

ORIGINAL ARTICLE

Frequency of venous thromboembolism risk factors assessed by the Caprini Score in patients undergoing elective lumbar spine surgery.

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ABSTRACT... Objective: To quantify the frequency of venous thromboembolism risk factors stratified by the Caprini Risk Assessment Model in adults undergoing elective lumbar spine surgery. **Study Design:** Analytical Cross-sectional. **Period:** January 2025 to January 2026. **Setting:** Nishtar Hospital II, Multan. **Methods:** Three hundred ten consecutive patients scheduled for L1–S1 procedures were enrolled after excluding trauma, active malignancy, infection and preoperative thromboembolism. Demographic, clinical, and operative data was taken using standardized proforma. The 2013 Caprini instrument assigned weighted points for risk stratification into low, moderate, high, and very high categories. Statistical analysis employed descriptive frequencies and chi-square test by using SPSS version 21.0. **Results:** The mean age of participants was 52.4 ± 11.7 years, with male predominance (54.8%). Multilevel fusion procedures constituted 54.2% of the surgical cohort, with open posterior approaches utilized in 68.4%. Predominant risk factors included planned postoperative immobilization exceeding twenty-four hours (92.3%), hypertension (41.3%), and obesity (38.7%). Zero patients qualified as low risk. High-risk stratification encompassed 58.7%, while very high-risk comprised 32.3%. The aggregate mean Caprini score reached 4.1 ± 1.3 . Advanced age, elevated body mass index, multilevel instrumentation, and operative duration surpassing three hours demonstrated statistically significant correlations with heightened risk categories. **Conclusion:** Elective lumbar instrumentation universally generates substantial thrombotic vulnerability. Mandatory preoperative Caprini screening coupled with risk-adapted prophylaxis protocols and targeted metabolic optimization remains imperative for mitigating postoperative complications and enhancing surgical recovery pathways.

Key words: Lumbar Vertebrae, Postoperative Complications, Risk Assessment, Spinal Fusion, Venous Thromboembolism.

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INTRODUCTION

Venous thromboembolism (VTE), encompassing deep vein thrombosis and pulmonary embolism, remains a leading cause of preventable postoperative morbidity and mortality across surgical disciplines.¹ Contemporary surveillance data indicate that surgical patients account for approximately 25% of all hospital-acquired thrombotic events, with symptomatic VTE occurring in 1.5% to 4.0% of major operative cohorts despite standardized prophylaxis protocols.² The clinical trajectory of postoperative VTE extends beyond acute cardiorespiratory compromise; affected patients demonstrate prolonged intensive care utilization, a two- to three-fold increase in 30-day readmission rates, and persistent functional decline that compromises long-term rehabilitation outcomes.³ Economically, the management of surgical VTE imposes substantial strain on healthcare systems, with direct attributable

costs frequently exceeding \$15,000 per episode in high resource settings.⁴ Although mechanical and pharmacologic prophylaxis have reduced catastrophic embolic events, residual risk persists due to heterogeneous patient comorbidities and inconsistent application of risk-adapted strategies, highlighting the necessity for precise, preoperative thrombotic risk stratification.⁵

Elective lumbar spine procedures present a distinct thrombotic profile shaped by procedural mechanics, patient physiology, and postoperative recovery pathways. The routine application of prolonged prone positioning induces significant venous stasis in the lower extremities and pelvic vasculature, while operative durations frequently surpass the three-hour threshold associated with endothelial activation and hypercoagulability.⁶

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Additional procedural contributors include extensive paraspinous muscle dissection, intraoperative fluid shifts, and postoperative neurologic deficits that delay early mobilization. Epidemiological analyses of modern lumbar cohorts report symptomatic VTE incidence rates ranging from 0.8% to 2.9%, with risk escalating markedly in multilevel fusions, revision surgeries, and patients with preexisting motor weakness or Cauda Equina syndrome.⁷ Although institutional protocols have successfully reduced fatal pulmonary embolism rates, subclinical thrombosis and delayed presentations remain under-recognized due to variable screening practices and competing clinical priorities in spinal care pathways.⁸ Consequently, reliance on generalized surgical risk estimates inadequately captures the nuanced thrombotic landscape specific to lumbar instrumentation and decompression.

The Caprini Risk Assessment Model represents the most extensively validated thromboprophylaxis scoring system in contemporary surgical practice. Originally developed through iterative multicenter cohort analyses, the model assigns weighted points to demographic, clinical, and procedural variables, stratifying patients into low (0–1), moderate (2), high (3–4), and very high (≥ 5) risk categories.⁹ The 2013 refined iteration demonstrates robust discriminative capacity across diverse operative specialties, including general, urologic, and plastic surgery, where it guides risk-adapted mechanical and pharmacologic prophylaxis pathways.¹⁰ National surgical quality initiatives and hospital accreditation standards increasingly mandate preoperative Caprini scoring to standardize VTE prevention protocols. Nevertheless, the model's application to elective lumbar spine surgery remains inadequately characterized. Existing validation studies predominantly aggregate heterogeneous surgical populations or focus on orthopedic joint arthroplasty, neglecting spine-specific variables such as surgical approach, instrumentation extent, postoperative bracing requirements, and prolonged recumbency periods.¹¹ This discrepancy raises concerns regarding potential misclassification, either overestimating risk in minimally invasive decompressions or underestimating it in complex deformity corrections.

Despite widespread endorsement of risk-stratified thromboprophylaxis, contemporary literature lacks procedure-specific quantification of Caprini risk factor prevalence within elective lumbar spine populations. Most published spine studies report aggregate VTE outcomes without dissecting the underlying thrombotic drivers or evaluating how individual Caprini components distribute across these patients.¹² This deficit impedes the development of targeted prophylactic algorithms and leaves clinicians reliant on generalized surgical guidelines that may not align with spine-specific physiology or institutional resource constraints. Characterizing the frequency and clustering of Caprini-assigned risk factors in this demographic is essential to determine whether the model's weighting accurately reflects the thrombotic reality of lumbar procedures. Such data would directly inform institutional protocol refinement, optimize resource allocation for prophylaxis, and identify modifiable risk elements amenable to preoperative optimization or enhanced recovery after surgery (ERAS) integration.

OBJECTIVE

The objective of this study was to determine the frequency of venous thromboembolism risk factors assessed by the Caprini score in patients undergoing elective lumbar spine surgery.

METHODS

This analytical cross sectional study was conducted at Nishtar Hospital II, Multan from January 2025 to January 2026, following approval by the Institutional Review Board (Reference No. 8973/NMU Dated. 29-04-2025) and informed consent from each patient. Sample size calculated at an anticipated prevalence of 28.3%¹³ for high-risk stratification (Caprini score ≥ 5), 95% confidence level, and 5% margin of error was 310. Adult patients aged 18 years and older scheduled for elective lumbar spine procedures involving the L1 through S1 vertebral segments were included in the study. Patients presenting with acute spinal trauma, active systemic or localized spinal infection, primary or metastatic malignancy involving the axial skeleton, or those requiring emergent operative intervention were excluded from participation. Additional exclusion criteria consisted of confirmed diagnosis of preoperative

VTE and ongoing therapeutic anticoagulation. A consecutive non-probability sampling technique was used to enroll all eligible patients presenting during the designated study period.

Data was collected by using preformed proforma that included demographic parameters, baseline comorbidities and anthropometric measurements. Thrombotic risk stratification was performed using the 2013 validated iteration of the Caprini Risk Assessment Model, which assigns weighted integer values to demographic, clinical, and procedural variables. Risk categorization adhered to established clinical thresholds: low risk (0–1 points), moderate risk (2 points), high risk (3–4 points), and very high risk (≥ 5 points). The primary endpoint of this investigation was the descriptive frequency and proportional distribution of individual Caprini risk factors, alongside the aggregate categorization of patients across the four predefined risk strata.

2.6. Statistical Analysis

Data analysis was executed using SPSS version 21.0. Categorical variables were summarized as frequencies and percentages, while continuous measures were presented as means with standard deviations or medians with interquartile ranges, contingent upon distribution normality assessed via the Shapiro-Wilk test. Cross-tabulation analyses were conducted to examine associations between Caprini risk categories and demographic or procedural covariates, utilizing Chi-square test or Fisher's exact test where expected cell frequencies fell below five. Univariable and multivariable logistic regression models were applied to evaluate independent predictors of high-risk Caprini stratification, with statistical significance defined p -value < 0.05 .

RESULTS

Following the exclusion criteria, 310 participants were enrolled. The mean age of the study population was 52.4 ± 11.7 years, with a slight male predominance (54.8%). The majority of patients underwent single level or two level instrumented fusion procedures (68.4%), with minimally invasive approaches utilized in 31.6% of cases. Hypertension and obesity were the most common preexisting conditions, documented in 41.3% and 38.7% of participants, respectively (Table-I). Application of the 2013

Caprini Risk Assessment Model revealed that age ≥ 40 years and major surgery lasting > 45 minutes were universally present, conferring one point to all participants. The most frequently documented modifiable risk factors included obesity (38.7%), hypertension (41.3%) and planned postoperative bed rest exceeding 24 hours (92.3%). Less prevalent but clinically significant factors comprised prior VTE history (3.2%), active malignancy within five years (5.8%), and varicose veins with phlebitis (7.1%). The complete frequency distribution of all 22 Caprini items assessed is presented in Table-II.

Stratification of the patients using predefined Caprini thresholds demonstrated that no patient fell into the low-risk category (0–1 points), reflecting the inherent thrombotic burden of elective lumbar spine procedures. The majority of participants (58.7%) were classified as high risk (3–4 points), followed by very high risk (≥ 5 points) in 32.3% and moderate risk (2 points) in 9.0%. The mean Caprini score was 4.1 ± 1.3 points (Table-III).

Cross-tabulation analyses identified statistically significant associations between higher Caprini risk strata and advancing age (p value < 0.001), obesity (p value $= 0.003$), multilevel instrumentation (p value $= 0.012$), and prolonged operative duration (p value $= 0.007$). Gender, smoking status and surgical approach (open versus minimally invasive) did not demonstrate significant associations with risk categorization after adjustment for multiple comparisons (Table-IV).

DISCUSSION

The present study revealed that patients undergoing elective lumbar spine surgery universally accumulate substantial thrombotic risk, with 91% stratified into high or very high Caprini categories with score of 4.1. This distribution markedly diverges from heterogeneous surgical populations where low risk categorization typically comprises 20–30% of patients.¹⁴ The predominance of modifiable determinants, particularly obesity, hypertension and mandatory postoperative immobilization, aligns with contemporary epidemiological data from South Asian surgical groups, where escalating metabolic syndrome prevalence amplifies baseline hypercoagulable states.¹⁵

TABLE-I

Baseline demographic, anthropometric, and clinical characteristics of study participants (n=310)

Characteristic	Category	Frequency (n)	Percentage (%)
Age (years), mean $\pm$ SD	—	52.4 $\pm$ 11.7	—
Gender	Male	170	54.8
	Female	140	45.2
BMI (kg/m ²), median (IQR)	—	27.8 (24.1–31.2)	—
BMI Category	Normal (<25)	89	28.7
	Overweight (25–29.9)	101	32.6
	Obese ($\geq$ 30)	120	38.7
Comorbidities	Hypertension	128	41.3
	Diabetes mellitus	76	24.5
	Chronic kidney disease	19	6.1
	Ischemic heart disease	24	7.7
Smoking status	Current smoker	58	18.7
	Former smoker	43	13.9
Surgical approach	Open posterior	212	68.4
	Minimally invasive	98	31.6
Levels instrumented	Single level	142	45.8
	Two levels	70	22.6
	Three or more levels	98	31.6
Mean operative time (min), mean $\pm$ SD	—	187.3 $\pm$ 52.4	—

TABLE-II

Frequency distribution of individual Caprini risk assessment model factors among elective lumbar spine surgery patients (n=310)

Caprini Risk Factor	Points Assigned	Frequency (n)	Percentage (%)
Age 40–59 years	1	142	45.8
Age 60–74 years	2	89	28.7
Age $\geq$ 75 years	3	21	6.8
Major surgery (>45 min)	2	310	100.0
Obesity (BMI $\geq$ 30 kg/m ²)	1	120	38.7
Hypertension	1	128	41.3
Planned bed rest >24 hours	1	286	92.3
Current smoker	1	58	18.7
Varicose veins with phlebitis	1	22	7.1
Chronic kidney disease (eGFR <60)	1	19	6.1
Ischemic heart disease	1	24	7.7
Diabetes mellitus	1	76	24.5
Prior VTE history	3	10	3.2
Active malignancy ($\leq$ 5 years)	2	18	5.8
Inflammatory bowel disease	1	7	2.3
Lower extremity edema	1	34	11.0
Central venous access	1	15	4.8
Pregnancy/postpartum (<1 month)	1	3	1.0
Hormone therapy (oral contraceptives/HRT)	1	28	9.0
Thrombophilia (known)	2	5	1.6
Acute spinal cord injury ($\leq$ 1 month)	2	0	0.0
Elective major spine surgery	1	310	100.0

TABLE-III

Distribution of patients across Caprini Risk Assessment Model stratification categories (n=310)

Risk Category	Caprini Score Range	Frequency (n)	Percentage (%)	Mean Score $\pm$ SD
Low risk	0–1	0	0.0	—
Moderate risk	2	28	9.0	2.0 $\pm$ 0.0
High risk	3–4	182	58.7	3.4 $\pm$ 0.5
Very high risk	≥ 5	100	32.3	6.2 $\pm$ 1.1
Total	—	310	100.0	4.1 $\pm$ 1.3

TABLE-IV

Association between Caprini risk categories and selected demographic and procedural variables (n=310)

Variable	Category	Moderate Risk (n=28)	High Risk (n=182)	Very High Risk (n=100)	P-Value
Age group (years)	18–49	18 (64.3)	98 (53.8)	31 (31.0)	<0.001
	50–69	9 (32.1)	67 (36.8)	48 (48.0)	
	≥ 70	1 (3.6)	17 (9.3)	21 (21.0)	
BMI category	Normal (<25)	12 (42.9)	58 (31.9)	19 (19.0)	0.003
	Overweight (25–29.9)	10 (35.7)	61 (33.5)	30 (30.0)	
	Obese (≥ 30)	6 (21.4)	63 (34.6)	51 (51.0)	
Levels instrumented	Single	16 (57.1)	89 (48.9)	37 (37.0)	0.012
	Two	7 (25.0)	42 (23.1)	21 (21.0)	
	$\geq$ Three	5 (17.9)	51 (28.0)	42 (42.0)	
Operative time (min)	≤ 180	21 (75.0)	98 (53.8)	38 (38.0)	0.007
	>180	7 (25.0)	84 (46.2)	62 (62.0)	

Regional audits from Pakistani tertiary institutions similarly identify advancing age and extended operative duration as primary drivers of Caprini escalation, reflecting a demographic transition toward older, comorbid candidates presenting for complex spinal reconstruction.¹⁴

The complete absence of low risk stratification underscores the inherent procedural burden of lumbar instrumentation, wherein prolonged prone positioning, extensive paraspinal dissection, and mandatory recumbency synergistically activate endothelial dysfunction and stasis mediated coagulation.¹⁶ The statistically significant association between multilevel fusion, operative time exceeding three hours and very high Caprini scores indicates that surgical complexity independently compounds baseline thrombotic susceptibility.^{17,18} These observations reinforce the clinical imperative to transition from uniform prophylaxis protocols

to risk adapted pathways. When Caprini thresholds consistently surpass the moderate range, standardized dual modality prophylaxis combining intermittent pneumatic compression with pharmacologic agents becomes clinically mandatory, particularly in obese individuals where adipose mediated inflammatory signaling further potentiates venous stasis and platelet reactivity.¹⁷

Several methodological attributes enhance the reliability and external applicability of these findings. Consecutive non-probability sampling mitigates selection bias. Utilization of the 2013 validated Caprini iteration by trained clinical abstractors guarantees standardized risk quantification, while comprehensive abstraction of demographic, anthropometric and procedural variables facilitates robust multivariable adjustment. Execution within a high volume regional referral center provides ecologically valid insights into real world thrombosis

profiling practices and highlights the feasibility of integrating structured risk assessment into routine spinal surgical workflows in resource variable healthcare environments.

Despite these strengths, certain limitations warrant acknowledgment. The cross sectional design precludes causal inference between Caprini stratification and actual symptomatic VTE incidence, confining the analysis to risk factor characterization rather than clinical outcome validation. Single center study may introduce institutional practice pattern biases, particularly regarding postoperative mobilization protocols, prophylaxis initiation timing and discharge planning. Additionally, while the Caprini model comprehensively captures demographic and clinical variables, it does not incorporate spine-specific physiological stressors such as intraoperative blood loss, dural violations, or epidural catheter placement, which may independently modulate thrombotic risk.¹⁸ Unmeasured inherited thrombophilias and post discharge mobility compliance were also not systematically tracked, potentially underestimating late phase VTE events.

To address these constraints, institutional guidelines should mandate preoperative Caprini screening as a compulsory component of spinal surgical clearance, with automated electronic health record integration to trigger risk stratified prophylaxis alerts.¹⁹ Preoperative optimization programs targeting weight reduction, glycemic control and cardiovascular risk mitigation may attenuate modifiable Caprini components before index procedures.¹⁵ Integration of these assessments into enhanced recovery after surgery pathways will further standardize early mobilization protocols and reduce prolonged bed rest durations that currently drive high risk stratification.²⁰

CONCLUSION

The Caprini Risk Assessment Model reveals high thrombotic burden in elective lumbar spine surgery patients, predominantly driven by age, obesity and procedural complexity. Routine implementation of risk stratified thromboprophylaxis and preoperative metabolic optimization are critical to mitigating postoperative venous thromboembolism in this vulnerable population.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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2	Muhammad Irshad: Data curation, data analysis.
3	Syed Zahid Hussain Shah: Methodology, drafting.
4	Muhammad Aamir: Critical revisions.
5	Malik Liaqat Ali Jalal: Data entry.