Procedural and Indwelling Complications with Inferior Vena Cava Filters: Frequency, Etiology, and Management

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Abstract

Keywords

- IVC filter
- filter complication
- pulmonary embolism
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- deep vein thrombosis

Inferior vena cava (IVC) filters are commonly used in select high-risk patients for the prevention of pulmonary embolism. Potentially serious complications can arise from the use of IVC filters, including thrombosis of the filter itself and filter fragment embolization. This article discusses the utility of IVC filters and reviews the management of two cases of filter-related complications.

Objectives: Upon completion of this article, the reader will be able to identify the utility of IVC filters and potential complications that can arise with their use.

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The incidence of nonfatal pulmonary embolism (PE) within the United States has been estimated between 400,000 and 630,000 cases per year, with 50,000 to 200,000 deaths per year attributed directly to PE.¹ Inferior vena cava (IVC) filters serve as an effective alternate method for reducing risk of PE in patients with absolute contraindications to or complications of anticoagulation, or for those who develop recurrent

deep vein thrombosis (DVT) while on full-dose anticoagulation. Current filter placement rates vary significantly across different geographic locations; the estimated number of filter placements in 2012 in the United States was approximately 25-fold higher compared with comparable sized populations in Europe. Similarly, there is significant variability in filter placement rate in the continental United States.^{2–4} Causes for increased utilization rates of IVC filter devices and variability may include differences within existing guideline recommendations, physician awareness, and poor compliance with guidelines, hospital reimbursement incentives, as well as the litigation climate.⁵

Despite low overall complication rates with IVC filters, there have been increasing reports of complications from IVC filters both in the literature and within the United States Food and Drug Administration's (FDA) Manufacturer and User Device Experience database.^{6–13} The majority of filter complications are silent or have specific presentation and are only identified on imaging.^{14,15} Here, the authors present two complications of IVC filters and their management. The first case involves an IVC filter fracture and leg embolization following retrieval of a retrievable device. The second case involves IVC filter thrombosis as of a retrievable IVC filter.

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Case 1: Inferior Vena Cava Filter Fragment Retrieval

A 20-year-old male with a retrievable Gunther Tulip IVC filter (Cook Medical, Bloomington, IN) was scheduled for filter removal. His medical history was significant for ulcerative colitis for which he had recently undergone a subtotal colectomy. During his postoperative course, he had several episodes of rectal bleeding. He also developed a DVT in his right lower extremity. In light of active bleeding, anticoagulation was not deemed to be appropriate and a retrievable IVC filter was placed.

Two separate attempts were made at removing the IVC filter. The first attempt at 90 days postinsertion was unsuccessful. Under fluoroscopic guidance, the right internal jugular vein was accessed and a 5 French OmniFlush catheter (Angiodynamics, Latham, NY) was used to perform a cava-gram. This demonstrated a markedly posterior-tilted filter with its apex embedded in the posterior caval wall. In addition, legs of the filter were noted to be entering the right renal vein (►Fig. 1a). Many attempts were made to remove the filter with an array of catheters, wires, and snares using both an internal jugular and common femoral vein approach. The decision was made to terminate the procedure and reattempt in 2 weeks' time with a larger sheath size, which was not available at the time of the initial procedure. Two weeks later, the second attempt at removing the filter was successful. The right internal jugular vein was accessed, and an angled 16 French 65 cm vascular sheath and an 11 French Gunther-Tulip (Cook Medical, Bloomington, IN) removal sheath were advanced coaxially. A wire was passed across the apex of the filter without engaging the apical hook and snared (►Fig. 1b). The inner and outer sheaths were then gradually advanced over the filter, while keeping tension on the wire sling allowing for successful removal of the filter.

Fig. 1 (a) Venogram with inferior vena cava (IVC) filter in situ during the first attempted IVC filter retrieval. One strut protrudes into the renal vein (white arrow). (b) Snared IVC filter on second attempt, the strut in the right renal vein is no longer appreciated.

Fig. 2 Fractured inferior vena cava filter strut visible on fluoroscopy of left chest lateral to the heart, suspected location within the left descending pulmonary artery branch (white arrow).

Completion venogram showed minimal adherent clot along the left caval wall and no evidence of extravasation.

Before commencing the second retrieval procedure, it was noted that one of the filter legs, previously seen in the left renal vein, was not identified upon fluoroscopy (►Fig. 1). Fluoroscopy of the chest demonstrated a filter leg fragment in a descending branch of the left main pulmonary artery (►Fig. 2). Following consultation with the referring physician and hematology service, the patient was heparinized and brought back several days later to remove the embolized fragment.

Under fluoroscopic guidance, the right internal jugular vein was accessed and a long 7 French sheath (Cook Medical, Bloomington, IN) was advanced into the main pulmonary trunk. A 5F Davis catheter (Cook Medical, Bloomington, IN) was used to cannulate the descending branch of the left main pulmonary artery. An angiogram demonstrated persistence of the filter fragment (►Fig. 3a). Multiple unsuccessful attempts were made to snare the fragment. However, with the assistance of flexible endobronchial biopsy forceps (Lyal Willis & Co., East Sussex, United Kingdom), the fragment was successfully removed (►Fig. 3b).

Case 2: Inferior Vena Cava Filter Thrombus

A 67-year-old male was transferred to the authors' hospital intensive care unit with acute renal failure and recurrent bilateral PE despite an IVC filter being in place. On physical examination, the patient had extensive swelling and discoloration of the left leg with no pulses or motor or sensory function below the knee level, in keeping with DVT-induced compartment syndrome. The heart rate was 115 beats per minute, blood pressure was 118/76 mm Hg, and O₂ saturations on 3 liters of O₂ by nasal cannula was 97%. He had a history of right leg DVT and PE with a Gunther-Tulip filter (Cook Medical, Bloomington, IN) inserted 3 years ago in an outside institution for recurrent PEs despite adequate anticoagulation. The patient was also known to have Factor 5 Leiden mutation. Ultrasound of the left femoral vein revealed a deep venous thrombosis, and an outside abdominal computed tomography (CT) scan revealed an extensive left

Fig. 3 (a) Digital subtraction angiography demonstrating the fractured strut within the left pulmonary artery (white arrows). (b) Left main pulmonary arteriography following removal of the fractured strut using bronchoscopic forceps.

femoral, popliteal, and occlusive bilateral ilio caval thrombosis. Vascular surgery recommended endovascular treatment by interventional radiology.

Under ultrasound guidance, the left popliteal vein was accessed and a 5 French vascular sheath was advanced. A limited venogram confirmed the diagnosis and extent of the disease (**Fig. 4a**). A Cragg-McNamara 135/20 cm valved infusion catheter (Covidien, Plymouth, MN) was inserted over a guidewire into the femoral vein. Thrombolysis was initiated with a bolus of 5 mg of tissue plasminogen activator (tPA) (Activase; Genentech, South San Francisco, CA) followed by catheter-directed infusion of tPA at 1 mg per hour and heparin at 400 units an hour.

After 8 hours, venograms of the IVC and femoral vein demonstrated persistence of the clot (**Fig. 5**); venograms of the iliac, suprarenal IVC, and renal veins demonstrated patency. Thrombolysis was resumed with a bolus of 8 mg of tPA followed by an infusion of tPA at 5 mg per hour and heparin at 400 units an hour, this time parking the infusion catheter tip in the contralateral iliac vein given the extent of venous thrombosis.

After 20 hours, venograms were performed once again. Improved patency was noted in the left femoral vein and IVC (**Fig. 6b**). Antegrade IVC flow was noted with an intraluminal central clot. Thrombolysis was continued and the catheter was advanced to the iliac vein.

At 41 hours, venograms demonstrated minimal residual clot in the left femoral vein and the apex of the indwelling IVC filter (**Fig. 7**). Thrombolysis was continued for another 15 hours until the clot was no longer visible on imaging (**Fig. 4b**). The patient's symptoms related to his PE and right leg DVT rapidly resolved over the next few days, and the patient was subsequently started on Coumadin. He was scheduled for IVC filter repositioning but was lost to follow-up.

Fig. 4 Popliteal and deep femoral venogram: (a) At initiation of thrombolysis demonstrating deep vein thrombosis (white arrows), (b) after approximately 56 hours of thrombolysis therapy with significantly improved flow.

Inferior Vena Cava Filter Placement

There are currently more than 10 different types of retrievable and permanent filters available for commercial use, and many sets of guidelines from various professional societies exist regarding the utilization of IVC filters (**Table 1**).¹⁶⁻²³ Despite this, a recent population-based study by Spencer et al

Fig. 5 Cavography of the inferior vena cava (IVC) at the level of iliac bifurcation with the low-lying IVC filter (white arrow) visible and reduced flow due to significant thrombosis (interrupted arrows) 8 hours after initiation of thrombolysis.

Fig. 6 Venogram of the iliac vein with improving flow following (white arrows): (a) 20 hours of thrombolysis and (b) 41 hours of thrombolysis.

showed that only half of all IVC filter placements indications were appropriate according to published guidelines.¹⁶ The only agreed-upon indication for IVC filter placement across all society guidelines is the use of IVC filters in patients with documented thromboembolic disease with absolute or relative contraindications to anticoagulation. The guidelines most

Fig. 7 Digital subtraction angiography of the inferior vena cava (IVC) showing improving flow in the IVC (white arrows) following 41 hours of thrombolysis therapy.

commonly utilized by interventional radiologists are the Society of Interventional Radiology (SIR) consensus guidelines, which outline absolute, relative, and prophylactic indications for IVC filter placement.²² These guidelines provide significantly broader indications for IVC filter placement, including prophylactic use for high-risk trauma patients. The Eastern Association for the Surgery of Trauma (EAST) is the only other organization to recommend IVC filter placement in high-risk trauma patients.¹⁸ Despite this controversy and conflicting guideline recommendations, more than 17% of the filters placed are used prophylactically in trauma patients.²⁰

The estimated incidence of venous thromboembolism (VTE) in major trauma patients is approximately 60% and in those patients surviving initial injury, PE is the most common cause of mortality.^{21,23} In particular, patients with closed head injuries, spinal cord injuries, or complex pelvic fractures have the highest risk of developing PE.²³ Retrievable IVC filters have been demonstrated to decrease the incidence of PE, and the number needed to treat to prevent one additional PE with IVC filter is between 109 and 969, depending on the patient baseline PE risk.^{24,25}

Prophylactic IVC filter placement in a preoperative setting has been a contentious topic in the medical community. Recently, IVC filters are being placed in many patients who are undergoing bariatric procedures and have a concern of higher risk of VTE.^{26,27} There is conflicting literature on IVC filter placement in this group of patients, but, in general, no benefit for PE prevention has been demonstrated and none of the current guidelines support IVC filter placement in patients undergoing bariatric procedures.^{25–28}

To determine the feasibility, safety, and efficacy of IVC filter placement requests, there are several questions that need to be answered: (1) Does the patient have a documented history of venous thromboembolic disease; (2) does the patient have contraindications to pharmacologic anticoagulation, has failed anticoagulation therapy, or is unable to be therapeutically anticoagulated; and (3) what is the patient's life expectancy? If the first two questions are answered in the affirmative and patient's life expectancy is more than 3 months, the patient should undergo IVC filter placement.²⁹ However, if these conditions are not met, more rigorous assessment of the patient's VTE risk factors, overall health, and alternative options should be considered before making a decision regarding IVC filter placement.

Inferior Vena Cava Filter Retrieval

In general, retrievable IVC filters that are placed for temporary clinical indications should be retrieved once indication of caval filtration is no longer present and the risk for PE is sufficiently low. The current rate of successful retrieval of retrievable IVC filters varies from 20 to 50% based on patient factors, indication for placement, technical challenges with removal, and physician preference.^{30–33} Prompt retrieval of indwelling filters that are no longer clinically indicated is required given the risk of

Table 1 Indications for IVC filter placement based on the SIR, ACCP, EAST, and BSH/BCSH guidelines^{18–20,23}

Indication	SIR	ACCP	EAST	BSH/BCSH
Therapeutic (patients with documented thromboembolic disease)				
Absolute or relative contraindication to anticoagulation	R	R	R	R
Complications resulting from anticoagulation treatment	R	–	–	–
Failure of anticoagulation	R	–	–	–
Recurrent PE in patients with adequate anticoagulation therapy	R	–	–	R
Inability to achieve or maintain adequate anticoagulation	R	–	–	–
Progression, advancement, or propagation of DVT while therapeutically anticoagulated	R	–	–	R
Massive PE with residual DVT at risk for further PE	R	–	–	–
Free-floating iliofemoral or IVC thrombus	R	–	–	–
Severe cardiopulmonary disease and DVT	R	–	–	–
Filter use in addition to effective anticoagulation	–	NR	–	NR
Pregnant patients with contraindication to anticoagulation, develop VTE < 2 wk to delivery	–	–	–	R
Patients with PE undergoing thrombolysis	–	–	–	NR
Preoperated patients requiring anticoagulation interruption with recent VTE (< 1 mo)	–	–	–	R
Patients with CTEPH undergoing pulmonary endarterectomy or some CTEPH patients	–	–	–	R
Prophylactic (patients with no current documented thromboembolic disease)				
Primary DVT prevention in patients undergoing surgery	–	NR	–	–
Patients undergoing orthopedic surgery receiving IVC filter over no prophylaxis	–	NR	–	–
Severe trauma without documented PE or DVT	R	NR	R	–
Closed head injury	R	–	R	–
Spinal cord injury	R	–	R	–
Multiple long-bone or pelvic fractures	R	–	R	–
High-risk patients, i.e., immobilized, admitted to intensive care units	R	–	R	–
Free-floating thrombus	–	–	–	NR

Abbreviations: ACCP, American College of Chest Physicians; BCSH, British Committee for Standards in Haematology; BSH, British Society of Haematology; CTEPH, chronic thromboembolic pulmonary hypertension; DVT, deep vein thrombosis; EAST, Eastern Association for the Surgery of Trauma; IVC, inferior vena cava; NR, not recommended; PE, pulmonary embolism; R, recommended; SIR, Society of Interventional Radiology; VTE, venous thromboembolism.

complications and increased difficulty of filter removal. There is a significant risk of long-term IVC filter complications with increased dwell time, including IVC thrombosis, IVC perforation, penetration of adjacent viscera, device migration, filter fracture, and DVT.^{34,35} In addition, it has been suggested that increased filter dwell time is a risk factor for failure of IVC filter removal using routine techniques.³⁶ Modeling the risk–benefit of IVC filters has shown that the benefit of indwelling device reaches its minimum within 29 to 54 days following implantation.³⁷

There are many barriers to timely and effective IVC filter retrieval, including loss of patients to follow-up, long dwell time, filter malpositioning, lack of suitable venous access, ongoing contraindication to anticoagulation, and physician refusal.³⁸ One strategy for improving IVC filter retrieval rates is the implementation of an IVC filter and mandatory post-marketing registries.³⁸ The Heart and Vascular Outcomes Research Institute (HVORI) is currently in collaboration with multiple U.S. medical institutions to run a large

multicenter U.S. trial, the iRetrieve study (NCT02160964), utilizing a novel algorithm to manage patients with retrievable IVC filters which is expected to start in August 2014.³⁹ This study aims to improve IVC filter retrieval rates, while also reducing costs associated with programs, such as dedicated IVC filter clinics.

Filter retrieval using routine retrieval techniques could be difficult when any of the following exist: prolonged filter dwell time, severe filter tilt or significant thrombus, caval occlusion, filter strut caval wall penetration, and embedded hooks.⁴⁰ Pre-retrieval CT could be helpful to detect filter complications in any patient presenting for IVC filter retrieval, particularly in those with dwell times > 180 days.⁴¹ In cases where routine retrieval techniques fail, there are several advanced techniques available, including stiff-wire displacement, modified loop snare (*Hangman technique*), dual-access wire and snare extraction, balloon displacement, endomyocardial/endobronchial forceps dissection, and photothermal tissue ablation.^{42,43}

Inferior Vena Cava Filter Complications

Complications can be divided into those that occur at the time of insertion, those that occur in the days and months following implantation, and those that occur at the time of retrieval. Early complications include puncture site complications, filter malposition, delivery system complications, tilting, and incomplete opening. Delayed complications include caval thrombosis, filter fracture, recurrent PE, and filter migration. Reported filter complication rates could vary significantly based on type of filter, duration and method of follow-up, and location where the filter is deployed (► **Table 2**).^{34,35,44}

With a few exceptions, it is common practice to place the apex/leading edge of the filter in, at, or just below the level of renal vein inflow. Operator error, faulty devices, omission in appreciation of patient anatomy, and knowledge of where the device is being deployed (size of cava, lumbar vein, aorta, etc.), extent of the venous thrombosis, and use of alternate or unfamiliar tools (i.e., intravascular ultrasound or new device) all could contribute to complications occurring at the time of device insertion.^{6–15}

While IVC filters do reduce the frequency of symptomatic PE, paradoxically, they have also been shown to increase overall thrombotic risk. One large randomized controlled trial of 400 patients with proximal DVT who received anticoagulation compared two groups: one group with IVC filter and one with no filter. Two years postfilter insertion, 20.8% of the filter group patients and 11.6% of the no filter group patients had developed recurrent DVT (OR, 1.87; 95% CI, 1.10–3.20).³³ Ray and Prochazka, in their 2008 systematic review of the topic, found little in the way of evidence to support or refute the use of anticoagulant following IVC filter placement and suggested it would be reasonable to use anticoagulant in patients with known hypercoagulable state.⁴⁵

Caval thrombosis is a common complication after IVC filter placement reported to occur anywhere between 2.3 and 50% of patients in multiple case series.^{46–48} IVC filters may promote thrombus formation due to thrombogenicity of the device, trapped embolus from a distal site, and cephalad extension of the distal DVT.^{48,49} Caval thrombosis is often asymptomatic but can present with lumbar pain, increasing edema of the lower extremity, nonhealing venous ulcers, phlegmasia cerulea dolens, renal dysfunction if the thrombus is at the juxtarenal region, and occasionally with sciatica-type pain.²³ Minimal caudal filter migration is thought to occur commonly and is of little clinical significance.⁵⁰ However, significant caudal migration or central migration to the heart and great vessels is much less common, occurring in approximately 0.1 to 1.2% of patients.^{48,51} The first line of treatment for filter migration is an attempt at endovascular retrieval. Rarely does migration into the heart occur, and may make endovascular retrieval exceptionally challenging and dangerous, where surgical retrieval maybe warranted.^{48,51}

According to SIR guidelines, IVC perforation is defined as penetration of a filter strut or anchor device extending more than 3 mm outside the wall of the IVC as demonstrated on CT, cavagram, or autopsy.²² Cavagram has been shown to significantly underestimate the presence of IVC penetration. A large

Table 2 Reported rates of complications and adverse events involving inferior vena cava filters

Complication	Reported rate (%)
IVC penetration	0–41
IVC occlusion	2–30
Access site thrombosis	0–25
Insertion complication	5–23
Filter migration	0–18
Filter fracture	2–10
IVC filter deployment outside of target region	1–9
Recurrent PE	0.5–6
Filter embolization	< 1
Death	0.12

Abbreviations: IVC, inferior vena cava; PE, pulmonary embolism.
Source: Adapted from Caplin et al.²²

case series of 690 patients followed by CT revealed that 39% had IVC penetration at 30 days and 80% had penetration at 90 days postplacement. Remarkably, penetration into adjacent organs (e.g., duodenum, aorta, psoas muscle) occurred in 13.2% of patients. Fortunately, perforation is nearly always completely asymptomatic.¹⁵ Filter tilt > 15 degrees as well as duration of placement are thought to be significant predictors of IVC penetration.^{15,22}

Filter fracture is a relatively common complication with potentially serious consequences. Case reports have described filter fragment emboli causing cardiac perforation and tamponade.¹¹ In a retrospective series of 363 patients, an estimated 5.5-year filter fracture risk was 40%.⁵² All 20 patients who experienced filter fracture in this series were asymptomatic. IVC filters should be inspected carefully upon removal for missing components. Filter fragment embolus can often be removed with snares or endobronchial forceps.⁵²

In the first case presented here, the authors encountered difficulty with filter retrieval. After multiple attempts, retrieval was successful using the loop snare technique. These difficulties were undoubtedly due to the filter's marked posterior tilt compounded by the apex embedded in the IVC wall. Once the filter was removed, the authors were certain to carefully inspect the filter to ensure that it was intact. A leg was noted to be missing, and fluoroscopy of the lungs revealed the location of the embolized fragment. Snare removal was unsuccessful but endobronchial biopsy forceps allowed for straightforward removal of the filter fragment from the pulmonary artery. Certainly, manipulation of the filter during sequential retrieval attempts could have contributed to filter fracture and/or embolization. Vigilance in excluding filter fracture and embolization is required in all patients with indwelling filter, particularly in those with difficult filter retrievals. It should be noted that modifying the grasper of the biopsy forceps by removing its sharp spike may improve the safety of the procedure. Despite the small size of the filter fragment and the fact that the patient was

asymptomatic, considering the patient's young age and concerns of committing patients to long-term anticoagulant treatment, the authors decided to remove the filter embolus in consultation with the referring service. Alternatively, a conservative approach could have been to commence long-term anticoagulant therapy to allow endothelialization of the filter fragment and perhaps monitor the patient with serial chest X-rays to assess for further migration.

In the second case, the authors encountered an IVC filter thrombosis in a patient with recurrent PE despite anticoagulation. The caudal position of the filter certainly could have contributed to caval thrombosis in addition to the patient's clotting factor mutation. In retrospect, consideration should have been given for repositioning the filter at the time of deployment. This patient was treated at a site where there was limited access to dedicated devices for thrombolysis and thrombectomy; therefore, the authors were able to offer stand-alone catheter-directed thrombolysis (CDT) using a relatively high dose of thrombolytic infusion. Although treatment was successful, this did expose the patient to a higher risk of bleeding and also required an extended stay in the intensive care unit. Although mechanical devices are often used in such cases, the authors determined that the use of AngioJet (Medrad, Warrendale, PA) would not have been appropriate in this case, given the history of acute renal failure. In hindsight, also given the extent of venous thrombosis and history of PE, a retrievable suprarenal filter could have been placed to protect the patient from massive PE during the procedure. In a multicenter randomized controlled trial in which 92 patients received infusion-only CDT, there were no cases of procedure-related symptomatic PE⁵³; therefore, in the authors' practice the routine placement of IVC filters before infusion-only CDT or infusion-first pharmacomechanical CDT was not usually performed. Finally, not having an IVC filter clinic at the time likely contributed to the lack of appropriate follow-up in this patient.

IVC filter placement has become increasingly common, particularly with the commercial availability of retrievable filters. Although uncommon, complications with such devices do occur and can be clinically devastating for patients. Early recognition of such complications, as well as developing the skill set to treat such complications, is necessary for any physician using such devices.

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