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Incidence and Risk Factors of Deep Vein Thrombosis in Patients With Pelvic and Acetabular Fractures

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Abstract

This study aimed to investigate the incidence and risk factors for deep vein thrombosis (DVT) in patients with pelvic and acetabular fractures. Patients with pelvic or acetabular fractures were included. Demographic data, fracture classification, time to surgery, and D-dimer levels at admission and one day after surgical intervention were recorded. Duplex ultrasonography was performed in the lower extremities for DVT evaluation. All patients received mechanical and chemical thromboprophylaxis. One hundred ten patients with a mean age of 44.2 ± 13.8 years were included. There were 48 patients with pelvic fractures and 62 patients with acetabular fractures. Thirty-two (29.09%) patients sustained DVT; 21 (19.09%) patients exhibited proximal thrombosis, and 3 patients suffered pulmonary embolism. The incidence of DVT in patients with acetabular fractures was significantly higher than that of patients with pelvic fractures ($\chi^2 = 4.42$, $P = .04$). The incidence of proximal DVT was significantly higher in patients with complex acetabular fractures than in patients with simple acetabular fractures ($\chi^2 = 6.65$, $P = .01$). Multivariate analysis showed that age older than 60 years, associated injuries, and the time to surgery longer than 2 weeks were independent risk factors ($P < .05$). Despite mechanical and chemical thromboprophylaxis, the risk of DVT in patients with pelvic and acetabular fractures is still very high, and most of the thromboses were localized proximally. The risk of DVT is higher in patients older than 60 years, in those with associated injuries, and when the time from injury to operation is more than 2 weeks.

Keywords

pelvic, acetabular, fracture, deep vein thrombosis, risk factors

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Introduction

Pelvic and acetabular fractures are common following high-energy trauma, and their management remains challenging.[1-4] Venous thromboembolism (VTE), including deep vein thrombosis (DVT) and pulmonary embolism (PE), are among the most fearful complications associated with these fractures.[5,6]

In the absence of thromboprophylaxis, the incidence of DVT in patients with pelvic fractures is variable, up to 61%,[7] while that of asymptomatic DVT is reported to be 15% to 68%.[8,9] However, even with anticoagulation, the incidence of DVT ranges from 3% to 30.5% in patients with pelvic and acetabular fractures,[10-13] with approximately 50% of those being pelvic (proximal) in origin.[14,15]

While anticoagulation therapy is necessary to prevent VTE, it can cause bleeding and prolonged length of hospital stay or readmission, resulting in increased cost.[16-18] Most studies on VTE focus on hip and knee arthroplasty and hip fractures.

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However, the incidence and risk factors of VTE in patients with pelvic and acetabular fractures who routinely received thromboprophylaxis are rarely reported in the Asian population.[11] This prospective study was performed to analyze the incidence and risk factors of DVT in patients with pelvic and acetabular fractures in a cohort of consecutive patients.

Materials and Methods

The institutional review board approved the study. This prospective, single-center study was conducted at our level 1 trauma center from August 2015 to December 2016. The inclusion criteria were as follows: (1) patients with pelvic and/or acetabular fractures; (2) age older than 18 years. The exclusion criteria were (1) pathological fractures, (2) anticoagulation before injury, and (3) fractures associated with an open injury that required emergency surgical intervention.

After admission, all patients were placed on mechanical thromboprophylaxis (intermittent pneumatic compression device). Chemical prophylaxis was administered with low molecular weight heparin for prophylaxis (4100 U once a day, GlaxoSmithKline Co, Brentford, United Kingdom). For patients with hemodynamic instability, chemical prophylaxis was administered once stable. Deep vein thrombosis screening of the lower extremities was performed with duplex ultrasonography (DUS) before and after surgery. Patients diagnosed with DVT were administered low molecular weight heparin at therapeutic dose (4100 U, twice a day), and mechanical thromboprophylaxis was stopped immediately. Patients diagnosed with proximal DVT (popliteal vein or more proximal) underwent preoperative placement of a retrievable inferior vena cava filter. Computed tomography (CT) arteriography was conducted in patients with suspected PE. After discharge, rivaroxaban (Bayer, Leverkusen, Germany) with 10 mg once a day was administered for prophylaxis until 5 weeks after surgery. Rivaroxaban with 15 mg twice a day was administered until 3 weeks followed by 20 mg once a day until 5 weeks after surgery for therapeutic dose. All fractures were classified by 2 senior pelvic surgeons (K.Z and Y.Z) based on their review of X-rays and CT scans. Combined pelvic and acetabular fractures were classified into one type (pelvic or acetabular fractures) according to which one was predominant. Two senior pelvic and acetabular surgeons (K.Z and Y.Z) performed all operations.

The following data were collected: (1) demographics: gender, age, body mass index (BMI), comorbidities, and the time from injury to surgery; (2) the type of fracture: pelvic fractures were classified per Young-Burgess classification,[19] and acetabular fractures were classified per Judet-Letournel classification[20]; (3) associated injuries; (4) injury severity score (ISS); (5) surgical approach; (6) blood transfusion; and (7) D-dimer levels.

Screening for DVT with DUS is routinely performed at our institution for all trauma patients. One senior sonographer (ZH) performed DUS of the bilateral lower extremities before and after surgery with Philips IU 22 duplex scanners (Royal Philips Electronics, Amsterdam, the Netherlands). The criteria of positivity for VTE included noncompressibility, the presence of intraluminal defect, an absent or a nonphasic Doppler signal, lack of respiratory variation above the knee segments, and inadequate flow augmentation to calf and foot compression maneuvers.[21] Deep vein thrombosis was classified as proximal if it was localized in the popliteal vein or proximally. Distal DVT was defined as thrombosis localized distal to the popliteal vein. Patients who had DVT in both distal and proximal veins were classified in the proximal DVT group.

The blood samples were tested by an automatic blood coagulation analyzer (CA1500, Sysmex Corporation, Japan). D-dimer levels were measured at 2 hours after admission and one day after surgery. The positive threshold of the D-dimer level was more than 1.4 mg/L.

Statistical Analysis

The Statistical Package for Social Sciences software version 19 (IBM, Chicago, Illinois) was used. The data are presented as the means and standard deviations except where noted. χ^2 and Fisher exact tests were performed for the categorical variables as appropriate. Comparisons between intergroups were performed using Student *t* test for continuous variables. Multivariate logistic regression was used to identify independent associations between various risk factors and DVTs. A *P* value of <.05 was defined as statistically significant.

Results

One hundred ten patients with pelvic and acetabular fractures were included. The mean age was 44.2 $\pm$ 13.8 years (range: 18-76); 76 were males and 34 were females. Forty-eight patients sustained pelvic fractures (anterior–posterior compression [APC] type in 12 patients, lateral compression [LC] type in 16 patients, vertical shear [VS] type in 20 patients), and 62 patients sustained acetabular fractures (simple fracture type in 26 patients, complex fracture type in 36 patients).

The Incidence of DVT

Overall, 29.09% (32/110) of patients were diagnosed with DVT. Proximal DVT was detected in 21 (19.09%) patients. Three (2.73%) patients had PE and proximal DVT simultaneously. Distal DVT was detected in 11 (10.0%) patients.

Deep vein thrombosis was diagnosed in 18.75% (9/48) of patients with pelvic fractures and in 37.10% (23/62) of patients with acetabular fractures. There was a significant difference in the rate of DVT between the pelvic fracture group and acetabular fracture group ($\chi^2 = 4.423$, $P = .041$). Proximal DVT was detected in 12.50% (6/48) of patients with pelvic fractures and in 24.19% (15/62) of patients with acetabular fractures. There was no significant difference between these 2 groups ($\chi^2 = 2.404$, $P = .118$).

No DVT was diagnosed in the 12 patients with APC type pelvic fractures. Deep vein thrombosis was detected in 12.50% (2/16) of patients with LC type pelvic fractures and in 35% (7/20) of patients with VS type pelvic fractures. The rate of DVT was significantly higher in patients with LC type and VS type

Table 1. The Incidence of DVT and Proximal DVT in Pelvic and Acetabular Fractures.

Classification	Incidence of DVT (%)	Incidence of proximal DVT (%)
Pelvic fractures	9/48 (18.75%)	6/48 (12.50%)
APC	0/12 (0%)	0/12 (0%)
LC	2/16 (12.5%)	1/16 (6.25%)
VS	7/20 (35.00%)	5/20 (25.00%)
Acetabular fractures	23/62 (37.10%)	15/62 (24.19%)
Simple	6/26 (23.08%)	2/26 (7.69%)
Complex	17/36 (47.22%)	13/36 (36.11%)

Abbreviations: APC, anterior–posterior compression; DVT, deep vein thrombosis; LC, lateral compression; VS, vertical shear.

pelvis fractures than in those with APC type fractures ($\chi^2 = 6.646$, $P = .036$). The incidence of DVT in the VS type group was significantly greater than that in the LC type group ($\chi^2 = 4.317$, $P = .025$).

Deep vein thrombosis was detected in 23.08% (6/26) of patients with simple acetabular fractures, and 7.69% (2/26) had proximal DVT. Deep vein thrombosis was detected in 47.22% (17/36) of patients with complex acetabular fractures, and 36.11% (13/36) had proximal DVT. There was a significant difference in the overall incidence of DVT between the simple acetabular fracture group and the complex acetabular fracture group ($\chi^2 = 3.776$, $P = .047$) and in the incidence of proximal DVT between the 2 groups ($\chi^2 = 6.645$, $P = .008$). The incidence of DVT in all patients is described in detail in Table 1.

Risk Factors for DVT

There was no significant difference in gender, BMI, medical comorbidity, ISS, surgical approach (closed reduction and internal fixation [CRIF] vs open reduction and internal fixation [ORIF]), operation time, intraoperative blood transfusion, or in admission or postoperative D-dimer levels between patients with DVT and without DVT ($P > .05$). Compared to patients without DVT, patients with DVT were older, had more injuries, and had a longer duration from injury to surgery ($P < .05$; Table 2).

After univariate analyses, the factors with $P > .1$ were removed, and the factors that met the conditions were analyzed by multivariate logistic regression analysis, including age and time from injury to surgery. The results showed that patients older than 60 years, patients with associated injuries, and time from injury to surgery of more than 2 weeks were independent risk factors for DVT in pelvic and acetabular fractures (Table 3).

Table 2. Univariate Analysis of Perioperative DVT Risk in Patients With Pelvic and Acetabular Fractures.[a]

	DVT (n = 32)	Non-DVT (n = 78)	Test Statistics	*P* Value
Age			11.683	.014
≤60	22	74		
>60	10	4		
Gender			3.118	.072
Male	26	50		
Female	6	28		
BMI			0.113	.948
≤18 Kg/m^2	6	13		
>18 ~ 25 Kg/m^2	17	44		
>25 Kg/m^2	9	21		
Associate injury			9.827	.042
Chest	6	8		
Abdomen	3	2		
Brain	2	4		
Extremities	10	13		
None	11	51		
Comorbidity			1.953	.577
HT	6	19		
CAD	2	7		
DM	5	6		
None	19	46		
ISS			1.353	.509
≤16	5	20		
>16	22	46		
>25	5	12		
Time from injury to surgery			14.801	.000
≤2 weeks	14	63		
>2 weeks	18	15		
Surgical approach			0.003	1.001
ORIF	24	70		
CRIF	4	12		
Operation time			0.708	.398
<2 hours	8	14		
≥2 hours	24	64		
Large amount of blood transfusion			0.012	.924
Yes	21	52		
No	11	26		
D-dimer on admission			—	1.000
Positive	32	76		
negative	0	2		
D-dimer after operation			—	1.000
Positive	32	77		
negative	0	1		

Abbreviations: BMI, body mass index; CAD, coronary heart disease; CRIF, closed reduction and internal fixation; DM, diabetes mellitus; DVT, deep vein thrombosis; HT, essential hypertension; ISS, injury severity score; ORIF, open reduction and internal fixation.

[a]Large amount of intraoperative blood transfusion means blood transfusion more than 1600 mL totally or transfusion faster than 1.5 mL/(kg·min).

Discussion

Deep Vein Thrombosis Incidence of Pelvic and Acetabular Fractures

Pelvic and acetabular fractures are commonly due to high-energy injuries. Previous studies have shown that pelvic and acetabular fractures are associated with a broad spectrum of incidence of DVT (range: 2%-60%) and PE (range: 0.99%-21.74%; Table 4).[5,6,8,10,11,13,22-26] In a study with 318 554 trauma patients, the incidence of PE in patients with pelvic fractures was 2 times higher than that in the overall trauma patients (0.6% vs 0.3%).[27] In our study, the incidence of

Table 3. Multivariate Analysis of Perioperative DVT Risk in Patients With Pelvic and Acetabular Fractures.

Factor	β	SE	Wald	Exp (β)	95% CI	*P* Value
Age >60	3.561	0.523	12.120	10.33	3.96-18.01	.014
Associated with other injuries	3.084	0.251	9.201	10.02	5.71-20.22	.042
Time from injury to surgery >2weeks	5.624	0.493	14.224	27.56	6.45-46.17	.000

Abbreviations: β, beta; CI, confidence interval; DVT, deep vein thrombosis; Exp (β), exponentiation of the β Coefficient; SE, standard error; Wald, Wald test.

Table 4. Comparison of the Current Study With Previous Reports.

	Fishmann et al[13]	Montgomery et al[15]	Stannard et al[5]	Steele et al[23]	Moed et al[8]	Niikura et al[6]	Kim et al[11]	Current Study
n	197	101	222	103	229	46	95	110
Mean age	40	42	–	37	37	53.4	57	44.2 ± 13.80
Associated injury	120	66	–	77	–	95 (in control group)	–	48
Radiological screening	Color duplex	MRV	MRV ultrasound	Color duplex	Ultrasound	Contrast-enhanced CT or ultrasonography	CT venography	Color duplex
DVT	11 preop, 6 postop	34 proximal	24	10	35 proximal 16 preop 19 Postop	9 (3 pts in proximal and 6 pts in distal)	29 (16 pts in proximal 13 pts in distal	32 (21 pts in proximal and 11 pts in distal)
PE	2 (nonfatal), 1 (fatal)	1 (nonfatal)	3 (nonfatal)	5 (4 nonfatal, 1 fatal PE)	2 (nonfatal)	10 (nonfatal)	9 (nonfatal)	3 (nonfatal)
The overall								
DVT	2%	33.67%	10.81%	9.71%	15.28%	19.57%	30.53%	29.09%
PE	1%	0.99%	1.35%	4.85%	0.87%	21.74%	9.47%	2.73%
Prophylaxis	Mechanical + Warfarin	Heparin + IVF	Mechanical + LMWH	LMWH + GCS	Chemoprophylaxis + SCD	GCS + IPCD	GCS	IPCD + LMWH

Abbreviations: CT, computed tomography; DVT, deep vein thrombosis; GCS, graduated compression stockings; n, number of patients; IVF, inferior vena cava filter; IPCD, intermittent pneumatic compression device; LMWH, low molecular weight heparin; MRV, magnetic resonance venography; PE, pulmonary embolism; preop, preoperative; postop, pos operative; SCD, sequential compression device.

perioperative DVT in patients with pelvic and acetabular fractures was higher than the expected incidence. Despite physical and chemical prophylaxis, the overall incidence of DVT was 29.09%. The incidence of proximal DVT was 19.09%, which was far higher than the incidence of DVT in patients with other fractures. Three (2.73%) patients sustained symptomatic PE that was confirmed by CT pulmonary angiography in our study. This rate is lower than that in previous studies reporting the incidence based on routine screening. Sen et al reported 17.85% (10/56), and Kim et al reported 9.47% (9/95).[11,12]

Deep Vein Thrombosis in Pelvic Versus Acetabular Fractures

In the current study, there was a significant difference in the rate of DVT in the pelvic fracture group and the acetabular fracture group (18.75% vs 37.10%). Only a few previous studies distinguished DVT in pelvic fractures or acetabular fractures.[6,11,26] Similar to the current study, Sen et al reported that the rate of DVT in acetabular fractures was higher than that in pelvic fractures (23.21% vs 5.36%).[12] In contrast, Kim et al did not find any difference between pelvic and acetabular fractures (32.7% vs 35%, respectively). Consistent with the current study, Kim et al found the highest rate of DVT in VS injuries in the pelvic fracture group.

In the current study, the incidence of DVT was higher in patients with complex acetabular fractures than in those with simple acetabular fractures. This result can be explained by the severity of injury, which is associated with the injury to or stasis of adjacent intrapelvic vessels due to displacement of bony fragments or increased bleeding. In addition to injury, the surgical approach may be associated with DVT. Anterior or anterior combined with posterior approaches are usually used in complex acetabular fractures. Endothelial injury to the femoral vein and/or external iliac vein and stasis during intraoperative retraction and/or positioning through the ilio-inguinal approach and/or Stoppa approach, as well as increased bleeding and transfusion, may have contributed to a high incidence of proximal thrombosis.

Risk Factors of DVT in Pelvic and Acetabular Fractures

Age is an independent risk factor for thrombosis in adult trauma patients.[28] It is even reported that patients over the age of 30 have a higher risk of developing DVT.[22] However, no relationship between DVT and patient age was found in some studies.[12,29] Despite the controversy, older age is often considered one of the factors associated with the development of DVT.[8] In the current study, the rate of DVT in patients over the age of 60 years was 71.4%, which was much higher than the rate in those under 60 years old (22.9%; $P = .014$). Consistently, Kim et al reported a significantly increased rate of DVT in patients with pelvic and acetabular fractures over 50 years old. Therefore, elderly patients with pelvic acetabular fractures should be evaluated more closely and at a high level of suspicion for DVT.

While gender, ISS, BMI, and comorbidities are reported to increase the risk of DVT,[30,31] the current study showed no association between the incidence of DVT and these factors. Similar to previous reports, this result may be due to the higher incidence of DVT in patients with pelvic acetabular fractures.[32]

Trauma, bleeding, anesthesia, increased hypercoagulability, and subsequent manipulation during surgery further injures the vascular endothelium,[7] resulting in increased risk of DVT. Based on the exposure, the degree of soft tissue, vascular endothelial injury, coagulated substances released into vessels are expected to be different in the ORIF than in the CRIF group. Consequently, a higher incidence of DVT is expected in the ORIF group. However, in our study, there was no significant difference between these 2 groups ($\chi^2 = 0.003$, $P = 1.001$), which may be related to the selection basis.

Ultrasonography is the most commonly used method for the diagnosis of DVT; on the other hand, it cannot predict the occurrence of DVT in patients with fractures. Many studies have focused on predicting the occurrence of DVT using early detection methods, especially blood D-dimer levels. Increased D-dimer levels have been associated with the degree of trauma, the degree of inflammatory reactions, pregnancy, aging, and other factors.[33] The findings of the current study suggest that D-dimer testing in patients with pelvic and acetabular fractures has limited significance because the D-dimer test was positive in all patients.

The role of the time from injury to surgery in the development of DVT is controversial. Steele et al[23] reported that there was no correlation between DVT incidence and the time from injury to surgery. This finding is in contrast to the studies by Stannard et al,[34] Arroyo et al,[10] and Dennis et al.[35] Symptomatic VTE and lethal PE occur most commonly 2 to 5 weeks after injury.[34,36] Therefore, 2 weeks from injury to surgery was used as the time point threshold for comparison in the current study. We found that the incidence of DVT was significantly higher if the time to surgery was longer than 2 weeks. While the patient may not always be medically ready before 2 weeks, the goal should be to perform the surgery as soon as the patient is medically stable.

The present study found that the incidence of DVT in patients with pelvic and acetabular fractures combined with other injuries was significantly higher than that in patients without other injuries. Multivariate logistic regression analysis showed that the associated injury was an independent risk factor for DVT in patients with pelvic and acetabular fractures. One of the reasons for the high incidence of DVT in these patients is the failure of effective anticoagulation therapy in the early posttraumatic period because of the risk of bleeding.[37] For high-risk cases, regular DUS screening should be performed preoperatively and postoperatively. If patients are diagnosed with DVT, low molecular weight heparin at a therapeutic dose (4100 U, twice a day) should be prescribed, and mechanical thromboprophylaxis should be stopped immediately. Patients who are diagnosed with proximal DVT (popliteal vein or more proximal) should undergo preoperative placement of a retrievable inferior vena cava filter.

The current study has limitations. The reason for the higher incidence of proximal DVT in this study may be related to the surgical approach. However, the smaller sample size groups are not compared according to the surgical approach. In addition, the diagnostic value of DUS for DVT is still controversial, but it is still the most widely used method in clinical practice. Venography was not used, which might also lead to underdiagnosis. Another limitation was that the intrapelvic veins were not evaluated.

Conclusion

In summary, even with mechanical and chemical thromboprophylaxis, the rate of DVT in patients with pelvic and acetabular fractures is still very high, and most of the thromboses are located proximal to the popliteal vein. The rate of DVT is higher in acetabular fractures compared to pelvic fractures. Age older than 60 years, associated injuries, and the time from injury to operation of more than 2 weeks were independent risk factors.

Authors' Note

Ping Liu and Kun Zhang contributed equally to this work.

Declaration of Conflicting Interests

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