Review Article

Inferior vena cava filter retrievals, standard and novel techniques

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Abstract: The placement of an inferior vena cava (IVC) filter is a well-established management strategy for patients with venous thromboembolism (VTE) disease in whom anticoagulant therapy is either contraindicated or has failed. IVC filters may also be placed for VTE prophylaxis in certain circumstances. There has been a tremendous growth in placement of retrievable IVC filters in the past decade yet the majority of the devices are not removed. Unretrieved IVC filters have several well-known complications that increase in frequency as the filter dwell time increases. These complications include caval wall penetration, filter fracture or migration, caval thrombosis and an increased risk for lower extremity deep vein thrombosis (DVT). Difficulty is sometimes encountered when attempting to retrieve indwelling filters, mainly because of either abnormal filter positioning or endothelization of filter components that are in contact with the IVC wall, thereby causing the filter to become embedded. The length of time that a filter remains indwelling also impacts the retrieval rate, as increased dwell times are associated with more difficult retrievals. Several techniques for difficult retrievals have been described in the medical literature. These techniques range from modifications of standard retrieval techniques to much more complex interventions. Complications related to complex retrievals are more common than those associated with standard retrieval techniques. The risks of complex filter retrievals should be compared with those of life-long anticoagulation associated with an unretrieved filter, and should be individualized. This article summarizes current techniques for IVC filter retrieval from a clinical point of view, with an emphasis on advanced retrieval techniques.

Keywords: Inferior vena cava (IVC); filter retrieval; complex; complications; retrievable

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Introduction

Venous thromboembolism (VTE) occurs at a rate of 1 in 1,000 in the general population and in up to 1 in 100 in high-risk subpopulations (1). The risk of developing pulmonary embolism (PE) is present in as many as 25% of patients if inadequately treated (2). With the development of retrievable (optional) inferior vena cava (IVC) filters, placement of these devices for the prevention of VTE complications has become increasingly popular, and has resulted in a dramatic surge in the placement rate (3). Accepted indications for filter placement are in patients in whom anticoagulant therapy is either contraindicated or has failed. However, filters are increasingly being placed for VTE prophylaxis in certain other patient populations despite a lack of supporting evidence for this practice. While the rate of filter implantation has more than doubled within the past several years, with a continuously increasing trend, the retrieval rates remain quite low, with a mean retrieval rate of 34%; figures as low as 8.5% are also reported. Thus the majority of retrievable IVC filters are not removed (4-7). One prospective randomized trial

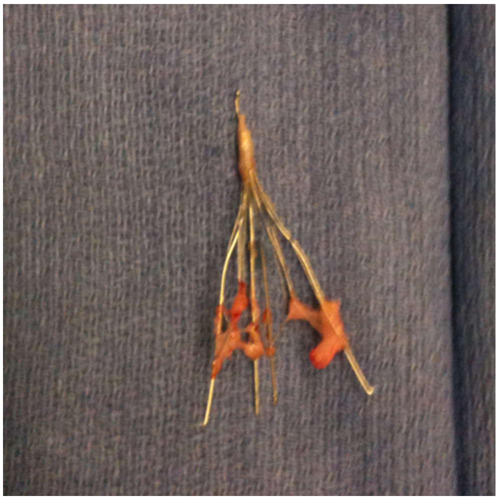

Figure 1 This retrieved IVC filter shows extensive endothelialization of various components of the device. This occurs at points of contact between the filter and the caval wall and becomes progressively more exuberant as the filter dwell time increases. IVC, inferior vena cava.

showed a statistically significant increase in the incidence of lower-extremity deep venous thrombosis in patients in whom IVC filters were implanted as compared to control patients (8). Based upon these and other findings, the U.S. Food and Drug Administration (FDA) issued a safety alert in 2014 recommending IVC filter removal as soon as is clinically appropriate and shared the responsibility of filter removal equally between the implanting physician and the clinician responsible for the ongoing care of patients in whom a retrievable IVC filter has been placed (9). Although the majority of IVC filters can be removed using standard retrieval techniques, there are certain circumstances that may make retrieval challenging. In such cases advanced retrieval techniques may be necessary for successful IVC filter removal. The most common reason that an IVC filter cannot be retrieved using standard techniques is tilting of the filter, so that the tip of the filter becomes embedded in the wall of the IVC as a result of endothelial overgrowth (*Figure 1*). Prolonged filter dwell times, filter migration and filter fracture can also complicate and decrease the success rate of standard retrieval techniques (10,11). Different retrieval techniques have been described in the medical literature ranging from minor modifications of standard techniques to more advanced ones such as the endovascular use of forceps or lasers to dissect away endothelial tissue that has surrounded various filter components. This article reviews various techniques that have been described in the medical literature, based on a standard classification that was described earlier by Iliescu *et al.* with the addition of newer techniques that have subsequently been described (12).

IVC filter retrieval techniques

Standard technique

The standard technique for IVC filter retrieval typically involves using a snare and sheath combination to engage, collapse and remove the filter, with reported retrieval success rates of 80–90%. In selected series these high percentage successful retrieval rates using standard techniques have generally been seen in filters in which there has been a relatively limited dwell time (7,13). Success rates when using a snare for retrieval may depend to varying degrees upon the manufacturer's instructions, the filter type and the operator experience. The standard retrieval technique almost always involves achieving single venous access, generally through the right jugular vein, for introduction of the sheath and snare combination. If filter deployment was via a transfemoral venous approach, as is necessary for introduction of the OptEase® IVC filter (Cordis; Fremont, CA, USA), the retrieval hook is caudally oriented, thus necessitating transfemoral venous access for retrieval. Various modifications of standard retrieval techniques are commonly used for removing filters that are tilted off-axis, but have had relatively limited dwell times with minimal or no endothelization of the filter hook or other filter components. Because standard snare and sheath combinations are almost always oriented centrally within the IVC upon introduction, successful retrieval of a tilted filter may require introduction of an angled or curved catheter that can be used to manipulate a either a guidewire or a snare appropriately for filter removal. This technique may be used to retrieve filters in which the retrieval hook has been completely endothelialized and is embedded in the caval wall; a stiff guidewire is directed between the indwelling filter and the caval wall so as to displace and center the filter within the IVC for subsequent standard retrieval. A coaxial loop snare can also be introduced and used to grasp the filter apex and wire together alternatively. Several modified techniques have been described for displacing a filter from the IVC wall and realigning it centrally within the cava. Hagspiel *et al.* reported the use of a tip-deflecting guidewire to move a recovery filter away from the caval wall into the center of the IVC for successful

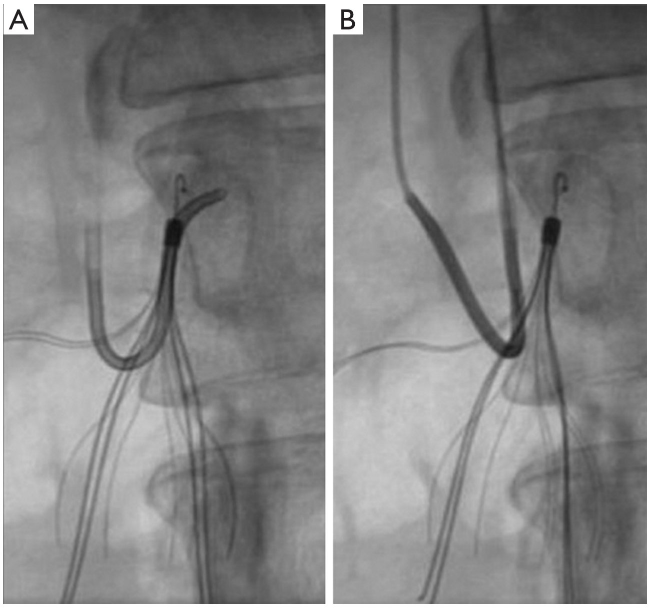

Figure 2 Use of the wire loop and snare technique for retrieval of a tilted or embedded filter. In image (A) a reverse-curve catheter has been introduced and (B) has been used to direct a guidewire cephalad through the legs and beneath the apex of the filter.

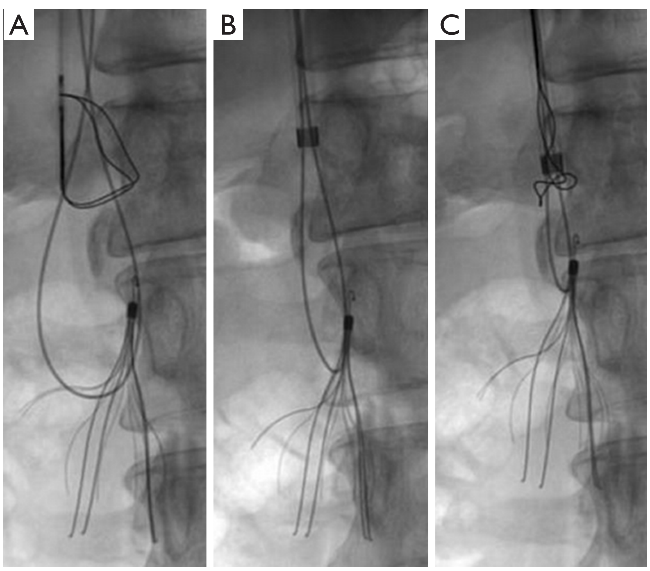

Figure 3 In image (A) the guidewire tip has been snared above the filter (B) thereby creating a loop over which a sheath is advanced. (C) The sheath is advanced over the filter apex, so as to collapse the filter for subsequent removal.

retrieval (14). Tip-deflecting guidewire techniques could avoid an exchange of the retrieval snare and could thereby decrease procedure times. Similarly, placement of a curved 8-F introducer sheath via the right femoral vein has been used to displace the filter tip away from the IVC wall and allow subsequent successful snaring and retrieval via a transjugular venous approach (15). A disadvantage of this modification of the standard retrieval technique is the necessity of obtaining dual venous access via transfemoral and transjugular approaches.

Single access techniques

Single access techniques are preferred given the decreased risk of access-related complications such as injury to the adjacent artery or nerve, hematoma, venous thrombosis or access site infection.

Wire loop-and-snare

Tilted or embedded filters can often be retrieved using the guidewire loop and snare technique described by Rubenstein (16) and others (17). A reverse-curve catheter is placed in IVC below the level of the filter and is used to direct a guidewire through filter legs so that the guidewire tip courses cephalad underneath the filter apex where the legs join. A snare is then introduced via the same venous access and is used to grasp the tip of the guidewire and externalize it. A long (30–40 cm) large caliber (e.g., 14–16 Fr) access sheath is then introduced over the two externalized limbs of the guidewire and is advanced to the apex of the filter, where traction is applied to both ends of the guidewire. This is done in order to pull the filter from the caval wall and position it more centrally within the IVC. The sheath can then be advanced over the filter apex so that the filter can be collapsed and then removed (*Figures 2,3*). Alternatively, the large caliber venous access sheath may be placed first and used to introduce both the reverse curve catheter and snare in parallel. A problem that may be encountered when using this technique is an unwanted reorientation of the filter. This malpositioning may occur if the loop of the snared guidewire does not course immediately beneath the filter apex, but instead encircles one or more filter legs. As traction is applied to the externalized guidewire ends, instead of centering the entire filter, the anchoring hooks of the encircled legs are freed from the caval wall and the legs are pulled cephalad. The apex and hook of the filter remain still embedded within the caval wall. This can cause the filter to acquire a somewhat transverse position, thereby worsening the orientation for retrieval (*Figures 4,5*). This is most problematic in filters

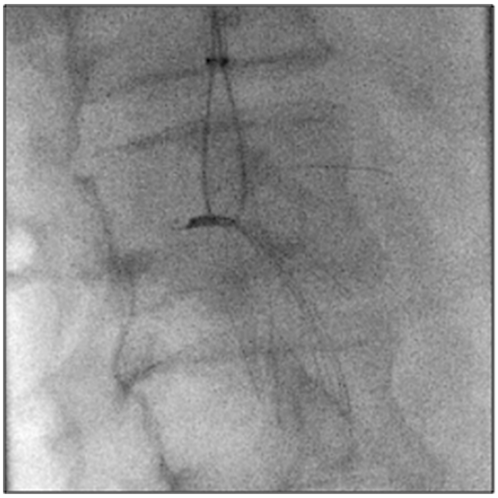

Figure 4 Using the wire loop and snare technique can sometimes be problematic, particularly with filters that are made of relatively malleable materials. The loop surrounding the filter courses predominantly through the legs and is directing them cephalad, while the filter tip remains embedded in the caval wall.

Figure 5 After unsuccessfully using the wire loop and snare technique the IVC filter has been reoriented into an even less desirable position for retrieval, as it is now in a transverse position, with legs coursing both cephalad and caudally. IVC, inferior vena cava.

that are constructed of "softer" or more malleable material such nitinol, as opposed to stainless steel.

Balloon-displacement technique

An IVC filter that is adherent to the caval wall can also sometimes be dissected free by advancing a guidewire between the filter and the section of the caval wall with which the filter has contact. An angioplasty balloon is then advanced over the guidewire between the embedded filter and the caval wall and is inflated in order to realign the filter more centrally within the IVC. This may then provide a better angle for snaring the filter hook (17,18). Another advantage of this technique is that even partial tracts that are created by the guidewire may be used to sequentially separate the embedded areas of the IV filter from the caval wall in a piecemeal fashion. These multiple dilatations and partial or complete realignment of the filter more centrally within the IVC may then allow a successful retrieval using a snare and sheath combination.

Dual-access techniques

Double guidewire and snare technique

Tilted filters with extended dwell may not only become endothelialized but may also be embedded in the IVC wall via fibrotic tissue. Traction forces using the previously described methods may fail to separate the embedded filter from contact with the caval wall (19). The double guidewire and snare technique involves using an additional guidewire and snare to utilize the previously described guidewire loop and snare technique via two separate venous accesses (16). Both transjugular and transfemoral venous accesses are required. Separate guidewires are introduced from both the femoral and jugular approaches and are directed between the filter apex, the IVC wall and the endoluminal aspect of the filter. Both guidewires free ends are then snared and are externalized via each venous access point. Guidewire traction is simultaneously applied in both directions. If traction is insufficient to free the filter using this technique, long intravascular sheaths may be advanced from both accesses over the guidewires as a modification of technique described by Yamagami (15). This technique has been successfully used to remove permanent filters such as the TrapEase® (Cordis; Fremont, CA, USA) (*Figures 6,7*) (20).

Dissection techniques

Endobronchial forceps dissection and removal

The use of endobronchial forceps to micro dissect the fibrinous endothelial cap overlying an embedded filter hook, and then grasp the freed hook with either the forceps or a snare for retrieval through an access sheath was described by Stavropoulos in 2006 (10). The success rate for removing tip-embedded IVC filters on an intention-to-treat basis was reported to be 96%. Stavropoulos *et al.* later concluded that this endobronchial forceps technique could be safely used to successfully remove embedded filters (21,22). In

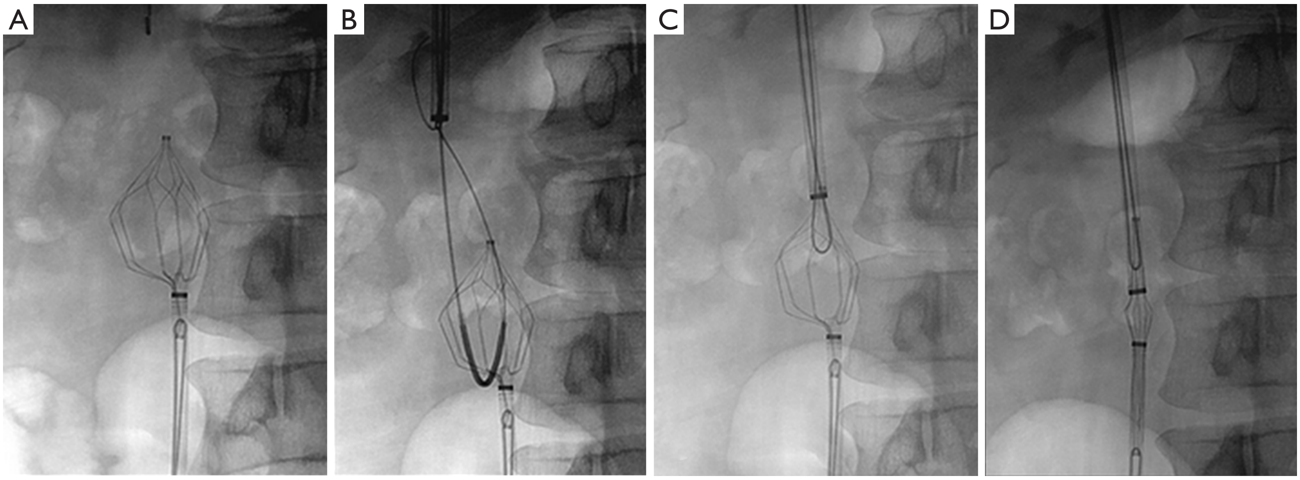

Figure 6 The double guidewire and snare technique requires two venous access points. In image (A) a wire loop and snare technique has been used to encircle the caudal end of a permanent TrapEase® IVC filter. Image (B) shows the wire loop and snare being used to also encircle the cephalad end of the filter so that (C) a sheath can be advanced. In image (D), sheaths have been advanced from both the femoral and jugular venous access points, successfully collapsing the filter for retrieval. IVC, inferior vena cava.

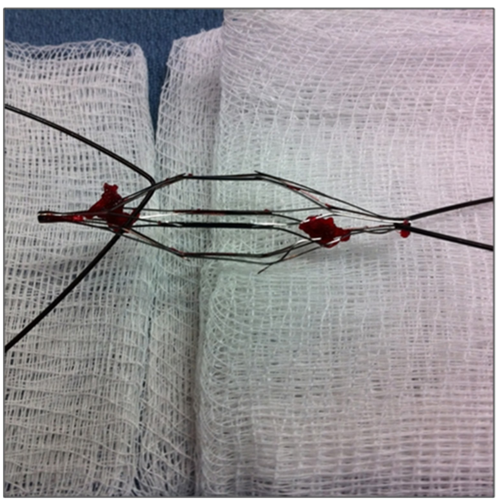

Figure 7 The TrapEase® IVC filter has been successfully removed through the femoral sheath. IVC, inferior vena cava.

this technique a rigid endobronchial forceps is introduced through a large caliber venous access sheath (14–18 Fr) and is used to dissect the hook of the IVC filter free from the caval wall. The tip or hook of the filter may then be grasped with the forceps so that the access sheath can be advanced over the filter apex in order to collapse the filter and allow subsequent removal using the forceps (*Figure 8*). Alternatively, after the hook has been dissected free, a snare catheter may be used to grasp the hook and retrieve the filter. Multiple attempts at grasping and freeing the filter hook may be necessary when using this technique, which may significantly increase the procedure time. Additionally the filter may be inadvertently fractured when using the endobronchial forceps so that multiple components of the filter must be individually removed (*Figures 9,10*) (21-23). The latter technique is suggested by Stavropoulos *et al.* in cases in which over-sheathing of filter is not possible (21,22). Avery *et al.* further suggested that dissection using an endobronchial forceps for filter retrieval could be less costly and more effective and might also be used for standard filter removals (24). However Stavropoulos described this technique as fairly aggressive and noted that with excessive traction fractured filter components may embolize to the cardiac chambers and or pulmonary arteries thereby requiring aggressive foreign body retrieval and potentially even necessitating surgical removal (22-24).

Laser thermal dissection for IVC filter retrieval

In 2010 Kuo *et al.* reported percutaneous IVC filter retrieval using a laser sheath technique for circumferential ablation of dense fibrotic tissue embedding an IVC filter into the caval wall (11). The authors suggested that using an intravascular laser to free the filter from the surrounding endothelial and fibrotic tissue could minimize or prevent tearing of the underlying cava, and that this technique might be preferable for IVC filters with extended dwell times. A success rate of 98% was reported using this

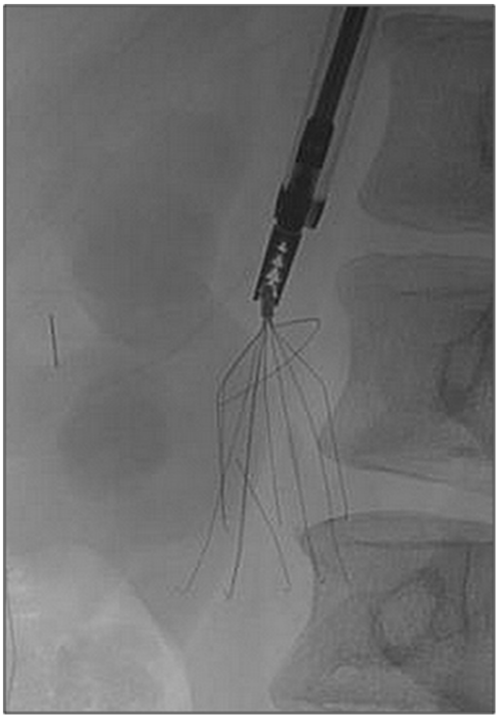

Figure 8 An endobronchial biopsy forceps has been introduced and used to dissect away endothelial tissue that has embedded the filter hook into the caval wall. In this case the forceps is also being used to grasp the tip of the filter so that a sheath can be advanced to collapse the filter for removal.

Figure 9 Occasionally a filter fractures when an endobronchial forceps is used for retrieval because the filter components have been so extensively endothelialized.

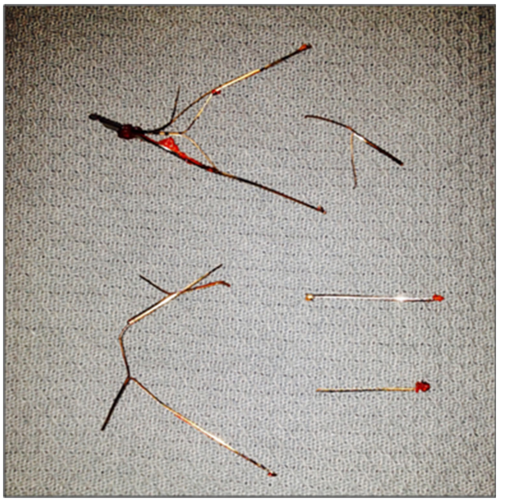

Figure 10 It is important to document that all filter components have been successfully retrieved if a filter is fractured during an attempted removal.

technique in this single institution prospective study (25). The main advantage includes a decrease in the traction forces that are required for filter removal when compared with other techniques. The authors suggested that the decreased traction will lessen mechanical complications such as fracture and possible embolization of filter components. Equipment costs might limit the use of this technique in standard practice outside of tertiary medical centers.

Complications of IVC filter retrievals

Significantly higher complications rates are reported for IVC filters when using some of the previously described advanced retrieval techniques. Longer dwell times, more transverse tilt, and an embedded hook were all associated with increased complication rates and the necessity of using advanced retrieval techniques for filter removal (26). Reported complications of IVC filter retrievals include significant IVC injury causing breach of the caval wall integrity, venous pseudoaneurysms or stenoses, filter fragmentation and embolization of filter components to the cardiac chambers and/or pulmonary arteries unretrieved or permanent IVC filters also have many well-known complications that include an increased risk of lower extremity deep vein thrombosis (DVT), IVC thrombosis and occlusion, and penetration of filter legs beyond the caval wall (*Figures 11,12*) causing a variety of problems such as abdominal and/or back pain, injury to adjacent bowel

Figure 11 This coronal view from a CTA shows that a filter leg has penetrated the caval wall as well as the abdominal aorta.

Figure 12 This axial view shows multiple filter legs have penetrated the caval wall as well as the duodenum.

loops such as the duodenum, aortic wall penetration, and small-bowel volvulus. Filter migration and spontaneous fracture and embolization of filter components have also been reported (8,10,14,27,28). Nonetheless, before using advanced techniques for IVC filter retrieval, the associated possible complications should always be compared to the potential risks of leaving the filter permanently indwelling, and should be individualized. Filter retrieval could be favored for the following situations: avoiding the risk of long-term thrombotic complications in younger patients, to treat symptomatic filter-related IVC stenosis and thrombosis and to treat symptomatic filter penetration, and to avoid the need for lifelong anticoagulation (28,29).

Discussion

IVC filters are increasingly being used in clinical practice to prevent fatal complication of VTE, pulmonary emboli since its conception in 1973 by Greenfield (30). There has been a rapid evolution in technology that includes the introduction of retrievable filters in 2003 (31). Recent studies of the risk and benefit profile have favored filter removal between 29 and 54 days after insertion if the patient's transient risk of PE has passed (7,26). Indications for filter placement can be divided into three major categories: absolute, relative, and prophylactic indications. The Society of Interventional Radiology recommends the use of filters in patients who have a documented VTE, are at high risk of clinically significant PE, and have a contraindication to or complication or failure of pharmacologic therapy (32).

Complications of retrievable IVC filters that remain indwelling include leg penetration, filter fracture, migration, venous thrombosis, pneumothorax, hemothorax, caval occlusion and perforation, and device infection (7,33,34). Such complications with recent systematic review of 37 studies revealing the mean retrieval rate of 34% with figures as low as 8.5% resulted in U.S. Food and Drug Administration (FDA) realizing safety alert in 2010 and again updated in 2014 informing physicians who placed retrievable filters to be responsible for the ongoing management and retrieval of filters as well as clinicians managing patient (4,9). Retrievable filters should at least theoretically offer the benefits of permanent filters without complications of permanent ones; however, recent evidence suggests complication rates for retrievable filters to be higher than for permanent filters due to low retrieving rates. Failure to retrieve of IVC filter could be caused by several reasons including, patients being lost to follow-up, considerable thrombus within the filter, substantial filter tilt, embedded filter tip, embedded filter struts, strut perforation, and filter fracture. Multidisciplinary and systematic follow-up protocol, dedicated IVC filter clinic and proactive attitude previously shown to optimize filter retrieval rates in addition to optimization of resource allocation, and increased patient safety (6,7,35).

With standard retrieval techniques it is typically not possible to easily retrieve every filter. As many as 40–60% of retrievable-type filters cannot be removed using standard methods alone either because they have become firmly adherent to the caval wall or are tilted or malpositioned, particularly after prolonged dwell times (32,36). Filter tilt may occur either at the time of placement or may result from filter migration occurring subsequent to placement. Endothelialization of filter components occurs where there is contact between the filter and the caval wall; if this involves the filter apex and hook, an endothelial cap forms over these components. Histological studies have shown that the tissue formed between the filter and the IVC eventually becomes mostly fibrotic, thereby rendering standard retrieval techniques ineffective for filter removal (19). Additionally during retrieval attempts the fibrotic tissue that adheres the filter to the IVC wall may lead to mechanical complications such as filter fragmentation and IVC injury. Complicated retrievals are commonly reported with longer dwell times and the decision to retrieve or not retrieve a filter should be made with caution (28,37).

Conclusions

Many filters cannot be removed by using standard methods. Despite heightened awareness for closer follow-up and removal of implanted devices filter retrieval rate is far from ideal. Filters with increased dwelling times and tilting necessitates alternative and complex retrieval techniques. Several new techniques are described in the medical literature with single institution prospective studies showing them to be effective in retrieval of complicated filters, with excellent success rates. Multicenter prospective studies are necessary in order to better document actual success and complication rates when using advanced retrieval techniques for IVC filter removal.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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