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ORIGINAL PAPER

Prophylactic inferior vena cava filters for operative pelvic fractures: a twelve year experience

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Abstract

Introduction Conflicting evidence exists regarding the role of inferior vena cava filters (IVCFs) in the prevention of pulmonary embolism. The aim of this study was to review an institutional policy of prophylactic IVCF placement in all operative pelvic and acetabular fractures as a means of preventing PE by comparing it to a historical prepolicy period of significantly less aggressive IVCF placement.

Methods The trauma registry of a single level 1 trauma center was retrospectively queried for all pelvic or acetabular fractures for the prepolicy and intervention periods as defined as January 2003–December 2008 and January 2009–December 2014, respectively—yielding 231 patients for analysis. The primary and secondary outcomes measured were the incidence of PE and deep vein thrombosis.

Results The rate of prophylactic IVCF insertion significantly increased during the study period ($p < 0.001$). The incidence of pulmonary embolism (1.8% vs. 5.1%, $p = 0.351$) and DVT (19.3% vs. 10.3%, $p = 0.231$) were not significantly different when comparing the prepolicy and intervention cohorts. In patients with operative fractures, a nonsignificant trend of increasing incidence of DVTs was appreciated in patients with a prophylactic IVCF versus those without prophylactic IVCF (13 vs. 2, $p = 0.222$).

Discussion A policy of increased use of prophylactic IVCFs in patients with operative pelvic and acetabular fractures failed to reduce the incidence of PE or DVT. In contrast, several case reports and institutional series have published several risks associated with IVCF placement including failure to retrieve temporary IVCF.

Conclusion The benefit of prophylactic IVCF in this patient population is unclear.

Keywords Inferior vena cava filter · Pelvic fracture · Deep venous thrombosis · Pulmonary embolism

Introduction

Patients who sustain fractures of the pelvis or acetabulum are at increased risk of deep venous thrombosis (DVT) and/or pulmonary embolism (PE) [1, 2]. Estimates of the incidence of DVT after pelvic trauma range from 35 to 61% [3] while the risk of PE is anywhere between 2 and 10% [4]. The pathophysiology behind this increased risk may be related to disruption of the pelvic vasculature at the time of the trauma, manipulation of the vasculature during subsequent operative

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fixation or secondary to the prolonged period of immobilization required thereafter [5].

For these reasons, inferior vena cava filters (IVCFs) have been suggested for use as prophylaxis against PE, particularly in patients where chemical thromboprophylaxis is contraindicated [6]. Nationwide, IVCF use had increased in the 1990s and 2000s [7, 8]. Several studies published in this same period demonstrated significant reductions in pulmonary emboli in trauma patients through the use of prophylactic IVCFs [9–13]. In 2002, the Eastern Association for the Surgery of Trauma (EAST) recommended consideration of IVCFs for PE prophylaxis in high-risk trauma patients [14].

However, more recently in 2012, the American College of Chest Physicians (ACCP) recommended against the use of IVCFs as prevention of PE in operative orthopaedic trauma patients [15]. Additionally, as recently as 2015, a statewide database review over a four year period concluded that "high rates of prophylactic [IVCF use had] no effect on reducing trauma patient mortality" [16]. Cherry et al. also failed to show a reduction in PE's in 244 patients who met EAST inclusion criteria for prophylactic IVCF placement [17]. Based on the available data in the 1990s and early 2000s as mentioned above, our institution practiced a very aggressive policy of placing IVCFs in operative pelvic and acetabular fractures to prevent PE. Given the high risk for PE and DVT, specifically in operative pelvic and acetabular fractures, our policy involved placing pre-operative prophylactic IVCFs in those fractures indicated for operative fixation. As conflicting data has begun to emerge challenging the efficacy and safety of prophylactic IVCFs, we wanted to examine our institutional experience. This study investigates whether prophylactic IVCFs are beneficial as a means of prophylaxis in patients with operative pelvic and acetabular fractures. We hypothesized that our aggressive use of prophylactic IVCFs had not decreased or changed the rate of PE. We secondarily hypothesized that prophylactic IVCF use resulted in an increase in the DVT rate of among operative pelvic and acetabular fractures.

Patients and Methods

Towards the end of 2008, our institution began an aggressive policy of placing prophylactic preoperative IVCFs in all operative pelvic and acetabular fractures. Operative fractures were targeted based on the assumption that these patients would have more interruptions in their DVT and PE chemoprophylaxis as compared to non-operative fractures and thus would be at a higher risk for DVT and PE. The prepolicy period and the intervention period were defined between January 2003–December 2008 and January 2009–December 2014, respectively. January 2009 was chosen as the beginning of the intervention period since our institutional policy was fully and consistently implemented by that date. Patients in the prepolicy cohort had IVCFs placed at the discretion of the trauma surgery team on a case-by-case basis. In contrast, during the policy or intervention period, the goal was to place IVCFs pre-operatively in all pelvic and acetabular fractures indicated for operative fixation. Per institutional policy, patients were identified as candidates for prophylactic IVCF at two points during their care. First, if a patient with a pelvic fracture was indicated for intrapelvic embolization by interventional radiology (IR), an IVCF filter was placed at that time. Secondly, if the orthopedic surgery team indicated the patient for operative management of their pelvic or acetabulum fracture, a consult to IR was placed for placement of a prophylactic IVCF prior to internal fixation. Due to the retrospective nature of the study, the authors were not able to determine why patients who would otherwise have been indicated for prophylactic IVCF were not selected.

All patients received prophylactic anticoagulation with either low molecular weight heparin or unfractionated heparin unless contraindicated. Contraindications included intracranial haemorrhage, spinal column fracture, or spinal cord injury. In those cases, prophylaxis was held for 72 h and required neurosurgical clearance prior to initiation. For cases of intracranial hemorrhage, a second CT was typically obtained within that period to confirm that there was no evolution of the haemorrhage. These policies remained constant throughout the study period and did not vary.

After obtaining Institutional Review Board approval, the trauma registry was queried for all pelvic and acetabular fractures from 2003 to 2014. Patients with avulsion injuries, those misdiagnosed based on initial imaging and patients who died within 24 hours of presentation either in the trauma bay or in the operating suite were excluded from the study. Demographic data (age, sex), disposition, length of stay (LOS), injury severity score (ISS), admission Glasgow Coma Score (GCS), and in-hospital complications (excluding DVT and PE) were collected directly from the trauma registry. Data on DVT, PE, surgical versus nonsurgical management, and radiographic screening for thromboembolism were collected via chart review. The primary study outcome evaluated was a comparison of the incidence of PE between the prepolicy and intervention periods. Secondary outcomes included the incidence of DVT and time to initiation of chemical DVT prophylaxis.

Prophylactic filters were defined as an IVCF placed before the diagnosis of DVT or PE irrespective of other clinical variables. Therapeutic filters included all filters placed after the diagnosis of DVT or PE. All IVCFs, including therapeutic and prophylactic, were place by the interventional radiology department via the jugular or femoral route. Before filter placement, an inferior vena cavogram was performed to determine the presence of thrombus in the inferior vena cava. Regarding screening and diagnosis of DVT, lower-extremity duplex ultrasound was employed for all cases except in one instance where magnetic resonance venography was utilized.

Table 1 Patient characteristics and demographic information

Patient Characteristics	
Total, *N*	231
Age, median [IQR]	49 [31.0–65.3]
Sex	
Male	134 (58.0%)
Female	97 (42.0%)
ISS, median [IQR]	9 [4.0–17.0]
TBI	25 (10.8%)
Spinal injury	17 (7.4%)
TBI and spinal injury	2 (0.9%)
Long bone fracture	42 (18.18%)
Received chemical prophylaxis	213 (92.2%)
Time from admission to chemical DVT prophylaxis (days), median [IQR]	2 [1.0–4.0]
Early (< 72 h from admission) prophylaxis	159 [65.2%]
Operative management	96 [39.3%]
Time from admission to pelvic or acetabular surgery (days), median [IQR]	5 [3.0–6.0]
Deep vein thrombosis	25 (10.8%)
Occurred in inpatient rehab	6 (24%)
DVT on readmission within 30 days of initial discharge	2 (8%)
Pulmonary embolism, total	6 (2.6%)
Fatal pulmonary embolism	0 (0.0%)
Pulmonary embolism on readmission within 30 days of initial DC	1 (16.7%)
Time to DVT (days), median [IQR]	8.5 [5.0–16.0]
Time to PE (days), median [IQR]	5.5 [2.8–8.3]
Distal DVT	6 (2.6%)
Proximal DVT	19 (8.2%)
Prophylactic IVCF placed	98 [42.4]
Therapeutic IVCF placed	8 [3.5]
Days to IVCF placement (days), median [IQR]	2.0 [1.0–4.0]
Complications	
Pneumonia	15 (6.5%)
Sepsis	4 (1.7%)
Deep surgical site infection	1 (0.4%)
ARDS	3 (1.3%)
Urinary tract infection	1 (0.4%)
Acute kidney injury	4 (1.7%)
Mortality	8 (3.5%)
LOS (days), median [IQR]	11 [6.0–19.3]
DVT screening	
Patients screened for DVT	118 [51.1%]
Of those screened, time to first screening (days), median [IQR]	5.0 [3.0–9.3]
Number of screenings per hospitalization/inpatient rehab stay, mean [SD]	1.0 [± 1.2]
Of those who had DVT, what was the average time to first screening, mean [SD]	6.4 [± 5.8]

Pulmonary emboli were diagnosed using CT angiograms of the chest.

Demographic data are presented in raw numbers and percentages. All continuous data with a normal distribution were analyzed with Student's *t* test, whereas non-normally distributed data were evaluated using Mann-Whitney test. A Pearson's chi square or Fisher's exact test was used to compare all categorical data. All *p* values are two tailed and a $p < 0.05$ was considered significant. All data were analyzed using IBM SPSS, version 21.0 (Armonk, NY).

Results

Between 2003 and 2014, a total of 231 patients with operative and nonoperative pelvic and/or acetabular fractures who met the inclusion criteria were treated at our centre. Demographic characteristics are summarized in Table 1. The study group was 58% male with a median age of 49 and median ISS of 9 (Table 1). A total of six, nonfatal, PEs and 25 DVTs occurred, representing 2.6% and 10.8% of the entire cohort, respectively (Table 1). Of the DVTs, all were in the lower extremities with nineteen occurring in the proximal vasculature and six distally.

Figure 1 illustrates the breakdown of patients based on the date of admission. Ninety-six and 135 patients were admitted during the prepolicy and intervention years, respectively. Within the prepolicy cohort, 21 of the 39 patients with operative fractures were treated with a prophylactic IVCF as compared to 50 of the 57 cases in the intervention cohort (Fig. 1). This difference represented a significant ($p < 0.001$) increase in the frequency of prophylactic IVCFs placed during the

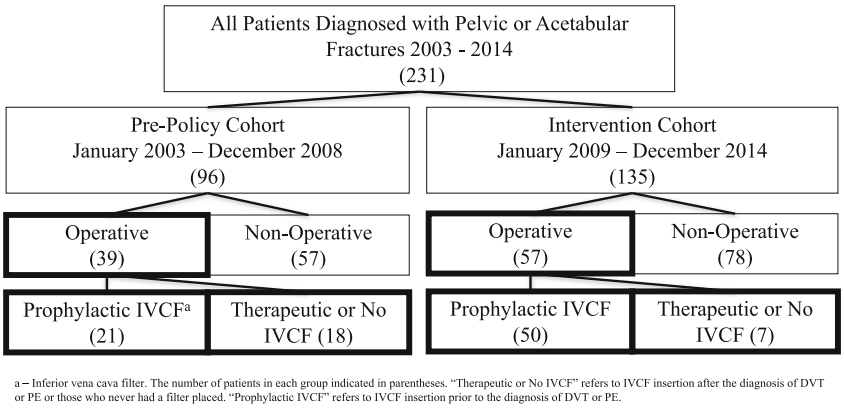

Fig. 1 Schematic breakdown of patients included in the study

a – Inferior vena cava filter. The number of patients in each group indicated in parentheses. "Therapeutic or No IVCF" refers to IVCF insertion after the diagnosis of DVT or PE or those who never had a filter placed. "Prophylactic IVCF" refers to IVCF insertion prior to the diagnosis of DVT or PE.

study period (Table 2). The retrieval rate of prophylactic IVCF placed in patients with both operative and nonoperative fractures was 19.3% (Table 2). A total of four complications were observed during placement and retrieval of the IVCF. In two instances, the IVCF was malpositioned on initial placement and had to be corrected during the same procedure. In two other cases, temporary IVCFs were unable to be retrieved as they had become embedded in the wall of the vena cava and were therefore deemed permanent.

In comparing the prepolicy and intervention cohorts of operative fractures (Table 3), a slightly but statistically significant higher median ISS score was observed during the intervention period (10 vs. 9, $p = 0.034$). However, no statistical difference in the rates of cranial ($p = 0.259$), spinal ($p = 0.259$), and long bone ($p = 0.085$) injuries between the two periods was appreciated. The increased frequency of prophylactic IVCF placement did not produce a significant difference in the incidence of pulmonary embolism (2 vs. 1, $p = 0.351$) or DVT (4 vs. 11, $p = 0.231$) between the prepolicy and intervention cohorts, respectively.

In an attempt to elucidate the overall impact of IVCFs, patients with operative pelvic or acetabular fractures were compared across the entire study period. Patients were grouped depending on whether they received a prophylactic IVCF or not (Table 4). The rate of PE was not significantly different between the two groups (2 vs. 1, $p = 0.770$). A nonstatistically significant trend towards increased DVT in those patients who received a prophylactic IVCF as compared to those who did not was observed (13 vs. 2, $p = 0.222$). Lastly, patients who received prophylactic IVCF had a significant delay in initiation of chemoprophylaxis (3.63 days vs. 1.96 days, $p = 0.021$).

Table 2 Annual rate of prophylactic IVCF insertion in operative and non-operative cases

Year	Prophylactic IVCF placement
2003	11.10%
2004	6.30%
2005	31.60%
2006	30.40%
2007	30.80%
2008	50.00%
2009	57.10%
2010	62.50%
2011	61.90%
2012	55.20%
2013	47.10%
2014	38.10%
Overall retrieval Rate of IVCF: 19/98 (19.3%)	

IVCF inferior vena cava filter

Discussion

This study demonstrated that an aggressive policy of placing prophylactic IVCFs in operative pelvic and acetabular fractures failed to significantly reduce the rate of PE. We were able to demonstrate a significant increase in the rate of prophylactic IVCF in the intervention cohort as compared to the prepolicy cohort. Although not statistically significant, a trend towards a higher incidence of DVTs in patients with prophylactic IVCFs was observed.

While this study's conclusions are consistent with other studies which have determined that increased prophylactic IVCF placement does not produce a decrease in the incidence of pulmonary embolism [17, 20, 23], the existing literature remains inconclusive on definitive indications for prophylactic IVCF placement in trauma. While not evaluated directly in our study, others have shown a failure of prophylactic IVCFs to impact mortality in trauma patients [16, 24]. Unfortunately, to our knowledge, no randomized control study evaluating the effectiveness of prophylactic IVCF has ever been completed—although one small pilot study did conclude that such a study would be feasible [22]. Webb et al. published one of the few studies evaluating

Table 3 Comparison of patients with operative pelvic or acetabular fractures pre- and post institutional policy change

Variable	2003–2008	2009–2014	*p* value
Total operative pelvic and acetabular fractures	39 [40.6%]	57 [59.4%]	
Prophylactic IVCF placement	21 [53.8%]	50 [87.7%]	< 0.001
PE rate	2 [5.1%]	1 [1.8%]	0.351
Patients with prophylactic IVCF	1 [2.5%]	1 [1.8%]	0.520
DVT rate	4 [10.3%]	11 [19.3%]	0.231
Patients with prophylactic IVCF	3 [7.7%]	10 [17.5%]	0.741
Median ISS [IQR]	9 [4–13]	10 [5–22]	0.034
Traumatic brain injury	4 [10.3%]	2 [3.5%]	0.259
Spinal column injury	2 [5.1%]	4 [7.0%]	0.259
Long bone fracture	5 [12.8%]	16 [28.1%]	0.085
Time from admission to chemical DVT prophylaxis	3.15 [3.66]	3.23 [2.76]	0.910
Early initiation (< 3 days from admission) of chemical DVT prophylaxis	29 [74.4%]	37 [64.9%]	0.327

IVCF inferior vena cava filter, *PE* pulmonary embolism, *DVT* deep vein thrombosis, *ISS* injury severity score

prophylactic IVCF use specific to pelvic trauma. In this series, a lower incidence of PE was found in the filter group [12], directly at odds with this study's conclusions. However, one should note that the Webb study was published almost 25 years before this study. In sum, while the literature seems to be moving away from prophylactic IVCF as a general intervention for high-risk trauma patients, when to actually use them has yet to be defined clearly.

While significant disagreement may exist on the effectiveness of IVCF as prophylaxis against PE, the association between IVCF and an increased risk of DVT is more strongly supported [21, 23, 25]. In particular, prophylactic IVCFs are associated with a nearly twofold increase in the risk of developing subsequent DVT [16]. Thrombosis related to insertion of the IVCF is an uncommon but described complication and further increases the risk [18]. Although many authors have published on the link between IVCF and DVT, the anatomic location of the DVT (proximal versus distal) is seldom disclosed. This site distinction is important as the treatment algorithm differs based on the location of the DVT. In our series, 19 proximal and six distal DVTs were diagnosed (Table 1).

Table 5 summarizes the published rates of DVT and PE in patients with prophylactic IVCF based on the authors' review of the literature.

The risk of DVT related to IVCF insertion is further increased when one considers the consistently low rates of removal of these filters once patients have recovered from their traumatic insults. Removal rates as low as 8.5% have been reported [26], with other authors reporting rates as high as 58.6% [17]. Our retrieval rate of 19.3% was dismal but within the range of other published results. As more time passes from initial placement to attempted removal, IVCF become increasingly more difficult to retrieve and are sometimes declared permanent [17]. This phenomenon was observed in two patients in this cohort. The PREPIC trial studied the safety and efficacy of permanent IVCF randomly placed in patients at risk for PE. They demonstrated both at two and eight years of follow-up that those assigned to the filter group suffered from recurrent DVTs not seen in the nonfilter group [27, 28].

Table 4 Comparison of patients with operative pelvic or acetabular fractures, all years (2003–2014)

Variable	Prophylactic IVCF	No Prophylactic IVCF	*p* value
Total	71 [74.0%]	25 [26.0%]	
PE rate	2 [2.8%]	1 [4.0%]	0.770
DVT rate	13 [18.3%]	2 [8.0%]	0.222
Median ISS [IQR]	10 [4–20]	9 [4–13]	0.161
Traumatic brain injury	5 [7.0%]	1 [4.0%]	0.675
Spinal column injury	4 [5.6%]	2 [8.0%]	0.675
Long bone fracture	19 [26.8%]	2 [8.0%]	0.055
Time from admission to chemical DVT prophylaxis	3.63 [3.39]	1.96 [1.81]	0.021
Early initiation (< 3 days from admission) of chemical DVT prophylaxis	43 [60.6%]	23 [92.0%]	0.002

IVCF inferior vena cava filter, *PE* pulmonary embolism, *DVT* deep vein thrombosis, *ISS* injury severity score

Table 5 Rates of DVT and PE published in trauma patients with prophylactic IVCF

Author	Year	Number of patients with IVCF	Prophylactic Versus Therapeutic IVCF	ISS	DVT	PE	Notes
Webb et al. [12]	1992	24	Prophylactic	Not disclosed	Not disclosed	0% (0)	Three patients with mild lower-extremity edema, one with phlegma cerulea dolens
Rogers et al. [10]	1993	34	Prophylactic	28.9 ± 1.5	17.6% (6)	0% (0)	
Khansarinia et al. [11]	1995	108	Prophylactic	28.0 ± 1.0	9% (10)	0% (0)	Two patients with IVCF complications
Rogers et al. [18]	1995	60	Prophylactic	Not disclosed	30% (19)	1.5% (1)	
Rogers et al. [19]	1997	35	Prophylactic	22.8 ± 8.6	Not disclosed	2.85% (1 patient)	Two patients with insertion site thrombosis, one patient with a tilted filter
Gosin et al. [9]	1997	99	Prophylactic	23.4	Not disclosed	0% (0)	
McMurtry et al. [20]	1999	248	Prophylactic	23.1 ± 13.5	2.41% (6)	1.61% (4)	Two patients with misplaced IVCF
Langan et al. [13]	1999	187	Prophylactic	26.1	12.8% (24)	0.5% (1)	Three filter related complications
Carlin et al. [6]	2022	78	Prophylactic	23.1 ± 11	6.4% (5)	0% (0)	
Cherry et al. [17]	2008	244	Prophylactic	26.7 ± 12.8	9.0% (22)	1.6% (4)	Five filter related complications
Gorman et al. [21]	2009	54	Prophylactic	Not disclosed	20.4% (11 patients)	1.85% (1 patient)	
Rajasekhar et al. [22]	2011	18	Prophylactic	26.6 ± 15.7	5.56% (1)	0% (0)	
Hemmila et al. [16]	2015	803	Prophylactic	5–15 (28.1%), 16–24 (27.8%), 25–35 (30.6%), > 35 (13.5%)	6.72% (54)	1.12% (9)	

Other complications of IVCF include the following: thrombosis at the insertion site [11, 18], initial misplacement of the IVCF [20], failure or inability to remove the IVCFs [17, 26], thrombosis at the IVCF or the distal veins [20, 29], phlegmasia cerulea dolens [12], and caudal or intracardiac filter migration [11, 30].

Another important unintended consequence of prophylactic IVCFs not often discussed in the literature is the potential for delay in initiation of chemical DVT prophylaxis in patients who have an IVCF in place. Patients with prophylactic IVCF in our study were significantly less likely to begin DVT chemoprophylaxis within 72 hours of admission. Slobegean et al. reviewed the literature regarding DVT and PE prevention in patients with pelvic and acetabular fractures and concluded that early administration of low molecular weight heparin was the only intervention that demonstrated a clear reduction [31]. While others have demonstrated that IVCFs are protective for PE [19], protection is not absolute and PEs can and do occur in the setting of an IVCF [16, 26, 32]. Therefore, chemoprophylaxis should begin as soon as deemed safe regardless of placement of an IVCF.

The authors acknowledge important limitations to this study, and our results should be interpreted with these limitations in mind. First, given the low incidence of PE and DVT our sample size of only 231 cases does make a type II error a possibility. Our study is unpowered to detect small changes in the rate of PE and DVT within our sample group. However, while the statistical significance of our results can be challenged, detecting even a difference of one major PEs is certainly *clinically* significant. Further, the total number of cases reviewed, while relatively small, is on par with previously published studies [17, 23]. Another important limitation involves the retrospective nature of our study, which made it impossible to determine the indications for prophylactic IVCF placement in the prepolicy period. Lastly, as this was a retrospective study, the two cohorts were not matched based on age, medical comorbidities, or ISS. As shown in Table 3, there was a difference in the ISS score between the pre- and postpolicy cohorts. Increased ISS has been shown to be a risk factor for DVT and PE [33].

In conclusion, our study failed to show that a policy of increased use of prophylactic IVCFs in patients with operative pelvic and acetabular fractures lead to a reduction the incidence of PE. While a direct causality cannot be shown, this study additionally demonstrated a trend where more DVTs were diagnosed in patients with prophylactic IVCFs as compared to those without. Furthermore, fewer than one in five filters were successfully removed upon further follow-up of our study group. This research has led to consideration of reversal of our policy of aggressive prophylactic IVCF placement in pelvic and acetabular fractures in need of operative fixation. Likewise, these results should serve as an impetus for similar critical review at other institutions with policies of

aggressive placement of prophylactic IVCFs in operative pelvic and acetabular fractures.

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Compliance with ethical standards

Institutional Review Board approval was obtained from the Albert Einstein College of Medicine prior to conducting the study.

Conflict of interest The authors declare that they have no conflict of interest.

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