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# Risk factors for deep vein thrombosis of the lower extremity after total hip arthroplasty

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## Abstract

**Objective** To investigate the risk factors for deep vein thrombosis (DVT) following total hip arthroplasty (THA).

**Methods** Patients who underwent THA in the Department of Joint Surgery at the Sixth Affiliated Hospital of Xinjiang Medical University from September 2020 to December 2022 were retrospectively selected based on inclusion criteria. They were divided into the DVT group ($n=65$) and the non-DVT group ($n=397$) according to the occurrence of postoperative DVT. The following variables were reviewed for both groups: age, sex, Body Mass Index (BMI), affected limb, previous history (smoking and drinking), diabetes, hypertension, operation time, total cholesterol, triglycerides, fibrinogen, hemoglobin, albumin, platelets, D-dimer, International Normalized Ratio (INR), and fibrin degradation products. Univariate analysis was conducted on these factors, and those with statistical significance were further analyzed using a binary logistic regression model to assess their correlation with DVT after THA.

**Results** A total of 462 patients were included in the study, with the DVT group representing approximately 14% and the non-DVT group approximately 86%. The DVT group had an average age of $67.27 \pm 4.10$ years, while the non-DVT group had an average age of $66.72 \pm 8.69$ years. Univariate analysis revealed significant differences in diabetes mellitus, preoperative fibrinogen, preoperative D-dimer, preoperative INR, and preoperative and postoperative fibrin degradation products between the DVT and non-DVT groups. Binary logistic regression analysis identified diabetes mellitus, elevated preoperative fibrinogen, preoperative D-dimer, and preoperative INR ($p<0.05$) as risk factors for DVT after THA.

**Conclusion** This study found that diabetes mellitus, elevated preoperative fibrinogen, preoperative D-dimer, and preoperative INR are independent risk factors for DVT following THA. Surgeons should thoroughly assess these risk factors, implement timely and effective interventions, and guide patients to engage in functional exercises as early as possible to reduce the incidence of DVT, thereby improving the outcomes of THA and improving patient quality of life.

**Keywords** Total hip replacement, Deep venous thrombosis, Hip joint, Risk factor

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## Introduction

As the population ages and the prevalence of hip disease rapidly rises, many people are undergoing total hip arthroplasty (THA) treatment [1]. Worldwide, more than 1 million THAs are performed annually [2]. THA is commonly used in orthopedic surgery for the treatment of hip diseases [3, 4] and is generally considered a highly successful surgical intervention that can relieve pain, improve function, and improve patient quality of life. However, deep vein thrombosis (DVT) remains a major complication of this surgery [5]. DVT, a serious global health issue, involves the abnormal coagulation of blood in the deep veins, leading to venous obstruction. This obstruction impedes venous return, causing distal venous hypertension, limb swelling, pain, and superficial venous dilation, which may result in varying degrees of chronic deep vein insufficiency. Globally, there are nearly 10 million cases of DVT each year in patients with post-THA [6], and approximately 300,000 deaths in the United States are attributed to DVT each year [7]. The healthcare costs associated with DVT are estimated at $3.3 billion in Europe and $10 billion in the United States [8, 9]. Beyond the increased healthcare burden, DVT can lead to long-term disability, reduce quality of life, and poses significant mortality risks. Studies [10] indicate that DVT risk is particularly high among orthopedic surgery patients due to several factors: (1) the use of tourniquets, bed rest, and immobilization, leading to venous stasis; (2) trauma increasing thromboplastin levels; (3) injury to endothelial cells during limb surgeries; and (4) the use of polymethyl methacrylate bone cement, which promotes hypercoagulability. Therefore, VTE prevention is crucial. This study retrospectively analyzed perioperative data from patients undergoing THA at our institution to investigate pre- and post-operative risk factors for DVT, aiming to provide insights for early risk factor identification and tailored thrombosis prophylaxis, thereby reducing the perioperative incidence of DVT in THA patients.

## Subjects and methods

**Inclusion criteria** ① Patients undergoing unilateral total hip replacement (THR) due to femoral head necrosis admitted to the Department of Joint Surgery at the Sixth Affiliated Hospital of Xinjiang Medical University from September 2020 to December 2022 were selected. ② No DVT detected in preoperative ultrasonography. ③ Patients who are self-aware and can express themselves clearly. ④ Patients requiring THR were clearly diagnosed by preoperative imaging. ⑤ The same group of surgeons performed the posterolateral approach THR. ⑥ Patients with a follow-up time of at least 1 month and complete follow-up data.

**Exclusion criteria** ① Patients previously diagnosed with DVT. ② Patients with severe neurological, psychiatric, or underlying diseases or other conditions that do not cooperate with pain assessment. ③ Patients unable to receive drug anticoagulation therapy due to severe heart, liver, or kidney dysfunction and a severe tendency for organ bleeding. ④ Patients allergic to anticoagulant drugs. ⑤ Patients who underwent THR by other surgical methods. ⑥ Diseases or conditions that may interfere with coagulation dysfunction or the risk of DVT: rheumatoid arthritis, previous hip surgery, previous treatment with ASA or anticoagulants.

### Ultrasound diagnostic criteria for deep venous thrombosis of lower extremities

Patients underwent intravenous color Doppler ultrasound 5 to 7 days before surgery and again 7 days after surgery to detect deep vein thrombosis (DVT). The color Doppler probe was used to examine the proximal deep veins of the lower extremity by intermittently compressing the transverse section from the femoral vein to the muscular venous plexus of the lower leg, followed by examination along the longitudinal section of these veins. The diagnostic criteria included: (1) Low or absent echo in the lumen; (2) Veins that could not be compressed; (3) Absence of autonomy in color and pulse Doppler ultrasound at the thrombus site, or the absence of changes in agitated blood flow or spectrum with respiration; (4) No blood flow signal or only a small amount of blood flow signal detected in the vein of the thrombus segment.

### Deep vein thrombosis prevention

We routinely implement measures to prevent deep vein thrombosis in all patients, followed by a series of standard treatments and rehabilitation exercises after surgery. Additionally, postoperative prevention included the administration of 0.4 ml: 4100 AXaIU of Nadroparin Calcium injection and/or 10 mg of rivaroxaban tablets per day.

### THA surgical method

All patients were positioned in the lateral posture, and following intraspinal anesthesia combined with epidural anesthesia, the conventional surgical area was disinfected. The posterolateral incision approach was chosen for the affected hip joint. A subcutaneous incision approximately 15 cm in length was made, followed by an incision of the deep fascia. The femoral greater trochanter bursa was excised, exposing the external rotator muscle group. The piriformis muscle, along with the superior and inferior gemellus muscles, was sutured using 0 Vicryl thread. A portion of the external rotator muscle group was incised, and the joint capsule was opened. The femoral head was dislocated to expose the

acetabulum. The soft tissue within the acetabulum was removed, the hyperplastic synovium was excised, and the acetabulum was polished to the subchondral bone. Acetabular reamers of increasing size were used, and after satisfactory press-fit testing, a biologic acetabular cup of the corresponding size was rinsed and implanted to reveal a polished surface. The acetabular prosthesis was correctly positioned in terms of angle and placement, and a polyethylene liner of matching size was inserted. The femoral component was then implanted into the femoral shaft, the femoral head was placed, and the joint was checked for concentricity and the absence of dislocation signs through range of motion tests. The joint cavity and wound were irrigated with tranexamic acid, and the external rotator muscle group was reapproximated and sutured. Local analgesia was injected around the incision site. The external rotator muscles, tensor fascia lata, and superficial fascial layers were sutured sequentially using 0 Vicryl thread, 0 intermittent Vicryl thread, and 0 fishbone barb line, respectively. The deep fascia was closed layer by layer with 2−0 Vicryl thread, and the skin was closed with 3−0 fishbone barb line. A drainage tube was placed as needed, without dressing, and the patient was then transported back to the ward on a flatbed.

### Postoperative management

#### *Postoperative rehabilitation training*

Based on postoperative CT or X-ray examinations, each patient's rehabilitation progress was assessed, and a corresponding functional exercise program was developed. The goals were to increase blood circulation in the lower extremities, prevent DVT, increase muscle strength, improve joint mobility, and prevent hip dislocation. The training regimen included independent transfers and safe mobility from bed, seat, and toilet. Patients were also trained to walk independently on level ground and stairs using a cane or staff.

### Statistical methods

All statistical analyses were performed using SPSS 22.0. Continuous numerical variables are expressed as mean ± standard deviation. Data were analyzed using the t-test, chi-square test, or univariate logistic regression analysis, as appropriate. A $p$-value < 0.05 was considered statistically significant.

## Results

### General information

A total of 462 patients who underwent THA surgery in our hospital from September 2020 to December 2022 were retrospectively analyzed, comprising 162 males and 300 females. Based on the occurrence of postoperative DVT, patients were categorized into the DVT group ($n$ = 65) and the non-DVT group ($n$ = 397). The mean age of the DVT group was 67.27 ± 4.10 years, while the mean age of the non-DVT group was 66.72 ± 8.69 years.

### Comparison of preoperative data

Significant differences were observed in diabetes mellitus, preoperative fibrinogen, preoperative D-dimer, preoperative INR, and preoperative fibrin degradation products between the DVT group (approximately 14%) and the non-DVT group (approximately 86%) ($p$ < 0.05). Refer to Table 1.

**Table 1** Preoperative data comparison table

| factor | DVT group($n$ = 65) | Non-DVT group($n$ = 397) | $X^2$/t-value | $p$-value |
|---|---|---|---|---|
| age($\bar{x}$±s) | 67.27 ± 4.10 | 66.72 ± 8.69 | 8.668 | 0.616 |
| sex (man/woman, n) | 21/44 | 141/256 | 0.253 | 0.615 |
| BMI($\bar{x}$±s, kg/m2) | 23.83 ± 3.79 | 23.40 ± 3.79 | 0.034 | 0.854 |
| The affected limb(Left/Right, n) | 32/33 | 214/183 | 0.490 | 0.484 |
| Smoking history(n/%) | 13(19.89%) | 120(30.12%) | 2.850 | 0.091 |
| Drinking history(n/%) | 13(19.89%) | 106(26.60%) | 1.311 | 0.252 |
| hypertension(n/%) | 13(19.89%) | 97(24.346%) | 0.605 | 0.437 |
| diabetes(n/%) | 24(36.72%) | 92(23.09%) | 5.615 | **0.018** |
| Preoperative total cholesterol($\bar{x}$±s, mmol/L) | 5.10 ± 0.91 | 4.94 ± 1.12 | 1.726 | 0.190 |
| Preoperative triglycerides($\bar{x}$±s, mmol/L) | 1.44 ± 0.73 | 1.45 ± 1.18 | 1.598 | 0.207 |
| Preoperative fibrinogen($\bar{x}$±s, g/L) | 3.25 ± 0.98 | 3.78 ± 1.20 | 6.457 | **0.011** |
| Preoperative hemoglobin($\bar{x}$±s, g/L) | 123.24 ± 21.56 | 121.29 ± 21.46 | 0.150 | 0.699 |
| Preoperative albumin($\bar{x}$±s, g/L) | 40.21 ± 4.62 | 39.17 ± 4.51 | 0.231 | 0.631 |
| Preoperative platelet($\bar{x}$±s, $10^9$/L) | 223.92 ± 65.70 | 198.42 ± 78.72 | 1.271 | 0.260 |
| Preoperative D-dimer($\bar{x}$±s, mg/L) | 0.67 ± 0.81 | 0.58 ± 0.47 | 19.255 | **0.000** |
| Preoperative INR($\bar{x}$±s) | 1.07 ± 0.13 | 1.03 ± 0.11 | 8.403 | **0.004** |
| Preoperative fibrin degradation products($\bar{x}$±s, ug/mL) | 1.40 ± 1.35 | 3.79 ± 1.88 | 20.980 | **0.000** |

There was a statistically significant difference between the two groups （P<0.05）

**Table 2** Postoperative data comparison table

| factor | DVT group($n=65$) | Non-DVT group($n=397$) | $X^2$/t-value | *p*-value |
|---|---|---|---|---|
| Operation time($\bar{x}\pm s$, min) | 144.00 ± 35.82 | 140.13 ± 32.46 | 0.579 | 0.447 |
| Postoperative total cholesterol($\bar{x}\pm s$, mmol/L) | 3.73 ± 1.55 | 4.02 ± 1.15 | 0.141 | 0.708 |
| Postoperative triglycerides($\bar{x}\pm s$, mmol/L) | 1.57 ± 0.86 | 1.84 ± 1.65 | 1.087 | 0.298 |
| Postoperative fibrinogen($\bar{x}\pm s$, g/L) | 4.62 ± 1.08 | 4.69 ± 1.14 | 0.038 | 0.845 |
| Postoperative hemoglobin($\bar{x}\pm s$, g/L) | 102.36 ± 16.99 | 104.87 ± 18.43 | 2.050 | 0.153 |
| Postoperative albumin($\bar{x}\pm s$, g/L) | 34.20 ± 5.48 | 34.66 ± 4.53 | 3.883 | **0.049** |
| Postoperative platelet($\bar{x}\pm s$, $10^9$/L) | 269.24 ± 86.55 | 248.59 ± 84.89 | 0.055 | 0.814 |
| Postoperative D-dimer($\bar{x}\pm s$, mg/L) | 3.21 ± 1.85 | 5.33 ± 4.33 | 9.719 | **0.002** |
| Postoperative INR($\bar{x}\pm s$) | 1.13 ± 0.12 | 1.07 ± 0.14 | 1.255 | 0.263 |
| Postoperative fibrin degradation products($\bar{x}\pm s$, ug/mL) | 6.69 ± 5.57 | 5.34 ± 3.03 | 26.955 | **0.000** |

There was a statistically significant difference between the two groups （P<0.05）

**Table 3** Risk of DVT after total hip replacement (logistic regression analysis)

| Clinical parameter | B-value | Se-value | Wald-value | *P*-value | OR-value | 95%CI(Lower limit to upper limit) |
|---|---|---|---|---|---|---|
| diabetes. | **2.289** | 0.529 | 18.726 | **0.000** | 9.867 | 3.499—27.827 |
| Preoperative fibrinogen | **1.008** | 0.203 | 24.638 | **0.000** | 2.741 | 1.841—4.082 |
| Preoperative D-dimer | **1.075** | 0.301 | 12.713 | **0.000** | 2.930 | 1.623—5.289 |
| Preoperative INR | **3.106** | 1.543 | 4.050 | **0.044** | 22.326 | 1.084—459.694 |
| Preoperative fibrin degradation products | -1.086 | 0.172 | 39.835 | 0.000 | 0.338 | 0.241—0.473 |
| Postoperative albumin | 0.068 | 0.041 | 2.696 | 0.101 | 1.070 | 0.987—1.160 |
| Postoperative D-dimer | -0.136 | 0.096 | 1.987 | 0.159 | 0.873 | 0.722—1.055 |
| Postoperative fibrin degradation products | 0.131 | 0.040 | 10.890 | 0.001 | 1.140 | 1.055—1.233 |

### Postoperative index comparison

Significant differences were noted in postoperative albumin, postoperative D-dimer, and postoperative fibrin degradation products between the DVT and non-DVT groups ($p<0.05$). Refer to Table 2.

### Single factor analysis

Univariate analysis revealed significant differences in diabetes mellitus, preoperative fibrinogen, preoperative D-dimer, preoperative INR, preoperative fibrin degradation products, postoperative albumin, postoperative D-dimer, and postoperative fibrin degradation products between the DVT and non-DVT groups ($p<0.05$).

### Binary logistic regression analysis

Following the results of the univariate analysis, all statistically significant variables (diabetes mellitus, preoperative fibrinogen, preoperative D-dimer, preoperative INR, preoperative fibrin degradation products, postoperative albumin, postoperative D-dimer, postoperative fibrin degradation products) were included in a binary logistic regression analysis (refer to Table 3). The analysis identified that diabetes mellitus, preoperative fibrinogen, preoperative D-dimer, and preoperative INR were risk factors for DVT after total hip arthroplasty, whereas postoperative albumin, postoperative D-dimer, preoperative fibrin degradation products, and postoperative fibrin degradation products were not identified as risk factors (refer to Fig. 1).

**Typical cases**(see also Figs. 2–3):

## Discussion

### Summary of evidence

Hip replacement (THA) is a significant intervention in the treatment of hip diseases and plays an essential role in improving the quality of life for elderly patients [11]. As the number of patients undergoing joint replacement increases, so too do postoperative complications such as deep vein thrombosis (DVT) [12]. The three primary factors contributing to DVT of the lower limbs are slow venous blood flow, venous wall injury, and high blood coagulation. With aging, the vascular elasticity of the elderly significantly decreases, combined with restricted movement, leading to slow blood flow in the lower limbs. Intraoperative and postoperative bleeding further places the blood in a hypercoagulable state, ultimately resulting in DVT formation [13]. DVT is a significant complication in hospitalized patients, serving as a main cause of death and morbidity following THA [14]. Its clinical manifestations are highly variable; some patients with mild DVT may exhibit no obvious symptoms, detectable only through ultrasound or other diagnostic tests. Others may experience swelling and pain in the affected limbs, reduced functional status, and delayed recovery. Due to lengthy operation times and complex surgical procedures, orthopedic operations, especially hip replacements, are prone to thrombosis in the lower limb veins [15, 16]. Current research on the etiology of

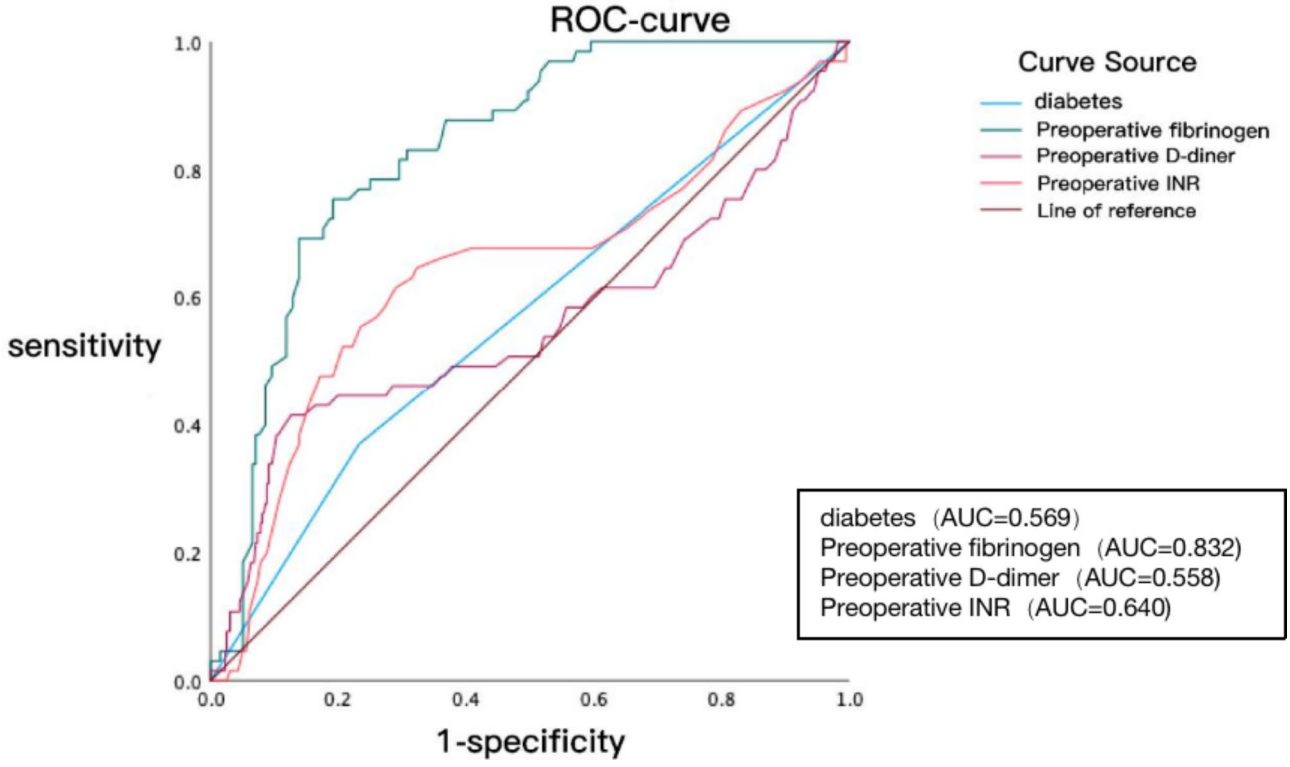


**Fig. 1** ROC curves of diabetes mellitus, preoperative fibrinogen, preoperative D-dimer, and preoperative INR predicted DVT after total hip replacement

post-traumatic venous thrombosis remains incomplete, and existing preventive treatments have shortcomings, leaving the issue of venous thrombosis after joint replacement not fully understood. Therefore, the focus of DVT management should be on better understanding its causes to effectively and accurately prevent it. We must excel in evaluating high-risk factors, actively adopt scientific and rational treatment and nursing approaches, and implement effective preventive interventions.

Numerous studies [17, 18] have reported that diabetes is a significant risk factor for DVT. Kahn [19] observed that with aging, the elasticity of blood vessels decreases, making the vessel walls more prone to damage. Elderly patients with underlying conditions such as diabetes are at an increased risk for DVT. Deng et al. [20] found that the total incidence of postoperative VTE in diabetic patients undergoing THA or TKA was 46.8%, indicating a notably high risk. Chen [21] noted that elderly diabetic patients are more susceptible to arterial atherosclerosis. Elevated blood glucose levels reduce the deformability of red blood cells and increase blood viscosity, leading to slower blood circulation. Additionally, the aggregation of red blood cells can damage the vascular wall, thereby increasing the risk of postoperative DVT in the lower limbs. Yu et al. [22] identified diabetes as an independent risk factor for lower limb DVT in THA patients, emphasizing the importance of improved blood glucose control during the perioperative period to reduce the incidence of DVT. Li et al. [23] noted that patients undergoing orthopedic surgery are in a state of stress, with diabetic patients experiencing greater fluctuations in blood glucose levels compared to non-diabetic patients, leading to the release of a large number of cytokines that can activate the coagulation system and elevate the risk of thrombosis. This study supports the conclusion that diabetes mellitus is an independent risk factor for lower extremity DVT after THA, as it can cause vascular endothelial dysfunction and arteriovenous plaque formation, leading to vascular blockage, reduced blood flow, and increased blood viscosity, thus promoting thrombosis formation. These findings are consistent with those of Kaur et al. [24]. Therefore, it is crucial to assess patient conditions early to effectively control blood glucose levels and prevent the occurrence of VTE.

D-dimer is a product of fibrin degradation that occurs in the blood after blood clot destruction and is widely used in screening for deep vein thrombosis (DVT) [25–28]. D-dimer levels are an important indicator for DVT screening and serve as one of the main means of routine screening or evaluation in suspected DVT cases, offering good predictive value for DVT. Our study suggests that high levels of preoperative D-dimer are an independent risk factor for postoperative VTE. This finding is supported by Deng [20] and Cushman [29] and aligns with research by scholars such as Li [30] and Gao [31]. Sun et al. [32] also indicated that an increase in D-dimer

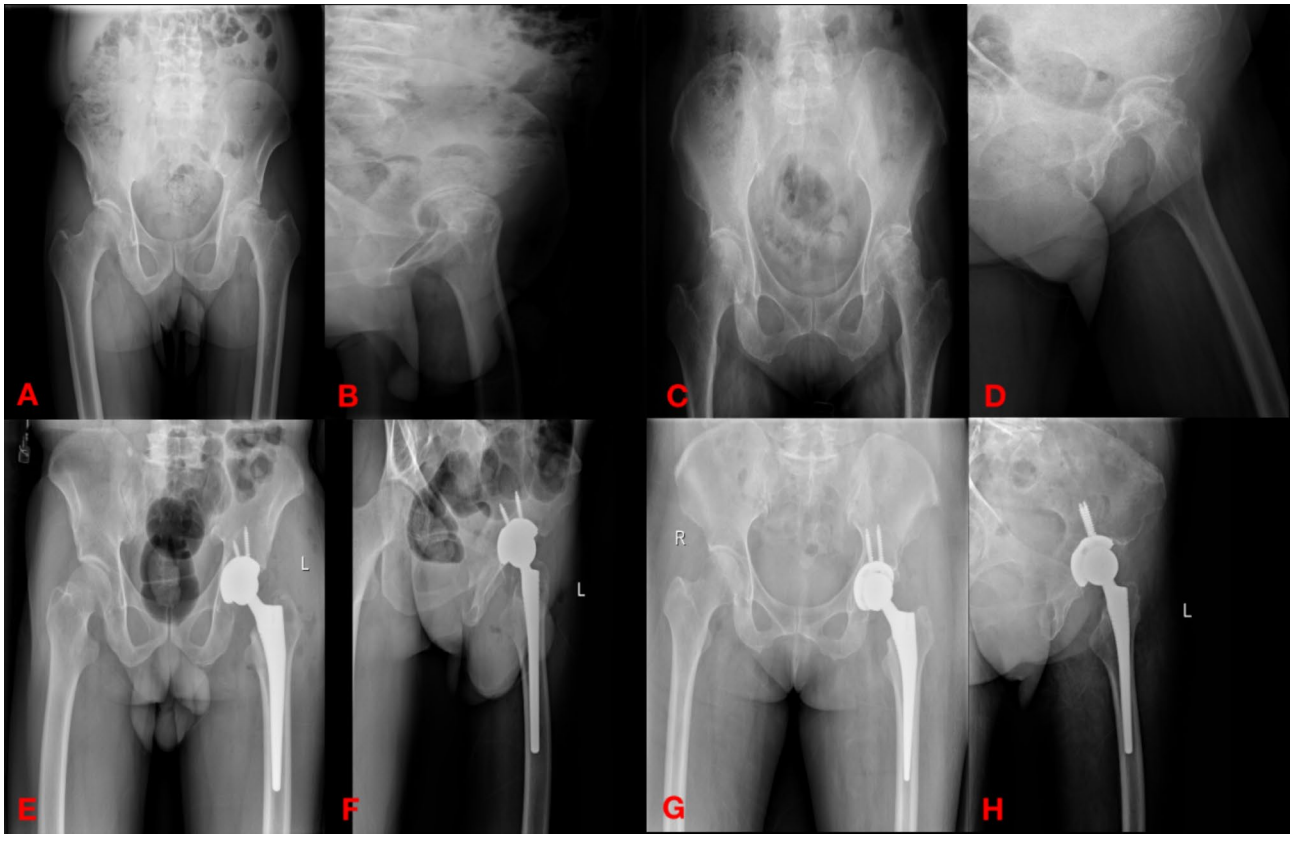


**Fig. 2** Preoperative and postoperative anterolateral X-rays of the hip. Note: (1) male, 64 years old, necrosis of left hip and femoral head. (**A**) Normal x-ray of preoperative hip; (**B**) x-ray of preoperative hip side; **E**. Normal x-ray of postoperative hip; **F**. x-ray of postoperative hip side. (2) Female, 66 years old, with necrosis of the left hip joint and femoral head. (**C**) x-ray preoperative hip position; (**D**) x-ray preoperative hip side position; **G**. x-ray postoperative hip position; **H**. postoperative hip side x-ray

positively predicts the occurrence of lower limb deep vein thrombosis (LDVT) one week post-surgery. It is generally accepted that acute DVT can be effectively ruled out when D-dimer levels are below 0.5 mg/L, but progressively increasing levels of D-dimer can be utilized as an indicator for thrombosis through dynamic monitoring.

The results of this study also indicate that preoperative fibrinogen elevation is a risk factor for DVT after THA. An abnormal increase in plasma fibrinogen (FIB) content suggests that both plasma viscosity and whole blood viscosity are elevated, which increases platelet aggregation and reflects an increased risk of thrombosis and atherosclerosis in patients. Bai et al. [33] demonstrated that an abnormal increase in fibrinogen and D-dimer levels is an important independent risk factor for DVT after hip replacement in middle-aged and elderly individuals, with a OR value of 13.294. Studies [34] have shown that the high incidence period of DVT in patients undergoing THA for reasons such as hip fracture occurs 1–3 days after surgery, and fibrinogen has certain predictive value for DVT formation following lower limb fractures [35].

The results of this study suggest that decreased INR is a risk factor for DVT. INR is the ratio of prothrombin time (PT) to the International Sensitivity Index (ISI) of the assay. An increase in INR indicates a decrease in coagulation function and an increased risk of bleeding, whereas a decrease in INR suggests blood hypercoagulability, commonly associated with thrombotic diseases. PT primarily reflects the levels of coagulation factors II, V, VII, and X, serving as a standard index for screening tests of the exogenous coagulation system. Shortening of PT is observed in conditions of blood hypercoagulability and thrombotic diseases. Relevant studies have shown [36] that the expression levels of D-dimer and PT are correlated with the risk of DVT formation, consistent with the findings of this study. Gao et al. [37] indicated that hypercoagulability is the pathological basis of DVT, and coagulation function indices are somewhat correlated with DVT. For THA patients, it is advisable to dynamically monitor plasma D-dimer, PT, and other coagulation function indices to provide a basis for early and targeted clinical prevention and treatment.

#### Limitations of the article

① We only conducted color Doppler ultrasonography within 7 days post-surgery and did not assess long-term

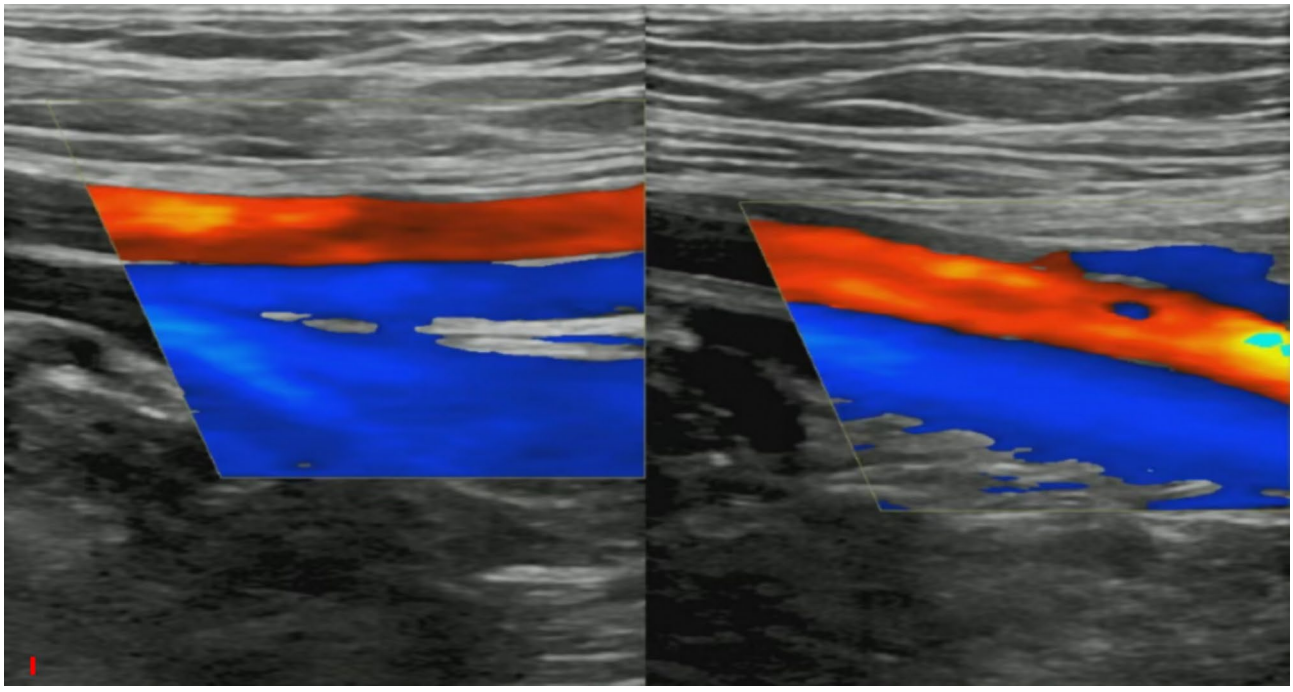

**Fig. 3** Thrombus sonogram. Note: A 66-year-old man who underwent postoperative color Doppler ultrasound of lower limb veins was found to have left intermuscular venous plexus thrombosis

DVT outcomes. ② Other factors such as infection, medications, cancer, trauma, and smoking significantly contribute to postoperative complications. Due to data limitations, these factors were not explored in this study, highlighting the need for further research to examine their relationship with postoperative DVT. ③ The follow-up period was not sufficiently long. ④ This study is retrospective in nature, which may introduce potential inaccuracies in recorded data, possibly leading to biased results.

## Conclusion

The results of this study demonstrated that diabetes mellitus, preoperative fibrinogen, preoperative D-dimer, and preoperative INR are independent risk factors for DVT following THA. Surgeons should thoroughly evaluate these risk factors and actively intervene by implementing timely and effective measures. Additionally, guiding patients to engage in functional exercises as early as possible can reduce the incidence of DVT, thereby improving the outcomes of THA and improving patient quality of life.

### Abbreviations

| | |
|---|---|
| THA | Total hip replacement |
| DVT | Deep venous thrombosis |
| INR | International normalized ratio |
| FIB | Fibrinogen |

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Not applicable.

### Author contributions

Study design, conception, and critical revision: L.H. Analysis and interpretation of data: L.H. and A.H. Literature search and drafting of manuscript: L.H, A.H and A.K. L.H and T.A. contributed to critical revision of the manuscript for important intellectual content and approved the fnal version of the manuscript. All authors read and approved the fnal version of the manuscript.

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Not applicable.

### Data availability

In-depth analysis and evaluation of risk factors for lower extremity deep vein thrombosis (DVT) in patients after total hip replacement, and provide reference for effective prevention of deep vein thrombosis, so the dataset analyzed in this study is not publicly available but is available to the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

We confrm that all experiments were performed in accordance with the Declaration of Helsinki. The study was approved by the Ethical Committee of the Sixth Afliated Hospital of Xinjiang Medical University, NO. LFYLLSC20240507-01. Each patient provided written informed consent before participating in the study.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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