Received: 30 March 2022 | Revised: 20 November 2022 | Accepted: 24 November 2022

https://doi.org/10.1016/j.rpth.2023.100040

ORIGINAL ARTICLE

rpth research & practice in thrombosis & haemostasis

Improving the rate of inferior vena cava filter retrieval through multidisciplinary engagement

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Funding information
None.

Handling Editor: Mary Cushman

Abstract

Background: The placement of retrievable inferior vena cava (IVC) filters occurs commonly, but retrieval rates remain low. Consequently, there is an unmet clinical need to ensure appropriate follow-up and retrieval of these devices.

Objectives: To determine the association between an IVC filter surveillance team with filter retrievals or a documented filter plan, time to retrieval, and incidence of filter complications or recurrent venous thromboembolism.

Methods: Ambidirectional cohort study evaluating consecutive IVC filter insertions before and after the implementation of a multidisciplinary surveillance team (MDST). We report an odds ratio (OR) with 95% CIs, adjusted by age, sex, weight, and malignancy status.

Results: Overall, 453 patients were included, with 272 individuals in the pre-MDST cohort and 181 individuals in the post-MDST cohort. The MDST was associated with a higher composite primary outcome of IVC filter retrieval or a documented filter plan from 79.4% in the pre-MDST cohort to 96.1% in the post-MDST cohort (OR, 6.44; 95% CI, 3.06–15.84). Compared with the pre-MDST cohort, IVC filter retrieval rates were higher in the post-MDST cohort (52.6%–73.5%, respectively; (OR, 2.50; 95% CI, 1.67–3.78). The MDST was associated with a shorter median time-to-filter retrieval (187–150 days, hazard ratio, 1.78; 95% CI, 1.39–2.29), but there was no significant difference when comparing symptomatic or clinically significant IVC filter complications, recurrent venous thromboembolism, or mortality.

Conclusion: Our study demonstrates the importance of a structured program to ensure timely IVC filter retrieval and ultimately improve patient care.

KEYWORDS
cohort study, patient care, vena cava filters, venous thromboembolism

Hannah Stevens and Hadley Bortz are considered to be as first authors and contributed equally to this study

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Essentials

- Inferior vena cava filters are inserted to reduce risk of life-threatening venous blood clots.
- The rate of inferior vena cava filter retrievals remains low worldwide.
- In this study, a surveillance team was associated with a higher rate of filter retrievals.
- The surveillance team did not alter the rate of filter complications or recurrent blood clots.

1 | INTRODUCTION

Venous thromboembolism (VTE), encompassing both deep vein thrombosis (DVT) and pulmonary embolism (PE), is a common cause of preventable inpatient hospital mortality [1]. Once VTE is diagnosed, patients are typically treated with anticoagulation [1–3]. However, anticoagulation is contraindicated in several patient cohorts because of a higher risk of bleeding. As a result, patients with contraindications to anticoagulation may require other definitive or adjunct therapies to reduce the risk of acute VTE, including caval interruption techniques such as placement of an inferior vena cava (IVC) filter.

IVC filters were first developed in the late 1960s, with newer, retrievable devices becoming more widely available in the last 2 decades [4]. The role of IVC filters for the prevention and treatment of VTE garnered substantial interest following the publication of the randomized Prévention du Risque d'Embolie Pulmonaire par Interruption Cave (PREPIC) study, which evaluated the use of IVC filters in patients randomized to anticoagulation and IVC filter placement compared with anticoagulation alone for treatment of acute DVT [5]. The authors found a reduced incidence of early PE but a higher risk of recurrent DVT diagnosed within 2 years follow-up [5], with similar findings of lower rates of symptomatic PE but a higher incidence of recurrent DVT at the 8-year follow-up [6]. More recently, the PREPIC2 study found that the placement of an IVC filter in addition to therapeutic anticoagulation did not reduce the occurrence of symptomatic PE, including fatal PE, suggesting that there is no benefit in using an IVC filter if therapeutic anticoagulation is tolerated [7]. Consequently, the classic indication for IVC filter placement is in patients with acute VTE where anticoagulation cannot be either commenced or continued because of the high risk of bleeding complications, such as acute bleeding, marked thrombocytopenia, or emergency surgery. In this setting, it is proposed that the use of IVC filters may mitigate the risk of life-threatening PE, and most international guidelines would support the consideration of IVC filter placement in this patient cohort [8–11], as no other proven treatment options exist.

A second, and more controversial, indication for IVC filter insertion is for the prevention of VTE in patients who cannot receive prophylactic anticoagulation because of high risk of bleeding, such as those with major trauma or intracranial hemorrhage. To date, the use of IVC filters in this setting is not supported by randomized trial data, with no reduction in the rate of symptomatic PE or death compared with no IVC filter placement [12] and, as a result, their use is not routinely recommended as primary prophylaxis in major guidelines [2,8,9] but may be appropriate if other pharmacological or mechanical prophylaxis is contraindicated [10,11]. Despite the limited data supporting the benefit of IVC filters as primary prophylaxis, the placement of IVC filters for prophylactic indications is frequent and retrieval rates across all patient cohorts remains low [13,14].

Importantly, the placement of IVC filters is not without risk. Complications may include access site complications (infection or hematoma), filter tilt, filter fracture, caval penetration, embolization/migration, and caval occlusion. Although uncommon, these potential complications can cause morbidity, and the complication risk increases with prolonged filter dwell time [15–18]. Concerningly, the majority of IVC filters are not retrieved even after the transient risk factor for VTE has passed or anticoagulation has been commenced [14,19]. The low IVC filter retrieval rates and potential for significant ramifications have been highlighted in a safety warning from the US Food and Drug Administration and, more recently, the Society of Interventional Radiology has released updated IVC filter guidelines recommending the use of a structured follow-up program to increase retrieval rates and detect complications [8,19]. As such, it is apparent that the ongoing management of IVC filters remains an area of unmet clinical need, and ultimately highlights the requirement for a framework to ensure timely and accessible IVC filter retrieval. Several studies have now demonstrated that a definitive process for facilitating IVC filter retrievals is associated with higher retrieval rates [20–26], but whether this process modifies the rate of IVC filter complications or thrombotic complications remains an important question. Here, we describe a cohort study evaluating the establishment and implementation of a multidisciplinary surveillance team (MDST) on filter retrieval rates and IVC filter complications.

2 | METHODS

2.1 | Study Design and Participants

Ambidirectional cohort study performed at a large quaternary hospital between January 2015 and December 2018. Patient data were collected retrospectively from January 2015 to December 2016, and prospectively from July 2017 to December 2018. The study cohort was identified using hospital Radiology Information System coding for IVC filter insertion, and all consecutive filter insertions during the study period were eligible for inclusion. Individuals were excluded from the study if they were <18 years of age or if follow-up occurred at another center. Health and demographic data were sourced from electronic medical records and included demographics, medical history including venous thromboembolic disease, and treatment and indications for IVC filter placement. The indication for filter insertion was independently evaluated by 2 study authors and was characterized as prophylactic or as definitive or adjunct therapy for acute VTE. Prophylactic IVC filter was defined as IVC filter placement in patients without radiologically confirmed VTE, and an IVC filter as definitive or adjunct treatment was defined as filter insertion within 90 days of a radiologically confirmed acute VTE in patients whom therapeutic anticoagulation was contraindicated. All participants were followed for 12 months from the date of IVC filter insertion.

An MDST was introduced in July 2017, comprised of interventional radiologists, hematologists, trauma physicians, nursing staff, and an anticoagulation stewardship pharmacist who had oversight of a central electronic repository of consecutive IVC filter insertions. The rationale for MDST implementation was high rates of IVC filter insertion with low retrieval rates. MDST members were invited to participate in addition to their usual responsibilities and no renumeration was received for participation. The intervention by the MDST included review of patient medical records weekly to ensure follow-up or a plan for the IVC filter was in place. If no IVC filter follow-up was organized within 120 days, the MDST would contact the treating physician or relevant unit coordinator to ensure follow-up occurred. Reminders from the MDST would continue until the filter was removed, or it was documented that the IVC filter was to remain in place permanently. The weekly contact was initiated by the MDST pharmacist, and further contact was made by MDST physicians if required. The MDST was developed and implemented between January 2017 and June 2017 and no patient data was collected during this time.

Of note, the study was planned to recruit participants until July 2019 to achieve similar preintervention and postintervention population sizes. However, the COVID-19 pandemic resulted in significant disruption to medical services from January 2020, with a pause on elective procedures including IVC filter removal. As a result, we do not report data for patients recruited after December 2018, where the 12-month follow-up period would be impacted by COVID-19.

2.2 | Outcome measures

The primary outcome measure was a composite of IVC filter retrieval or a documented plan for the IVC filter (either for retrieval or permanency). If the IVC filter was not removed, the reason for this was classified as 1 of the following options: a) documented plan for IVC filter permanency, b) filter removal after end of study period, or c) the patient was deemed lost to follow-up. The indication for IVC filter permanency was decided by the treating clinician and included reasons such as life expectancy <6 months, treating clinician decision because of other medical comorbidities, failed IVC filter retrieval attempt, or patient refusal for filter retrieval. Patients were defined as lost to follow-up if the IVC filter was not retrieved within 12 months.

Secondary outcomes included the rate of IVC filter complications, recurrent VTE post-IVC filter insertion, and all-cause mortality. The complications of IVC filters have been described previously [27, 28]. In brief, IVC occlusion was defined as any complete thrombotic occlusion demonstrated on radiological imaging such as ultrasound or computed tomography or venogram. IVC penetration was defined as a filter strut extending >3 mm outside the wall of the IVC demonstrated on radiological imaging. IVC filter migration refers to filter movement of >2 cm, and IVC filter embolization was defined by the filter, or part of the filter, embolizing to a distant anatomical site. Presence of IVC filter tilt was defined as >15° of angulation, and access site complications included access site hematoma, infection, or other clinically relevant complications requiring medical review or prolonged hospitalization. IVC filter complications were defined as clinically significant according to Cirse classification of complications [29]. We defined complications graded 4-6 as clinically significant, which includes those causing permanent sequelae, or death. Recurrent VTE was evaluated as a separate entity and was defined as radiological evidence of a new, acute proximal DVT of the leg (involving the popliteal vein or above) or new, acute PE (excluding isolated subsegmental emboli) with or without DVT, diagnosed >30 days from IVC filter insertion.

2.3 | Statistical analysis

Statistical analysis was performed using GraphPad Prism version 9.3.1 and R (version 4.2.1; cran.r-project.org) on the RStudio platform (2022.07.1+554 "Spotted Wakerobin" Release); Free Software Foundation, Boston, MA, USA. Continuous variables were analyzed using an unpaired *t*-test with Welsh's correction and categorical variables were evaluated using Fisher's exact test. A 2-sided p value of <0.05 was considered statistically significant. For each outcome measure, we performed simple logistic regression and report an odds ratio (OR) with 95% CI. To evaluate the impact of potential confounding variables, we also performed multiple logistic regression and report an adjusted odds ratio (aOR) adjusted by the variables of age, sex, weight, and malignancy status. Additionally, for the outcome of time-to-filter retrieval, we perform a time-to-event analysis using the Kaplan–Meier method and we report a hazard ratio (HR) with 95% CI using the Mantel–Haenszel method.

2.4 | Ethics

This project received ethical approval from the Alfred Hospital ethics review board (project number 142/18) and a waiver of consent was granted for the project.

3 | RESULTS

Overall, 453 patients were included in the analysis, with 272 and 181 individuals included in the pre-MDST and post-MDST cohorts,

TABLE 1 Demographics and characteristics of the study cohort.

Characteristics	Pre-MDST (n = 272)	Post-MDST (n = 181)	P value[a]
Male sex, n (%)	181 (66.5)	120 (66.3)	>0.99
Age (y), median (IQR)	51 (36 – 67)	50 (35.5 – 70)	0.59
Weight (kg), median (IQR)	78 (65 – 90)	75 (62.25 – 88.75)	0.44
Nationality			
Australian/New Zealander	195 (71.7)	131 (72.4)	
British	11 (4)	7 (3.9)	
Chinese	1 (0.4)	4 (2.2)	
Egyptian	3 (1.1)	2 (1.1)	
Filipino	3 (1.1)	0 (0)	
German	3 (1.1)	2 (1.1)	
Greek	1 (0.4)	4 (2.2)	
Indian	5 (1.8)	2 (1.1)	
Italian	5 (1.8)	2 (1.1)	
Scottish	2 (0.7)	3 (1.7)	
Other	29 (10.7)	20 (11.0)	
Not stated	14 (5.1)	4 (2.2)	
Access to free public hospital services?			>0.99
Yes	267 (98.2)	178 (98.3)	
No	5 (1.8)	3 (1.7)	
Prior history of VTE, n (%)	29 (10.7)	16 (8.8)	0.63
Active malignancy, n (%)	18 (6.6)	25 (13.8)	0.01
Indication for IVC filter insertion, n (%)			>0.99
Acute VTE with contraindication to anticoagulation	121 (44.5)	81 (44.7)	
Prophylaxis	151 (55.5)	100 (55.3)	

IQR, interquartile range; IVC, inferior vena cava; kg, kilogram; MDST, multidisciplinary surveillance team; n, number; VTE, venous thromboembolism

[a]Continuous variables were analyzed using an unpaired *t*-test with Welsh's correction and categorical variables were evaluated using Fisher's exact test.

respectively. Demographic data are outlined in Table 1. Approximately, 66% of included individuals were male, median age was 51 years (interquartile range [IQR] 36–68.5) and median weight was 77 kg (IQR 65–90). In both cohorts, ∼98% of patients had access to free public hospital services including IVC filter retrieval. In both the pre- and post-MDST groups, ∼55% of IVC filter insertions were considered prophylactic, and 45% were placed for patients with acute VTE with a contraindication to anticoagulation. Baseline characteristics were matched in the pre- and post-MDST cohorts, apart from a higher rate of patients with active malignancy in the post-MDST cohort (6.6% vs 13.8%, respectively, $p < 0.01$).

Results of the study outcomes are shown in Table 2, with both unadjusted and adjusted OR shown. The implementation of the MDST was associated with a higher odds of the primary outcome (IVC filter retrieval or documented filter plan). The primary outcome was obtained in 79.4% in the pre-MDST cohort and 96.1% in the post-MDST cohort (OR, 6.44; 95% CI, 3.06–15.84) (Figure 1). The IVC filter retrieval rate was 52.6% in the pre-MDST cohort and 73.5% in the post-MDST cohort (OR, 2.50; 95% CI, 1.67–3.78) (Figure 2). In the pre-MDST cohort, 26.8% of patients had a documented filter plan (including plan for filter permanency or IVC filter retrieval after study period) compared with 22.7% of patients in the post-MDST cohort. Following the implementation of the MDST, fewer patients were lost to follow-up (20.6% in the pre-MDST cohort and 3.9% in the post-MDST cohort; (OR, 0.11; 95% CI, 0.04–0.25). When compared with the pre-MDST cohort, the establishment of the MDST was also associated with a shorter median time-to-filter retrieval, from 187 days to 150 days, respectively (HR, 1.78; 95% CI, 1.39–2.29).

We found no difference in the rate of IVC filter complications between the 2 cohorts (Table 2). The complication rate was 4.8% in the pre-MDST cohort, and 4.4% in the post-MDST cohort (OR, 0.92; 95% CI, 0.36–2.23) and no complications were found to be clinically significant resulting in permanent sequelae or death. Similarly, we found no difference between the cohorts when evaluating for recurrent VTE (5.2% vs 4.4%, respectively; OR, 0.79; 95% CI, 0.31–1.86) (Table 2). Although no statistical difference was demonstrated, there were 2 of 280 (0.71%) episodes of symptomatic IVC occlusion in the pre-MDST cohort and no episodes of symptomatic IVC occlusion in the post-MDST cohort. There were no deaths related to IVC filter complications, and the all-cause mortality within the 12-month follow-up period was similar between the cohorts (12.5% compared with 14.9%; OR, 1.22; 95% CI, 0.71–2.11) (Table 2).

4 | DISCUSSION

In this study evaluating IVC filter retrieval rates and complications, we have demonstrated that the implementation of an IVC filter surveillance program is associated with a higher rate of IVC filter retrieval and a documented retrieval plan, in addition to a shorter median time to retrieval. However, our study found no difference in the rate of IVC filter complications, recurrent VTE, or mortality when compared with no formal strategies for IVC filter follow-up. After adjustment for potential confounders, the results remain consistent with the unadjusted OR. When evaluating IVC filter complications, there is trend toward higher filter complications within the post-MDST cohort, but this does not reach statistical significance. These data builds on previous studies in this area highlighting the importance of surveillance following IVC filter insertion [20–26,30], and we provide additional important information regarding time to retrieval, complication rates, and recurrent VTE in this setting.

TABLE 2 Results of study outcome measures.

	Pre-MDST (n = 272)	Post-MDST (n = 181)	Unadjusted OR (95% CI)	Adjusted OR[b] (95% CI)
Primary outcome (IVC filter retrieval or retrieval plan), n (%)	216 (79.4)	174 (96.1)	6.44 (3.06–15.84)	10.59 (3.96–33.43)
IVC filter retrieval, n (%)	143 (52.6)	133 (73.5)	2.50 (1.67–3.78)	4.05 (2.22–7.59)
Documented IVC filter plan	73 (26.8)	41 (22.7)	–	–
Lost to follow-up, n (%)	56 (20.6)	7 (3.9)	0.11 (0.04–0.25)	0.06 (0.02–0.18)
Median time to IVC filter retrieval, days	187	150	1.78[a] (1.39–2.29)	–
IVC filter complications, n (%)	13 (4.8)	8 (4.4)	0.92 (0.36–2.23)	3.71 (1.00–15.74)
IVC penetration from filter perforation	4	0		
Filter tilt with filter adherent to IVC wall	4	8		
Filter tilt (no embedding)	1	0		
Filter fracture	1	0		
Filter migration	1	0		
Filter embolization	0	0		
Access site complications	2	0		
Acute VTE >30 days post filter insertion, n (%)	14 (5.2)	8 (4.4)	0.79 (0.31–1.86)	1.02 (0.34–3.00)
Proximal DVT (excluding IVC thrombosis)	8	3		
Pulmonary embolism	0	0		
IVC thrombosis	4	5		
IVC occlusion	2	0		
All-cause mortality, n (%)	34 (12.5)	27 (14.9)	1.22 (0.71-2.11)	1.09 (0.45-2.59)

IVC, inferior vena cava; MDST, multidisciplinary surveillance team; OR, odds ratio; VTE, venous thromboembolism
[a]Time-to-event analysis was performed using the Kaplan–Meier method and comparison between the groups was assessed with a Mantel–Haenszel test. We report hazard ratio with corresponding 95% CI.
[b]Adjusted odds ratio adjusted by the variables of age, sex, weight, and malignancy status

These data are noteworthy for several reasons. Firstly, we have demonstrated the utility of a dedicated service whereby patients with IVC filters are routinely followed and planned for filter removal, resulting in enhanced compliance with major societal guidelines and improved continuity of care. Additionally, our study also highlights the importance of ensuring evidence-based rationale for filter insertion,

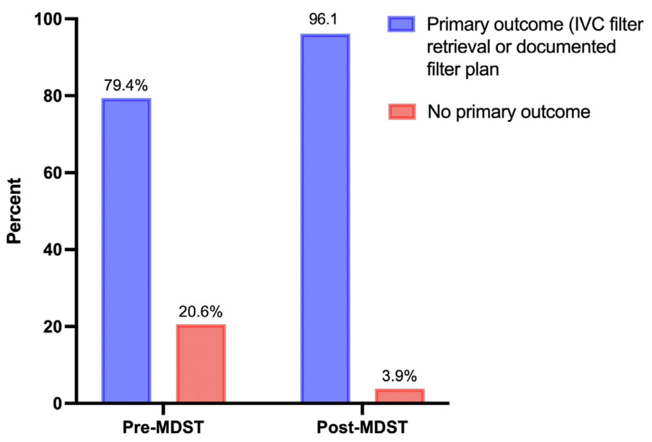

FIGURE 1 Primary outcome (inferior vena cava filter retrieval or documented retrieval plan) at the completion of the 12-month follow-up period before and after the implementation of the multidisciplinary surveillance team (MDST)

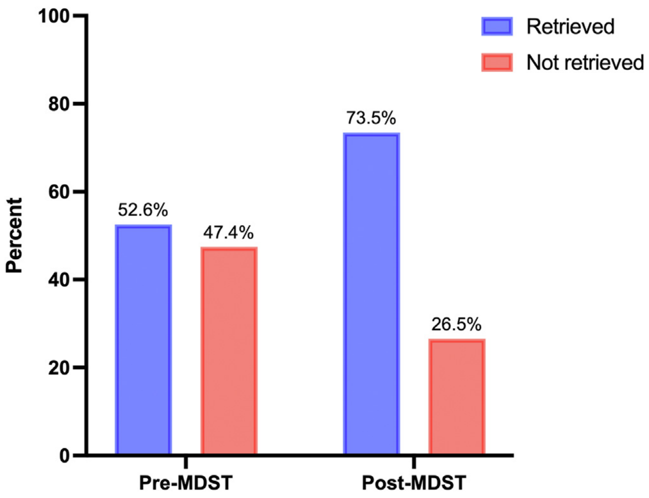

FIGURE 2 Retrieval rates of inferior vena cava filters by the completion of the 12-month follow-up period before and after the implementation of a multidisciplinary surveillance team (MDST)

with ∼55% of the study cohort having a prophylactic indication for an IVC filter. Our hospital operates the largest trauma service in Australasia, with many patients receiving IVC filters for thromboprophylaxis because of major orthopedic injuries or intracranial hemorrhage. We acknowledge that IVC filter use for prophylactic indications remains controversial and is not recommended in many clinical practice guidelines [11]. However, if placement of IVC filters does occur, our findings show the important role of MDST to ensure timely removal, particularly when global retrieval rates remain low [14,24,31–33].

Previous studies have highlighted that the rate of IVC filter complications increases in proportion with device dwell time [15,18] and IVC filters are associated with an increased risk of recurrent VTE [33]. The Food and Drug Administration decision analysis suggests that the benefit of IVC filter removal, compared with leaving devices in situ, commences between 29 and 54 days from filter insertion because of perceived risk of longer dwell times [19]. In the current study, the median retrieval time reduced from 187 to 150 days, but even after the implementation of the surveillance team the dwell time remains longer than recommended. Following the conclusion of the study, we have reconsidered the MDST structure and have taken steps to further improve filter dwell time, including reviewing the requirement for IVC filters on hospital discharge, ensuring follow-up is booked within 30 days of hospital discharge, and contacting treating doctors within 90 days if IVC filter is not removed.

In the current study, following the establishment of the MDST, we still found that 3.9% of patients were lost to follow-up. In these 7 patients that were lost to follow-up, there was no significant correlation with age or medical comorbidities, and all patients had access to free public health care (data not shown). The reasons for lack of follow-up appeared to be both patient-specific and system-specific, including lack of booked follow-up at hospital discharge as well as patients failing to attend planned outpatient clinics. These reasons further highlight the rationale for ensuring any possible filter retrievals occurs before hospital discharge, or ensuring patients receive education and written communication regarding the importance of filter follow-up.

In accordance with previous reports [27,34], our study found an overall filter complication rate of 4.6%. However, there were no filter complications that were deemed clinically significant, and no significant difference in IVC filter complications between the study cohorts. Although the overall complication rate is favorable, these findings highlight that caval filtration is not without risk and emphasize the importance of ensuring that the indication for IVC filter placement is robust and evidence based.

In contrast to the PREPIC study [5,6], we found no difference in the rate of recurrent VTE between the pre- and post-MDST cohorts, or when considering patients with IVC filters retrieved compared with those who did not have filters retrieved (data not shown). Several reasons for these findings exist, including the lack of surveillance imaging in our study, or the possibility that the risk of recurrent VTE continues to increase with filter dwell time, and our study period was not sufficient to evaluate this. Alternatively, it should be considered that the PREPIC study is >20 years old and several subsequent generations of IVC filters have been utilized since this study was conducted, which may also account for some of these differences. When considering the 2 episodes of IVC occlusion, it should be noted that both occurred in patients with IVC filters in situ >6 months (192 days and 221 days, respectively). Although spontaneous IVC occlusion/thrombosis and filtration of thromboembolism in-transit cannot be further differentiated, it is plausible that IVC occlusion may not have eventuated with earlier IVC filter removal. Further prospective studies will be required to evaluate these outcomes.

The strengths of this study include the large patient cohort for analysis. Limitations to this study include the single center design, and the follow-up time of 12 months. Additionally, nationality but not ethnicity is recorded in the hospital records, and thus it is unclear how these findings may apply across different ethnic groups. Further, because of the historical control cohort, there may be other reasons associated with improved retrieval rates such as increased awareness regarding IVC filters, which may bias these results. Finally, our center does not use a routine imaging protocol for patients post-IVC filter insertion, and consequently asymptomatic IVC filter complications may not have been identified. This may result in an underestimation of the true IVC filter complication rate.

In summary, the formation of an IVC filter MDST was associated with higher IVC filter retrieval rates and shorter median time-to-filter retrieval. These findings highlight the importance of implementing a primary point of contact following IVC filter insertion to ensure optimal follow-up and ultimately improve patient-centered care.

ACKNOWLEDGMENTS

H. Stevens is supported by the Monash University Research Training Program Scholarship and Wheaton Family Scholarship. K. Peter is supported by a National Health and Medical Research Council (NHMRC) Senior Principal Research Fellowship. J.D. McFadyen is supported by a NHMRC and Heart Foundation, Australia Early Career Fellowship.

FUNDING

The authors received no funding for this study.

AUTHOR CONTRIBUTIONS

H.S. contributed to concept, design, data analysis and critical writing and revision of content. H.B. contributed to concept, design, data analysis, and revision of content. S.C. contributed to data analysis. R.R. contributed to the data analysis. W.C. contributed to concept and revision of content. K.P. contributed to revision of content and final approval. J.M. contributed to concept, design, revision of content, and final approval. H.T. contributed to concept, design, revision of content, and final approval.

RELATIONSHIP DISCLOSURE

There are no competing interests to disclose.

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