Current IVC Filter Retrieval Techniques

A problem-solving approach to retrieving embedded inferior vena cava filters.

BY KUSH R. DESAI, MD; ROBERT K. RYU, MD, FSIR;
AND ROBERT J. LEWANDOWSKI, MD, FSIR

The development of retrievable inferior vena cava filters (rIVCFs) has resulted in significant increases in device implantation; today, they represent the majority of filters placed.[1] The growth in rIVCF use is largely due to the potential for device retrieval, which has resulted in decreases in utilization thresholds as well as expansion of relative indications for placement.[2,3]

Although rIVCFs are designed to be removed when no longer indicated, device retrieval rates are very low.[4,5] One study reported a retrieval rate of 8.5%,[6] and retrieval rates of < 2% have been observed in cancer patients.[7] The US Food and Drug Administration (FDA) has cleared rIVCFs for permanent implantation; however, findings from recent studies suggest that rIVCFs do not have equivalent safety profiles to permanent IVCFs,[8,9] and thus, permanent rIVCF implantation may be problematic. These findings prompted the FDA to issue safety communications in 2010 and 2014, stating that physicians and clinicians charged with the implanting and ongoing care of patients with rIVCFs should consider device retrieval when no longer indicated.[10] Indeed, the management of patients with rIVCFs has now garnered significant national media and medicolegal attention.

THE ROLE OF PROLONGED FILTER IMPLANTATION

Prolonged filter implantation time plays a key, multifactorial role in patient outcomes. Prolonged rIVCF dwell time has been associated with retrieval failure rates as high as 43%,[11] which has been confirmed in numerous studies.[12-14] Retrieval failure has been primarily attributed to filter component incorporation into the IVC wall. These findings have led to a widely held belief that rIVCF with extended implantation times should be left in situ, due to the theoretical risk of injury to vascular or retroperitoneal structures from the retrieval procedure.[15]

However, prolonged filter dwell time has been associated with device-related complications including perforation/penetration of the IVC wall and adjacent structures,[16-19] and most notably fracture with subsequent component migration/embolization.[20-23] Retrievable IVCFs with extended implantation times potentially encounter prolonged exposure to caval forces, which may result in metal fatigue and increase the risk of fracture/embolization.[24,25]

The development of advanced retrieval techniques has significantly affected retrieval of embedded rIVCFs, many of which have extended implantation times, and were previously deemed irretrievable.[25] A 2015 study demonstrated that filter retrieval can be performed regardless of dwell time, with a failure rate of ≤ 3% when advanced endovascular techniques are used. Despite the complex nature of some of these advanced retrieval procedures, low complication rates were reported and were not associated with filter dwell time.[26] More recently, a 2017 study suggested that prolonged implantation should be defined as the point at which the risk of standard retrieval technique failure increases significantly, thereby requiring advanced retrieval techniques to maintain overall retrieval success rates. Retrievable devices in place after 7 months frequently required advanced retrieval techniques; thus, such patients may benefit from referral to centers with expertise in advanced filter retrieval.[27]

FILTER RETRIEVAL TECHNIQUES

Standard Technique

The basic method of rIVCF retrieval is based on the capture of the filter apex/hook, followed by the coaxial collapse of the device into a sheath. Capture of the filter apex/hook is typically performed with an endovascular snare device. In addition, manufacturers of rIVCFs may supply proprietary retrieval devices.

We typically begin a retrieval procedure by introducing a pigtail flush catheter over a wire caudal to the filter. After performing a cavography to assess for in situ filter thrombus, we typically place 8- and 12-F telescoping sheaths immediately adjacent to the filter. Once the filter hook is captured, equal and opposite traction/counter-traction is applied to the snare and sheath to disengage the filter from the caval wall.

Standard filter retrieval techniques typically fail when the filter is significantly tilted, the apex of the filter is embedded in the wall, or the filter struts are incorporated into the wall. In one analysis, standard filter retrieval techniques were noted to fail more frequently after a 7-month implantation time.[27]

In cases where the filter has been in for extended periods of time, preprocedural planning is critical. It is our practice to review imaging from the initial placement, as well as to perform a CT scan of the abdomen/pelvis. As advanced retrieval techniques are frequently necessary in these retrieval cases, CT allows identification of factors that increase procedural complexity, including filter tilt, embedded or extracaval filter hooks/apices, device fracture, perforation of components into extracaval structures, and caval thrombosis.[28]

One of the most commonly encountered reasons for failure of standard retrieval techniques is encasement of the filter apex/hook in fibrinous tissue along the caval endothelial surface. In these cases, snare and proprietary cone devices are typically unable to engage the apex/hook. This "fibrin cap" is typically radiolucent, although it is frequently identified during digital subtraction angiography. Several techniques have been described as an approach to this problem; however, in our experience, the most important techniques are formation of a loop snare and use of rigid endobronchial forceps.

Loop Snare Technique

The loop snare technique was initially described as a method to engage a tilted or embedded filter by forming a wire loop through the main body of the rIVCF.[15] We have developed a variation of this technique, where the fibrin tissue cap is engaged and a wire loop is formed in the plane between the caval lumen and tissue cap.[29] In our technique, a reverse-curve catheter is formed and used to engage the cap. Once engaged, a hydrophilic wire is then advanced cranially and snared to form a wire loop through the tissue cap. The sheath is then advanced coaxially over the wire loop, either resulting in rIVCF collapse within the sheath or release of the fibrin tissue cap. If the latter occurs, the rIVCF is then typically retrieved via standard techniques. Figure 1 depicts the procedural steps of the loop snare technique.
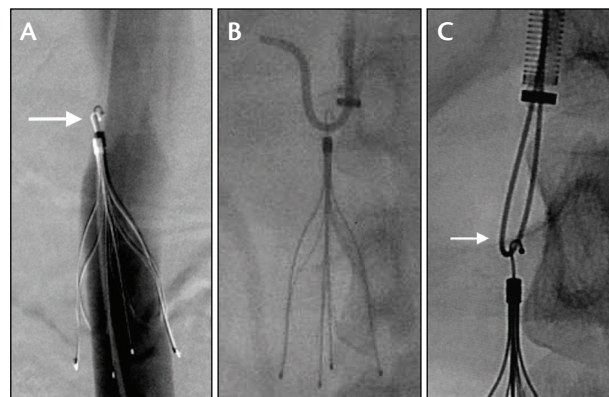

Figure 1. Loop snare technique. Digital subtraction angiogram of the IVC demonstrating a fibrin cap encasing the filter hook/apex (A) (arrow). Fluoroscopic imaging demonstrating reverse-curve catheter utilized to engage fibrin cap (B). Looped wire engaging radiolucent fibrin cap (C).
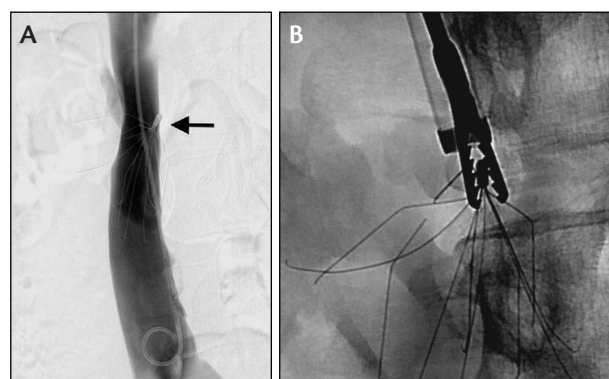

Figure 2. Digital subtraction angiograms of the IVC demonstrating filter apex abutting caval wall (A) (arrow). Note that the filter was fractured prior to retrieval attempt. Spot fluoroscopic image demonstrating forceps capturing filter apex (B).

Rigid Endobronchial Forceps

Rigid endobronchial forceps (model 4162, Lymol Medical Corporation) are used off-label for filter retrieval; however, they have developed into a critical tool in advanced rIVCF retrieval. They have been used to dissect hyperplastic tissue from the rIVCF apex/hook, thereby permitting capture of the apex once it is exposed, followed by coaxial collapse of the filter within the sheath (typically 12 F or larger) (Figure 2).[30] These forceps are malleable and can be shaped to provide the optimal curvature to dissect tilted, encased filter apices. Operator experience with forceps is critical, as there are significant complications that can arise from misuse. For example, large curvatures of the forceps can result in significant caval distention, which can lead to patient discomfort. When possible, we perform forceps retrieval under deep sedation provided
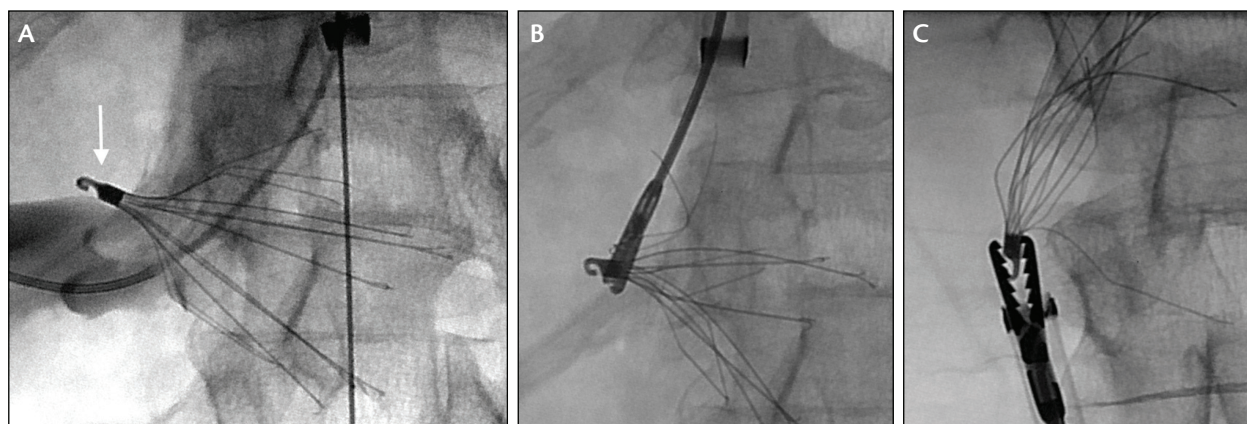
Figure 3. Right renal venogram demonstrating hook (arrow) of severely malpositioned filter eroded through the dorsal renal vein wall (A). Spot fluoroscopic imaging showing forceps used from jugular access to reposition hook into renal vein lumen (B). Forceps from right femoral access were used to capture the hook of malpositioned filter followed by complete filter inversion and retrieval (C).

by anesthesiology. Furthermore, trauma to the IVC can occur if the operator inadvertently grasps the caval wall.

Forceps also permit retrieval of severely malpositioned filters, including devices where the filter apex has eroded through the caval wall. In these cases, dual jugular and femoral venous access may be necessary to sequentially manipulate and retrieve the rIVCF (Figure 3). In these cases, great care must be taken not to apply large, unopposed forces to the device, as this poses a risk of significant caval injury.

Finally, forceps also aid in the retrieval of fractured rIVCF struts. A recently published study demonstrated that forceps, along with snares, can be utilized to retrieve fractured filter fragments from the IVC.[31] Retrieval of these fragments, if feasible, is important

due to the possibility of future embolization, which can result in serious morbidity including cardiac tamponade and arrhythmia. As shown in Figure 4, introduction of the forceps through a large-diameter sheath (16 F or larger) can be used to retrieve fractured struts; however, care must be taken to use a gentle technique when retrieving these struts, as there is a risk of intraprocedural embolization.

Figure 4. Spot fluoroscopic imaging demonstrating fractured strut fragment retrieval from the femoral approach.
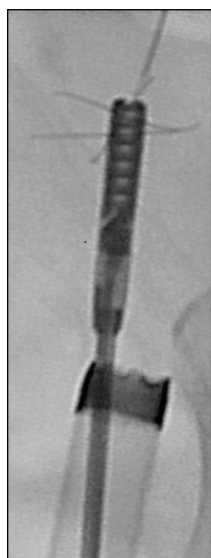
Excimer Laser Sheath-Assisted Photothermal Ablation

Incorporation of the rIVCF struts in the caval wall can make device retrieval hazardous or impossible, despite successful filter apex/hook engagement and exertion of large forces. The application of large forces in these cases can result in significant morbidity, including caval disruption, intussusception, and torsion. In these cases, laser sheaths that are on-label for pacemaker lead extraction have been successfully used in an off-label manner
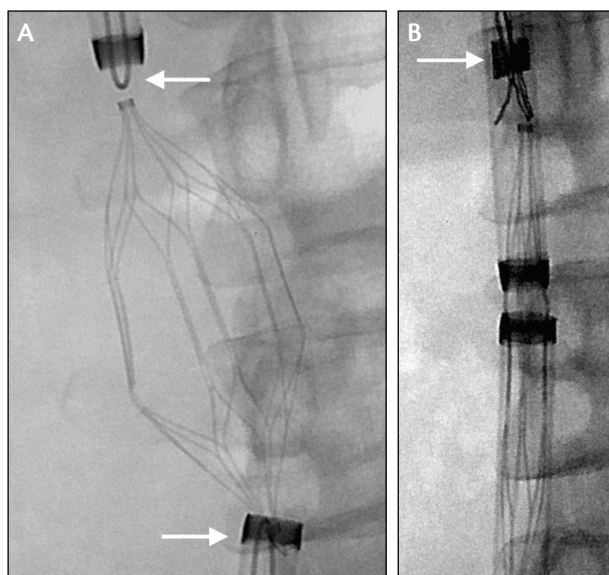

Figure 5. Photothermal laser ablation for embedded IVCF struts. Spot fluoroscopic imaging demonstrating secured cranial and caudal apices (arrows) of filter prior to introduction of laser sheath (A). After snare capture of filter apex, the laser sheath (arrow) was sequentially activated to enable ablation of fibrinous scar tissue, thus enabling filter removal (B).

to ablate fibrinous tissue encasing the filter struts, minimizing the large forces that would be applied during the retrieval procedure when standard techniques are used.[32] The CVX-300 Excimer laser system (Spectranetics Corporation) utilizes 12-, 14-, and 16-F, 50-cm sheaths (GlideLight, Spectranetics Corporation) to ablate the tissue encasing filter struts. These sheaths are introduced through a larger outer sheath, typically 16 F or larger (Figure 5). It is critically important to have control of the filter apex/hook before using the laser sheath; in many of our complex retrieval cases, other advanced techniques are necessary to gain control of the rIVCF apex/hook before the introduction and use of the laser sheath.

CONCLUSION

Retrieval of rIVCFs has taken on heightened importance, particularly considering device-related complications, which appear to increase with prolonged filter dwell time. The development of advanced filter retrieval techniques permits retrieval of most devices regardless of their implantation time. As such, rIVCF retrieval may mitigate patient risk and should now be considered in all patients in whom the rIVCF is no longer indicated. ∎

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Kush R. Desai, MD
Co-Director
IVC Filter Clinic
Assistant Professor of Radiology
Section of Interventional Radiology
Department of Radiology
Northwestern University, Feinberg School of Medicine
Chicago, Illinois
kdesai007@northwestern.edu
Disclosures: Speaker's bureau for Cook Medical and Boston Scientific Corporation; consultant for Spectranetics Corporation and AngioDynamics.

Robert K. Ryu, MD, FSIR
Division Chief
Interventional Radiology
Professor of Radiology
University of Colorado, Anschutz Medical Campus
Aurora, Colorado
Disclosures: None.

Robert J. Lewandowski, MD, FSIR
Co-Director
IVC Filter Clinic
Northwestern University, Feinberg School of Medicine
Chicago, Illinois
Disclosures: None.