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ORIGINAL PAPER

Thromboembolic events in pelvic and acetabulum fractures: a systematic review of the current literature on incidence, screening, and thromboprophylaxis

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Abstract

Purpose Rates of venous thromboembolic events (VTEs) as high as 41% deep vein thrombosis (DVT) were reported in association with pelvic and acetabular fractures (PAFs). There is no clear consensus on VTE prophylaxis for PAFs. Extracting evidence-based guidelines is key to overcome this challenging complication. The aims of this review are (A) to highlight the incidence of VTEs in PAFs, (B) to examine the screening and prophylaxis methods available in the current literature, and (C) direct future creation of a best practice protocol to reduce the risk of VTE in PAFs.

Methods We performed a systematic search of Medline, EMBASE databases, and the Cochrane library. MESH terms were used to identify studies pertinent to VTE in PAFs, including incidence, prophylaxis, and screening.

Results In total, 28 studies were identified and grouped into four categories including incidence, screening, prophylaxis, and the use of inferior vena cava filters (IVCFs). Incidence of VTE ranged from 0.21 to 41% for DVT and 0 to 21.7% for PE. Nine studies screened 1360 patients using different imaging modalities. Ten articles, 2836 patients, examined different thromboprophylaxis protocols. Two out of three studies investigating the use of IVCF showed significant reduction of the rates of PE.

Conclusion Incidence of VTE in PAF varies significantly with different protocols. The current literature shows that screening is still controversial. The combination of chemical and mechanical prophylaxis starting at 24 hours from the injury would provide the best protection. Guidelines were extracted; however, higher level multicenter studies are still required to guide future protocols.

Keywords Pelvis · Acetabulum · Fracture · Venous thromboembolism · Prophylaxis · Vena cava filter

Introduction

Venous thromboembolic events (VTE) (including deep vein thrombosis [DVT] and pulmonary embolism [PE]) are known to further accentuate the complexity of managing patients with pelvic and acetabular fractures (PAFs). VTEs are associated with significant morbidity and mortality of the affected population. Patients who were diagnosed with DVT experienced significant reduction of their health-related quality of life (HrQoL) in addition to the long-term higher mortality rates [1]. The overall 30-day mortality rate of PE can reach 11.4% [2].

PAFs are high-energy complex injuries, usually associated with other fractures and require multidisciplinary team approach in highly specialised trauma centres. In spite of this level of care, exceptionally high rates of thromboembolism are still encountered by the treating surgeons. Incidences of up to 41% percent were reported for DVT and 21.7 percent for PE [3, 4].

Aiming to guide the process of VTE Prophylaxis in those patients, we present this review with three main goals: (A) highlight the incidence of VTE in PAFs and identify the risk factors, (B) investigate the screening methods available in the current literature to assess their sensitivity and validity and examine

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their impact on the diagnosis and treatment, (C) search the VTE prophylaxis protocols to extract best practice guidelines for PAF patients.

Materials and methods

Search strategy

We performed a systematic review following the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines [5]. The online published databases of PubMed and EMBASE together with the Cochrane library were searched from inception to May 2021. PubMed and EMBASE databases were individually searched through the OVID Online research platform, while the Cochrane library was searched through its online website. Our search included EPUB ahead of print and in-process and other non-indexed citations. The MeSH terms searched were "Pelvis/Pelvic", "Acetabulum/Acetabular" AND "Fracture", "Thrombosis", "Embolism", "Thromboembolism", "Pulmonary Embolism" and "Filter". Subsequently, the terms were paired together to create lists of results. All search terms were "Exploded"; then all subheadings were included. Reference lists of the included studies were also screened for relevant publications.

Eligibility criteria

All publications pertinent to thromboembolic events in relation to PAFs were reviewed. Level V publications were ruled out. Search was limited to English literature and human studies.

Study selection and critical appraisal

The titles and abstracts of the list of studies were independently reviewed by each of the authors to confirm eligibility. Subsequently, final agreement on included publications was reached by discussion among all authors. Selected studies were then assessed for the risk of bias using MINORS criteria for non-randomized trials and RoB-2 tool for randomized trials [6, 7].

Study classification

Selected studies were subsequently classified into studies pertaining incidence of VTEs, screening for thrombosis, and methods of thromboprophylaxis including the use of inferior vena cava filters (IVCF). This created 4 groups of listings to aid data extraction and review narration.

Data extraction

All manuscripts, but one [8], were downloaded and data extracted including number of patients, incidence of DVT, incidence of PE, study methodology, and conclusion.

Data from different studies were downloaded (or requested) in an attempt to establish fracture types related to VTEs.

For screening studies, methods of screening were considered, and for prophylaxis studies, the prophylaxis methods were listed.

Results

Numbers of records retrieved per database together with the search strategy are presented in Fig. 1. In addition to the previously excluded records, one study had to be ruled out because of methodology issue failing to separate and present pelvic trauma patients from other trauma patients.

In total, 28 studies were found relevant to the reviewed topic. These included one prospective randomized study [9], four comparative studies [10–13], and four registry data-based studies [14–16], and the rest were cohort studies. All studies were assessed for the risk of Bias. RoB-2 can be used to assess two studies, both of which were found to have a high risk of bias.

The rest of studies were scored according to MINORS criteria, and the most common score noticed was 7 (range [5–10]:).

For the purpose of the review, studies were grouped into four categories. Further critique and details of the studies involved will be presented in each group.

Incidence of thromboembolic events in pelvic and acetabular fractures

Ten studies, published between 1993 and 2020, reported the incidence of VTEs. Eight were cohort studies, four prospective and four retrospective, and two were registry/database retrieval reports. Collectively, all studies included 89,046 patients with PAFs. Minimum follow-up was 90 days [14] and varied between studies up to a maximum of seven years [17]. Follow-up was not documented in two studies [3, 18]. The reported incidence of DVT was highly variable starting from as low as 0.21% [14] and reaching up to 41% [17]. Other reported values are listed in Table 1. Similarly, incidence of PE ranged from zero [21] and up to 21.7% [22].

Multiple factors could have contributed to the noted significant variation. Firstly, the diversity of diagnostic tools used by the investigators could result in either over- or under reporting of the VTE events. Secondly, different protocols were used to identify patients for investigation; while some studies screened all patients [3, 23], others were selective in choosing patients for investigation [18],

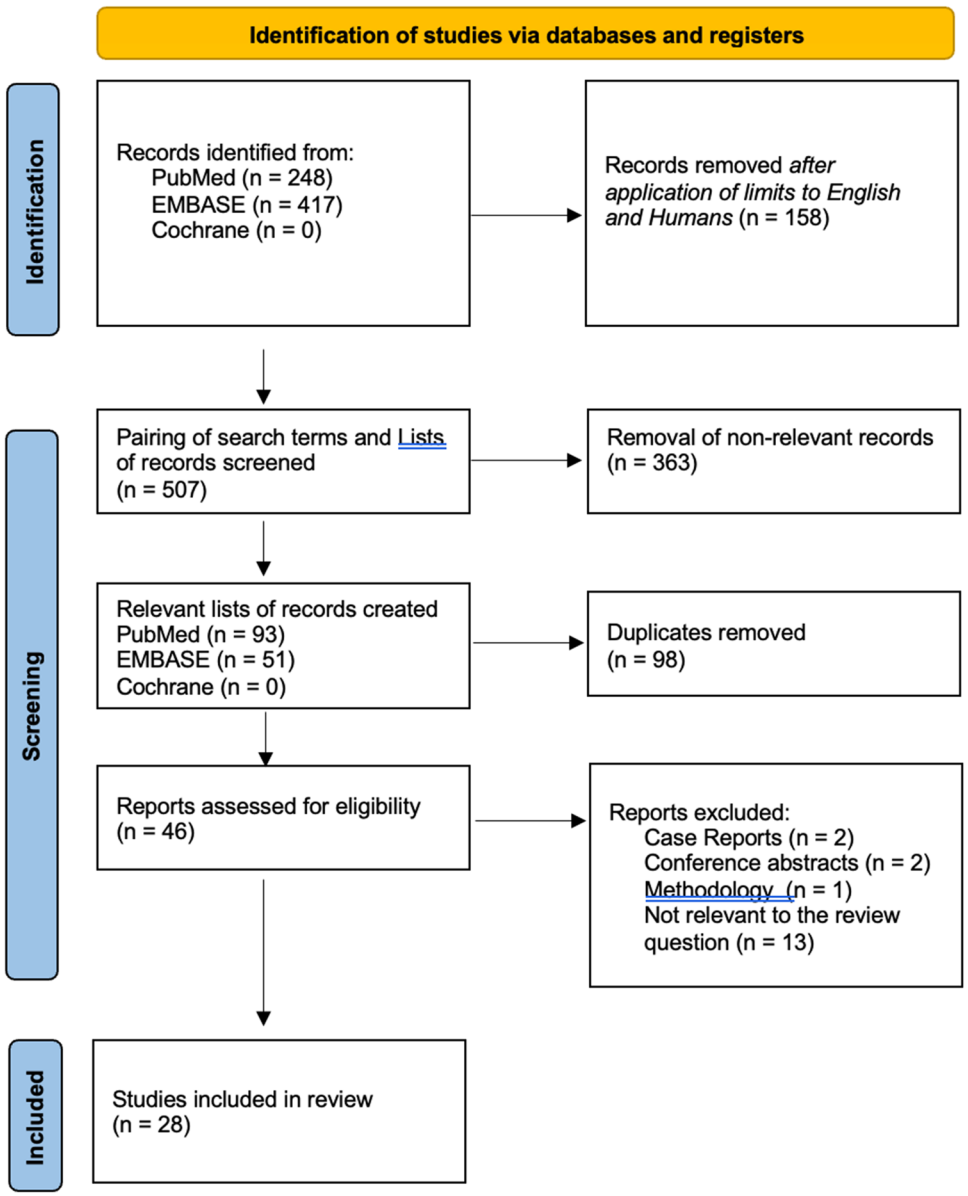

Fig. 1 PRISMA search flow chart

and in a single study, by Niikura et al., two different protocols were applied to their patient cohort [17]. Thirdly, our search produced three national database publications [14 – 16]. These were noted to report significantly lower rates of VTEs.

Screening for VTE in pelvic and acetabular trauma patients

Nine studies, published between 1990 and 2020, including 1360 patients, presented different screening modalities, all of which aiming at early detection of VTE in PAFs (Table 2). These included duplex ultrasound scan (USS), contrast venography, venographic contrast computed tomography (CTV), and magnetic resonance venography (MRV) [10, 21, 23–28]. All studies, but one [10], are prospective cohort studies. Follow-up intervals varied from two weeks post-operative [24] and up to six months [23].

Some investigators used ultrasound scanning protocols to guide future management [10, 24–26]. These included either further investigations [10, 26] or initiation of the anticoagulation protocols [23–25]. The later was followed in three studies, in which a total of 638 patients were screened pre- and post-operatively [23–25]. Patients with pre-operative

Table 1 Incidence of VTE in pelvic and acetabular fracture patients

	Author	Journal	Year	*N*	Incidence of DVT	Incidence of PE	Conclusion	Risk of bias score
1	Buerger P et al [19]	*The American Surgeon*	1993	198		4 (2%)	– No screening – Clinically significant PE – Incidence of PE correlated with ISS – Incidence of PE in Pelvic and Acetabular trauma patients was significantly higher than other trauma patients	MINORS: 7
2	Niikura T et al [16]	*J Orthop Science*	2012	46	19 (41.3%)	10 (21.7%)	– Used contrast-enhanced CT and USS – Incidence of DVT and PE was significantly higher in pelvic and acetabular trauma patients compared with other trauma patients	MINORS: 9
3	Lee J et al [20]	*Scientific Reports*	2020	363	45 (12.4%)	19 (5.2%)	– Patients with pelvic and acetabulum and lower extremity fractures – Symptomatic patients were investigated using CTA – A higher Charlson comorbidity index and external fixation were risk factors for VTE – Male sex and above the knee fractures were associated with an increased risk of PE among patients with VTE – Peripheral vascular disease is a significant risk factor for VTE	MINORS 8
4	Dwyer et al. [12]	*J Orth Surg* (Hong Kong)	2019	13,589	0.21%	0.51%	– Registry data extraction – Most of the VTE events occur over 35 days. However, the overall risk of fatal PE is low	MINORS 5
5	Sen RK et al. [4]	*Int Orth*	2011	56	28.57%	17.85%	– Highlighted the importance of routine prophylaxis	MINORS 8
6	Godzik J et al [13].	*Orthopedics*	2014	73,706	0.46%	0.58%	– National Trauma Data Bank – Increased incidence of PE in patients with multiple fractures, obesity, and history of warfarin use	MINORS 5
7	Wang P et al. [3]	*Clin Applied Thromb Haemostasis*	2019	110	29.09%	2.72%	– Used duplex ultrasound for all patients – The incidence of DVT in patients with acetabular fractures was significantly higher than that of patients with pelvic fractures – Proximal DVT was significantly higher in patients with complex acetabular fractures than in patients with simple acetabular fractures – Other independent risk factors included: age older than 60 years, associated injuries, and the time to surgery longer than 2 weeks	MINORS 8

Table 1 (continued)

	Author	Journal	Year	*N*	Incidence of DVT	Incidence of PE	Conclusion	Risk of bias score
8	Lowe JA et al. [14]	*J Orthop Trauma*	2020	P:510 A:240	Pelvis: 0.98% Acetabulum: 0%	Pelvis: 0.78% Acetabulum: 0.42%	– Database review study – Chemical and mechanical prophylaxis – Investigated the incidence of VTE following operative fixation of pelvic, acetabulum, and lower extremity fractures	MINORS 6
9	Fishmann A et al [21]	*Clin Orth Rel Res*	1994	197 (203 fractures)	Pre-op 6% Post-op 3%	Post-op 1%	– Proposed a protocol of preoperative non-invasive screening of both LLs, followed by the intraoperative and postoperative use of mechanical antithrombotic devices and chemical prophylaxis with warfarin for 3 weeks following removal of surgical drains	MINORS 7
10	Gruen G et al. [18]	*Orthopedics*	1995	31	3%	0%	– Duplex USS preoperative and 1 week post-operative – Additional scans when clinically indicated	MINORS 9

DVT underwent IVC filter insertion, while therapeutic anticoagulation was prescribed for those with post-operative proximal DVT. None of the studies presented their rates of DVT, PE, or VTE related mortality prior to the screening program. Elnahal et al. [24] reported that their protocol has changed the management in five patients; therefore, none of them developed PE. Nevertheless, it was noted that in all three studies, USS screening programs could not prevent post-operative PE which was diagnosed in ten patients (1.6%). In this scenario, PE could be either due to progression of DVT that was not detected on USS or a de novo PE (DNPE) triggered by the acute inflammatory response [29].

White et al. used the USS for serial screening, and subsequent contrast venography was used to confirm the USS findings [26]. Borer et al. presented the difference between the incidence of PE in a group of screened patients (using USS and MRV) and another group of unscreened patients. At the end of the study, the incidence of PE was even higher in the screened group (2 versus 1.4%). All patients diagnosed with PE initially tested negative upon screening [10].

The literature available pertaining MRV as a screening tool was controversial. Two studies, same authors, reported it to be sufficiently sensitive, noninvasive test and superior to invasive venography. They reported one incidence of PE among 146 patients (0.6%) [28, 30]. On the other hand, Stover et al. used MRV and CTV for screening and identified unacceptably high false positive results of both tests, 100% and 50% respectively, in comparison to invasive pelvic venography [27].

VTE prophylaxis in pelvic and acetabular fractures

Ten papers published between the years 1994 and 2021, including 2836 patients, have specifically investigated VTE prophylaxis in PAFs. Two studies were retrospective [21, 31], one database analysis [20], and the remaining was prospective [9, 11–13, 22, 23, 32]. All studies followed up patients only during the acute episode of admission and/or shortly after, with the longest follow-up being 6 months [23]. All studies, apart from one [33], included adult patients (Table 3).

Patient age

Greenwald et al. analyzed the incidence of VTE in pediatric patients with PAFs [33]. Of their large cohort, 8.8% (948 patients) received some form of prophylaxis and the incidence of DVT was only 0.17% with no detected PE events. They demonstrated the low risk of VTE related morbidity and mortality in this age group.

Table 2 Screening for VTE in pelvic and acetabular trauma patients

	Author	Journal	Year	*N*	Screening method	Incidence of DVT	Incidence of PE	Conclusion	Risk of bias
1	Borer D et al. [8]	*J Orthop Trauma*	2005	486	USS and MRV		2%	– Compared screening to non-screened cohort – 8/10 screened patients who sustained PE had negative screening tests – Screening for DVT did not change the incidence of PE (1.4% incidence prior to screening)	MINORS 9
2	Moed B et al. [23]	*J Trauma Acute Care Surg*	2012	229	Sequential duplex USS (pre- and postoperative)	15% (Asymptomatic)		– 1% (2 patients) with negative scans still developed PE – Sequential USS did not reduce the risk of PE	MINORS 10
3	Stover et al. [24]	*J Orthop Trauma*	2002	30	CTV and MRV	CTV 7% MRV 13%		– 50% FP for CTV and 100% FP for MRV – Both modalities could not be recommended for screening	MINORS 7
4	Montgomery K et al. [25]	*J Orthop Trauma*	1997	101	MRV	34%	1%	– Acetabular fractures – Used preoperative MRV to categorize patients into two different prophylaxis pathways	MINORS 7

Table 2 (continued)

	Author	Journal	Year	*N*	Screening method	Incidence of DVT	Incidence of PE	Conclusion	Risk of bias
5	Montgomery K et al. [26]	*JBJS-Am*	1995	45	Contrast venography MRV	MRV 33%	0%	– Acetabular fractures – Preoperative contrast Venography and MRV – 58% of thrombi detected on MRV were missed on contrast venography (located in deep pelvic veins) – MRV is less invasive and more precise investigation	MINORS 6
6	White R et al. [27]	*JBJS-Am*	1990	60	Serial duplex USS venography	15%		– Used serial USS to screen all patients – Invasive Venography for positive patients	MIINORS 5
8	Elnahal et al. [22]	*Eur J Orth Surg Traum*	2020	212	Duplex USS	4%	2.8%	– Protocol based approach – Pre- and postoperative screening – Patients were risk stratified and higher risk patients received IVC filter	MINORS 8
9	Fishmann A et al. [21]	*Clin Orth Rel Res*	1994	197 (203 fractures)	– Preoperative screening – Mechanical – Chemical	Pre-op 6% Post-op 3%	Post-op 1%	– The authors found their protocol successful in early detection DVT and prevention of VTE	MINORS 7

Mechanical prophylaxis

Two studies were primarily focused on mechanical VTE prophylaxis. Stannard et al. [7] performed a randomized controlled trial comparing the high-pressure pulsatile mechanical to the standard low-pressure sequential calf compression devices. A trend towards a lower incidence of DVT (9 versus 19%) was noted with pulsatile compression; however, the difference did not reach statistical significance.

Another cohort study reported, unsurprisingly, high rates of DVT and PE (18 and 12% respectively) in PAF patients following isolated use of mechanical prophylaxis (graduated compression stockings and intermittent pneumatic compression devices) [22].

Timing of pharmacological prophylaxis

Two studies questioned the late administration of pharmacological prophylaxis [low molecular weight (LMWH) and unfractionated heparin (UH)] as a risk factor for VTE. Both have confirmed that administration after 48 h from arrival to the emergency department was associated with significantly increased risk of VTE in PAF patients [13, 31]. Using LMWH for prophylaxis, Steele et al. [35] have shown that administration within 24 hours from the injury, or achieving haemodynamic stability, was associated with significant reduction of the incidence of DVT.

With the increasing use of the direct oral anticoagulant (DOAC), rivaroxaban, Monzon et al. [12] visited the same question. They found that administration of rivaroxaban within 24 h was associated with significant reduction of the incidence of DVT without increased risk of intra- or post-operative bleeding.

LMWH versus DOACs

Hamidi et al. [20] were the only group to compare the use of LMWH to DOACs in PAF patients. They presented database analysis of a large number of non-operatively treated patients. They identified that DOACS were associated with significant reduction of the risk of DVT, but not PE, without increasing the risk of bleeding or mortality.

Dosage monitoring

Constantini et al. [32] demonstrated the advantage of using plasma anti-Xa in trauma patients to monitor the therapeutic effects of LMWH. Only 29.5% of their patients were found to have the expected circulating therapeutic levels of anti-Xa. Hence, they recommended using higher prophylactic doses of LMWH (more than 30mg twice daily). Alternatively, anti-Xa can be routinely assessed for dose adjustment in trauma patients.

Inferior vena cava filter (IVCF) for thromboprophylaxis in pelvic and acetabular fractures

Our search revealed three studies, published between 1992 and 2019 and included 370 patients. Two comparative studies [8, 36] examined two groups of patients, IVCF and non-IVCF; both were single centre studies with non-randomized allocation (Table 4).

The first study (Cohen-Levy et al. [36]) failed to show significant reduction of the incidence of PE. They have also noted an associated nonsignificant rise in the incidence of DVT among IVCF patients. Therefore, it could not confirm the benefit of the IVCFs.

In the second study, Webb et al. [8] showed a reduction of the incidence of PE among the IVCF group (0% versus 7%). However, 17% of the IVCF patients developed leg oedema. The oedema was severe enough to result in peripheral lower extremity tissue loss in one patient.

The third study, by Toro et al. [37], presented a four-year follow-up result of 88 patients who were preoperatively diagnosed with DVT requiring the insertion of IVCF. None of their patients developed PE or recurrent DVT. 7% developed bilateral lower limb swellings, and 1% suffered from post thrombotic syndrome affecting both lower limbs.

Discussion

Despite all advances in recent anticoagulation therapy and thromboprophylaxis, PAF patients still suffer from significantly high rates of thromboembolic events. The current literature highlights the fact that, despite its low rates, PE is challenging to predict and eliminate. Mortality rate due to untreated PE can reach as high as 30%, while in diagnosed and treated PE, it is 8%. Two of three patients with PE die within two hours after presentation [19].

The incidence of VTEs was highly variable in the current literature, and only one study reported zero PE in their patients; otherwise, both DVT and PE were unavoidable.

Risk factors for VTEs in PAF patients include lower limb external fixation and those with high Charlson comorbidity index [18]. Patients with high body mass index (BMI > 30) and those who underwent pelvic angioembolization were found to be at higher risk (up to 2.6 times) of VTE [13, 38].

When it comes specifically to PE, risks included obese (BMI > 40) males, with history of warfarin use, intensive

Table 3 Methods of VTE prophylaxis in pelvic and acetabular trauma patients

	Author	Journal	Year	*N*	Prophylaxis method	Incidence of DVT	Incidence of PE	Conclusion	Risk of bias
1	Stannard JP et al. [7]	*JBJS-Am*	2001	107	Mechanical	Sequential 19% Pulsatile 9%	Sequential 2% Pulsatile 0%	- Prospective Randomised study comparing two modes of mechanical compression; sequential versus pulsatile - Trend, not statistically significant, towards less DVT with the pulsatile compression group	RoB-2: High Risk
2	Schellenberg M et al. [11]	*J Surg Res*	2021	146	Pharmacologic	7% with late prophylaxis 0% with early prophylaxis	3-4%	- Prospective study comparing early (48 hrs or less) versus late (more than 48h) VTE prophylaxis in pelvis trauma patients - Early prophylaxis resulted in less DVT, but not PE, among pelvic trauma patients	RoB-2: High Risk
3	Niikura T et al. [33]	*J Orth Surg*	2012	126	Mechanical (compression stockings and intermittent pneumatic compression)	18%	12%	- Used only mechanical prophylaxis for all patients - Patients with high D-dimers were screened and treated accordingly	MINORS: 6
4	Berning B et al. [30]	*The Am Surg*	2020	212	Pharmacologic	Early: 5.2% Late: 5.7%	Early: 1.5% Late: 6.8%	- Early (within 48 h) anticoagulation VTE prophylaxis reduced the risk of PE, but not DVT, without increasing bleeding complications	MINORS: 5

Table 3 (continued)

	Author	Journal	Year	*N*	Prophylaxis method	Incidence of DVT	Incidence of PE	Conclusion	Risk of bias
5	Costantini T et al. [29]	*J Traum Acute Care Surg*	2013	61	Pharmacologic prophylaxis	3.3%	1.6%	- Used anti-Xa levels to assess therapeutic levels of enoxaparin - Only 29.5% of the patients had therapeutic levels - Suggested dose adjustment for trauma and high-risk patients	MINORS: 8
6	Fishmann AJ et al. [21]	*Clin Orth Rel Research*	1994	197 (203 frac-tures)	- Preoperative screening - Mechanical - Pharmacologic	Pre-op 6% Post-op 3%	Post-op 1%	Proposed a protocol of preoperative noninvasive screening of both LLs, followed by intraoperative and postoperative use of mechanical antithrombotic devices and chemical prophylaxis with warfarin for 3 weeks following removal of surgical drains	MINORS: 7
7	Greenwald L et al. [17]	*J Paed Orth*	2012	948	Mixed	0.31%	0%	- Investigated incidence of VTE in paediatric patients presenting with pelvic and/or femoral fractures - Only 8.8% received Prophylaxis	MINORS: 5
8	Hamidi M et al. [15]	*J Amer Col Surg*	2019	852	- Pharmacologic (DOACs and LMWH)	5.2%	1.4%	- Database study - Compared DOACs vs LMWH for non-operatively treated pelvic fractures - DOACs were associated with significantly less incidence of DVT (not PE) without increasing the risk of bleeding complications	MINORS 5

Table 3 (continued)

	Author	Journal	Year	*N*	Prophylaxis method	Incidence of DVT	Incidence of PE	Conclusion	Risk of bias
9	Monzon DG et al. [34]	*J Emerg Med*	2012	84	Pharmacologic (rivaroxaban)	- Early: 9.4% - Late: 45%	2.4% (one died)	- Oral AG (Rivaroxaban) - Compared early (within 24 h of injury) to late (after 24hrs) administration - Early administration reduced the incidence of DVT (not PE)	MINORS: 7
10	Steele N et al. [32]	*JBJS Br*	2005	103	Pharmacologic (LMWH)		-Early:3% -Late: 22%	- Compared incidence of DVT between two groups of patients who received VTE prophylaxis (LMWH) early versus late. - Early VTE prophylaxis (within 24 h) significantly reduced the incidence of DVT	MINORS: 6

care unit admission, high ISS scores (>15), and associated fractures above the knee [15, 18, 34].

Wang et al. reported that the incidence of DVT was higher among patients older than 60 years old, with associated injuries and who underwent late surgical fixation (> 2 weeks). In addition, they found that DVTs were significantly increased in patients with acetabular fractures more than those with pelvic ring injuries and that proximal DVT was significantly higher with complex than simple acetabular fractures [3].

Dwyer et al. highlighted the importance of close follow-up of those patients and immediate attention to any suspicious symptoms of VTE. In their cohort, 28% of DVTs and 23% of PEs happened more than 35 days after discharge [14].

Screening for VTE still cannot be coined as the best practice in those patients for many reasons.

Firstly, none of the screening methods has shown itself to be the gold standard technique. In spite of being noninvasive, economic, and easy to organize, USS was not sensitive enough to reduce the incidence of PE [10, 25]. Some authors used it as an initial screening method and used more advanced tests to confirm the finding [26]. In addition, PAF patients are commonly polytraumatized. Hence, an associated lower limb injury, cast, or external fixation can hinder the use of USS.

MRV is the most recent imaging modality for detection of VTEs. It has the advantage of being noninvasive and offering a detailed high-resolution picture of the venous tree (Fig. 2) [39].

Nevertheless, although it was considered very precise by some [30], it was found to be too sensitive and resulting in 100% false positive results by others [27]. Ironically, both studies based their conclusions by comparing MRV to invasive contrast venography. MRV also have the disadvantages of being an expensive study, not readily available, requiring patient transfer to another department, and it can be affected by implanted metal work.

Secondly, the screening process itself can be inconvenient. Those patients, frequently, have multiple visits to the operating theatres prior to the pelvic fixation; some of them would even attend the angiography suite for embolization prior to screening. Hence, the complexity of identifying the best time to perform the screening test.

In addition, a recent survey of the PAF surgeons of the Orthopaedic Trauma Association (OTA) showed that only 8.7% of the surgeons would obtain routine VTE screening for their patients on admission [40].

Both mechanical and pharmacological VTE prophylaxis were visited in multiple studies. Our review highlighted four key messages:

(1) Both mechanical and pharmacological VTE prophylaxis are essential in PAF patients. Studies attempting

Table 4 Use of IVCF in pelvic and acetabulum fractures

	Author	Journal	Year	*N*	Incidence of DVT	Incidence of PE	Conclusion	Risk of bias
1	Cohen-Levy W et al. [31]	*International Orth*	2019	231	11%	1%	- Compared the incidence of PE and DVT between two cohorts of patients with and without IVCF - No significant difference - A nonsignificant trend of increasing incidence of DVTs was appreciated in patients with a prophylactic IVCF versus those without prophylactic IVCF - Could not confirm the benefit of IVCF	MINORS: 7
2	Webb L et al. [6]	*J Orthop Trauma*	1992	51		0%	- Risk stratified patients for filter insertion - Compared the incidence of PE and DVT between two groups of patients with and without IVCF - No PE detected in patients receiving IVCF and 7% incidence of PE in the no filter group	MINORS: 7
3	Toro J et al [35]	*J Traum, Inj, Inf and Crit care*	2008	88	1% post-thrombotic syndrome	0%	- Investigated the incidence of PE in pelvic fracture patients treated with IVCF insertion preoperatively for DVT - IVCF is safe and effective in preventing PE	MINORS: 7

the isolated use of mechanical methods have shown unacceptably high rates of VTE [4, 22].

(2) Unless contraindicated, pharmacological agents must be started as soon as possible once haemodynamic stability is achieved, ideally within 24 hours of the patients' attendance to the emergency department [11–13, 31].

(3) Despite the preferred use of LMWH among orthopedic surgeons [40], two studies have confirmed the safety

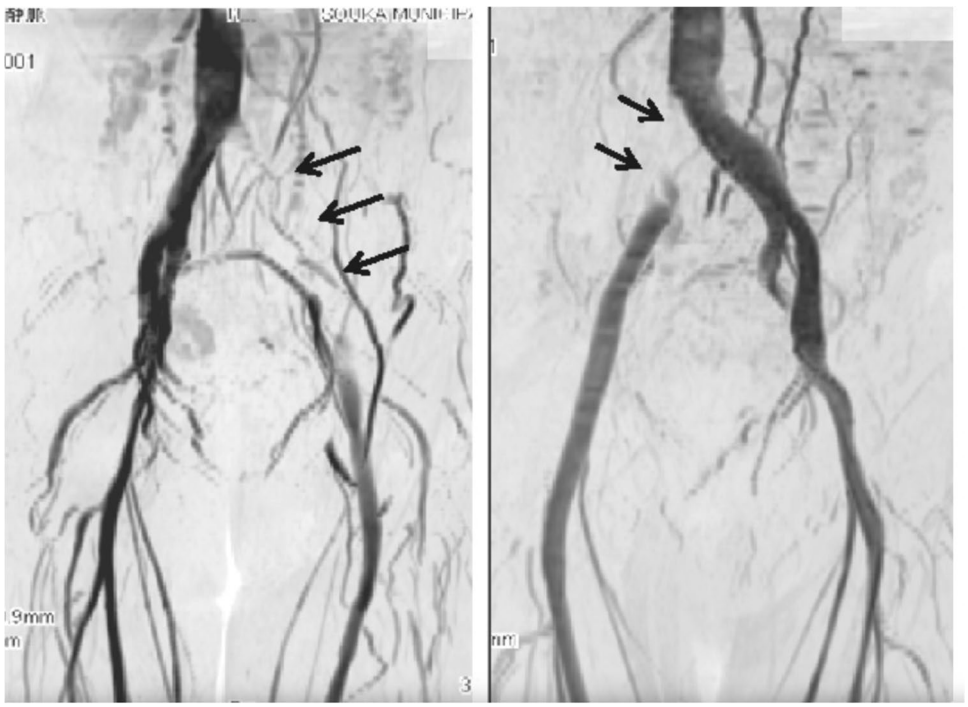

Fig. 2 Example of MRV Image demonstrating DVT of the left common iliac vein (left image) and the right common iliac vein (right image). [Obtained from Tamura K et al. MR Venography for the Assessment of Deep Vein Thrombosis in Lower Extremities with Varicose Veins. *Ann Vasc Dis*. 2014;7(4):399-403]

and efficacy of using DOACs in VTE prophylaxis for PAF patients [12, 20].

(4) Caution needs to be exercised before the elaborate use of IVCFs for patients with PAFs. Two studies confirmed its benefit [8, 37] and one declined it [36].

Our review provided a broad presentation of the available literature on VTE in patients with PAFs. Limitations included level of evidence of the studies included (level II and below) and the absence of meta-analysis due to the heterogeneity of the studies.

High-level studies are still required to provide the best practice guidelines on VTE prophylaxis in patients with pelvic and acetabular fractures.

Author contribution All authors contributed to the study conception and design. Material collection and analysis were performed by Samer SS Mahmoud. The first draft of the manuscript was written by the same author. All authors commented on subsequent versions of the manuscript. All authors read and approved the final manuscript."

Data availability All extracted data used for this work was included in the submitted manuscript

Declarations

Ethics approval Not applicable

Consent to participate Not applicable

Consent for publication Not applicable

Competing interests The authors declare no competing interests.

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