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The effect of calf muscular vein thrombosis on the prognosis within one year postoperatively of geriatric hip fracture patients: a propensity score-matched analysis

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Abstract

Introduction Calf muscular vein thrombosis (CMVT) is a type of distal deep vein thrombosis, which is common in geriatric hip fracture patients. However, studies focusing on whether the orthopedic operation has an impact on the prognosis of geriatric hip fracture patients with CMVT are very limited. Therefore, the aim of this study was to explore whether geriatric hip fractures with CMVT affect the mortality of patients within one year postoperatively. The difficulty of the operation, postoperative complications, the status of thrombosis, and function scores were also compared.

Materials and methods Geriatric hip fracture patients who underwent surgery between January 2019 and January 2021 were included. Patients were divided into groups with and without CMVT by preoperative color Doppler ultrasound examination. Propensity score-matching (PSM) was performed in a ratio of 1:1 between the patient with and without CMVT groups. Baseline characteristics, laboratory results, perioperative indicators and prognosis of patients were collected retrospectively. Intraoperative and postoperative comparisons were conducted between patients with and without CMVT.

Results Two hundred and sixty geriatric hip fracture patients were included. Eighty-nine patients in each group were matched after PSM. There was no significant difference in mortality between the two groups at one-month, three-month, six-month, and one-year postoperatively. However, patients with CMVT had longer hospital stays, a higher incidence of postoperative complications, and a higher incidence of thrombosis progression than patients without CMVT in the follow-up.

Conclusion No significant difference in mortality within one year postoperatively was observed in Chinese geriatric hip fracture patients with or without CMVT formation. Strategies such as close monitoring the status of thrombosis,

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individualized care, and strengthening rehabilitation are recommended to reduce the risk of complications and optimize patient outcomes in this patient population.

Trial registration Chinese Clinical Trial Registry (ChiCTR2300069411). Registered March 15, 2023, https://www.chictr.org.cn/showproj.html?proj=192079.

Keywords Calf muscular vein thrombosis, Geriatric patients, Deep vein thrombosis, Hip fracture, Propensity score-matched analysis

Introduction

Calf muscle venous thrombosis (CMVT) is a type of distal deep vein thrombosis (DVT) in which the thrombosis is original and confined to the venous plexus of the soleus and gastrocnemius muscles [1]. CMVT is a category of DVT with a high incidence. It has been shown that isolated CMVT accounts for approximately 25% of all lower limb DVT and up to 47-79% of those containing CMVT [2, 3]. However, because of the small extent of its formation, its effect on venous blood return and stimulation of the inflammatory response is less severe [4]. The clinical symptoms are not obvious and are often overlooked by clinicians.

Hip fractures in the geriatric population are very common in clinical practice. The characteristics are high mortality and disability rates and expensive medical treatment. As the global population ages, it is predicted that the number of hip fractures worldwide will increase from 1.26 million in 1990 to 4.5 million in 2050, with approximately half of these likely to occur in Asia, particularly in China [5]. Geriatric patients with hip fractures are at high risk for DVT, and most have CMVT with an incidence rate ranging from 9.94 to 30.5% [6–11].

However, there are many geriatric hip fracture patients with isolated CMVT. Most of them inevitably require surgical treatment. However, studies on whether conventional orthopedic surgery has an impact on the prognosis of such patients are very limited. Current opinions on this aspect are still controversial. It has been reported that CMVT may perpetuate and progress into the deep veins of the lower limbs, causing proximal DVT and inducing pulmonary embolism [1]. It has also been shown that the incidence of isolated CMVT developing into pulmonary embolism is only 0-6.2% and does not lead to the development of fatal pulmonary embolism [12]. We propose the hypothesis that orthopedic surgery would not significantly affect the prognosis of such patients. Therefore, the primary outcome of this study was to explore whether geriatric hip fracture patients with CMVT would affect patient mortality within one year postoperatively. Secondary outcomes included surgical difficulty, postoperative complications, the status of thrombosis, and function scores.

Materials and methods

Patients

The study was conducted in accordance with the ethical principles of the Helsinki declaration and was approved by the Ethical Review Committee of West China Hospital, Sichuan University. Informed consent procedures for this study have been waived due to the retrospective design. The clinical trial registration number is ChiCTR2300069411. Hip fracture patients who underwent surgery at the West China Hospital between January 2019 and January 2021 were included in this study. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines [13].

The inclusion criteria for our study included the following: (1) acute hip fractures including femoral neck and intertrochanteric fractures (≤7 days); (2) the fracture has been proven by X-ray or CT preoperatively; (3) treated by internal fixation such as cannulated cancellous screw, dynamic hip screw, femoral neck system, and proximal femoral nail anti-rotation or arthroplasty; (4) the patient agrees to participate in this study. The exclusion criteria of our study included the following: (1) age<65 years; (2) multiple fractures; (3) open fractures; (4) pathological fracture; (5) fracture with vascular or nerve lesion; (6) history of arthroplasty or venous thromboembolism; (7) incomplete clinical data; (8) coexistence of DVT at other locations than CMVT.

Data collection

Data on selected patients were retrospectively retrieved from our hospital medical database. Demographic characteristics included gender, age, body mass index (BMI), type of fracture, injury side, surgical procedure, American Society of Anesthesiologists (ASA) grade, time from injury to admission, routine blood indexes (including the concentrations of hemoglobin and platelet), blood biochemistry indexes (including the concentrations of serum albumin, potassium, and sodium), coagulation indexes (including prothrombin time (PT), activated partial prothrombin time (APTT), thrombin time (TT), and the concentrations of fibrinogen and D-dimer), and Charlson comorbidity index (CCI) score. The CCI score was calculated to obtain an overall assessment of preoperative comorbid conditions. The CCI score consists of

nineteen severe, chronic diseases, each assigned a weight from one to six corresponding to the relative risk of mortality from the disease [14]. One's CCI score is calculated by summing all the weights.

All patients routinely received a color Doppler ultrasound on admission. Color Doppler ultrasound is conducted by an experienced radiologist in the color ultrasound room. All ultrasound results were reviewed by a senior radiologist. Re-examination of the ultrasound was conducted when there were different opinions. According to guideline recommendations all geriatric hip fracture patients at our institution received DVT prophylaxis [15]. The prophylactic regimen consisted of low molecular heparin (4000 AxaIU/0.4 ml) or fondaparinux (2.5 mg) to be injected subcutaneously once daily. Routine ultrasound or any other imaging will not be performed on the patient postoperatively unless they have preoperative thrombosis or symptoms suggesting assessment. Signs and symptoms of DVT include changes in skin temperature and color, swelling, pain and tenderness in the thigh or calf [16].

Outcome measures

The primary outcome measures were mortality within one year after undergoing hip fracture surgery. The one-month postoperative observation window is the most common follow-up period in the literature [8, 17]. Considering the temporal correlation between the surgical delay and the development of complications, longer follow-up periods of three-month, six-month, and one-year were also analyzed. The secondary outcomes include intraoperative indicators (preoperative waiting time, hospital stays, surgical time, intraoperative blood loss), postoperative complications (incision infection, hematoma, hip or thigh pain, urinary tract infection, postoperative delirium, implant failure, pulmonary infection), Harris score [18], visual analogue scale (VAS) score, and Barthel Index. All pain and functional scores were documented at the one-year postoperative follow-up. Postoperative complications were diagnosed by a senior doctor. Incision infection was defined as infection occurring at surgical incision within thirty days after surgery, with symptoms such as pain, redness, swelling, fever and discharge, and definitive culture evidence of causative organism. Hematoma was defined as local swelling and pain due to bleeding within the surgical incision and was assessed by color Doppler ultrasound. Hip or thigh pain was defined as postoperative pain interfering with the patient's sleep, and the patient's VAS score was greater than four. Urinary tract infection was defined as symptoms of urinary tract irritation and definitive culture evidence of causative organism. Postoperative delirium was defined as acute cognitive dysfunction. Implant failure was defined as internal fixation cut out or breakage, dislocation or peripheral fracture of the artificial joint prosthesis. Pulmonary infection was defined as symptoms such as cough, sputum, fever and definitive culture evidence of causative organism and chest computed tomography findings.

Statistical analysis

Continuous variables are expressed as mean and standard deviation (SD) if normally distributed, and as median and interquartile range (IQR) otherwise, while categorical variables are presented as absolute numbers and percentages. Categorical variables were compared using $\chi 2$ analysis or Fisher's exact test; continuous variables were compared using t-test or Wilcoxon rank sum test for normally and nonnormally distributed data, respectively. The rationale and methodology of PSM for assessing causality have been well demonstrated in retrospective studies [19, 20]. PSM has certain advantages over traditional regression methods in controlling confounding [21]. The R software (version × 64 3.5.1, http://www.r-project.org) was used to conduct the propensity score-matched (PSM) analysis with 1:1matching method to reduce confounding bias from the confounding variables in the baseline and avoid influencing the study outcomes. Survival analysis was also performed using Kaplan-Meier survival curves, and differences between groups were estimated using the log-rank test. All statistical computations were performed using SPSS statistical software (version 25.0; IBM Corp, Armonk, NY, USA). $P<0.05$ was considered statistically significant; all tests were two-sided.

Results

Baseline characteristics of patients before and after PSM

The baseline characteristics of the patients were shown in Table 1. There were two hundred and sixty patients included in the study after screening, consisting of ninety-three patients with CMVT and one hundred and sixty-seven patients without CMVT. The difference of time from injury to admission, hemoglobin, blood platelet, serum albumin, and serum potassium in two groups have statistical significance. Eighty-nine patients were included in each group after PSM, and no significant differences in baseline characteristics were observed between patients with and without CMVT after matching. The sampling procedure of Chinese geriatric patients with hip fracture in our study was shown in Fig. 1. After PSM the bias was effectively reduced for confounding variables such as the time from injury to admission, hemoglobin, blood platelet, serum albumin, and serum potassium. The scatter plots of the above confounding variables before and after PSM for each group were shown in Fig. 2.

Table 1 Baseline characteristics of patients before and after propensity score matching

Variables	Before Propensity Score-Matching			After Propensity Score-Matching		
	Without CMVT	With CMVT	*P* Value	Without CMVT	With CMVT	*P* Value
Patients (%)	167(64.23)	93(35.77)		89(50.00)	89(50.00)	
Age(years)	80.25 (7.70)	80.53 (7.71)	0.778	80.56 (7.98)	80.30 (7.77)	0.827
BMI	21.74 (3.66)	22.09 (3.48)	0.447	22.00 (3.60)	22.00 (3.53)	0.995
Time from injury to admission (days)	1.00(0.50-2.00)	1.00 (0.50-5.00)	0.029	1.00 (0.50–3.50)	1.00 (0.50-4.00)	0.560
CCI score	1.00 (0.00–2.00)	1.00 (0.00–2.00)	0.234	1.00 (0.00–2.00)	1.00 (0.00–2.00)	0.579
Hemoglobin (g/L)	113.16 (21.95)	107.38 (21.45)	0.041	108.53 (23.11)	108.63 (20.74)	0.976
Blood platelet (109/L)	155.05 (62.04)	173.49 (73.21)	0.032	165.71 (73.87)	172.21 (72.95)	0.555
Serum albumin (g/L)	37.56 (4.05)	36.37 (4.28)	0.026	36.98 (4.18)	36.54 (4.20)	0.487
Serum potassium (mmol/L)	3.89 (0.48)	4.03 (0.60)	0.043	4.02 (0.52)	4.01 (0.59)	0.838
Serum sodium (mmol/L)	139.24 (3.90)	139.32 (3.91)	0.875	139.03 (4.36)	139.33 (3.91)	0.626
PT (s)	11.55 (0.90)	11.66 (1.00)	0.356	11.55 (0.88)	11.62 (0.96)	0.632
APTT (s)	28.92 (3.17)	28.69 (3.75)	0.596	28.86 (3.30)	28.64 (3.62)	0.664
TT (s)	17.52 (1.62)	17.61 (5.15)	0.834	17.60 (1.77)	17.64 (5.26)	0.947
Fibrinogen (g/L)	3.94 (1.22)	4.09 (1.21)	0.338	3.98 (1.28)	4.07 (1.20)	0.641
D-dimer (μg/ml)	4.61 (2.16–14.85)	5.86 (3.01–15.78)	0.339	4.24 (2.33–15.13)	5.86 (3.01–15.78)	0.464
Gender (%)			0.311			1.000
Female	112 (67.10)	68 (73.10)		65 (73.00)	65 (73.00)	
Male	55 (32.90)	25 (26.90)		24 (27.00)	24 (27.00)	
Type of fracture (%)			0.912			0.881
Intertrochanteric fracture	85 (50.90)	48 (51.60)		44 (49.40)	45 (50.60)	
Femoral neck fracture	82 (49.10)	45 (48.40)		45 (50.60)	44 (49.40)	
Injury side (%)			0.940			0.764
Right	87 (52.10)	48 (51.60)		49 (55.10)	47 (52.80)	
Left	80 (47.90)	45 (48.40)		40 (44.90)	42 (47.20)	
Surgical procedure (%)			0.768			0.529
Arthroplasty	58 (34.70)	34 (36.60)		29 (32.60)	33 (37.10)	
Internal fixation	109 (65.30)	59 (63.40)		60 (67.40)	56 (62.90)	
ASA grade (%)			0.253			0.950
2	52 (31.10)	34 (36.60)		35 (39.30)	33 (37.10)	
3	104 (62.30)	49 (52.70)		45 (50.60)	47 (52.80)	
4	11 (6.60)	10 (10.80)		9 (10.10)	9 (10.10)	

CMVT = calf muscular vein thrombosis; BMI = body mass index; CCI = Charlson comorbidity index; PT = prothrombin time; APTT = activated partial prothrombin time; TT = thrombin time; ASA = American Society of Anesthesiologists. Data are expressed as mean (standard deviation) or median (interquartile range)

Survival outcomes of hip fracture patients with and without CMVT

There was no significant difference in postoperative one-month mortality between the group of patients without CMVT and the group of patients with CMVT (1.1% vs. 2.2%; Odds Ratio, 2.02; 95% Confidence Interval, 0.18–22.72, $P=1.000$; Table 2). And no significant differences were found in mortality between the groups at three-month, six-month, and one-year postoperatively. Kaplan-Meier analysis showed that one-year accumulated survival rate was higher in the group of patients without CMVT without reaching a significant level (Fig. 3). A total of nineteen deaths were documented within the first year after surgery (seven in the group of patients without CMVT and twelve in the group of patients with CMVT). One-, three-, six-month and one-year mortality of geriatric hip fracture patients without CMVT, and with CMVT were shown in Table 2.

Operative outcomes of hip fracture patients without and with CMVT

The length of hospital stays for hip fracture patients with CMVT was significantly longer than that of patients without CMVT ((10.90±4.84 vs. 8.89±3.24 days, $p=0.001$; Table 3). However, no significant differences were found in the preoperative waiting time, surgical time and intraoperative blood loss between the groups. The incidence of overall postoperative complications was significantly higher in the group of patients with CMVT than in the group of patients without CMVT (7.9% vs. 29.2%, $P<0.001$; Table 3). However, there was no significant difference between the groups in the incidence of other complications, such as pneumonia and urinary tract infections. (Table 3).

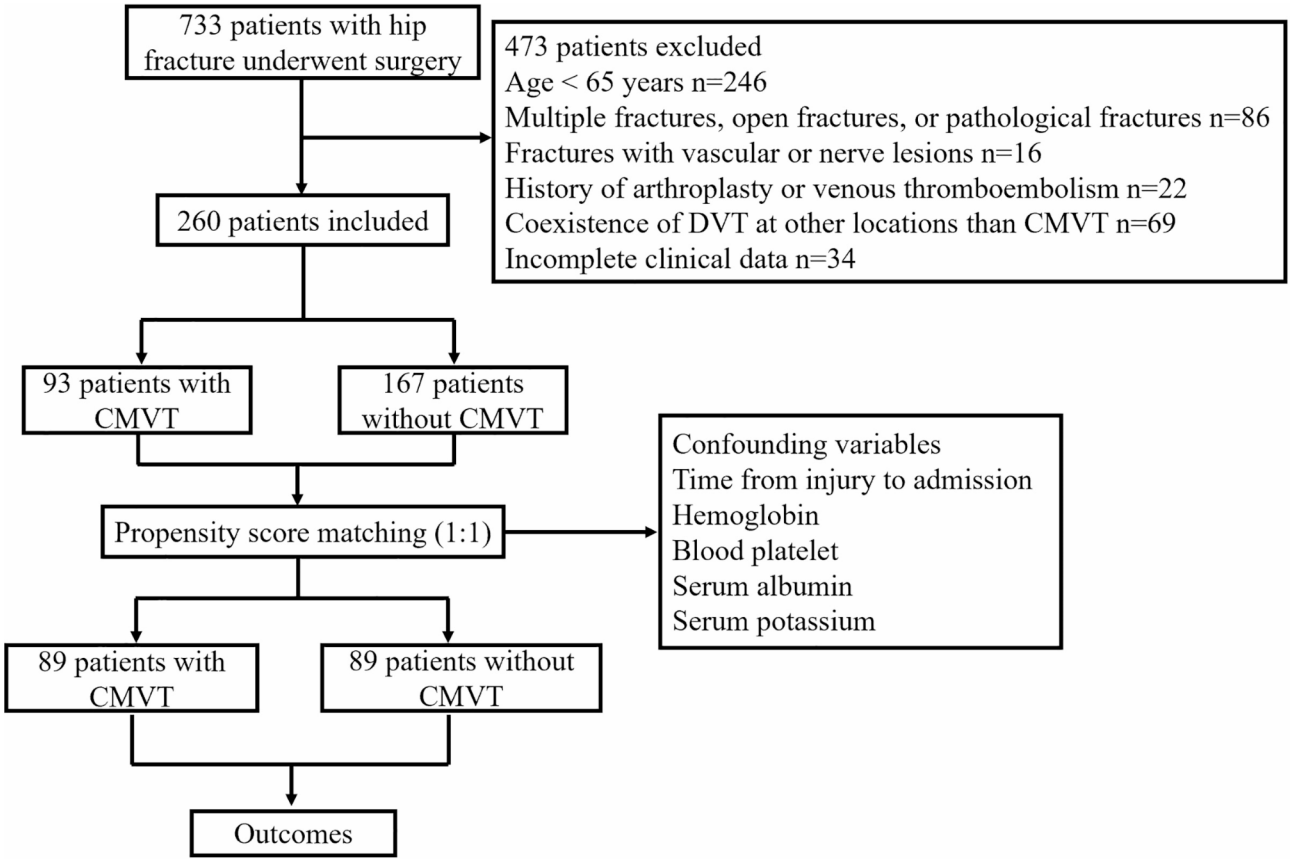

Fig. 1 The sampling procedure used for all geriatric patients with hip fracture in this study. CMVT, Calf muscular vein thrombosis

Clinical outcomes of hip fracture patients without and with CMVT

The group of patients without CMVT and the group of patients with CMVT were comparable in terms of Harris scores postoperatively (82.79±13.13 vs. 83.30±11.22, P=0.795; Table 4). There was no significant difference between the two groups in terms of VAS scores and Barthel Index. In terms of the state of thrombosis, the incidence of thrombosis progression was significantly higher in the group of patients with CMVT than in the group of patients without CMVT (14.6% vs. 1.1%, P=0.001; Table 4). The details of thrombosis progression in each group of patients are summarized in Table 5. In the group of patients without CMVT, only one patient developed unilateral CMVT postoperatively, and no thrombosis was found in other patients. The majority of patients in the group with CMVT progressed from unilateral to bilateral CMVT postoperatively.

Discussion

Currently, there are no long-term follow-up studies of clinical differences between geriatric hip fracture patients with and without CMVT. The clinical relevance of CMVT to the prognosis of geriatric hip fracture patients undergoing surgical treatment remains controversial [22, 23]. DVT or PE is one of the most serious complications that can occur in hip fracture patients, significantly increasing perioperative mortality [24]. Current guidelines recommend that hip fracture patients should be operated on within forty-eight hours of admission for a positive prognosis [25, 26]. However, a point of controversy is whether patients with CMVT should undergo a rigorous cycle of anticoagulation before surgery, or whether surgery should be performed following routine anticoagulation with perfect preoperative preparation. As no literature is available, the primary aim of this study was to compare the effects of CMVT on the prognosis in geriatric hip fracture patients.

There is a high incidence of CMVT in geriatric hip fracture patients. However, due to its insidious symptoms, large-scale multicenter randomized controlled studies are still lacking. In this study, there were still some confounding factors at baseline for unmatched patients that could directly affect the veracity of the comparison between the control and experimental groups. As many variables as possible were included in our propensity score model to maximize the propensity to inform the dependent variable. the PSM model included nineteen independent variables that were proven to influence or potentially influence mortality. The variables described

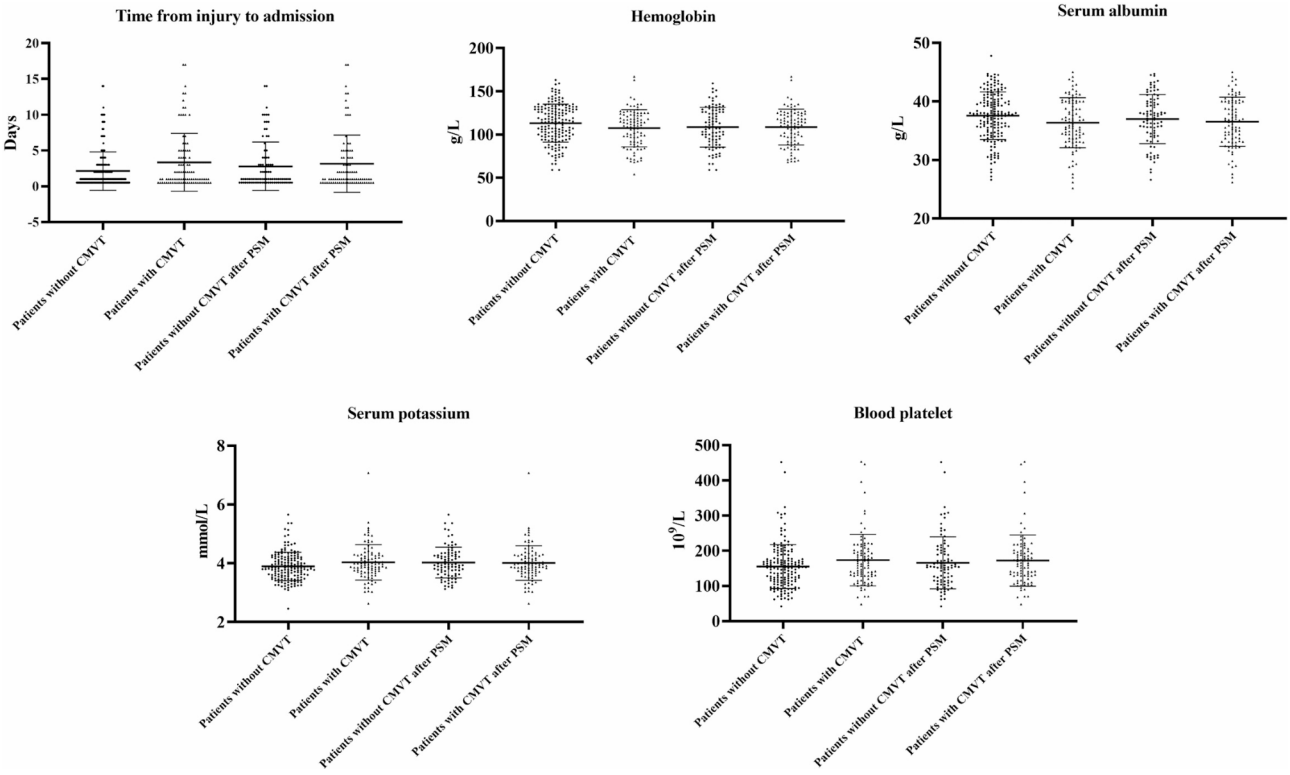

Fig. 2 Scatter plot of baseline characteristics of all geriatric hip fracture patients before and after propensity score matching. CMVT, Calf muscular vein thrombosis

Table 2 One-, three-, six-month, and one-year mortality of all geriatric hip fracture patients, geriatric hip fracture patients without CMVT, and with CMVT, respectively

Variables	Fracture patients	Patients without CMVT	Patients with CMVT	Odds Ratio (95% CI)	*P* Value
One-month mortality (%)	3 (1.70)	1(1.10)	2 (2.20)	2.02 (0.18–22.72)	1.000
Three-month mortality (%)	4 (2.20)	1(1.10)	3 (3.40)	3.07 (0.31–30.09)	0.613
Six-month mortality (%)	11 (6.20)	4 (4.50)	7 (7.90)	1.81 (0.51–6.43)	0.350
One-year mortality (%)	19 (10.70)	7 (7.90)	12 (13.50)	1.83 (0.68–4.88)	0.225

CMVT = calf muscular vein thrombosis; CI = Confidence Interval

in previous studies that were associated with postoperative mortality were also included in the study, such as gender, age, CCI score, and level of D-dimer [20, 27]. Previous studies have reported that the longer the time from injury to admission, the higher the risk of DVT and the increase in perioperative mortality [28]. All baseline variables were comparable between the two groups after PSM. In our study, PSM effectively reduced confounding bias and made the results as close as possible to a randomized controlled study.

In our study, there was no significant difference in mortality between the two groups at one-month, three-month, six-month, and one-year postoperatively. The formation of CMVT does not increase the risk of death within one year postoperatively in hip fracture patients on the same anticoagulation regimen. Previous studies have also found no significant association between CMVT and mortality [29, 30]. It has also been reported that CMVT in geriatric hip fracture patients is associated with increased mortality at thirty days postoperatively, but disappeared at ninety days follow-up [8]. We believe that the difference in mortality at one month postoperatively may be related to the perioperative management and quality of care in different hospitals, and the underlying conditions of the patients included. The one-year mortality rate in hip fracture patients can reach up to 30% [31]. However, there are fewer studies focusing on mortality in geriatric hip fracture patients with CMVT. The one-year postoperative mortality of patients with CMVT in our study was 13.5%, which could be attributed to the standardized anticoagulation protocol and advances in enhanced recovery after surgery.

In terms of operative outcomes, no significant differences were found in the preoperative waiting time, surgical time and intraoperative blood loss between the groups. It demonstrates that the formation of CMVT

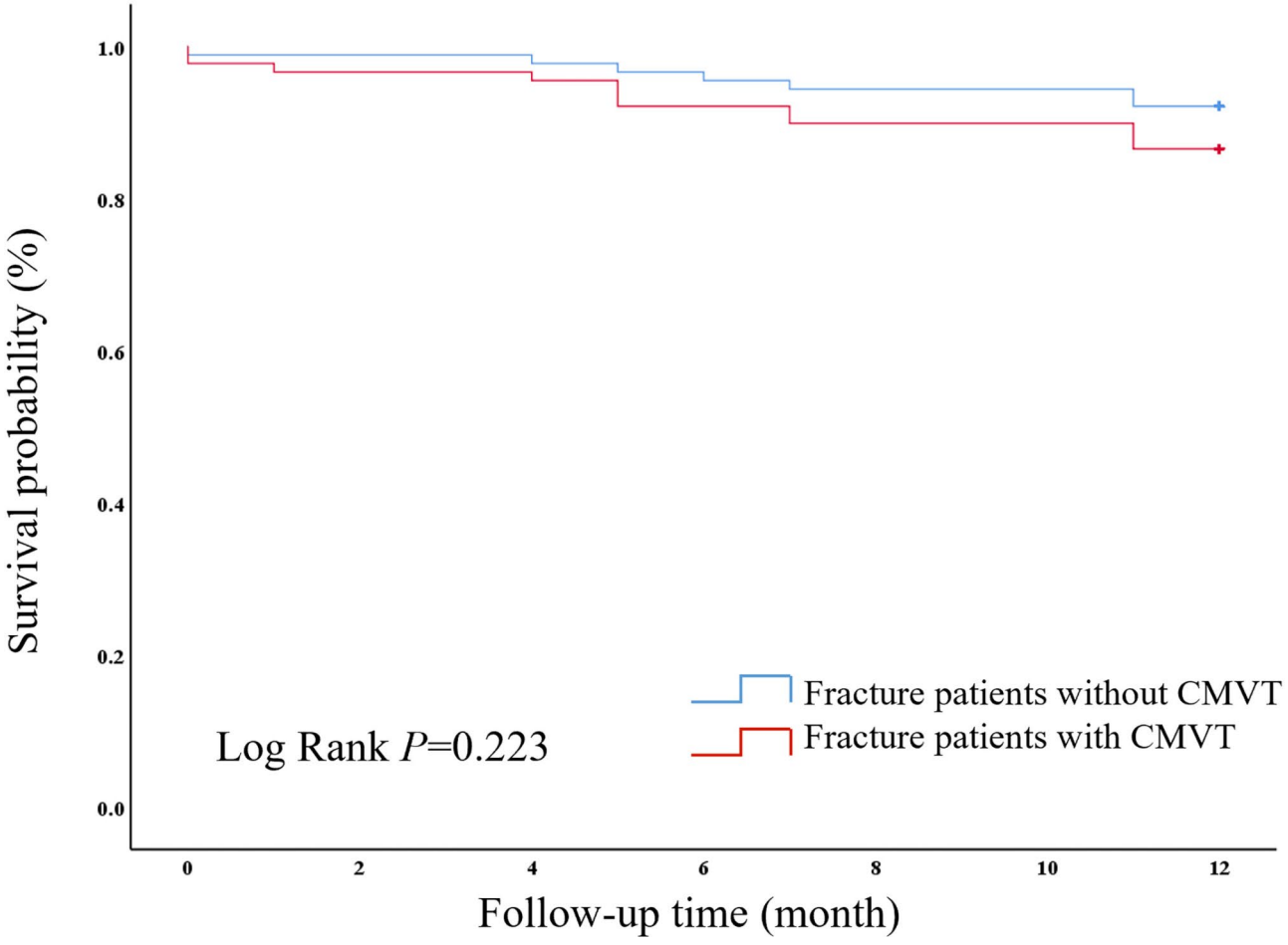

Fig. 3 Kaplan-Meier survival curve of geriatric hip fracture patients with and without CMVT. CMVT, Calf muscular vein thrombosis

Table 3 Operative outcomes of all geriatric hip fracture patients, geriatric hip fracture patients without CMVT, and with CMVT, respectively

Variables	Fracture patients	Patients without CMVT	Patients with CMVT	*P* Value
Preoperative waiting time in hospital (day)	5.32(3.07)	4.91 (2.70)	5.73(3.36)	0.074
Hospital stays (day)	9.89(4.23)	8.89(3.24)	10.90 (4.84)	0.001
Surgical time (min)	79.63 (31.44)	76.89 (33.44)	82.37 (29.25)	0.246
Intraoperative blood loss (mL)	101.93 (73.14)	107.85 (81.84)	96.00 (63.18)	0.281
Complication (overall) (%)	33 (18.50)	7 (7.90)	26 (29.20)	< 0.001
Incision infection	3	0	3	0.244
Hematoma	2	1	1	1.000
Hip or thigh pain	6	1	5	0.213
Urinary tract infection	3	0	3	0.244
Postoperative delirium	2	0	2	0.477
Implant failure	2	1	1	1.000
Pulmonary infection	15	4	11	0.059

CMVT = calf muscular vein thrombosis. Data are expressed as mean (standard deviation)

does not make the procedure more difficult for the surgeon with the same anticoagulation regimen. However, our study found that hip fracture patients with CMVT had longer hospital stays and a higher incidence of postoperative complications compared with patients without CMVT. We believe that longer hospital stays may be associated with a longer postoperative period of clinical observation. The operation may cause the patient's existing CMVT to dislodge, or progress proximally [32]. These patients usually require dynamic monitoring of

Table 4 The outcomes of function scores and state of thrombosis in all geriatric hip fracture patients, geriatric hip fracture patients without CMVT, and with CMVT, respectively

Variables	Fracture patients	Patients without CMVT	Patients with CMVT	*P* Value
Harris score	83.04 (12.20)	82.79 (13.13)	83.30 (11.22)	0.795
VAS score	1.72 (1.02)	1.63(0.96)	1.81(1.08)	0.292
Barthel Index	83.49 (18.46)	82.74(19.88)	84.29(16.91)	0.600
State of thrombosis (%)				0.001
No progress	164 (92.10)	88 (98.90)	76 (85.40)	
Progression	14 (7.90)	1 (1.10)	13 (14.60)	

CMVT = calf muscular vein thrombosis; VAS = visual analogue scale. Data are expressed as mean (standard deviation)

Table 5 Details of the thrombotic progression in geriatric hip fracture patients with and without CMVT

Variables	Patients without CMVT	Patients with CMVT
From no thrombosis to unilateral CMVT	1	0
From unilateral CMVT to bilateral CMVT	0	8
From unilateral CMVT to bilateral CMVT and left peroneal vein thrombosis	0	2
From unilateral CMVT to bilateral CMVT and left posterior tibial vein thrombosis	0	1
From bilateral CMVT to right common femoral vein and bilateral popliteal vein thrombosis	0	1
From bilateral CMVT to right external iliac vein thrombosis	0	1

CMVT = calf muscular vein thrombosis;

the thrombosis and further examination or treatment postoperatively [33]. And the higher incidence of postoperative complications is associated with a longer time in bed postoperatively for patients with CMVT. In order to avoid dislodgement of the thrombosis by movement of the calf muscles, most clinicians recommend braking of the affected limb or early functional exercises based on ankle pump [34]. The longer time in bed can lead to a series of postoperative complications, such as urinary tract infections and pulmonary infections [35]. Although these complications can cause discomfort and pain for patients. With the continuous development of enhanced rehabilitation surgery, these complications can be identified earlier and intervened promptly, reducing their severity. Generally, these complications do not directly lead to death or affect the patient's function in the long term. We believe that this explains the similar postoperative mortality and functional scores between patients with and without CMVT, despite the significant differences in overall complications. Currently, it is still controversial whether such patients can get out of bed early for functional exercise after surgery [36]. Some studies have shown that early ambulation is effective in reducing the progression of DVT and improving limb pain without increasing the incidence of complications compared to bed rest [37, 38]. However, there are no clear recommendations in this respect in the relevant guidelines and further research is needed in the future [39].

The calf muscle venous plexus is located in the dorsal and ventral calf muscles, which is characterized by slow blood flow and susceptibility to thrombosis [40]. Although CMVT is less harmful to patients than proximal DVT, there is also a risk of upward spread [41]. Furthermore, the formation of preoperative CMVT may have an impact on the quality of life of geriatric hip fracture patients. In our study, there was no significant difference in Harris score, VAS score, or Barthel Index between the two groups of patients. It was demonstrated that the formation of CMVT did not affect the hip function or quality of daily life of geriatric hip fracture patients. However, the group of patients with CMVT had a higher incidence of progression of thrombosis postoperatively than the group of patients without CMVT. Only two patients progressed from CMVT to proximal DVT, the remaining patients remained with distal DVT and no fatal pulmonary embolism occurred. Currently, the natural history of CMVT can be divided into dissolution recanalization, spreading, and embolization [42]. On the basis of anticoagulation therapy, the CMVT will gradually dissolve in most patients, increasing the probability of revascularization. Similar outcomes have been observed in patients underwent knee arthroscopy and total knee replacement [43, 44]. The patient's CMVT will progress due to the repeated intraoperative pulling of the leg muscles and the interaction between the thrombosis, but whether it can lead to pulmonary embolism is still controversial [41, 45]. Therefore, multidisciplinary treatment, enhanced thrombosis management and monitoring, and meticulous care are recommended in the postoperative period for geriatric hip fracture patients with CMVT.

There are several limitations in our study. First, although we performed PSM to minimize the effect of baseline confounding factors, the relatively small sample size of this study may affect the authenticity of the results. Second, although our study reported indicators of postoperative mortality, operative outcomes, function scores, and state of thrombosis, recall bias is inevitable because of restrictions of retrospective studies. Third, our institution did not routinely perform color Doppler ultrasound

in all patients postoperatively and only in patients with relevant symptoms, which may miss some asymptomatic DVT.

Conclusion

No significant difference in mortality within one year postoperatively was observed in Chinese geriatric hip fracture patients with or without CMVT formation. However, patients with CMVT had longer hospital stays, a higher incidence of postoperative complications, and a higher incidence of thrombosis progression compared to patients without CMVT in the follow-up. PSM can effectively reduce the impact of baseline confounders and improve the credibility of our findings. Therefore, we recommend that orthopedic surgeons pay more attention to close monitoring the status of thrombosis, individualized care, and strengthening rehabilitation when treating geriatric hip fracture patients with CMVT for better clinical outcomes and prognosis. The small sample size of this study may lead to insignificant differences between the two groups. Future large - scale, multicenter, and randomized controlled studies are needed to clarify the relationship between CMVT and mortality and to confirm our findings.

Abbreviations

CMVT	Calf muscular vein thrombosis
PSM	Propensity score-matching
ChiCTR	Chinese Clinical Trial Registry
DVT	Distal deep vein thrombosis
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
BMI	Body mass index
ASA	American Society of Anesthesiologists
PT	Prothrombin time
APTT	Activated partial prothrombin time
TT	Thrombin time
CCI	Charlson comorbidity index
VAS	Visual analogue scale
SD	Standard deviation
IQR	Interquartile range
CI	Confidence interval

Author contributions

Jiabao Jiang and Fei Xing contributed equally to this work. Jiabao Jiang wrote the manuscript. Fei Xing, Rong Luo, Zhao Chen, and Hao Liu collected the data and assisted in the data analysis. Xin Duan and Zhou Xiang designed and supervised this project.

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Data availability

The datasets used during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The present study was approved by the Ethical Review Committee of West China Hospital, Sichuan University. Informed consent procedures for this study have been waived due to the retrospective design. Also, it was registered in Chinese Clinical Trial Registry with registration number of ChiCTR2300069411 on 15/03/2023. All procedures were conducted according to the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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