Research Square

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Preoperative incidence and risk factors of deep vein thrombosis in patients with an isolated patella fracture

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Abstract

Background

The purpose of this study was to investigate the incidence, location, and related factors of preoperative deep venous thrombosis (DVT) in patients with isolated patellar fractures.

Methods

Patients with an isolated patellar fracture, admitted between January 2013 and December 2019 at our institution, were retrospectively analyzed. Upon admission, patients underwent routine Doppler ultrasound scanning (DUS) of the bilateral lower extremities to detect DVT; those with DVT were assigned to the case group and those without DVT to the control group. Data on demographics, comorbidities, and laboratory test results upon admission were extracted. Differences between the two groups were evaluated using univariate analyses, and independent risk factors associated with DVT were identified by logistic regression analysis.

Results

During the study window, 827 patients were included, of whom 5.8% (48/827) were found to have preoperative DVT. Among those with DVT, 85.4% (41/48), 8.3 % (4/48), and 6.3% (3/48) occurred in the injured, non-injured, and bilateral lower extremities, respectively. Multivariate analysis showed that age (each increase of 1 year) (odds ratio, OR = 1.02), residential area (OR = 5.00), delay of injury to DUS (in each day, OR = 1.33), and elevated plasma D-dimer level (> 0.5 μg/mL, OR = 2.47) were independent risk factors associated with DVT.

Conclusions

Despite the low prevalence of DVT after an isolated patellar fracture, this study underscores the importance of identifying those with a high risk of DVT, especially those with multiple identifiable factors, as well as the early targeted use of thromboembolic agents, to reduce DVT occurrence.

Background

DVT is a common complication and cause of death in hospitalized patients [1]. According to reports, the incidence of DVT in hospitalized patients is 30.4% overall, and the related mortality rate is approximately 1.3% [2]. DVT is also common in patients with lower limb fractures. Studies have reported that the incidence of DVT in the perioperative period is as high as 10.1% to 29.1% [3, 4], and that of pulmonary embolism was approximately 2.73% [3]. DVT has a serious impact on postoperative rehabilitation and quality of life in patients with fractures, which necessitates early diagnosis and appropriate treatment [5].

Therefore, in the management of patients with fractures, it is vital to distinguish preoperative DVT and postoperative DVT for timely diagnosis and treatment.

The literature reported that the incidence of lower extremity DVT in patients with fracture upon admission is 20.1– 29.8% [6, 7]. Patients with lower extremity fractures often require surgical treatment to restore lower extremity function. Preoperative DVT seriously affects the surgery, prolong the treatment period, and hinders the healing process. Current research on the incidence and location of preoperative DVT in fractures mainly focuses on the lower extremity, such as pelvic fractures, femoral fractures, and tibial fractures [3, 8, 9] or the entire lower extremity fracture [10-12]. Patella is an important structure in the process of knee extension, with an incidence rate in the population being 0.13‰ to 0.61‰ [13, 14], accounting for 0.5% to 1.5% of the total incidence of adult fractures [15, 16]. It has been reported in the literature that the incidence of perioperative DVT for patellar fractures is 0.3–9% [10-12]. However, these studies did not distinguish between the preoperative and postoperative incidence of DVT. In addition, the reports on risk factors for DVT have been inconsistent across studies. For example, Zhang et al. found that preoperative time and plasma D-dimer are independent risk factors for perioperative DVT [10]. Li et al. found that age > 50 years, arthroplasty, and surgery time longer than 3 hours are independent risk factors [12]. However, in these studies, the risk factors for DVT in patients with fracture were only considered for the entire lower extremity fracture.

To the best of our knowledge, there are no studies about the epidemiologic characteristics and risk factors associated with preoperative DVT in patients with isolated patellar fractures. The purpose of this study was to retrospectively analyze the data of patients with an isolated patellar fracture in our institution and to evaluate the characteristics of preoperative DVT in these patients.

Methods

Patients

This study retrospectively collected information on patients with patellar fracture treated in our hospital from January 2013 to December 2019. This study was approved by the Ethics Committee of the Third Hospital of Hebei Medical University. The inclusion criteria were age > 18 years, isolated patellar fracture, and surgical treatment. The exclusion criteria were bilateral patellar fracture, multiple fractures, open fracture, old fracture and pathological fracture, use of blood circulation pumps, autoimmune diseases, anticoagulant use within 3 months of admission, and incomplete medical records.

Data collection

The data covered demographics, chronic comorbidities, and laboratory biomarkers. These include age, gender, body mass index (BMI), smoking, residential area, hypertension, diabetes, cerebrovascular disease, chronic heart disease, lung disease, any surgery history, history of allergies (self-reported of patients), time from fracture to Doppler Ultrasound (DUS) examination, the American Society of Anesthesiologist (ASA) score; Laboratory tests included measurements of levels of total protein (TP),

albumin (ALB), alanine transaminase (ALT), aspartate aminotransferase (AST), total bilirubin (TBIL), alkaline phosphatase (ALP), high-sensitivity C-reactive protein (HCRP), creatine kinase (CK), lactic dehydrogenases (LDH), total cholesterol (TC), triglycerides (TG), glucose (GLU), creatinine (CREA), Uric Acid (UA), D-dimer, , fibrinogen (FIB), fibrinogen degradation product (FDP), and counts of the following blood-cell types: white blood cells (WBC), neutrophils (NEU), lymphocytes (LYM), red blood cell (RBC), hemoglobin (HGB) level, hematocrit (HCT), platelets (PLT), prothrombin time (PT), prothrombin activity (PTA), international normalized ratio (INR), activated partial thromboplastin time (APTT), and thrombin time (TT).

Diagnosis criteria of thrombosis

After admission and before surgery, the patients were subjected to routine DUS of the lower extremity. The “Guidelines for the Diagnosis and Treatment of Deep Vein Thrombosis (2016 3rd Edition)” issued by the Chinese Medical Association was used for diagnosis and treatment of DVT. Positive diagnostic criteria for DVT included (a) loss or incompressibility of the vein, (b) lumen obstruction or filling defects, (c) lack of respiratory variability in the vein segments above the knee, and (d) insufficient increase in blood flow during compression of the leg and foot. The common femoral vein, superficial femoral vein, deep femoral vein, popliteal vein, posterior tibial vein, anterior tibial vein, and peroneal vein were detected. Otherwise, thrombi in the tibial vein and fibular vein are defined as distal DVTs.

According to the thrombotic test criteria, the ultrasound physician examined and reported the findings of the femoral vein trunk and the femoral deep, superficial, popliteal, tibial, and fibular veins of both lower extremities. Patients found to be present with DVT were consulted with an experienced vascular surgeon for appropriate treatment based on their medical conditions. The clinical significance of the intermuscular vein, small saphenous vein, and great saphenous vein is relatively small; therefore, they were excluded from this study [17].

Statistical analysis

SPSS 25.0 software (IBM, Armonk, New York, USA) was used for statistical analysis. The measurement data were first explored using the Shapiro–Wilk test for their distribution status (normal or non-normal). Normal distribution data were expressed as mean ±standard deviation (Sd), and an independent sample *t*-test was used to compare the differences between groups. The Mann–Whitney *U* test was used for non-normally distributed data. Categorical variables were evaluated using the chi-square or Fisher's exact tests. P values < 0.10 in the univariate analyses were further analyzed by multivariate logistic regression. P values < 0.05 were considered statistically significant for all analyses.

Results

A total of 1,049 patients with patellar fractures were admitted during the study period. Among them, 73 patients were excluded because they were younger than 18 years; 39 due to bilateral patellar fracture and non-surgical treatment; 41 due to multiple fractures, open fracture, old fracture, and pathological

fractures; 16 due to use of blood circulation pumps, 25 due to autoimmune diseases, and anticoagulant drugs were used in the last 3 months and 28 due to incomplete medical records (Fig 1).

A total of 827 patients with patellar fracture were included in this study. Of these, 63.0% (521/827) were males and 37% (306/827) were females, with an average age of 51.9 years (Sd, 14.9; range, 18–92 years), and 20.1% (166/827) were aged 65 years or above. The average BMI was 24.6 (Sd, 3.4; range 17.3–46.7) (Table 1).

Among patients, 5.8% (48/827) were found to have preoperative DVT, with 79.2% (38/48) in males and 20.8% (10/48) in females. Their average age was 57.0 years (Sd, 15.5, range 28–90 years). The BMI was 24.2 (Sd, 3.02; range 18.7–30.1). In addition, 25% (12/48) of patients were 65 years or older. The average time from injury to the diagnosis of DVT was 7.6 days (Sd, 4.5; range 1–24 days). All DVTs were asymptomatic.

Among the DVT patients, 22 had left-sided fractures and 26 had right-sided fractures. Of the 22 patients with left-sided fracture, 21 had thrombus in the injured extremity and 1 had thrombus in the bilateral extremity. Among the 26 patients with right-sided fractures, the thrombus was located in the injured extremity, non-injured extremity, and bilateral extremity in 20, 4, and 2 patients, respectively (Table 2). The distribution of thrombus in blood vessels was as follows: 1 in the femoral superficial vein, 7 in the popliteal veins, 20 in the peroneal veins, and 20 in the posterior tibial veins in patients with left-sided fractures; and 1 in the femoral superficial vein, 2 in the popliteal veins, 15 in the peroneal veins, and 9 in the posterior tibial veins in patients with right-sided fractures (Table 3). None of the patients developed preoperative pulmonary embolism.

Comparison of the variables between the DVT and non-DVT groups showed statistically significant differences in sex, age, residential area, time from injury to DUS, ALB lower limit, ALT upper limit, CREA upper limit, NEUT upper limit, and D-dimer upper limit ($P < 0.05$, Table 1).

In the multivariate logistic regression model analysis, age (each increase 1 year), (OR=1.02), residential area (urban or rural, OR=5.00), delay of injury to DUS (in each day, OR=1.33), and elevated plasma D-dimer level (> 0.5 μg/mL, OR=2.47) were identified as independent risk factors for preoperative DVT (Table 4).

Discussion

DVT is a common complication in patients with fracture, potentially affecting their prognosis. In addition, there are many uncertainties about the risk factors associated with thrombus. It is important to understand the significance of preoperative DVT in patients with isolated patellar fractures. In this study, we found that the preoperative incidence of DVT after patellar fracture was 5.8% (48/827), and 85.4% (41/48) occurred in the injured extremity. We also found that the associated risk factors were age, residence, time from injury to DUS, and plasma D-dimer level.

DVT is a common problem in patients with fractures and has been widely discussed in clinical practice [18]. We found a 5.8% (48/827) preoperative incidence of DVT after an isolated patellar fracture. However, Wang et al. [9] reported a 15.3% incidence of 59 patellar fractures. Li et al. [12] also reported an overall 8.2% rate in lower extremity fractures, with 9% of DVT in 177 knee fractures. The use of DUS, compared to the use of computed tomography (CT) or magnetic resonance imaging (MRI) venography for the detection of DVT may be partly explained by the relatively large gap in incidence rates. We also found that DVT occurred not only in the injured extremity but also in the non-injured extremity, which is consistent with the findings of Wang et al. [19]. This suggests the equal importance of screening for DVT in both the non-injured and injured extremities.

In this study, we found that for each additional increment of 1 year in age, the risk of DVT increased by 2%. Similarly, Li et al. [12] found that the risk of DVT in patients over 50 years of age increased by 43% in 829 patients with lower limb fractures. Auer et al. [20] also found that patients in the DVT group had a higher age than those in the non-DVT group. According to Virchow's principles, age-related decreases in physiological function, vascular elasticity, increased blood viscosity, and poorer venous valve function account for the propensity to develop DVT [21, 22]. Therefore, elderly patients with trauma remain the focused population with a higher risk of DVT and should be emphatically monitored or suspected.

Our results showed that the preoperative days were significantly longer in the DVT group than in the non-DVT group, with a 33% increased risk of preoperative DVT for delay time from injury to DUS (in each day). Similarly, Zuo et al. [6] found that the days before admission to the hospital in the DVT group were longer than in the non-DVT group after intertrochanteric fractures, and the risk of DVT was increased by 37% every day delay to admission. The hypercoagulable state of blood after trauma is the pathophysiological basis of DVT. In particular, the blood coagulation dynamic value was the highest in the first 24 hours after the trauma and remained hypercoagulable during the first 4 days [23]. Similar conclusions were reached in the study conducted by Decker et al. [24].

It is known from current reports that D-dimer is a highly sensitive laboratory marker for DVT [25, 26]. Our results showed that D-dimer levels above 0.5 ug/ml at admission were associated with a 47% increased risk of DVT, which was comparable to the findings of Zhang et al. [10] study of lower extremity fractures. D-dimer is a fibrin degradation marker that represents secondary fibrinolytic activity, hypercoagulability, and fibrinolytic activity in the blood, which has clinical value in the diagnosis of thrombus events [27]. Yamasaki et al. [28] retrospectively collected 588 patients undergoing lumbar spine surgery and found that the risk of DVT increased by 9% with D-dimer greater than 19.2 ug/ml one week after surgery. However, the cut-off values used in various researchers are highly variable, which may be due to the heterogeneity of the subjects and the study designs. Therefore, the age-adjusted D-dimer levels should be more appropriately applied.

Our study has several limitations. First, since it was a retrospective study, and information might have been missing in the data collected. Second, we might have underreport DVTs, primarily because of the use of DUS due to its relatively lower sensitivity compared to CT or MRI angiography. Considering that

angiography is an invasive examination, routine DUS use for DVT screening is acceptable and is generally used in most medical centers. Third, we conducted a cross-sectional rather than a cohort study with long-term follow-up. Therefore, the causative relationship of variables with DVT cannot be established. Instead, there is an association which should be cautiously treated during interpretation.

Conclusions

In summary, the incidence of preoperative DVT following an isolated patellar fracture was 5.8%. Age (each increase 1 year), residential area (urban or rural area), fracture detected by DUS, and elevated plasma D-dimer levels were independent risk factors for preoperative thrombosis. Despite a low prevalence of DVT after an isolated patellar fracture, this study underscores the importance of identifying those with a high risk of DVT, especially those with multiple identifiable factors, as well as the early targeted use of thromboembolic agents, to reduce DVT occurrence.

Declarations

Acknowledgements

Not applicable.

Authors' contributions

Y.B.Z. and W.C. contributed to the conception or design of the work. M.L. and K.D. contributed to the acquisition, analysis, and interpretation of data. H.C.W. and C.L. contributed to the creation of new software used in the work. W.J.Y. and Q.W. contributed to the drafting of the work and substantial revision of it. All authors reviewed the manuscript. All authors have approved the submitted version.

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Availability of data and materials

All the data will be available upon motivated request to the corresponding

author of the present paper

Ethics approval and consent to participate

This study was approved by the ethics committee of the 3rd Hospital of

Hebei Medical University.

Consent for publication

Written informed consent was obtained from each patient to authorize the

publication of their data.

Conflicts of Interest

All authors have read and contributed to the submitted manuscript and have no conflict of interest to declare.

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Abbreviations

DVT: Deep vein thrombosis; DUS: Doppler ultrasound scanning; OR: Odds ratio; CI: Confidence interval; BMI: Body mass index; ASA: American Society of Anesthesiologist; TP: Total protein; ALB: Albumin; ALT: Alanine transaminase; AST: Aspartate aminotransferase; TBIL: Total bilirubin; ALP; Alkaline phosphatase; HCRP: High-sensitivity C-reactive protein; CK: Creatine kinase; LDH: Lactic dehydrogenases; TC: Total cholesterol; TG: Triglycerides; GLU: Glucose; CREA: Creatinine; UA: Uric Acid; FIB: Fibrinogen; FDP: Fibrinogen degradation product; WBC: White blood cells; NEU: Neutrophils; LYM: lymphocytes; RBC: Red blood cell; HGB: Hemoglobin; HCT: Hematocrit; PLT: Platelets; PT:Prothrombin time; PTA: Prothrombin activity; INR: International normalized ratio; APTT: Activated partial thromboplastin time; TT: Thrombin time; Sd: standard deviation

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Tables

Table1. Univariate analyses of risk factors associated with preoperative DVT following Patellar fracture.

Variables	NO. (%) without DVT (n=779)	NO. (%) with DVT (n=48)	*P* value
Gender			0.017
Man	483 (62.0)	38 (79.2)	
Woman	296 (38.0)	10 (20.8)	
Age (years)	51.6 ± 14.8	56.9 ± 15.4	0.016
Smoking	88 (11.3)	9 (18.8)	0.119
Residence			0.008
Rural	422 (54.2)	37 (77.1)	
Urban	356 (45.7)	11 (22.9)	
BMI, kg/m^2	24.7 ± 3.3	24.2 ±3.0	0.407
<18	182 (23.3)	17 (37.4)	
18-23.9	268 (34.4)	18 (37.5)	
24.0-27.9	256 (32.9)	8 (16.7)	
≥28	73 (9.4)	5 (10.4)	
Hypertension	175 (22.5)	11 (22.9)	0.942
Diabetes	94 (12.1)	5 (10.4)	0.733
Cerebrovascular disease	58 (7.4)	5 (10.4)	0.451
Chronic heart disease	182 (23.4)	15 (31.3)	0.213
Lung disease	5 (0.6)	1 (2.1)	0.253
Surgery history	147 (18.9)	7 (14.6)	0.459
History of allergy	125 (16.0)	3 (6.3)	0.069
Time from injury to DUS	3.1 ± 2.7	7.6 ± 4.5	0.001
ASA			0.488
□-□	691 (88.7)	41 (85.4)	
□-□	88 (11.3)	7 (14.6)	
TP (< 60 g/L)	70 (9.0)	8 (16.7)	0.077
ALB (< 35 g/L)	59 (7.6)	9 (18.8)	0.006
ALT (> upper limit)	61 (7.8)	8 (16.7)	0.032
AST (> upper limit)	31(4.0)	3 (6.3)	0.442
TBIL (> upper limit)	60 (7.7)	5 (10.4)	0.498
ALP (> upper limit)	8 (1.0)	2 (4.2)	0.053

HCRP (> 8 mg/L)	361 (46.3)	28 (58.3)	0.106
CK (> upper limit)	63 (8.1)	5 (10.4)	0.569
LDH (> 250 U/L)	61 (7.8)	7 (14.6)	0.098
TC (> 5.8 mmol/L)	124 (15.9)	5 (10.4)	0.308
TG (> 1.7 mmol/L)	150 (19.3)	9 (18.8)	0.931
GLU (> 6.1 mmol/L)	255 (32.7)	18 (37.5)	0.496
CREA (> upper limit)	14 (1.8)	3 (6.3)	0.035
UA (> upper limit)	76 (9.8)	3 (6.3)	0.423
WBC (> $10*10^9$/L)	182 (23.4)	17 (35.4)	0.058
NEUT (> $6.3*10^9$ /L)	314 (40.3)	27 (56.3)	0.029
LYMT (< $1.8*10^9$ /L)	167(21.4)	13 (27.1)	0.358
RBC (< lower limit)	195 (25.0)	14 (29.2)	0.522
HGB (< lower limit)	142 (18.2)	11 (22.9)	0.417
HCT (< lower limit)	341 (43.8)	23 (47.9)	0.575
PLT (> $300*10^9$ /L)	24 (3.1)	4 (8.3)	0.051
PT (> 12.5 s)	9 (14.0)	1 (14.6)	0.568
PTA (< 80%)	46 (5.9)	3 (6.3)	0.922
INR (> 1.4)	25 (3.2)	1 (2.1)	0.664
APTT (< 28 s)	219 (28.1)	18 (37.5)	0.163
TT (> 17 s)	81 (10.4)	3 (6.3)	0.356
FIB (> 4 g/L)	118 (15.1)	11 (22.9)	0.150
FDP (> 5 mg/L)	129 (16.6)	13 (27.1)	0.061
D-dimer (> 0.5 ug/mL)	205 (26.3)	33 (68.8)	0.001

Notes: ALT, Alanine transaminase, reference range: female, 7-40 U/L; male, 9-50 U/L; AST, aspartate transaminase, reference range: female, 13-35 U/L; male, 15-40 U/L; TBIL, total bilirubin, reference range: female, 0-21 umol/L; male, 0-26 umol/L; ALP, alkaline phosphatase, reference range: female, 35-100 U/L; male, 45-125 U/L; CK, creatine kinase, reference range: female, 40-200 U/L; male, 50-310 U/L; CREA, creatinine, reference range: female, 41-73 umol/L; male, 57-111 umol/L; UA, uric acid; reference range: female, 155-357 umol/L; male, 208-248 umol/L; RBC, red blood cell, reference range: Female, 3.5-$5.0*10^{12}$/L; male, 4.0-$5.5*10^{12}$/L; HGB, hemoglobin, reference range: Female, 110-150g/L; male, 120-160g/L; HCT, hematocrit, reference range: Female, 35-45%; male, 40-50%.

Table 2. Distribution of thrombus in lower extremities.

Fracture sides	Thrombus			
	Left	Right	Bilateral	Total
Left fracture	21 (95.4)	0 (0.0)	1 (4.6)	22 (100)
Right fracture	4 (15.4)	20 (76.9)	2 (7.7)	26 (100)
Total	25	20	3	48

Table 3. The distribution of thrombus in blood vessels.

Fracture sides	Femoral superficial vein	Popliteal vein	Peroneal vein	Posterior tibial vein	Total
Left fracture	1 (2.0)	7 (14.6)	20 (41.7)	20 (41.7)	48 (100)
Right fracture	1 (3.7)	2 (7.4)	15 (55.6)	9 (33.3)	27 (100)
Total	2	9	35	29	75

Table 4. Multivariate analyses of risk factors associated with preoperative DVT after patellar fracture.

Variable	OR and 95%CI	*P* value
Age (increase in each year)	1.02 (1.00-1.05)	0.042
Residence (urban vs rural)	5.00 (2.17-11.1)	0.001
Time from injury to DUS (in each day delay)	1.33 (1.23-1.44)	0.001
D-dimer level (>0.5 ug/ml)	2.47 (1.73-3.53)	0.001

Figures

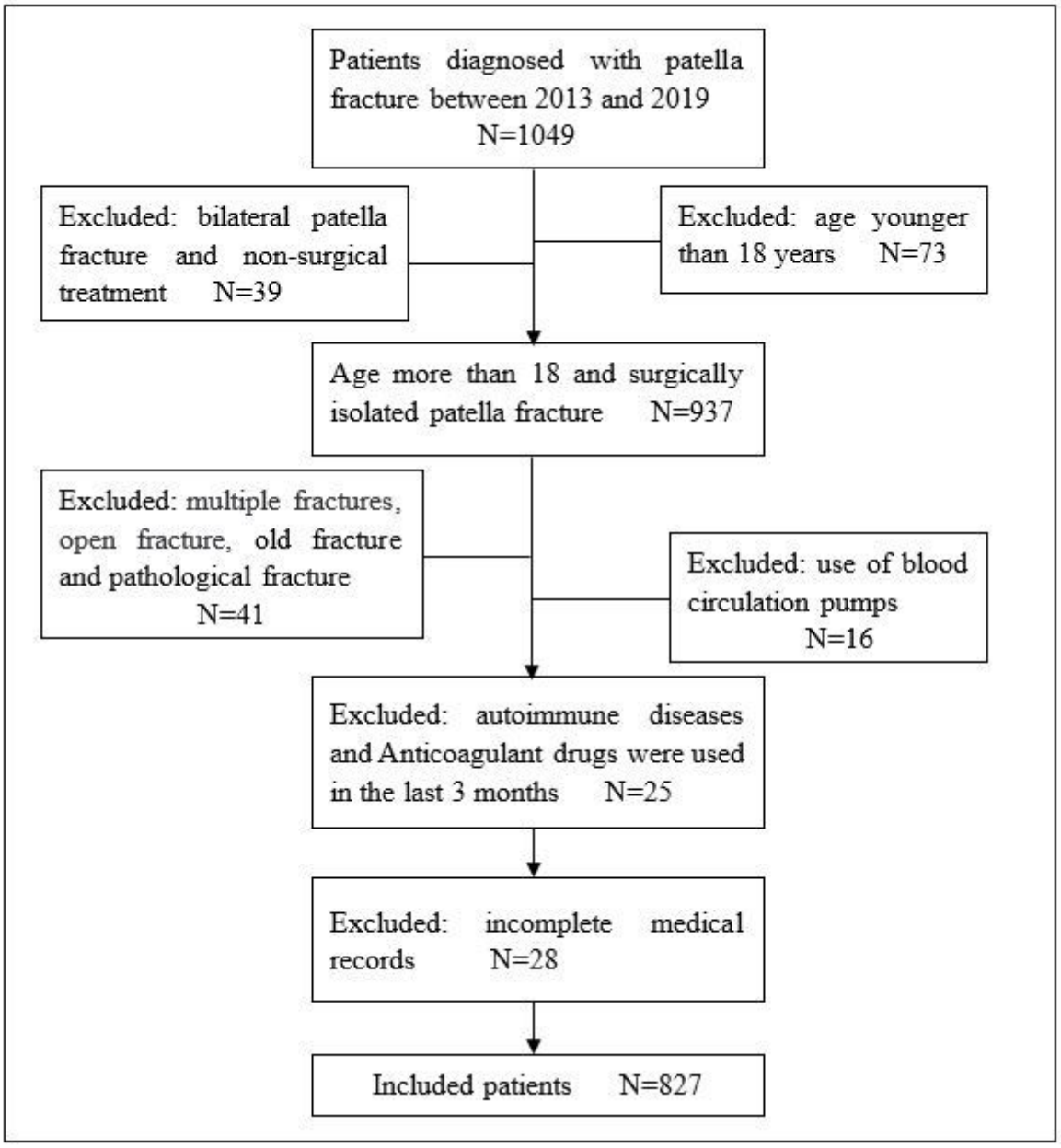

Figure 1

Flow chart of patient inclusion and exclusion in this study.