Original Article

AOSPINE

Global Spine Journal
2019, Vol. 9(4) 409-416

DOI: 10.1177/2192568218797094
journals.sagepub.com/home/gsj
SAGE

Risk Factors for Postoperative Venous Thromboembolic Events in Patients Undergoing Lumbar Spine Surgery

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Abstract

Study Design: Retrospective, database study.

Objectives: The aim of this study was to investigate incidence and risk factors associated with venous thromboembolic events (VTEs) after lumbar spine surgery.

Methods: Patients who underwent lumbar surgery between 2007 and 2014 were identified using the Humana within PearlDiver database. ICD-9 (International Classification of Diseases Ninth Revision) diagnosis codes were used to search for the incidence of VTEs among surgery types, patient demographics and comorbidities. Complications including DVT and PE were queried each day from the day of surgery to postoperative day 7 and for periods 0 to 1 week, 0 to 1 month, 0 to 2 months, and 0 to 3 months postoperatively.

Results: A total of 64 892 patients within the Humana insurance database received lumbar surgery between 2007 and 2014. Overall VTE rate was 0.9% at 1 week, 1.8% at 1 month, and 2.6% at 3 months postoperatively. Among patients that developed a VTE within 1 week postoperatively, 45.3% had a VTE on the day of surgery. Patients with 1 or more identified risk factors had a VTE incidence of 2.73%, compared with 0.95% for patients without risk factors ($P < .001$). Risk factors associated with the highest VTE incidence and odds ratios (ORs) were primary coagulation disorder (10.01%, OR 4.33), extremity paralysis (7.49%, OR 2.96), central venous line (6.70%, OR 2.87), and varicose veins (6.51%, OR 2.58).

Conclusions: This study identified several patient comorbidities that were independent predictors of postoperative VTE occurrence after lumbar surgery. Clinical VTE risk assessment may improve with increased focus toward patient comorbidities rather than surgery type or patient demographics.

Keywords

risk factors, venous thromboembolic events, lumbar surgery, retrospective

Introduction

Spinal disorders are one of the most common musculoskeletal problems encountered by physicians in clinical practice today. National statistics collected by the US Department of Health and Human Services show an increased frequency of spinal fusion surgeries, irrespective of spinal level, during the past 20 years.[1] Between 2002 and 2009, the annual rates for fusion surgery were greatest for the lumbar spine compared to cervical and thoracic levels, increasing from 45 per 100 000 in 2002 to 72 per 100 000 in 2009.[2] Currently, the United States has the highest rate of spine surgery in the world with expenditures for spine-related disorders accounting for $200 billion in total costs from 2002 to 2004.[3]

Because of the high volume and cost of spine surgery, it is important to investigate and assess postoperative complications

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in these patients. Venous thromboembolic events (VTEs), including pulmonary emboli (PE) and deep venous thrombosis (DVT), are preventable complications associated with high morbidity and mortality despite advances in diagnosis and treatment. Although approximately 20% of patients present with a PE as the first sign of an underlying DVT, there are inconclusive data on the clinical relevance of an asymptomatic DVT.[4,5] The potential for clinically undetected DVTs to develop into life-threatening PEs highlights the importance of physicians to identify, preoperatively, patients who are at an increased risk of thromboembolic events after spine surgery.[6]

Preoperative risk assessment has been identified as a key component of preventing further increases in the incidence of DVT and PEs.[7] Both modifiable and nonmodifiable risk factors including immobility, obesity, advanced age and malignancy have been reported.[4,8-10] Thromboembolic prophylaxis is seldom used in spine surgery irrespective of a patient's preoperative risk due to possible spine epidural hematoma associated with prophylaxis. The American College of Chest Physicians (ACCP) updated guidelines suggest the use of mechanical prophylaxis alone in most patients undergoing spine surgery.[11]

Current literature regarding the risk factors and incidence associated with thromboembolic events after lumbar surgery is limited. Part of this difficulty may stem from the fact that thromboembolic events are rare complications and therefore require large sample sizes to detect a true difference in incidence between 2 cohorts. Previous database studies on thromboembolic complications after spine surgery have focused on general trends among all surgery types rather than examining incidence and timing specific to lumbar surgery. Therefore, the aim of the present study was to use the data collected in the PearlDiver database to determine if patient- or procedure-related risk factors exist for developing VTEs after lumbar spine surgery. Also, trends, epidemiology, and postoperative timing of VTEs after lumbar surgery were investigated.

Methods

We studied trends in the postoperative incidence of thrombotic complications, including DVT and PE, in patients undergoing lumbar surgery from 2007 to 2014. Institutional review board approval was not required based all the data was deidentified.

Data Sources

Patients who underwent first time isolated lumbar surgery from 2007 to 2014, including any of 5 types of single- or multilevel lumbar procedures (anterior lumbar interbody fusion [ALIF], posterior lumbar interbody fusion [PLIF], posterior lumbar fusion [PLF], discectomy [DISC] and laminectomy [LAMI]), were identified using the PearlDiver insurance database (PearlDiver Technologies, Inc, Fort Wayne, IN, USA). This is a publicly available insurance database which contains records primarily from private insurance Humana's nationwide member population. Between 2007 and 2014, the PearlDiver database recorded data from 6.3 million to 9.5 million Humana patients (2.1% to 3.0% of the US population) each year.

Procedure and Diagnosis Codes

Lumbar surgery cases from 2007 to 2014 were identified in the PearlDiver database with the use of Current Procedural Terminology (CPT) codes from the American Medical Association and diagnosis codes from the International Classification of Diseases, Ninth Revision (ICD-9-D). Lumbar surgeries were further sub-classified based on CPT codes into 5 types of instrumented and noninstrumented procedures (Appendix A). Patients classified in laminectomy or discectomy groups had these isolated procedures with all fusion surgeries excluded. Database search algorithms were coded to exclude patients with a history of prior lumbar surgery before the analyzed procedure and those with repeat lumbar surgery during the three-month postoperative follow-up period. Data on patient comorbidities was collected using ICD-9-D diagnosis codes. Patient demographics, including age (using 10-year groupings) and gender, were collected. Hospital data collected including location of surgery which was grouped by region in the database (Table 1).

Complication Codes

Complications, including DVT and PE, were queried each day from the day of surgery to postoperative day 7 and cumulatively for periods 0 to 1 week, 0 to 1 month, 0 to 2 months, and 0 to 3 months postoperatively (Appendix B). Patients were recorded as having a DVT only, DVT and PE, or PE only in each follow-up period.

Drug Codes

PearlDiver generic drug codes, including warfarin, heparin, and low-molecular-weight heparin, were queried for each patient on 2 days prior to surgery, day of surgery, and postoperative day 2.

Statistical Analysis

Data extracted from the PearlDiver database between 2007 and 2014 was pooled for analysis. Summary statistics, including VTE incidence rates and odds ratios (ORs), were calculated for risk factors and demographics. Pearson's chi-square test for independence was used to analyze significance of risk factors and gender on postoperative risk of VTE. All statistical analyses were performed in SPSS (Version 23.0, IBM Corp, Armonk, NY).

Results

A total of 64 892 patients were found in the PearlDiver database from 2007 to 2014 whom underwent one of the lumbar surgeries and met search criteria. Of these patients,

Table 1. Breakdown of Regions by State.

Region	States Included
Midwest	IA, IL, IN, KS, MI, MN, MO, NE, NO, OH, SD, WI
Northeast	CT, MA, ME, NH, NJ, NY, PA, RI, VT
South	AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV, PR
West	AK, AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY, HI

Table 2. VTE Incidence According to Age, Sex, Hospital Location, and Surgery Type.

		VTE Incidence (%) by Follow-up Period		
Characteristic	n	1 Week	1 Month	3 Months
Total	64892	0.93	1.83	2.57
Sex				
Male	31610	0.90	1.75	2.48
Female	33282	0.97	1.91	2.66
Age (y)				
40-49	5369	0.50	1.19	1.56
50-59	9506	0.60	1.18	1.82
60-69	20434	0.95	1.79	2.53
70-79	20431	1.14	2.29	3.21
80-89	4446	1.61	3.01	4.03
90+	744	1.88	2.96	3.63
Hospital location				
Midwest	17710	1.12	2.01	2.70
Northeast	1348	1.19	2.08	2.89
South	38916	0.82	1.70	2.42
West	6918	1.06	2.08	2.98
Surgery type				
ALIF	4095	1.27	2.78	3.69
Discectomy	18190	0.42	0.94	1.36
Laminectomy	21700	0.73	1.50	2.18
PLF	18983	1.31	2.46	3.39
PLIF	14643	1.30	2.38	3.26

Abbreviations: ALIF, anterior lumbar interbody fusion; PLF, posterior lumbar fusion; PLIF, posterior lumbar interbody fusion; VTE, venous thromboembolic event.

21778 underwent laminectomy, 18960 underwent PLF, 18261 underwent discectomy, 14738 underwent PLIF, and 4146 underwent ALIF (Table 2). Obtained data showed an increase in the number of lumbar surgeries performed annually during the 8-year period analyzed from N = 4846 in 2007 to N =12650 in 2014. Most common age groups identified in the database were aged 60-69 years (31.49%) and 70-79 years (31.49%). Fifty-one percent of patients included in this study were female. Hospital locations were recorded based on region; South (60.0% of patients), Midwest (27.2%), West (10.7%), and Northeast (2.1%). Database identified 58967 patients (90.87%) with one or more searched preoperative risk factors for a VTE (Table 3). Most common preoperative risk factors included hypertension (74.37%), hypercholesteremia (68.60%), tobacco smoking (31.16%), and obesity (22.40%).

Complications and Postoperative Timing

The PearlDiver database identified a total of 1994 VTEs (685 PE and 1259 DVT) in 1667 (2.6%) of these patients at 3-month follow-up. Annual VTE incidences ranged from 2.08% in 2007 to 2.74% in 2014 with all incidences by year differing by less than 1% (Figure 1). Patients with a VTE were recorded as having a DVT only (51.9%), DVT and PE (30.6%) or PE only (17.5%) in the follow-up period. Patients with VTE were recorded by follow-up period; 608 patients (36.5%) at 1 week, 582 new patients at 1 month (34.9%), and 477 new patients (28.6%) at 3-month follow-up. Among patients that developed a VTE within 1 week postoperatively, 45.3% (N = 263) had a VTE on the day of surgery (Figure 2).

Patients undergoing ALIF had a modestly higher VTE incidence (3.69%) compared with PLIF (3.26%) and PLF (3.39%) at 3-month follow-up (Figure 3). Overall, the lowest VTE incidence amongst lumbar surgeries was found for isolated laminectomy (2.18%) and discectomy (1.36%) procedures.

VTE incidences among age groups ranged from 1.56% in the 40- to 49-year age group to 4.03% in the 80- to 89-year age group. Data on VTE incidence in patients younger than 40 years was not obtained due to the low cohort sizes in these age brackets. No significant differences in incidences of VTE at 3-month follow-up were found between male (2.48%) and female (2.66%) patients ($P = .15$). Similar incidences of VTE were found among regions at three months follow-up and ranged from 2.49% in the South to 2.93% in the West.

Risk Factors

Patients identified in the database with one or more risk factors had a VTE incidence of 2.73%, compared with 0.95% for patients without risk factors ($P < .001$). Patients with each of the investigated preoperative risk factors had a higher than average VTE incidence, with the exception of tobacco smoking (Table 3). The risk factors associated with the highest VTE incidence and ORs at 3-month follow-up were primary coagulation disorder (10.01%, OR 4.33), extremity paralysis (7.49%, OR 2.96), central venous line (6.70%, OR 2.87), and varicose veins (6.51%, OR 2.58). All risk factors except for myocardial infarction ($P = .11$) and hypertension ($P = .19$) were significantly associated with postoperative VTEs based on Pearson's chi-square test of independence ($P < .001$). Tobacco smoking had the lowest VTE incidence (2.33%) and OR (0.87) among searched risk factors and was associated with decreased postoperative VTEs ($P = .01$).

Drug Prophylaxis

The PealDiver database found a total of 39 patients (0.06%) with VTE prophylaxis 2 days prior to surgery, 17 patients (0.03%) with VTE prophylaxis on day of surgery and 94 patients (1.5%) with VTE prophylaxis on postoperative day 2.

Table 3. VTE Incidence and Odds Ratios at 3-Month Follow-up by Risk Factor.

Risk Factor	n	VTE Incidence (%) by Follow-up Period			Odds Ratio [CI][a]	$P^{a,b}$
		1 Week	1 Month	3 Months		
No risk factor	59 25	0.34	0.69	0.95		
One or more risk factors	58 967			2.73	2.89 [2.21, 3.78]	**<.001**
Diabetes	20 582	1.02	2.04	3.02	1.28 [1.16, 1.42]	**<.001**
Hypercholesteremia	44 498	0.99	1.96	2.80	1.36 [1.21, 1.52]	**<.001**
Obesity	14 538	1.18	2.43	3.48	1.51 [1.36, 1.68]	**<.001**
Varicose veins	722	2.22	3.74	6.51	2.58 [1.91, 3.48]	**<.001**
Primary coagulation disorder	2178	3.49	7.44	10.01	4.33 [3.73, 5.03]	**<.001**
Hypertension	48 258	1.07	2.08	2.94	1.02 [0.91, 1.14]	.19
Heart failure	5146	1.50	3.24	4.53	1.89 [1.64, 2.17]	**<.001**
Arrythmia	13 709	1.51	2.77	3.98	1.81 [1.64, 2.02]	**<.001**
Pacemaker	1269	1.58	3.00	4.26	1.68 [1.27, 2.21]	**<.001**
Central venous line	3509	2.62	5.16	6.70	2.87 [2.49, 3.31]	**<.001**
Myocardial infarction	1216	0.99	2.14	3.29	1.29 [0.94, 1.77]	.11
Malignancy	2100	1.67	3.29	4.76	1.91 [1.55, 2.35]	**<.001**
Extremity paralysis	494	3.04	5.26	7.49	2.96 [2.11, 4.15]	**<.001**
Tobacco smoking	20 223	0.83	1.62	2.33	0.87 [0.78, 0.97]	**.01**

Abbreviation: VTE, venous thromboembolic event.
[a]Calculated using VTE data at 3-month follow-up.
[b]Based on Pearson's chi-square test for independence. *P* values in boldface indicate statistical significance.

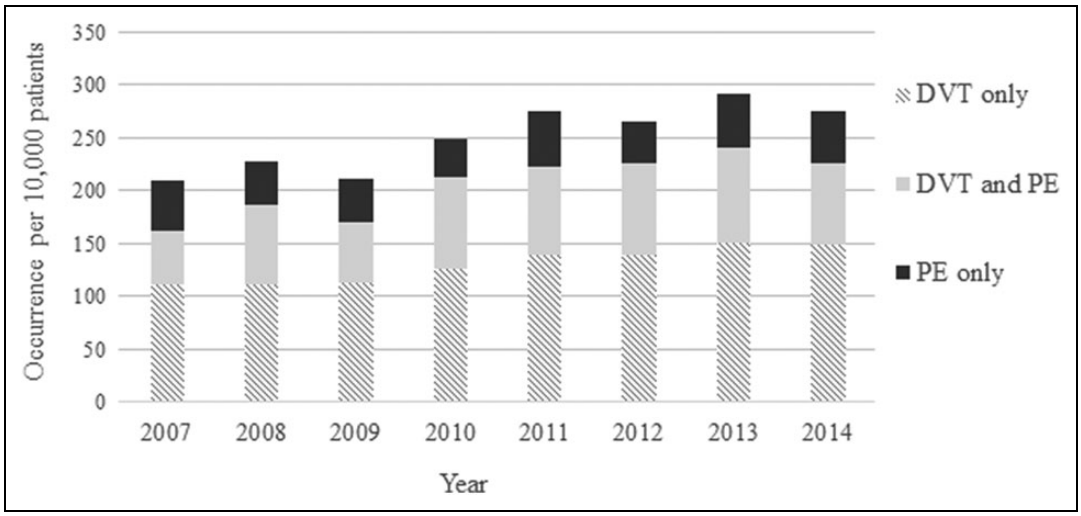

Figure 1. Incidence of venous thromboembolic events (VTEs) at 3-month follow-up based on year.

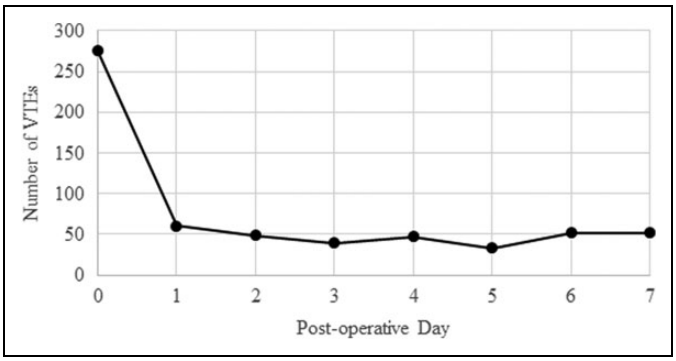

Figure 2. Venous thromboembolic event (VTE) complications by postoperative day.

Discussion

We found an overall VTE incidence of 2.57% at 3 months postoperatively in patients undergoing lumbar surgery between 2007 and 2014 in the Humana insurance database. Previous studies have reported VTE incidences after spine surgery from 0.3% to 8.3%[7,12-14] and specific to lumbar surgery from 0.2% to 4.3%,[15-17] consistent with our results. Hohl et al[18] reported a prevalence of developing a VTE was 1.5% in a case control study of 5766 patients whom underwent elective thoracolumbar degenerative spine surgery. Schoenfield et al,[19] in a retrospective study of National Surgical Quality Improvement Program data for 27 730 patients reported a VTE rate of 1%. They found body mass index

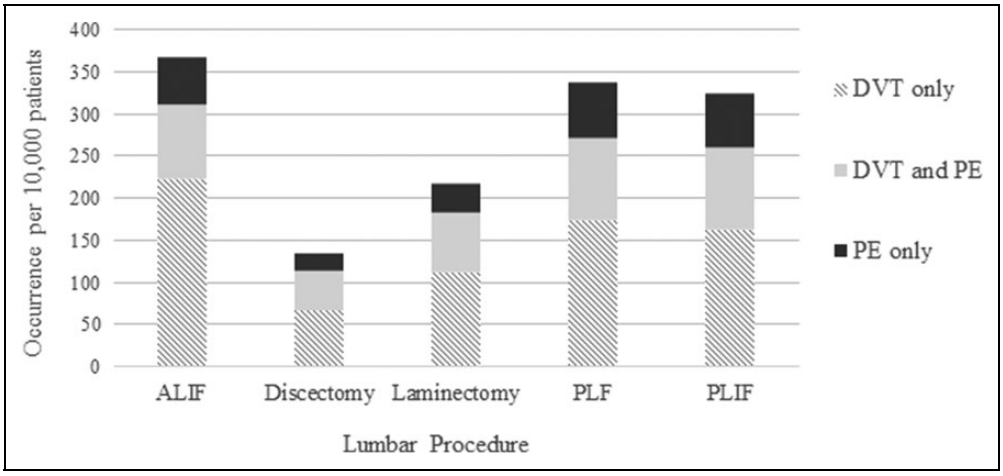

Figure 3. Incidence of venous thromboembolic events (VTEs) at 3-month follow-up based on lumbar surgery type.

greater than 40 kg/m^2 and operative time to be significantly associated with the development of both DVT and PE. Current ACCP guidelines estimate a 0.5% to 1.5% baseline risk for a symptomatic VTE after spine surgery, which increases to 2% in high-risk patients.[11] Although representative of a single private insurance database, results of our study indicate these guidelines may underestimate true VTE incidence rates in lumbar spine surgery. Similar incidences of postoperative VTEs were found among procedure type, age group, and gender groupings. Less invasive lumbar procedures, including isolated laminectomy and discectomy, had lower postoperative VTE incidences at all follow-up periods compared with fusion procedures. Interestingly, anterior lumbar interbody fusions were associated with only minor increases in VTE incidence (<1%) compared with posterior fusion procedures.

All searched patient risk factors except for tobacco smoking, hypertension, and myocardial infarction were significantly associated with postoperative VTEs based on Pearson's chi-squared tests. Four risk factors (varicose veins, extremity paralysis, primary coagulation disorder, central venous line) were associated with VTE incidences greater than 5% at 3-month follow-up. Goz et al[12] investigated patients at risk for a VTE after spinal fusion using the Nationwide Inpatient Sample database and found similar independent risk factors for VTE development. Both their overall VTE incidence (0.50%) and incidence rates for similar high-risk comorbidities (0.55%-5.98%) were substantially lower than results found in this study. However, patients were only followed until hospital discharge and therefore follow-up time was significantly shorter than in the present study. These numerical differences may reflect difficulties encountered when directly comparing database studies that are heterogeneous in study design, patient population, and follow-up. Nonetheless, both studies identify a common group of high risk patients that may benefit from stricter prophylaxis and screening measures after spine surgery.

Tobacco smoking was associated with a decreased risk of VTE based on our analysis and had the lowest VTE incidence among comorbidities and risk factors examined.[20] Although tobacco use is a well-established risk factor for atherosclerotic disease, its role as an independent risk factor or effect modifier for VTE remains controversial. Several prospective studies have reported smoking to be an independent risk factor,[21,22] whereas others failed to detect a significant relationship between smoking and VTE.[23,24] A recent meta-analysis found tobacco smoking to be associated with a slightly increased risk of VTE and reported a relative risk for developing a VTE of 1.17 when compared with nonsmokers.[20] It is possible that smokers tend to have a lower body mass index on average compared with nonsmokers, which may partially reduce the risk and mask the true association between smoking and VTE.[25]

However, because of the large-scale nature of this study the underlying etiology for the relationship found between tobacco smoking and VTE incidence cannot be determined.

VTEs that were recorded within 1 week postoperatively in the database were most commonly coded on the day of surgery. Bohl et al[26] found, in a retrospective study of 11 807 patients undergoing PLF, that the median day of diagnosis for DVT and PE were 5 and 10 days, respectively. However, their study did not report a breakdown of VTEs by postoperative day making it difficult to directly compare results. Our results indicate that patients undergoing lumbar surgery may be at increased risk of VTE on the day of surgery and could benefit from heightened clinical awareness among spine surgeons and health care providers during this postoperative time period. To the best of our knowledge, this is the first study to examine the incidence of VTEs after lumbar surgery by postoperative day.

PEs and DVTs are thought to represent 2 clinical manifestations of the same disease and it has been widely reported that approximately 90% of symptomatic pulmonary emboli arise from thrombi located in the leg veins.[27-29] Our study found that the diagnosis of DVT was present in 63.7% of patients with a postoperative PE after lumbar surgery. Ogelsby et al[13]

reported, in a study of patients undergoing cervical surgery, that the diagnosis of DVT was present in 21.7% of patients with a postoperative PE. A recent report from the Centers for Disease Control and Prevention demonstrated that DVT was diagnosed in only 28.3% of all admissions with a PE.[30] The etiology for the underreporting of DVTs in patients with PEs is multifactorial and likely not specific to spine surgery. First, studies have demonstrated that up to 50% of patients diagnosed with a PE will have no clinical evidence of DVT on ultrasound.[31] Furthermore, in patients with a diagnosis of PE there is typically no need to perform further testing to rule out a DVT because it has no effect on treatment or management.

This present study in addition to previous literature has identified multiple independent predictors for developing a VTE after lumbar spine surgery. Future studies using a similar analytical approach are needed to identify effective prophylaxis protocols and screening measures in these high-risk patients. More clinical data is required to determine if strict VTE prophylaxis is warranted in high risk patients despite possible complication of an epidural hematoma.

There are several limitations to this study, including those common to retrospective database studies. Available data was limited to certain demographics without the possibility to search for additional patient characteristics, outcomes, or hospital course information. This limits our ability to determine the impact of postoperative VTE on patient outcomes in lumbar surgery and to explain the underlying etiology of trends found. Because the PearlDiver database is dependent on ICD-9 and CPT coding, it is possible that provider bias or systematic errors in coding may have reduced the accuracy of patient information collected. Zhan et al[32] reported the sensitivity of ICD-9 coding for a PE was approximately 74% and for a DVT was approximately 67%. Research has shown that positive predictive values associated with many of the VTE-related ICD-9-CM codes used in this study may be between 75% and 95%.[33] The PearlDiver database is composed of records from private insurance companies and does not include Medicare patients, creating potential selection bias. However, results of this study can be used in conjunction with those from other Medicare database studies to gain a better representation of the entire patient population. Lack of data on VTE screening limits our understanding of whether patients were symptomatic at time of diagnosis. DVTs are often clinically silent and PEs may have varying and nonspecific clinical presentations that are challenging to diagnose. Therefore, it is likely that were a number of undiagnosed VTEs not accounted for by this study. The effectiveness of prophylaxis, diagnosis, and treatment measures could not be evaluated; these were outside the scope of this study. Prospective studies may be better designed to evaluate these interventions, but it may be difficult to obtain the sample size for adequate statistical power. Heterogeneity in surveillance and prophylaxis protocols in addition to intraoperative variables, including operative time, blood transfusion, and blood loss cannot be assessed. Despite its limitations, the present study provides useful information to the spine community and hopefully will aid in the design of future studies aimed at evaluating therapeutic and screening measures in high-risk patients undergoing lumbar surgery.

In conclusion, this study identifies several patient comorbidities that were independent predictors of postoperative VTE occurrence after lumbar surgery. Tobacco smoking was not predictive of increased VTE risk, which may reflect increased VTE preventative measures in this patient population. Similar incidences of VTEs were found among procedure type, age group, and gender compared with higher incidences and wider variation when stratifying by searched risk factors. Clinical VTE risk assessment may improve with increased focus toward select high-risk patient comorbidities instead of surgery type or patient demographics based on results of our study. Patients undergoing lumbar surgery may be at an increased risk of postoperative VTE occurrence on the day of surgery and could benefit from heightened surveillance during this time period. We believe our findings on incidence and timing of VTEs after lumbar surgery will provide useful information to clinicians when assessing patient risk in the pre- and postoperative periods.

Appendix A

ALumbar Surgery Procedure Codes.

Billing Code	Description
CPT-22 633	Arthrodesis, combined posterior or posterolateral technique with posterior interbody technique, including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression), single interspace, and segment; lumbar
CPT-22 634	Arthrodesis, combined posterior or posterolateral technique with posterior interbody technique including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression), single interspace and segment; each additional interspace and segment (list separately in addition to code for primary procedure)
CPT-22 630	Arthrodesis, posterior inter body technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; lumbar
CPT-22 632	Arthrodesis, posterior interbody technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; each additional interspace (List separately in addition to code for primary procedure)
CPT-22 558	Anterior approach for lumbar fusion
CPT-22 585	Arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); each additional interspace (list separately in addition to code for primary procedure)
CPT-22 612	Arthrodesis, posterior technique, lumbar (with lateral transverse technique, when performed)

(continued)

(continued)

Billing Code	Description
CPT-22 614	Arthrodesis, posterior or posterolateral technique, single level; each additional vertebral segment (list separately in addition to code for primary procedure)
CPT-63 030	Laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy, and/or excision of herniated intervertebral disc; 1 interspace, lumbar
CPT-63 035	Laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy, and/or excision of herniated intervertebral disc; each additional level
CPT-63 005	Laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (eg, spinal stenosis), 1 or 2 vertebral segments; lumbar, except for spondylolisthesis
CPT-63 012	Laminectomy with removal of abnormal facets and/or pars interarticularis with decompression of cauda equina and nerve roots for spondylolisthesis, lumbar (Gill-type procedure)
CPT-63 017	Laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (eg, spinal stenosis), more than 2 vertebral segments; lumbar
CPT-63 047	Laminectomy, facetectomy and foraminotomy (unilateral or bilateral with decompression of spinal cord, cauda equina and/or nerve root[s], [eg, spinal or lateral recess stenosis]), single vertebral segment; lumbar
CPT-63 056	Transpedicular approach with decompression of spinal cord, equina and/or nerve root(s) (eg, herniated intervertebral disc), single segment; lumbar (including transfacet, or lateral extraforaminal approach) (eg, far lateral herniated intervertebral disc)
CPT-63 087	Vertebral corpectomy (vertebral body resection), partial or complete, combined thoracolumbar approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic or lumbar; single segment
CPT-63 102	Vertebral corpectomy (vertebral body resection), partial or complete, lateral extracavitary approach with decompression of spinal cord and/or nerve root(s) (eg, for tumor or retropulsed bone fragments); lumbar, single segment
ICD-9-8051	Excision of intervertebral disk
ICD-9-8106	Lumbar and lumbosacral fusion of the anterior column, anterior technique (ALIF)
ICD-9-8107	Lumbar and lumbosacral fusion of the posterior column, posterior technique (PLF)
ICD-9-8108	Lumbar and lumbosacral fusion of the anterior column, posterior technique (PLIF/TLIF)
ICD-9-8162	Fusion or refusion of 2-3 vertebrae
ICD-9-8163	Fusion or refusion of 4-8 vertebrae
ICD-9-8164	Fusion or refusion of 9 or more vertebrae
ICD-9-0309	Other exploration and decompression of spinal canal

Appendix B

Complication Codes.

Billing Code	Description
Deep vein thrombosis	
ICD-9-45 340	Acute venous embolism and thrombosis of unspecified deep vessels of lower extremity
ICD-9-45 341	Acute venous embolism and thrombosis of deep vessels of proximal lower extremity
ICD-9-45 342	Acute venous embolism and thrombosis of deep vessels of distal lower extremity
ICD-9-45 382	Acute venous embolism and thrombosis of deep veins of upper extremity
ICD-9-45 384	Acute venous embolism and thrombosis of axillary veins
ICD-9-45 385	Acute venous embolism and thrombosis of subclavian veins
ICD-9-45 386	Acute venous embolism and thrombosis of internal jugular veins
ICD-9-45 387	Acute venous embolism and thrombosis of other thoracic veins
Pulmonary embolism	
ICD-9-41 512	Septic pulmonary embolism
ICD-9-41 511	Iatrogenic pulmonary embolism and infarction
ICD-9-41 513	Saddle embolus pulmonary artery
ICD-9-41 519	Other pulmonary embolism and infarction

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: ZB – Xenco Medical (consultancy), AO Spine (consultancy); JCL – Viseon (consulting); JCW – Royalties: Biomet, Seaspine, Amedica, DePuy Synthes; Investments/Options: Fziomed, Promethean, Paradigm Spine, Benvenue, Nexgen, Vertiflex, Electrocore, Surgitech, Expanding Orthopedics, Osprey, Bone Biologics, Pearldiver; Board of Directors: North American Spine Society, North American Spine Foundation, AO Foundation, Cervical Spine Research Society; Fellowship Funding (paid to institution): AO Foundation.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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