Advanced IVC Filter Retrieval Techniques

Options when risks of permanent device implantation outweigh the potential complications of retrieval.

BY BRIAN G. DERUBERTIS, MD

Although surgical caval interruption for prevention of massive pulmonary thromboembolism (PE) had been performed since before the 1950s, the contemporary era of PE prevention was ushered in by the advent of percutaneously implantable inferior vena cava (IVC) filters in the 1990s. Early IVC filters included permanently implantable devices such as the Bird's Nest (Cook Medical, Bloomington, IN), the Vena Tech (B. Braun Interventional Systems, Inc., Bethlehem, PA), the Simon Nitinol (Bard Peripheral Vascular, Inc., Tempe, AZ), and the Greenfield (Boston Scientific Corporation, Natick, MA) filters.[1,2]

These devices proved to be effective in preventing fatal or massive PE in patients with deep venous thrombosis who had contraindications to systemic anticoagulation. Over the past decade, the use of percutaneously implantable IVC filters has skyrocketed, due in large part to the development of retrievable filters that can be removed once they are no longer deemed necessary. In 1999, there were approximately 49,000 IVC filters placed in the US, and in 2012, this number is estimated to reach over 250,000.

RATIONALE FOR AN AGGRESSIVE APPROACH TO FILTER RETRIEVAL

Although IVC filters are essential for treating patients with deep venous thrombosis who have contraindications to anticoagulation, they do not come without the risk of complications. IVC filter strut fracture, migration, and embolization have all been reported with indwelling filters.[3-5] Additionally, filter thrombosis and loss of caval patency has been a concern since the time of early permanent percutaneously implanted filters, with rates of caval occlusion ranging from 4% to 30% in longitudinal studies.[2,6-8] Finally, recent reports have increasingly documented higher rates of recurrent venous thromboembolism in patients with indwelling IVC filters.[9] These issues highlight the importance of removing retrievable filters once the contraindication to anticoagulation has passed and caval interruption is no longer necessary.

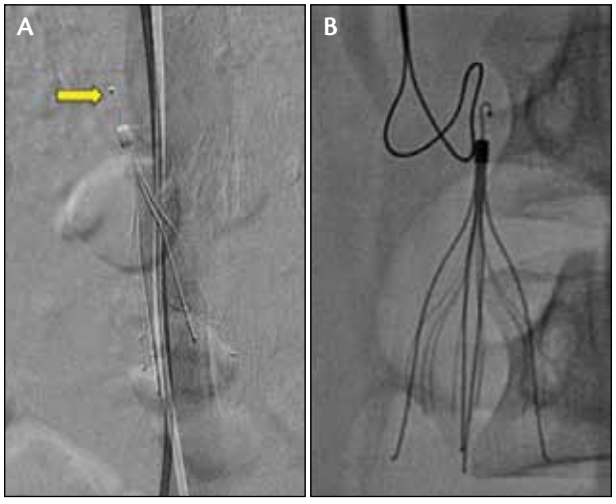

Figure 1. Tilting or poor centering of an IVC filter can result in the hook becoming embedded in the caval wall (yellow arrow) due to overgrowth of intimal hyperplasia over the hook (A). Cine images demonstrate the inability of the snare to loop around the hook despite the close proximity of the snare and hook because of the overgrowth of tissue around the retrieval hook (B).

IMPEDIMENTS TO RETRIEVAL OF TEMPORARY IVC FILTERS

Despite the obvious benefits of retrievable filters, studies unfortunately suggest that the retrieval rates of temporary or retrievable filters are quite low and seldom exceed 20% in most series.[10,11] In only a minority of the patients who fail to have filter retrieval is there a persistent need for caval inter-

TABLE 1. CURRENTLY AVAILABLE IVC FILTERS IN THE US, WITH RETRIEVAL WINDOWS BASED ON EARLY, DEVICE-SPECIFIC CLINICAL TRIALS

Filter	Manufacturer	Material	Design	Retrieval Approach	Retrieval Window in Initial Clinical Trials
ALN Optional	ALN	Stainless steel	Conical with centering legs	Internal jugular	6–722 days
Option	Argon Medical Devices, Inc. (Plano, TX)	Nitinol	Conical	Internal jugular	1–175 days
Eclipse	Bard Peripheral Vascular, Inc.	Nitinol	Conical with centering struts	Internal jugular	5–300 days
Celect	Cook Medical	Conichrome	Conical with centering struts	Internal jugular	7–466 days
Tulip	Cook Medical	Conichrome	Conical	Internal jugular	2–20 days
Optease	Cordis Corporation	Nitinol	Hexagonal double basket	Internal jugular, femoral	3–48 days
Crux[a]	Crux Biomedical Inc.	Nitinol, ePTFE	Helical	Internal jugular, femoral	6–190 days

[a]Available in 2013, received FDA clearance July 2012.

ruption, and the remainder fail to have filter retrieval for one of several reasons. The most common reason for retained filters is likely a result of patients being lost to follow-up and not offered retrieval. This is especially true in the trauma population—a group that receives a relatively high percentage of filters placed for prophylactic reasons and is known to have low follow-up rates. Strategies to improve retrieval rates in this group include filter removal before hospital discharge and increased use of IVC filter registries to improve follow-up of patients receiving retrievable filters.[12,13]

Although technical failure during attempted IVC filter retrieval is a less common reason for filter retention, the incidence of this increases with longer dwell times and with specific technical issues encountered in some patients. Attempting retrieval during the manufacturer's reported safe retrieval window, as well as familiarity with advanced retrieval techniques highlighted in this article, may help reduce the likelihood of undesired filter retention.

STANDARD IVC FILTER RETRIEVAL

The accepted window of retrievability for each filter generally mirrors the protocols in the device's premarket clinical trials (Table 1). Several filters are recognized as having an open indication for retrieval (G2 Eclipse, Bard Peripheral Vascular, Inc.; ALN Implants Chirurgicaux, Ghisonaccia, France), with no defined limit to the retrievability window. Despite these retrieval window guidelines, most interventionists have found that filters can be safely retrieved outside of these windows, even though the ease with which they can be retrieved seems to diminish with increasing dwell time. At our institution, we attempt retrieval as soon as the contraindication to anticoagulation has passed, generally proceeding during the same hospitalization or within 2 weeks of hospital discharge.

For standard, normal-risk retrievals, the protocol for retrieval follows that which is outlined in the specific device's instructions for use. Most currently available filters are retrieved via an internal jugular vein approach using retrieval kits designed for the specific filter, although the basic protocol is similar across most filter types. The procedure is performed under conscious sedation and/or local anesthesia, beginning with duplex-guided puncture of the right internal jugular vein and introduction of a 5-F sheath. A pigtail catheter is then advanced over a guidewire to the caval confluence, and venography is performed. If the filter is patent and free from significant clot burden (< 25% filled with thrombus), removal is then performed.

To do this, a stiff guidewire is placed to a level below the filter, and this wire is used to introduce the retrieval kit sheath (9 to 11 F) into the infrarenal IVC. Next, an endosnare catheter or retrieval cone is used to grasp the hook or retrieval hub on the top of the filter device. Once engaged, tension is gently applied to the snare as the retrieval sheath is advanced coaxially over the filter in order to collapse the filter struts and disengage them from the caval wall. The filter is then removed, and completion venography is performed through the sheath.

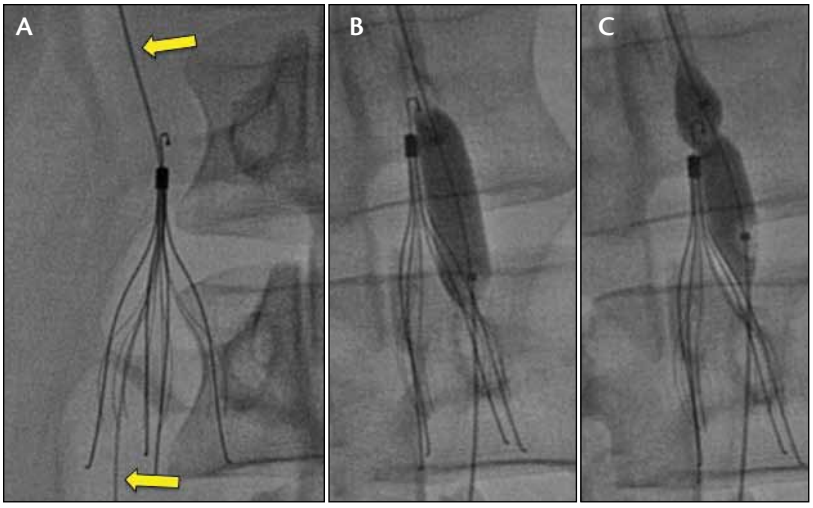

Figure 2. Right internal jugular-to-right femoral wire access (yellow arrows) can be used to try to center the filter within the cava, thus allowing better access at the retrieval hook by the snare catheter (A). Inflation of a balloon between the filter and the caval wall can disrupt the intimal hyperplastic tissue that has covered the retrieval hook and can help to center the filter (B). Intimal hyperplastic tissue around the hook causes a waist in the balloon that can be seen during balloon inflation (C).

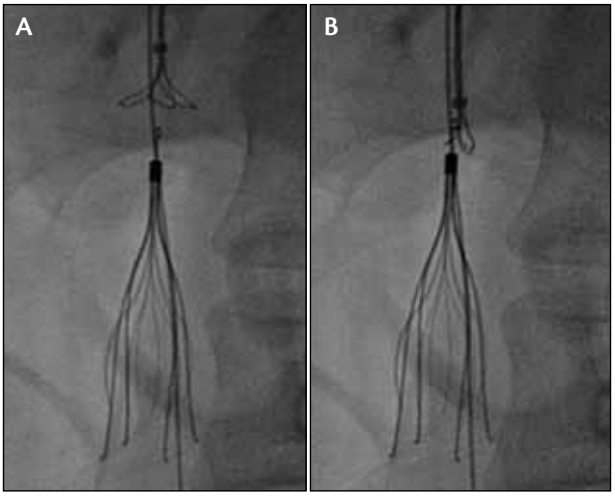

Figure 3. In the snare-over-guidewire technique, the guidewire adjacent to the retrieval hook is backloaded through the snare (A), and the snare catheter is then advanced over this guidewire in order to guide the snare loop around the retrieval hook (B).

DECISION MAKING AND TECHNIQUES FOR RETRIEVAL OF TILTED AND ADHERENT FILTERS

Reasons for technical failure of filter retrieval tend to fall in one of two categories: (1) inability to grasp the proximal hook/hub of the filter due to filter tilt, or (2) dense adherence of the filter struts to the caval wall. Predicting which filter retrievals will be technically difficult is not always possible, but generally speaking, longer dwell times and a history of caval thrombosis increases the likelihood of encountering such difficulties. Additionally, specific types of retrieval difficulties can be predicted by filter type, as those without centering arms are more prone to filter tilt and associated hook-capturing difficulties, and those with larger amounts of metal opposing the caval wall tend to become more firmly embedded.

Most of the difficulties encountered during filter removal attempts can be overcome with careful planning and the use of certain advanced retrieval techniques. However, it is important to realize that aggressive attempts at filter retrieval may be associated with increased risks of complications, including access site issues secondary to the large sheath size required, intraprocedural caval thrombosis or vasospasm, and the potential for caval injury and hemorrhage. Additionally, these techniques involve maneuvers that are outside the device manufacturer's instructions for use, and complication rates for these attempts are poorly defined and must be extrapolated from small, single-institution series reporting on these techniques.[14-17]

These concerns should be carefully weighed against the long-term risks of indwelling filters, including filter fractures and migration, strut erosion into adjacent structures, loss of caval patency, and increased subsequent deep venous thrombosis risk, and a thorough discussion of these concerns should be undertaken with the patient. During these maneuvers, the patient is fully anticoagulated with intravenous heparin to prevent caval thrombosis, and he or she is kept under moderate sedation so the surgical interventionist can monitor for escalating pain or discomfort during retrieval attempts, which may signify impeding caval injury.

Centering Techniques

Although some of the contemporary filters available in the US and Europe have centering legs that help prevent filter tilt (G2 Eclipse, Bard Peripheral Vascular, Inc.; Celect, Cook Medical), all filters can nonetheless tilt in a manner in which the retrieval hook lies against the caval wall, and this in turn allows for growth of intimal hyperplastic tissue over the hook, thus preventing capture of the hook by standard techniques (Figure 1). Centering maneuvers are among the techniques used for repositioning the hook to the middle of

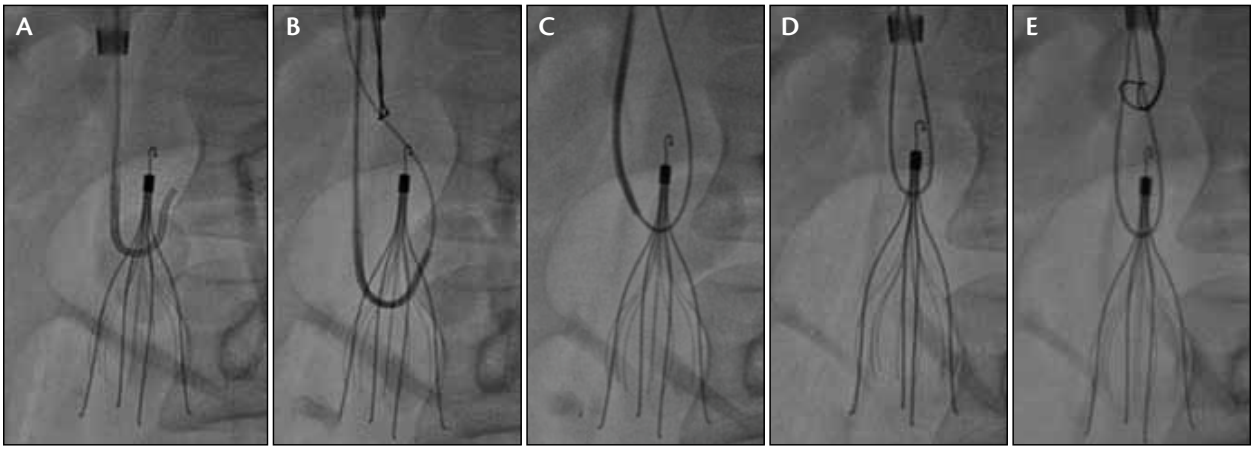

Figure 4. The snare-over-loop technique uses a curved catheter placed between the struts of the filter (A) in order to create a guidewire loop, which is then snared (B, C) and brought out of the cephalad internal jugular sheath. Traction applied to this guidewire loop (D) then allows for centering of the filter and can be used to guide a snare down to and around the retrieval hook (E).

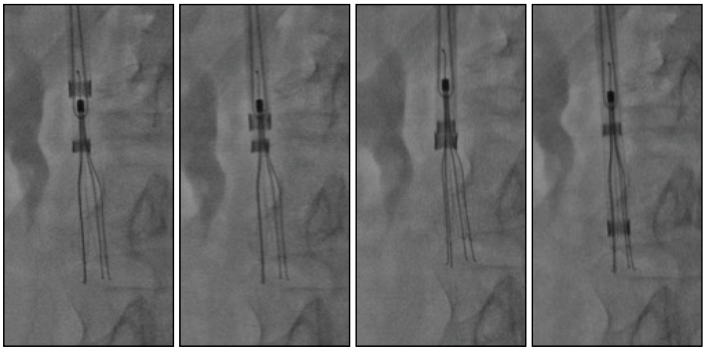

Figure 5. The double-sheath dissection technique utilizes a coaxial sheath configuration in which the two sheaths are manipulated simultaneously in a twisting and to-and-fro motion to dissect the attachments between the filter and the caval wall.

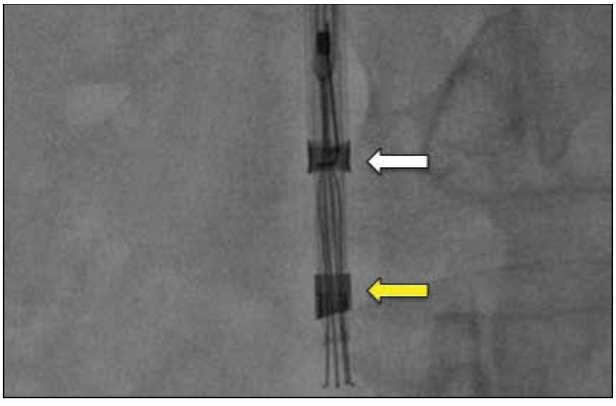

Figure 6. Laser-assisted filter retrieval uses a coaxial sheath system, including a 12-F SLS II laser sheath (yellow arrow) through a 14-F Performer sheath (white arrow). This method takes advantage of the double-sheath dissection technique and the effects of laser photoablation of the overlying intimal hyperplastic tissue.

the cava. Figure 2A demonstrates a steerable 0.035-inch guidewire being directed from the internal jugular vein down to the lateral aspect of the filter (toward the embedded hook). This wire can then be brought out through a sheath in the right common femoral vein and, by applying traction to each end of the wire, the wire helps to deflect the filter away from the wall and toward the center of the cava.

If this is unsuccessful, an angioplasty balloon can be inflated between the wall of the cava (Figure 2B) and the filter to disrupt the intimal hyperplasia that has grown over the filter retrieval hook and to center the filter within the cava. Finally, centering of the filter can be attempted by advancing devices up through a femoral access approach in order to engage the underside of the filter and direct it centrally within the vena cava. Devices that have been utilized for this purpose include the 0.035-inch Reuter tip-deflecting wire guide (Cook Medical), rigid bronchoscopy forceps, and endomyocardial biopsy forceps.

Snare-over-guidewire technique. If centering techniques have not allowed for engagement of the retrieval hook, the snare can be brought over the guidewire, which acts as a "rail-wire" to help line up the retrieval hook with the snare (Figure 3).

Snare-over-loop guidewire technique. Additional centering of the filter and retrieval hook can be accomplished by passing a wire between the struts of the filter and then applying tension to the filter with this wire. This is done by upsizing the standard 9- to 11-F retrieval sheath to a 12- or 14-F sheath (50 cm), reforming a 5-F VCF catheter (Cook Medical) between the legs of the filter (Figure 4A) and then passing a 0.035-inch angled Glidewire (Terumo Interventional Systems, Inc., Somerset, NJ) through the VCF

catheter. The floppy end of the wire is then grasped with a snare catheter (Figure 4B and C) and brought out through the internal jugular sheath so that both ends are coming out through the sheath.

The VCF catheter can then be removed, and the snare is reloaded on the two ends of this wire to help guide the snare down to the retrieval hook. Tension is applied to the two ends of the looped guidewire while the snare is advanced over the loop until it can engage the retrieval hook (Figure 4D). Once the hook is grasped with the snare, the wire is removed to allow for collapse of the filter, and the sheath is coaxially advanced over the filter to collapse the filter's struts and release its attachment from the caval wall (Figure 4E).

Coaxial Double-Sheath Dissection

In addition to filter tilt resulting in coverage of the retrieval hook, some patients have densely adherent tissue that anchors the filter struts to the caval wall so securely that the filter will not separate from the caval wall with a standard amount of force. In these cases, alternating "to-and-fro" movements between the two coaxial sheaths with a gentle twisting motion of the inner sheath can allow dissection of the adherent tissue from the legs of the filter. We generally employ the use of a 10-F, 55-cm sheath placed coaxially within a 14-F, 45-cm Performer sheath (Cook Medical). The inner sheath is used primarily to collapse the filter up to the portion of the struts that are heavily embedded, and the outer sheath is used to dissect tissue away from the filter (Figure 5).

Laser-Assisted Double-Sheath Dissection

Recently, several groups have employed the use of pacemaker lead extraction laser sheaths with the CVX-300 excimer XeCl laser system (Spectranetics Corporation, Colorado Springs, CO) as an adjunct to the double-sheath dissection technique.[15,16] This technique is performed by passing the 12-F, 50-cm inner laser cannula (from the 14-F SLS II laser sheath lead extraction system [Spectranetics Corporation], calibrated at 60 mJ/mm^2) through a 14-F, 45-cm Performer sheath (Figure 6). A 6-F, 23-cm Brite-Tip sheath (Cordis Corporation, Bridgewater, NJ) is inserted into the end of the laser sheath to achieve hemostasis, as there is no hemostatic valve on the laser sheath. Once the retrieval hook of the filter has been snared, the outer sheath is advanced over the filter until resistance is met (either using a snare catheter alone or in conjunction with the snare-over-looped-guidewire technique), and the laser sheath is brought just beyond the outer sheath.

The laser sheath is then activated for 2 to 5 seconds at a time as it is gently advanced down the filter. The laser energy can result in effective photoablation of the intimal hyperplastic tissue around the struts, thereby freeing the filter's attachment to the wall. Evidence of tissue ablation has been demonstrated on pathologic analysis of retrieved filters by Kuo et al following this procedure; results with this technique appear favorable, although the safety profile has not yet been firmly established.[16,17] Series reporting the use of this laser lead extraction system with a similar technique in its intended use for removal of embedded pacemaker wires suggest a major vessel perforation rate of < 5%.[17,18]

CONCLUSION

Retrievable IVC filters have allowed for temporary caval interruption to prevent pulmonary embolization in patients with contraindications to anticoagulation. Potential long-term complications due to indwelling filters justify an aggressive approach to filter retrieval, both in terms of patient follow-up and application of advanced techniques for filter retrieval. Aggressive maneuvers to remove heavily embedded or adherent filters can generally be performed safely, but the risk of these maneuvers has not been clearly elucidated and must be weighed against the risks of permanent filter implantation. ■

Brian G. DeRubertis, MD, is with the Division of Vascular Surgery, David Geffen School of Medicine at UCLA in Los Angeles, California. He has disclosed that he has no financial interests related to this article. Dr. DeRubertis may be reached at (310) 825-3684; bderubertis@mednet.ucla.edu.

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