Deep vein thrombosis in the lower extremities after femoral neck fracture: A retrospective observational study

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Abstract

Purpose: The actual incidence of deep vein thrombosis (DVT) in femoral neck fractures is underestimated. This study aimed to investigate the incidence of DVT in the lower extremities after femoral neck fracture before and after operation.

Methods: The clinical data of patients with femoral neck fractures treated at Xi’an Honghui Hospital between July 1, 2016, and December 31, 2018, were collected. The patients were examined with ultrasonography before and after operation and divided into thrombosis and non-thrombosis groups according to their ultrasonographic results. The incidence of DVT was reported as a percentage.

Results: The incidence rates of preoperative and postoperative DVT were 32% and 56%, respectively. DVT on the uninjured side constituted 45% of all preoperative DVT and 43% of all postoperative DVT. Peripheral DVT constituted 90% and 84% of all preoperative and postoperative DVT, respectively. Diabetes was an independent risk factor of preoperative DVT. Blood loss was an independent risk factor of postoperative DVT, and open reduction and internal fixation surgical procedure was independent protective factor of postoperative DVT as compared with hemiarthroplasty and total hip replacement.

Conclusions: The incidence rates of preoperative and postoperative DVT in the patients with femoral neck fracture were high, and orthopedists should pay more attention to DVT as a complication.

Keywords

anticoagulation, deep vein thrombosis, femoral neck fracture, low-molecular-weight heparin, ultrasonography

Introduction

In recent years, the incidence of femoral neck fractures has significantly increased with the growth of the aging population. Owing to trauma itself, immobilization, advanced age, and comorbidity, some patients experience perioperative complications. Deep vein thrombosis (DVT) of the lower extremities is one of the common complications in these patients, which is a high risk of fatal pulmonary embolism in some patients. Traditionally, chemical and mechanical thromboprophylaxes are well-established routines in the prevent and treatment of DVT.

The incidence of DVT has been considered low in Asia, but the data are based on the general population, not the patients suffered fractures. As for femoral neck fractures, the incidence of DVT is reported to range from 2.6% to 19.5%. However, we consider the actual incidence of DVT after femoral neck fracture is underestimated.

Firstly, asymptomatic DVT is often ignored in previous studies, which carries a similar risk of symptomatic DVT
but not enough to be paid more attention. Sun et al. reported that asymptomatic DVT accounts for approximately 75% of all DVT cases. Other studies have reported that all DVT were clinically asymptomatic. Secondly, other studies did not examine the uninjured extremity, thereby possibly missing DVT on the uninjured side, which has been shown to occur. Decker and Weaver demonstrated that DVT could occur in both the injured and uninjured legs with a trend for higher incidence rates in the injured leg. Thirdly, because of the risk for these elderly patients of complications, it should be striving for hip fracture patients to the operating room in modern fracture units by 24–36 h. However, that is not the norm in China where it takes several days to get a hip fracture patient to operating room so the incidence of DVT may be much higher.

On the basis of these factors, this study aimed to investigate the incidences rates of DVT in the lower extremities after femoral neck fracture before and after operation in this retrospective observational study conducted at a single institution.

**Methods**

**Ethical statement**

This study retrospectively analyzed the data of patients with femoral neck fractures who were admitted between July 1, 2016, and December 31, 2018, in Xi’an Honghui Hospital. The study was approved by the ethics review board of Xi’an Jiaotong University (no. 20140426).

**Patient inclusion and exclusion criteria**

The inclusion criteria were as follows: (a) age of ≥16 years, (b) fresh isolated femoral neck fractures that require surgical treatment, and (c) availability of preoperative and postoperative ultrasonography results. We excluded patients with femoral neck fractures with delayed treatment, serious medical problems that make surgery intolerable, and poor compliance.

**Treatment**

All the patients with femoral neck fractures were assessed for thromboembolism risk using the Risk Assessment Profile for Thromboembolism score upon hospital admission. For the patients without contraindications, low-molecular-weight heparin (LMWH; 3800 IU/0.4 mL, once per day; Fraxiparine, Glaxo Wellcome Production, GlaxoSmithKline) was subcutaneously injected to prevent DVT, according to the guidelines. The anticoagulant therapy was discontinued 12 h before operation and resumed 24 h after operation. In addition, a mechanical pressure pump (20 min, twice per day) was used to promote blood reflux. Doppler ultrasonography was used to diagnose DVT, and vascular ultrasonography with a bedside machine was performed by three trained operators. The diagnostic criterion of fresh thrombosis was the presence of a constant intraluminal filling defect. All the patients received an examination in both lower limbs 1 day before the planned surgery and on the third to fifth day after the operation.

The patients were divided into thrombosis and nonthrombosis groups according to their ultrasonography results. In addition, DVT was classified into central (femoral and iliac veins), peripheral (calf muscle, fibular, and anterior/posterior tibial veins), and mixed thrombosis (both central and peripheral thromboses). For the patients without thrombosis, LMWH was continuously subcutaneously injected. For the patients with thrombosis, physicians from the department of vascular surgery prescribed the DVT treatment, and LMWH (3800 IU/0.4 mL, twice per day; Fraxiparine, Glaxo Wellcome Production, GlaxoSmithKline) was subcutaneously injected. If needed, an inferior vena cava (IVC) filter was used to prevent fatal pulmonary embolism when there was preoperatively central or proximal mixed thrombosis.

**Statistics analysis**

Statistical analysis was performed using SPSS Version 19.0 (SPSS Inc., Chicago, Illinois, USA). The incidence was reported as a percentage. An independent sample t-test and the χ² test were used in the statistical analysis. If the p of a factor was <0.05 in the univariate analysis, the variable was selected for the multivariate analysis. A multivariate analysis was used to detect the risk or protective factors. The difference was statistically significant (p < 0.05).

**Results**

**Patient characteristics**

A total of 228 patients with femoral neck fractures who were admitted to our hospital were included. The patients’ mean (SD) age was 71.3 (13.5) years. One hundred fifty patients (66%) were female, and 78 (34%) were male. Open reduction and internal fixations (ORIFs) were performed in 48 (21%) patients, hemiarthroplasty was performed in 152 (67%) patients, and total hip replacement (THR) was performed in 28 (12%) patients. The average days of preoperative screening DVT was 3.6 days postfracture. Of all the patients, only six patients had placement of an IVC filter before operation, and the IVC filters were removed after operation. No fatal bleeding events or pulmonary embolism was found in this study. No death was recorded.

**Incidence of DVT on preoperative ultrasonography**

Seventy-three patients (32%) had thrombosis and 155 (68%) had no thrombosis (Table 1). Of the cases, 66 (29%) were peripheral DVT, 1 (0.4%) was central DVT, and 6 (2.6%) were mixed DVT. Peripheral DVTs occurred in 63 (90%) of all patients with DVTs. Symptomatic DVTs occurred in 7 (9.6%) patients.
The incidence of preoperative DVT on the uninjured side was 14%, accounting for 45% of all preoperative DVT cases. Of the patients, 15 (20%) had uninjured lower extremity DVT and 18 (25%) had DVT in both lower extremities. There were three (4.1%) central DVTs on the uninjured side. Forty (55%) patients had a single DVT in the injured lower extremity.

Univariate analysis of preoperative DVT

No statistical differences were observed in the unilateral or bilateral limb, medical morbidity (excluding diabetes and coronary heart disease), body mass index (BMI), American Society of Anesthesiologists (ASA) classification, D-dimer level at admission and before operation, and C-reactive protein (CRP) level at admission between the two groups (Table 1).

Multivariate analysis of preoperative DVT

A multivariate analysis was used to detect the risk factors by entering age, sex, diabetes, coronary heart disease, and number of days between fracture and operation. The results showed that diabetes (odds ratio (OR), 2.72; 95% confidence interval (CI), 1.23–6.01; \( p = 0.01 \)) was an independent risk factor of preoperative DVT (Table 2).

Univariate analysis of postoperative DVT

No statistically significant differences in age, unilateral or bilateral limbs, fracture type, medical morbidity (excluding coronary heart disease), BMI, length of hospital stay, etc., were observed between the thrombosis and no thrombosis groups. The incidence of postoperative DVT on the uninjured side was 24%, accounting for 43% of all postoperative DVT cases. Of the 128 patients, 13 (10%) had uninjured lower extremity DVT and 42 (33%) had a DVT in both lower extremities. There were one (0.7%) central DVT on the uninjured side. Seventy-three (57%) patients had a single DVT in the injured lower extremity.

Incidence of DVT on postoperative ultrasonography

After operation, 128 (56%) patients developed a thrombosis and 100 (44%) did not. Of the cases, 107 (44%) were peripheral DVT, 1 (0.4%) was central DVT, and 20 (8%) were mixed DVT. Peripheral DVT was 107 (84%) of all DVT cases (Table 3). Symptomatic DVT was found in 31 (24%) patients of all DVT cases.

The incidence of postoperative DVT on the uninjured side was 24%, accounting for 43% of all postoperative DVT cases. Of the 128 patients, 13 (10%) had uninjured lower extremity DVT and 42 (33%) had a DVT in both lower extremities. There were one (0.7%) central DVT on the uninjured side. Seventy-three (57%) patients had a single DVT in the injured lower extremity.

### Table 1. Patient characteristics according to preoperative ultrasound.

|                          | Thrombosis | No thrombosis | Overall | \( p \) |
|--------------------------|------------|---------------|---------|--------|
| Number                   | 73         | 155           | 228     | 0.01   |
| Age                      | 74.49 ± 10.60 | 69.76 ± 14.41 | 71.28 ± 13.47 | 0.01 |
| Gender                   |            |               |         |        |
| Female                   | 56         | 94            | 150     | 0.02   |
| Male                     | 17         | 61            | 78      |        |
| Unilateral or bilateral fracture |          |               |         |        |
| Left low limb            | 38         | 88            | 126     | 0.50   |
| Right low limb           | 35         | 67            | 102     |        |
| Medical morbidity         |            |               |         |        |
| Hypertension (%)          | 31 (42.47) | 51 (32.90)    | 82      | 0.16   |
| Diabetes (%)              | 18 (24.66) | 16 (10.32)    | 34      | 0.01   |
| Coronary heart disease (%)| 30 (41.10) | 42 (27.10)    | 72      | 0.03   |
| Arrhythmia (%)            | 4 (5.48)   | 24 (15.48)    | 28      | 0.09   |
| Stroke (%)                | 6 (8.22)   | 10 (6.45)     | 16      | 0.63   |
| Associated trauma (%)     | 2 (2.74)   | 5 (3.22)      | 7       | 1.00   |
| BMI                       | 22.52 ± 4.51 | 22.26 ± 3.84  | 22.34 ± 4.04 | 0.79 |
| Days between fracture and hospitalization (days) | 3.38 ± 6.32 | 1.78 ± 4.08 | 2.29 ± 4.95 | 0.05 |
| Days between fracture and operation (days) | 7.66 ± 7.35 | 5.73 ± 4.20 | 6.35 ± 5.48 | 0.04 |
| ASA classification        |            |               |         |        |
| 1                        | 2          | 17            | 19      | 0.06   |
| 2                        | 50         | 103           | 153     |        |
| 3                        | 21         | 33            | 54      |        |
| 4                        | 0          | 2             | 2       |        |
| Serum markers             |            |               |         |        |
| D-dimer at admission (mg/L) | 13.79 ± 16.83 | 13.56 ± 16.45 | 13.63 ± 16.53 | 0.92 |
| D-dimer at preoperation (mg/L) | 5.02 ± 4.56 | 5.35 ± 9.25 | 5.23 ± 7.79 | 0.85 |
| CRP at admission (mg/L)   | 28.28 ± 37.64 | 20.82 ± 29.94 | 23.19 ± 32.64 | 0.21 |

BMI: body mass index; ASA: American Society of Anesthesiologists; CRP: C-reactive protein.

The incidence of preoperative DVT on the uninjured side was 14%, accounting for 45% of all preoperative DVT cases. Of the patients, 15 (20%) had uninjured lower extremity DVT and 18 (25%) had DVT in the both lower extremities. There were three (4.1%) central DVTs on the uninjured side. Forty (55%) patients had a single DVT in the injured lower extremity.
interval (days) between fracture onset and hospitalization, operation duration, transfusion, liquid transfusion, drainage, D-dimer level at admission and before operation, and CRP level at admission and at postoperative day 5 were found between the two groups. However, the thrombosis group had more female patients \((p = 0.01)\) than the non-thrombosis group. In addition, coronary heart disease \((p = 0.03)\), ASA classification \((p = 0.02)\), surgical procedures \((p < 0.01)\), and blood loss \((p = 0.00)\) were significantly associated contributing factors to postoperative thrombosis. Among the serum markers, the D-dimer levels on postoperative days 1 and 5 were higher in the thrombosis group (Table 3).

Multivariate analysis of postoperative DVT

The multivariate analysis results showed that blood loss (OR, 1.00; 95% CI, 1.00–1.01; \(p = 0.05\)) was an independent risk factor of postoperative DVT, and ORIF surgical procedure (OR, 0.18; 95% CI, 0.48–0.67; \(p = 0.01\)) was an independent protective factor of postoperative DVT, as compared with hemiarthroplasty and THR (Table 2).

Dynamic changes of DVT before and after operation

The dynamic preoperative and postoperative changes of DVT are shown in Figure 1. Of the 228 patients, 144 (63%) showed no changes in hospitalization duration. New DVT arose in 64 (28%) of the patients after operation, and peripheral DVT constituted 56 (88%) of all new DVT cases. Of the DVT cases, nine (3.9%) disappeared after operation (Figure 1).

Discussion

This retrospective study has the following findings: (a) the incidence of preoperative and postoperative DVT was 32% and 56%, respectively; (b) the incidence of preoperative DVT on the uninjured side was 14%, accounting for 45% of all preoperative DVT cases; the incidence of postoperative DVT on the uninjured side was 24%, accounting for 43% of all postoperative DVT cases; (c) diabetes was the independent risk factor of preoperative DVT; (d) blood loss was an independent risk factor, and ORIF surgical procedures were an independent protective factor of postoperative DVT; (e) peripheral DVT constituted 90% and 84% of all preoperative and postoperative DVT cases, respectively; and (f) the changes of DVT obviously increased from before to after operation. Little is known regarding DVT before fracture onset in the general population. We assumed that DVT develops after injury, not before a fall or fracture. Kniffin et al. reported that the annual incidence rate of DVT per 10,000 persons was 18 at age 65–69 years, and this rate increased steadily to 31 by age 85–89 years.16 The incidence rates were low. Thus, most of the DVT cases in our study were not preceded by injury.

In this study, ultrasonography was used to diagnose DVT. We chose ultrasonography based on its high accuracy and widespread acceptance. Ultrasonography is a simple, robust and noninvasive diagnostic tool and serves as a first choice in the diagnostic workup of DVT in lower extremities. Although the sensitivity and specificity of venography and magnetic resonance imaging are within the range of ultrasonography, they may serve as an alternative or complementary imaging tool to ultrasonography.17 In addition, when there was no DVT under ultrasonography, the thromboelastography could be tested to assess the DVT risk.

| Table 2. Multivariate analysis of preoperative and postoperative DVT. |
|---------------------------------------------------------------|
| **Factors**          | **B** | **SE** | **Wald** | **p** | **OR** | **95% CI** |
|----------------------|-------|--------|----------|-------|--------|------------|
| **Preoperation**     |       |        |          |       |        |            |
| Age                  | 0.02  | 0.01   | 1.68     | 0.19  | 1.02   | 0.99–1.05  |
| Gender               | −0.42 | 0.36   | 1.37     | 0.24  | 0.66   | 0.33–1.32  |
| Diabetes             | 1.00  | 0.40   | 6.12     | 0.01  | 2.72   | 1.23–6.01  |
| Coronary heart disease| 0.36  | 0.34   | 1.12     | 0.29  | 1.43   | 0.74–2.77  |
| Days between fracture and operation | 0.05  | 0.03   | 3.46     | 0.06  | 1.05   | 1.00–1.11  |
| Constant             | −2.52 | 1.02   | 6.10     | 0.01  | 0.08   |            |
| **Postoperation**    |       |        |          |       |        |            |
| Blood loss           | 0.00  | 0.00   | 6.72     | 0.05  | 1.00   | 1.00–1.01  |
| Gender               | −0.55 | 0.31   | 3.06     | 0.08  | 0.58   | 0.31–1.07  |
| Coronary heart disease| 0.54  | 0.33   | 2.66     | 0.10  | 1.71   | 0.90–3.25  |
| Surgical procedures  |       | 7.22   | 0.03     |       |        |            |
| Hemiarthroplasty     | −0.54 | 0.48   | 1.25     | 0.26  | 0.59   | 0.23–1.50  |
| ORIF                 | −1.34 | 0.55   | 5.88     | 0.01  | 0.18   | 0.48–0.67  |
| ASA classification   | −0.17 | 0.26   | 0.43     | 0.51  | 0.84   | 0.50–1.41  |
| Constant             | 0.43  | 0.80   | 0.29     | 0.59  | 1.54   |            |

DVT: deep vein thrombosis; OR: odds ratio; CI: confidence interval; ORIF: open reduction and internal fixation; ASA: American Society of Anesthesiologists.
Many factors contribute to the development of thrombosis after trauma. In this study, we found that diabetes was an independent risk factor of preoperative DVT in patients with femoral neck fracture. The result is similar to those of the studies from Yang et al. and Su et al., and diabetes increases the risk of DVT and pulmonary embolism. The possible pathophysiological mechanisms included increased platelet and procoagulant protein activities together with the compromised function of the fibrinolytic system in diabetes with enhanced thrombotic milieu.

In the multivariate analysis, blood loss and surgical treatment method were independent risk or protective

| Table 3. Patient characteristics according to postoperative ultrasound. |
|-----------------|-----------------|------------|
|                  | Thrombosis       | No thrombosis | p       |
| Number           | 128              | 100         |         |
| Age              | 72.57 ± 11.01    | 69.62 ± 15.98 | 0.12   |
| Gender           |                  |             |         |
| Female           | 94               | 56          | 0.01    |
| Male             | 34               | 44          |         |
| Unilateral or bilateral fracture |                  |             |         |
| Left low limb    | 69               | 57          | 0.64    |
| Right low limb   | 59               | 43          |         |
| Medical morbidity|                  |             |         |
| Hypertension (%) | 49 (38.28)       | 33 (33.00)  | 0.41    |
| Diabetes (%)     | 23 (17.97)       | 11 (11.00)  | 0.14    |
| Coronary heart disease (%) | 48 (37.50)       | 24 (24.00)  | 0.03    |
| Arrhythmia (%)   | 9 (7.03)         | 15 (15.00)  | 0.05    |
| Stroke (%)       | 7 (5.47)         | 9 (9.00)    | 0.30    |
| Associated trauma (%) | 5 (3.91)         | 2 (2.00)    | 0.41    |
| BMI              | 22.41 ± 4.33     | 22.33 ± 3.56 | 0.84   |
| Length of hospital | 10.13 ± 4.83   | 9.34 ± 3.91 | 0.18    |
| Days between fracture and hospitalization (days) | 2.49 ± 5.59 | 2.04 ± 3.99 | 0.50 |
| Days between fracture and operation (days) | 6.79 ± 6.37 | 5.80 ± 4.04 | 0.17 |
| ASA classification|                  |             |         |
| 1                | 6                | 13          | 0.02    |
| 2                | 93               | 60          |         |
| 3                | 29               | 25          |         |
| 4                | 0                | 2           |         |
| Surgical procedures |              |             |         |
| ORIF             | 18               | 30          | <0.01   |
| Hemiarthroplasty  | 89               | 63          |         |
| THR              | 21               | 7           |         |
| Duration of operation (min) | 95.64 ± 45.48 | 87.47 ± 39.05 | 0.15   |
| Transfusion (U)  | 0.91 ± 1.12      | 0.80 ± 1.06 | 0.47    |
| Blood loss (mL)  | 276.19 ± 151.62  | 218.38 ± 99.64 | <0.01 |
| Liquid transfusion (mL) | 1666.14 ± 448.67 | 1607.14 ± 430.59 | 0.32 |
| Drainage (mL)    | 181.16 ± 54.82   | 163.22 ± 68.57 | 0.23   |
| Serum markers    |                  |             |         |
| D-dimer at admission (mg/L) | 14.49 ± 16.52 | 12.58 ± 16.56 | 0.40 |
| D-dimer at preoperation (mg/L) | 5.74 ± 9.13 | 4.48 ± 5.30 | 0.45 |
| D-dimer at postoperative 1 day (mg/L) | 9.87 ± 9.17 | 5.43 ± 6.35 | <0.01 |
| D-dimer at postoperative 5 day (mg/L) | 9.60 ± 7.52 | 5.28 ± 4.02 | 0.01 |
| CRP at admission (mg/L) | 25.51 ± 35.95 | 20.67 ± 28.67 | 0.38 |
| CRP at postoperative 5 day (mg/L) | 39.20 ± 60.19 | 27.76 ± 40.47 | 0.31 |

BMI: body mass index; ASA: American Society of Anesthesiologists; ORIF: open reduction and internal fixation; THR: total hip replacement; CRP: C-reactive protein.

Figure 1. Dynamic changes of DVT before and after operation. DVT: deep vein thrombosis.
factors of postoperative DVT. Riha et al. also reported that blood loss was an independent factor that promotes postoperative hypercoagulability states.24 In additional, Selby et al. and Meissner et al. proved that the hypercoagulability state persists for a long time after fractures.15,26 Thus, blood loss is a contributing factor to postoperative DVT. Blood loss in the thrombosis group (276 ± 152 mL) was greater than that in the non-thrombosis group (218 ± 100 mL). We also observed that the surgical treatment method influenced the formation of DVT. The patients who underwent an internal fixation had a lower incidence of DVT than those who underwent hemiarthroplasty or THR. The reasons should be as follows: First, most of the patients who underwent internal fixation were younger,15,27 with mean ages of 55 ± 14, 68 ± 6, and 77 ± 9 years in the ORIF, THR, and hemiarthroplasty group, respectively, and had a relatively low incidence of thrombosis. Second, the injury was relatively mild in the ORIF group, and the patients who underwent an ORIF had less pain and were more active than those who underwent hemiarthroplasty or THR. Third, the mean blood loss was lower in the ORIF group (215 ± 190 mL) than in the THR (329 ± 108 mL) and hemiarthroplasty groups (247 ± 111 mL), so the hypercoagulability state may be milder with ORIF than with the latter two treatment methods.

In the subgroup analysis, the DVT cases were classified into central, peripheral, and mixed groups. Owing to the small number of patients with only central DVT, we compared the postoperative results between the peripheral and mixed groups. The results showed that the D-dimer level on postoperative day 1 was higher in the mixed group than in the peripheral group (15 ± 11 vs. 9 ± 8 mg/L, p = 0.02).

In femoral neck fractures, the incidence of DVT was reported to be up to 19.5%.7 In our study, the incidence was higher than in other studies. The reasons include the following aspects. As we described in the introduction section, previous studies focused on symptomatic DVT and some studies ignored DVT in uninjured extremities. First, in this study, preoperative and postoperative symptomatic DVT accounted for only 9.6% and 24% of all DVT cases, respectively. Second, after removing the data on DVT on the uninjured side only, the incidence rate of DVT decreased to 25% preoperatively and 50% postoperatively. The preoperative and postoperative incidence rates of DVT on the uninjured side were 14% and 24%, respectively. Thus, owing to the high incidence of asymptomatic DVT involving the uninjured limb, we recommend routine DVT ultrasonography screening.

Even though the study has included the large cohort of patients, analyzed preoperative and postoperative DVT respectively, there were some limitations should be clarified. At first, the design was retrospective study, which was introduced confounding factors easily. Secondly, the mean interval between fracture onset and operation was 6 ± 5 days in all the patients. The more delayed, the more thrombosis. The reason of the delayed treatment was mainly transportation from other hospitals to our trauma center and the poor comorbidity of elderly patients, which needs more time for preoperative preparation. In fact, one of the few things that saves lives in the elderly population is the early surgery. Therefore, fast track pathway should be considered for elderly population.

Conclusions

In conclusion, the incidence rates of preoperative and postoperative DVT in the patients with femoral neck fracture were high, and orthopedists should pay more attention to DVT as a complication.

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Author contributions

ZBF, ZY, and ZK helped in conceptualization. FC, WPF, XX, SK, YK, and KC performed data curation. ZBF and FYH were in charge of formal analysis. FYH and LP discussed the roles, writing, and original drafting.

Availability of data and materials

The survey was conducted by Xi’an Honghui Hospital. According to relevant regulations, the data could not be shared.

Ethics approval and consent to participate

The study was approved by the ethics review board of Xi’an JiaoTong University (no. 2014026).

Declaration of conflicting interests

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References

1. Clement RC, Strassle PD, and Ostrum RF. Should all orthopaedists perform hemiarthroplasty for femoral neck fractures? A volume-outcome analysis. J Orthop Trauma 2018; 32: 354–360.
2. Cho YH, Byun YS, Jeong DG, et al. Preoperative incidence of deep vein thrombosis after hip fractures in Korean. Clin Orthop Surg 2015; 7: 298–302.
3. Brill JB, Badiee J, Zander AL, et al. The rate of deep vein thrombosis doubles in trauma patients with hypercoagulable
1. Thromboelastography. *J Trauma Acute Care Surg* 2017; 83: 413–419.

2. Di Nisio M, van Es N, and Buller HR. Deep vein thrombosis and pulmonary embolism. *Lancet* 2016; 388: 3060–3073.

3. Nam JH, Kim DH, Yoo JH, et al. Does preoperative mechanical prophylaxis have additional effectiveness in preventing postoperative venous thromboembolism in elderly patients with hip fracture? Retrospective case-control study. *PloS One* 2017; 12: e0187337.

4. Chen CY and Liao KM. The incidence of deep vein thrombosis in Asian patients with chronic obstructive pulmonary disease. *Medicine (Baltimore)* 2015; 94: e1741.

5. Li Q, Dai B, Xu J, et al. Can patients with femoral neck fracture benefit from preoperative thromboprophylaxis?: a prospective randomized controlled trial. *Medicine (Baltimore)* 2017; 96: e7604.

6. Sun Y, Chen D, Xu Z, et al. Incidence of symptomatic and asymptomatic venous thromboembolism after elective knee arthroscopic surgery: a retrospective study with routinely applied venography. *Arthroscopy* 2014; 30: 818–822.

7. Froehlich JA, Dorfman GS, Cronan JJ, et al. Compression ultrasonography for the detection of deep venous thrombosis in patients who have a fracture of the hip. A prospective study. *J Bone Joint Surg Am* 1989; 71: 249–256.

8. Smith EB, Parvizi J, and Purtill JJ. Delayed surgery for patients with femur and hip fractures-risk of deep venous thrombosis. *J Trauma* 2011; 70: E113–E116.

9. Song K, Yao Y, Rong Z, et al. The preoperative incidence of deep vein thrombosis (DVT) and its correlation with postoperative DVT in patients undergoing elective surgery for femoral neck fractures. *Arch Orthop Trauma Surg* 2016; 136: 1459–1464.

10. Decker S and Weaver MJ. Deep venous thrombosis following different isolated lower extremity fractures: what is known about prevalences, locations, risk factors and prophylaxis? *Eur J Trauma Emerg Surg* 2013; 39: 591–598.

11. Kearon C, Akl EA, Comerota AJ, et al. Antithrombotic therapy for VTE disease: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians evidence-based clinical practice guidelines. *Chest* 2012; 141: e419S–e496S.

12. Mantoni M. Ultrasound of limb veins. *Eur Radiol* 2001; 11: 1557–1562.

13. Zhang BF, Wei X, Huang H, et al. Deep vein thrombosis in bilateral lower extremities after hip fracture: a retrospective study of 463 patients. *Clin Interv Aging* 2018; 13: 681–689.

14. Kniffin WD Jr, Baron JA, Barrett J, et al. The epidemiology of diagnosed pulmonary embolism and deep venous thrombosis in the elderly. *Arch Intern Med* 1994; 154: 861–866.

15. Madhusudhana S, Moore A, and Moormeier JA. Current issues in the diagnosis and management of deep vein thrombosis. *Mo Med* 2009; 106: 43–48.

16. Chen F, Xiong JX, and Zhou WM. Differences in limb, age and sex of Chinese deep vein thrombosis patients. *Phlebology* 2015; 30: 242–248.

17. Park MS, Perkins SE, Spears GM, et al. Risk factors for venous thromboembolism after acute trauma: a population-based case-cohort study. *Thromb Res* 2016; 144: 40–45.

18. Yang Z, Liu H, Xie X, et al. The influence of diabetes mellitus on the post-operative outcome of elective primary total knee replacement: a systematic review and meta-analysis. *Bone & Joint J* 2014; 96-B: 1637–1643.

19. Su H, Liu H, Liu J, et al. Elderly patients with intertrochanteric fractures after intramedullary fixation: analysis of risk factors for calf muscular vein thrombosis. *Orthopade* 2018; 47: 341–346.

20. Chung WS, Lin CL, and Kao CH. Diabetes increases the risk of deep-vein thrombosis and pulmonary embolism. A population-based cohort study. *Thromb Haemost* 2015; 114: 812–818.

21. Pechlivani N and Ajjan RA. Thrombosis and vascular inflammation in diabetes: mechanisms and potential therapeutic targets. *Front Cardiov Med* 2018; 5: 1.

22. Riha GM, Kunio NR, Van PY, et al. Uncontrolled hemorrhagic shock results in a hypercoagulable state modulated by initial fluid resuscitation regimens. *J Trauma Acute Care Surg* 2013; 75: 129–134.

23. Selby R, Geerts W, Ofosu FA, et al. Hypercoagulability after trauma: hemostatic changes and relationship to venous thromboembolism. *Thromb Res* 2009; 124: 281–287.

24. Meissner MH, Chandler WL, and Elliott JS. Venous thromboembolism in trauma: a local manifestation of systemic hypercoagulability? *J Trauma* 2003; 54: 224–231.

25. Williams JR, Little MT, Kramer PA, et al. Incidence of preoperative deep vein thrombosis in calcaneal fractures. *J Orthop Trauma* 2016; 30: e242–e245.