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Article

Analysis of Risk Factors for Deep Vein Thrombosis Complications after Percutaneous Coronary Intervention in Elderly Patients: A Retrospective Case-Control Survey

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Abstract

Purpose: The objective of this study is to comprehensively analyze the risk factors associated with deep vein thrombosis (DVT) complications after percutaneous coronary intervention (PCI) in elderly patients. **Methods**: A retrospective case-control study was conducted by analyzing the data of 101 elderly patients who underwent PCI. On the basis of the occurrence of postoperative DVT, the patients were divided into non-DVT (n = 57) and DVT (n = 44) groups. Baseline characteristics, procedural details, laboratory indicators, medication use, postprocedural complications, length of hospital stay, and rehospitalization were assessed. **Results**: Procedural characteristics showed lengthened procedural time (45.62 ± 7.81 *vs.* 42.17 ± 8.43 min, t = 2.105, p = 0.038) and increased contrast volume (161.05 ± 27.56 *vs.* 150.14 ± 25.67 mL, t = 2.051, p = 0.043) in the DVT group. Significant differences were observed in hemoglobin (13.92 ± 1.58 g/dL *vs.* 13.18 ± 1.76 g/dL, t = 2.221, p = 0.029) and serum albumin levels (4.33 ± 0.38 g/dL *vs.* 4.09 ± 0.42 g/dL, t = 3.006, p = 0.034) between the two groups. Moreover, compared with the non-DVT group, the DVT group had longer hospital stays (6.41 ± 2.05 days *vs.* 5.32 ± 1.76 days, t = 2.872, p = 0.005) and increased rehospitalization rates (27.27% *vs.* 10.53%, t = 4.755, p = 0.029). Correlation and logistic regression analyses identified several statistically significant associations between the risk factors and complications of DVT in elderly patients with PCI. **Conclusion**: The present study provides novel insights into the multifaceted nature of DVT after PCI in elderly patients and emphasizes the substantial effects of DVT on clinical outcomes. The findings underscore the need for comprehensive risk assessment, vigilant monitoring, and proactive management of DVT in this patient population to optimize patient outcomes after PCI. Future research should focus on developing targeted interventions and risk stratification tools tailored to the unique needs of elderly patients with PCI to improve clinical treatment.

Keywords

risk factors; deep vein thrombosis; complications; percutaneous coronary intervention; elderly patients

Introduction

Deep vein thrombosis (DVT) is a common and potentially serious complication that occurs after percutaneous coronary intervention (PCI), and studies have reported that its incidence ranges from 1% to 7% in patients undergoing this procedure, which encompasses angioplasty and stent placement to restore blood flow to the heart [1–3]. Elderly patients, in particular, are at a high risk of developing DVT after PCI because of age-related factors, such as reduced mobility and altered coagulation profiles [4–7]. DVT occurs when a blood clot forms in a deep vein, often in the lower limbs, and can lead to life-threatening complications, such as pulmonary embolism (PE), if the clot dislodges and travels to the lungs [8–10]. PE is prevalent in patients with DVT. The incidence of PE in patients with DVT ranges from 11% to 46% for high-probability pulmonary scintigraphy, and up to 72% of incidence has been reported when computed tomography pulmonary angiography is used for screening [11].

Elderly patients undergoing PCI are at an increased risk of DVT because of age-related changes in blood composition, prolonged immobilization, and comorbid conditions [12,13]. Age-related changes, such as decreased mobility, altered coagulation pathways, and reduced venous compliance, contribute to an elevated risk of thrombotic events in elderly patients [14–16]. Moreover, the presence of comorbid conditions, including cardiovascular disease, diabetes, and hypertension, further exacerbates the risk of DVT in this population [17,18]. Prolonged immobilization post-PCI, often necessitated by the procedure and recovery period, can lead to blood flow stasis, endothelial dysfunction, and venous stasis, all of which predispose elderly patients to the development of DVT [19–22]. Understanding the specific risk factors for DVT in this population is crucial for the development of effective preventative strategies and improved patient outcomes.

Despite existing studies, the majority of research on DVT after PCI has focused on the general population or specific age groups, and limited attention has been devoted to the unique considerations and risk factors associated with elderly patients [23]. The innovation of this study is that it focused on the risk factors for DVT in elderly individuals undergoing PCI, which has been rarely done before. Currently, novel insights that are directly applicable to the clinical care of elderly patients with PCI are lacking. This retrospective case-control study aims to comprehensively analyze the risk factors associated with DVT complications following PCI in elderly patients. By focusing on this specific patient population, the present study seeks to contribute novel insights that are directly applicable to the clinical care of elderly PCI patients, thus filling a crucial gap in current literature.

Materials and Methods

Study Population and Grouping

A retrospective case-control study was conducted to analyze the risk factors for DVT following PCI in elderly patients. The study analyzed the clinical data of elderly patients who underwent PCI at our institution from January 2022 to December 2023, and the total number of cases was 101. On the basis of the occurrence of postoperative DVT, the patients were divided into non-DVT (n = 57) and DVT (n = 44) groups. The non-DVT group comprised 28 male and 29 female patients, with a mean age of 76.86 $\pm$ 5.32 years, and the DVT group included 20 male and 24 female patients, with a mean age of 78.15 $\pm$ 4.78 years. This study was approved by the Ethics Committee of Hubei No. 3 People's Hospital of Jianghan University, with approval no. 2024LW2024010, and complies with the relevant statements of the Declaration of Helsinki. All participants included in this study gave their informed consent.

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: elderly patients (age 65 years or older) who had undergone PCI and patients with complete medical records containing information on baseline characteristics, procedural details, laboratory indicators, medication use, postprocedural complications, length of hospital stay, and rehospitalization.

The exclusion criteria were as follows: patients below the age of 65 years; patients with incomplete or missing medical records, which make the assessment of key study parameters difficult; patients with a history of DVT prior to the PCI procedure; patients with a diagnosis of conditions that could independently predispose them to DVT, such as known coagulopathies, venous thromboembolism, or active cancer; patients who had recent major surgery or trauma in the past three months; patients with limited life expectancy due to a terminal illness because this could affect the assessment of study outcomes; and patients with failed radial artery access during surgery.

The aforementioned criteria may independently affect the risk of DVT. For example, patients who have undergone a major surgery or experienced trauma within the past three months might develop DVT because of factors other than PCI, which could confound the study results, so they were excluded from this study.

Surgical Procedure

The patients and their families were informed about the risks associated with the surgery, and the surgery was prepared after the signing of the informed consent form. All surgical procedures were conducted in the hospital's interventional catheterization room and strictly followed the principles of aseptic operation. Prior to arterial puncture, the Allen test was performed on all the research subjects. Iodine tincture was used to disinfect the puncture site outward three times, with the puncture point as the center. Local anesthesia with 2% lidocaine was administered to all the patients, followed by the Seldinger technique for puncture. Upon successful puncture, a 6F arterial sheath was inserted, and glyceryl trinitrate (200 µg) was injected through the radial artery sheath to prevent vasospasm, followed by 3000 U normal saline heparinization (the additional heparin dosage during the surgery was determined based on the patient's weight, duration of the surgery, and surgical requirements). Subsequently, the catheter for contrast medium injection was separately guided to the openings of the left and right coronary arteries for angiography. The coronary angiographic images were jointly interpreted by two associate chief physicians or above from our hospital. Interventional treatment of target blood vessels was then performed based on the coronary angiography results. The choice of stent was based on the size of the coronary artery lumen and followed a 1:1 principle. The Thrombolysis in Myocardial Infarction (TIMI) grade was used to assess the coronary blood flow status during the procedure. The criteria for a successful surgery were as follows: (1) the stent adequately covered the narrowed part of the coronary artery, (2) residual stenosis after stent placement was <20%, and (3) the postoperative distal blood flow was at the TIMI grade 3 level. All stents implanted during the procedure were drug-coated stents. After stent placement, the coronary blood flow status was reassessed using the TIMI grade.

After surgery, the patients were subjected to routine dual antiplatelet therapy, which included ticagrelor (90 mg bid) or clopidogrel (75 mg qd) combined with enteric-coated aspirin (0.1 g qd), for at least one year. Aspirin was used for long-term treatment after stent placement. In the absence of obvious contraindications, dual antiplatelet therapy was changed to aspirin monotherapy after one year, along with long-term lipid-lowering therapy and stable plaque treatment on the basis of the patient's underlying diseases. Moreover, strict control of blood pressure, heart rate, blood sugar, and other indicators was implemented.

DVT Detection Methods

General Electric Company's (the USA) ViVid7 color Doppler ultrasound diagnostic instrument was used. The instrument had a probe frequency of 7.5–14 MHz, a sampling volume of 2 mm, and a blood flow Doppler angle $\leq$60°. A 3.5 MHz convex array probe was employed to examine the common iliac vein and the proximal end of the external iliac vein. The individual being examined was placed in a supine position, with the lower limbs slightly abducted and externally rotated for the examination of the external iliac, femoral, superficial femoral, anterior tibial, and great saphenous veins. The examination of the popliteal, posterior tibial, and peroneal veins was conducted in the prone or lateral position. The probe was lightly placed at the groin to examine the iliac–femoral veins and the proximal end of the great saphenous vein, and their collateral branches were gradually tracked. Key observations included the diameter, patency, compressibility, wall thickness, and smoothness of the vessels and the presence and location of any abnormal intravascular echoes. Color Doppler flow imaging was performed to observe the direction and patency of the blood flow, and the pulsed Doppler mode was used to detect the blood flow spectrum, measure its velocity, and observe changes in the spectrum with respiration. The Valsalva test and the distal limb compression test were employed as adjuncts to examine venous blood flow patency.

Data Collection

Data on baseline characteristics, procedural characteristics, laboratory indicators, medication use, length of hospital stay, and rehospitalization were collected from patient medical records. The Zubrod/Eastern Cooperative Oncology Group (ECOG)/WHO ZPS five-point scale was employed to test the physical status of the patients. All risk factors were collected in the absence of postoperative DVT. All data were completed by the same experienced clinician.

Statistical Analysis

This study implemented a standardized data cleaning process before data analysis to uncover and rectify any inconsistencies, errors, or missing values. The process involved a comprehensive review of the dataset, elimination of duplicate entries, correction of data entry errors, and addressing missing values. The missing values were handled using deep neural networks with the DataWig and Pandas libraries in Python 3.6.0 (Python Software Foundation Beaverton, OR, USA) to ensure that the percentage of missing data remained below 5% to mitigate potential selection bias. Moreover, sensitivity analyses were conducted to calculate outcomes for cases lost to follow-up by using worst- and best-case scenarios. The absence of a considerable difference implied that the loss to follow-up had a minimal effect on the study's conclusions, validating their reliability. The final results were reported after the imputation of missing values.

Data analysis was performed using SPSS 29.0 (SPSS Inc, Chicago, IL, USA). Categorical data were presented as [n (%)]. The chi-square test was utilized when the sample size was $\geq$40 and the expected count was T $\geq$5. A corrected chi-square test was applied for samples $\geq$40 but with $1 \leq T < 5$. For sample sizes <40 or when the expected count was T <1, Fisher's exact test was applied. The Shapiro–Wilk test was employed to assess normally distributed continuous variables. Normally distributed variables were presented as ($\bar{x} \pm$ s). The *t*-test was used for the analysis because it conforms to a normal distribution. Non-normally distributed data were expressed as median (25th percentile, 75th percentile) and analyzed using the Wilcoxon rank-sum test. Bilateral $p < 0.05$ was considered statistically significant. Spearman's correlation analysis was employed to assess correlations. Subsequently, indicators demonstrating statistically significant differences between the two groups were selected for logistic regression analysis. Logistic regression was chosen because of its computational efficiency and robust performance on small datasets. Furthermore, the logistic regression model is easily interpretable and straightforward to understand, qualities that are particularly valuable in the medical field.

Given that the main purpose of the study was to reveal the difference between groups, rather than between different age points, ANOVA was not adopted. Instead, an independent sample *t*-test was applied to assess the differences between the non-DVT and DVT groups at different age points.

Results

Baseline Characteristics

The baseline characteristics of the study participants are presented in Table 1. The participants in the non-DVT and DVT groups were comparable in terms of age, and the mean ages were 76.86 $\pm$ 5.32 and 78.15 $\pm$ 4.78 years, respectively (t = 1.269, p = 0.208). The distribution of gender was also similar between the two groups, with 49.12% males and 50.88% females in the non-DVT group and 45.45% males and 54.55% females in the DVT group (χ^2 = 0.134, p = 0.714). No significant differences in body mass index, ECOG score, hypertension, smoking status, alcohol consumption, prevalence of diabetes, previous myocardial infarction, PCI, coronary artery bypass grafting, type of coronary artery disease, six-minute walk test, left ventricular end-diastolic diameter, left ventricular end-systolic diameter, left ventricular ejection fraction, and nutritional status were found between the two groups. Overall,

Table 1. Baseline characteristics of the study participants.

Parameters	Non-DVT Group (n = 57)	DVT Group (n = 44)	t/χ^2	p value
Age (years)	76.86 ± 5.32	78.15 ± 4.78	1.269	0.208
Gender			0.134	0.714
Male	28 (49.12%)	20 (45.45%)		
Female	29 (50.88%)	24 (54.55%)		
Body Mass Index (kg/m^2)	27.93 ± 2.89	28.91 ± 3.25	1.569	0.120
Zubrod/ECOG/WHO (ZPS) five-point scale	2.31 ± 0.34	2.26 ± 0.31	0.761	0.448
Hypertension (n, %)	42 (73.68%)	35 (79.55%)	0.471	0.493
Diabetes (n, %)	19 (33.33%)	22 (50.00%)	2.860	0.091
Smoking (n, %)	8 (14.04%)	7 (15.91%)	0.069	0.793
Alcohol (n, %)	12 (21.05%)	8 (18.18%)	0.129	0.720
Previous MI [n (%)]	11 (19.30%)	6 (13.64%)	0.569	0.451
Previous PCI [n (%)]	7 (12.28%)	4 (9.09%)	0.035	0.851
Previous CABG [n (%)]	4 (7.02%)	2 (4.55%)	0.009	0.923
Type of coronary artery disease			0.209	0.901
ACS	23 (40.35%)	16 (36.36%)		
CCS	21 (36.84%)	18 (40.91%)		
Others	13 (22.81%)	10 (22.73%)		
Six-minute walk test (6MWT) (m)	404.56 ± 10.16	406.97 ± 9.73	1.204	0.232
Left ventricular end-diastolic diameter (LVEDD) (mm)	62.86 ± 4.13	63.16 ± 3.92	0.370	0.712
Left ventricular end-systolic diameter (LVESD) (mm)	59.44 ± 4.17	59.12 ± 3.86	0.395	0.694
Left ventricular ejection fraction (LVEF) (%)	39.23 ± 9.37	38.67 ± 9.41	0.297	0.767
Nutritional status [n (%)]			0.216	0.898
Normal	36 (63.16%)	26 (59.09%)		
Mild malnutrition	18 (31.58%)	15 (34.09%)		
Moderate to severe malnutrition	3 (5.26%)	3 (6.82%)		

DVT, deep vein thrombosis; ECGO, Eastern Cooperative Oncology Group; WHO, World Health Organization; ZPS, Zubrod Performance Status; MI, Myocardial Infarction; PCI, percutaneous coronary intervention; CABG, Coronary Artery Bypass Graft; ACS, Acute Coronary Syndrome; CCS, Chronic Coronary Syndrome.

the baseline characteristics indicated similarity between the two groups.

Procedural Characteristics

The procedural characteristics of PCI for the non-DVT and DVT groups are outlined in Table 2. Comparison of the two groups showed no significant differences in the number of stents implanted (1.92 ± 0.85 *vs.* 2.15 ± 0.76, t = 1.411, p = 0.161), total stent length (38.64 ± 7.92 *vs.* 40.28 ± 8.47 mm, t = 1.001, p = 0.319), and stent diameter (3.01 ± 0.28 *vs.* 3.07 ± 0.31 mm, t = 1.019, p = 0.311). Moreover, the use of drug-eluting stents was comparable between the groups, with 68.42% in the non-DVT group and 70.45% in the DVT group (χ^2 = 0.048, p = 0.826). However, the procedural time in the DVT group was slightly longer than that in the non-DVT group (45.62 ± 7.81 *vs.* 42.17 ± 8.43 min, t = 2.105, p = 0.038), and the contrast volume used in the non-DVT group was larger than that in the DVT group (161.05 ± 27.56 *vs.* 150.14 ± 25.67 mL, t = 2.051, p = 0.043). These findings suggest that although the basic procedural aspects are similar between the groups, subtle differences in procedural time and contrast volume exist and warrant consideration in the context of DVT.

Laboratory Indicators

The comparison of laboratory indicators between the non-DVT and DVT groups revealed significant differences in hemoglobin levels (13.92 ± 1.58 g/dL *vs.* 13.18 ± 1.76 g/dL, t = 2.221, p = 0.029) and serum albumin levels (4.33 ± 0.38 g/dL *vs.* 4.09 ± 0.42 g/dL, t = 3.006, p = 0.034), as shown in Table 3. Platelet count, serum creatinine, and prothrombin time (PT) did not demonstrate statistically significant differences between the two groups. This analysis highlights the potential importance of hemoglobin and serum albumin levels as risk factors of DVT after PCI in elderly patients.

Medication Use

The comparison of medication use between the non-DVT and DVT groups revealed no significant differences in the usage of antiplatelet agents ($p > 0.05$, Table 4). Similarly, no significant differences were observed in the utilization of statins (p = 0.436), beta-blockers (p = 0.659), ACE inhibitors/ARBs (p = 0.730), and oral anticoagulants (p = 0.722) between the two groups. These findings suggest comparable medication usage in both groups and may

Table 2. Procedural characteristics of PCI.

Parameters	Non-DVT Group (n = 57)	DVT Group (n = 44)	t/χ^2	*p* value
Number of Stents	1.92 ± 0.85	2.15 ± 0.76	1.411	0.161
Total Stent Length (mm)	38.64 ± 7.92	40.28 ± 8.47	1.001	0.319
Stent Diameter (mm)	3.01 ± 0.28	3.07 ± 0.31	1.019	0.311
Use of Drug-eluting Stents (%)	39 (68.42%)	31 (70.45%)	0.048	0.826
Procedural Time (minutes)	42.17 ± 8.43	45.62 ± 7.81	2.105	0.038
Contrast Volume (mL)	150.14 ± 25.67	161.05 ± 27.56	2.051	0.043

Table 3. Comparison of the laboratory indicators of patients in the two groups.

Parameters	Non-DVT Group (n = 57)	DVT Group (n = 44)	t	*p* value
Hemoglobin (g/dL)	13.92 ± 1.58	13.18 ± 1.76	2.221	0.029
Platelet Count ($\times 10^9$/L)	245.81 ± 35.67	252.16 ± 40.29	0.838	0.404
Serum Creatinine (mg/dL)	1.08 ± 0.21	1.15 ± 0.19	1.731	0.087
Serum Albumin (g/dL)	4.33 ± 0.38	4.09 ± 0.42	3.006	0.034
PT (seconds)	12.58 ± 2.35	13.42 ± 2.07	1.875	0.064

PT, prothrombin time; DVT, deep vein thrombosis.

Table 4. Comparison of the medication use of patients in the two groups.

Parameters	Non-DVT Group (n = 57)	DVT Group (n = 44)	t/χ^2	*p* value
Antiplatelet Agents (%)	57 (100%)	44 (100%)		–
Statins (%)	56 (98.25%)	41 (93.18%)	0.607	0.436
Beta-blockers (%)	46 (80.70%)	37 (84.09%)	0.195	0.659
ACE Inhibitors/ARBs (%)	41 (71.93%)	33 (75.00%)	0.120	0.730
Oral Anticoagulants (%)	3 (5.26%)	4 (9.09%)	0.126	0.722

ACE, angiotensin-converting enzyme; ARBs, angiotensin II receptor blockers.

Table 5. Length of hospital stay and rehospitalization of patients in the two groups.

Parameters	Non-DVT Group (n = 57)	DVT Group (n = 44)	t/χ^2	*p* value
Hospital Stay (days)	5.32 ± 1.76	6.41 ± 2.05	2.872	0.005
Rehospitalization (%)	6 (10.53%)	12 (27.27%)	4.755	0.029

provide insights into the alternative risk factors associated with DVT aside from the assessed medications.

Hospital Stay and Rehospitalization Rates

The comparison of length of hospital stay and rehospitalization rates between the non-DVT and DVT groups revealed significant differences (Table 5). The DVT group had a longer hospital stay compared with the non-DVT group (6.41 ± 2.05 days *vs.* 5.32 ± 1.76 days, t = 2.872, *p* = 0.005). Furthermore, the rehospitalization rates were significantly higher in the DVT group compared with those in the non-DVT group (27.27% *vs.* 10.53%, t = 4.755, *p* = 0.029). These findings highlight the potential effects of DVT on prolonged hospitalization and increased rehospitalization rates and emphasize the need for targeted interventions to mitigate these outcomes in affected patients.

Correlation Analysis

Table 6 presents a correlation analysis of the various risk factors associated with DVT following PCI therapy in elderly patients. Procedural time (r = 0.207, *p* = 0.039) and hospital stay duration (r = 0.265, *p* = 0.008) were positively correlated with the incidence of DVT, suggesting that prolonged procedures and extended hospital stays may contribute to an increased risk of developing DVT among elderly patients post-PCI. Moreover, rehospitalization rates (r = 0.224, *p* = 0.025) showed a positive association with DVT, indicating that patients who are readmitted to the hospital may be at a high risk of experiencing DVT complications. Conversely, hemoglobin levels (r = –0.206, *p* = 0.040) and serum albumin (r = –0.311, *p* = 0.002) exhibited negative correlations with DVT, suggesting that low levels of these biomarkers could be predictive of a high risk of DVT in this patient population. The contrast volume administered during PCI did not demonstrate a statistically significant correlation with the risk of DVT, indicating that this variable alone does not appear to substantially influence the risk of DVT in elderly patients undergoing PCI. These findings emphasize the multifactorial nature of the DVT risk in elderly patients undergoing PCI and highlight the need for vigilant monitoring and targeted interventions to mitigate these risks. Clinicians should consider these factors when assessing individual patient risks and developing appropriate prevention strategies to reduce the likelihood of DVT occurring in elderly patients undergoing PCI therapy.

Table 6. Correlation analysis of the risk factors of DVT complications in elderly patients after PCI therapy.

Parameters	r	*p*
Procedural Time (min)	0.207	0.039
Contrast Volume (mL)	0.179	0.074
Hemoglobin (g/dL)	−0.206	0.040
Serum Albumin (g/dL)	−0.311	0.002
Hospital Stay (days)	0.265	0.008
Rehospitalization (%)	0.224	0.025

Logistic Regression Analysis

These findings underscore the importance of considering patient-specific characteristics and procedural variables in the assessment and management of DVT in elderly patients undergoing PCI therapy. Clinicians should tailor prophylactic measures on the basis of these identified risk factors to effectively mitigate the likelihood of DVT occurring in this patient population. In the logistic regression analysis of the risk factors and complications of DVT after PCI therapy in elderly patients, several statistically significant associations were identified (Table 7). Procedural time demonstrated a positive association with DVT complications, with a coefficient of 0.053 and odds ratio (OR) of 1.055 (p = 0.043), indicating that long procedural time is associated with high odds of DVT. Similarly, contrast volume had a positive association with DVT complications, with a coefficient of 0.016 and OR of 1.016 (p = 0.048), suggesting that increased contrast volume is linked to elevated odds of DVT. Conversely, hemoglobin levels exhibited a negative association with DVT complications, with a coefficient of –0.275 and OR of 0.759 (p = 0.034), a result that implies that low hemoglobin levels are associated with high odds of DVT. Furthermore, serum albumin levels demonstrated a negative association with DVT complications, with a coefficient of –1.538 and OR of 0.215 (p = 0.006), indicating that low serum albumin levels are associated with increased odds of DVT. Hospital stay had a positive association with DVT complications, with a coefficient of 0.311 and OR of 1.364 (p = 0.008), suggesting that prolonged hospital stay is a significant risk factor for DVT in elderly patients with PCI. Moreover, rehospitalization exhibited a positive association with DVT complications, with a coefficient of 1.191 and OR of 3.290 (p = 0.030), indicating that increased rehospitalization is a significant risk factor for DVT in elderly patients with PCI. These results emphasize the importance of these variables as risk factors for DVT following PCI in elderly patients and highlight the need for tailored interventions to mitigate these complications and optimize patient outcomes. Multiple regression analysis revealed that procedural time and hospital stay were positively correlated with DVT complications, whereas hemoglobin and serum albumin levels were negatively correlated with DVT complications (Table 8). Rehospitalization and contrast volume were not identified as multifactorial regression risk factors.

Discussion

This work investigated the risk factors of DVT after PCI in elderly patients via a retrospective case-control study. The manifestations of DVT remain a critical public health concern, particularly among the elderly demographic with altered coagulation pathways, decreased mobility, and increased comorbidities [24–26]. Our findings corroborate the multidimensional nature of DVT and highlight the criticality of proactive risk management to optimize patient outcomes post-PCI.

We observed significant differences between the DVT and non-DVT groups in terms of multiple procedural characteristics, including contrast volume and procedural time. Compared with the non-DVT group, the DVT group used a higher volume of contrast medium and underwent longer procedures, both of which emerged as potential risk factors in the development of post-PCI DVT [27,28]. Contrast media can potentially impair the renal function and worsen patient prognosis by inducing toxicity [6,12,22]. Furthermore, lengthened invasive procedures may predispose patients to thromboembolic events possibly due to the prolongation of endothelial irritation and local trauma [29,30].

Our analysis also uncovered differences in several laboratory indicators, particularly hemoglobin and serum albumin levels, between both groups. Anemia exacerbates the risk of cardiovascular disorders partly because of the associated hypoxemia and hypercoagulability that may promote stasis and thrombosis [17,22,31]. Moreover, a decrease in serum albumin could signify malnutrition and inflammation conditions, both of which are known to predispose patients to DVT [32]. Our findings underscore the need for vigilant monitoring of these indicators when assessing and managing the DVT risk in post-PCI elderly patients.

Although no significant differences in most of the medications used by both groups were found, we noted a nonstatistically significant higher use of oral anticoagulants in the DVT group compared with the non-DVT group. This observation might appear counterintuitive, given the thromboprotective properties of anticoagulants [21,32]. However, it implies that the study participants might already be facing an inherent high risk of thrombotic events, un-

Table 7. Logistic regression analysis of the risk factors of DVT complications in elderly patients after PCI therapy.

Parameters	Coefficient	Std Error	Wald	*p* value	OR	95% CI
Procedural Time (min)	0.053	0.026	4.155	0.043	1.055	1.003–1.113
Contrast Volume (mL)	0.016	0.008	4.000	0.048	1.016	1.001–1.033
Hemoglobin (g/dL)	−0.275	0.130	4.475	0.034	0.759	0.581–0.971
Serum Albumin (g/dL)	−1.538	0.560	7.543	0.006	0.215	0.067–0.612
Hospital Stay (days)	0.311	0.117	7.066	0.008	1.364	1.096–1.739
Rehospitalization (%)	1.191	0.549	4.706	0.030	3.290	1.156–10.290

Std, error, standard error; OR, odds ratio; 95% CI, 95% Confidence Interval.

Table 8. Multiple regression analysis of the risk factors of DVT complications in elderly patients after PCI therapy.

Parameters	Coefficient	Std Error	Wald Stat	*p* value	OR	95% CI
Procedural Time (min)	0.062	0.036	2.966	0.088	1.064	0.991–1.143
Contrast Volume (mL)	0.017	0.012	2.007	0.153	1.017	0.994–1.041
Hemoglobin (g/dL)	−0.495	0.235	4.437	0.035	0.609	0.385–0.965
Serum Albumin (g/dL)	−2.517	0.873	8.313	0.004	0.081	0.015–0.446
Hospital Stay (days)	0.443	0.210	4.450	0.035	1.557	1.031–2.350
Rehospitalization (%)	1.618	0.868	3.475	0.062	5.042	0.920–27.626

derscoring the complex interactions among patient-specific characteristics, medications, and DVT risk. Future studies should elucidate the interactions between various preventive strategies, including anticoagulation therapy, and the risk of post-PCI DVT in elderly patients.

The positive correlation and logistic regression analysis outcomes for procedural time, contrast volume, hospital stay, rehospitalization, and DVT complications further revealed their importance as risk factors. The negative associations among hemoglobin levels, serum albumin levels, and DVT complications were equally noteworthy. In the multiple regression analysis, procedural time and hospital stay were found to be positively correlated with DVT complications, whereas hemoglobin and serum albumin levels were negatively correlated with DVT complications. Rehospitalization and contrast volume were not multifactorial regression risk factors. These findings provide insights into managing potential confounders and emphasize the importance of comprehensive management in mitigating the risk of DVT among patients with PCI.

Several limitations of this study should be acknowledged. First, the study's retrospective design may have introduced biases and limited the availability of certain data. Second, the sample size was relatively small, and the study was conducted at a single institution, which potentially limit the generalizability of the findings. Last, this study did not design an adequately long follow-up period. In the future, prospective studies with large and diverse multicenter patient cohorts are needed to validate and expand the findings of this study. Future research also needs to have a perfect, long-term design to ensure a comprehensive study of DVT patients after PCI.

Conclusion

In conclusion, our research offers a novel understanding of the risk factors associated with DVT after PCI in elderly patients and underscores the complex interplay between different variables. The substantial effects on patient outcomes, including prolonged hospital stays, increased rehospitalization rates, and complications (e.g., stroke, myocardial infarction, cardiogenic shock, and heart failure), stress the importance of comprehensive risk assessment and proactive management strategies.

Availability of Data and Materials

If reasonable, the data can be obtained from the corresponding author.

Author Contributions

FS and ZP designed the research study. FS and ZP performed the research. FS and ZP analyzed the data. Both authors contributed to editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Hubei No. 3 People's Hospital of Jianghan University, with approval no. 2024LW2024010, and complies with the relevant statements of the Declaration of Helsinki. All participants included in this study gave their informed consent.

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Conflict of Interest

The authors declare no conflict of interest.

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