Endobronchial forceps-assisted complex retrieval of inferior vena cava filters

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ABSTRACT

Objective: The objective of this study was to assess the safety, feasibility, and effectiveness of endobronchial forceps-assisted retrieval of inferior vena cava (IVC) filters when standard retrieval techniques fail.

Methods: An Institutional Review Board-approved single-center retrospective review during a 6-year period identified 60 consecutive patients (23 men and 37 women; mean age, 49.3 years; range, 19-77 years) in whom rigid endobronchial forceps were required for IVC filter retrieval after standard techniques failed. Factors affecting retrieval success, including an embedded or tilted filter, overall dwell time, filter fracture, and caval penetration, were recorded, as were success rates, procedural details, and complications.

Results: Mean dwell time between filter placement and removal was 565 days (range, 15-7366 days). Various IVC filters were encountered: 33 Option (Argon Medical, Frisco, Tex), 8 Celect (Cook Medical, Bloomington, Ind), 9 Günther Tulip (Cook Medical), 4 G2 and 3 Eclipse (Bard, Murray Hill, NJ), 2 OptEase (Cordis, Bridgewater, NJ), and 1 Simon Nitinol (Bard). Imaging before retrieval showed grade 1 (3/60), grade 2 (44/60), and grade 3 (13/60) filter interaction with IVC wall. The degree of secondary tilt as assessed on images acquired before attempted retrieval was <10 degrees (n = 22; 36.7%), 10 to 20 degrees (n = 26; 43.3%), and >20 degrees (n = 12; 20%), with an average tilt of 13.8 degrees (range, 0-48.9 degrees). Of the 60 filters, 58 were retrieved successfully (96.7%). Two of these required a second attempt (one because of migration into the right atrium and the other because of extreme discomfort of the patient requiring subsequent general anesthesia). Five of 60 procedures were forceps-assisted loop snare retrievals in which the forceps were used to dissect the embedded hook free from surrounding hyperplastic caval venous endothelium. Mean fluoroscopy retrieval time was 33.2 minutes (range, 10-76.9 minutes). Intraprocedural inconsequential filter fracture was observed in 10 patients. There were four complications: one retroperitoneal hemorrhage, one IVC dissection flap, and two filter fractures with subsequent migration of filter components to the right side of the heart and to the right pulmonary artery. The first two complications required hospital admission and conservative management; in the last two, the fractured and migrated filter limbs were retrieved successfully using a snare device.

Conclusions: Rigid endobronchial forceps can be safely and reliably used to remove embedded, fractured, or tilted retrievable IVC filters from patients in whom standard retrieval techniques are unsuccessful. There is a high success rate and minimal complications. We propose that the degree of filter tilt, caval penetration, and filter fracture are predictive of the need for the use of forceps as a first-line retrieval technique. (J Vasc Surg: Venous and Lym Dis 2019;7:413-9.)

Keywords: IVC filter; Endobronchial forceps; Filter retrieval

The U.S. Food and Drug Administration issued a safety report in August 2010 (updated in May 2014) stating that physicians should consider removal of retrievable inferior vena cava (IVC) filters as soon as protection from pulmonary embolism is no longer necessary and placed the onus on the clinician responsible for the long-term care of the patient as well as on the physician who initially placed the retrievable device.[1] This recommendation was based on numerous reports of complications from indwelling filters, namely, migrations, fractures, penetrations, and possible thrombotic complications, and data showing that retrievable IVC filters can be safely removed with a high degree of success and a low complication rate, particularly when caval filtration is no longer needed and a patient's indication for mechanical venous thromboembolism (VTE) protection is no longer clinically indicated.[2-4] However, in cases in which there are chronically embedded and adherent filters with long dwell times, filter component penetration or perforation through the caval wall and into adjacent structures, device fracture, or high degree of off-axis tilt, standard retrieval techniques may be ineffective for removal of such filters. In such cases, physicians need to be aware of the various advanced

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retrieval techniques that have been described and used with varying degrees of success for filter removal. These techniques include filter realignment with a curved catheter, tip-deflecting stiff guidewire displacement, guidewire and snare use with dual access, balloon displacement, sling formation, sandwich with dual sheath, and dissection with a forceps or an endovascular laser sheath.[5] Assessment of preretrieval factors to support the use of endobronchial forceps as a primary advanced retrieval device is lacking. We present results from a single-center retrospective study investigating the use of rigid endobronchial forceps in facilitating complex IVC filter retrievals. In addition, we suggest that given the high success and low complication rates that we and others have observed with the use of endobronchial forceps for filter removal, this method may be the preferred primary advanced retrieval technique for a number of reasons.

ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center, retrospective, 6-year, cross-sectional study
- **Key Findings:** In 60 consecutive patients, 58 inferior vena cava (IVC) filters were successfully retrieved with rigid endobronchial forceps; two required two attempts and five were forceps-assisted loop snare retrievals, with a mean fluoroscopy time of 33.2 minutes (range, 10-76.9 minutes). Intraprocedure filter fractures occurred in 10 patients. There were four complications, including 1 retroperitoneal hemorrhage, 1 IVC flap, and 2 filter component migrations, one to the right side of the heart and one to the right pulmonary artery, with both retrieved with a snare device.
- **Take Home Message:** This study suggests that rigid endobronchial forceps can safely and reliably be used to remove embedded, fractured, or tilted retrievable IVC filters and perhaps can be considered a first-line procedure for IVC filter retrieval that is likely to be complex.

METHODS

This single-institution retrospective research was performed after Institutional Review Board approval; obtaining of informed consent was not required. During a 6-year period, from November 2009 to June 2016, a total of 435 IVC filter retrievals were performed. Of these, endobronchial forceps use was required for successful filter removal in 60 patients. Study patients were identified through a manual search of our interventional radiology procedural database (Hi-IQ [Society of Interventional Radiology, ConexSys, Lincoln, RI] and a homegrown departmental data-mining research tool). Patients' information including demographics and clinical data were obtained from electronic medical records. All relevant images were retrieved and were then reviewed with a picture archiving and communication system. The reviewed images included any preprocedural, intraprocedural, or postprocedural imaging. These included the initial inferior venacavogram obtained during filter placement, any subsequent interval abdominal computed tomography (CT) or Doppler ultrasound images of the deep veins of the lower extremities before retrieval, the fluoroscopic images obtained during IVC filter retrieval, and any relevant postretrieval abdominal CT or lower extremity Doppler ultrasound images.

Demographics, indication for IVC filter placement or removal, and risk factor assessment. There were 60 patients (23 men and 37 women) with a mean age of 49.3 years (range, 19-77 years). All patients in this study met the following inclusion criteria: prior placement of an IVC filter, subsequent failed attempt at filter retrieval by either standard or advanced techniques, and finally an attempt at retrieval that required the use of a rigid endobronchial forceps device (2.5-mm × 55-cm alligator forceps for hard foreign body with double action [Product ID 10370HL; Karl Storz, El Segundo, Calif]).

Indications for initial IVC filter placement included VTE in a patient with a contraindication to anticoagulation (n = 42; 70%), VTE in a patient who failed to respond to anticoagulation (n = 6; 10%), and prophylactic IVC filter placement before surgery (n = 12; 20%). Twenty-four of the IVC filters were placed within our department; the remaining filters (n = 36) were placed in outside institutions. Filter retrievals were referred from an outside institution in 15 of 36 patients after a failed retrieval attempt by either standard or advanced techniques that did not involve the use of an endovascular laser sheath or an endobronchial forceps. Otherwise, however, only limited data were available for the actual methodology used for the prior retrieval attempts at the various outside institutions. Indications for retrieval included patients who were symptomatic with IVC filter-related complications (n = 9; 15%), asymptomatic patients who could now tolerate anticoagulation (n = 11; 18.3%), and asymptomatic patients in whom neither caval filtration nor anticoagulation was further indicated (n = 40; 66.7%). The type of IVC filter placed and the mean dwell time were assessed.

The electronic medical record of each patient was reviewed to assess for underlying hypercoagulability and prothrombotic conditions. Two patients were noted to have antiphospholipid antibody syndrome, one patient had antithrombin III deficiency, and one patient had factor V Leiden. Fourteen patients were on an anticoagulation regimen immediately before attempted filter retrieval. In total, six patients with either an underlying thrombophilia (ie, antiphospholipid syndrome, antithrombin III deficiency, factor V Leiden) or atrial fibrillation continued therapeutic anticoagulation for life. The

majority of patients (n = 34) had already discontinued anticoagulation before attempted retrieval and did not resume anticoagulation after filter retrieval. All others (n = 26) resumed anticoagulation after successful filter retrieval and continued the regimen thereafter for a minimum of 30 days to reduce postprocedure or filter-related thrombotic risks.

Evaluation of IVC filter tilt, penetration, and complications. Factors potentially affecting the success of an IVC filter retrieval, including an embedded filter, degree of filter tilt, fracture of one or more components, and filter penetration of the caval wall, were recorded and analyzed.[6] An unopacified cap of tissue or frank demonstration of the filter hook outside of the IVC lumen on either venography or CT defined the presence of an embedded filter tip.[7] The degree of secondary tilt occurring after IVC filter placement was assessed by measuring the angle between the long axis of the IVC and that of the IVC filter and categorized as either <10 degrees, between 10 and 20 degrees, or >20 degrees. This measurement was calculated on either the preprocedural CT image or the procedural cavogram. When available, preprocedural CT as well as intraprocedural fluoroscopy imaging was used to grade the IVC filter interaction with IVC wall by the classification proposed by Oh et al.[8]

Preprocedure preparation and technique. Preprocedural anticoagulation was not routinely administered, as has been suggested by others.[9] However, if patients were already receiving therapeutic oral warfarin (target international normalized ratio of prothrombin time of 2-3), they were switched to therapeutic subcutaneous enoxaparin (1 mg/kg subcutaneously twice daily) at least 1 week before the attempted filter retrieval. All patients taking subcutaneous enoxaparin were advised to withhold one dose before the procedure, typically on the morning of the procedure.[10]

Before attempted filter retrieval, all patients underwent an extensive informed consent process in which the various risks associated with the filter remaining indwelling, the risks associated with a complex filter removal with endobronchial forceps assistance, and the individual's relative risk of VTE after filter removal were discussed. In addition, any relevant preprocedure imaging was reviewed before attempted retrieval.

Thirteen patients underwent CT venography of the abdomen and pelvis before attempted retrieval; two had magnetic resonance venography of the abdomen and pelvis, whereas 37 patients had lower extremity duplex ultrasound examination. Two patients were found to have chronic nonobstructive lower extremity deep venous thrombosis. An additional two patients were found to have May-Thurner anatomy.

All procedures were performed using either moderate sedation or general anesthesia. An attending interventional radiologist (experience range, 4-25 years) was involved in all procedures. Ultrasound was used to access the internal jugular or common femoral veins in all patients. An inferior venacavogram (digital subtraction venography with rate of contrast agent administration of 15 mL/s for a total of 30 mL delivered through a 5F flush catheter) was performed before retrieval in all patients to evaluate for any acute caval thrombus and the relative position of the filter within the cava. Compliant occlusion balloons and large-diameter vascular stents were readily available within the fluoroscopy suite. After serial dilation of the venous access site, a vascular sheath was placed in the IVC. The vascular sheath size used for retrieval was recorded for all patients. The endobronchial forceps were introduced through the sheath, and the apex or limb of the filter was grasped and freed from the wall as needed, and then the filter hook was grasped by the jaws of the forceps. In five patients, the endobronchial forceps were used only for freeing the embedded filter hook or realigning the filter within the cava, after which a standard loop snare device was used to remove the filter. Depending on the degree of filter tilt and angulation, in a few patients a gentle curve was made on the forceps manually to achieve directionality. An inferior venacavogram was performed after filter removal on the basis of the operator's preference. The total procedural fluoroscopy time in minutes was recorded.

Assessment of outcomes and complications. The safety profile of the procedure was assessed by noting the occurrence of any complications, such as thrombosis, bleeding, caval perforation, filter fracture, and migration. Postprocedure follow-up clinical evaluation in the interventional radiology outpatient clinic was performed only if a complication was noted at the time of the filter retrieval procedure. The remaining patients were counseled and continued any necessary clinical follow-up with their primary care physicians. The efficacy of the procedure was assessed by calculating the percentage of technically successful outcomes, defined as successful removal of the IVC filter, and the degree of clinical success, defined as the resolution of any presenting symptoms, the successful resumption of anticoagulation, or the absence of any recurrent VTE on follow-up imaging.

RESULTS

The mean dwell time between filter placement and removal was 565 days (range, 15-7366 days [0-20 years]). Various retrievable IVC filters were encountered: 33 (55%) Option (Argon Medical, Frisco, Tex), 8 (13.3%) Celect (Cook Medical, Bloomington, Ind), 9 (15%) Günther Tulip (Cook Medical), 4 (6.7%) G2 and 3 (5%) Eclipse (Bard, Murray Hill, NJ), 2 (3.3%) OptEase (Cordis, Bridgewater, NJ), and 1 (1.7%) Simon Nitinol (Bard).

The grading system proposed by Oh et al[8] was used to assess IVC filter interaction with IVC wall (Table). Imaging before retrieval showed fractured struts in 3 of 60 filters

Table. Grading system for inferior vena cava (*IVC*) filter interaction with IVC wall[8]

Grade 0	Normal; filter strut confined entirely within IVC	0/60 (0)
Grade 1	Filter strut is immediately adjacent to external aspect of IVC wall, likely reflecting tenting of IVC wall	3/60 (5)
Grade 2	Filter strut is entirely outside IVC lumen within retroperitoneum as evidenced by a "halo" of retroperitoneal fat around axially viewed strut	44/60 (73.3)
Grade 3	Filter strut interacts with adjacent organ outside of IVC[a]	13/60 (21.7)

Values are reported as n/N (%).
[a]An "interaction" was defined as a strut touching, impressing, or perforating any other organ. Other organs included liver, bowel, aorta, lymph nodes, psoas muscle, and vertebral body.

and caval penetration by filter struts (56/60) and the apex or hook (28/60; Fig 1, *A*). Of the 57 filters that had perforated the caval wall, 4 had struts penetrating the duodenum (Fig 1, *B* and *C*) and 3 caused erosions of the adjacent L3 vertebral body (Fig 1, *D*); 2 filters had a leg within the wall of the aorta (Fig 1, *C*), another within the superior mesenteric artery, 4 within the renal veins (Fig 2, *A*), 1 within an azygos vein (Fig 2, *B*), and 2 within lumbar veins. Two of the three fractured filters (Option and G2) had struts within the right renal parenchyma and the right ureter and a leg remodeling the adjacent L3 vertebral body.

The degree of secondary tilt as assessed on images acquired before or during the attempted retrieval was <10 degrees (n = 22; 36.7%), 10 to 20 degrees (n = 26; 43.3%), and >20 degrees (n = 12; 20%), with an average tilt of 13.8 degrees (range, 0-48.9 degrees). The total number of successful retrievals was 58 of 60 (96.7%). In most patients (n = 48; 80%), the filter was removed in total; the remainder required retrieval of fractured limbs (n = 10; 20%) after reintroduction of the forceps (Fig 2, *C* and *D*). There were 55 IVC filters retrieved from the right internal jugular vein access, whereas three were retrieved through a right common femoral venous access. Of the 55 patients in whom a transjugular approach was used, eight also required simultaneous right transfemoral venous access. In two of the three patients in whom the retrieval was performed from the right common femoral vein, this was necessitated because the initial removal attempt flipped the filter upside-down. The third patient required transfemoral venous access for retrieval as the embedded device was an OptEase IVC filter, for which this retrieval route is routinely indicated. In 5 of the 60 patients, the forceps were used only to free the embedded hook or strut and was followed by use of standard loop snares for the actual retrieval. The most common vascular sheath size used for retrieval was 16F (n = 32; range, 14F-22 F). During the retrieval process, 10 of the 60 filters (5 Argon Option) were

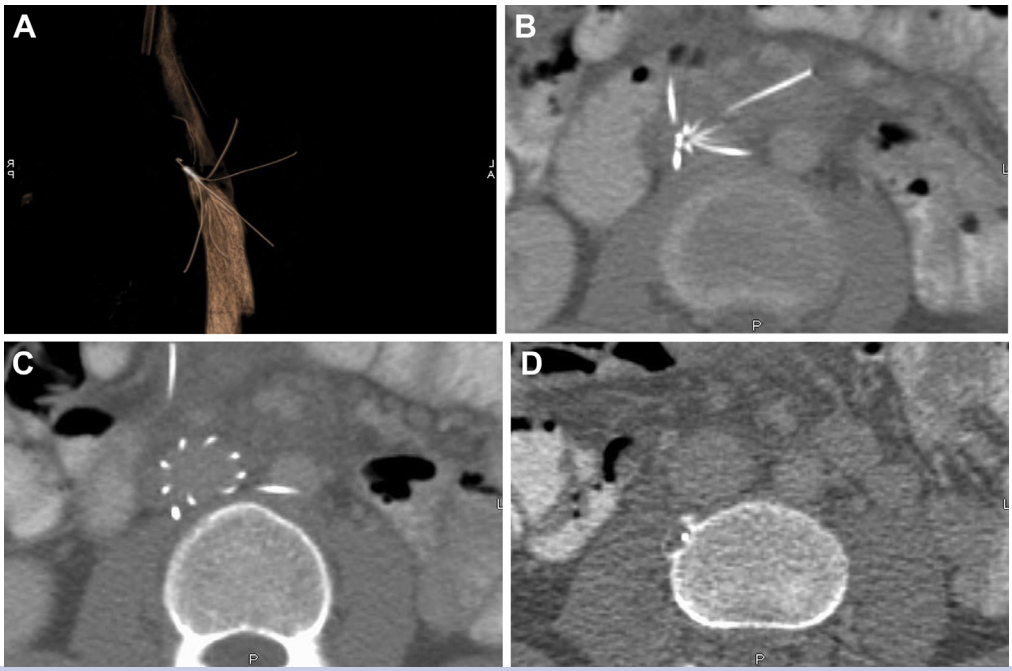

Fig 1. Three-dimensional reformatted image of the inferior vena cava (IVC) demonstrates most of the filter limbs extending beyond the walls of the IVC **(A)**. Axial computed tomography (CT) shows perforation of the IVC filter limbs through the wall and extending into the duodenum **(B)**, abdominal aorta **(C)**, and lumbar vertebral body **(D)**.

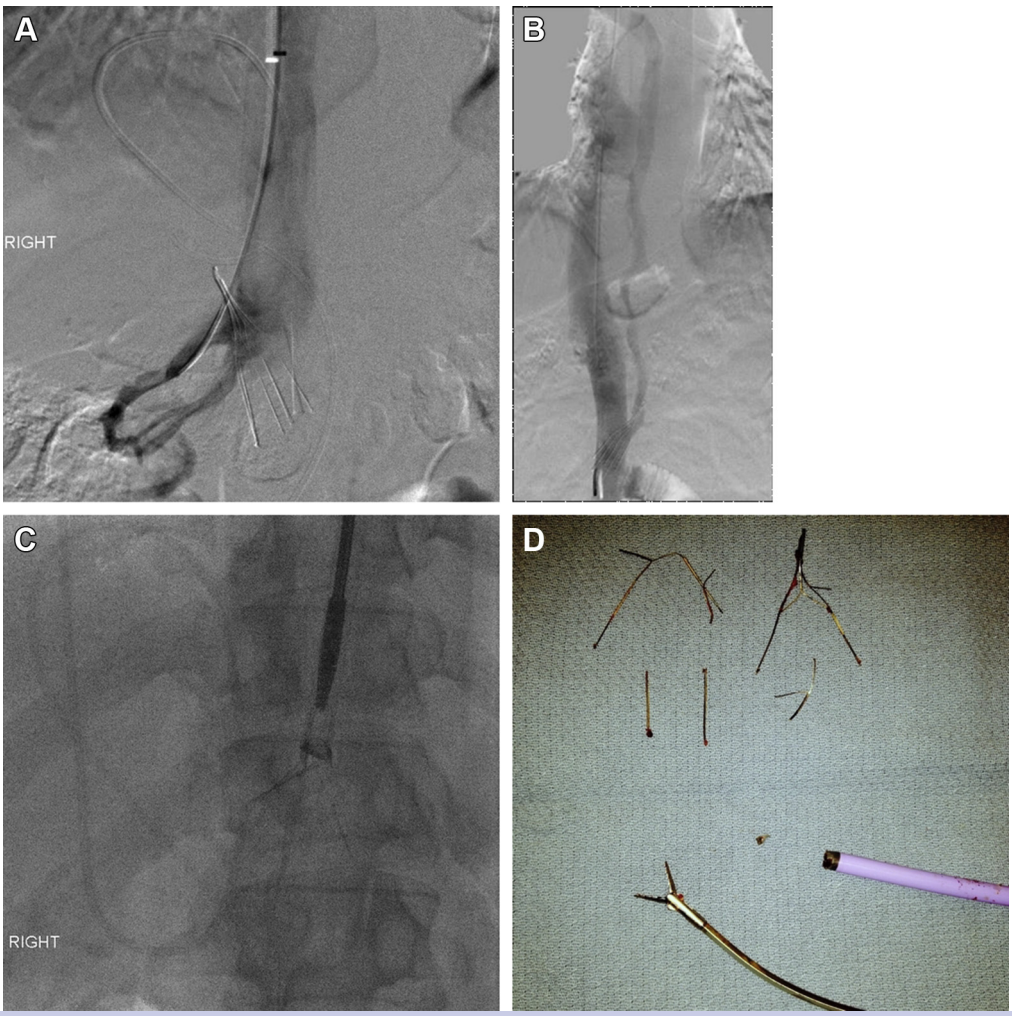

Fig 2. Anteroposterior cavogram demonstrates a tilted filter with its tip embedded in the right renal vein **(A)** and azygos vein **(B)**. In both cases, the filter was retrieved successfully with endobronchial forceps after failure of routine removal techniques. Anteroposterior fluoroscopy image **(C)** shows an endobronchial forceps grasping an embedded inferior vena cava (IVC) filter through the sheath, which led to fractured fragments during the procedure, and gross picture **(D)** demonstrates vascular sheath, rigid endobronchial forceps, and multiple filter fragments ex vivo. Note the curve on the forceps made manually to facilitate directionality during retrieval.

iatrogenically fractured, two of which had migration of fractured filter components (1 to the right atrium and 1 to the right pulmonary artery) necessitating subsequent snare retrieval of the components. The mean fluoroscopy retrieval time was 33.2 minutes (range, 10-76.9 minutes). Of the 60 filters, 58 (96.7%) were retrieved successfully. Of these 58 filters, 56 were retrieved successfully on the initial attempt in which endobronchial forceps were used. A second retrieval attempt was required in two patients because of migration of a fractured limb into the right atrium in one and extreme discomfort of the other patient that required general anesthesia at a second sitting.

Two immediate major complications occurred: an IVC dissection flap requiring an overnight admission, which was managed with anticoagulation medications including heparin, enoxaparin, and warfarin and subsequent clinical follow-up after discharge; and a pericaval retroperitoneal hemorrhage with subsequent urosepsis, which required a 5-day hospital admission and supportive management. Additional complications involved two other patients, each of whom had migration of fractured filter components as previously described; in both patients, the fragments were retrieved successfully with a snare device.

A total of 26 patients resumed anticoagulation (enoxaparin or warfarin) after the procedure for a minimum of 30 days. Six patients remained on anticoagulation for life, whereas the rest discontinued anticoagulation.

DISCUSSION

IVC filters have become a standard component of the prevention algorithm for VTE, and that is reflected in the dramatically increased rate of implantation that

has occurred within the past decade.[1] Unfortunately, when the increased rate of filter placement is combined with prolonged filter dwell times, lack of clinical follow-up, and overall low retrieval rates that range from 1.0% to 40.5%, filter-related adverse events have escalated.[5] It has become increasingly apparent that with longer IVC filter dwell times, it often is more difficult to remove these filters, and more advanced retrieval techniques may be necessary.[2]

To the best of our knowledge and from literature review, this is the second largest study that uses forceps for difficult IVC filter retrieval. In this retrospective review of 60 patients in whom forceps-assisted retrieval was attempted, the success rate was 96.7%. These data are comparable to a recent large retrospective review by Stavropoulos et al,[11] in which the success rate of tip-embedded complex filter retrieval with forceps was 95%. Novel to our study is the assessment of filter tilt from the longitudinal axis of the IVC, where the average tilt was 13.8 degrees with a range of 0 to 48.9 degrees. Although we did not have a control group that underwent standard snare retrieval as a part of this study, we propose that imaging assessment of the degree of filter tilt, any caval penetration by hook or limbs into surrounding tissues, and the presence of fractured filter components should be performed in advance of attempted filter retrieval. If the tilt is >10 degrees, if the filter is embedded or there is significant caval wall penetration by the hook or limbs, or if there is filter component fracture, rigid endobronchial forceps may be considered the first-line retrieval device. At present, a common practice is initially to use a snare device for attempted retrieval, regardless of the filter anatomy, and if that is unsuccessful to resort to one of the various advanced retrieval techniques. Some of the previously described advanced retrieval techniques have varying success rates for filter removal, some require dual venous access and multiple devices, and many involve lengthy procedure times with associated excessive radiation exposure to the patient and operator. Although using endobronchial forceps for filter retrieval sometimes results in a lengthy and complex procedure, more often in the hands of an experienced operator it is a faster, simpler, and more effective technique than most of the other advanced retrieval techniques, in our opinion. When performing these procedures with less experienced operators (eg, trainees), we have noted that there is an intuitive and relatively simpler technical skill set needed for effectively using this tool compared with the complexity of some of the other advanced retrieval techniques. We believe that first-line use of forceps after a failed attempt by standard retrieval techniques may potentially decrease overall procedure times and radiation exposure and in many cases may have an additional cost benefit. There is a definite cost advantage over laser-assisted removal. Once purchased, the forceps can be easily resterilized and reused, as opposed to single-use items that are routine components of other retrieval techniques. Forceps use may also minimize some of the complications that may be associated with failed attempts with other techniques; such complications include further filter tilt or worsened malpositioning and filter fracture with migration of components.

The most common filter we encountered in our study was the Argon Option (54%); in the only other large study by Stavropoulos et al,[11] it was Bard G2 (29%). In our study, 10 of the 60 filters were iatrogenically fractured during their removal. In two patients, components of the fractured filter migrated centrally but were successfully retrieved. This was earlier in our experience with performing forceps-assisted filter retrieval. In the eight more recent cases, the iatrogenic filter fractures that occurred during removal were well controlled and were sometimes intentional when it was necessary to remove an embedded filter in "piecemeal" fashion. It is extremely challenging to remove a filter in total if one of the limbs is chronically embedded in a vertebral body, and it is, in fact, a reasonable strategy to remove the filter in a controlled piecemeal fashion if needed. Although all filter limbs were removed in our study, in some cases it may be reasonable to leave a chronically embedded and fractured filter limb in situ if it has a minimal or absent intraluminal component.

There are different varieties of rigid endobronchial forceps with variations in length, angle of the neck, and type of jaws. For the physicians who intend to add this tool to their IVC filter removal armamentarium, a visit to the bronchoscopy suite, interaction with inventory managers to discuss various vendors and routinely stocked forceps, and collaboration to minimize costs are suggested. In addition, we recommend using larger vascular sheaths to optimally facilitate forceps-assisted retrievals as, in our experience, larger sheaths allow easier maneuverability of both the forceps and the filter during the retrieval process. The most commonly used sheath size in our study was 16F, although even larger sheaths of up to 24F diameter were also occasionally used.

Our study has a few limitations. This is a retrospective study and is limited to a small number of patients; however, it is still the second largest study reported to date. The follow-up period is short and is limited to <1 year. A prospective study with a large number of patients and a longer follow-up period would be advantageous in better understanding the long-term benefit of this procedure. Another limitation, as previously mentioned, is the lack of a control group with which to correlate the degree of filter tilt, caval penetration, and filter fracture with successful standard snare retrievals. However, in all of the patients in this study, initial standard (snare) retrieval attempts failed. In the future, we intend to prospectively use forceps as a first-line retrieval device in anticipated difficult cases.

CONCLUSIONS

Retrievable IVC filters offer protection against VTE and are easily removed by standard retrieval techniques in most patients. However, if a retrievable IVC filter is significantly tilted, has penetrating or fractured components, or is embedded within the wall of the IVC as a result of a prolonged dwell time, the use of rigid endobronchial forceps offers an alternative method for retrieving the filter. This technique may be used as a reliable option with a high success rate and minimal complications. Moreover, in patients in whom a difficult retrieval is anticipated, rigid forceps may be considered a first-line retrieval device to minimize procedure time, degree of radiation exposure, potential complications from failed attempts, and overall costs.

AUTHOR CONTRIBUTIONS

Conception and design: ST, IP, SG, TW
Analysis and interpretation: ST, IP, PK, ZI, TW
Data collection: ST, IP, PK, ZI, TW
Writing the article: ST, IP, TW
Critical revision of the article: ST, IP, PK, ZI, SG, TW
Final approval of the article: ST, IP, PK, ZI, SG, TW
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Overall responsibility: ST

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