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ORIGINAL ARTICLE

Retrievable Inferior Vena Cava Filters: A 10-Year Retrospective Analysis

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ABSTRACT

Introduction: *Inferior vena cava (IVC) filters are an effective form of venous thromboembolism prophylaxis when treatment with anticoagulation is contraindicated. In recent times, the retrievable IVC filter has gained favour in clinical practice as it circumvents the consequences of permanent filters, such as deep venous thrombosis. This study is a retrospective review of the retrievability of IVC filters since their introduction in our department.*

Methods: *Retrospective analysis was conducted on 118 consecutive adult patients (mean age 63.6 years) who underwent IVC filter insertion over a 10-year period. Patient data, including underlying medical condition, indication for filter insertion, number of retrievals, and filter complications, were recorded. Dwell time was calculated using Kaplan-Meier survival analysis.*

Results: *Among the 118 patients, the most common indication for filter insertion was bleeding due to anticoagulation therapy. Mean dwell time for IVC filters was 101.7 days. One patient died before retrieval. The overall successful retrieval rate was 89.0%. Among the 13 patients whose filters could not be retrieved, nine required lifelong anticoagulation and four were lost to follow-up. Three patients developed lower limb deep venous thrombosis due to delayed filter retrieval.*

Conclusion: *The majority of these filters can be retrieved successfully within the first year of insertion. Retrievable IVC filters are a feasible alternative to traditional permanent IVC filters. Complicating factors occur in a small percentage of these patients, which may prevent successful retrieval.*

Key Words: *Pulmonary embolism; Radiology, interventional; Vena cava filters; Venous thromboembolism; Venous thrombosis*

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Data Availability: All data generated or analysed during the present study are available from the corresponding author on reasonable request.

Ethics Approval: This research was approved by the Human Research Ethics Committee of Monash Medical Centre, Melbourne, Australia (Ref No.: 76899). The patients were treated in accordance with the tenets of the Declaration of Helsinki and provided written informed consent for all treatments and procedures.

中文摘要

可回取下腔靜脈濾器的經驗：10 年回顧性分析

R Sum、KKP Lau

簡介：當有抗凝治療禁忌時，下腔靜脈濾器是預防靜脈血栓栓塞的一種有效方法。近年來，可回取下腔靜脈濾器在臨床實踐中獲得了青睞，因為它規避了永久性過濾器的後果，例如深靜脈血栓形成。本研究回顧本部門引入可回取下腔靜脈濾器的經驗。

方法：我們對10年間接受下腔靜脈濾器置入的118名連續成年患者（平均年齡63.6歲）進行回顧性分析。本研究記錄了患者數據，包括基礎疾病、濾器置入的指徵、濾器回取次數和濾器併發症，並使用Kaplan-Meier生存分析計算濾器置留時間。

結果：在該118名患者中，濾器置入最常見適應症為抗凝治療導致出血。下腔靜脈濾器平均置留時間為101.7天。一名患者在濾器回取前死亡。濾器回取整體成功率為89.0%。在濾器無法回取的13名患者中，9人需要終生抗凝，4人失訪。三名患者由於濾器回取延遲而出現下肢深靜脈血栓形成。

結論：大多數濾器可在置入第一年內成功回取。可回取下腔靜脈濾器是傳統永久性下腔靜脈濾器的可行替代方案。小部分患者出現併發因素，或會阻礙濾器成功回取。

INTRODUCTION

The use of inferior vena cava (IVC) filters to prevent venous thromboembolism (VTE) is a proven and effective treatment for patients with a contraindication to standard anticoagulation therapy or refractory VTE that has failed anticoagulation.[1] There have been significant developments in IVC filters over recent years. Permanent IVC filters were first introduced into clinical practice over 30 years ago — these remain inside the patient for life. However, evidence in the current literature demonstrates that the rate of complications increases with extended dwell times of IVC filters.[2,3] These complications can have significant detrimental clinical implications, including filter thrombosis and an increased risk of developing subsequent deep venous thrombosis (DVT) which may require lifelong anticoagulation.[3] For this reason, the retrievable filter was developed as an attractive alternative that avoids the long-term implications of permanent filters while still being able to provide protection against VTE in the relevant setting. However, retrievable filters are also subject to a series of complicating factors that can prevent their successful removal. Certain filter elements such as the hook, struts, and barbs are prone to endothelial overgrowth. Misalignment, migration, and fractures are also commonly encountered issues.[4] Retrievability can be delayed by emboli trapped by the filter.[5] According to the current literature, the incidence rates of these complications can vary significantly between institutions.[4]

Because the risk of VTE requires individual assessment and the intention of filtration is to prevent pulmonary embolism (PE), discontinuation is recommended as soon as the perceived risk of developing clinically significant PE is acceptably low.[2] There is no consensus on the recommended duration for filter dwell time. This study is a retrospective review of the retrievability of an IVC filter (Celect Platinum; Cook Medical, Bjaeverskov, Denmark) since its introduction in our department more than a decade ago.

METHODS

We reviewed 118 consecutive cases of adult patients who underwent IVC filter insertion and retrieval at a tertiary referral centre between 1 January 2008 and 1 August 2018. We excluded eight other patients as their IVC filters were inserted external to our institution. One patient died before any attempt at retrieval was feasible and this patient was excluded from data analysis. Patients' age, sex, underlying medical conditions, and indications for IVC filter insertion were recorded. Details of the insertion, including approach and dates, were noted. Details of subsequent retrieval attempts including the date, number of attempts, reasons for failure (if any), and complications were also recorded.

Filter insertion was undertaken either through a right jugular or right or left femoral venous puncture approach. The IVC filter was chosen for insertion through a 7-Fr introducer sheath. A cavagram was routinely performed after deployment to confirm its position.

As part of our department's filter retrieval procedure, an initial cavagram was performed through a right internal jugular venous puncture to exclude filter thrombus and other complicating factors. Filter retrieval was performed using a retrieval set (Günther Tulip; Cook Medical, Bjaeverskov, Denmark) through a right internal jugular venous approach. An 11-F introducer sheath was used for venous access. A 6.3-F retrieval loop system using the loop-snare technique was used to engage the filter hook. Kaplan-Meier analysis comparing successful and unsuccessful retrieval was performed with SPSS (Windows version 24.0; IBM Corp, Armonk [NY], United States). Statistical significance was calculated using Fisher's exact test. A p value of < 0.05 was considered to be statistically significant.

This study was prepared in accordance with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) reporting guidelines. Ethics approval in accordance with the National Health and Medical Research Council of Australia was obtained from the Human Research Ethics Committee of Monash Medical Centre, Melbourne, Australia.

Table 1. Patient demographics (n = 118).*

Sex	
Female	60 (50.8%)
Male	58 (49.2%)
Age, y (median [range])	63.6 (28-92)
Underlying medical conditions	
Malignancy	27 (22.9%)
Antiphospholipid syndrome	2 (1.7%)
Chronic lung/heart disease	4 (3.4%)
Intracranial haemorrhage†	16 (13.6%)
Liver disease	3 (2.5%)
Crohn's disease	2 (1.7%)
Sepsis	6 (5.1%)
Trauma	16 (13.6%)
Nil significance	42 (35.6%)

Abbreviation: CNS = central nervous system.
* Data are shown as No. (%), unless otherwise specified.
† Defined as any clinically significant intracranial bleeding during the current inpatient admission.

Table 2. Indications for filter insertion (n = 118).

	No. (%)
Bleeding	55 (46.6%)
Imminent surgery	35 (29.7%)
Thrombocytopaenia/coagulopathy	1 (0.8%)
Recent surgery	7 (5.9%)
Recurrent VTE despite anticoagulation therapy	4 (3.4%)
Inability to monitor anticoagulation	2 (1.7%)
Extensive proximal DVT	14 (11.9%)

Abbreviations: DVT = deep vein thrombosis; VTE = venous thromboembolism.

RESULTS

Patient Demographics

Most patients had had an underlying medical condition predisposing them to developing VTE (64.4%). The most common underlying condition was malignancy (22.9%), followed by intracranial haemorrhage (13.6%), trauma (13.6%), sepsis (5.1%), chronic heart and lung disease (3.4%), liver disease (2.5%), Crohn's disease (1.7%), and antiphospholipid syndrome (1.7%) [Table 1].

Indications for Inferior Vena Cava Filter Insertion

Consultation and approval by our institution's haematology unit was required prior to filter insertion. In all, 118 patients required IVC filters because anticoagulation was contraindicated. The most common reason for filter insertion was bleeding due to anticoagulation (46.6%), followed by imminent surgery (29.7%), extensive proximal DVT (11.9%), recent surgery (5.9%), recurrent VTE despite anticoagulation (3.4%), inability to monitor anticoagulation (1.7%), and thrombocytopaenia/coagulopathy (0.9%) [Table 2].

There were 79 filters inserted through a femoral approach and 39 inserted through a jugular approach. A total of 117 filters were successfully inserted without immediate complications. One filter demonstrated tilt immediately after being deployed but no attempts were made to reposition it thereafter (Figure 1).

In all successful retrievals, there were no immediate complications identified on routine post-retrieval cavagram. All retrievals were attempted through a right jugular approach.

Rates of Inferior Vena Cava Filter Retrieval

The indwelling time for filters was calculated using Kaplan-Meier product limit estimation (median = 88.0 days; range, 6.0-348.0). Out of the 117 retrieval attempts, 105 were successful (90.0%) with six of these 105

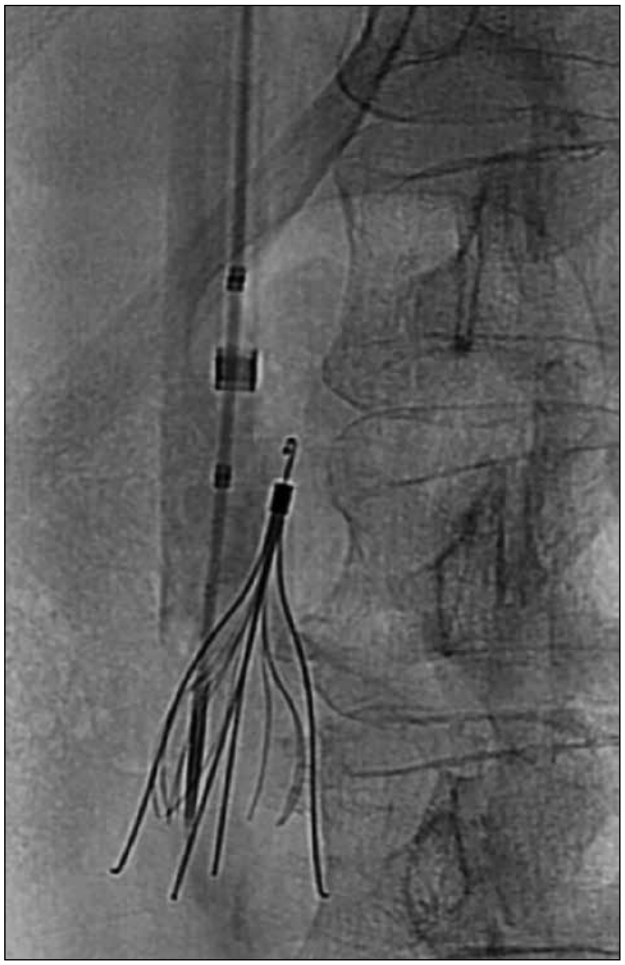

Figure 1. Cavagram in a 58-year-old male demonstrates significant medial tilt filter. The filter hook has embedded into the left lateral aspect of the caval wall. Multiple unsuccessful attempts were made at snaring at the hook and the decision was made to leave the filter in situ permanently.

Table 3. Retrieval outcomes (n = 117).*

Dwell time, days	
Mean	101.7
Median (range)	88.0 (6.0-348.0)
Retrieval outcome	
Not retrieved	12 (10.3%)
Retrieved	105 (89.7%)
Attempts	
1	106 (90.6%)
2	9 (7.7%)
3	2 (1.7%)
Patients undergoing their first attempt	
Successful	99 (84.6%)
Unsuccessful	18 (15.4%)
Aborted after unsuccessful first attempt (n = 7)	
Filter kept in situ permanently	5 (71.4%)
Lost to follow-up	2 (28.6%)
Patients undergoing a second attempt (n = 11)	
Successful	5 (45.5%)
Unsuccessful	6 (54.5%)
Aborted after unsuccessful second attempt (n = 4)	
Filter kept in situ permanently	3 (75.0%)
Lost to follow-up	1 (25.0%)
Patients who underwent their third attempt (n = 2)	
Successful	1 (50.0%)
Unsuccessful	1 (50.0%)

* Data are shown as No. (%), unless otherwise specified.

filters requiring more than one attempt (5.7%) [Table 3]. Twelve filters could not be retrieved (10.3%); their reasons are outlined below. A single retrieval attempt was conducted in 106 patients. Two attempts were performed in nine patients. Two patients underwent three retrieval attempts [Table 3].

During the first attempt, 99 filters were successfully retrieved (84.6%) while 18 filters could not be removed (15.4%). The barriers to retrieval in these 18 filters were endothelialisation of the filter hook in six patients (33.3%) [Figure 2], a large trapped thrombus in another six patients (33.3%) [Figure 3], thrombus formation around the filter hook in four patients (22.2%), and protrusion of the filter legs beyond the caval wall in two patients (11.1%) [Figure 3]. A second attempt was not performed in seven of these patients; in five, retrieval

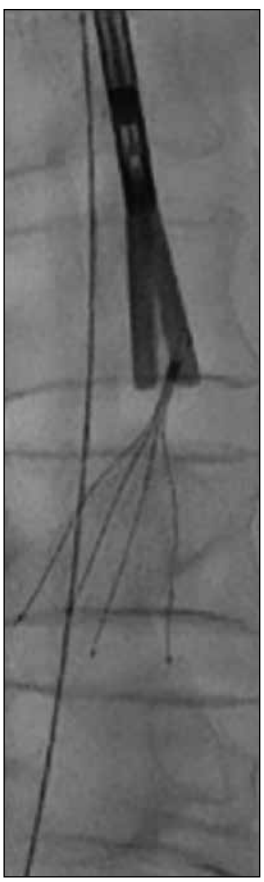

Figure 2. Cavagram in a 42-year-old female demonstrates filter tilt and endothelialisation of the filter into the caval wall. Endovascular forceps were used to carefully dissect the endothelial tissue incorporating the filter hook into the inferior vena cava. This allowed the hook to be freed and successfully snared.

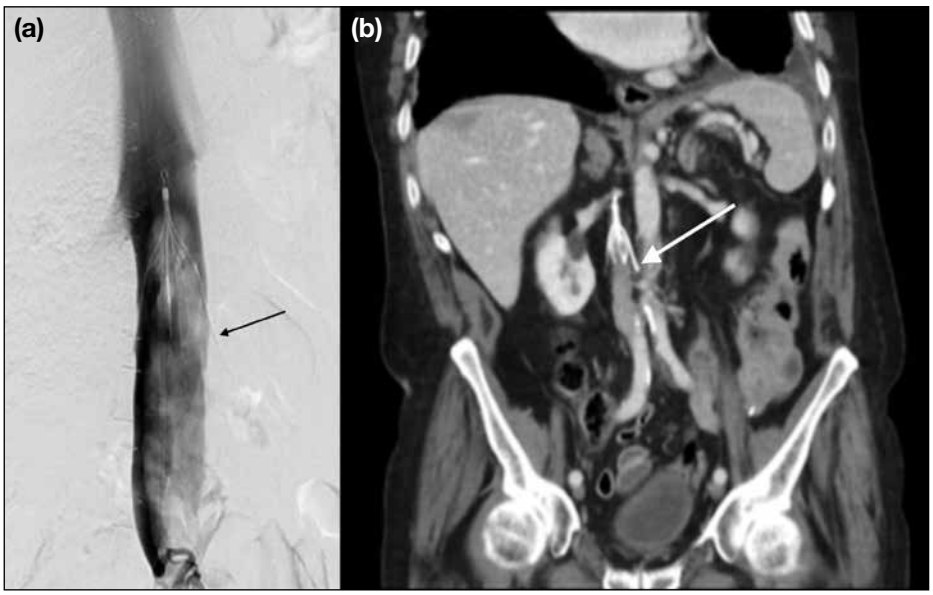

Figure 3. (a) Cavagram in a 70-year-old male demonstrates a large thrombus inside the filter (arrow). (b) There is penetration of the filter struts beyond the caval wall of the same patient on subsequent contrast-enhanced computed tomography (arrow). The filter could not be removed due to significant incorporation of the filter struts into the caval wall from all sides.

of the filter was deemed technically too difficult. The clinical haematology unit decided to keep them as permanent filters and these patients were started on long-term anticoagulation with warfarin. The remaining two patients were lost to follow-up (Table 3).

Of the 18 patients who failed first retrieval attempts, 11 underwent a second attempt while two of them had a third attempt. Among 11 patients who had the second retrieval attempt, five were successfully removed (45.5%) and six were not (54.5%). The reasons for a second failed retrieval were an inability to snare due to thrombus surrounding the filter hook (n = 3), filter thrombus (n = 2), and protrusion of the filter legs beyond the caval wall (n = 1). From these six unsuccessful second retrieval attempts, three filters were kept permanently and the patients were commenced on warfarin therapy. One patient was lost to follow-up (Table 3).

In the two remaining patients who failed the second retrieval attempt, a third retrieval attempt was performed. One was successfully retrieved after a period of anticoagulation for filter hook thrombus in addition to the use of a loop wire snare to engage the filter hook. The other retrieval was unsuccessful despite a third attempt and the decision was made by the clinical haematology unit to keep this as a permanent filter. The patient was subsequently commenced on long-term warfarin therapy (Table 3).

Rates of Follow-up

From the total cohort of 105 successful retrievals, 69 of these patients (65.7%) were reviewed by haematology while 36 patients (34.3%) were not. Among the 12 unsuccessful retrievals, nine patients were commenced on anticoagulation and were managed by a haematologist and three were lost to follow-up (Table 4).

Reasons for Failed Filter Retrieval

There were several factors complicating successful filter retrieval (Table 5). Eighteen patients had had complications with their filter at the time of attempted retrieval (15.3%) with some patients having more than one concurrent complication. Two of the most prevalent factors were trapped embolus within the filter (n = 8) and endothelialisation of the filter hook into the caval wall (n = 8). Filter tilt was seen in six patients. In four patients, the filter hook could not be snared despite multiple attempts at passing the retrieval wire, presumably due to the presence of thrombus surrounding the hook. There were two filters where elements other than the hook (such as the struts) were incorporated into the caval wall. In one patient, there was a combination of filter tilt and endothelialisation of the hook, which led to failure of retrieval (Figure 1). No subsequent attempts at retrieval were made for this patient.

In all cases where retrieval could not be performed due to a trapped embolus, a period of therapeutic low molecular

Table 4. Follow-up status (n = 117).*

	Not removed	Removed
Total	12 (10.3%)	105 (89.7%)
Reviewed by a haematologist after filter insertion	9 (75.0%)	69 (65.7%)
Not reviewed by a haematologist after filter insertion	3 (25.0%)	36 (34.3%)
Outcomes		
Lost to follow-up	3 (2.6%)	0
No referral was submitted to the haematology unit after filter insertion	0	36 (30.8%)
IVC filter left in situ	9 (7.7%)	0
Death before attempted retrieval	1 (0.9%)	0

Abbreviation: IVC = inferior vena cava.
* Data are shown as No. (%), unless otherwise specified.

Table 5. Reasons for failed inferior vena cava filter retrieval (n = 118).

	No. (%)
Total No. of patients with complications	18 (15.3%)
Tilt	6 (5.1%)
Endothelialisation	8 (6.8%)
Incorporation of other filter elements (struts and barbs) into the caval wall	2 (1.7%)
Trapped filter embolus	8 (6.8%)
Inability to snare due to filter hook thrombus	4 (3.4%)

weight heparin was commenced by the haematology unit for 3 months to reduce the thromboembolic load before further attempts at retrieval were considered. This occurred in four filters, three of which were thereafter successfully removed on the second attempt.

One patient had filter tilt and endothelialisation of the hook into the left side of the caval wall. After multiple attempts at manipulating the hook using a variety of snares and balloon insufflation to correct the tilt, the filter tip was eventually freed through blunt dissection of the hook from the caval wall using endovascular forceps and removed without immediate complications (Figure 2).

Three patients developed bilateral lower limb DVT as a result of prolonged dwell time of the IVC filter and multiple non-retrieval attempts, requiring a period of anticoagulation before successful retrieval.

DISCUSSION

This retrospective study provides insight into the management of retrievable IVC filters at our institution. Specifically, the data confirm a high retrieval performance in our department with 105 retrieved (89.0%) successfully from a total of 118 filters inserted over the 10-year study period.

A review of the current literature demonstrates that retrieval rates elsewhere are highly variable, ranging from 49.6% to as high as 96.6%.[6-9] Nearly 60.0% of our IVC filter retrievals occurred within the first 100 days of insertion with the final retrieval rate of 89.0% achieved by 350 days after insertion. Previous studies reveal that the retrieval of Celect filters is most likely to be successful within 3 to 4 months of placement which is also in keeping with our results.[10]

Currently, there is no well-documented consensus on a safe dwell time for retrievable filters. It is recommended that filters should be removed as soon as the risk of PE has resolved due to the risk of complications, although others have suggested that removal times be guided by manufacturers' guidelines.[11] Further, additional delays in retrieval can occur, especially if there are unforeseen changes in the patient's clinical trajectory during their admission or follow-up.

Prolonged dwell times can be problematic and result in a variety of complications as evidenced in our study. Analyses have shown retrievable IVC filters to have an overall complication rate ranging from 11.7% to 20.0%, which is also consistent with our findings (15.3%).[6,7] For instance, strut penetration is reported at a higher rate among conical filters such as the Celect filter.[12-15] While penetration is common among Celect filters, it is rarely associated with breakthrough PE, retrieval failure, or other local complications.[16] An example is seen in one patient where retrieval could not be performed on two attempts due to extensive trapped thrombus within the filter and strut penetration. The third attempt on the same patient was complicated by filter tilt and hook embedment into the posterior caval wall that prevented successful snaring (Figure 3).

The inherent morbidity implicated by long-term filter implantation should not be dismissed. In the PREPIC (Prevention of Recurrent Pulmonary Embolism by Vena Cava Interruption) trial, permanent IVC filters were associated with increased odds of developing recurrent DVT and a reliance on long-term anticoagulation.[3,17] This outcome was seen in seven patients who underwent failed retrieval attempts and were subsequently subjected

to lifelong warfarin. Short-term anticoagulation therapy was also required for three patients who experienced delays in filter retrieval and subsequently developed new lower limb DVT.

Currently, IVC filter insertion at our institution requires formal approval from the haematology unit prior to the procedure. However, there is no protocol for follow-up after their insertion. As a result, three patients were lost to follow-up and no clear anticoagulation plan or plan for filter removal was documented in their medical records. Delays in filter retrieval result in prolonged dwell times, which are detrimental from the increased risk of developing DVT and, in some cases, may subject patients to lifelong anticoagulation. A dedicated follow-up system is therefore required so that all patients undergoing IVC filter insertion are monitored by both interventional radiologists and haematologists to ensure appropriate filter retrieval timing and the optimal use of anticoagulation therapy.

Limitations

This study was from a single tertiary radiology centre, which was its major limitation. Another limitation was the lack of direct contact with those patients who were not followed up by the haematology unit.

CONCLUSION

Retrievable IVC filters are a feasible and safe alternative to permanent filters in VTE prevention. Our study demonstrates that a high retrieval rate can be achieved within 1 year of insertion. However, it is important to be aware that a small percentage of filters may be complicated by several factors that may warrant the use of advanced retrieval techniques. Prompt removal of the IVC filter when safe to do so is necessary due to the increased risk of developing DVT.

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