Risk Factors for Venous Thromboembolism following Thoracolumbar Surgery: Analysis of 43,777 Patients from the American College of Surgeons National Surgical Quality Improvement Program 2005 to 2012

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Abstract

Study Design Retrospective clinical study of a prospectively collected, national database.

Objective Determine the 30-day incidence, timing, and risk factors for venous thromboembolism (VTE) following thoracolumbar spine surgery.

Methods The American College of Surgeons National Surgical Quality Improvement Program Participant Use File identified 43,777 patients who underwent thoracolumbar surgery from 2005 to 2012. Multiple patient characteristics were identified. The incidence and timing (in days) of deep vein thrombosis (DVT) and pulmonary embolus (PE) were determined. Multivariable regression analysis was performed to identify significant risk factors.

Results Of the 43,777 patients identified as having had thoracolumbar surgery, 202 cases of PE (0.5%) and 311 cases of DVT (0.7%) were identified. VTE rates were highest in patients undergoing corpectomy, with a 1.7% PE rate and a 3.8% DVT rate. Independent risk factors for VTE included length of stay (LOS) $\geq$ 6 days (odds ratio [OR] 4.07), disseminated cancer (OR 1.77), white blood cell count $>$ 12 (OR 1.76), paraplegia (OR 1.75), albumin $<$ 3 (OR 1.73), American Society of Anesthesiologists class 4 or greater (OR 1.54), body mass index $>$ 40 (OR 1.49), and operative time $>$ 193 minutes (OR 1.43). LOS $<$ 3 days was protective (OR 0.427).

Conclusions We report an overall 30-day PE rate of 0.5% and DVT rate of 0.7% following thoracolumbar spine surgery. Patients undergoing corpectomy were at highest risk for VTE. Multiple VTE risk factors were identified. Further studies are needed to develop algorithms to stratify VTE risk and direct prophylaxis accordingly.

Keyword
- ACS-NSQIP
- thoracolumbar surgery
- venous thromboembolism
- VTE

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Introduction

Venous thromboembolism (VTE) is a significant cause of postoperative morbidity and mortality following orthopedic surgery. The incidence of VTE, which includes deep vein thrombosis (DVT) and pulmonary embolus (PE), following major joint arthroplasty is well defined in the literature.[1] However, the reported incidence of VTE following spine surgery is highly variable, with rates ranging between 0.3 and 31%.[2] The variability in reported rates is secondary to heterogenous studies involving specific subgroups and various surveillance methods.[2,3] Although less is known about VTE following spine surgery, patients undergoing spinal surgery are subject to longer operative times and often prolonged immobilization, potentially placing them at increased risk.[4] In fact, recent studies have shown that the incidence of VTE following spine surgery may be higher than previously reported.[5,6] The issue of VTE following spine surgery is even more complex because postoperative anticoagulation may increase the risk of postoperative epidural hematoma, a rare but potentially devastating complication.[7,8]

Multiple studies have examined the incidence of VTE and associated risk factors following thoracolumbar surgery.[9] However, many of the studies are limited to specific cohorts of patients such as those with oncologic conditions, thoracolumbar trauma, or deformity.[10,11] Of the studies with broader inclusion criteria and larger patient cohorts, many utilize databases that rely on the International Classification of Diseases, Ninth Revision coding to define VTE incidence and risk factors instead of clinically abstracted data limiting the utility of the obtained results.[4,12] More work is needed to define VTE rates following thoracolumbar surgery and to define independent risk factors that might help identify vulnerable patients who may require more aggressive screening surveillance or prophylaxis.

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) has been used effectively to study postoperative outcomes following spine surgery.[13,14] The ACS-NSQIP is well suited to studying postoperative VTE. The ACS-NSQIP tracks 30-day outcomes prospectively, and it is subject to rigorous oversight and external validation. In addition, the ACS-NSQIP has been used to examine complications following thoracolumbar surgery.[13] However, no previous studies have used the ACS-NSQIP specifically to examine VTE incidence following thoracolumbar surgery, the timing of VTE, and associated risk factors.

Materials and Methods

After Institutional Review Board approval, we identified patients who underwent thoracic and/or lumbar (thoracolumbar) spine surgery from the 2005 to 2012 ACS NSQIP Participant Use File by using Current Procedural Terminology codes (see online ►**supplementary Table 1**). The surgical procedures were broken down into categories to include posterior decompression, posterior spinal fusion, posterior interbody fusion (including posterior and transforaminal interbody fusions), anterior interbody fusion, corpectomy, oncologic surgery, transpedicular decompression, lateral extracavitary arthrodesis, disk arthroplasty, and spinal deformity surgery including spinal osteotomies. The ACS-NSQIP specifically excludes admissions for trauma, and so patients undergoing operations for spine trauma were excluded from this cohort. A detailed list of Current Procedural Terminology codes utilized is presented in the online supplementary Table 1.

The ACS NSQIP Participant Use File is deidentified and was therefore deemed exempt by our institutional review board. Patient demographic information including age, sex, ethnicity, and medical comorbidities was obtained in addition to preoperative laboratory values, transfusion data, operative characteristics, and length of stay data. The incidence and timing of 30-day postoperative DVT and PE were determined using established criteria from the ACS NSQIP database for each of the procedural categories. Detailed data on 30-day unplanned readmissions for the cohort was available from 2011 to 2012.

Following descriptive analysis, patient characteristics were broken down into categorical variables, and chi-square tests were used to determine the characteristics of patients who suffered a VTE event within 30 days of surgery. Continuous variables were tested with a *t* test to determine significance. Based on the findings of univariate analysis, multivariable logistic regression analysis was performed to identify the independent risk factors for VTE events. The findings were considered statistically significant when $p < 0.05$. The analysis was conducted using SAS software, version 9.3 (SAS, Cary, North Carolina, United States).

Results

A total of 43,777 patients were identified in the ACS-NSQIP as having undergone thoracolumbar spinal surgery between 2005 and 2012. VTE events within 30 days postoperatively occurred in 453 patients (1.0%), with 311 patients (0.7%) having a DVT and 202 patients (0.5%) having a PE. Overall, the mean time to diagnosis of DVT took 10.3 ± 7.4 days, and the mean time to diagnosis of PE took 9.4 ± 7.3 days. The most common procedures were posterior decompression (65.2%), posterior fusion (15.4%), and posterior interbody fusion (8.4%). The lowest VTE rates were observed in the posterior decompression group with a DVT rate of 0.5% and a PE rate of 0.3%. In contrast, the highest VTE rates were in the corpectomy group with a DVT rate of 3.8% and a PE rate of 1.7% (►**Table 1**).

The average age of the cohort was 57.1 ± 15.3 years with 48.6% of patients being female. Morbid obesity, with a body mass index (BMI) > 35, was identified in 19.2% of patients. Other comorbidities identified were smoking (23.1%), diabetes mellitus (15.2%), and peripheral arterial disease (0.5%). The majority of patients were American Society of Anesthesiologists (ASA) class 1 or 2 (59.0%). Bleeding disorders were present in 1.7% of patients, with 0.3% of patients undergoing transfusion for bleeding (≥4 U) postoperatively. In addition, 2.6% of patients were identified as paraplegic and 0.1% were quadriplegic. The mean operative time was 152.3 ± 103.3 minutes with a mean length of stay of 2.9 ± 4.0 days. From 2011 to 2012, 28% of patients with postoperative VTE underwent an unplanned readmission.

Table 1 VTE rates following thoracolumbar spine surgery

Procedure	*n*	PE rate	Days until PE	DVT rate	Days until DVT
Total	43,777	202 (0.5%)	9.4 ± 7.3	311 (0.7%)	10.3 ± 7.4
Posterior decompression	28,529	98 (0.3%)	9.7 ± 7.5	149 (0.5%)	10.5 ± 7.6
Posterior fusion	6,746	47 (0.7%)	10.4 ± 8.1	70 (1.04%)	11.0 ± 7.2
PLIF/TLIF	3,689	22 (0.6%)	7.7 ± 5.8	29 (0.8%)	7.9 ± 6.4
AIF	2,179	13 (0.6%)	7.2 ± 5.4	12 (0.6%)	9.8 ± 5.4
Corpectomy	474	8 (1.7%)	12.4 ± 8.1	18 (3.8%)	8.9 ± 7.5
Oncologic	920	5 (0.5%)	8.8 ± 6.4	22 (2.4%)	12.6 ± 8.6
Transpedicular decompression	823	7 (0.9%)	6.0 ± 5.3	8 (1.0%)	7.9 ± 6.7
Lateral extracavitary arthrodesis	194	1 (0.5%)	14.0 ±	2 (1.0%)	15.0 ± 1.4
Disc arthroplasty	120	1 (0.8%)	6.0 ±	1 (0.8%)	6.0 ±
Spinal deformity	1,138	11 (1.0%)	9.5 ± 7.3	20 (1.8%)	10.6 ± 7.3
Anterior osteotomy	312	1 (0.3%)	9.0 ±	5 (1.6%)	10.2 ± 5.2
Posterior osteotomy	209	2 (1.0%)	2.5 ± 3.5	11 (1.8%)	11.3 ± 7.1

Abbreviations: AIF, anterior interbody fusion; DVT, deep vein thrombosis; PE, pulmonary embolus; PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion; VTE, venous thromboembolism.

Table 2 Univariate analysis of risk factors for VTE

Variable	VTE ($n = 43,324$)	No VTE ($n = 453$)	*p* value
Age > 70 y	9,164 (21.2%)	142 (31.3%)	<0.001
African American	2,599 (6.0%)	44 (9.7%)	<0.001
BMI			
> 35	8,296 (19.1%)	126 (27.8%)	<0.001
> 40	3,117 (7.2%)	62 (13.7%)	<0.001
Hypertension	21,558 (49.8%)	284 (62.7%)	<0.001
Insulin-dependent diabetes	2,100 (4.8%)	38 (8.4%)	<0.001
Cancer	572 (1.3%)	41 (9.1%)	<0.001
Chronic steroid use	1,555 (3.6%)	37 (8.2%)	<0.001
Bleeding disorders	717 (1.7%)	19 (4.2%)	<0.001
Transfusions	135 (0.3%)	5 (1.1%)	0.012
Recent operation	310 (0.7%)	11 (2.4%)	<0.001
Albumin < 3	506 (1.2%)	36 (7.9%)	<0.001
Hematocrit < 33	1,806 (4.2%)	50 (11.0%)	<0.001
Platelets < 100	259 (0.6%)	9 (2.0%)	<0.001
INR > 1.6	26,049 (60.1%)	330 (72.8%)	<0.001
Operative time (min)	151.4 ± 102.3	233.2 ± 149.2	<0.001
Length of stay (d)	2.9 ± 3.8	8.7 ± 9.9	<0.001
Paraplegia	1,084 (2.5%)	42 (9.3%)	<0.001

Abbreviations: BMI, body mass index; INR, international normalized ratio; VTE, venous thromboembolism.

Univariate analysis of the patient factors revealed several associated factors (►**Table 2**). Of note, age > 70 years (31.3%, $p < 0.001$) and African American race (9.7%, $p < 0.001$) were associated with VTE. Multiple medical comorbidities were also identified as potential risk factors, including morbid obesity (BMI > 35, 27.8%, $p < 0.001$), hypertension (62.7%, $p < 0.001$), diabetes (20.8%, $p < 0.001$), and disseminated cancer (9.1%, $p < 0.001$). Several preoperative laboratories were significant including hematocrit < 33 (11.0%, $p < 0.001$), international normalized ratio > 1.6 (72.8%, $p < 0.001$), and platelets < 100

(2.0%, $p < 0.001$). Perioperative factors that were associated with VTE included longer operative times (233.2 ± 149.2 minutes, $p < 0.001$) and length of stay (8.7 ± 9.9 days, $p < 0.001$).

Multivariable logistic regression analysis identified several independent predictors of VTE. Medical comorbidities that were predictive included disseminated cancer (odds ratio [OR] 1.77, $p < 0.001$), ASA class 4 or greater (OR 1.54, $p = 0.035$), and BMI > 40 (OR 1.49, $p = 0.030$). Preoperative laboratory values predictive of VTE included white blood cell count > 12 (OR 1.76, $p < 0.001$) and albumin < 3 (OR 1.73, $p = 0.012$). Perioperative factors including operative time > 193 minutes (OR 1.43, $p = 0.050$), paraplegia (OR 1.75, $p = 0.003$), and length of stay 6 days or greater (OR 4.07, $p < 0.001$). Of note, length of stay less than 3 days was protective (OR 0.427, $p < 0.001$). When the spinal deformity cohort was analyzed separately, bleeding disorders were predictive of VTE (OR 5.86, $p = 0.008$).

Discussion

The rates of VTE following spine surgery reported in the literature are highly variable, which is likely a result of heterogenous methodologies, many of which incorporate screening surveillance methods or evaluate specific patient subgroups.[2,3] Of the larger database studies available, many rely on administrative data that only captures in-hospital complications and is subject to high degrees of discordance and coding errors.[4,12,15] Utilization of the ACS-NSQIP database in this study allowed many of these limitations to be avoided. This large cohort of 43,777 patients represents thoracolumbar surgery performed at over 400 institutions across the country. In addition, standardized follow-up to 30 days postoperatively and rigorous oversight of the ACS NSQIP database ensures that the results presented are valid.[16–18] To the authors' knowledge, this study is the first using the ACS-NSQIP to examine VTE specifically in a broad group of thoracolumbar patients.

Although the overall rate of VTE (1.0%) was low in this retrospective study, there was considerable variation in VTE rates by procedural group with rates as low as 0.8% in the posterior decompression group and rates as high as 5.5% in the corpectomy group. This result is consistent with previous studies that have shown higher VTE rates in patients undergoing higher morbidity surgery, such as those associated with deformity, cancer, or trauma.[19–21] In fact, VTE has been demonstrated as being higher in patients who undergo corpectomy in comparison with posterior procedures in both the cervical and thoracolumbar spine.[13,22] Of note, our corpectomy cohort included various anatomic approaches such as transthoracic, retroperitoneal, and lateral extracavitary approaches. This study also demonstrates higher rates of VTE in spinal deformity cases (2.8%), which is also consistent with previous reports in the literature.[23]

An important finding to highlight is the average time to diagnosis of VTE. Both DVT and PE were diagnosed at an average of around 10 days postoperatively. Given that the average length of stay was around 3 days, it is clear that a large percentage of VTE events occur after discharge. This finding is consistent with previous studies showing that nearly one-half of VTE diagnoses are made postdischarge.[12] These findings highlight the importance of educating patients on the signs and symptoms of VTE following spine surgery and surveillance in the outpatient setting. As a result, a significant unplanned readmission rate (28%) associated with postoperative VTE was identified in this study. This finding is of critical importance. Although studies have shown that most VTE events do not result in mortality, they do incur significant additional medical costs and the potential for increased morbidity. As spine surgery moves into an era in which reimbursement is increasingly linked to performance measures, readmissions for postoperative complications may also lead to lost reimbursement.[24]

Several independent risk factors for VTE following thoracolumbar surgery were identified. Several medical comorbidities were identified including cancer, higher ASA class, and very severe obesity (BMI > 40). Cancer has been demonstrated as risk factor for VTE in multiple studies in orthopedic surgery. The reasons are likely multifactorial and are related to induced hypercoagulability, adjuvant therapies, and immobility.[25] Recent literature has shown obesity to be a risk factor for major postoperative complications.[26] Evidence has shown that obesity is a proinflammatory and prothrombotic condition. Central obesity in particular is a well-known risk factor. Obesity-related comorbidities including atherosclerosis and hypertension may predispose obese patients to VTE.[27]

Preoperative laboratories including white blood cell count > 12 and albumin < 3 were also identified as independent risk factors for VTE. Although these results are more difficult to interpret, leukocytosis may be a surrogate for infection. Studies have shown that infection causes both venous stasis as well as a hypercoagulable state.[28,29] In fact, Schmidt et al demonstrated a higher rate of VTE following acute respiratory and urinary tract infections.[29] Hypoalbuminemia is found in malnutrition and may be representative of overall poor health or medical comorbidities such as cirrhosis. In addition, low albumin may lead to peripheral edema and possibly increased venous stasis, another known risk factor for VTE.[30,31]

Paralysis has been well demonstrated as a risk factor for VTE following spine surgery.[32,33] As a result, a more aggressive approach toward VTE surveillance and prophylaxis is often undertaken in this patient population.[8,34] Other perioperative factors predictive of VTE included longer operative times and length of stay. The importance of surgical efficiency in minimizing postoperative complications has been well described. Previous studies in arthroplasty surgery have shown higher VTE rates associated with longer operative times.[35] Although this finding could certainly be confounded by increased case complexity, it highlights the importance of monitoring for VTE more carefully after longer cases. Similarly, longer length of stay was also predictive of VTE. Although this finding may represent increased stay for treatment of VTE, as previously discussed, most of the VTE events were diagnosed postdischarge. In addition, length of stay less than 3 days was protective, which indicates that other factors associated with longer lengths of stay including more

complex cases, increased immobilization, and in-hospital complications other than VTE may be responsible.

This study does have some important limitations. The ACS-NSQIP does not collect data regarding mechanical or pharmacologic VTE prophylaxis. Thus, no recommendations regarding prophylaxis, either mechanical or pharmacologic, can be made as a result of this study. In addition, other factors of interest to surgeons such as intraoperative blood loss and use of antifibrinolytics are not captured in ACS-NSQIP.

In conclusion, in this retrospective study of 43,777 patients who underwent thoracolumbar surgery, we report an overall 30-day PE rate of 0.5% and a DVT rate of 0.7%. Postoperative VTE resulted in a 28% unplanned readmission rate. A higher risk of VTE was identified in patients undergoing corpectomy or deformity surgery. Multiple independent risk factors for VTE were identified. Of note, the patients with length of stay 6 days or greater were more than four times as likely to suffer a VTE event. Future studies directed at the development of VTE risk calculators may aid in updating the current recommendations regarding VTE prophylaxis.

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