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Balloon-assisted inferior vena cava filter retrieval: A novel technique to enhance irretrievable filter extraction

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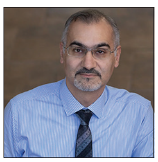

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ABSTRACT

Although the use of inferior vena cava (IVC) filters has expanded, complications have led to the recommendation to remove all unnecessary filters. Several techniques exist to aid in retrieving irretrievable IVC filters. The balloon-assisted retrieval technique has previously been described to aid in cases of an embedded hook. This report describes an alternative use of the balloon-assisted technique, specifically to aid in the retrieval of Greenfield IVC filters in cases of strut perforation of the cava wall. This technique was successfully performed in six out of six attempted cases with no associated complications.

Keywords: IVC filter, Venous intervention, Venous thromboembolism, Balloon-assisted retrieval

INTRODUCTION

Since Kazi Mobin-Uddin, M.D. placed the first inferior vena cava (IVC) filter for pulmonary embolism (PE) prevention, there has been exponential expansion due to the profound impact on patient care. Despite the widespread popularity, many complications have been cited, including migration, structural degradation, filter fragment embolization leading to cardiopulmonary manifestations, cava injury, penetration of adjacent vessels and viscera, and increased risk of clot formation inferiorly, leading to IVC thrombosis and deep venous thrombosis (DVT).[1] Due to these complications, in August 2010, the FDA recommended the removal of retrievable IVC filters if protection from PE was no longer necessary. Although retrievable filters are becoming more common, a significant number of patients have permanent filters in place, making extraction difficult. In addition, factors such as epithelialization of filter parts, apex tilt, and prolonged dwelling time >6 months have been shown to further hinder extraction.[2] With these potential impediments, and as the necessity of filter removal becomes more evident, it is essential to have reliable techniques to enhance retrieval rates and minimize complications.

Several advanced techniques for IVC filter retrieval have been described, such as hangman technique, loop snare technique, and photothermal ablation using an excimer laser.[3-7] At our center, we utilize many of these techniques and have modified some of these techniques to facilitate safer and more effective IVC filter extraction. Here, we report our balloon-assisted IVC filter retrieval technique in six patients who have had Greenfield filters (Boston Scientific, Place Natick, MA, USA) *in situ* with prolonged dwell time.

MATERIAL AND METHODS

Patient selection

We conducted a retrospective review of all IVC filter retrieval attempts over a 3-year period, from January 2017 to March 2021. The search utilized Nuance mPower (Nuance Communications, Burlington, MA). Fluoroscopic images and procedural reports were reviewed and analyzed. All patients who underwent retrieval of titanium Greenfield filters were included in this study.

Pre-procedure assessment

All patients were seen in the interventional radiology clinic for clinical evaluation. A clinical history, including the indication for filter placement, dwell time, and symptoms that could be attributed to the IVC filter *in situ*, was obtained. All patients underwent CT scan of the abdomen and pelvis with contrast prior to the procedure. Contraindication for filter retrieval, such as IVC thrombus, new or extending DVT, and continued intolerance to anticoagulation, was excluded in all patients prior to retrieving IVC filter.

Technique

The balloon-assisted retrieval technique requires two ultrasound-guided venous accesses. A 16 French vascular sheath (Cook, Bloomington, IN, USA) is placed in right the internal jugular vein (IJV) for IVC filter retrieval, and a second seven French vascular sheath (Terumo, Somerset, NJ, USA) is placed in the right common femoral vein (CFV) for balloon insertion. An IVC venogram is performed to exclude IVC thrombus and delineate anatomy. Endobronchial forceps or a loop snare is then inserted via the IJV access and used to firmly grab the superior end of the cone-shaped Greenfield filter, followed by advancing the IJV vascular sheath to cover all the free intraluminal portion of the filter. In all cases, the struts are firmly attached to the IVC wall and, in most cases, have penetrated through it. Thus, the above maneuver pulls the IVC wall circumferentially inward toward the tip of the vascular sheath. A 0.035" stiff glidewire (Terumo, Somerset, NJ, USA) is then advanced through the right CFV sheath and sequentially interposed between the inward-retracted IVC wall and the gaps between the filter struts, followed by positioning a 6–12 mm × 40 mm CONQUEST® 40 PTA balloon (BD, Tempe, AZ, USA) over the wire in these gaps. In the first two procedures, a cautious approach was used when selecting balloon size, which was sequentially increased (6, 8, 10, and finally 12) until freeing the strut from the IVC wall and obliterating the waist, which was caused by the IVC wall retracting toward the partially sheathed filter. Given that a 12 mm balloon was required to achieve this outcome in these two cases, a 12 mm balloon was used from the onset in the subsequent four cases. The balloon is then expanded for approximately thirty seconds to gently displace the IVC wall outwards while retracting the extra-luminal portion of the struts inward. While maintaining a longitudinal force, this maneuver is repeated circumferentially around the base of the IVC filter until the filter struts are freed from the cava wall. The IJV sheath is then further advanced to completely re-sheath and extract the IVC filter [Figure 1]. All procedures were performed by faculty interventional radiologists with between 2 and 4 years of experience, with or without interventional radiology residents present.

RESULTS

Six patients (4 male) with a mean age of 53 (range 38–72) years with Greenfield IVC filters *in situ* underwent balloon-assisted IVC filter retrieval. The mean dwell time was approximately 9.13 (range 1–14) years. Mean procedure time was 104 (range 67–205) min and mean radiation dose was 338.4 (range 157.3–553.6) mGy. Patient demographics, clinical history, and procedure details are summarized in [Table 1].

These 6 patients each had Greenfield filters and no longer met the criteria necessitating IVC filter *in situ*. Every case was complicated with strut epithelization and penetration of the cava wall [Figures 2 and 3]. Review of pre-procedural computed tomography scan showed the depth of maximal strut perforation outside the cava wall to have an interquartile range of 1–3 centimeters in all patients, with a median of 2 centimeters.

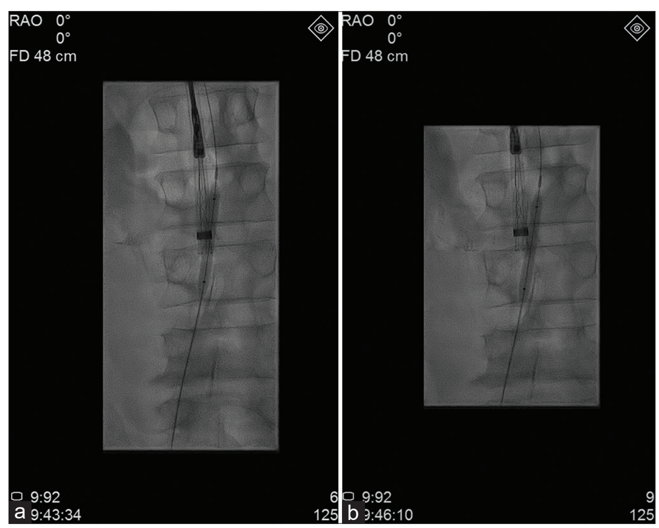

Figure 1: 55-year-old male with IVC filter struts embedded into vena cava wall. (a) Fluoroscopy is used while a 6 mm × 4 cm conquest balloon is inflated and used to displace/separate the struts from the IVC wall. (b) Under fluoroscopic guidance, the balloon is inflated multiple times in different locations to dislodge the IVC filter from the caval wall. IVC: Inferior vena cava.

Table 1: Data collection summary.

Age	Sex	Dwelltime (years)	Procedure time (minutes)	Radiation dose (mGy)	Average contrast (milliters)	Indication of IVC filter placement	Symptoms on presentation
38	M	17	120	309.1	155	Prophylactic after polytrauma	None
55	M	14	68	167.55	95	Prophylactic after polytrauma	Back pain
72	F	15	91	157.29	80	DVT/PE	None
*46	M	1	205	309.1	216	DVT/PE with subsequent hemorrhagic pericardial effusion	None
45	F	5	73	534	85	Post-surgical DVT/PE	None
62	M	2.75	67	553.6	60	PE	None

*Procedure time was longer in this case due to severely embedded apical cap. Extensive maneuvering with use of hangman technique was required to free the proximal end of the filter. IVC: Inferior vena cava, DVT: Deep venous thrombosis, PE: Pulmonary embolism

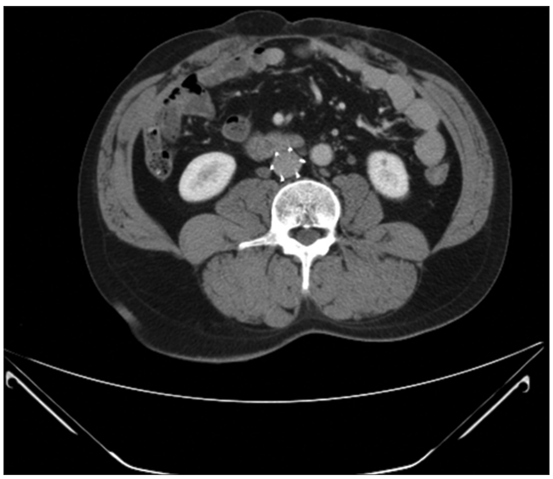

Figure 2: 55-year-old male who presented with back pain thought to be related to IVC filter *in situ*. Contrast-enhanced CT image shows all filter struts perforating vena cava wall. IVC: Inferior vena cava.

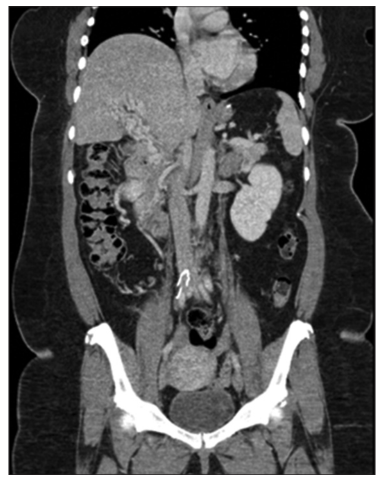

Figure 3: A 45-year-old female with a history of post-operative DVT/PE and subsequent IVC filter placement who presented for routine filter retrieval. Pre-procedure contrast-enhanced CT image shows tilted filter with struts perforating vena cava wall. IVC: Inferior vena cava, DVT: Deep venous thrombosis, PE: Pulmonary embolism.

The endobronchial forceps technique was used in five patients, while the sixth patient required loop-snare technique due to close adherence of the filter cap to the cava wall. One patient also required hangman technique in addition to endobronchial forceps; this procedure took the longest time to perform, which was related to the embedded proximal end of the filter and the extensive maneuvering required to free the cap. The balloon-assisted technique was utilized in all six patients to displace the struts from the cava wall and complete the filter retrieval. A final venogram was performed after retrieval to assess for cava injury. Technical success rate was 100% (6 of 6) of cases. Procedures were performed on an outpatient basis, and all patients were discharged same day. There was no morbidity or mortality associated with this procedure.

DISCUSSION

The frequency of IVC filter placement has drastically increased, and despite widespread popularity, many complications have been cited.[1] Barriers to retrieval, including epithelialization of filter parts, apex tilt, and prolonged dwell time, complicate matters and make it essential to have reliable techniques to enhance retrieval rates and minimize complications. Techniques such as hangman's, loop wire, loop snare, modified loop snare, endobronchial forceps, and photothermal ablation have been shown to be effective in many situations.[3-7] The focus of our study was to provide a technically uncomplicated, alternate technique to use in difficult cases where other specialized techniques may have failed or are not readily available.

The design of the Greenfield filter naturally opposes migration and retrieval. The recurved strut hooks are configured to oppose unidirectional movement

Figure 4: Greenfield filter post-removal. Recurved strut hook shown inside the circle.

[Figure 4]. When these hooks are epithelialized and embedded within the cava wall, extraction becomes complicated.

We postulated that the balloon-assisted technique's radial force outward from the cava wall would increase the probability of retrieval, instead of solely relying on the longitudinal force used in other techniques. In addition, the balloon-assisted technique is a more economical option in comparison with the excimer laser and requires no special training. Due to our relatively small sample size, direct comparison of advanced techniques would not have been statistically feasible.

CONCLUSION

The balloon-assisted technique has successfully been utilized to free the apex of tilted filters with endothelial apical caps.[8] At our center, balloon-assisted retrieval has been shown to be a viable alternative to aid in retrieving irretrievable IVC filters with strut perforation of cava wall. Although this technique has not yet been required at our center to aid in strut perforation of retrievable filters, it can be presumed to be a viable technique for these types of filters as well.

As the necessity of filter, retrieval becomes more evident, and with the known potential obstacles to retrieval, it is essential to have more reliable techniques to enhance retrieval rates. The balloon-assisted technique has been shown to be safe and beneficial. Continued investigation may be warranted across other centers to further substantiate the efficacy and safety of this novel technique.

Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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