Filter Considerations and Techniques for Challenging Retrievals

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Abstract: Inferior vena cava (IVC) filter placement has spanned several decades and several iterations, from permanent to optional filters; historically, they were left in permanently. In 2010, after several studies and legal proceedings showing complications related to long-term indwelling filters, the FDA made an official statement mandating that physicians involved must evaluate and remove filters as soon as medically appropriate and safe to do so. Adverse events were thought to be related to "the filter remaining in the body for long periods of time, beyond the time when the risk of pulmonary embolism (PE) has subsided,"[1] which has led to a desire and need to retrieve IVC filters as soon as protection from PE is no longer necessary. Although most filters can be removed without much difficulty when done early, there are factors that increase the risk of filter retrieval failure. Additionally, despite concerted efforts and due to the lack of a consistent and dependable national registry or other established universal tracking system, retrieval rates overall are still abysmal. The aim of this article is to review and describe the technical factors that may lead to filter retrieval failure, and to describe advanced techniques that may be utilized to retrieve these complex IVC filters.

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Key words: inferior vena cava filters, pulmonary embolism, filter retrieval failure, venous thromboembolism

Introduction

Venous thromboembolism (VTE) is the third most common cause of cardiovascular disease, following myocardial infarction and stroke.[2] The standard therapy for VTE is anticoagulation; however, when there is a contraindication for anticoagulation or failure of anticoagulation, an inferior vena cava (IVC) filter placement is warranted. Originally, the treatment option for PE protection was surgical ligation/interruption. Following this, in the late 1970s, percutaneous caval devices that filter the blood, such as the Mobin-Uddin umbrella filter (made of silicone rubber) was utilized. Subsequently, the Kimray-Greenfield metal-based filter, the first conical filter, was developed and utilized around 1990. These required large sheaths and over the years were found to have complications of their own. It was after this that a flurry of IVC filters were produced, and caval filter usage surged between 1979 and 2010, despite no clear data suggesting a mortality benefit.[2]

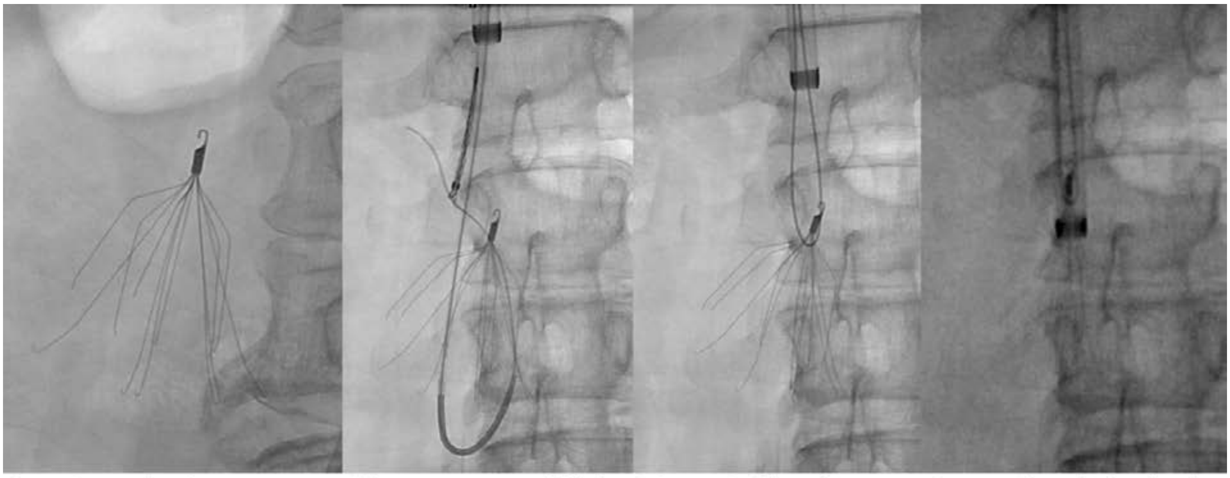
After the peak in 2010, there has been a steady decline in IVC filter placement (secondary to the FDA mandate in 2010), and studies demonstrated that unretrieved IVC filters can lead to a variety of complications, such as deep venous thrombosis (DVT), filter migration/embolization, filter fracture, IVC perforation, and filter-related iliocaval thrombosis.[3] This has led to a desire to retrieve these filters as early as safely possible, as it is known that complications can increase after as early as 30 days of filter dwell time.

Several factors can increase the risk of filter retrieval failure, including filter penetration into the caval wall, caval occlusion/thrombosis, severe tilt (>15 degrees), and an embedded filter hook.[4] This has led to the development and adoption of various basic and advanced techniques for filter removal. In addition, with increasing experience and innovations, many institutes have changed their approach to IVC filter retrieval; they provide algorithms considering the potential for retrieval failure and utilize advanced techniques to improve filter retrieval rates.[4]

Advanced Techniques

As the filter dwell time increases, difficulty in filter removal also can increase. This is especially true when a filter has excessive tilting during placement, or has tilted over time, which causes repetitive contact with the IVC wall due to natural respiratory motion, resulting in collagen/fibrin formation over the hook and cone of the filter. Additionally, as the struts of conical filters extend outside of the caval wall, along with potentially causing symptomatic irritation to adjacent structures such as the spine, intestines, arteries, and aorta, the struts can become scarred into the wall. Non-conical filters, such as the polyhedral Optease and Trapease (Cordis Medical), tend to become increasingly difficult to remove in an earlier period compared with conical filters. This is primarily because these devices have far more contact with the caval wall, resulting in increased embedment. Apart from these issues, fractured filters, filter fragments, severe angulations, thrombosis, and chronic occlusions cause significantly increased difficulty in retrieval attempts, which is why advanced techniques

Example Case

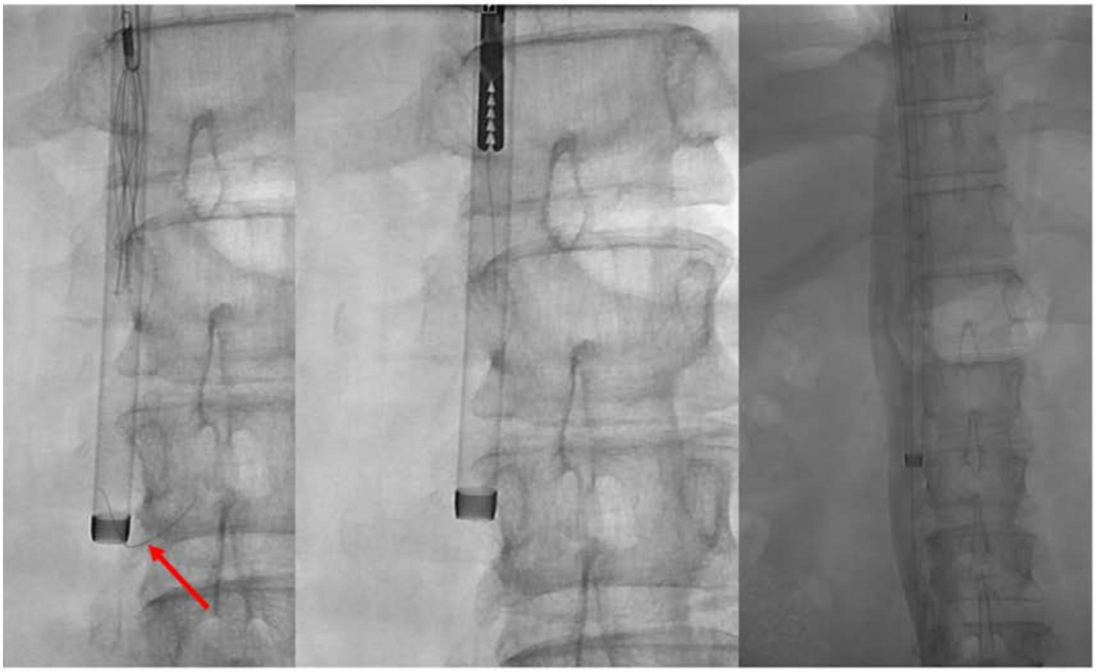


Scout image showing a retrievable filter, with secondary struts

After snare attempt failed due to hook being embedded in the caval wall, loop wire technique hangman technique utilized.

Prior to significant force, we ensure that the loop wire is indeed at the top of the cone, near the hook, and not just a single strut.

Once confirmed, the sheath is advanced steadily over the filter to collapse all the struts.



The filter once in the sheath was pulled out, however notice a broken struct left behind (red arrow)

Endobronchial forceps were used to successfully remove the broken filter strut.

Completion venogram. performed due to complex nature of removal, showed no complication.

are required. These techniques are often performed after failure of simple sheath-snare approaches, although experienced operators may skip this attempt based on imaging findings. The most important learning lesson, and fundamental understanding to note, is that the filter should not be dragged into a sheath; it should be ensheathed. This will avoid complications that should have been avoided. For most advanced techniques, a minimum of 16 Fr sheath size is recommended to start with, which allows most approaches to be utilized. When planning for laser use, the authors prefer to start with a 20 Fr sheath.

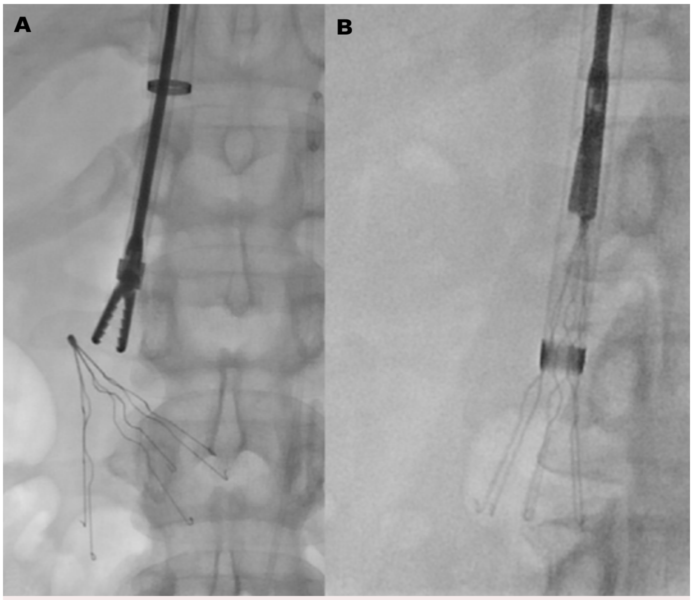


Figure 1. (A) Markedly tilted Greenfield inferior vena cava filter unable to be removed with standard techniques. **(B)** Utilizing endobronchial forceps and careful technique, the filter was successfully ensheathed and removed entirely.

Wire Loop/Hangman Technique

The wire loop technique is used when a standard snare cannot grasp the hoop of a non-embedded filter. Using a reverse curve catheter that is guided through at least 2 filter struts, a hydrophilic wire is advanced cranially and the free end of the wire is snared and brought out of the sheath. Back tension on the wire loop is performed while the sheath is coaxially deployed to collapse the filter internally. It is important to perform oblique projections to ensure that the loop is not simply over a single strut, especially in filters that may have easily fractured struts, such as secondary struts in Celect filters (Cook Medical). Once confirmed, the continued tension, counter-tension technique between the loop wire and the sheath can help to safely collapse and remove the filter in its entirety.

The hangman technique is a modification of the wire loop technique when the hook/cone of the filter is embedded within the IVC wall due to formation of fibrin. In addition to the steps described above, considerably more continuous tension and counter-tension will be needed to gradually disrupt the fibrous capsule and successfully bring the proximal aspect of the filter into the sheath. Often, both techniques are used interchangeably.

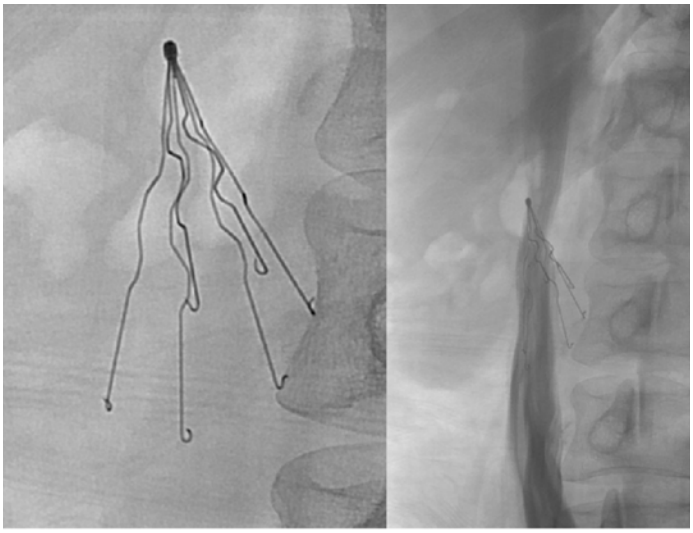
Endobronchial/Endoscopic Forceps

The forceps technique for filter retrieval has a significant benefit in patients where the tip or hook is embedded in the IVC wall, thus limiting the ability to snare the top of the filter. This has often become a go-to option for advanced operators compared with wire-loop or hangman approaches. This is mostly because it can help avoid situations such as bending the proximal filter aspect, elongating the hook, filter strut fracturing, and loop wire breakage that is seen with the other techniques. However, it should be noted that use of forceps requires caution, and a certain level of experience, as novice users can easily find themselves in complications with misuse or unnecessarily aggressive maneuvers. The most-used endobronchial forceps is the Lymol 4162 (Lymol Medical), which is off-label, and can be advanced through a sheath ≥12 Fr; however, ≥16 Fr is recommended if using forceps to bring the filter into the sheath rather than just for fibrin maceration. Again, experience is beneficial when using rigid forceps, as haphazard use can cause significant complications including caval perforation, adjacent arterial damage, and twisting/intussusception of the IVC, which can be devastating. These forceps can be sterilized, and shaped as needed, to approach tilted filters. During its use, the forceps is mostly used to gently dissect the filter tip free from the fibrin cap coating, and once freed, can assist to move the filter away from the wall (**Figure 1**). Once the forceps' teeth contact the metal tip/hook of the filter, it is used to maintain gentle traction on the filter while the remainder of the filter is captured by advancing the sheath; again, the filter should never be pulled up completely.

Laser Sheath

Often, the amount of fibrin formation associated with the filter cannot be overcome with techniques such as wire loops and endobronchial forceps. Due to this, many advanced operators use laser-assisted filter removal, as the photoablative and mechanical qualities of the laser can release the filter from the caval wall. The CavaClear (Philips) IVC filter removal sheath is the first and only FDA-approved device for advanced filter removal, granted a De Novo designation in 2022. Prior to this, many operators utilized this device off-label, with considerable success. The CavaClear

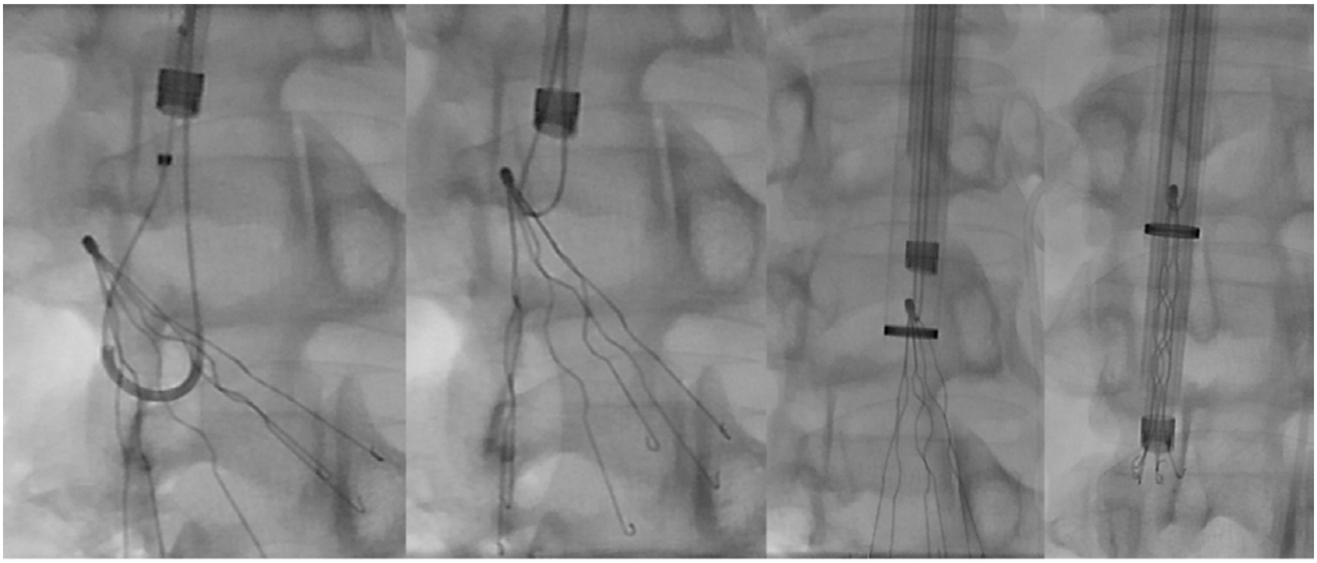
Example Case



Tilted chronic >20year old Greenfield Filter, in a symptomatic patient.

Venogram showing several struts outside of the caval confines. On CT scan (not included), struts were interactive with the spine and aorta.

Example Case



Hangman Wire Loop technique, performed through the 16Fr laser sheath, was used to free the embedded cone of the filter from the caval wall

Once Freed, the cone was brough towards the laser sheath.

The outer larger braided sheath is brough over the laser sheath and wire-looped filter to provides stability

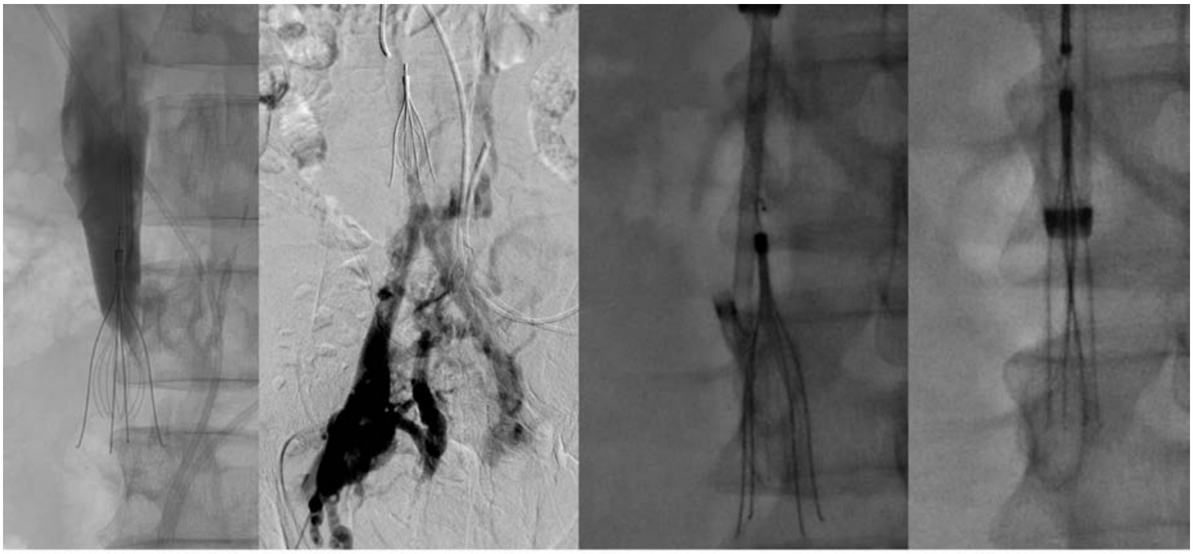
With steady, progressive activation of the laser, the filter is completely collapsed, and eventually safely removed in entirety.

catheters come in 14 Fr and 16 Fr sizes and are used with the Nexcimer and CVX-300 laser generators (Philips). To use the laser catheter, first the hook, cone, or proximal aspect of the filter must be able to be brought into the sheath or catheter, either by using a snare, loop wire, or forceps. Often, the authors prefer to start with a 20 Fr sheath with a 16 Fr coaxial braided sheath, and attempt with the above-mentioned approaches to grab control of the filter. If, after having control of the top of the filter the attempt is not successful, the 16 Fr sheath is exchanged for the laser catheter, which can be advanced over a loop wire control. Once the laser is positioned over the top of the filter, whether it be conical or polyhedral, the laser is then activated in steady, short bursts, progressively advancing the catheter over time. Eventually the filter collapses and can be removed once it is completely within the catheter. An additional advantage of the laser sheath is that it has a metal tip, which can help disengage and remove the strut ends of filters that otherwise shred braided sheaths, such as the Greenfield filters. With growth of laser experience, permanent filters previously thought to be not removable have been removed, such as VenaTech LGM (B. Braun).[6] With the recent FDA approval, it is likely that advanced interventionalists will often prefer to go straight to this approach when possible.

Complex IVC Filter Removal With Iliocaval Occlusion

As described above, a well-known complication of long-term indwelling IVC filters is thrombosis of the venous system and possibly chronic occlusion. This can be a very complex situation as the decision has to be made whether to attempt a complex IVC filter removal and iliocaval reconstruction. This should be a carefully assessed approach. Once chronically occluded, it may be prudent to leave the filter in place and not pursue reconstruction if the patient is not symptomatic, as they may have collateralized sufficiently and may be able to tolerate mild symptoms such as minimal swelling. However, patients with such situations can be found to have post-thrombotic syndromes; these are especially troubling for patients with nonhealing or recurrent venous ulcers of the lower extremities, which can be debilitating and often take months to years of wound care and have other complications. Other indications may include venous claudication, symptomatic varicose veins, etc. If the intervention is undertaken, the decision also includes whether to perform exhaustive attempts to remove the embedded IVC filter, to potentially stent through and exclude the filter. There are no definitive data regarding which method provides the best outcome; however, we feel that if the filter can be removed, it should be, and this may reduce issues with pushing the filter against the caval wall (conical filters) by the stent scaffolds, which may cause additional caval perforation and symptomatic irritation of adjacent structures. If the proximal and/or distal aspect of the filter can be controlled, we feel it should be removed. If extracaval or in some instances with the polyhedral filters, it may be easier to stent through the filter. Regardless of approach, good preoperative cross-sectional imaging, frank discussions with patient/family and referrers, and access and experience with advanced techniques are recommended.

Example Case

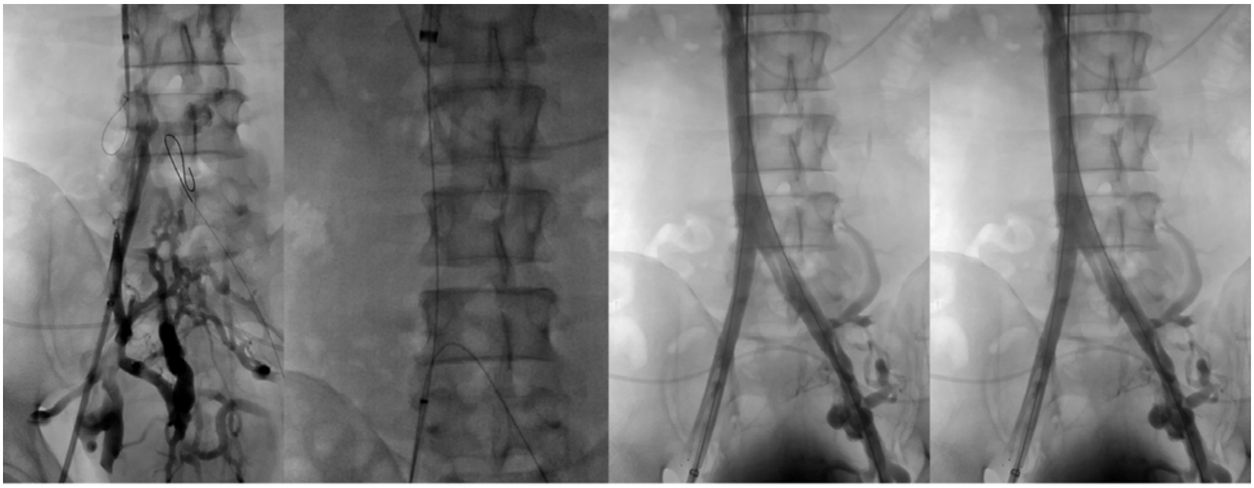


Initial inability to pass a wire beyond the filter suggests occlusion. Proximal venogram shown here.

Venograms from bilateral common femoral vein access shows extent of chronic iliocaval occlusion.

A tip deflecting sheath was used to center the filter from the caval wall.

While filter was centered, snare was used to capture the filter hook and collapse completely into the sheath and removed.



Images from the Iliocaval reconstruction showing initial crossing from right neck and both groins, with eventual double barrel stenting of the IVC and iliac veins.

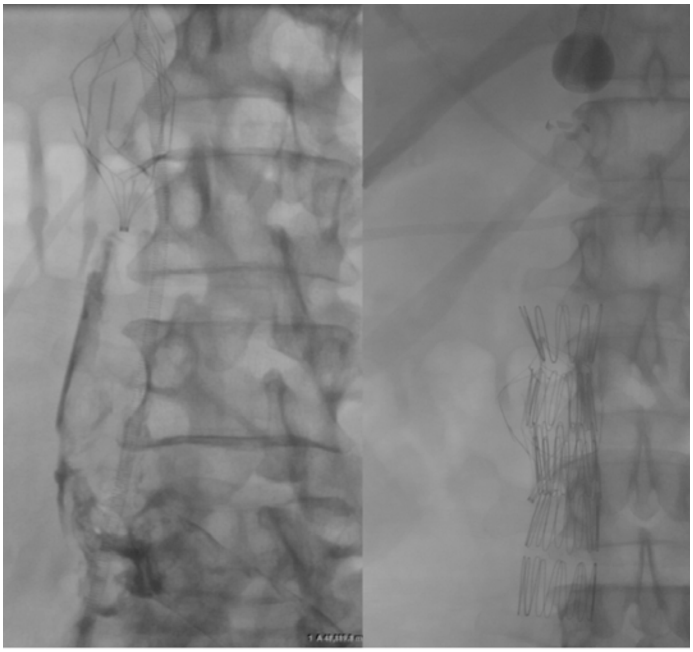
Example Case of Iliocaval Occlusion with IVC Filter

The patient is a septuagenarian male with a history of stroke and an incidentally found IVC filter, which he was not aware of 12 years earlier when he was being worked up for abdominal pain and lower extremity venous ulcers. The patient had a CT scan, which showed iliocaval occlusion with collateral formation, and he was planned for intervention. Post procedure, the patient experienced improvement of abdominal pain and eventual wound healing of the lower extremity. His venous insufficiency has been managed lifelong with compression therapy and other conservative measures.

Conclusion

IVC filters are critically important devices which,when present for prolonged dwell times, can lead to significant and debilitating complications. Due to widespread use in the last few decades and an understanding of the complications they can cause, progressively advanced percutaneous techniques have been developed to retrieve these filters. Despite the heightened awareness for closer follow-up and early removal of implantable IVC filters, filter retrieval rate continues to range from 8.5% to 34%.[7] Filters that penetrate the caval wall and cause caval occlusion/thrombosis, severe tilt, increased dwell time, and embedded filter hooks often

Example Case of Filter Exclusion



Fractured Trapease Stent with extensive, acute IVC thrombosis, which can be seen as large filling defects below the filter.

After successful large bore veno-veno extracorporeal aspiration thrombectomy and Gianturco Z Stent Assisted exclusion of the filter.

cannot be removed by standard methods. Advanced techniques are then utilized and can increase the success rate while minimizing complications. With experience and support, most of these filters can be effectively and safely removed in the appropriate clinical context. It is recommended that filters that require advanced techniques, or have failed conventional attempts, be referred to advanced centers and if embedded, be removed with the aid of laser catheter systems. ■

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