Diagn Interv Radiol 2025; DOI: 10.4274/dir.2025.253409

INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

Establishment of an inferior vena cava filter retrieval program: the effect on trauma and non-trauma patient populations

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Received 25 June 2025; revision requested 01 August 2025; accepted 01 September 2025.

Epub: 29.09.2025

Publication date: xx.xx.2025

DOI: 10.4274/dir.2025.253409

PURPOSE

This study aimed to compare the effect of establishing an inferior vena cava filter (IVCF) retrieval program (IVCFRP) on the IVCF retrieval rates in trauma and non-trauma patients.

METHODS

This was an institutional review board-approved retrospective study. IVCF retrieval in trauma and non-trauma patients was compared before and after the establishment of an IVCFRP in a single Level I Trauma Center. The IVCFRP at our institution was established in April 2020. All patients who underwent IVCF placement between January 2016 and March 2020 were compared with patients who had an IVCF placed between April 2020 and June 2024. A medical record review included the collection of demographic information, indication for IVCF insertion and retrieval, date of IVCF insertion and retrieval, IVCF retrieval rate, clinical outcomes, and complications. The patients were stratified into trauma and non-trauma groups. Univariate analyses were performed with a *P* value of <0.05 considered statistically significant.

RESULTS

A total of 164 patients underwent IVCF placement between January 2016 and June 2024. Fifty-two IVCFs were implanted before and 112 after the establishment of the IVCFRP. The overall rate of IVCF retrieval was significantly higher following the establishment of an IVCFRP (33.3% vs. 51%, $P = 0.047$). In non-trauma patients, the retrieval rate was significantly higher after the establishment of an IVCFRP (37.5% vs. 61.3%, $P = 0.03$). The retrieval rate in trauma patients (22.2% vs. 21.4%) was not significantly changed by the establishment of an IVCFRP. Clinical outcomes and complications were similar between groups.

CONCLUSION

IVCF retrieval rates significantly improved after the establishment of an IVCFRP. This increase in IVCF retrieval rate was driven by an increase in filter retrievals in the non-trauma patient population. The rate of IVCF retrieval in trauma patients was not affected by the implementation of an IVCFRP. Special considerations and changes in practice may need to be established to improve IVCF retrieval rates in trauma patients.

CLINICAL SIGNIFICANCE

Implementation of a structured IVCFRP significantly improved retrieval rates in non-trauma patients but did not yield similar results in trauma patients, highlighting the need for alternative strategies in this population.

KEYWORDS

Inferior vena cava filter, trauma, retrieval program, complex retrieval, inferior vena cava filter complication

You may cite this article as: Gill K, Ferral H, Fairchild AH, et al. Establishment of an inferior vena cava filter retrieval program: the effect on trauma and non-trauma patient populations. *Diagn Interv Radiol*. 29 September 2025 DOI: 10.4274/dir.2025.253409 [Epub Ahead of Print].

Venous thromboembolism (VTE), which comprises deep vein thrombosis (DVT) and pulmonary embolism (PE), represents an important morbidity in hospitalized patients.[1] PE secondary to DVT carries a high risk of mortality and remains the third leading cause of death in trauma patients who survive the first day of hospital admission.[2] Inferior vena cava filters (IVCFs) are indicated in patients with VTE or PE who have contraindications to anticoagulation.[3] Trauma patients are at high risk of developing VTE and often have contraindications to anticoagulation secondary to injuries and bleeding complications.[3,4]

Current IVCF guidelines recommend removal of retrievable IVCFs once the filters are no longer indicated.[5] The implementation of structured IVCF follow-up programs has been proven to increase filter retrieval rates and decrease the number of patients lost to follow-up;[6-8] however, this practice concept has not been validated in trauma patients.[9,10] The working hypothesis of this retrospective study was that creation of an IVCF database and establishment of an IVCF retrieval program (IVCFRP) would increase IVCF retrieval rates both in non-trauma and trauma patients. The purpose of this study was to compare IVCF retrieval rates in trauma and non-trauma patients before and after establishing an IVCFRP at a single Level I Trauma Center in the United States.

Methods

Patient population

This is a retrospective, institutional review board-approved, Health Insurance Portability and Accountability Act of 1996-compliant study with a waiver of consent. The study group included patients who underwent IVCF insertion and retrieval by interventional radiology (IR) at a single Level I Trauma Center before and after implementation of an IVCFRP. The IVCFRP was established in April 2020 (Figure 1). This retrospective study was approved by the Louisiana State University Health Sciences Center New Orleans Institutional Review Board (approval: IRB #4222, date: May 29, 2023). The inclusion criteria for this study were as follows: patients aged ≥18 years with IVCFs placed at the University Medical Center New Orleans by the IR service between January 2016 and June 2024. The exclusion criteria were as follows: patients aged <18 years, pregnant women, patients with IVCF not inserted at the institution, or prisoners. Patients who underwent IVCF insertion by other services (e.g., cardiology or vascular surgery) were excluded, as only patients with IVCF placed by the IR service were entered in the database and were part of the IVCFRP. Patients who had IVCF placement at outside institutions and were referred to the center for IVCF retrieval were identified but not included in the analysis. One hundred ninety-six patients who met the study criteria were included in the medical record review.

Main points

- Timely inferior vena cava filter (IVCF) retrieval is necessary to prevent filter complications associated with prolonged dwell time.
- IVCF retrieval programs (IVCFRPs) have been shown to increase IVCF retrieval rates, though this intervention did not significantly increase filter retrieval in trauma patients.
- The implementation of IVCFRPs facilitates referrals for complex filter removals secondary to prolonged filter dwell time.

The electronic records of patients who had IVCF insertion between January 2016 and March 2020 were identified using the SlicerDicer program in the EPIC (version 11.3.0.11, Verona, WI, USA) software platform. The records of the patients who underwent IVCF placement after April 2020 were identified through the IVCFRP database. The collected clinical variables included the following: indication for IVCF insertion and removal, IVCF retrieval rates, IVCF dwell time, IVCF complications [tilting, fractures, filter migration, filter leg penetration through the inferior vena cava (IVC) wall, filter thrombosis]. Other variables included the following: in-hospital mortality, 6-month mortality, hospital length of stay (HLoS), and intensive care unit length of stay (ICULoS).

Filter tilt was defined as the deviation of the cephalon–caudal axis of the IVCF by >30 degrees compared with the IVC axis. Inferior vena cava thrombosis was defined as direct visualization of thrombus during the retrieval cavagram. Inferior vena cava occlusion was defined as the inability to pass a wire caudal to the IVCF during the retrieval procedure. Protrusion of struts was defined as perforation >5 mm past the IVC wall or extension into surrounding structures on computed tomography.

Inferior vena cava filter retrieval program

At the University Medical Center New Orleans, IVCFs are placed by fellowship-trained interventional radiologists in accordance with current guidelines.[5] Following the implementation of IVCFRP in April 2020, details of patients who undergo IVCF insertion at the institution are entered into a database, and the patients are enrolled in a structured IVCF follow-up program. Details of IVCFs inserted by other services are not entered in the IR IVCF database and are not included in the IR IVCF surveillance and follow-up program. At the time of IVCF insertion, patients are scheduled for a visit to the IR clinic to discuss eligibility for filter retrieval. The clinic visit for IVCF removal evaluation is scheduled 8-12 weeks after the date of the IVCF insertion. Patients eligible for filter retrieval are scheduled for the procedure. Patients who

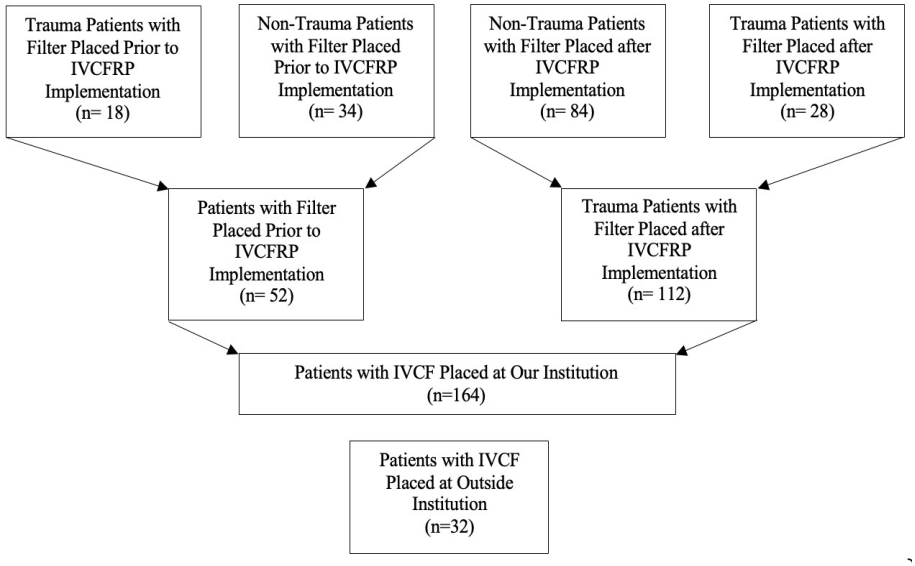

Figure 1. Flowchart of patient inclusion. IVCF, inferior vena cava filter; IVCFRP, inferior vena cava filter retrieval program.

are evaluated and considered ineligible for retrieval enter active surveillance and are scheduled for an IR clinic visit with a kidney, ureter, and bladder X-ray every 6 months to assess for filter complications and reevaluate retrieval eligibility. Patients who do not show up to IR clinic appointments are contacted by phone by the IR service navigators to reschedule a visit. If contact with the patient cannot be established, or the patient does not show up for additional appointments, they are deemed lost to follow-up.

Statistical analysis

Patients were stratified into groups based on their time of presentation (before vs. after IVCFRP implementation) and clinical presentation (trauma vs. non-trauma). In total, four groups were compared: (1) trauma patients before program implementation, (2) non-trauma patients before program implementation, (3) trauma patients after program implementation, and (4) non-trauma patients after program implementation. Patients with IVCF placed between January 2016 and March 2020 were stratified into before-program implementation groups. Patients with IVCF placed between April 2020 and June 2024 were stratified into after-program implementation groups. The IVCF retrieval rates were adjusted for filter retrieval eligibility and intent to retrieve. Patients with permanent filters or filters placed within 6 months of study initiation and patients who died within 6 months of implantation were excluded from the IVCF retrieval analysis. Univariate analysis was performed using Fisher's exact test for categorical variables or Student's t-test for continuous variables. Data were analyzed using IBM SPSS (version 27, Armonk, NY, USA) and GraphPad Prism (version 10.0.0, La Jolla, CA, USA). A *P* value of <0.05 was considered statistically significant.

Results

Inferior vena cava filter indications and complications

One hundred ninety-six patients were included in the study, of whom 164 had an IVCF placed at the institution. The indications for IVCF insertion were as follows: (1) contraindication to anticoagulation due to active bleeding (n = 43, 26.2%), upcoming or recent surgery (n = 30, 18.3%), bleeding disorders (n = 6, 3.7%), unspecified contraindications to anticoagulation (n = 12, 7.3%); (2) massive PE with cor pulmonale and residual DVT (n = 29, 17.7%); (3) failure of anticoagulation (n = 3, 1.8%); (4) prophylactic with no concurrent DVT or PE (n = 4, 2.4%); and (5) non-specified (n = 55, 33.5%). A total of 14 IVCF complications were identified in patients with IVCFs placed at the institution. Identified complications included IVC thrombosis (n = 6, 3.7%), protrusion of struts through the IVC (n = 5, 3%), filter tilting (n = 2, 1.2%), and PE after IVCF insertion (n = 1, 0.6%) (Table 1).

Inferior vena cava filter retrieval before and after program implementation

Before IVCFRP implementation, 52 patients underwent IVCF insertion, and 112 patients had an IVCF placed after implementation of the program. Baseline demographic [age, gender, body mass index (BMI)] and clinical outcomes (mortality, HLoS, ICULoS) were similar between groups ($P > 0.05$). The percentage of patients seen in the IR clinic for filter retrieval significantly increased from before-program implementation to after-program implementation (40.4% vs. 58.9%, $P = 0.03$). Eight (9.5%) patients had a permanent filter placed.

Insertion and retrieval procedure lengths and fluoroscopy times were similar between groups ($P > 0.05$). Patients who had their filter placed after IVCFRP implementation had a significantly longer filter dwell time (142.9 ± 133.4 days) than patients who had their IVCF placed before program implementation (50.1 ± 83.4 days) ($P = 0.002$). The IVCF retrieval rates were adjusted for retrieval eligibility and intent to retrieve. In the group who had filters placed before IVCFRP implementation, 4 (7.7%) patients died within 6 months of filter implantation, leaving 48 patients eligible for filter retrieval. In the group who had filters placed after IVCFRP implementation, 19 (16.9%) of patients died within 6 months, and 8 (7.1%) patients had permanent filters placed, leaving 85 patients eligible for IVCF retrieval. When adjusted for IVCF retrieval eligibility, patients who had IVCFs placed after program implementation had a significantly higher rate of IVCF retrieval (44/85, 51.8%) than patients who had IVCFs placed before program implementation (16/48, 33%) ($P = 0.047$). There was no significant difference in IVCF complications between groups ($P > 0.05$) (Table 2).

Retrieval of inferior vena cava filters in trauma patients

Forty-six trauma patients had an IVCF placed at the institution. Eighteen patients (39.1%) had their filter placed before IVCFRP implementation, and 28 (60.9%) after. The overall average HLoS for trauma patients who had an IVCF implanted was 30.6 ± 23.9 days. Fifty percent (23/46) of trauma patients with IVCFs placed had an HLoS >21 days, and 37% (17/46) had an HLoS >30 days. Baseline demographics (age, gender, BMI), clinical outcomes (mortality, HLoS, ICULoS), and IVCF complications were similar between groups ($P > 0.05$). The percentage of trauma patients seen in the IR clinic for IVCF retrieval evaluation was similar before and after program implementation (38.8% vs. 46.4%, $P = 0.76$). Two patients who had an IVCF placed before the program implementation died within 6 months of IVCF insertion, leaving 16 patients eligible for filter retrieval. Five patients who had an IVCF placed after the program implementation died within 6 months of IVCF insertion, leaving 23 patients eligible for IVCF retrieval. There was no significant difference in the rate of IVCF retrieval in eligible trauma patients who had IVCF placement before IVCFRP implementation (4/16, 25%) or after program implementation (6/23, 26.1%) ($P > 0.05$). The mean IVCF dwell time was 127.8 ± 159.3 days for patients with IVCFs placed before the program initiation and 85.4 ± 46.4 days for patients after the program initiation. Two patients (4.3%) had a failed IVCF retrieval attempt due to complete IVC thrombosis (Table 3).

Retrieval of inferior vena cava filters in non-trauma patients

One hundred eighteen non-trauma patients had an IVCF placed at the institution; 34 patients (28.8%) had an IVCF placed before and 84 patients (71.2%) after the program implementation. There was no significant difference in baseline demographics, clinical outcomes (mortality, HLoS, ICULoS), or IVCF complications between groups ($P > 0.05$). The percentage of patients seen in the IR clinic for IVCF retrieval evaluation significantly increased from before-IVCFRP to after-IVCFRP implementation (41.2% vs. 63.1%, $P = 0.04$). There was no significant difference in IVCF insertion or retrieval procedure length or fluoroscopy time between groups ($P > 0.05$). The mean filter dwell time for non-trauma patients who had an IVCF placed after program implantation (142.9 ± 133.4 days) was significantly longer than those who had an IVCF placed before program implementation (50.1 ± 83.4 days) ($P = 0.0003$). Two non-trauma patients who had an IVCF implanted before the program implementation died within 6 months of the procedure, leaving 32 patients eligible for filter retrieval. Fourteen patients who had an IVCF placed after the retrieval program implementation

Table 1. Indications for inferior vena cava (IVC) filter (IVCF) placement at our institution; IVCF filter complications; IVCF placed at outside institutions and referred for filter retrieval

Indications for IVCF implantation, n (%)	Filters placed at the institution (2016–2024) n = 164
Contraindication to anticoagulation in the setting of current deep vein thrombosis (DVT) and/or pulmonary embolism (PE)	91 (55.5)
Active bleeding	43 (26.2)
Gastrointestinal	18 (11.0)
Brain	12 (7.3)
Trauma site	6 (3.7)
Hematuria	2 (1.2)
Other	5 (3.0)
Upcoming/recent surgery	30 (18.3)
Bleeding disorder	6 (3.7)
Hemophilia	2 (1.2)
Anemia	2 (1.2)
Thrombocytopenia	1 (0.6)
Non-adherence to anticoagulants	1 (0.6)
Other/non-specified contraindication	12 (7.3)
Massive PE + cor pulmonale with residual DVT	29 (17.7)
Failure of anticoagulation	3 (1.8)
Prophylactic (no current DVT and/or PE)	4 (2.4)
Polytrauma	2 (1.2)
Prior to surgery	2 (1.2)
Other/unknown	37 (22.6)
IVCF complications, n (%)	
Total	14 (8.5)
Thrombosis	6 (3.7)
Protrusion of struts through IVC	5 (3.0)
Tilting	2 (1.2)
PE after IVCF insertion	1 (0.6)
Patients referred for IVCF retrieval, n (%)	Filters placed at outside institutions n = 32
Filters retrieved	17 (53.1)
Failed retrieval	2 (6.3)
Average dwell time, mean days (SD)	2,928.4 (2,915.5)
Retrieval not attempted	13 (40.6)
Never seen in clinic	5 (15.6)
Patient refused retrieval	3 (9.4)
No show for procedure	2 (6.3)
Deemed not eligible for retrieval	2 (6.3)
Filter deemed stable	1 (3.1)
IVCF complication	41
Protrusion of struts through IVC wall	10 (31.2)
Extension of struts into other structures	6 (18.8)
Duodenum	4 (12.5)
Other	4 (12.5)
Filter tilt with tip embedded in lumen	6 (18.8)
Filter fracture	6 (18.8)
	5 (15.6)
	1 (3.1)
	1 (3.1)
Filters with multiple complications	8 (25)

died within 6 months, and 8 patients had a permanent IVCF placed, leaving 62 patients eligible for IVCF retrieval. When adjusted for filter retrieval eligibility, non-trauma patients who had an IVCF placed after retrieval program implementation had a significantly higher rate of IVCF retrieval (38/62, 61.3%) than patients who had an IVCF placed before the program implementation (12/32, 37.5%) ($P = 0.03$). There was no significant difference in IVCF complications between groups ($P > 0.05$) (Table 4).

Filters placed at outside institutions

Thirty-two patients had their filters placed at an outside institution and were referred for IVCF retrieval. A total of 17 IVCF filters placed at outside institutions were retrieved at the University Medical Center New Orleans after the implementation of an IVCFRP. One patient had an IVCF removed surgically due to erosion of the filter into the right renal vein; the remaining 16 patients had their IVCFs removed using advanced endovascular techniques. Removal of the IVCF was unsuccessful in 2 (6.3%) patients. One patient had a failed IVCF retrieval attempt at another institution.

Table 2. Comparison of inferior vena cava (IVC) filter (IVCF) retrieval before and after the implementation of an IVCF retrieval program

	Before (n = 52)	After (n = 112)	*P* value
Demographics			
Age, mean years (SD)	53.4 (16.2)	56.1 (16.6)	0.33
Male, n (%)	35 (67.3)	63 (56.3)	0.23
Body mass index, mean (SD)	30.7 (11.5)	29 (9.3)	0.31
Clinical outcomes			
In-hospital mortality, n (%)	4 (7.7)	16 (14.3)	0.31
Mortality within 6 months, n (%)	4 (7.7)	19 (16.9)	0.15
Hospital length of stay (LoS), mean days (SD)	19.2 (16.5)	27.6 (39.7)	0.14
Intensive care unit LoS, mean days (SD)	7.6 (12.6)	11.4 (24.2)	0.29
Interventional radiology clinic follow-up, n (%)	21 (40.4)	66 (58.9)	0.03
Procedural information			
Insertion procedure length, mean mins (SD)	24.9 (10.1)	28.9 (18.3)	0.14
Insertion fluoroscopy, mean mins (SD)	2.2 (1.9)	3.5 (5)	0.07
Permanent filters placed, n (%)	0	8 (7.1)	0.06
Time from insertion to removal, mean days (SD)	69.5 (106.9)	131.5 (124.2)	0.002
Removal procedure length, mean mins (SD)	29.6 (15.1)	28.1 (7.9)	0.4
Removal fluoroscopy, mean mins (SD)	5.4 (6.5)	4.8 (1.6)	0.36
IVCF retrieval, n (%)	16 (30.8)	44 (39.3)	0.27
Adjusted IVCF retrieval, n (%)	16 (33.3)	44 (51.8)	0.047
Failure of IVCF retrieval, n (%)	0	2 (1.8)	1
IVCF complications, n (%)			
Total	3 (5.8)	11 (9.8)	0.55
Thrombosis	2 (3.8)	4 (3.6)	1
Protrusion of struts through IVC	1 (1.9)	4 (3.6)	1
Tilting	0	2 (1.8)	1
Pulmonary embolism after IVCF insertion	0	1 (0.9)	1

SD, standard deviation.

One patient was discovered to have a fractured filter that was embedded in a chronic clot that could not be removed, and the procedure was aborted. The average dwell time of IVCFs placed at outside institutions was 2,928.4 ± 2,915.5 days (8 years). IVCF retrieval was not attempted in 13 (40.6%) patients referred for retrieval for the following reasons: 5 (15.6%) patients did not show up for the initial appointment and were never evaluated in clinic, 3 (9.4%) patients refused IVCF retrieval, 2 (6.3%) patients did not show up for a scheduled retrieval, 2 (6.3%) patients were deemed not eligible for retrieval, and 1 (3.1%) filter was deemed stable at the time of evaluation and the risk of filter removal was deemed to be higher than the clinical benefit.

A total of 41 IVCF complications were identified in patients with IVCFs placed at outside institutions. Eight (25%) patients had multiple filter complications identified. Complications included protrusion of struts through the IVC wall (n = 10, 31.2%), extension of struts into other structures (n = 6, 18.8%), filter tilt with the tip embedded in the IVC lumen (n = 6, 18.8%), filter fracture (n = 6, 18.8%), IVC thrombosis (n = 5, 15.6%), filter migration to the right common iliac vein (n = 1, 3.1%), and filter collapse within the IVC (n = 1, 3.1%). Surrounding structures affected by protruded struts included the duodenum, right renal vein, right spermatic artery, L3 lumbar artery, and lumbar vertebral body (Table 1).

Discussion

An IVCFRP was implemented at the institution in April of 2020. The goal of this study was to assess the effect of an IVCFRP on the retrieval rate in trauma and non-trauma patients. We hypothesized that the establishment of an IVCFRP would increase IVCF retrieval rates in both trauma and non-trauma patients. This study showed that implementation of the IVCFRP was effective in the non-trauma population, increasing the rate of follow-up and IVCF retrieval. The percentage of non-trauma patients seen in the IR clinic for IVCF retrieval evaluation increased significantly from 41.2% to 63.1% after the IVCFRP implementation. The adjusted IVCF retrieval rates increased significantly from 37.5% to 61.3%. Nationally, the rate of IVCF retrieval is estimated to be as low as 12%–18%.[11] With the implementation of structured follow-up programs, the rate of IVCF retrieval has been noted to increase to 28.3%–72.9%, with retrieval rates as high as 92.5% observed at select institutions.[6,7,12,13] This increase in retrieval rates after the establishment of a dedicated retrieval program is consistent with the findings of our study.

This study showed that the establishment of an IVCFRP did not increase the filter retrieval rates in trauma patients. The IVCF retrieval rate in trauma patients was 22.2% before and 21.4% after the program implementation. A commonly reported problem

Table 3. Comparison of inferior vena cava (IVC) filter (IVCF) retrieval in trauma patients before and after IVCF retrieval program implementation

	Before (n = 18)	After (n = 28)	*P* value
Demographics			
Age, mean years (SD)	45.8 (15.2)	44.6 (17.3)	0.67
Male, n (%)	16 (88.9)	22 (78.6)	0.45
Body mass index, mean (SD)	26.9 (4.3)	26 (5)	0.26
Clinical outcomes			
In-hospital mortality, n (%)	2 (11.1)	5 (17.9)	0.69
Mortality within 6 months, n (%)	2 (11.1)	5 (17.9)	0.69
Hospital length of stay (LoS), mean days (SD)	24.2 (14.8)	36.2 (63.9)	0.18
Intensive care unit LoS, mean days (SD)	12.6 (13)	15.3 (14)	0.24
IR clinic follow-up, n (%)	7 (38.8)	13 (46.4)	0.76
Procedural information			
Insertion procedure length, mean mins (SD)	25.9 (8.9)	27.1 (10.1)	0.46
Insertion fluoroscopy, mean mins (SD)	2 (0.9)	2.3 (1.4)	0.16
Permanent filters placed, n (%)	0	0	1
Time from insertion to removal, mean days (SD)	127.8 (159.3)	85.4 (46.4)	0.22
Removal procedure length, mean mins (SD)	41.5 (24.8)	39.3 (13.9)	0.47
Removal fluoroscopy, mean mins (SD)	9.2 (8.6)	7.9 (3.6)	0.17
IVCF retrieval, n (%)	4 (22.2)	6 (21.4)	1
Adjusted IVCF retrieval, n (%)	4 (25)	6 (26.1)	1
Failure of IVCF retrieval, n (%)	0	2 (7.14)	0.51
IVCF complications, n (%)			
Total	0	4 (14.3)	0.14
Thrombosis	0	3 (10.7)	0.27
Protrusion of struts through IVC	0	0	1
Tilting	0	0	1
Pulmonary embolism after IVCF insertion	0	1 (3.6)	1

SD, standard deviation.

in the trauma patient population from other similar Level 1 Trauma Centers is the low compliance with follow-up appointments, which is consistent with the results of our study.[9,10] The results of this study suggest that attempting to improve IVCF retrieval rates by increasing adherence to follow-up appointments may not be an effective solution for this patient population. The retrieval of IVCFs with prolonged dwell times is more difficult, typically requiring advanced retrieval techniques and possibly leading to retrieval-related complications.[14,15] For this reason, timely filter retrieval is necessary to reduce the risk of filter-related complications associated with prolonged dwell time.[5]

The findings of this study emphasize the need for increased focus on improving the rate of IVCF retrieval in trauma patients.[3,4,16,17] The use of IVCFs in trauma patients has been investigated and documented in the literature in recent years.[18-21] Considerable focus has been placed on the efficacy of and indications for IVCF implantation in trauma patients, ultimately resulting in recent guideline changes.[5] However, this fixation on the indications for IVCF implantation in trauma patients has not been met with a similar focus on ensuring that implanted IVCFs are retrieved. As current guidelines regarding IVCF use in trauma patients evolve, measures to improve retrieval rates in this patient population should be included. One proposed strategy to increase the rate of IVCF retrieval has been the removal of filters before patient discharge.[22] In our study, 50% (23/46) of trauma patients with IVCFs placed had a HLoS >21 days, and 37% (17/46) had a HLoS >30 days. For trauma patients with prolonged lengths of stay, it may be possible to retrieve IVCFs before discharge as long as the patients no longer have contraindications to anticoagulation. This intervention could be an effective way to improve IVCF retrieval rates in trauma patients without the need for increased follow-up visits. The premature retrieval of IVCFs may increase the risk of complications from thromboembolic events;[23,24] however, our study did not identify any subsequent PEs following IVCF retrieval. An additional strategy cited as having an 86.9% retrieval rate in trauma patients was a reduction in the number of IVCFs placed in trauma patients combined with the use of a dedicated trauma nurse practitioner or physician's associate to ensure strict patient follow-up.[17,25]

This study showed an overall complication rate of 12.2%, which is consistent with the reported 10%–22.2% complication rate.[26-29] The incidence of IVC thrombosis was significantly higher in the trauma population; this complication, in particular, has been associated with prolonged dwell times, as the risk-to-benefit ratio becomes less favorable.[4] To reduce the risk of filter-related complications associated with prolonged dwell times and improve patient outcomes, timely IVCF retrieval in trauma patients is necessary.

Table 4. Comparison of inferior vena cava (IVC) filter (IVCF) retrieval in non-trauma patients before and after IVCF retrieval program implementation

	Before (n = 34)	After (n = 84)	*P* value
Demographics			
Age, mean years (SD)	57.4 (15.5)	59.9 (14.6)	0.32
Male, n (%)	19 (6.3)	40 (47.6)	0.54
Body mass index, mean (SD)	32.7 (13.6)	29.7 (10.2)	0.12
Clinical outcomes			
In-hospital mortality, n (%)	2 (5.9)	11 (13.1)	0.34
Mortality within 6 months, n (%)	2 (5.9)	14 (16.7)	0.15
Hospital length of stay (LoS), mean days (SD)	17.3 (17)	24.9 (42.6)	0.22
Intensive care unit LoS, mean days (SD)	5.4 (12.2)	9.1 (26.2)	0.33
IR clinic follow-up, n (%)	14 (41.2)	53 (63.1)	0.04
Procedural information			
Insertion procedure length, mean mins (SD)	25.1 (10.7)	29.5 (20.2)	0.14
Insertion fluoroscopy, mean mins (SD)	2.5 (2.2)	3.7 (5.4)	0.13
Permanent filters placed, n (%)	0	8 (9.5)	0.10
Time from insertion to removal, mean days (SD)	50.1 (83.4)	142.9 (133.4)	0.0003
Removal procedure length, mean mins (SD)	31.8 (17)	29.4 (8.2)	0.22
Removal fluoroscopy, mean mins (SD)	4.3 (5.3)	3.8 (1.6)	0.36
IVCF retrieval, n (%)	12 (35.3)	38 (45.2)	0.41
Adjusted IVCF retrieval, n (%)	12 (37.5)	38 (61.3)	0.03
Failure of IVCF retrieval, n (%)	0	0	1
IVCF complications, n (%)			
Total	3 (8.8)	7 (8.3)	1
Thrombosis	2 (5.9)	1 (1.2)	0.2
Protrusion of struts through IVC	1 (3.0)	4 (4.8)	1
Tilting	0	2 (2.4)	1
Pulmonary embolism after IVCF insertion	0	0	1

SD, standard deviation.

An interesting collateral finding in this study was that the establishment of an IVCFRP resulted in patient referrals for complex filter retrievals. A total of 32 patients were referred to our center for complex filter retrieval. Retrieval was possible in 53.1% of these patients. The mean indwelling time in this group of patients was approximately 8 years. All retrievals required advanced techniques, as most filters with prolonged dwell times had a filter-associated complication, and many filters were discovered to have multiple complications. The establishment of an IVCFRP may increase the retrieval rates of filters in patients who have been lost to follow-up and experience a complication with the IVCF.[13,30] The limitations of this study are that it is a retrospective, single-center study with a relatively low number of trauma patients who underwent IVCF insertion. In addition, the implementation of the IVCFRP occurred during the coronavirus disease-2019 pandemic, possibly introducing residual confounding that was not adjusted for. The results of this study confirm that there is a need to establish specific filter retrieval guidelines for trauma patients.

In conclusion, this study showed that in our center, the implementation of an IVCFRP improved the overall rate of IVCF retrieval and the rate of IVCF retrieval in non-trauma patients but did not significantly increase the rate of IVCF retrieval in trauma patients. With current guidelines focusing on increasing IVCF retrieval rates through improved patient follow-up, additional strategies may be necessary to increase IVCF retrieval in the trauma population, which has been associated with low follow-up adherence. Practice strategies, including retrieval before discharge or the establishment of a dedicated trauma nurse practitioner, may increase retrieval rates in trauma patients.

Footnotes

Conflict of interest disclosure

A.A. Smith is a paid consultant for Aroa Biosurgery and on the advisory board for Prytime Medical Devices. P Greiffenstein is a paid consultant for Zimmer Biomet and MedExpert. JS is a paid consultant for Polynovo, Avita Medical, Lifesciences Plus, and Livanova. The other authors have no disclosures.

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