



Use of a funneled sheath for embolic protection during removal of thrombosed Simon Nitinol filters

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ABSTRACT

Inferior vena cava (IVC) filters should be removed when no longer needed, given their association with complications such as thrombosis of the IVC and lower extremities, fracture, migration, and growth into adjacent structures. While this is generally straightforward in the setting of retrievable filters, permanent filters present more of a challenge. In fact, many operators will not attempt to do so for fear of intraprocedural complications, among them, filter fracture and fragment embolization. Despite this, leaving the filters *in situ* places patients at risk of the complications described above. Here, the authors illustrate a novel technique for retrieving permanent filters using a funneled sheath to protect against embolization.

KEYWORDS

Anticoagulant therapy, deep vein thrombosis, inferior vena cava filter, thrombolysis, venography

Inferior vena cava (IVC) filters should be removed when no longer needed, given their association with complications such as thrombosis, filter fracture, filter migration, and IVC perforation.¹ However, patients with permanent filters are at higher risk of retrieval-related complications due to the frequent need for using complex retrieval techniques.² The Simon Nitinol filter (Bard Medical, Murray Hill, New Providence, NJ) may be particularly difficult to remove because of its bi-level filtration design. The recently released Protrieve sheath (Inari Medical, Irvine, California) has a retractable nitinol mesh funnel designed to entrap dislodged thrombus, but it can also be used off-label to protect against embolization of other materials. It comprises a sheath with 20-Fr inner and 24-Fr outer diameters; the funnel extends from the distal end of the sheath, measures up to 33.5 mm in diameter, and faces the caval walls when fully deployed (Figure 1). Herein, we describe three cases in which the funneled sheath was used during the removal of thrombosed Simon Nitinol filters, one of which was complicated by the embolization of a filter fragment that was caught by the funnel and subsequently extracted without issue.

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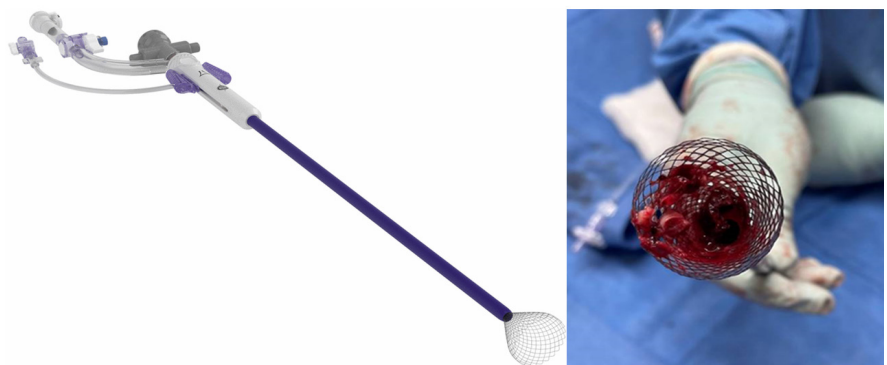


Figure 1. Photograph of the Protrieve sheath (left) and an image of the funnel containing a clot (right).

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Technique

Case 1

A 76-year-old woman who underwent placement of a Simon Nitinol filter nine years prior presented with one day of bilateral leg pain and swelling and was found to have acute thrombus extending from the filter into both lower extremities. Her medical history was notable for morbid obesity, diabetes mellitus type 2 on insulin, and osteoarthritis post bilateral total knee replacements; she was ambulatory with the assistance of a walker. The circumstances of the filter placement were not available, and the patient could provide no further history. She was started on therapeutic heparin; after three days at therapeutic levels, she had not improved so intervention was performed.

Under general anesthesia, bilateral popliteal and double right internal jugular vein accesses were obtained. The funneled sheath was introduced via one internal jugular access and a 16-Fr 45 cm sheath via the other. After deploying the funnel in the suprarenal IVC, the through-and-through wire



Figure 2. Coronal CT image showing thrombosis of the IVC filter (arrow). The filter extends into adjacent structures (arrowheads). CT, computed tomography; IVC, inferior vena cava.

Main points

- Removal of inferior vena cava filters, permanent or otherwise, may be accompanied by filter fracture and embolization.
- The Inari Protrieve funneled sheath was designed to protect against embolization of thrombus.
- Where there is concern that filter fracture may occur during filter retrieval, the use of the funneled sheath may be indicated to protect against fragment embolization.

position was established. Wire position was confirmed using intravascular ultrasound (IVUS), after which the filter was retrieved via the 16-Fr sheath with rigid endobronchial forceps. After confirming the absence of extravasation or other vascular injury, thrombectomy was performed using mechanical (Inari ClotTrievers Bold) and aspiration (Inari Triever24 and Protrieve sheath) techniques. Activated clotting time was maintained at approximately 250 seconds throughout the procedure to prevent *in situ* clot formation. Wide patency was restored, and the procedure was terminated without complication. The patient's symptoms improved, and she was discharged on post-procedure day six on apixaban. As of six months later, she has not experienced a recurrence.

Case 2

A 66-year-old woman who underwent placement of a Simon Nitinol filter 10 years prior in the setting of combined deep venous thrombosis (DVT) and pulmonary embolism presented with five days of left-greater-than-right-leg pain and swelling and was found to have acute thrombus extending from the filter into both lower extremities. She had been taking warfarin for many years but switched to rivaroxaban 10 days prior to presentation. Pre-procedural imaging showed that the filter extended beyond the caval wall into adjacent veins and the small bowel (Figure 2). After failure to improve despite two days of therapeutic heparin administration, an intervention was undertaken.

As in case 1, bilateral popliteal and double right internal jugular vein accesses were obtained; both funneled and 16-Fr sheaths

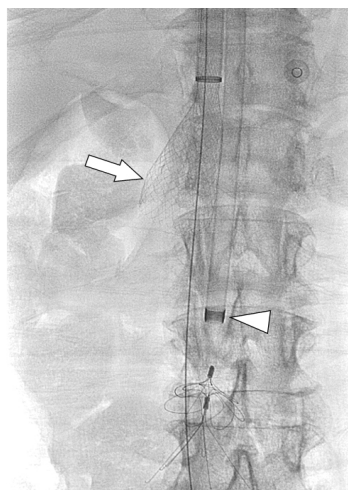


Figure 3. Fluoroscopic image showing the funneled sheath with deployed funnel (arrow) and adjacent 16-Fr sheath (arrowhead). The IVC filter is visible at the bottom of the image. IVC, inferior vena cava.

were introduced, and through-and-through wire positioning was achieved with the assistance of IVUS (Figure 3). After deploying the funnel in the suprarenal IVC, rigid forceps were used to remove the filter. However, during this process, the filter fractured and one strut remained embedded in the caval wall while a second embolized into the sheath funnel (Figure 4). The former was removed with forceps while the latter was snared and removed through the funneled sheath (Figure 5). Mechanical thrombectomy was then performed as in case 1. Wide patency was restored without complication. The patient recovered uneventfully and was discharged on post-procedure day three on warfarin. As of four months later, no recurrence has occurred.

Case 3

A 56-year-old woman who underwent placement of a Simon Nitinol filter 24 years prior presented with five days of bilateral leg swelling and was found to have acute thrombus extending from the filter into the bilateral iliac veins. Medical history was notable for systemic lupus erythematosus complicated by nephritis, cerebritis, and serositis, as well as prior DVT, for which the filter was placed. Reportedly, she had never previously been on anticoagulation medication. After failure to improve following six days of therapeutic heparin administration, intervention was performed.

Bilateral common femoral, right internal jugular, and right external jugular accesses were obtained. The funneled sheath was placed in the larger internal jugular vein while an 18-Fr 40 cm sheath was placed in

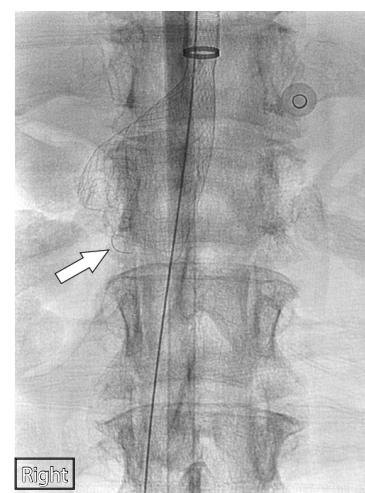


Figure 4. Fluoroscopic image showing a filter fragment (arrow) that was trapped in the funnel sheath.

the smaller external jugular vein. After the achievement of the through-and-through positioning and confirmation of the wire positioning, the filter was removed unevent-

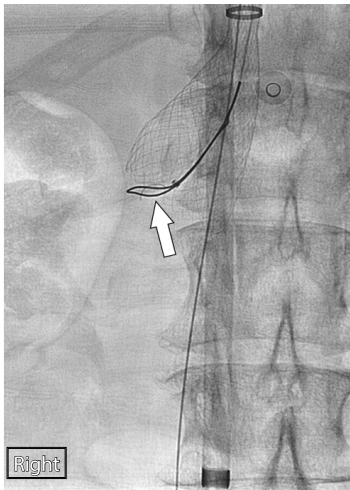


Figure 5. Fluoroscopic image showing snare removal of the filter fragment (arrow) from the sheath funnel.

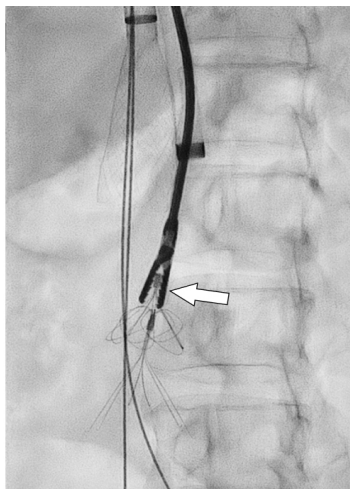


Figure 6. Fluoroscopic image showing forceps retrieval of the 24-year-old Simon Nitinol filter (arrow) through an 18-Fr sheath. The sheath funnel is visible at the top of the image.

fully through the 18-Fr sheath with forceps (Figure 6). Mechanical thrombectomy was then completed as in case 1 without complication. The patient's symptoms improved and she was discharged on post-procedure day four on apixaban. As of four months later, no recurrence has occurred.

Given its retrospective nature, patient consent was not required.

Discussion

Removal of Simon Nitinol IVC filters has only been described in small study series.³ Although no thrombus or filter fragment embolization was reported, this remains a concern during any complex filter retrieval. Given these risks, the appropriateness of retrieval may be questioned. However, the availability of the Protrieve device potentially tips the balance in favor of removal. In the present series, no patient had a contraindication to anticoagulation medication (on which they continued following the procedure) such that the filters were no longer needed. Despite this, they were left in place given the risk associated with removal. However, these patients had already experienced and were at risk of experiencing further complications from the presence of the filter, and the ability to use the funneled sheath reduced the risks associated with removal. Consequently, in this specific subgroup of patients, filter retrieval with embolic protection was indicated.

Considering the risks associated with removal, this funneled sheath represents a useful adjunct for the removal of Simon Nitinol and, potentially, other permanent, fractured, or severely ingrown filters. However, removal is not without limitations. Because the outer diameter of the sheath is 26-Fr, a vein large enough to accommodate it may not be available. Furthermore, because it measures

a total of 50 cm in length, separate access is needed to accommodate rigid forceps, which at the authors' institution, measure 55 cm in length and are thus not long enough to exit the sheath and engage the filter. Although the authors initially placed both sheaths in the same internal jugular vein, subsequent experience has led to the preference for a single puncture of each of the ipsilateral internal and external jugular veins. In either case, the use of parallel sheaths may produce a gap between the funnel and caval wall through which filter fragments could pass. Additionally, small fragments, in particular, could theoretically traverse the holes in the funnel mesh (the holes vary in size depending on the extent of funnel expansion but at 30 mm, these measure 0.90 mm proximally, 1.34 mm in the mid portion, and 2.25 mm distally); however, the implications of the embolization of such fragments are of unclear clinical significance. Despite these limitations, the Protrieve sheath shows potential as an adjunctive device in cases of complex IVC filter retrieval and warrants further study in this role.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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