, 0.80%)	NO DVT (n = 149,471, 99.2%)	p
Ascites	6 (1.4%)	95 (0.22%)	<0.01	2 (0.20%)	41 (0.03%)	0.045
Diabetes (Insulin dependent)	41 (9.4%)	3484 (8.0%)	0.200	52 (4.40%)	5733 (3.84%)	0.360
Dyspnea at rest	10 (2.3%)	505 (1.1%)	0.034	5 (0.42%)	414 (0.28%)	0.020
Ventilator	5 (6.8%)	73 (0.98%)	<0.01	0 (0.0%)	16 (0.01%)	0.999
Hx COPD	41 (9.4%)	3965 (9.0%)	0.834	55 (4.64%)	5958 (3.99%)	0.290
Hx CHF	13 (3.0%)	1135 (2.6%)	0.704	6 (0.50%)	468 (0.30%)	0.360
Hypertension	298 (68.2%)	25525 (57.8%)	<0.01	797 (67.2%)	94017 (62.90%)	<0.01
Hx MI	3 (0.70%)	192 (0.43%)	0.640	2 (0.20%)	55 (0.04%)	0.150
Pneumonia	2 (0.50%)	115 (0.26%)	0.720	0 (0.0%)	18 (0.01%)	0.999
Disseminated cancer	22 (5.0%)	1111 (2.5%)	0.305	4 (0.34%)	347 (0.23%)	0.660
Steroid use	35 (8.0%)	2017 (4.6%)	<0.01	52 (4.38%)	5148 (3.44%)	0.090
Bleeding disorder	69 (15.8%)	5546 (12.6%)	0.050	54 (4.60%)	4518 (3.02%)	<0.01
Dialysis dependent	11 (2.5%)	828 (1.9%)	0.420	3 (0.25%)	337 (0.23%)	0.999
Renal Failure	9 (2.1%)	260 (0.59%)	<0.01	2 (0.20%)	80 (0.05%)	0.290
Receiving radiotherapy	4 (0.92%)	92 (0.21%)	<0.01	0 (0.0%)	31 (0.02%)	0.999
Peripheral Vascular disease	3 (0.70%)	564 (1.3%)	0.400	6 (0.51%)	312 (0.21%)	0.090
Preoperative sepsis	11 (2.5%)	556 (1.3%)	<0.01	9 (0.76%)	261 (0.17%)	<0.01
Weight loss in last 6 months	10 (2.3%)	510 (1.2%)	0.048	3 (0.25%)	389 (0.26%)	0.999
Operative characteristics						
Prior Operation within 30 days	14 (3.2%)	429 (0.97%)	<0.01	7 (0.59%)	306 (0.20%)	0.018
Operative time minutes (median, IQR)	73.0 (49.0–108.0)	65.0 (44.0–95.0)	<0.01	93 (72–120)	90 (71–117)	0.010

Bold values are significant ($p<0.05$).

Table 3

Comparison of risk factors for DVT between Trauma vs. Total Joints.

Risk factor	Orthopaedic trauma (n = 22,361)			Total Joint		
	Odds ratio	95% confidence interval	p	Odds ratio	95% confidence interval	p
Patient Demographics						
Age	1.02	1.00–1.03	<0.01	1.02	1.00–1.03	0.083
Gender						
Female	Reference	–	–	Reference	–	–
Male	1.11	0.76–1.63	0.580	0.93	0.66–1.31	0.669
Race						
White	Reference	–	–	Reference	–	–
Black	0.85	0.43–1.67	0.630	1.56	0.93–2.62	0.095
Functional Status						
Independent	Reference	–	–	Reference	–	–
Dependent	1.39	0.74–2.63	0.305	0.50	0.02–12.00	0.675
BMI	1.01	0.99–1.03	0.425	1.00	0.98–1.02	0.950
Smoke	0.96	0.56–1.64	0.872	1.03	0.58–1.82	0.930
Alcohol	1.54	0.69–3.48	0.294	1.51	0.60–3.79	0.380
ASA score						
1	Reference	–	–	Reference	–	–
2	1.60	0.47–5.50	0.454	1.19	0.28–4.97	0.820
3	1.54	0.43–5.54	0.505	1.57	0.37–6.72	0.540
4	1.46	0.37–5.73	0.585	1.94	0.34–11.00	0.450
Preoperative Comorbidities						
Ascites	5.14	1.04–25.40	0.044	0.00	–	0.978
Diabetes (Insulin dependent)	1.27	0.72–2.23	0.410	1.18	0.56–2.45	0.666
Dyspnea at rest	1.67	0.60–4.63	0.324	4.25	1.05–17.23	0.043
Ventilator	3.34	0.36–30.70	0.286	0.00	–	0.936
Hx COPD	0.62	0.32–1.22	0.165	0.53	0.20–1.40	0.200
Hx CHF	0.98	0.34–2.80	0.963	0.77	0.03–17.70	0.870
Hypertension	1.17	0.77–1.77	0.465	1.01	0.69–1.49	0.940
Hx MI	1.92	0.61–6.03	0.750	3.68	0.37–36.80	0.270
Pneumonia	0.97	0.21–4.50	0.970	0.00	–	0.934
Disseminated cancer	1.70	0.63–4.60	0.293	0.00	–	0.890
Steroid use	2.00	1.07–3.75	0.031	1.35	0.57–3.18	0.420
Bleeding disorder	1.03	0.62–1.73	0.902	1.14	0.51–2.56	0.755
Dialysis dependent	1.04	0.35–3.12	0.950	0.00	–	0.890
Renal Failure	2.46	0.80–7.54	0.117	12.25	1.40–107.4	0.024
Receiving radiotherapy	1.18	0.22–6.24	0.845	0.00	–	0.932
Peripheral Vascular disease	0.40	0.12–1.33	0.134	3.29	1.13–9.55	0.029
Preoperative sepsis	2.24	0.93–5.40	0.073	0.00	–	0.909
Weight loss in last 6 months	1.98	0.68–5.75	0.209	2.92	0.61–13.96	0.180
Operative Characteristics						
Prior Operation within 30 days	3.93	2.10–7.33	<0.01	5.23	1.83–14.97	0.002
Operative time minutes	1.00	1.00–1.01	0.065	1.01	1.00–1.01	<0.01

Bold values are significant ($p < 0.05$).

may not benefit from the use of chemical prophylaxis in the acute setting. Mechanical prophylaxis may be impractical in patients with lower extremity injuries. Thus, any generalized guideline for DVT prophylaxis must take into account the complexities associated with caring for trauma patients. The system of bundled payments must also take into account these difficulties when assessing adverse events and financial compensation.

Our study has several limitations. First, we were constrained by the data points recorded in the NSQIP database. Other risk factors, not recorded by investigators, may play a role in the development of DVT, thus confounding our results. Second, use of large databases relies on accurate CPT coding and data entry. Inaccuracies in data entry will confound results. Perhaps most significant to our study is the lack of standardization in DVT prophylaxis across institutions and surgeons involved in NSQIP. Treatments range from mechanical prophylaxis to varying chemical prophylaxis including antithrombin agents, anti-platelets and factor X inhibitors. Currently, the optimal DVT prophylaxis strategy is still

unknown.^{21,22} The effect of differing prophylaxis regimens could have influenced our results. Additionally, NSQIP data does not distinguish between isolated and multi-extremity injuries. Therefore it was not possible to separate polytrauma patients from the cohort. A high injury severity score (ISS) has been found to be an independent risk factor for VTE, including DVTs.²³ In our study, ascites was an independent risk factor for DVT in the trauma patient cohort. This may be a surrogate for patients with a high ISS, developing traumatic ascites after massive fluid resuscitation.²⁴

DVT prophylactic guidelines have been successful at reducing thromboembolic events in arthroplasty patients. One must use caution when attempting to apply such recommendations to orthopaedic trauma patients. The findings of our study indicate that risk factors for DVT in trauma patients differ from those of the joint patient population. Further research is needed to elucidate which subset of trauma patients are most at risk for a thromboembolic event and will benefit from chemical and mechanical prophylaxis.

Conflict of Interest Statement

Author William Obremsky has previously consulted for biometrics; done expert testimony in legal matters, has a grant from the Department of Defense, and has been a Board Member of the OTA and SEFC. For the remaining authors, no conflicts of interest are declared.

Ethical Review Committee Statement

This study was performed in accordance with the relevant regulations of the US Health Insurance Portability and Accountability Act (HIPPA) and the ethical standards of the 1964 Declaration of Helsinki. The protocol was approved by the Vanderbilt Institution Review Board.

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