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# The deep vein thrombosis of lower limb after total hip arthroplasty: what should we care

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## Abstract

**Background:** Deep vein thrombosis (DVT) of lower limb is one of the common complications after total hip arthroplasty (THA), we aimed to evaluate the potential risk factors of DVT of lower limb in patients with THA, to provide insights into the management of THA.

**Methods:** Patients who underwent THA in our hospital from January 1, 2017 to November 30, 2020 were included. The personal characteristics and clinical data of DVT and no-DVT patients were compared and analyzed. Logistic regression analyses were performed to identify the potential risk factors of DVT in patients with THA.

**Results:** A total of 182 THA patients were included, the incidence of DVT of lower limb in patients with THA was 19.78%. There were significant differences in the age, BMI, diabetes, number of replacement, duration of surgery, type of prosthesis and duration of days in bed between DVT and no-DVT patients (all  $P < 0.05$ ). And there were no significant differences in the gender, hypertension, hyperlipidemia, preoperative D-dimer, type of anesthesia and anticoagulant drugs use (all  $P > 0.05$ ). Logistic regression analysis indicated that age  $> 70$  y (OR 4.406, 95% CI 1.744 ~ 6.134), BMI  $\geq 28$  (OR 2.275, 95% CI 1.181 ~ 4.531), diabetes (OR 3.949, 95% CI 1.284 ~ 5.279), bilateral joint replacements (OR 2.272, 95% CI 1.402 ~ 4.423), duration of surgery  $\geq 120$  min (OR 3.081, 95% CI 1.293 ~ 5.308), cemented prosthesis (OR 2.435, 95% CI 1.104 ~ 4.315), and duration of days in bed  $> 3$  days (OR 1.566, 95% CI 1.182 ~ 1.994) were the risk factors of DVT of lower limb in patients with THA.

**Conclusions:** DVT in the lower limb after THA is common, and its onset is affected by many factors. In clinical work, attention should be paid to identify the risk factors for DVT and targeted interventions are highlighted to prevent the postoperative DVT.

**Keywords:** deep vein thrombosis, total hip arthroplasty, management, nursing, care

## Background

Total hip arthroplasty (THA) is a common surgical treatment in the department of orthopedics and one of the effective treatments for end-stage hip joint diseases, mainly for the elderly [1]. THA is mainly used to treat joint pain and dysfunction caused by hip joint disease, including

hip joint osteoarthritis, femoral head necrosis, bone neck fractures and so on [2]. At present, more than 500,000 people worldwide receive artificial joint replacement due to fractures, osteoarthritis, bone tumors and other diseases each year [3]. In China, 30,000 to 50,000 people undergo THA every year [4, 5]. Through artificial hip replacement, it can relieve joint pain, improve joint function, and correct deformity. And with proper postoperative functional exercise, the patient's hip joint function may meet the needs of daily life and improve the quality of life [6].

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Deep venous thrombosis (DVT) is a common complication after hip arthroplasty, with an incidence rate of 40–60%[7]. The formation of DVT of the lower extremities can increase the suffering of patients, prolong hospitalization time, and increase medical expenses[8]. Once it falls off, it can easily cause pulmonary embolism, and severe cases can lead to death. The relevant guidelines[9, 10] point out that patients who have undergone major operations such as hip replacement without obvious bleeding tendency need to use anticoagulant drugs within 24 h after surgery, but there are still some patients who have DVT under the condition of standardized anticoagulant application. At present, there are many reports[11, 12] on DVT of the lower extremities after THA at home and abroad, but there are few studies on systemic analysis of DVT after artificial hip replacement, and the risk factors reported in related studies are relatively limited. It is necessary to further explore the related risk factors. Therefore, in this present study, we aimed to evaluate the influencing factors of DVT of lower limb after THA, to provide evidence support for the prevention and treatment of clinical THA.

## Methods

### Ethical issues

In this study, all methods were performed in accordance with the relevant guidelines and regulations. Our study had been verified and approved by the ethics committee of The Third Affiliated Hospital of Anhui Medical University (No.1,700,342), and all the included patients had signed the written informed consents.

### Patients

Patients who underwent THA in our hospital from January 1, 2017 to November 30, 2020 were selected as the research population. The inclusion criteria of patients in our study were: (1) The patient met the criteria for hip replacement and underwent the first THA in our hospital; (2) The age was  $\geq 50$  years old, regardless of gender; (3) Preoperative color Doppler ultrasound indicated that there was no DVT in both lower extremities during the examination; (4) The patient's medical record was complete and available for data analysis. The exclusion criteria for patients were: (1) the pathological fractures caused by malignant tumors, tuberculosis which might influence the development of DVT; (2) DVT of the lower extremities existed before THA; (3) patients who disagreed to participate in this study.

### The diagnosis of DVT of lower extremity

The diagnosis of lower extremity DVT was based on the standards in the relevant diagnosis and treatment guidelines[13, 14]. Postoperative observation of the affected limbs for the following manifestations including limb

swelling, pain, elevated skin temperature, skin color changes, venous return disorder, Homans sign, Neuhof's sign. Color Doppler ultrasound indicated that there was no color blood flow signal and spectrum signal in the venous cavity, no collapse of the venous pressurized lumen, extremely low echo in the venous lumen, and irregular pulse Doppler spectrum. The ultrasound was generally used in the surgical leg, and if there were abnormal symptoms in another leg, we would also detect it for DVT. The inspection area for ultrasound scanning was from inguinal ligament to the distal leg. Patients underwent ultrasound examination every two days after surgery. And if necessary, the venography was performed.

### DVT preventions

We routinely conducted the mechanical post-operative DVT preventions for all patients as previous report[15]. We would encourage patients get out of bed as early as possible, and to massage the lower limb frequently and observe the status regularly. Besides, all the patients accepted the electrical stimulation for four days with Deming X100 massager(Deming biotechnology company, Wuxi, China), the massage started within 12 h after operation. The frequency was 30/50/30, the pulse width was 400/360/410, the massage continued 30 min each time. Besides, the intensity of stimulation was given differently based on the tolerance of patient, and it was set to the maximum intensity that could be tolerated by patients without discomfort. Besides, 10 mg per day of Rivaroxaban and 0.4ml of Low-molecular weight heparin calcium was used for the prevention of DVT.

### Data collection

We reviewed patients' medical records, and we collected the general patient information including gender, age, body mass index(BMI), personal history, comorbid diseases, surgical factors including prosthesis type, duration of surgery, anesthesia method, postoperative factors including postoperative days in bed, anticoagulant drug application and laboratory indicators including preoperative D-dimer. Then we observed and analyzed the correlation between the above data and DVT.

### Data analysis

The observed data are statistically analyzed using SPSS23.0 statistical software. The measurement data are all expressed as mean  $\pm$  standard deviation or percentage. According to the difference in the nature of each data, chi-square test, t-test were applied to identify the difference of DVT and no-DVT group. And logistic regression analyses were conducted to identify the potential risk factors of DVT in patients with THA.  $P < 0.05$  indicated that the difference was statistically significant.

## Results

### The characteristics of included patients

A total of 182 THA patients were included, of whom 36 patients had suffered from DVT of lower limb, the incidence of DVT of lower limbs in patients with THA was 19.78%. Of the 36 cases of DVT, there were 15 cases of proximal DVTs and 21 cases of distal DVTs. As presented in Table 1, there were significant differences in the age, BMI, diabetes, number of replacement, duration of surgery, type of prosthesis and duration of days in bed between DVT and no-DVT patients (all  $P < 0.05$ ). And there were no significant differences in the gender, hypertension, hyperlipidemia, preoperative D-dimer, type of anesthesia and anticoagulant drugs use (all  $P > 0.05$ ).

### The risk factors of DVT in patients with THA

We included the factors that were found to be significant differences between two group into further logistic regression, and the variable assignments of logistic regression were showed in Table 2.

As indicated in Table 3, The logistic regression analysis found that age  $> 70$ y (OR4.406, 95 %CI1.744 ~ 6.134), BMI  $\geq 28$  (OR2.275, 95 %CI1.181 ~ 4.531),

diabetes (OR3.949, 95 %CI1.284 ~ 5.279), bilateral joint replacements (OR2.272, 95 %CI1.402 ~ 4.423), duration of surgery  $\geq 120$  min (OR3.081, 95 %CI1.293 ~ 5.308), cemented prosthesis (OR2.435, 95 %CI1.104 ~ 4.315), and duration of days in bed  $> 3$  days (OR1.566, 95 %CI1.182 ~ 1.994) were the risk factors of DVT of lower limb in patients with THA.

## Discussions

DVT is a disorder of venous return caused by abnormal blood coagulation in the deep veins of the lower extremities, which completely or incompletely obstruct the blood vessels [16]. It is a common complication after THA and an important cause of unexpected deaths during the perioperative period of such patients [17]. Therefore, DVT has attracted extensive attention from clinical medical workers. Studies [18–20] have shown that the incidence of DVT in patients treated with THA is 14.13–20.18%. The results of this study indicate that the incidence of lower limb DVT in patients after THA is 19.78%, which is lower than the previous report [21, 22]. It may be related to the differences in the conditions of included patients, surgical method and perioperative preventive anticoagulation treatment amongst different studies.

**Table 1** The characteristics of included patients

Variables	DVT group (n = 36)	Non-DVT group (n = 146)	$\chi^2/t$	P
Male/female	20/16	92/54	1.046	0.102
Age(y)	72.14 ± 8.02	68.11 ± 9.35	4.328	0.025
BMI(kg/m <sup>2</sup> )	28.26 ± 4.55	26.02 ± 3.29	3.144	0.032
Diabetes	19(52.78%)	25(17.12%)	1.118	0.009
Hypertension	21(58.33%)	77(52.71%)	1.207	0.068
Hyperlipidemia	10(27.78%)	42(28.77%)	1.084	0.106
Preoperative D-dimer (mg/L)	0.69 ± 0.11	0.66 ± 0.12	1.230	0.074
Number of replacement joints				
Unilateral	11(30.56%)	38(26.03%)	1.140	0.031
Bilateral	25(69.44%)	108(73.97%)		
Duration of surgery(min)	133.62 ± 30.18	102 ± 27.42	9.124	0.015
Type of Anesthesia				
General anesthesia	16(44.44%)	68(46.57%)	1.122	0.078
Epidural anesthesia	20(55.56%)	78(53.42%)		
Type of prosthesis				
Biological prosthesis	6(16.67%)	72(49.32%)	1.205	0.036
Cemented prosthesis	30(83.33%)	74(50.68%)		
Duration of days in bed	4.24 ± 1.22	2.79 ± 1.02	1.177	0.042
Anticoagulant drugs				
Rivaroxaban	22(61.11%)	85(58.22%)	1.145	0.103
Low-molecular weight heparin calcium	14(38.89%)	61(41.78%)		

**Table 2** The variable assignments of logistic regression

Factors	Variables	Assignment
VTE	Y	Yes = 1, no = 2
Age(y)	X <sub>1</sub>	≥ 70 = 1, < 70 = 2
BMI(kg/m <sup>2</sup> )	X <sub>2</sub>	≥ 28 = 1, < 28 = 2
Diabetes	X <sub>3</sub>	Yes = 1, No = 2
Number of replacement joints	X <sub>4</sub>	Bilateral = 1, unilateral = 2
Duration of surgery(min)	X <sub>5</sub>	≥ 120 = 1, < 120 = 2
Type of prosthesis	X <sub>6</sub>	Cemented prosthesis = 1, biological prosthesis = 2
Duration of days in bed	X <sub>7</sub>	≥ 3 = 1, < 3 = 2

Endometrial injury, venous blood flow stasis and blood hypercoagulability are the three factors that induce DVT[23]. The subjects of this study are elderly patients 50 years and older. The elasticity of blood vessels are poor and elder patients are complicated by the physiological or organic changes of multiple organs, and the perioperative period of lower extremity joint mobility and the amount of activity are significantly reduced, so the risk of DVT is higher[24–26]. We have found that age > 70y, BMI ≥ 28, diabetes, bilateral joint replacements, duration of surgery ≥ 120 min, cemented prosthesis, and duration of days in bed > 3 days were the independent risk factors of DVT of lower limb in patients with THA. It is clinically necessary to carry out early prevention and intervention for these risk factors of DVT to reduce the occurrence of DVT.

With the increase of age, the elasticity of blood vessels in patients decreases, the blood vessel walls are easily damaged, and elderly patients are prone to have primary diseases such as diabetes, which increases the incidence of DVT[27]. The results of our study are consistent with the findings of previous studies. BMI is a factor that affects the occurrence of DVT after surgery, which has been confirmed by many studies[28–30]. The guidelines set BMI ≥ 30 kg/m<sup>2</sup> as an influencing factor of DVT. WHO uses BMI ≥ 30 kg/m<sup>2</sup> as the obesity standard[31], and the WHO Western Pacific Region and the International Working Group recommend that for the Asian

population BMI > 25 kg/m<sup>2</sup> is taken as obesity [32]. Experts from the Chinese Obesity Working Group considered that BMI ≥ 28 kg/m<sup>2</sup> is more appropriate for obesity[33], this study used the standard of BMI ≥ 28 kg/m<sup>2</sup>, the results have showed that BMI ≥ 28 kg/m<sup>2</sup> is a risk factor affecting the occurrence of DVT. Therefore, for patients with BMI > 28, DVT should be warned in advance.

Many studies[34, 35] have reported that diabetes is a risk factor for DVT. Orthopedic surgery patients are in a state of stress. Diabetic patients' blood glucose changes more than that of non-diabetic patients[36]. A large number of cytokines are released in the body during surgery, which easily activates the endogenous and exogenous coagulation system and increases the risk of thrombosis[37]. The results of this study suggest that blood glucose control in patients with THA perioperative should be strengthened to reduce the incidence of DVT. For patients with cemented prostheses, intraoperative bone cement can cause the release of mononuclear cytokines and the deformation and separation of endothelial cells, further covering the endothelial surface with fibrinogen, which in turn activates the exogenous blood coagulation pathway, resulting in high blood coagulation state, thereby increasing the risk of DVT[38]. Elderly patients with hip replacement are weak and require bed rest. Slow blood flow in the lower limb can also increase the risk of DVT[39]. The results of this study show that

**Table 3** The logistic regression analysis on the risk factors of DVT in patients with THA

Variables	β	S'x	OR	95 %CI	P
Age > 70y	0.133	0.227	4.406	1.744 ~ 6.134	0.016
BMI ≥ 28	0.119	0.230	2.275	1.181 ~ 4.531	0.023
Diabetes	0.103	0.151	3.949	1.284 ~ 5.279	0.007
Bilateral joint replacements	0.147	0.183	2.272	1.402 ~ 4.423	0.033
Duration of surgery ≥ 120 min	0.149	0.102	3.081	1.293 ~ 5.308	0.026
Cemented prosthesis	0.126	0.117	2.435	1.104 ~ 4.315	0.042
Duration of days in bed > 3 days	0.113	0.124	1.566	1.182 ~ 1.994	0.037

the days in bed  $\geq 3$  days after surgery is a risk factor for DVT. Therefore, it should be as early as possible to perform functional exercises of the lower limb to promote blood return to the lower limb and reduce the risk of thrombosis.

The prevention and treatment of DVT is of great significance to the prognosis of patients. It is necessary for doctors and nurses to strengthen preoperative assessment. Before surgery, it is necessary to understand the patient's past medical history, general condition and blood coagulation, strengthen the screening of high-risk patients with DVT, and actively correct the effects of anemia, hypertension, diabetes and other cardiovascular diseases[40]. During the operation, the doctor should be familiar with the anatomy and surgical techniques, and reduce the operation and anesthesia duration. And the operation should be gentle and meticulous, and reduce unnecessary tissue damage, especially the intraoperative blood vessel damage, so as not to damage the vascular intima and induce thrombosis[41]. After the operation, the affected limb should be raised in certain position, and functional exercise should be performed as early as possible to increase venous blood return. Besides, the patients should regulate mood, eat lightly, and maintain smooth stools to reduce the obstruction of lower limb venous return caused by forced defecation and increased abdominal pressure[42, 43].

Several limitations must be concerned in this present study. Firstly, it is worth noting that the sample size of cases selected in this study is small and our study is a single-center study. The results of the study should be treated with caution. Secondly, patient risk stratification is a valid initial approach to ensure better management of patients undergoing THA and to predict who can benefit from a pharmacological preventive strategy, we did not perform individual thromboembolic risk before surgery in this present study. Thirdly, hyperglycemia has been found to be associated with many postoperative complications, in our clinical practice, we would correct the hyperglycemia before surgery. However, we did not detect the glycated hemoglobin routinely, since our study is a retrospective design, we could not collect the most data on the glycated hemoglobin, therefore we could not include those indicators for analysis. Besides, other factors including infections, medications, cancer, trauma and smoking et al. play a significant role in the total amount of post-surgical complications, limited by data, we did not investigate those factors in this present study, more studies on the association of those factors and postoperative DVT are needed. Future studies with larger samples and multi-centers need to further explore the risk factors of DVT in patients undergoing THA, to provide reliable evidence to the prophylaxis of DVT.

## Conclusions

In summary, the occurrence of DVT after THA is associated with many factors. In clinical work, attention should be paid to identify the risk factors that induce DVT and actively intervening are needed. The health care provider should take effective measures targeted on the risk factors in time, and to guide patients to early perform functional exercises to reduce the incidence of DVT, thereby increasing the efficacy of THA and improving the life quality of patients.

## Abbreviations

DVT: deep vein thrombosis; THA: total hip arthroplasty

## Acknowledgements

None.

## Authors' contributions

R N designed research; X Y, Y W, R N conducted research; X Y, R N analyzed data; X Y, R N wrote the first draft of manuscript; R N had primary responsibility for final content. All authors read and approved the final manuscript.

## Funding

None.

## Availability of data and materials

All data generated or analyzed during this study are included in this published article.

## Declarations

### Ethics approval and consent to participate

In this study, all methods were performed in accordance with the relevant guidelines and regulations. Our study had been verified and approved by the ethics committee of The Third Affiliated Hospital of Anhui Medical University (No.1700342), and all the included patients had signed the written informed consents.

### Consent for publication

Not applicable.

### Competing interest

The authors declare that they have no competing interests.

Received: 18 February 2021 Accepted: 10 May 2021

Published online: 15 June 2021

## References

- Pfluger MJ, Fromel DE, Meurer A: Total Hip Arthroplasty Revision Surgery: Impact of Morbidity on Perioperative Outcomes. *J Arthroplasty* 2021, 36(2):676–681.
- Shapira J, Chen SL, Rosinsky PJ, Maldonado DR, Lall AC, Domb BG: Outcomes of outpatient total hip arthroplasty: a systematic review. *Hip Int* 2021, 31(1):4–11.
- Pollock M, Somerville L, Firth A, Lanting B: Outpatient Total Hip Arthroplasty, Total Knee Arthroplasty, and Unicompartmental Knee Arthroplasty: A Systematic Review of the Literature. *JBJS Rev* 2016, 4(12):01874474-201612000-00004.
- Tan Z, Cao G, Wang G, Zhou Z, Pei F: Total hospital cost, length of stay, and complications between simultaneous and staged bilateral total hip arthroplasty: A nationwide retrospective cohort study in China. *Medicine (Baltimore)* 2019, 98(11):e14687.
- Shi XT, Li CF, Cheng CM, Feng CY, Li SX, Liu JG: Preoperative Planning for Total Hip Arthroplasty for Neglected Developmental Dysplasia of the Hip. *Orthop Surg* 2019, 11(3):348–355.

6. Li J, Zhu H, Liao R: Enhanced recovery after surgery (ERAS) pathway for primary hip and knee arthroplasty: study protocol for a randomized controlled trial. *Trials* 2019, **20**(1):599.
7. Wainwright TW, Gill M, McDonald DA, Middleton RG, Reed M, Sahota O, Yates P, Ljungqvist O: Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery After Surgery (ERAS(R)) Society recommendations. *Acta Orthop* 2020, **91**(1):3–19.
8. Matharu GS, Kunutsor SK, Judge A, Blom AW, Whitehouse MR: Clinical Effectiveness and Safety of Aspirin for Venous Thromboembolism Prophylaxis After Total Hip and Knee Replacement: A Systematic Review and Meta-analysis of Randomized Clinical Trials. *JAMA Intern Med* 2020, **180**(3):376–384.
9. Falck-Ytter Y, Francis CW, Johanson NA, Curley C, Dahl OE, Schulman S, Ortel TL, Pauker SG, Colwell CW, Jr: Prevention of VTE in orthopedic surgery patients: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest* 2012, **141**(2 Suppl):e278S–e325S.
10. Nadi S, Vreugdenburg TD, Atukorale Y, Ma N, Maddern G, Rovers M: Safety and effectiveness of aspirin and enoxaparin for venous thromboembolism prophylaxis after total hip and knee arthroplasty: a systematic review. *ANZ J Surg* 2019, **89**(10):1204–1210.
11. Warren JA, Sundaram K, Anis HK, Kamath AF, Higuera CA, Piuzei NS: Have Venous Thromboembolism Rates Decreased in Total Hip and Knee Arthroplasty? *J Arthroplasty* 2020, **35**(1):259–264.
12. Kim JS: Deep Vein Thrombosis Prophylaxis after Total Hip Arthroplasty in Asian Patients. *Hip Pelvis* 2018, **30**(4):197–201.
13. Chari A, Khokhar A, Murray D, McNally M, Pandit H: Venous thromboembolism and its prophylaxis in elective total hip arthroplasty: an international perspective. *Hip Int* 2012, **22**(1):1–8.
14. Colwell CW: The ACCP guidelines for thromboprophylaxis in total hip and knee arthroplasty. *Orthopedics* 2009, **32**(12 Suppl):67–73.
15. Tian Q, Li M: Risk factors of deep vein thrombosis of lower extremity in patients undergone gynecological laparoscopic surgery: what should we care. *BMC Womens Health* 2021, **21**(1):130.
16. Millar JS, Lawes CM, Farrington B, Andrew P, Misur P, Merriman E, Walker M: Incidence of venous thromboembolism after total hip, total knee and hip fracture surgery at Waitemata District Health Board following a peer-reviewed audit. *N Z Med J* 2020, **133**(1511):52–60.
17. Zeng GJ, Xu S, Pang HN: Incidence of deep vein thrombosis and pulmonary embolism in Asian patients after direct anterior total hip arthroplasty. *J Orthop* 2020, **21**:528–531.
18. Kawai T, Goto K, Kuroda Y, Matsuda S: Lower Activity and Function Scores Are Associated with a Higher Risk of Preoperative Deep Venous Thrombosis in Patients Undergoing Total Hip Arthroplasty. *J Clin Med* 2020, **9**(5):1257.
19. Santana DC, Emara AK, Orr MN, Klika AK, Higuera CA, Krebs VE, Molloy RM, Piuzei NS: An Update on Venous Thromboembolism Rates and Prophylaxis in Hip and Knee Arthroplasty in 2020. *Medicina (Kaunas)* 2020, **56**(9):416.
20. Wainwright TW, Burgess LC, Middleton RG: A Single-Centre Feasibility Randomised Controlled Trial Comparing the Incidence of Asymptomatic and Symptomatic Deep Vein Thrombosis Between a Neuromuscular Electrostimulation Device and Thromboembolism Deterrent Stockings in Post-Operative Patients Recovering From Elective Total Hip Replacement Surgery. *Surg Technol Int* 2020, **36**:289–298.
21. Kumazaki R, Imai N, Sakagami A, Hirano Y, Suzuki H, Endo N: Passive ankle motion and calf massage without anticoagulation therapy after total hip arthroplasty: A retrospective study. *J Orthop Sci* 2020, **12**:18;S0949-2658(20)30337-7.
22. Nemeth B, Nelissen R, Arya R, Cannegieter S: Preventing VTE following total hip and knee arthroplasty: Is prediction the future? *J Thromb Haemost* 2021, **19**(1):41–45.
23. Tang A, Sicut CS, Singh V, Rozell JC, Schwarzkopf R, Long WJ: Aspirin Use for Venous Thromboembolism Prevention Is Safe and Effective in Overweight and Obese Patients Undergoing Revision Total Hip and Knee Arthroplasty. *J Arthroplasty* 2020, **11**:S0883-5403(20)31245-6.
24. Mihara M, Tamaki Y, Nakura N, Takayanagi S, Saito A, Ochiai S, Hirakawa K: Clinical efficacy of risk-stratified prophylaxis with low-dose aspirin for the management of symptomatic venous thromboembolism after total hip arthroplasty. *J Orthop Sci* 2020, **25**(1):156–160.
25. Sloan M, Lee GC: Mortality and Complications in Patients with Metastatic Disease after Primary Total Hip and Total Knee Arthroplasty. *J Arthroplasty* 2020, **35**(12):3512–3516.
26. Tang A, Zak S, Iorio R, Slover J, Bosco J, Schwarzkopf R: Low-Dose Aspirin Is Safe and Effective for Venous Thromboembolism Prevention in Patients Undergoing Revision Total Hip Arthroplasty: A Retrospective Cohort Study. *J Arthroplasty* 2020, **35**(8):2182–2187.
27. Kahn SR, Shivakumar S: What's new in VTE risk and prevention in orthopedic surgery. *Res Pract Thromb Haemost* 2020, **4**(3):366–376.
28. Gonzalez Della Valle A, Shanaghan KA, Nguyen J, Liu J, Memtsoudis S, Sharrock NE, Salvati EA: Multimodal prophylaxis in patients with a history of venous thromboembolism undergoing primary elective hip arthroplasty. *Bone Joint J* 2020, **102-B**(7\_Supple\_B):71–77.
29. Yang Y, Li Z, Liang H, Tian J: Association between metabolic syndrome and venous thromboembolism after total joint arthroplasty: a meta-analysis of cohort studies. *J Orthop Surg Res* 2020, **15**(1):570.
30. Sodhi N, Anis HK, Acuna AJ, Vakharia RM, Piuzei NS, Higuera CA, Roche MW, Mont MA: The Effects of Opioid Use on Thromboembolic Complications, Readmission Rates, and 90-Day Episode of Care Costs After Total Hip Arthroplasty. *J Arthroplasty* 2020, **35**(6S):S237–S240.
31. Apovian CM: Obesity: definition, comorbidities, causes, and burden. *Am J Manag Care* 2016, **22**(7 Suppl):s176-185.
32. WHO: The Asia-Pacific perspective: redefining obesity and its treatment: Geneva: WHO; 2000.
33. Association OBoCM: Guidelines for venous thromboembolism in major orthopedic surgery in China. *Chinese Journal of Orthopaedics* 2016, **36**(2): 65–71.
34. Sloan M, Sheth N, Lee GC: Is Obesity Associated With Increased Risk of Deep Vein Thrombosis or Pulmonary Embolism After Hip and Knee Arthroplasty? A Large Database Study. *Clin Orthop Relat Res* 2019, **477**(3): 523–532.
35. El-Menyar A, Asim M, Al-Thani H: Obesity Paradox in Patients With Deep Venous Thrombosis. *Clin Appl Thromb Hemost* 2018, **24**(6):986–992.
36. Davies HO, Popplewell M, Singhal R, Smith N, Bradbury AW: Obesity and lower limb venous disease - The epidemic of phlebesity. *Phlebology* 2017, **32**(4):227–233.
37. Wang L, Duan S, Liao D, Luo Z, Hou X: [Effect of different use time of intermittent pneumatic compression on the incidence of deep vein thrombosis of lower extremities after arthroplasty]. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2020, **34**(5):585–590.
38. Mao Y, Ning C, Miaomiao L: Analysis of influencing factors of deep vein thrombosis of lower limbs in elderly patients undergoing hip replacement. *Journal of Practical Orthopaedics* 2020, **26**(1):8–11.
39. Zeng C, Bennell K, Yang Z, Nguyen UDT, Lu N, Wei J, Lei G, Zhang Y: Risk of venous thromboembolism in knee, hip and hand osteoarthritis: a general population-based cohort study. *Ann Rheum Dis* 2020, **79**(12):1616–1624.
40. Kittle H, Ormseth A, Patetta MJ, Sood A, Gonzalez MH: Chronic Corticosteroid Use as a Risk Factor for Perioperative Complications in Patients Undergoing Total Joint Arthroplasty. *J Am Acad Orthop Surg Glob Res Rev* 2020, **4**(7):e2000001.
41. Bawa H, Weick JW, Dirschl DR, Luu HH: Trends in Deep Vein Thrombosis Prophylaxis and Deep Vein Thrombosis Rates After Total Hip and Knee Arthroplasty. *J Am Acad Orthop Surg* 2018, **26**(19):698–705.
42. Wilson DG, Poole WE, Chauhan SK, Rogers BA: Systematic review of aspirin for thromboprophylaxis in modern elective total hip and knee arthroplasty. *Bone Joint J* 2016, **98-B**(8):1056–1061.
43. Lieberman JR, Hsu WK: Prevention of venous thromboembolic disease after total hip and knee arthroplasty. *J Bone Joint Surg Am* 2005, **87**(9): 2097–2112.

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