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Acute Deep Venous Thrombosis and Pulmonary Embolism in Foot and Ankle Trauma in the National Trauma Data Bank: An Update and Reanalysis

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ABSTRACT

The data regarding rates of deep venous thrombosis and pulmonary embolism after foot and ankle trauma remain sparse. In this study of the National Trauma Data Bank Data set (2007–2009 and 2010–2016), these rates were reexamined and risk factors associated with these complications were assessed. Data quality is improved in the later data set; the incidence of deep venous thrombosis and pulmonary embolism was 0.28% and 0.21%, respectively, in the 2010–2016 data. Prophylaxis, male gender, treatment in a university hospital, open reduction, chronic obstructive pulmonary disease, and hypertension were notable significant risk factors for pulmonary embolism. For deep venous thrombosis, male gender, bleeding disorder, angina, and prophylaxis were risk factors. Careful, individualized assessment of the risk factors associated with deep venous thrombosis and pulmonary embolism is important, and the merits of routine prophylaxis remain in question.

It is estimated that between 300,000 and 600,000 incidents of deep venous thrombosis (DVT) or pulmonary embolism (PE) occur each year in the United States (1,2). The incidence is less than 1:1000 for those younger than 15 years but rises to 5 to 6:1000 for those older than age 80 (1,2). Among those with DVT/PE, 10% to 30% die within 30 days, and most of these deaths occur in patients who have had PE, a risk that persists often many years after the initial diagnosis (1,3). Risk of recurrence is high, especially in the first year after PE; however, even at 10 years post initial presentation, the recurrence rate was estimated in a study as being 17.6% (4), and the annual risk of recurrence is estimated at near 7% (5).

In trauma patients, rates of DVT/PE vary depending on the population studied. A moderately sized National Trauma Data Bank (NTDB) study estimated that 0.36% of patients had DVT or PE, or both, and identified risk factors for occurrence, such as age > 40 years, severe lower extremity or head injury, venous injury, or major surgical procedures performed (6). A larger and more recent study using the same data set found similar rates (0.94% and 0.37% for DVT and PE, respectively) (7). Finally, a study examining patients with more severe injuries noted rates of 11.6% DVT and 1.9% PE in patients who had routine biweekly duplex ultrasound and 2.1% DVT and 7% PE in those who did not (8).

There are 100 million visits to emergency departments in the United States per year (9,10), with 14.6% of those visits relating to lower extremity injury (9). Among those, sprains and strains accounted for 36% of injuries, and ankle fractures had the highest incidence (206:100,000) (11). The ankle is also the most common lower extremity location for fracture or sprain, accounting for 19.2% and 39.3% of such injuries, respectively (11).

The rates of DVT and PE in lower extremity trauma are not well studied; in general, more is known in foot and ankle surgery. Mizel and colleagues (12) noted in 1998 rates for DVT and nonfatal PE of 0.22% and 0.15%, respectively; similar rates (0.4% and 0.3%) were observed by Wukich et al (13) in a more recent study. In a population with regular postoperative duplex ultrasound, calf clots were observed in 3.5% of patients, but none of these cases worsened (14). Hanslow and colleagues (15) followed their foot and ankle surgery patients, including trauma patients, noting a DVT rate of 4% and a PE rate of 1.3%. Two meta-analyses examined DVT/PE rates in foot and ankle surgery, both noting population level rates of < 1% (16,17). In 1 of these studies, the authors noted that radiological identification rates of DVT/PE were much higher than clinical

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identification rates and that prophylaxis did not affect rates of diagnosis, whether clinically or radiologically diagnosed (16). Both studies observed higher rates of DVT/PE in trauma patients, singling out Achilles tendon repair for special notice. In this regard, Lapidus and colleagues (18) noted very high rates of DVT/PE after both ankle fracture and Achilles tendon rupture, up to 20%; however, the clinical relevance is not clear, as many patients were tested with both duplex ultrasound and phlebography, perhaps resulting in overreporting, and rates of PE were not given. In fact, Rosfors and colleagues (19) followed patients who had DVT detected on duplex scan for 5 years and found that only 5% were clinically symptomatic. Both Lassen et al (20) and Spannagel and Kujath (21) noted that low-molecular-weight heparin (LMWH) reduced rates of DVT in patients who were immobilized; across these 2 studies, rates of DVT ranged from 4.8% to 19%. These rates are in stark contrast to the rates of 0.12% DVT and 0.17% PE found for 90% of ankle fractures (22) and the rates of 0.28% DVT and 0.21% PE in our own earlier examination of acute incidence of DVT/PE (23). Finally, a study published in 2018 examined Achilles tendon ruptures, ankle fractures treated with immobilization, and ankle fractures treated surgically, observing 90-day rates of DVT/PE of 4.8%, 2.2%, and 3%, respectively (24).

Table 1
Inclusion and exclusion *International Classification of Diseases, Ninth Revision*[*], codes

Inclusion (Foot and Ankle Trauma)	*Closed*
Medial malleolus	824
Lateral malleolus	824.2
Bimalleolar	824.4
Trimalleolar	824.6
Ankle	824.8
Calcaneus	825
Unspecified tarsal/metatarsal	825.2
Talus	825.21
Navicular	825.22
Cuboid	825.23
Cuneiform	825.24
Metatarsal	825.25
Metatarsal with tarsal	825.29
Phalanges	826
	Open
Medial malleolus	824.1
Lateral malleolus	824.3
Bimalleolar	824.5
Trimalleolar	824.7
Ankle	824.9
Calcaneus	825.1
Unspecified tarsal/metatarsal	825.3
Talus	825.31
Navicular	825.32
Cuboid	825.33
Cuneiform	825.34
Metatarsal	825.35
Metatarsal with tarsal	825.39
Phalanges	826.1

Exclusion (any other lower body orthopedic trauma)	
Acetabulum fracture	808.0, 808.1
Pelvic fracture	808, 808.2, 808.3, 808.4, 808.41–808.43, 808.49, 808.51–808.53, 808.59, 808.8, 808.9
Hip fracture	820.00–820.03, 820.09, 820.10–820.13, 820.19, 820.20–820.22, 820.30–820.32, 820.8, 820.9
Femur fracture	821.00, 821.01, 821.10, 821.11, 821.20–821.23, 821.29, 821.30–821.33, 821.39
Fracture of tibia/fibula	823.00–823.02, 823.10–823.12, 823.20–823.22, 823.30–823.32, 823.40–823.42, 823.80–823.82, 823.90–823.92

[*] Available at: https://www.cdc.gov/nchs/icd/icd9cm.htm

Given these varying results, we decided to reexamine our earlier work based on the NTDB (23) and to take the opportunity to update our epidemiological study with newly available NTDB data. We examined both the newly available data and the older and newer data together. This allowed us to determine whether the rates of DVT/PE, and the risk factors for it, have remained consistent in this data set. Further, we examined a local trauma database at a level I trauma center, attempting to capture the same patients as are followed in NTDB. Doing so offered the ability to track acute DVT/PE and to study DVT/PE rates within 60 days of discharge; this aligns with how DVT/PE is studied in many other works and gives insight into the utility and proper use of administrative databases such as NTDB.

Patients and Methods

Institutional review board approval for this study was received for the use of local trauma database and electronic health records. NTDB data are deidentified and requires no institutional review board approval to be used.

National-Level Data

The NTDB is a voluntarily, prospectively collected database of trauma encounters that is maintained by the American College of Surgeons. Currently, the database contains information on > 6 million cases, recorded at > 900 participating centers in the United States. The goal of the database is to encourage research, quality improvement, and sharing of trauma-related information. This study used data from 2007 to 2016.

We identified patients experiencing foot and ankle trauma using codes from the *International Classification of Disease, Ninth Revision* (ICD-9) (Table 1). Procedures performed on patients were classified into 6 categories using the ICD-9 codes listed in Table 2: closed reduction with fixation, open reduction with or without fixation,

Table 2
Categories of foot and ankle trauma procedures categorized using ICD-9 codes

Closed reduction with fixation	
93.54	Application of splint
93.56	Application of pressure dressing
93.59	Other immobilization, pressure, and attention to wound
79.16	Closed reduction of fracture with internal fixation, tibia and fibula
79.17	Closed reduction of fracture with internal fixation, tarsals and metatarsals
79.18	Closed reduction of fracture with internal fixation, phalanges of foot
79.46	Closed reduction of separated epiphysis, tibia and fibula
Open reduction with or without fixation	
79.26	Open reduction of fracture without internal fixation, tibia and fibula
79.27	Open reduction of fracture without internal fixation, tarsals and metatarsals
79.28	Open reduction of fracture without internal fixation, phalanges of foot
79.36	Open reduction of fracture with internal fixation, tibia and fibula
79.37	Open reduction of fracture with internal fixation, tarsals and metatarsals
79.38	Open reduction of fracture with internal fixation, phalanges of foot
79.56	Open reduction of separated epiphysis, tibia and fibula
79.87	Open reduction of dislocation of ankle
79.88	Open reduction of dislocation of foot and toe
Closed reduction without fixation	
79.06	Closed reduction of fracture without internal fixation, tibia and fibula
79.07	Closed reduction of fracture without internal fixation, tarsals and metatarsals
79.08	Closed reduction of fracture without internal fixation, phalanges of foot
79.77	Closed reduction of dislocation of ankle
79.78	Closed reduction of dislocation of foot and toe
Immobilization, special dressing	
93.5	Other immobilization, pressure, and attention to wound
93.51	Application of plaster jacket
93.53	Application of other cast
Soft tissue procedures, such as wound debridement	
79.66	Debridement of open fracture site, tibia and fibula
79.67	Debridement of open fracture site, tarsals and metatarsals
79.68	Debridement of open fracture site, phalanges of foot
Other and unspecified procedures	
79.96	Unspecified operation on bone injury, tibia and fibula
79.97	Unspecified operation on bone injury, tarsals and metatarsals
79.98	Unspecified operation on bone injury, phalanges of foot
84.25	Toe reattachment
84.26	Foot reattachment
84.27	Lower leg or ankle reattachment

closed reduction without fixation, immobilization or no treatment, soft tissue procedures (eg, wound debridement), and other/unspecified procedures. We also recorded use of prophylaxis, using ICD-9 codes 99.10 (injection or infusion of a thrombolytic agent), 99.19 (injection of an anticoagulant), and 99.20 (injection or infusion of a platelet inhibitor).

The other variables recorded are listed in Table 3, and the definitions are those provided by NTDB. The variables "open," "ankle," and "position" were constructed from those collected from the database. An incident was considered to have been an open trauma if there was an injury associated with that incident from the list of open injuries in Table 1. An injury was considered to involve the ankle if any associated ICD-9 code was in the 824.0–824.9 range or was 825 or 825.1. Rearfoot injuries were any coded 824–824.9, 825.0, 825.1, 825.21, or 825.31. Midfoot injuries were those coded 825.2, 825.3, 825.22, 825.23, 825.24, 825.25, 825.32, 825.33, 825.34, or 825.35. Forefoot injuries were those coded 825.29, 825.39, 826, or 826.1. Each incident was coded as its most proximal injury; this variable was only used in computing adjusted rates, as described below. The outcomes of interest were the NTDB-coded DVT and PE.

We focused on patients with isolated foot and ankle trauma and achieved this through 2 sets of exclusions. First, we excluded patients with other lower extremity fractures, as listed in Table 1. Second, we excluded patients with an injury severity score (ISS) of > 15. A trauma incident with a score > 15 is generally considered a polytrauma.

We were interested in extending our earlier work to include Achilles tendon ruptures, but these injuries may not be coded accurately in ICD-9. In 2015 and 2016, the NTDB began to include ICD-10 coded injuries, including Achilles tendon ruptures, codes S86.021A, S86.022A, S86.029A. Following the procedures given here, we thus extracted those patients with these injuries, in these years, to compare with the other patients already extracted for other injuries in those years.

Table 3
Additional variables recorded

Variables Used in Analyses	Combined	Data Collected for EHR Patients (Local Database)
Demographics	*Demographics*	*Demographics*
Age (10-y increments)	Age (years)	Age (years)
Gender (male/female)	Gender (male/female)	Gender (male/female)
Injury severity score (continuous; < 15)	Height (m)	Injury severity score (< 15)
Length of hospital stay (days)	Weight (kg)	Length of hospital stay (days)
Payment*	Body mass index (kg/m^2)	Height (m)
	Injury severity score (< 15)	Weight (kg)
Hospital characteristics	Length of hospital stay (days)	Body mass index (kg/m^2)
Status†	Payment	Hypertension requiring medication (yes/no, 401)
		Diabetes (yes/no, 250)
Injury characteristics	*Hospital characteristics*	Alcohol use disorder (yes/no, 303, 305)
Work related (yes/no)	Status	Current smoker (yes/no, 305.1)
Location‡		Respiratory disease (yes/no)
Trauma (blunt, burn, other, penetrating)	*Injury characteristics*	Bleeding disorder (yes/no, 286, 287.3)
Ankle (yes/no)	Work related (yes/no)	History of cerebrovascular accident (yes/no, 430‖–437‖)
Open (yes/no)	Location	Use of steroids (yes/no)
Position (rear/mid/fore)	Trauma (blunt, burn, other, penetrating)	Esophageal varices (yes/no, 456.0, 456.1, 456.3)
	Ankle (yes/no)	Congestive heart failure (yes/no, 428)
Comorbidity	Open (yes/no)	Myocardial infarction within 6 mo (yes/no, 410)
Hypertension requiring medication (yes/no)	Position (rear/mid/fore)	Disseminated cancer (yes/no, 199)
Diabetes mellitus (yes/no)		Dialysis or kidney transplant (yes/no)
Alcohol use disorder (yes/no)	*Comorbidity*	History of revascularization/amputation (yes/no)
Current smoker (yes/no)	Hypertension requiring medication (yes/no, 401)	Angina within 1 mo (yes/no, 413)
Chronic obstructive pulmonary disease (yes/no)	Diabetes (yes/no, 250)	Ascites within 30 d (yes/no, 789.5)
Bleeding disorder (yes/no)	Alcohol use disorder (yes/no, 303, 305)	Functionally dependent health status (yes/no)
Cerebrovascular accident (yes/no)	Current smoker (yes/no, 305.1)	Chemotherapy for cancer within previous 30 days (yes/no)
Steroid use (yes/no)	Respiratory disease (yes/no)	Personal/family history of DVT/PE‖ (yes/no, 415.1, 416.2, 453)
Congestive heart failure (yes/no)	Chronic obstructive pulmonary disease (yes/no)	Birth control use (yes/no)
History of myocardial infarction (yes/no)	Bleeding disorder (yes/no, 286, 287.3)	Disseminated cancer (yes/no, 199)
Chronic renal failure (yes/no)	History of cerebrovascular accident (yes/no, 430‖–437‖)	
History of peripheral vascular disease (yes/no)	Use of steroids (yes/no)	*Complication*
History of angina within 30 days (yes/no)	Esophageal varices (yes/no, 456.0, 456.1, 456.3)	Deep venous thrombosis (yes/no, 452)
Functionally dependent health status (yes/no)	Congestive heart failure (yes/no, 428)	Pulmonary embolism (yes/no, 415.1)
Currently receiving chemotherapy for cancer (yes/no)	Ascites within 30 d (yes/no, 789.5)	Myocardial infarction (yes/no, 410)
Disseminated cancer (yes/no)	Myocardial infarction within 6 mo (yes/no, 410)	Acute respiratory distress syndrome (yes/no, 769)
	Chronic renal failure (yes/no)	Stroke (yes/no, 430–437)
Complication	Dialysis or kidney transplant (yes/no)	Surgical site infection (yes/no, 998.5)
DVT (yes/no)	History of revascularization/amputation (yes/no)	
PE (yes/no)	History of peripheral vascular disease (yes/no)	
	Angina within 1 mo (yes/no, 413)	
	Functionally dependent health status (yes/no)	
	Currently receiving chemotherapy for cancer (yes/no)	
	Chemotherapy for cancer within previous 30 days (yes/no)	
	Personal/family history of DVT/PE (yes/no, 415.1, 416.2, 453)	
	Birth control use (yes/no)	
	Disseminated cancer (yes/no, 199)	
	Complication	
	Deep venous thrombosis (yes/no, 452)	
	Pulmonary embolism (yes/no, 415.1)	
	Myocardial infarction (yes/no, 410)	
	Acute respiratory distress syndrome (yes/no, 769)	
	Stroke (yes/no, 430–437)	
	Surgical site infection (yes/no, 998.5)	

Abbreviation: EHR, electronic health record.

* Blue Cross/Blue Shield, Medicaid, Medicare, no-fault auto, not billed, other, other government, private, self-pay, Workers' Compensation.

† Community, nonteaching, university.

‡ Farm, home, industry, mine, other, public building, recreation, residential institution, street, unspecified.

‖ Deep venous thrombosis/pulmonary embolism.

Local Data

Our institution's level I trauma center has maintained its own database since 1996. It contains identifiable information such as patient, injury, hospital characteristics, and short-term outcomes. Data from years 2010 to 2018 were searched for foot and ankle trauma patients using the ICD-9 diagnosis codes (Table 1). Patients with polytrauma (any other lower body orthopaedic trauma) were excluded. Variables collected included demographics (age, gender, race, ethnicity), comorbidities (body mass index, alcohol, diabetes, etc.), trauma type, any hospital procedures (and whether the procedure was forefoot, midfoot, or rearfoot and whether it was soft tissue, bone, or both), DVT prophylaxis, complications (DVT, PE, etc.), injury severity, and length of stay (LOS) (Table 3). The patient identifiers from this search were used to link to patient records in our institution's electronic health record (EHR). The EHR was searched for each patient to retrieve variables not available in the trauma database and to note any complications 60 days after discharge. Personal and family history of VTE, ICD-9 codes V12.59 and V17.49, respectively, use of DVT prophylaxis, and use of birth control, all within 30 days before admission, were collected from the EHR.

Statistical Analyses

National Data

All variables were summarized by using mean and standard deviation (SD) values or frequencies and percentages, for continuous and discrete variables, respectively. This was done separately for the data from 2007 to 2009 and 2010 to 2016, as well as for the entire cohort (excluding Achilles tendon injuries). The number of subjects for whom data were missing was recorded for each variable.

We next examined the association of each variable with the occurrence of DVT and PE by using bivariate logistic regression. Those variables whose associations with an outcome were at a value of $p \leq .2$ were included in a multivariate logistic regression for that outcome. Finally, logistic regression models, including age, gender, and use of prophylaxis, were built; adjusted rates of DVT and PE were computed from these models. Such models were also estimated to compute adjusted rates for patients with or without ankle injuries, patients with or without open injuries, and patients with or without prophylaxis and to examine adjusted rates in patients with rearfoot, midfoot, or forefoot injuries. All of these analyses were done separately for the data from 2007 to 2009 and from 2010 to 2016.

All variables, including outcomes, were compared between patients with Achilles tendon injuries and patients with other injuries, in the 2015 to 2016 data. Student's *t* tests and χ^2/Fisher's exact tests were used for these comparisons, for continuous and discrete variables, respectively. The small number of Achilles injuries precluded any further, more detailed analyses.

Local Data

All variables were summarized using means and standard deviations, or frequencies and percentages, for continuous and discrete variables, respectively. Given the small number of DVT and PE events, no bivariate or multivariate analyses were carried out.

Table 4
Univariate descriptions of variables in the data set, for the overall population, and the early and late years, separately

		2007–2009			2010–2016			2007–2016		UTMB EHR		
		n	%	% Missing	n	%	% Missing	n	%	n	%	% Missing
	No.	76,028			224,747			300,775		551		
Gender	Female	34,635	46.28	1.57	108,661	48.37	0.04	143,296	47.85	204	37.02	0
	Male	40,196	53.72		115,995	51.63		156,191	52.15	347	62.98	
Race	Black									72	13.48	0.36
	White									473	86.16	
	Other									2	0.36	
Ethnicity	Hispanic									104	18.94	0.36
	Non-Hispanic									445	81.06	
Status	Community	29,919	39.35	0	86,841	38.64	0	116,760	38.82			
	Nonteaching	11,265	14.82		40,453	18		51,718	17.19			
	University	34,844	45.83		97,453	43.36		132,297	43.99			
Payment	BC/BS	4279	7	19.61	13,362	6.36	6.58	17,641	6.51			
	Medicaid	5804	9.5		26,001	12.38		31,805	11.73			
	Medicare	10,973	17.95		46,241	22.02		57,214	21.11			
	No-fault auto	3219	5.27		10,946	5.21		14,165	5.23			
	Not billed	399	0.65		1051	0.5		1450	0.53			
	Other	3291	5.38		8314	3.96		11,605	4.28			
	Other government	1551	2.54		5451	2.6		7002	2.58			
	Private	17,797	29.12		61,985	29.52		79,782	29.43			
	Self-pay	10,525	17.22		28,910	13.77		39,435	14.55			
	Workers' Compensation	3278	5.36		7697	3.67		10,975	4.05			
Work related	No	56,675	92.1	19.06	194,446	93.36	7.33	251,121	93.07			
	Yes	4863	7.9		13,823	6.64		18,686	6.93			
Location	Farm	484	0.67	5.14	1408	0.64	2.56	1892	0.65			
	Home	23,767	32.96		82,262	37.56		106,029	36.42			
	Industry	3313	4.59		8205	3.75		11,518	3.96			
	Mine	63	0.09		127	0.06		190	0.07			
	Other	3865	5.36		11,210	5.12		15,075	5.18			
	Public building	3061	4.24		10,525	4.81		13,586	4.67			
	Recreation	4678	6.49		13,761	6.28		18,439	6.33			
	Residential institution	1185	1.64		4018	1.83		5203	1.79			
	Street	24,705	34.26		71,191	32.51		95,896	32.94			
	Unspecified	6997	9.7		16,284	7.44		23,281	8			
Trauma	Blunt	70,183	92.64	0.35	205,608	92.39	0.98	275,791	92.45			
	Burn	80	0.11		213	0.1		293	0.1			
	Other	2798	3.69		8564	3.85		11,362	3.81			
	Penetrating	2699	3.56		8161	3.67		10,860	3.64			
Open	No	61,835	81.33	0	183,261	81.54	0	245,096	81.49	449	81.49	0
	Yes	14,193	18.67		41,486	18.46		300,775	18.51	102	18.51	
Ankle	No	16,676	21.93	0	48,853	21.74	0	65,529	21.79	229	41.56	0
	Yes	59,352	78.01		175,894	78.26		235,246	78.21	322	58.44	
Age		43.72	20.5	0	45.48	21.1	0	45.04	20.96	46.57	16.48	0
ISS		5.52	3.1	0	5.43	2.99	0	5.45	3.01	7.91	7.3	0
LOS		528.31	716.26	0	574.46	760.96	0	562.8	750.18	4.28	7.63	15

Abbreviations: BC/BS, Blue Cross/Blue Shield; EHR, electronic health record; ISS, injury severity score; LOS, length of stay; UTMB, The University of Texas Medical Branch.
All discrete variables are described with frequencies and percentages, all continuous variables are described with means and standard deviations.

Results

Subjects

After applying inclusion and exclusion criteria, our final data set included 300,775 trauma incidents; 76,028 from 2007 to 2009 and 224,747 from 2010 to 2016. Several variables had substantial amounts of missing data; of particular note were payment (missing 19.61% and 6.58% from 2007 to 2009 and 2010 to 2016, respectively), work related (19.06% and 7.33% missing), and location (5.14% and 2.56% missing). Although 13.54% of incidents from 2007 to 2009 were missing comorbidity information, only 3.8% were missing this information from 2010 to 2016. In a similar vein, from the 2007 to 2009 and 2010 to 2016 time periods, respectively, 20.03% and 5.9% were missing outcome information and 17.09% and 8.65% were missing procedure information.

Univariate Analyses

The population of trauma incidents and its characteristics were relatively consistent across the 2 time periods, although some differences were notable. Because of how the data qre collected, the NTDB should not be used to study time trends; thus, our results are merely suggestive. Medicaid and Medicare payments were about 3% and 5% more common from 2010 to 2016 versus 2007 to 2009, and self-pay was less common by about 4%. More injuries occurred at home in the later data set, and the incidents in the later data set occurred in patients who were about 2 years older. Lengths of stay were about 400 minutes longer in the later data set. These and other demographic details are presented in Table 4. Prevalence of hypertension, smoking, and chronic obstructive pulmonary disease (COPD) all increased from the earlier to the later data set, by approximately 7%, 12%, and 2%, respectively (Table 5). Trauma was 6% less likely to be treated open, but more likely to be treated with closed fixation (up 3%) and immobilization (up 6%) in the later data set. Use of prophylaxis increased from 0.46% to 1.5% (Table 6). Rates of both PE (0.22% to 0.17%) and DVT (0.28% to 0.23%) decreased from the earlier to the later time period (Table 7).

Our population of incidents was roughly evenly split between males and females. Most patients presented to either a university or community hospital, with only 17.19% being treated in non teaching hospitals. Most injuries were not work related, and the majority occurred at home or in a residential institution. Blunt trauma constituted 92.45% of injuries, and only 18.51% were open, while 78.21% involved the ankle. Incidents occurred in patients with an average age of 45.04 (SD 20.96), and the average LOS was 562.8 minutes. These were generally very low ISS injuries, with an average of 5.45 (SD 3.01). Overall, about 50% of injuries were treated open, whereas only a quarter were treated closed, and a quarter were immobilized or not treated. Only 11.68% of injuries involved soft tissue treatment. In terms of comorbidity, we describe several that occur with high prevalence or are of interest as risk factors for DVT and PE. Hypertension, diabetes, and smoking were relatively prevalent, being observed in 26.71%, 12.16%, and 14.38% of incidents, respectively. COPD was far less common, occurring in 6.94% of cases, and bleeding disorders and renal failure were even less common, present in 3.08% and 0.76% of incidents, respectively.

Table 5
Univariate descriptions of comorbidity variables in the data set, for the overall population, and the early and late years, separately

		2007–2009		2010–2016		2007–2016		UTMB EHR	
		n	%	n	%	n	%	n	%
Hypertension	No	51,347	78.11	155,298	71.83	206,645	73.29	426	77.31
	Yes	14,386	21.89	60,906	28.17	7529	26.71	125	22.69
Diabetes	No	58,854	89.53	188,800	87.32	247,654	87.84	496	90.02
	Yes	6879	10.47	27,404	12.68	34,283	12.16	55	9.98
Alcohol use	No	61,777	93.98	203,747	94.24	265,524	94.18	497	90.2
	Yes	3956	6.02	12,457	5.76	16,413	5.82	54	9.8
Smoker	No	62,331	94.82	179,076	82.83	241,407	85.62	436	79.13
	Yes	3402	5.18	37,128	17.17	40,530	14.38	115	20.87
COPD	No	62,376	94.89	200,000	92.51	262,376	93.06	523	94.92
	Yes	3357	5.11	16,204	7.49	19,561	6.94	28	5.08
Bleeding disorder	No	64,463	98.07	208,794	96.57	273,257	96.92	538	97.64
	Yes	1270	1.93	7410	3.43	8680	3.08	13	2.36
CVA	No	64,872	98.69	213,121	98.57	277,993	98.6	548	99.46
	Yes	861	1.31	3083	1.43	3944	1.4	3	0.54
Steroid use	No	65,572	99.76	215,215	99.54	280,787	99.59	539	97.82
	Yes	161	0.24	989	0.46	1150	0.41	12	2.18
CHF	No	64,230	97.71	210,545	97.38	274,775	97.46	539	97.82
	Yes	1503	2.29	5659	2.62	7162	2.54	12	2.18
MI	No	64,918	98.76	214,063	99.01	278,981	98.95	550	99.82
	Yes	815	1.24	2141	0.99	2956	1.05	1	0.18
Disseminated cancer	No	65,488	99.63	215,353	99.61	280,841	99.61	550	99.82
	Yes	245	0.37	851	0.39	1096	0.39	1	0.18
Chronic renal failure	No	65,486	99.62	214,314	99.13	279,800	99.24	549	99.64
	Yes	247	0.38	1890	0.87	2137	0.76	2	0.36
PVD	No	65,716	99.97	215,433	99.64	281,149	99.72	547	99.27
	Yes	17	0.03	771	0.36	788	0.28	4	0.73
Angina	No	65,692	99.94	215,889	99.85	281,581	99.87	551	100
	Yes	41	0.06	315	0.12	356	0.13	0	0
Dependent status	No	65,389	99.48	213,242	98.63	278,631	98.83	538	97.64
	Yes	344	0.52	2962	1.37	3306	1.17	13	2.36
Chemotherapy	No	65,675	99.91	215,822	99.82	281,497	99.84	549	99.64
	Yes	58	0.09	382	0.18	440	0.16	2	0.36
		10,295 missing	13.54	8543 missing	3.8	18,838 missing	6.26	0 missing	0

Abbreviations: COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; CHF, chronic heart failure; EHR, electronic health record; MI, myocardial infarction; PVD, peripheral vascular disease; UTMB, The University of Texas Medical Branch.

Table 6
Univariate descriptions of proc3edure variables in the data set, for the overall population, and the early and late years, separately

		2007–2009		2010–2016		2007–2016		UTMB EHR	
		n	%	n	%	n	%	n	%
Closed with fixation	No	60,424	95.86	196,758	95.83	257,182	95.84	501	90.93
	Yes	2608	4.14	8552	4.17	11,160	4.26	50	9.07
Open	No	25,486	40.43	96,490	47	121,976	45.46	403	73.14
	Yes	37,546	59.57	108,820	53	146,366	54.54	148	26.86
Closed without fixation	No	50,908	80.77	159,189	77.54	210,097	78.29	370	67.15
	Yes	12,124	19.23	46,121	22.46	58,245	21.71	181	32.85
Immobilization	No	49,682	78.82	149,597	72.86	199,279	74.26	115	20.87
	Yes	13,350	21.18	55,713	27.14	69,063	25.74	436	79.13
Soft tissue	No	54,553	86.55	182,435	88.86	236,988	88.32	492	89.29
	Yes	8479	13.45	22,875	11.14	31,354	11.68	59	10.71
Other	No	63,015	99.97	205,258	99.97	268,273	99.97	551	100
	Yes	17	0.03	52	0.03	69	0.03	0	0
Prophylaxis	No	62,722	99.54	202,231	98.5	264,971	98.74	326	59.17
	Yes	292	0.46	3079	1.5	3371	1.26	225	40.83
		12,996 missing	17.09	19,437 missing	8.65	32,433 missing	10.78	0 missing	0

Bivariate Analyses

Several factors predispose to occurrence of DVT or PE. In the early cohort, university versus community hospital treatment, open traumas, ankle traumas, increasing age, ISS or LOS, open reduction, and soft tissue treatment were all risk factors for PE. Hypertension, diabetes, bleeding disorder, congestive heart failure (CHF), and prophylaxis were all also risk factors, the last with an odds ratio of 6.84 for the occurrence of PE. Most of these factors, with the exception of bleeding disorder and soft tissue procedures, remained significant from 2010 to 2016. The odds ratios for hypertension, diabetes, and CHF decreased to < 2, and that for prophylaxis decreased to 3.2. Male gender, smoking, peripheral vascular disease (PVD), and burn versus blunt trauma became significant risk factors; however, penetrating versus blunt and "other" versus blunt were protective against PE.

An even greater number of the covariates predispose to DVT; details are provided in Table 8. Of note, in the early cohort, university treatment was protective. Medicare or other payment increased the odds of DVT by > 3-fold, bleeding disorder conferred similar risk as Medicare and other insurance, renal disease increased the odds by a factor of 5.6, PVD increased the odds by a factor of 42.31, angina increased the odds by a factor of 10.57, and prophylaxis increased the odds by a factor of 9.72. All the factors remained significant in the later cohort, except for soft tissue treatment, and more became significant, including male gender, burn trauma, and steroid use. Prophylaxis remained a risk factor, with an odds ratio of 4.14 for DVT.

With the exception of ISS, all covariates that were significant risk factors for DVT and PE in the early cohort had attenuated odds ratios in the later cohort. As noted, there were also some factors that were not significant in the early cohort but became significant in the later cohort.

Multivariate Analyses

Multivariate logistic regression models for PE and DVT, in both the early and late cohorts, are shown in Table 9. We only report those variables in each model that were significant in that model. The variables included are those achieving a value of $p \leq .2$ on bivariate analysis (lists of specific variables available on request). Notably, prophylaxis, age, ISS, LOS, and open reduction remained significant risk factors for PE in both cohorts. Home versus farm was protective against PE in the early cohort, in contradistinction to the bivariate analysis, and closed reduction was a risk factor. For DVT, bleeding disorder, angina, prophylaxis, age, ISS, and LOS were risk factors common to both cohorts. Closed reduction without fixation in the early cohort and university treatment in the late cohort were protective factors not appearing as significant on bivariate analysis. In both cohorts, for both outcomes, prophylaxis was the most impactful risk factor. A very large

Table 7
Univariate descriptions of outcome variables in the data set, for the overall population, and the early and late years, separately

		2007–2009		2010–2016		2007–2016	
		n	%	n	%	n	%
PE	No	60,664	99.78	211,136	99.83	271,800	99.82
	Yes	134	0.22	352	0.17	486	0.18
DVT	No	60,628	99.72	211,003	99.77	271,631	99.76
	Yes	170	0.28	485	0.23	655	0.24
MI	No	60,723	99.88	211,251	99.89	271,974	99.89
	Yes	75	9.12	237	0.11	312	0.11
ARDS	No	60,605	99.68	210,981	99.76	271,586	99.74
	Yes	193	0.32	507	0.24	700	0.26
Stroke	No	60,768	99.95	211,369	99.94	272,137	99.95
	Yes	30	0.05	119	0.06	149	0.05
SSI	No	60,777	99.97	211,277	99.9	272,054	99.91
	Yes	21	0.03	211	0.1	232	0.09
		15,230 missing	20.03	13,259 missing	5.9	28,489 missing	9.47

Abbreviations: ARDS, acute respiratory distress syndrome; DVT, deep venous thrombosis; MI, myocardial infarction; PE, pulmonary embolism; SSI, surgical site infection.

Table 8
Bivariate associations with pulmonary embolism and deep venous thrombosis

	PE				DVT			
	2007–2009		2010–2016		2007–2009		2010–2016	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Gender male	0.85	(0.61 to 1.2)	1.33*	(1.07 to 1.64)	1	(0.74 to 1.35)	1.39*	(1.16 to 1.67)
Status: nonteaching	1.26	(0.74 to 2.14)	0.85	(0.6 to 1.19)	0.34*	(0.17 to 0.65)	0.6*	(0.45 to 0.8)
Status: university	1.5*	(1.03 to 2.19)	1.45*	(1.15 to 1.82)	0.91	(0.66 to 1.24)	0.89	(0.74 to 1.07)
Payment: Medicaid	1.01	(0.32 to 3.19)	0.7	(0.39 to 1.24)	1.45	(0.49 to 4.24)	1.17	(0.67 to 2.03)
Payment: Medicare	2.11	(0.81 to 5.46)	1.2	(0.73 to 1.95)	3.17*	(1.25 to 8.01)	2.08*	(1.27 to 3.41)
Payment: no-fault auto	1.5	(0.46 to 4.92)	1.28	(0.69 to 2.36)	2.75	(0.96 to 7.93)	3.8*	(2.23 to 6.46)
Payment: not billed	0	(0 to 0)	0.66	(0.09 to 4.95)	0	(0 to 0)	0.74	(0.1 to 5.52)
Payment: other	1.09	(0.29 to 4.07)	1.26	(0.65 to 2.47)	3.29*	(1.16 to 9.34)	2.16*	(1.16 to 4)
Payment: other government	2.18	(0.58 to 8.13)	1.19	(0.56 to 2.55)	1.63	(0.39 to 6.85)	1.46	(0.69 to 3.09)
Payment: private	1.86	(0.73 to 4.71)	0.98	(0.6 to 1.58)	1.9	(0.75 to 4.83)	1.26	(0.76 to 2.07)
Payment: self-pay	1.13	(0.41 to 3.13)	0.82	(0.47 to 1.41)	1.13	(0.41 to 3.13	1.16	(0.67 to 2)
Payment: Workers' Compensation	0.79	(0.19 to 3.31)	1.46	(0.76 to 2.78)	0.53	(0.1 to 2.72)	1.14	(0.55 to 2.37)
Work related	0.53	(0.22 to 1.3)	1.22	(0.82 to 1.82)	0.44	(0.18 to 1.07)	0.97	(0.66 to 1.41)
Location: home	0.4	(0.1 to 1.67)	0.97	(0.24 to 3.95)	0.54	(0.13 to 2.21)	0.67	(0.25 to 1.8)
Location: industry	0.31	(0.06 to 1.68)	1.12	(0.25 to 4.96)	0.54	(0.11 to 2.59)	0.43	(0.13 to 1.37)
Location: mine	0	(0 to 0)	0	(0 to 0)	0	(0 to 0)	0	(0 to 0)
Location: other	0.32	(0.06 to 1.68)	0.64	(0.14 to 2.94)	0.39	(0.08 to 1.93)	0.68	(0.23 to 1.97)
Location: public building	0.41	(0.08 to 2.14)	0.74	(0.16 to 3.33)	0.16	(0.02 to 1.17)	0.5	(0.17 to 1.52)
Location: recreation	0.21	(0.04 to 1.17)	0.52	(0.11 to 2.37)	0.05	(0 to 0.59)	0.26*	(0.08 to 0.83)
Location: residential institution	0.86	(0.16 to 4.7)	1.42	(0.3 to 6.7	0.64	(0.11 to 3.86)	1.78	(0.61 to 5.21)
Location: street	0.55	(0.13 to 2.28)	1.6	(0.4 to 6.45)	0.76	(0.19 to 3.11)	1.12	(0.42 to 3.03)
Location: unspecified	0.23	(0.05 to 1.12)	67	(0.15 to 2.95)	0.33	(0.07 to 1.51)	0.4	(0.14 to 1.19
Trauma: burn	0	(0 to 0)	5.69*	(1.41 to 23)	5.77	(0.79 to 41.86)	4.28*	(1.06 to 17.29)
Trauma: other	0.61	(0.19 to 1.92)	0.36*	(0.15 to 0.87)	0.82	(0.34 to 1.99)	0.92	(0.57 to 1.5)
Trauma: penetrating	1.05	(0.43 to 2.56)	0.45*	(0.2 to 1)	1.18	(0.55 to 2.51)	0.79	(0.46 to 1.34)
Open: yes	1.56*	(1.06 to 2.29)	1.31*	(1.02 to 1.68)	1.63*	(1.16 to 2.29)	1.38*	(1.12 to 1.71)
Ankle: yes	1.86*	(1.13 to 3.06)	1.33*	(1.01 to 1.76)	0.85	(0.6 to 1.2)	0.96	(0.78 to 1.19)
Age	1.02*	(1.01 to 1.03)	1.01*	(1.01 to 1.02)	1.02*	(1.01 to 1.03)	1.02*	(1.02 to 1.03)
ISS	1.1*	(1.05 to 1.16)	1.14*	(1.10 to 1.17)	1.16*	(1.11 to 1.21)	1.21*	(1.18 to 1.24)
LOS	1*	(1 to 1)	1*	(1 to 1)	1*	(1 to 1)	1*	(1 to 1)
Hypertension requiring medication	2.21*	(1.52 to 3.2)	1.79*	(1.45 to 2.23)	2.34*	(1.69 to 3.24)	1.93*	(1.61 to 2.32)
Diabetes	2.09*	(1.32 to 3.3)	1.59*	(1.21 to 2.09)	1.54	(0.99 to 2.4)	1.71*	(1.37 to 2.15)
Alcohol use disorder	1.38	(0.7 to 2.74)	1.27	(0.84 to 1.92)	0.57	(0.23 to 1.39)	1.61*	(1.17 to 2.21)
Current smoker	0.33	(0.08 to 1.32)	0.93	(0.69 to 1.24)	1.19	(0.61 to 2.34)	0.84	(0.65 to 1.08)
COPD	1.56	(0.79 to 3.08)	1.81*	(1.31 to 2.49)	2.07*	(1.21 to 3.54)	1.65*	(1.25 to 2.19)
Bleeding disorder	2.56*	(1.12 to 5.82)	1.47	(0.9 to 2.39)	3.74*	(2.02 to 6.92)	3.34*	(2.5 to 4.47)
CVA	1.93	(0.61 to 6.1)	1.68	(0.83 to 3.38)	2.53*	(1.03 to 6.18)	1.79*	(1.01 to 3.18)
Steroid use	3.86	(0.54 to 27.88)	0.64	(0.09 to 4.58)	0	(0 to 0)	3.73*	(1.85 to 7.53)
CHF	2.29*	(1.01 to 5.23)	1.75*	(1.04 to 2.94)	2.7*	(1.37 to 5.31)	1.83*	(1.19 to 2.81)
MI	0.66	(0.09 to 4.73)	0.89	(0.28 to 2.77)	1.56	(0.5 to 4.9)	1.48	(0.7 to 3.13)
Disseminated cancer	2.41	(0.34 to 17.37)	1.53	(0.38 to 6.16)	1.87	(0.26 to 13.42)	0	(0 to 0)
Chronic renal failure	2.36	(0.33 to 16.95)	2.08	(0.93 to 4.68)	5.6*	(1.77 to 17.71)	2.23*	(1.15 to 4.31)
PVD	0	(0 to 0)	3.47*	(1.29 to 9.33)	42.31*	(5.33 to 336.04)	3.08*	(1.27 to 7.46)
History of angina within 30 days	0	(0 to 0)	2.05	(0.29 to 14.65)	10.57*	(1.44 to 77.61)	5.92*	(2.2 to 15.94)
Functionally dependent health status	3.5	(0.86 to 14.24)	1.73	(0.86 to 3.49)	4.1*	(1.3 to 12.94)	1.85*	(1.04 to 3.28)
Currently receiving chemotherapy for cancer	0	(0 to 0)	0	(0 to 0)	0	(0 to 0)	2.39	(0.59 to 9.64)
Closed reduction with fixation	1.96	(0.99 to 3.89)	1.22	(0.75 to 1.98)	1.17	(0.55 to 2.5)	1.42	(0.96 to 2.1)
Open reduction	1.64*	(1.1 to 2.46)	1.27*	(1.02 to 1.58)	0.76	(0.55 to 1.05)	0.91	(0.76 to 1.09)
Closed reduction without fixation	1.07	(0.68 to 1.69)	1.19	(0.93 to 1.52)	0.64	(0.4 to 1.04)	0.75*	(0.59 to 0.95)
Immobilization	0.91	(0.57 to 1.44)	1.14	(0.9 to 1.44)	1.22	(0.83 to 1.78)	1.07	(0.88 to 1.31)
Soft tissue	1.92*	(1.24 to 2.98)	1.33	(0.98 to 1.8)	1.64*	(1.09 to 2.46)	1.19	(0.91 to 1.56)
Other	0	(0 to 0)	0	(0 to 0)	0	(0 to 0)	0	(0 to 0)
Prophylaxis	6.84*	(2.51 to 18.69)	3.2*	(1.93 to 5.29)	9.72*	(4.5 to 20.97)	4.14*	(2.82 to 6.08)

Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; CHF, chronic heart failure; DVT, deep venous thrombosis; ISS, injury severity score; LOS, length of stay; MI, myocardial infarction; OR, odds ratio; PE, pulmonary embolism; PVD, peripheral vascular disease.
* Statistically significant relationship.

percentage of patients had to be excluded from both early cohort models due to missing data.

Adjusted Rates

After controlling for age, gender, and use of prophylaxis, the estimated rates of PE were 0.22% and 0.17% in the early and late cohorts, respectively (Table 10). These numbers increased to 0.34% and 0.22% among those with open injuries. Further, with prophylaxis use and controlling for age and gender, the rates rose to 1.36% and 0.5% in the 2 cohorts. There was little variability based on position of injury, except for forefoot, where rates of PE were much lower.

Although rates of DVT were higher than rates of PE, the patterns were similar. The overall population rates of DVT were 0.29% and 0.24% in the early and late cohorts, respectively; rates increased to 0.45% and 0.31% in those with open trauma. Prophylaxis further increased adjusted rates of DVT to 2.39% and 0.86%. In contradistinction to the case with PE, rates of DVT were higher in forefoot for both early and late cohorts.

Table 9
Multivariate risk factors for deep venous thrombosis and pulmonary embolism

	2007–2009		2010–2016	
	OR	95% CI	OR	95% CI
Pulmonary embolism				
Male vs female			1.64	(1.28 to 2.10)
University vs community			1.43	(1.1 to 1.85)
Home vs farm	0.22	(0.05 to 0.97)		
Burn vs blunt			5.6	(1.33 to 23.54)
Hypertension requiring medication			1.34	(1.02 to 1.77)
COPD			1.6	1.1308
Closed reduction with fixation	2.41	(1.05 to 5.53)		
Open reduction	1.99	(1.17 to 3.37)	1.38	(1.07 to 1.77)
Prophylaxis	6.85	(2.39 to 19.61)	2.03	(1.15 to 3.59)
Age	1.02	(1 to 1.03)	1.01	(1.01 to 1.02)
Injury severity score	1.1	(1.02 to 1.17)	1.1	(1.07 to 1.14)
Length of stay	1	(1 to 1)	1	(1 to 1)
	Missing: 37,536		Missing: 49,819	
Deep vein thrombosis				
Male vs female			1.63	(1.31 to 2.01)
Nonteaching vs community	0.41	(0.17 to 0.97)		
University vs community			0.76	(0.61 to 0.94)
Medicare vs BC/BS	3.81	(0.87 to 16.80)		
Bleeding disorder	3.12	(1.46 to 6.71)	2.1	(1.51 to 2.94)
History of angina within 30 days	14.82	(1.83 to 119.78)	3.29	(1.12 to 9.08)
Functionally dependent health status	6.88	(2 to 23.7)		
Closed reduction without fixation	0.51	(0.27 to 0.98)	0.65	(0.50 to 0.85)
Prophylaxis	16.47	(6.91 to 39.24)	4.46	(2.97 to 6.69)
Age	1.01	(1 to 1.03)	1.02	(1.01 to 1.02)
Injury severity score	1.15	(1.08 to 1.22)	1.6	(1.13 to 1.20)
Length of stay	1	(1 to 1)	1	(1 to 1)
	Missing: 42,499		Missing: 49,819	

Abbreviation: BC/BS, Blue Cross/Blue Shield; COPD, chronic obstructive pulmonary disease.

Achilles Tendon Injuries

The population with Achilles tendon injuries was very small (n = 244), precluding a very detailed analysis. However, as described in Table 11, certain differences compared with the general population are noteworthy. These patients were predominantly male (68.02%) compared with other patients in 2015 and 2016 (50.84%). They were more likely than other patients with foot and ankle injuries to be treated at university hospitals and were much more likely to have Medicaid or be self-pay, but they were less likely to be on Medicare. Although 92.62% of other injuries were blunt traumas, 27.59% of Achilles injuries were penetrating. Achilles injury patients were an average age of 32.62 (SD 19.16) years compared with other patients, who were an average age of 46.08 (SD 21.25) years. Rates of PE and DVT in the Achilles injury patients were both 0.4%, compared with 0.12% and 0.18%, respectively, in all other foot and ankle trauma patients.

Table 10
Adjusted rates of deep venous thrombosis and pulmonary embolism

		2007–2009	2010–2016
Pulmonary embolism, %			
Population		0.22	0.17
Open	Closed	0.2	0.16
	Open	0.34	0.22
Ankle	No	0.13	0.15
	Yes	0.24	0.18
Prophylaxis	No	0.22	0.17
	Yes	1.36	0.5
Position	Rear	0.24	0.18
	Mid	0.14	0.17
	Fore	< 0.01	< 0.01
Deep vein thrombosis. %			
Population		0.29	0.24
Open	Closed	0.25	0.22
	Open	0.45	0.31
Ankle	No	0.38	0.28
	Yes	0.27	0.23
Prophylaxis	No	0.27	0.23
	Yes	2.39	0.86
Position	Rear	0.27	0.23
	Mid	0.35	0.26
	Fore	0.5	0.26

Adjusted for age, gender, and prophylaxis.

Local Data

The 551 patients in our local trauma database were predominantly male and less likely to have ankle fractures than were those in the NTDB. They were more likely to be smokers and functionally dependent and less likely to have myocardial infarction, angina, or cancer. Treatment patterns differed greatly from those in the NTDB; local patients were treated twice as often with closed fixation and half as often with open procedures. They were also more often treated closed without fixation and immobilized. We also recorded 40.83% use of prophylaxis: 27 treated with heparin, 57 with enoxaparin sodium, 46 with sequential compression, and 43 with thromboembolic deterrent hose. Overall, 137 patients received some form of prophylaxis. Only 2 patients had a DVT, and none had a PE. One patient had a family history of DVT but did not personally have a DVT.

Discussion

Notable in our results are some changes in the underlying study populations. The percentage of patients on Medicare has increased, perhaps as a reflection of policy changes like the Patient Protection and Affordable Care Act. The quality of data reporting has improved, as evidenced by less missing data, specifically regarding comorbidities. The large changes in rates of hypertension, smoking, and COPD are more difficult to explain but may again be due to expanded coverage, and thus closer surveillance, after the Patient Protection and Affordable Care Act implementation. Alternately, as the NTDB continues to evolve, data capture and collection may be improving. It is also interesting to note that practice may be changing, as the rate of open surgeries decreased; we did not, however, examine this on a surgery-by-surgery basis. The finding that prophylaxis rates are increasing and that the local rates are so much higher than the national-level rates may point to policy changes or issues of coding. Hospitals have global/nonspecific DVT prophylaxis protocols, and these may be becoming more prevalent. As the quality of data improves, more care may have been taken in recording prophylaxis. In terms of our local database, we have access to medical records and can thus examine patient care with much finer granularity than in the NTDB.

Although risk factors for DVT and PE have changed slightly between the 2 NTDB study groups, some of the additional factors in the later data set may be arising because of additional power that comes with a larger data set. Less easy to explain is the vanishing significance of closed reduction with fixation for PE and Medicare and functionally dependent status for DVT. The former may be due to effective hospital protocols for prophylaxis, though we cannot assess this. On the other hand, most factors remained significant, and primary among these is prophylaxis. That the significance of prophylaxis is attenuated in the later data set is likely due to its broader utilization in that population. In our earlier work, prophylaxis was associated with DVT/PE, most likely because it was given to those patients at high risk for DVT. Prophylaxis then reduced risk, but that reduced risk was still greater than that in low-risk patients. This led to the protopathic bias that DVT occurred in higher rates among those with prophylaxis. Prophylaxis is now being given to a wider or greater

Table 11
Bivariate comparison between the Achilles and non-Achilles cohorts in 2015–2016

		Non-Achilles		Achilles		
		n	%	n	%	*p*
Gender	Female	23,592	49.16	79	31.98	<.001
	Male	24,395	50.84	168	68.02	
Status	Community	18,354	38.24	82	33.2	.001
	Nonteaching	8677	18.08	30	12.15	
	University	20,964	43.68	135	54.66	
Payment	Medicaid	6899	15.08	66	27.5	<.001
	Medicare	10,822	23.66	20	8.33	
	Not billed	123	0.27	1	0.42	
	Other	1542	3.37	4	1.67	
	Other government	1296	2.83	5	2.08	
	Private	19,966	43.65	110	45.83	
	Self-pay	5094	11.14	34	14.17	
Work related	No	42,953	93.65	207	91.19	.13
	Yes	2914	6.35	20	8.81	
Location	Farm	299	0.64	1	2.5	.444
	Home	17,864	38.27	20	50	
	Industry	1690	3.62	1	2.5	
	Mine	22	0.05	0	0	
	Other	2091	4.48	1	2.5	
	Public building	2302	4.93	1	2.5	
	Recreation	2859	6.12	4	10	
	Residential institution	827	1.77	0	0	
	Street	15,505	33.21	9	22.5	
	Unspecified	3224	6.91	3	7.5	
Trauma	Blunt	43,289	92.62	16	55.17	<.001
	Burn	34	0.07	0	0	
	Other	1642	3.51	5	17.24	
	Penetrating	1771	3.79	8	27.59	
Hypertension	No	33,319	70.23	208	85.25	<.001
	Yes	14,121	29.77	36	14.75	
Diabetes	No	41,276	87.01	228	93.44	.028
	Yes	6164	12.99	16	6.56	
Alcohol use disorder	No	44,893	94.63	237	97.13	.084
	Yes	2547	5.37	7	5.6	
Current smoker	No	37,662	79.39	193	79.1	.911
	Yes	9778	20.61	51	20.9	
Chronic obstructive pulmonary disease	No	44,382	93.55	239	97.95	.05
	Yes	3058	6.45	5	2.05	
Bleeding disorder	No	45,355	95.6	240	98.36	.036
	Yes	2085	4.4	4	1.64	
Cerebrovascular accident	No	46,657	98.35	243	99.59	.198
	Yes	783	1.65	1	0.41	
Steroid use	No	47,172	99.44	242	99.18	.403
	Yes	268	0.56	2	0.82	
Chronic heart failure	No	46,173	97.33	242	99.18	.073
	Yes	1267	2.67	2	0.82	
Myocardial infarction	No	46,996	99.06	244	100	.18
	Yes	444	1.42	0	0	
Disseminated cancer	No	47,256	99.61	125	100	1
	Yes	184	0.39	0	0	
Chronic renal failure	No	46,858	98.77	243	99.59	.38
	Yes	582	1.23	1	0.41	
Peripheral vascular disease	No	47,218	99.53	244	100	.634
	Yes	222	0.47	0	0	
History of angina within 30 days	No	47,416	99.95	244	100	1
	Yes	24	0.05	0	0	
Functionally dependent health status	No	46,372	97.75	240	98.36	.52
	Yes	1068	3.41	4	1.64	
Currently receiving chemotherapy for cancer	No	47,315	99.74	244	100	1
	Yes	125	0.26	0	0	
Prophylaxis	No	45,217	98	189	99.47	.193
	Yes	924	2	1	3.57	
Age		46.08	21.25	32.62	19.16	<.001
Injury severity score		5.61	3	6.09	2.91	.01
Length of stay		576.45	722.49	651.79	826.98	.154
Pulmonary embolism	No	47,337	99.88	246	99.6	.264
	Yes	58	0.12	1	0.4	
Deep venous thrombosis	No	47,310	99.82	246	99.6	.361
	Yes	85	0.18	1	0.4	

percentage of the patient population, including moderate- or low-risk patients for whom it is not a medical necessity.

Perhaps most importantly, while the adjusted rates for DVT and PE have decreased slightly across most groups, they align with both the literature and our clinical data on these topics. It is also possible that patterns of diagnosis are changing as well, leading to a more conservative reading of DVT. Our Achilles tendon population was younger than the rest of the population and much more likely to be on Medicaid. While the high percentage of patients with penetrating injuries is somewhat surprising, the rates of comorbidities are what one would expect, and this younger population reflected a lower burden of chronic disease.

The low rates of DVT and PE observed in our populations raise questions about the necessity of prophylaxis for these patients. In analyzing the occurrence of DVT in all trauma patients, Knudson et al (6) also surveyed providers regarding institutional procedures for prophylaxis. Many trauma services did have protocols, vastly preferring use of LMWH as either first- or second-line prophylaxis. The study also noted a relatively high rate of prophylactic use of vena cava filters. Additionally, DVT may be overdiagnosed in certain settings. Dietch et al (7) examined the use of lower extremity ultrasound in trauma patients and showed that high utilization centers tended to have higher rates of both DVT and PE. However, while the relationship between DVT and ultrasound remained significant on multivariate analysis, the relationship with PE did not, indicating that many DVTs, clinically or otherwise diagnosed, are not clinically significant. On the other hand, Allen and colleagues (8) compared a group of patients receiving weekly surveillance for DVT with venous duplex ultrasound with a group that did not and noted that screening appeared to be protective against PE. In particular, DVT rates in those with and without surveillance were 11.6% and 2.1%, respectively, whereas PE rates were 1.9% and 7%.

Prophylaxis for DVT/PE is not without risks. For example, heparin-induced thrombocytopenia is more common in orthopedic surgeries than in other types of surgery after the use of unfractionated heparin, with a rate estimated at 0.35% in trauma patients (25,26); this is higher than our observed rates of either DVT or PE. It is also possible that some postoperative wound dehiscence or hematoma formation can be caused by anticoagulation therapy. Vena cava filters come with risks such as filter displacement, hemorrhage, and vessel-injury thrombosis (27,28). In terms of the utility of prophylaxis, a recent study that looked at the cost-effectiveness of LMWH prophylaxis found that it was beneficial for Achilles tendon ruptures and ankle fracture, but the cost was > $50,000 per quality-adjusted life year (29).

The American College of Foot and Ankle Surgeons, the American Orthopaedic Foot and Ankle Society, and the American College of Chest Physicians all have position pieces suggesting lack of evidence for, or advocating against, routine chemical prophylaxis for DVT/PE (30–32). According to the American College of Foot and Ankle Surgeons , routine chemical prophylaxis is not advised, and its use should be based on individual risk profiles, as well as whether the patient is to be immobilized. They advocate that LMWH be used in preference to other chemical prophylaxis and suggest that vena cava filters be used only for the highest-risk patients. Duplex ultrasound should be used for higher-risk patients. In keeping with this stance, the American Orthopaedic Foot and Ankle Society argues that there is insufficient evidence to recommend for or against prophylaxis in general and that the choice should be based on individual patient risk profiles. They note as well that chemical prophylaxis comes with risk for major bleeding. Although their recommendations are based on low-quality evidence, the American College of Chest Physicians recommends that no prophylaxis be done in low-risk patients who will be immobilized, in preference to chemical prophylaxis. Mayle et al (33) suggest some concerns with earlier versions of this same recommendation, pointing out weaknesses of the studies on which it is based; they suggest the use of compression in those with risk of bleeding and advocate against the use of duplex before discharge.

The NTDB is a valuable resource, but some limitations in using this data set must be mentioned. The data records incidents, not patients; thus, any given patient may appear more than once, and this cannot be accounted for in our analysis. As the focus of medical care and research changes with changing populations and policies, so, too, do the data recorded by the American College of Surgeons in the database. Several variables available in the earlier version of the data set are no longer tracked, including obesity, impaired sensorium, ascites, and esophageal varices. Given that obesity is a risk factor for DVT, the omission of that variable is regrettable (34,35). NTDB only follows patients until their discharge from trauma; on the other hand, DVTs can manifest long after the precipitating event, and tend to be discovered on average 4 to 6 weeks after foot and ankle surgery (12,36–38). Further, there are many missing data, as is expected with such a large database, though this appears to be improving with time. Finally, in our utilization of the data, we decided to group immobilization with no treatment. This is, at least in part, justified by our assumption that immobilization might not in any case be coded and is borne out to an extent by the drastic difference in immobilization rates that we see in our local versus national data.

NTDB data remain relatively consistent in terms of the rates of DVT and PE after isolated foot and ankle trauma, although the rates of both have decreased slightly. Rates of prophylaxis appear to be higher in more current data, raising questions as to whether this increase is due to better coding, more routine prophylaxis, or hospital-level policy changes. The risk factors for DVT and PE also remained relatively consistent, whereas the necessity of routine prophylaxis remains debatable.

Acknowledgments

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