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Venous thromboembolism rates remained unchanged in operative lower extremity orthopaedic trauma patients from 2008 to 2016

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ABSTRACT

Background: Venous thromboembolism (VTE) is a serious complication that contributes to morbidity, mortality, and healthcare costs during the surgical care of patient with lower extremity fractures. Despite this, few recommendations on the topic exist and the literature on VTE incidence is incomplete. Therefore, this study will attempt to estimate annual incidence and trends in 30-day thrombotic events and mortality for the following fractures: (1) hip, (2) femur, (3) patella, (4) tibia and/or fibula, and (5) ankle.
Methods: We identified 120,521 operative lower extremity orthopaedic trauma patients from 2008 to 2016 using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database. To evaluate the relationship between the year in which surgery was performed and comorbidities and demographic information bivariate analysis was performed. Bivariate analysis was also performed for the outcomes of interest and year in which the surgery was performed to assess for change. Additionally, bimodal multivariate logistic regression models for hip, femur, and ankle fractures were built, comparing the years 2009 to 2016 using 2008 as a baseline.
Results: Overall incidence for VTE over the study period was 1.7% for hip fractures, 2.4% for femur fractures, 0.9% for patella fractures, 1.1% in tibia and/or fibula fractures, and 0.6% in ankle fractures. Over the study period VTE incidence saw a significant decrease ($p < 0.05$) in hip and femur fractures, but not for patella, tibia and/or fibula, and ankle fractures. After adjusting for confounding factors with multivariate analysis, the change in hip and femur fractures was no longer significant, while no significant decrease was again found for ankle fractures ($p > 0.05$).
Conclusion: Our study demonstrates that VTE rates have remained unchanged in operative lower extremity orthopaedic trauma from 2008 to 2016. This highlights the need for higher quality evidence on this important topic in orthopaedic trauma, including a reevaluation on the necessity of thromboprophylaxis guidelines.
Level of Evidence: III.

Introduction

Venous thromboembolism (VTE) is a serious complication that occurs in 1.6%–21% of lower extremity orthopaedic trauma patients [1–4]. This complication can be devastating as illustrated by a 29.4% morality rate in hip fractures within 30 days of a VTE event, which is substantially greater than the 11% mortality rate in the general population [5]. This complication is also expensive, with an orthopaedic-related VTE costing US$5000 after 3 months, US$10,000 after 6 months, and US$33,000 after 1 year [6]. Due to the high incidence, associated mortality, and cost, attention is being put towards reducing the incidence of VTE in orthopaedic trauma.

Using risk factors to identify patients that may be at an increased risk for VTE may aid with prevention, diagnosis, and treatment of this complication. Numerous risk factors for VTE in the setting of orthopaedic trauma have been identified, including: comorbidities, advanced age, cancer, prolonged immobilization, longer operative times, Glasgow Coma Scale, polytrauma, obesity, and hormone treatment [4,7–9]. Risk scoring and assessment tools have been developed, including the Wells Score and Carpini model and been used effectively in other fields, however their relevance in orthopaedics trauma is limited, with only one article in existence to the best of the authors knowledgel [10–15].

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Specifically, the study supported the use of preoperative screening for DVTs in hip fractures with a Caprini score ≥12 and a Well's score of 0–1 indicted a low risk for preoperative DVT, allowing surgery to be performed without screening.

Several guidelines exist for thromboprophylaxis in hip fracture surgery including the United States guidelines from American College of Chest Physicians (ACCP) [16–20]. In hip fractures the ACCP recommends the "use of one of the following rather than no antithrombotic prophylaxis for a minimum of 10 to 14 days: low molecular weight heparin (LMWH), fondaparinux, low-dose unfractionated heparin, adjusted-dose vitamin-K antagonist, aspirin" (all grade 1B recommendations) "or intermittent pneumatic compression device (IPCD) (grade 1C)" [17]. Notably, the IPCD should only be used if it is capable of recording and reporting wear times, with 18 h of compliance needed a day.

While the ACCP recommends no routine thromboprophylaxis for isolated lower leg injuries treated with immobilization, to the best of the authors' knowledge, no national guidelines for the operative treatment of lower extremity orthopaedic trauma thromboprophylaxis other than for hip fractures exist. However the Orthopaedic Trauma Association did conduct survey of orthopedic trauma surgeons found a wide variety of screening and prophylaxis methods and an expert panel concurred with the recommendation of the ACCP that isolated lower extremity injuries treated with immobilization do not warrant routine chemoprophylaxis [21].A recent review article regarding thromboprophylaxis in orthopedics further emphasized these recommendations, while noting that in some isolated trauma patients treated with immobilization chemoprophylaxis is indicated as the risk of VTE outweighs that of bleeding [22]. Despite the recommendations against thromboprophylaxis numerous studies have looked at the effect of prophylaxis in lower extremity orthopaedic trauma [23–26]. Regardless of the recommendation, a survey of foot and ankle surgeons found that 98% use prophylaxis in high-risk foot and ankle fracture patients [9].

Although there are estimates in the literature regarding VTE incidence in operative lower extremity trauma, these estimates are largely outdated and have not been performed on a national scale. As a result, our study endeavored to identify annual incidence and trends of 1) VTE, 2) DVT, 3) PE, and 4) mortality rates, following operative treatment of hip, femur, patella, tibia and/or fibula, and ankle fractures in the United States.

Methods

Database

To perform our study we used the American College of Surgeons (ACS) National Improvement Quality Improvement Program (NSQIP) database. Over 600 institutions provide data on over 250 variables including intraoperative metrics, preoperative risk factors, and 30-day postoperative mortality and morbidity outcomes for major surgeries in the 2016 version [27,28]. The database has been used for a number of studies in orthopaedic trauma [29–31].

Study population

Operative lower extremity fracture patients from January 1st, 2008 to December 31st, 2016 were identified using International Classification of Diseases (ICD) 9 and 10 codes. Hip fractures including femoral neck, intertrochanteric, and subtrochanteric fractures were identified using any iteration of ICD-9 codes 820 and any iteration of ICD-10 codes S72.0-S72.2. Femurs fractures excluding hip fractures and including distal femur and femoral shaft fractures were identified using any iteration of ICD-9 codes 821.01, 821.11, 821.2, and 821.3 and any iteration of ICD-10 codes S72.3 and S72.4. Patella fractures were identified using any iteration of ICD-9 codes 822 and any iteration of ICD-10 codes S82.0. Tibia and/or fibula fractures including proximal tibial fractures, tibial shaft fractures, distal tibial fractures, and fibular shaft fractures were identified using any iteration of ICD-9 codes 823 and any iteration of ICD-10 codes S82.1-S82.4. Ankle fractures including medial and lateral malleolar fractures, pilon fractures, bimalleolar fractures, trimalleolar were identified using any iteration of ICD-9 codes 824 and any iteration of ICD-10 codes S82.5, S82.6, and S82.8. Cohort sizes by year for each of the different fracture groups are located in Table 1.

Measured outcomes

VTE, DVT, PE, and mortality at 30-days were the post-operative outcomes for this study. The NSQIP database defines DVTs as a new diagnosis of a blood clot or thrombus within the superficial or deep venous system which has been confirmed by duplex, venogram, or computed tomography (CT) scan [27]. PEs is defined as a new diagnosis of a blood clot in a pulmonary artery causing partial or complete obstruction of the lung vasculature with positive imaging (CT, CT angiogram, V-Q scan, or any other definitive imaging modality) by the NSQIP database. To determine the incidence of VTE in a given patient, any occurrence of DVT and/or PE was defined as a VTE occurrence.

Data analysis

For each fracture type, the annual incidence for 30-day VTEs, DVTs, PEs, and mortality were calculated for 2008 to 2016. For each outcome of interest, bivariate analysis was performed for the year of surgery with Pearson's chi-squared tests. Furthermore, bivariate analyses were performed to evaluate any associations between the year of fracture and patient demographics and comorbidities. One-way analysis of variance (ANOVA) tests were performed for continuous variables, while Pearson's Chi-squared tests, Fisher's exact tests, or Monte Carlo tests were utilized for categorical variables (Table 2).

Patient demographic and comorbidity variables that were significantly different on bivariate analysis across the study period

Table 1
Number of Cases per Year by Procedure.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Hip Fx	806	1,520	2,115	5,101	7,742	10,322	13,039	19,332	21,941	81,918
Femur Fx	77	152	248	363	485	726	867	1,163	1,364	5,445
Patella Fx	52	96	133	194	240	364	411	585	748	2,823
Tib-Fib Fx	158	250	403	490	700	976	1,217	1,806	2,301	8,301
Ankle Fx	437	709	1,061	1,369	2,033	2,758	3,579	4,537	5,540	22,023

Table 2
Demographics in Hip, Femur, Patella, Tib-Fib, and Ankle Fxs.

Demographic	Hip Fx (n = 81,918)	Femur Fx (n = 5,448)	Patella Fx (n = 2,825)	Tib-Fib Fx (n = 8,301)	Ankle Fx (22,029)
Age mean ± SD	76.80 ± 10.83	67.94 ± 16.47	58.73 ± 16.75	49.37 ± 17.48	49.63 ± 17.64
BMI	24.84 ± 5.73	29.57 ± 8.46	27.99 ± 6.44	29.28 ± 7.24	30.63 ± 7.25
Sex - Female	57,287 (69.9%)	4,008 (73.6%)	1,952 (69.1%)	4,044 (48.7%)	12,716 (57.7%)
Anesthesia					
General	19,103 (23.3%)	675 (12.4%)	304 (10.8%)	666 (8.0%)	1,917 (8.7%)
Spinal	58,750 (71.7%)	4,622 (84.9%)	2,406 (85.2%)	7,472 (90.0%)	19,357 (87.9%)
Other	4,061 (5.0%)	150 (2.8%)	115 (4.1%)	164 (2.0%)	753 (3.4%)
Diabetes					
Insulin Dependent	6,133 (7.5%)	635 (11.7%)	218 (7.7%)	544 (6.6%)	1,179 (5.4%)
Non-Insulin dependent	8,490 (10.4%)	611 (11.2%)	272 (9.6%)	470 (5.7%)	1,441 (6.5%)
Non-diabetic	67,310 (82.2%)	4,202 (77.1%)	2,335 (82.7%)	7,291 (87.8%)	19,408 (88.1%)
Smoker	9,948 (12.1%)	795 (14.6%)	508 (18.0%)	2,342 (28.2%)	5,606 (25.4%)
Functional Status					
Independent	61,907 (75.6%)	4,253 (78.1%)	2,642 (93.5%)	7,735 (93.1%)	20,824 (94.5%)
Partially Dependent	16,019 (19.6%)	891 (16.4%)	142 (5.0%)	455 (5.5%)	891 (4.0%)
Totally Dependent	3,194 (3.9%)	247 (4.5%)	8 (0.3%)	44 (0.5%)	68 (0.3%)
Unknown	813 (1.0%)	57 (1.0%)	33 (1.2%)	71 (0.9%)	245 (1.1%)
Hx of COPD	9,207 (11.2%)	489 (9.0%)	98 (3.5%)	316 (3.8%)	764 (3.5%)
Hx of CHF	2,943 (3.6%)	178 (3.3%)	17 (0.6%)	55 (0.7%)	145 (0.7%)
Dialysis	1,581 (1.9%)	127 (2.3%)	29 (1.0%)	85 (1.0%)	157 (0.7%)
Disseminated Cancer	1,279 (1.6%)	94 (1.7%)	5 (0.2%)	19 (0.2%)	54 (0.2%)
Wound Infection	3,754 (4.6%)	347 (6.4%)	66 (2.3%)	527 (6.3%)	806 (3.7%)
Use of Corticosteroids	4,205 (5.1%)	299 (5.5%)	66 (2.3%)	201 (2.4%)	381 (1.7%)
Weight Loss	1,134 (1.4%)	42 (0.8%)	4 (0.1%)	13 (0.2%)	23 (0.1%)
ASA Classification					
1 to 2	15,709 (19.2%)	1,381 (25.4%)	1,846 (65.4%)	5,762 (69.4%)	15,770 (71.7%)
3 to 5	66,092 (80.8%)	4,064 (74.6%)	975 (34.6%)	2,536 (30.6%)	6,224 (28.3%)

were used to build separate bimodal multivariate logistic regression models for each fracture type with greater than 100 VTEs over the study period. This limited the regressions to being performed on hip fractures, femurs fractures, and ankle fractures. Odds ratios (OR) were calculated using these regressions models to evaluate each individual year as a risk factor for the complications of interest compared to 2008, the earliest year included in our study. Statistical significance was maintained at a α value of less than 0.05. All data analysis was performed with IBM SPSS Statistics 23 for Mac (IBM Corporation, Armonk, NY).

Results

Hip fractures

In hip fractures, the VTE rate was 1.7% over the duration of the study and remained between 1.3% and 2.4% with significant changes (p = 0.029) (Table 3). The overall DVT incidence was 1.1% and ranged from 0.9% to 1.6%, with no significant change (p = 0.301). Overall, PE incidence was 0.7% and was between 0.5% and 1.0% without significant change (p = 0.220). Multivariate

Table 3
Incidence of VTE and Mortality in THAs and TKAs.

Procedure	Outcome	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total	P value
Hip Fx	VTE	17 (2.1%)	37 (2.4%)	33 (1.6%)	66 (1.3%)	127 (1.6%)	155 (1.5%)	245 (1.9%)	326 (1.7%)	350 (1.6%)	1,356 (1.7%)	**0.029**
(n = 81,918)	DVT	10 (1.2%)	24 (1.6%)	23 (1.1%)	44 (0.9%)	81 (1.0%)	101 (1.0%)	157 (1.2%)	211 (1.1%)	226 (1.0%)	877 (1.1%)	0.301
	PE	7 (0.9%)	15 (1.0%)	15 (0.7%)	25 (0.5%)	53 (0.7%)	59 (0.6%)	103 (0.8%)	141 (0.7%)	140 (0.6%)	558 (0.7%)	0.220
	Mortality	37 (4.6%)	84 (5.5%)	140 (6.6%)	307 (6.0%)	421 (5.4%)	520 (5.0%)	698 (5.4%)	1,069 (5.5%)	1,130 (5.2%)	4,406 (5.4%)	**0.033**
Femur Fx	VTE	6 (7.8%)	3 (2.0%)	13 (5.2%)	11 (3.0%)	9 (1.9%)	16 (2.2%)	25 (2.9%)	22 (1.9%)	25 (1.8%)	130 (2.4%)	**0.003**
(n = 5,448)	DVT	7 (7.8%)	4 (2.0%)	8 (3.2%)	6 (1.6%)	6 (1.2%)	11 (1.5%)	16 (1.8%)	11 (0.9%)	15 (1.1%)	82 (1.5%)	**<0.001**
	PE	0 (0.0%)	0 (0.0%)	6 (2.4%)	6 (1.6%)	5 (1.0%)	5 (0.7%)	14 (1.6%)	12 (1.0%)	11 (0.8%)	59 (1.1%)	0.201 (0.190-0.211)**
	Mortality	1 (1.3%)	6 (3.9%)	9 (3.6%)	9 (2.5%)	15 (3.1%)	23 (3.2%)	22 (2.5)	54 (4.6%)	48 (3.5%)	187 (3.4%)	0.279
Patella Fx	VTE	0 (0.0%)	0 (0.0%)	2 (1.5%)	5 (2.6%)	4 (1.7%)	3 (0.8%)	3 (0.7%)	5 (0.9%)	4 (0.5%)	26 (0.9%)	0.279*
(n = 2,825)	DVT	0 (0.0%)	0 (0.0%)	1 (0.7%)	3 (1.5%)	2 (0.8%)	1 (0.3%)	2 (0.5%)	5 (0.9%)	4 (0.5%)	18 (0.6%)	0.763*
	PE	0 (0.0%)	0 (0.0%)	2 (1.5%)	3 (1.5%)	2 (0.8%)	2 (0.5%)	1 (0.2%)	1 (0.2%)	0 (0.0%)	11 (0.4%)	**0.016***
	Mortality	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.5%)	0 (0.0%)	1 (0.3%)	0 (0.0%)	4 (0.7%)	4 (0.5%)	10 (0.4%)	0.741*
Tib-Fib Fx	VTE	2 (1.3%)	4 (1.6%)	7 (1.7%)	4 (0.8%)	11 (1.6%)	11 (1.1%)	6 (0.5%)	20 (1.1%)	29 (1.3%)	94 (1.1%)	0.414
(n = 8,301)	DVT	2 (1.3%)	4 (1.6%)	4 (1.0%)	4 (0.8%)	9 (1.3%)	5 (0.5%)	5 (0.4%)	10 (0.6%)	19 (0.8%)	62 (0.7%)	0.186 (0.176-0.196)**
	PE	0 (0.0%)	0 (0.0%)	3 (0.7%)	0 (0.0%)	3 (0.4%)	7 (0.7%)	1 (0.1%)	11 (0.6%)	12 (0.5%)	37 (0.4%)	0.149*
	Mortality	1 (0.6%)	0 (0.0%)	1 (0.2%)	4 (0.8%)	2 (0.3%)	1 (0.1%)	4 (0.3%)	5 (0.3%)	10 (0.4%)	28 (0.3%)	0.496*
Ankle Fx	VTE	2 (0.5%)	10 (1.4%)	7 (0.7%)	9 (0.7%)	9 (0.4%)	19 (0.7%)	23 (0.6%)	27 (0.6%)	32 (0.6%)	138 (0.6%)	0.359
(n = 22,029)	DVT	2 (0.5%)	4 (0.6%)	5 (0.5%)	6 (0.4%)	5 (0.2%)	12 (0.4%)	14 (0.4%)	15 (0.3%)	15 (0.3%)	78 (0.4%)	0.716*
	PE	0 (0.0%)	6 (0.8%)	2 (0.2%)	5 (0.4%)	6 (0.3%)	9 (0.3%)	9 (0.3%)	14 (0.3%)	19 (0.3%)	70 (0.3%)	0.504 (0.491-0.517)**
	Mortality	0 (0.0%)	2 (0.3%)	1 (0.1%)	2 (0.1%)	7 (0.3%)	3 (0.1%)	12 (0.3%)	10 (0.2%)	13 (0.2%)	50 (0.2%)	0.598*

* = Fisher's exact test, ** = Monte Carlo Fisher's exact test (99% Confidence Interval).

regression analyses found no significant association between year of surgery with DVT, PE, or VTE incidence ($p > 0.05$). Mortality incidence over the length of the study was 5.4%. Mortality rates ranged between a low of 4.2% in 2008 to high of 6.6% in 2010 ($p = 0.032$). After multivariate analysis, there was a 51% increase in mortality rates in 2016 ($p = 0.018$) when compared to 2008. Additionally, years 2010 to 2015 also saw increases in mortality when compared to 2008 ($p > 0.05$) (Table 4). Tracked incidence for the study period can be seen in Fig. 1. Overall incidence by injury location is depicted in Fig. 2.

Femur fractures

For femur fracture, the overall VTE incidence was 2.4%. The highest VTE incidence was in 2008 (7.8%) and the lowest VTE incidence was in 2016 (2.5%) and changes between these years were significant ($p = 0.003$). Over the study period, the overall DVT rate was 1.5% and ranged between 7.8% in 2008 and 0.9% in 2015 ($p > 0.001$). The incidence of PE from 2008 to 2016 was 1.1%. The PE incidence ranged between 0.0% in 2008 and 2009 to 2.4% in 2010, without significant change over the study period ($p = 0.201$). Overall all-cause mortality rate was 3.4% and ranged between a low of 1.3% in 2008 and 4.6% in 2015 without significant change ($p = 0.279$). No significant association between year of surgery and VTE, DVT, PE, and mortality rates was determined on multivariate analysis ($p > 0.05$).

Patella fractures

The overall VTE rate in Patella fractures was 0.9% with a low in 2008 and 2009 of 0.0% to a high in 2010 of 2.6%; however this change was not significant ($p = 0.279$). The DVT rate over the study was 0.6% and fell between 0.0% and 1.5%, without significant change ($p = 0.763$). Overall PE incidence was 0.4%. The incidence ranged between a low of 0.0% in 2008, 2009, and 2016 to a high of 1.5% in 2010 and 2011, with significant change ($p = 0.016$). Overall all-cause mortality incidence was 0.4%. Mortality rates ranged between 0.0% and 0.7%% without significant change ($p = 0.741$).

Tibia and/or fibula fractures

The overall VTE incidence was 1.1% in tibia and/or fibula fractures. VTE incidence ranged from 0.5% in 2014 to 1.7% in 2010, with no significant change over the study period ($p = 0.414$). Overall DVT rate was 0.7%. DVTs incidence ranged between 0.4% in 2014 and 1.6 in 2009, with no significant change ($p = 0.186$). Overall, PE rate was 0.4%. Yearly PE incidence was between a low of 0.0% in 2008, 2009, and 2011 to 0.7% in 2010 and 2013with no significant change from 2008 to 2016 ($p = 0.149$). The all-cause mortality rate was 0.3% and ranged between 0.0% in 2009 and 0.8% in 2011, without significant change over the study period ($p = 0.496$).

Table 4
Adjusted Multivariate Regression Analysis of VTE and Mortality.

Outcome	Year	Hip Fx (n = 81,918)*		Femur Fx (n = 5,448)**		Ankle Fx (22,029)***	
		Odds Ratio (95% CI)	P Value	Odds Ratio (95% CI)	P Value	Odds Ratio (95% CI)	P Value
VTE	2009	1.150 (0.643-2.058)	0.637	1.272 (0.230-7.042)	0.783	3.180 (0.689-14.683)	0.138
	2010	0.690 (0.378-1.260)	0.227	1.505 (0.309-7.342)	0.613	1.383 (0.276-6.918)	0.693
	2011	0.590 (0.344-1.014)	0.056	0.687 (0.124-3.794)	0.666	1.625 (0.266-6.015)	0.767
	2012	0.754 (0.451-1.261)	0.282	1.335 (0.292-6.110)	0.710	0.909 (0.191-4.333)	0.904
	2013	0.691 (0.415-1.150)	0.155	0.950 (0.208-4.344)	0.947	1.425 (0.325-6.245)	0.639
	2014	0.885 (0.537-1.459)	0.631	0.409 (0.082-2.053)	0.278	1.331 (0.309-5.729)	0.701
	2015	0.794 (0.484-1.304)	0.362	0.910 (0.210-3.946)	0.900	1.246 (0.292-5.327)	0.766
	2016	0.236 (0.742-1.216)	0.236	1.031 (0.243-4.376)	0.967	1.118 (0.263-4.749)	0.880
DVT	2009	1.265 (0.602-2.660)	0.535	1.271 (0.229-7.037)	0.784	1.263 (0.229-6.974)	0.789
	2010	0.788 (0.368-1.688)	0.540	0.837 (0.151-4.631)	0.839	0.911 (0.165-5.025)	0.914
	2011	0.666 (0.333-1.333)	0.250	0.669 (0.121-3.699)	0.645	0.810 (0.156-4.216)	0.802
	2012	0.810 (0.417-1.574)	0.534	1.044 (0.222-4.912)	0.956	0.575 (0.110-3.010)	0.512
	2013	0.764 (0.396-1.474)	0.422	0.414 (0.079-2.163)	0.296	1.017 (0.224-4.617)	0.982
	2014	0.954 (0.500-1.821)	0.886	0.327 (0.063-1.712)	0.186	0.798 (0.177-3.591)	0.769
	2015	0.870 (0.458-1.652)	0.670	0.436 (0.094-2.017)	0.288	0.713 (0.160-3.186)	0.658
	2016	0.805 (0.424-1.527)	0.506	0.647 (0.148-2.818)	0.562	0.449 (0.98-2.053)	0.302
PE	2009	1.151 (0.467-2.837)	0.760	1.026 (0.000-)	1.000	14,326,527.1 (0.000-)	0.993
	2010	0.821 (0.332-2.032)	0.669	13,273,405.0 (0.000-)	0.996	3,470,295.91 (0.000-)	0.994
	2011	0.543 (0.233-1.268)	0.158	1.116 (0.000-)	1.000	5,793,563.06 (0.000-)	0.994
	2012	0.775 (0.349-1.719)	0.531	7,778,557.73 (0.000-)	0.996	4,166,506.89 (0.000-)	0.994
	2013	0.647 (0.293-1.429)	0.282	12,872,084.4 (0.000-)	0.996	4,300,260.90 (0.000-)	0.994
	2014	0.918 (0.423-1.990)	0.828	1,457,142.59 (0.000-)	0.996	3,950,339.3 (0.000-)	0.994
	2015	0.844 (0.932-1.817)	0.664	10,717,983.1 (0.000-)	0.996	4,721,737.04 (0.000-)	0.994
	2016	0.739 (0.343-1.590)	0.439	9,134,439.90 (0.000-)	0.996	5,192,266.19 (0.000-)	0.994
Mortality	2009	1.265 (0.602-2.660)	0.535	0.000 (0.000-)	0.994	4,472,141.53 (0.000-)	0.993
	2010	0.788 (0.368-1.688)	0.540	0.333 (0.020-5.611)	0.446	1,878,551.67 (0.000-)	0.993
	2011	0.666 (0.333-1.333)	0.250	1.075 (0.114-10.088)	0.950	2,243,270.98 (0.000-)	0.993
	2012	0.810 (0.417-1.574)	0.534	0.323 (0.027-3.820)	0.370	6,060,016.63 (0.000-)	0.993
	2013	0.764 (0.396-1.474)	0.422	0.104 (0.006-1.766)	0.117	2,361,787.53 (0.000-)	0.993
	2014	0.954 (0.500-1.821)	0.886	0.406 (0.043-3.860)	0.433	5,944,602.36 (0.000-)	0.993
	2015	0.870 (0.458-1.652)	0.670	0.304 (0.034-2.748)	0.289	5,200,255.87 (0.000-)	0.993
	2016	0.805 (0.424-1.527)	0.506	0.504 (0.062-4.123)	0.523	4,575,247.13 (0.000-)	0.993

* = The model adjusted for: age, diabetes, dyspnea, functional status, Hx of CHF, hypertension medication, wound infection, corticosteroid use, bleeding disorder, transfusion, anesthesia modality, operative time, and LOS.

** = The model adjusted for: race, functional status, Hx of CHF, transfusion, anesthesia modality, ASA classification.

*** = The model adjusted for: sex, race, age, BMI, smoking status, dyspnea, functional status, hypertension medication, wound infection, operative time, LOS, anesthesia modality, and previous sepsis.

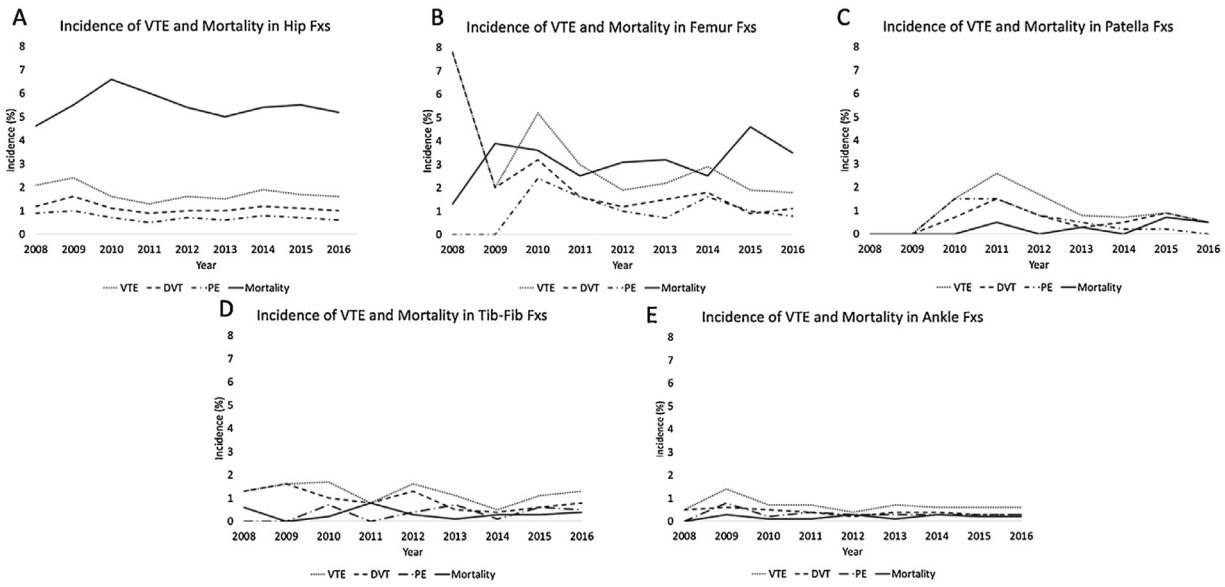

Fig. 1. Tracked Incidence of VTE, DVT, PE, and Mortality from 2008 to 2016 for (A) Hip, (B) Femur, (C) Patella, (D) Tibia and/or Fibula, and (E) Ankle Fractures.

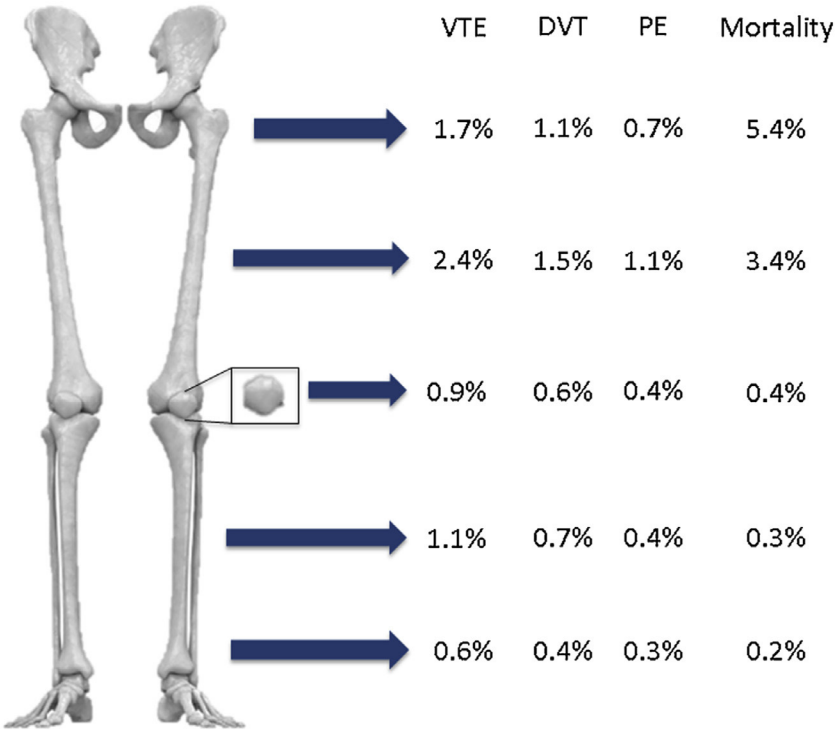

Fig. 2. Incidence of VTE, DVT, PE, and Mortality for Hip, Femur, Patella, Tibia and/or Fibula, and Ankle Fractures.

Ankle fractures

The overall VTE rate was 0.6% for ankle fractures. This remained between 0.4% and 1.4% without significant change ($p = 0.359$). The DVT incidence over the study period was 0.4% and ranged from 0.2% in 2012 to 0.6% in 2009, without significant change ($p = 0.716$). Overall PE incidence was 0.3% and was between 0.0% and 0.4% throughout the study period, without significant change ($p = 0.504$). Overall mortality incidence was 0.2%. Mortality rates ranged between 0.0% and 0.3%, with no significant change ($p = 0.598$). Multivariate regression analyses found no significant association between year of surgery with DVT, PE, VTE, or morality incidence ($p > 0.05$).

Discussion

During the surgical care of lower extremity trauma, VTE constitutes a relatively common, threatening and expensive complication [1–4,6]. While guidelines exist for hip fractures and isolated fractures treated with immobilization, no such guidelines exist for

operative treatment across lower leg fractures [16–20]. Furthermore, the literature on VTE incidence in lower extremity orthopaedic trauma is largely outdated and/or has not been performed on a national scale in the United States. Multivariate regression revealed that there were no statistically significant reductions in VTE for hip, femur, and ankle fractures ($p > 0.05$) from 2009 to 2016, when compared to 2008. There was a VTE incidence of 1.7% for hip fractures, 2.4% for femur fractures, 0.9% for patellar fractures, 1.1% for tibia and/or fibula fractures, and 0.6% for ankle fractures.

While our study provides on of the largest sample sizes in the current literature, its limitations should be addressed. Due to the broad inclusion criteria applied for ICD codes, specific fracture classifications remain unaddressed. For instance, femoral shaft fractures were grouped with supracondylar and other distal femurs fractures, as were isolated tibia and fibular fractures with comminuted tibia-fibula fractures. Further investigation of fractures by location and commonly accepted fracture classifications may garner more granular results. Treatment type was not accounted for as there were at least 75 CPT codes for each fracture type, making analysis by treatment type technically impractical. Several VTE risk factors were unavailable and thus not adjusted for, including: previous VTE, varicose veins, hyperlipidemia, Glasgow Coma Scale, femoral venous line insertion, major venous repair, polytrauma, bed rest time, previous surgery, obesity, hormone treatment [4,7–9]. Furthermore, neither the type of VTE prophylaxis nor treatment/rehabilitation protocols are included as variables in the NSQIP database. Nevertheless, our regression models included variables which are a part of the Carpini scoring system such as age, congestive heart failure, recent sepsis, and chronic obstructive pulmonary disease [10]. Lastly, the NSQIP database does not track outcomes past 30 days. Despite these limitations, this study is, to the best of the authors' knowledge, the most recent and comprehensive nationwide evaluation of VTE trends in operative lower extremity orthopaedic injures.

Similar incidence in VTE among the fractures investigations can be found in the current literature. A single center retrospective study which looked at VTEs incidence in various orthopaedic procedures found a VTE incidence of 1.7% in 1501 patients for hip fracture surgery during the years 2003 to 2011 [32]. Furthermore, the study found similar PE (0.8%) and DVT (0.9%) rates as our study. Similarly, retrospective a study from 2007 to 2011 of VTE incidence after various major surgeries found a VTE incidence 1.6% in (95% CI, 1.53–1.67) in 118,084 patients [33]. A retrospective database study of 78,309 tibia fracture patients from 2009 to 2011 found similar rates of PE (0.35%) and DVT (0.53%) as our study [34]. A National Health Services database study of 14,777 ankle fractures patients from April 2007 to September 2011 found PE rate (0.22%) comparable to what we found in our investigation [35]. A study using the NSQIP database from the years 2006–2015 of VTE incidence in foot and ankle surgery discovered a incidence of 0.7% VTE in 15,302 ankle fracture repair patients [36].

Conversely, some studies in the literature report different incidence rates than our study found. A single center prospective study of 5300 hip fractures found a symptomatic VTE rate of 2.2% (95% Confidence Interval [CI], 1.8–2.6) [37]. However, this study investigated a different time period (1989–2007) and was conducted on a UK population, not a US population. Furthermore, this study cited that 15% percent of the VTEs were discovered after 5 weeks, which would be outside the follow-up period for our study. A large observational study of 110,563 hip fracture patients using the Danish National Registry found a VTE incidence of 0.73% within the first 30-days [5]. While this study employed a large sample size, it was conducted during a different time period than our study (1995–2015) and in a different country. More importantly, the accuracy of the registry is in question due to coding errors for VTE and major bleeding in the database [38]. A French multi-center prospective study of 6860 hip fracture patients found a symptomatic rate of VTE was 1.34% (95% CI, 1.04–1.64) at 3 months [39]. While this reported incidence is lower than in our study, the study was performed over a two month period in 2002 and was of a different population than our study.

A single center retrospective study of 177 tibia fractures treated with a circular frame in the United Kingdom found a VTE incidence of 4.0%, which is substantially greater than our study [40]. However, this study's conclusion is limited by the small sample size, the use of a different population, and being focused on a single treatment. Similarly, a single center study of VTE incidence in 45,968 consecutive orthopaedic surgeries in Sweden found larger VTE rates for both internal fixation of the proximal tibia (3.8%; 95% CI, 2.3–6.3) and ankle (3.6%; 95% CI, 2.9–4.4) [2]. The discrepancies between this study and ours might be explained by the small sample sizes 395 and 2463 for proximal tibia and ankle respectively. Furthermore, this data was collected from 1996 to 2005 and was of a Swedish population. A multi-center randomized control trial of 814 ankle and foot fracture patients investigating the effects of low molecular weight heparin (LMWH) versus placebo on VTE found an overall VTE rate of 2.3% (95% CI, 0–31.9) and a VTE rate 0.98% (95% CI, 0–20.3) [41]. However, none of the VTE encountered were symptomatic and the conclusions are clouded by the small sample size as well as the grouping of foot and ankle fractures. A single surgeon study of the VTE incidence of various foot and ankle procedures from September 2006 to April 2016 reported a VTE incidence of 1.5% during surgical treatment of an ankle fracture [42]. Despite the study being performed over a similar time frame as ours, this study is limited by its small sample size of ankle fractures ($n = 425$) and its inclusion only one surgeon's patients.

Conclusion

Our study demonstrates that from 2008 to 2016 VTE incidence in operative lower extremity orthopaedic trauma patients has remained relatively unchanged. Investigation of VTE incidence outside of the 30-day window examined in our study with large cohort sizes is indicated to further assess the VTE risk for orthopaedic trauma patients. Importantly, these findings demonstrate the need to re-examine the use of thromboprophylaxis in operative lower extremity trauma patients based on risk stratification, fracture type, and other factors such as rehabilitation and rapid recovery protocols.

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Declaration of Competing Interest

The authors declare no conflicts of interest.

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