



Venous Thromboembolism After Degenerative Spine Surgery: A Nationwide Readmissions Database Analysis

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■ **BACKGROUND:** Venous thromboembolism (VTE) is an appreciable burden on health care. The protracted recumbency experienced by many spinal patients juxtaposed with concerns for postoperative hemorrhage from early anticoagulation results in conflicting stances regarding chemoprophylaxis. Identifying risk factors associated with VTE is therefore instrumental in guiding management.

■ **OBJECTIVE:** To identify VTE risk factors in patients undergoing degenerative spine surgery.

■ **METHODS:** The Nationwide Readmissions Database was searched for adults undergoing spine surgery for degenerative diseases between 2010 and 2014. The 30-day and 90-day VTE incidence was estimated from readmissions with new VTE diagnoses. A multivariate survey-adjusted logistic regression model was used to identify variables associated with VTE diagnoses on readmission.

■ **RESULTS:** Of 838,507 degenerative spine cases queried, 3499 patients (0.42%) were readmitted with a VTE diagnosis within 30 days and 4321 patients (0.62%) were readmitted within 90 days. In multivariate analysis, steroids were independently associated with a higher likelihood of readmission with VTE at both 30 days (odds ratio, 1.58; $P < 0.001$) and 90 days (odds ratio, 1.97; $P < 0.001$). Significant associations were also identified with thoracolumbar surgery, length of stay, and discharge to institutional care.

■ **CONCLUSIONS:** The incidence of readmission with VTE diagnoses in spine surgery is low. However, their devastating consequences underscore the need to identify those

patients deemed high risk. These patients include those having thoracolumbar surgery, of advanced age, with prolonged length of stay, using corticosteroids, and with a disposition to institutional care (e.g., skilled nursing facility or long-term acute care). Given the association between steroids and VTE, clinicians should be judicious about perioperative administration despite their obvious antiinflammatory benefits.

INTRODUCTION

Venous thromboembolism (VTE) comprises proximal and distal deep vein thromboses (DVTs) and their more sinister corollary, pulmonary embolism (PE). DVTs are the source of as many as 90% of PEs,¹ with the latter carrying a mortality of approximately 30%.^{2,3} Risk factors for VTE formation include restricted mobility from limb paresis or plegia, ventilator dependence, and poor baseline functional status.⁴⁻⁸ Although VTEs are common after major surgery,^{9,10} patients undergoing spine surgery often experience prolonged intraoperative and postoperative immobilization, which further predisposes them to thromboembolic complications.^{11,12} Despite the appreciable VTE risk, concerns for symptomatic surgical site hemorrhage with adverse neurologic sequelae can hamper widespread and early chemoprophylaxis use.¹³

Previous investigations have identified several associations with VTE, namely, neoplastic disease, infection, and advanced age.^{4,5,14-16} Other variables that have been implicated include increased procedure length and higher intraoperative blood

Key words

- Adult cohort
- Deep vein thrombosis (DVT)
- Nationwide database
- Pulmonary embolism (PE)
- Readmission
- Spine surgery
- Venous thromboembolism (VTE)

Abbreviations and Acronyms

DVT: Deep vein thrombosis

NRD: Nationwide Readmissions Database

NSQIP: National Surgical Quality Improvement Project

OR: Odds ratio

PE: Pulmonary embolism

VTE: Venous thromboembolism

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Table 1. International Classification of Diseases, Ninth Revision Diagnosis and Procedures Codes Used to Extract Index Cohort

Region	Diagnosis Code	Procedure Code
Cervical	721.0, 721.1, 722.0, 722.4, 722.71, 723.0, 723.4, 722.81, 723.1, 723.7, 738.2	80.50, 80.51, 81.00, 81.01, 81.02, 81.03, 81.31, 81.32, 81.33, 81.62, 81.63, 03.09, 80.51
Thoracolumbar	722.10, 722.11, 722.51, 722.52, 722.72, 722.73, 724.2, 721.3, 721.4, 721.41, 721.42, 738.4	81.04, 81.05, 81.06, 81.07, 81.08, 81.34, 81.35, 81.36, 81.37, 81.38, 03.09, 80.51

loss.^{6,16-18} However, many studies are limited to single-institution cohorts and, if conducted using national databases, are largely restricted to VTE incidents diagnosed during the index admission. Because VTEs frequently develop in a delayed fashion, sufficient postoperative follow-up is warranted to accurately capture VTE events attributable to spine surgery. Another challenge is that VTE events are frequently missed because of different-hospital follow-up; patients sought treatment at facilities outside the original center at which the index procedure was performed. Schairer et al.¹⁹ found that as many as 40% of patients with VTE diagnosed after discharge presented to a hospital other than the original institution at which surgery was performed. The Nationwide Readmissions Database (NRD) affords longitudinal follow-up within a calendar year and circumvents the challenges of different-hospital follow-up, because it assigns anonymized linkage numbers that enable patients to be tracked throughout a state irrespective of the institution at which care is being sought. We therefore endeavored to use the NRD to determine rates of hospital readmission with VTE diagnoses in patients undergoing elective spine surgery for degenerative diseases.

There are no universally accepted guidelines pertaining to VTE prophylaxis in spine surgery. Given the delicate balance between VTE risks and hemorrhagic complications, identifying potentially modifiable risk factors is central to risk stratification during the perioperative window. In this study, we evaluated from the NRD a large heterogeneous cohort of patients undergoing spine surgery to identify risk factors associated with postoperative VTE formation. The NRD is a pooled hospital admissions database featuring 20–27 states. De-identified patient data in this database permit researchers to track patient readmissions, thereby allowing accurate characterization of hospital readmission with VTE after surgery. The goals of this investigation were 1) to determine readmission rates with VTE diagnoses at 30 and 90 days after elective spine surgery for degenerative disease, 2) to characterize readmission trends, and 3) to analyze variables that were predictive of increased likelihood of VTE.

METHODS

Data Source

We queried the 2010–2014 cohorts of the NRD compiled by the Healthcare Cost and Utilization Project. This database assigns de-identified linkage numbers to all patients admitted to an inpatient facility in the 20–27 participating states and captures approximately 50% of admissions within the United States. Patients are tracked within state lines via these linkage numbers over the course of a single calendar year. All coding within the database meets quality assurance standards for hospital discharge.

Study Population

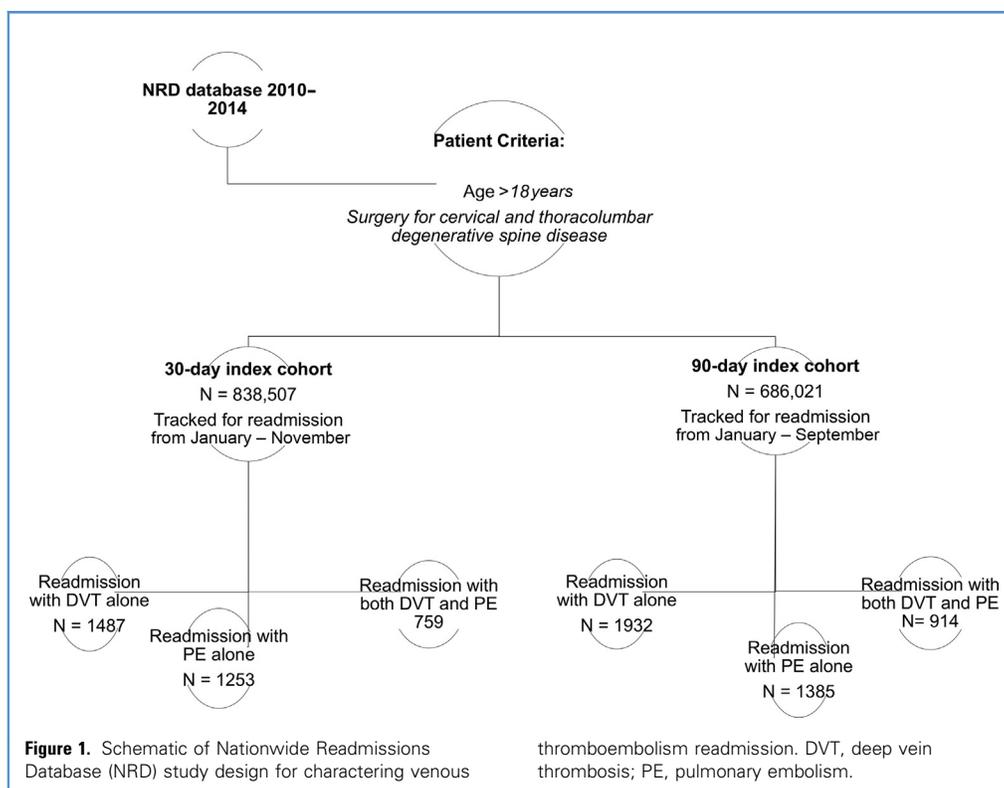
Primary inclusion criteria were patients older than 18 years who underwent elective spine surgery for degenerative disease. Patients were extracted using the corresponding International Classification of Diseases, Ninth Revision, Clinical Modification diagnosis and procedure codes detailed in [Table 1](#). These codes have previously been used in database studies of degenerative spine disease.²⁰ Index admission was defined as the initial hospitalization during which spine surgery was performed. Patients who died on index admission or who carried a diagnosis of acute or chronic VTE on index admission were excluded from our analysis. The remaining cohort was queried for 30-day and 90-day hospital readmissions with a new diagnosis of acute VTE (451.I, 451.IX, 451.2, 451.81, 451.83, 451.9, 453.2, 453.3, 453.4X, 453.6, 453.8X, 453.9, 415.I, 415.IX). The NRD tracks patients over a single calendar year; hence, only patients discharged between January and November were included in the 30-day readmission analysis and only patients discharged between January and September were included in the 90-day readmission analysis to allow for sufficient follow-up. Please see [Figure 1](#) for study design.

Patient and Hospital Demographics

Association analyses were performed for various patient, procedure, and hospital factors with the thrombotic events of interest. Variables identified as having an association with VTE in univariate analysis ($P < 0.15$) were subsequently factored into our multivariate model using 2-level mixed-effects modeling accounting for clustering. Hospital characteristics evaluated include teaching status and bed size (small, medium, or large). Demographic variables analyzed include gender and age categorized into the following cohorts: 18–44, 45–59, 60–74, and ≥ 75 years. Insurance payer type and median household income by ZIP code were also considered. Clinical variables such as underlying comorbidities (Elixhauser Index), length of stay, and discharge disposition were analyzed. In addition, clinical factors with a predisposition toward thrombosis were incorporated in our analysis: obesity^{16,21} (278.0, V85.3, V85.4), hypercoagulable state²² (289.81), steroid use^{8,23,24} (V58.65), systemic inflammatory response syndrome criteria^{6,8,19,25} (995.9x, 785.52), previous chemotherapy^{26,27} (V58.11, V87.41), ventilator dependence^{8,23} (V46.1x), and chronic lung disease²⁸ (CM_CHRNLUNG).

Statistical Analysis

The clinical outcome of interest in this study was readmission with VTE at 30 and 90 days after the index hospitalization. Readmissions were extracted from the NRD using standard



Healthcare Cost and Utilization Project methodology. In cases in which multiple admissions were identified, only the first readmission was included. Variables with $P < 0.05$ in univariate analyses were entered into the multivariate model. Multivariable analysis was performed using 2-level mixed-effects modeling accounting for clustering and reported using odds ratios (ORs) with 95% confidence intervals. Interactions between variables were tested to minimize the potential for confounding from collinearity. Statistical significance was defined as $P < 0.05$. All analysis was conducted with SAS 9.4 (SAS Institute Inc., Cary, North Carolina, USA).

RESULTS

Patient and Hospital Baseline Characteristics

A total of 838,507 spine operations for degenerative disease were identified that met our inclusion criteria (Table 2). Most were for thoracolumbar (61.4%, $n = 515,077$) followed by cervical disease (38.6%, $n = 323,430$). The median length of stay on index admission was 2 days, with a median cost of \$64,736. Most patients fell in the 45–74 years age cohort: 18–44 (19.7%), 45–59 (36.3%), 60–74 (33.5), and ≥ 75 years (10.5%). Both genders were approximately equally represented in our cohort: males (48.9%, $n = 410,331$) and females (51.1%, $n = 428,176$). Many patients had underlying comorbidities as identified by the Elixhauser Index (67.3%, $n = 564,607$). Most patients had either Medicare (37.1%, $n = 310,808$) or private insurance (42.7%, $n = 358,603$) and were treated at hospitals with a large bed size (64.5%, $n = 540,899$).

Rates of Hospital Readmission with VTE and Readmission Demographics

A total of 3499 patients were readmitted with VTE 30 days after discharge from the index hospitalization, with a corresponding incidence of 0.4%. Among patients with VTE, 1487 (42.5%) were readmitted with DVT alone, 1253 (35.8%) with PE alone, and 759 (21.7%) with both DVT and PE. The 30-day DVT and PE readmission rates were estimated to be 0.27% and 0.24%, respectively. The median time to readmission was 10 days, with a median readmission cost of \$34,000.

At 90 days, 4231 patients were readmitted with a diagnosis of VTE, corresponding to an incidence of 0.6%. There were 1932 patients (45.7%) with DVT alone, 1385 (32.7%) with PE alone, and 914 (21.6%) with both. The 90-day DVT and PE readmission rates were 0.41% and 0.34%, respectively. The median time to 90-day readmission was 17 days, with a median cost of \$34,266.

Factors Associated with Readmission with VTE within 30 and 90 Days

Various clinical factors were independently associated with VTE development (Tables 3–5). Operations for thoracolumbar disease carried a higher VTE risk relative to cervical procedures (OR, 1.19–1.26; $P < 0.001$). Patients on corticosteroids had nearly twice the odds of developing a VTE at both 30 days (OR, 1.58; $P < 0.0005$) and 90 days (OR, 1.97; $P < 0.0001$). Advanced age was also significantly associated with VTE readmission, with older patients (≥ 75 years) having nearly twice the odds compared with those 18–44 years (OR, 1.63–1.76; $P < 0.0001$). In addition, increased length of stay on index admission correlated with higher VTE

Table 2. Demographics of Patients Readmitted within 30 and 90 Days of Index Hospitalization

Variable of Interest	30 Days		90 Days	
	Number Readmitted	% Readmitted	Number Readmitted	% Readmitted
Anatomic location of disease				
Cervical	945	27.01	1195	28.24
Thoracolumbar	2554	72.99	3036	71.76
Age (years)				
18–44	434	12.4	472	11.16
45–59	934	26.69	1123	26.54
60–74	1434	40.98	1732	40.94
≥75	697	19.92	904	21.37
Gender				
Male	1852	52.93	2235	52.82
Female	1647	47.07	1996	47.18
Primary insurance				
Medicare	1772	50.64	2252	53.23
Medicaid	202	5.77	247	5.84
Private insurance	1176	33.61	1317	31.13
Self-pay	42	1.2	54	1.28
No charge	11	0.31	12	0.28
Other	289	8.26	340	8.04
Hospital bed size				
Small	353	10.09	418	9.88
Medium	773	22.09	944	22.31
Large	2373	67.82	2869	67.81
Teaching status				
Teaching	1983	56.67	2427	57.36
Nonteaching	1516	43.33	1804	42.64
Disposition				
Routine	1817	51.93	2102	49.68
Short-term hospital	39	1.11	49	1.16
Transfer other	919	26.26	1245	29.43
Home health care	720	20.58	831	19.64
Against medical advice	DS	DS	DS	DS
Volume				
>90th percentile	1344	38.41	1621	38.31
≤90th percentile (652/year)	2155	61.59	2610	61.69
Elixhauser comorbidity				
Yes	2701	77.19	3323	78.54
No	798	22.81	908	21.46
Medical complication				
Yes	157	4.49	214	5.06

Continues

Table 2. Continued

Variable of Interest	30 Days		90 Days	
	Number Readmitted	% Readmitted	Number Readmitted	% Readmitted
No	3342	95.51	4017	94.94
Neurologic complication				
Yes	160	4.57	191	4.51
No	3339	95.43	4040	95.49
Obesity				
Yes	17	0.49	23	0.54
No	3482	99.51	4208	99.46
Hypercoagulable state				
Yes	DS	DS	DS	DS
No	3493	99.83	4225	99.86
Index length of stay (days)				
0–1	475	13.58	577	13.64
2	511	14.6	618	14.61
3–4	1052	30.07	1245	29.43
≥5	1461	41.75	1791	42.33
Median household income for patient's ZIP code, based on current year				
0–25 percentile	780	22.29	969	22.9
26–50 percentile	778	22.23	981	23.19
51–75 percentile	944	26.98	1115	26.35
76–100 percentile	932	26.64	1090	25.76
Steroid use				
Yes	59	1.69	89	2.1
No	3440	98.31	4142	97.9
Systemic inflammatory response syndrome criteria				
Yes	42	1.2	59	1.39
No	3457	98.8	4172	98.61
History of chemotherapy				
Yes	13	0.37	17	0.4
No	3486	99.63	4214	99.6
Ventilator dependence				
Yes	DS	DS	DS	DS
No	3497	99.94	4229	99.5
Chronic lung disease				
Yes	562	16.06	738	17.44
No	2937	83.94	3493	82.56

DS, data suppressed according to Healthcare Cost and Utilization Project/Nationwide Readmissions Database regulations.

likelihood with stays ≥ 5 days having >3 -fold risk (OR, 3.42–3.68; $P < 0.0001$) compared with stays lasting 24 hours or less. Other factors with significant relationships with VTE include male

gender, presence of medical or neurologic complications, and final disposition with home health resources or to institutional care (e.g., skilled nursing or long-term acute-care facilities).

Table 3. Breakdown of Venous Thromboembolic Complications by Spine Region

Study Cohort	30-Day Readmission		90-Day Readmission	
	Deep Vein Thrombosis (Number of Events/Rate)	Pulmonary Embolism (Number of Events/Rate)	Deep Vein Thrombosis (Number of Events/Rate)	Pulmonary Embolism (Number of Events/Rate)
Cervical	574 (0.18)	574 (0.18)	777 (0.29)	665 (0.25)
Thoracolumbar	1672 (0.32)	1438 (0.28)	2069 (0.49)	1634 (0.39)

DISCUSSION

Unplanned hospital readmissions are a major source of patient morbidity and pose a substantial burden to the health care system.²⁹ In 2011 alone, the estimated cost associated with readmissions exceeded U.S. \$41 billion.³⁰ Because readmissions are increasingly being recognized as a surrogate for quality of care delivered, hospitals stand to face financial penalties from Medicare under the Hospital Readmissions Reduction Program, which endeavors to curb excessive 30-day readmissions.³¹ VTEs are a documented cause of unplanned readmissions in postsurgical cohorts.³² We therefore sought to evaluate the rates of hospital readmission with VTE in patients undergoing elective spine surgery for degenerative diseases as well as to identify risk factors predictive of thromboembolic complications.

VTE comprises DVT and PE. Because DVT formation uniformly precedes PE development, and both are subject to the same predisposing factors, they were analyzed as a single entity in our multivariate models. Previous estimates of VTE incidence in the spine surgery literature range from 0.3% to 31%.¹¹ This considerable variation is likely attributable to discrepancies in inclusion criteria,^{12,18,33-35} methods of VTE prophylaxis,^{18,36} and differences in screening criteria or modality for VTE detection.^{4,7,12,15,18,35,37} In our investigation, we determined 30-day and 90-day incidences of hospital readmission with VTE to be 0.4% and 0.6%, respectively. On further breakdown, the corresponding DVT rates at 30 and 90 days were 0.27% and 0.41%, whereas the PE rates over the same period were 0.24% and 0.34%. These figures are lower than rates reported by Piper et al. from a recent National Surgical Quality Improvement Project (NSQIP) database study⁵ in which their overall VTE incidence was 1.1% at 30 days, with DVT and PE rates of 0.8% and 0.4%, respectively. Reasons for this difference include but are not limited to restriction of our cohort to degenerative spine diseases alone versus a broader cohort in the study by Piper et al., use of *International Classification of Diseases, Ninth Revision* diagnosis and procedure codes for patient extraction in the NRD versus Current Procedural Terminology codes in NSQIP, and other differences in study methodology.

In a 2009 meta-analysis examining VTE events after spine surgery, a pooled DVT rate of 2.1% was found.¹¹ Although higher than our reported incidence, this study included variable follow-up as well as patients undergoing surgery for trauma and other cohorts with established propensity toward VTE development.¹¹ In addition, the meta-analysis included studies with scheduled Doppler surveillance for DVT detection, which is not standard practice in clinical settings. This factor might have contributed to

an artificial inflation of DVT incidence. We exclusively evaluated patients presenting for surgical management of degenerative spine disease. This criterion essentially excludes patients undergoing surgery for trauma, neoplasm, infection, and other risk factors implicated in VTE formation.^{5,16,19} We also excluded VTE events during the index admission, which might have underestimated true VTE incidence. Our decision to do so was predicated on the goal of this investigation, which was to identify predictors of hospital readmission with VTE after spine surgery. Although there is a potential for underestimating true VTE incidence in this manner, it also prevents overestimating of said events given that VTEs detected during the index stay could represent preexisting events that were already present before admission but that were then detected only on hospitalization.

Although the risk of VTE formation is low in patients undergoing spine surgery, it is not negligible and there is limited consensus regarding optimal prophylaxis.^{13,18,36,38-40} Because of the risk of clinically significant surgical site hemorrhage requiring take-back to the operating room, many clinicians are wary to institute aggressive chemoprophylaxis.¹³ Identification of high-risk VTE factors can therefore aid in tailoring medical management for high-risk patients. Patients who underwent thoracolumbar procedures were identified as having a higher likelihood for readmission with VTE than were those who had cervical procedures. Previous studies on DVT development after spine surgery have reported a similar outcome.^{7,18,35} The putative explanation for this observation is that prone intraoperative positioning exerts greater compression on the inguinal regions, with resultant venous stasis in the lower extremities.³⁵ In addition, and intuitively so, dissection of the larger lower back muscles is likely to result in higher pain sequelae and lower likelihood of ambulation in the immediate hours (or even days) after surgery. In this regard, thoracolumbar procedures show longer periods of postoperative immobility and therefore higher VTE risk.^{7,18}

In multivariate analysis, we found that corticosteroid use was independently associated with higher readmission rates with VTE diagnoses at both 30 and 90 days even after controlling for neurologic weakness as a confounding variable. Corticosteroids are used throughout spine surgery for their antiinflammatory effects to reduce mass effect on the spinal cord and exiting nerves in cases of pathologic compression. The association between steroid use and thromboembolic phenomena is not new. In a 2013 case-control study from Denmark,⁴¹ 70,000 patients were analyzed from the National Database of Reimbursed Prescriptions, in which patients could be identified as being “former,” “recent,” or “present” users of steroids. The investigators found that not

Table 4. Predictors of 30-Day Hospital Readmissions with Venous Thromboembolic Complications by Multivariate Analysis

Variables of Interest	Odds Ratio	95% Confidence Interval		P Value
Anatomic region				
Cervical	0.796	0.736	0.861	<0.0001
Thoracolumbar	Reference			
Age (years)				
45–59	1.078	0.96	1.211	0.2015
60–74	1.393	1.233	1.574	<0.0001
≥75	1.631	1.408	1.89	<0.0001
18–44	Reference			
Gender				
Male	1.336	1.249	1.43	<0.0001
Female	Reference			
Primary insurance				
Medicare	0.905	0.77	1.063	0.2241
Private insurance	0.928	0.797	1.081	0.3402
Self-pay	0.941	0.674	1.315	0.7224
No charge	1.558	0.844	2.875	0.1563
Other	0.758	0.632	0.91	0.0029
Medicaid	Reference			
Discharge disposition				
Short-term hospital	2.174	1.565	3.019	<0.0001
Transfer other	2.023	1.835	2.231	<0.0001
Home health care	1.227	1.117	1.348	<0.0001
Against medical advice	1.166	0.431	3.154	0.7626
Routine	Reference			
Medical complication				
Yes	1.243	1.052	1.467	0.0105
No	Reference			
Neurologic complication				
Yes	1.347	1.146	1.584	0.0003
No	Reference			
Index length of stay (days)				
2	1.687	1.485	1.916	<0.0001
Continues				

Table 4. Continued

Variables of Interest	Odds Ratio	95% Confidence Interval		P Value
3–4	2.173	1.933	2.443	<0.0001
≥5	3.676	3.261	4.144	<0.0001
0–1	Reference			
Steroid use				
Yes	1.582	1.22	2.052	0.0005
No	Reference			

only did steroid use correlate with VTE events but the temporality of use was also important: patients who were new to steroids (within 90 days) had the highest risk of VTE development. Other studies have also shown higher VTE incidence in patients with Cushing disease, further implicating corticosteroids in thromboembolic complications.⁴² The presumed explanation for this relationship is that steroids promote hypercoagulability via induction of factors VII, VIII, IX, von Willebrand factor, and thrombin.^{43–45} The increased VTE risk conferred by steroids, coupled with their ubiquity, calls for more judicious administration to surgical patients and represents a modifiable risk factor that should be capitalized on.

Consistent with other reports in the literature, we found that older age correlated with higher VTE rates.^{4,12,14,15,18,46} This is a well-established epidemiologic phenomenon, which has been partially attributed to the increased number of medical comorbidities in older patients. It follows, then, that the presence of medical or neurologic complications was also associated with higher VTE rates and that was the case in our study as well. Patients with neurologic deficits are more likely to experience extended periods of immobility, resulting in venous stasis and subsequent VTE formation. Likewise, patients subjected to conditions that are not conducive to native levels of mobility (such as being hospitalized for prolonged periods) also show higher rates of VTE. In our analysis, increased length of stay was proportionate with higher odds of VTE formation, because patients hospitalized for ≥5 days had a 3-fold to 4-fold higher chance of readmission with VTE. These findings are in line with the available literature, including a 2016 NSQIP study by Sebastian et al.¹⁶ in which spine patients hospitalized for longer than 6 days had a 4.07-fold higher risk of VTE development.

Patients discharged with home health resources or to institutional care (e.g., skilled nursing facility or long-term acute care) showed a higher likelihood of readmission with VTE. The risks conferred by institutional placement likely have to do with many of the same predisposing factors inherent to prolonged inpatient hospitalization. Regardless of resources, there are limitations to the level of individualized care that such facilities can provide compared with care for patients who are discharged home. Consequently, patients are inevitably at a lower functionality compared with their baseline. In a 2008 population-based study

Table 5. Predictors of 90-Day Hospital Readmissions with Venous Thromboembolic Complications by Multivariate Analysis

Variables of Interest	Odds Ratio	95% Confidence Interval		P Value
Anatomic region				
Cervical	0.838	0.78	0.899	<0.0001
Thoracolumbar	Reference			
Age (years)				
45–59	1.186	1.063	1.323	0.0022
60–74	1.479	1.318	1.66	<0.0001
≥75	1.758	1.534	2.015	<0.0001
18–44	Reference			
Gender				
Male	1.341	1.261	1.426	<0.0001
Female	Reference			
Primary insurance				
Medicare	0.913	0.789	1.057	0.2227
Private insurance	0.86	0.748	0.988	0.0333
Self-pay	1.001	0.744	1.347	0.9962
No charge	1.413	0.783	2.549	0.2506
Other	0.734	0.622	0.867	0.0003
Medicaid	Reference			
Discharge disposition				
Short-term hospital	2.327	1.734	3.122	<0.0001
Transfer other	2.386	2.185	2.605	<0.0001
Home health care	1.239	1.135	1.353	<0.0001
Against medical advice	1.017	0.377	2.739	0.9739
Routine	Reference			
Medical complication				
Yes	1.321	1.143	1.526	0.0002
No	Reference			
Neurological complication				
Yes	1.296	1.117	1.504	0.0006
No	Reference			
Index length of stay (days)				
2	1.683	1.499	1.889	<0.0001
Continues				

Table 5. Continued

Variables of Interest	Odds Ratio	95% Confidence Interval		P Value
3–4	2.041	1.834	2.272	<0.0001
≥5	3.418	3.064	3.814	<0.0001
0–1	Reference			
Steroid use				
Yes	1.967	1.588	2.436	<0.0001
No	Reference			

by Liebson et al.,⁴⁷ there was a strong association between recent hospitalization and VTE development in nursing home residents. These data highlight institutional discharge as a high-risk feature for VTE in perioperative cohorts. Vigilance for thromboembolic complications through early mobilization and mechanical and chemical prophylaxis should thus be maintained when transitioning patient care from inpatient to outpatient nursing and rehabilitation facilities.

Our study is limited by the constraints imposed by pooled databases, such as clerical errors of omission or inaccurate transcription. Although the NRD is the first nationwide database to specifically track hospital readmissions, patient linkage numbers are valid only for a single calendar year. Consequently, follow-up data on 30-day and 90-day readmissions do not extend beyond November and September, respectively, resulting in the potential for underreporting of readmission rates. In addition, the NRD allows patients to be tracked only within state lines. Patients who seek care at hospitals outside the original state are not captured in our analysis. Other potential limitations include the fact that certain demographic variables are omitted from NRD on account of patient confidentiality, which effectively limits any comprehensive analyses on socioeconomic variables, which potentially have a bearing on outcomes. The NRD does not provide details regarding VTE prophylaxis or other aspects of perioperative care. We are therefore constrained in our ability to draw correlations between events that were extracted and the corresponding clinical management that might have contributed to their occurrence.

CONCLUSIONS

Using the NRD, we determined the VTE incidence in patients undergoing elective spine surgery for degenerative disease and identified factors that predicted thromboembolic complications. The 30-day VTE incidence was 0.4%, with corresponding DVT and PE rates of 0.27% and 0.24%, respectively. The 90-day VTE incidence was 0.6%, with corresponding DVT and PE rates of 0.41% and 0.34%. Various procedure and patient-related factors correlated with increased likelihood for readmission with VTE after spine surgery, namely, thoracolumbar procedures, corticosteroid use, and disposition with home health resources or to institutional care. In addition, advanced age, presence of neurologic or medical

complications, and increased hospital length of stay correlated with higher odds of VTE. The association between steroids and VTE, coupled with their ubiquity in spine surgery, underscores

their importance as a potentially modifiable risk factor in VTE formation. Careful attention should be paid to balancing their antiinflammatory benefits against their potential for VTE.

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