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Retrieval of Tip-embedded Inferior Vena Cava Filters by Using the Endobronchial Forceps Technique: Experience at a Single Institution[1]

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Purpose: To evaluate the use of endobronchial forceps to retrieve tip-embedded inferior vena cava (IVC) filters.

Materials and Methods: This institutional review board–approved, HIPAA-compliant retrospective study included 114 patients who presented with tip-embedded IVC filters for removal from January 2005 to April 2014. The included patients consisted of 77 women and 37 men with a mean age of 43 years (range, 18–79 years). Filters were identified as tip embedded by using rotational venography. Rigid bronchoscopy forceps were used to dissect the tip or hook of the filter from the wall of the IVC. The filter was then removed through the sheath by using the endobronchial forceps. Statistical analysis entailed calculating percentages, ranges, and means.

Results: The endobronchial forceps technique was used to successfully retrieve 109 of 114 (96%) tip-embedded IVC filters on an intention-to-treat basis. Five failures occurred in four patients in whom the technique was attempted but failed and one patient in whom retrieval was not attempted. Filters were in place for a mean of 465 days (range, 31–2976 days). The filters in this study included 10 Recovery, 33 G2, eight G2X, 11 Eclipse, one OptEase, six Option, 13 Günther Tulip, one ALN, and 31 Celect filters. Three minor complications and one major complication occurred, with no permanent sequelae.

Conclusion: The endobronchial forceps technique can be safely used to remove tip-embedded IVC filters.

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Retrievable inferior vena cava (IVC) filters are designed to be removed if they are no longer required to protect against pulmonary embolism or as a permanent device for prolonged pulmonary embolism protection (1–3). Retrievable IVC filters are safe to deploy, prevent pulmonary embolism, and are safe to retrieve (4–6). These devices also have the potential to decrease the long-term risks of permanent IVC filters, including IVC thrombosis, filter migration, filter fracture, and filter perforation, but only if they are removed. Unfortunately, many retrievable IVC filters are not removed (7–9).

Reasons for not removing a retrievable IVC filter include indefinite ongoing need for IVC filtration, patients being lost to follow-up, considerable thrombus within the filter, substantial filter tilt, embedded filter tip, embedded filter struts, strut perforation, and filter fracture (10,11). Among patients who undergo attempted IVC filter retrieval, filter tilt and subsequent tip embedding in the wall of the IVC are the most common causes of failed filter removal (7,11).

The endobronchial forceps technique for removing tip-embedded IVC filters was initially described in 2006 (12). Other nonstandard techniques used for filter retrieval include variations on the loop-snare technique and laser-assisted retrieval (11). The current study evaluated the use of endobronchial forceps to retrieve tip-embedded IVC filters.

Materials and Methods

We used our quality assurance database of prospectively captured IVC filter retrievals to identify all patients who had an attempted removal of a tip-embedded IVC filter from January 2005 (when the technique was first used at this institution) to April 2014. All these patients were included in this study. All data were evaluated by three authors of this article (S.W.S., S.O.T., and B.H.G.). During this period, 114 patients presented to the interventional radiology clinic for attempted removal of a tip-embedded IVC filter. All patients who presented to our institution since we started using this technique are included in the study. This group consisted of 77 women and 37 men with a mean age of 43 years (range, 18–79 years). Twelve of these patients had been included in an earlier description of this technique (13). The institutional review board approved this Health Insurance Portability and Accountability Act–compliant, retrospective study and waived the need for informed consent.

All patients who underwent retrieval of an IVC filter were seen in the interventional radiology clinic for evaluation by an interventional radiology attending physician. Before the clinic visit, patients underwent computed tomographic (CT) venography of the abdomen and pelvis to evaluate for filter tilt, fracture, filter strut penetration, and IVC thrombus. Filter strut penetration was evaluated by using the grading system of Oh and colleagues (14): grade 0, no penetration; grade 1 penetration, tenting of the IVC; grade 2 penetration, extraluminal appearance on CT scan; and grade 3 penetration, involvement of the strut with an adjacent organ. The deep venous system of the legs was evaluated with Doppler ultrasonography (US) or CT venography at the same time as abdominopelvic CT venography. During this visit, current need for the IVC filter was determined. Indications for filter retrieval included the following: The risk for pulmonary embolism had passed or the patient could safely undergo anticoagulation.

If the filter appeared likely to be embedded according to CT or an imaging examination performed outside the hospital during a prior retrieval attempt, an extensive informed consent process was undertaken in which the potential need for the endobronchial forceps technique was explicitly discussed with the patient. Because the rigid endobronchial forceps (model 4162, Bryan, Woburn, Mass) is a class 1 device, this does not constitute off-label use; there are no instructions for use. Final determination of an embedded filter tip was not made until rotational venography was performed at the start of the retrieval procedure.

All procedures were performed with the patient receiving moderate sedation with fentanyl (Akorn, Lake Forest, Ill) and midazolam (Roche, Basel, Switzerland), titrated to effect, by one of seven interventional radiologist attending physicians who were board-certified and certified or eligible for certificate of added qualification, with 2–23 years of experience, including five authors of this article (S.O.T., S.W.S., J.I.M., R.S.G., D.S.).

Magnification spot radiographs (Fig 1) of the filter were obtained prior to venous access to further assess for fracture before manipulation of the filter. After US-guided access of the right

Advances in Knowledge

- Rotational venography can help in the diagnosis of tip-embedded inferior vena cava (IVC) filters.
- Endobronchial forceps can safely be used to remove tip-embedded IVC filters.

Implications for Patient Care

- The endobronchial forceps technique can be used to remove tip-embedded IVC filters and should be considered when the filter tip is shown to be embedded.
- This technique has the potential to be transferable and useful to many interventionalists with standard endovascular skills.

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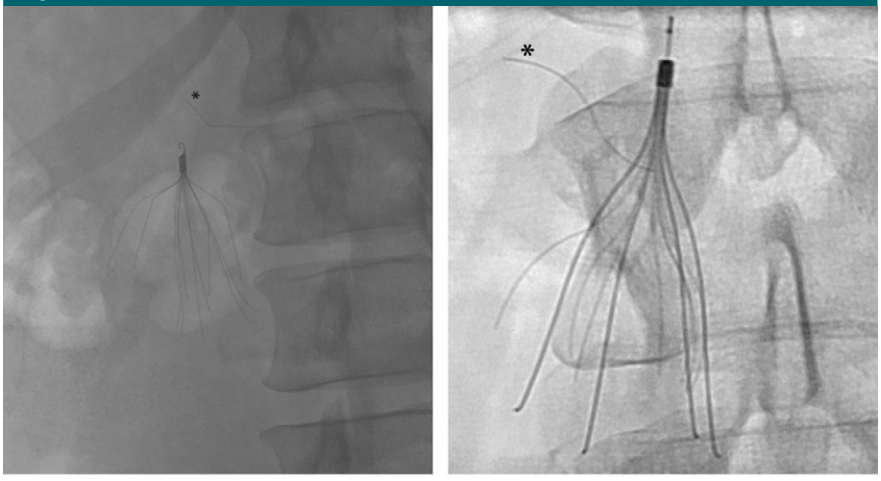
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Abbreviation:
IVC = inferior vena cava

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Guarantors of integrity of entire study, S.W.S., S.O.T.; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; approval of final version of submitted manuscript, all authors; agrees to ensure any questions related to the work are appropriately resolved, all authors; literature research, B.H.G., S.O.T.; clinical studies, all authors; statistical analysis, B.H.G.; and manuscript editing, B.H.G., J.I.M., R.D.S., D.S., S.O.T.

Conflicts of interest are listed at the end of this article.

Figure 1



a. b.

Figure 1: **(a)** Scout radiographic view of fractured (*) and tip-embedded G2 IVC filter. **(b)** Scout radiographic view of fractured (*) and tip-embedded Celect IVC filter.

Figure 2

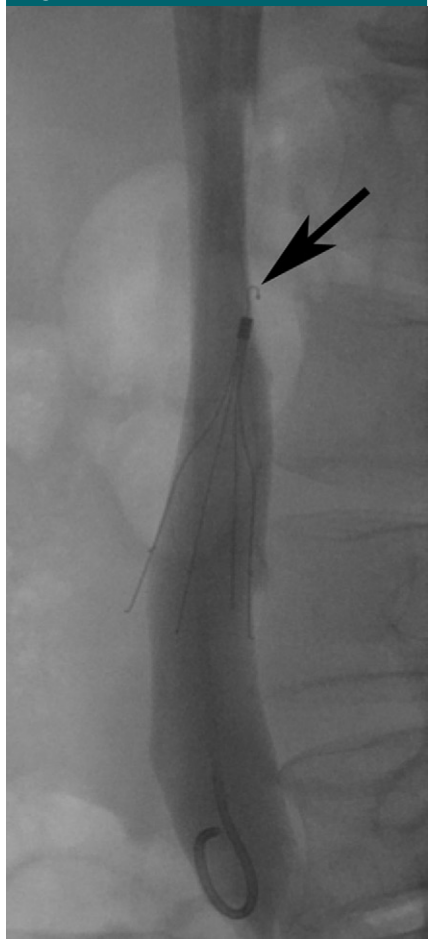


Figure 2: Rotational venogram of tip-embedded (arrow) Günther Tulip IVC filter.

internal jugular vein was obtained, rotational venography was performed by using a flush catheter with half-strength contrast material (Isovue 300; Bracco Diagnostics, Monroe Township, NJ) with an injection rate of 15 mL/sec for 6 seconds and a 2-second x-ray delay (Fig 2). When an embedded filter was diagnosed at venography, the endobronchial forceps technique was used.

A 12-F, 45-cm sheath (Cook Medical, Bloomington, Ind) was loaded coaxially into a 14-F, 30-cm sheath (Cook Medical) and advanced into the IVC via the right internal jugular vein. The sheaths were positioned just above the tip of the IVC filter. Rigid bronchoscopy forceps were then placed through the 12-F sheath to the top of the filter. The forceps were gently bent near the grasping end (Fig 3) on the basis of the tip location identified at CT and rotational venography, such that the tip of the forceps could be positioned at the superior aspect of the filter hook. Further, the bend was performed in such a way as to allow the open jaws of the forceps to approach the filter tip. The C-arm was then angled in a position that optimally showed the embedded tip according to the findings on the rotational venogram.

The forceps were then used to dissect the tip of the IVC filter free from the wall of the IVC by using gentle movements to remove tissue around the filter tip. Once the forceps were thought to contact the metal of the hook or tip of the IVC filter, the tip was grasped with the forceps (Fig 4). This often took several attempts before the tip was firmly in the jaws of the forceps. The forceps were then turned 90° to ensure that the tip was not protruding from the side, which would preclude withdrawal into the sheath. Depending on filter design, the captured tip was oversheathed (Günther Tulip [Cook Medical], OptEase [Cordis, Warren, NJ], Celect [Cook Medical], and Option [Argon, Plano, Tex]) or pulled into the sheath (Recovery [Bard PV, Tempe, Ariz], G2 [Bard PV], G2X [Bard PV], Eclipse [Bard PV], and ALN [ALN International, Miami, Fla]) per the manufacturer's instructions. Combinations of these two maneuvers were often necessary. If the filter could not be oversheathed, the most common reason was grasping of the filter too far below the superior tip, with the endobronchial forceps not allowing the hook or tip of the filter to go into the sheath.

On retrieval of the filter, postretrieval venography was then performed in the same projection as the dissection. Attempts were then made to remove fractured filter fragments, if any, by using the forceps or a snare during the same procedure. The patient was then observed in the interventional radiology recovery area for 2–4 hours and was subsequently discharged. Follow-up was performed in the office (or by telephone for patients living out of the area) at 1 month.

Calculations of percentages, ranges, and means were the statistical tests used on the data. These tests were performed with spreadsheet software (Excel 2010; Microsoft, Redmond, Wash).

Results

The endobronchial forceps technique was attempted in 113 of 114 patients

Figure 3



a. b.

Figure 3: **(a)** Subtracted venogram of tip-embedded (arrow) Celect IVC filter. **(b)** Unsubtracted venogram of tip-embedded (arrow) Celect IVC filter.

presenting to our institution with tip-embedded IVC filters (Table 1). One hundred nine of these patients had their filters successfully retrieved. On an intention-to-treat basis, the success rate for retrieval with forceps since our institution adopted this technique was 96% (109 of 114). The mean filter-dwell time was 465 days (range, 24–2976 days), and the median was 310 days. The most common reason for filter placement was history of pulmonary embolism and/or deep-vein thrombosis with a contraindication to anticoagulation (Table 2). One hundred one filters (89%) had been placed at an outside institution, and 13 had been placed at our institution. Seventy-nine patients underwent at least one prior attempt to retrieve the filter at an outside institution; 10 patients underwent two prior attempts at retrieval. The filters were retrieved in 66 patients (58%) because they no longer needed protection from venous thromboembolic disease and pulmonary embolism. In 48 patients (42%), the filters were removed because the patients could tolerate anticoagulation therapy.

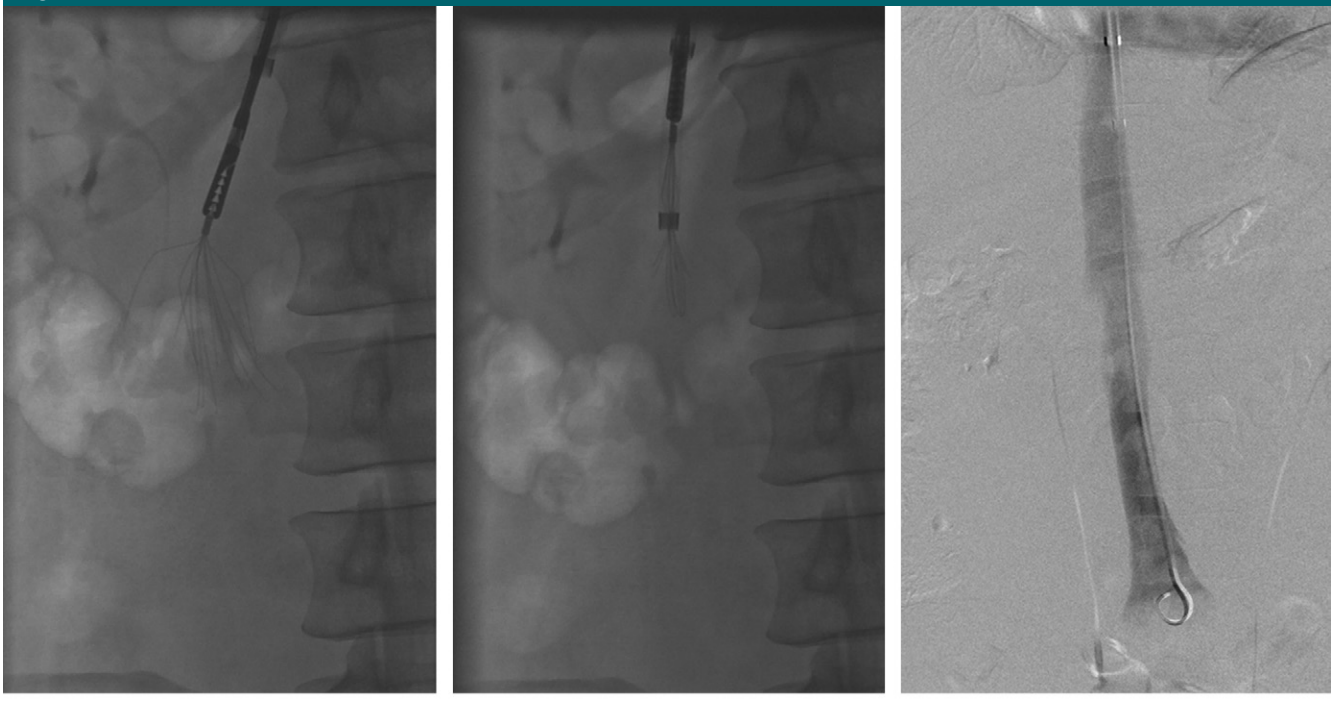
All retrieval attempts but one occurred via the right internal jugular vein; the exception was a single OptEase filter that was removed by using a right common femoral venous approach (Table 3). Twenty-eight patients were symptomatic and 86 were asymptomatic. Ten patients with a Celect filter, five patients with a Günther Tulip filter, eight patients with a G2 filter, three patients with a Recovery filter, two patients with an Eclipse filter, and one patient with a G2X filter had abdominal or back pain. One patient with a Recovery filter that had a filter leg in the duodenum presented with gastrointestinal bleeding.

Preprocedure spot radiography revealed fractures in 31 filters. This included one G2X, five Recovery, 12 G2, three Eclipse, eight Celect, and two Günther Tulip filters. According to the grading system of Oh et al (14), evaluation of the filter struts for penetration on available CT scans revealed grade 0 penetration in 12 patients, grade 1 penetration in 14, grade 2 penetration in 42, and grade 3 penetration in 44 (Table 3). Three filters had a thrombus, but in all cases the clot made up less than 25% of the filter volume; therefore, the filters were retrieved. One hundred eleven patients had no thrombus in the filter at the time of retrieval. Median fluoroscopy time for the entire procedure, including access, setup for rotational venography, and retrieval, was a median of 21 minutes and mean of 24 minutes (range, 3–88 minutes). For 82 filter retrievals that did not include removal of a fractured filter fragment, the median fluoroscopy time was 16 minutes. All procedures were performed by using pulsed fluoroscopy at 7.5 pulses per second.

Of the four failed retrieval attempts, two were for G2 filters, one was for a Recovery filter, and one was for a Celect filter. Three of the four failed attempts (75%) occurred in the first 15 patients in whom this technique was attempted, and no failed attempts occurred in the last 64 attempts with this technique. The operator with the greatest experience (75 retrievals) has had a 100% success rate when the technique was attempted. In one patient with a tip-embedded filter, the forceps technique was not attempted. After two attempted retrievals of this filter at an outside institution, the Eclipse filter was in a near-perpendicular position in the IVC; the entire head of the filter and the upper parts of the struts were through the wall of the IVC. Forceps retrieval in this case was considered ineffective and unsafe and therefore was not attempted. This filter remains in place, with no plans to attempt another retrieval. Clinical follow-up lasting at least 1 month in 85 patients has revealed no evidence of symptomatic recurrent pulmonary embolism or caval thrombosis after filter retrieval.

As assessed according to the Society of Interventional Radiology clinical practice guidelines, three minor

Figure 4



a. b. c.

Figure 4: **(a)** Endobronchial forceps engaged with tip of embedded G2 IVC filter. **(b)** Pulling of the embedded G2 IVC filter into 12-F sheath. **(c)** Postretrieval venogram obtained after embedded G2 IVC filter was removed.

complications and one major complication occurred during these procedures (15). One case involved an embolized filter fragment during an Option filter removal. This occurred when the upper struts of the filter were grabbed with the forceps and pulled into the sheath. The embolized fragment migrated to the right pulmonary artery. This fragment was then removed with an endovascular snare system (EN Snare; Merit Medical, South Jordan, Utah) during the same procedure. In another case, a tip-embedded Eclipse filter that was fractured before presentation was removed without complication. During removal of the previously fractured fragment with use of the endobronchial forceps, the fragment was released accidentally and migrated to the left pulmonary artery, where it was retrieved with a snare. One patient developed a small IVC pseudoaneurysm after endobronchial forceps were used to dissect the tip of a Günther Tulip filter. No treatment was required. The patient was asymptomatic, and CT revealed no retroperitoneal hematoma. The patient was discharged after a 4-hour observation. US at 1 month revealed no IVC abnormalities, and the patient was asymptomatic.

The one major complication was a small IVC pseudoaneurysm. This occurred with a Günther filter that was tip embedded and wall embedded and had been in place for 4 months. Endobronchial forceps were used to remove the tip from the wall of the IVC. Once the filter tip was in the sheath, the sheath was used to oversheath and dissect the legs off the wall of the IVC; the filter was then removed. At postprocedure venography, an IVC pseudoaneurysm was seen at the point where the legs were wall embedded in the IVC. This was successfully treated with balloon tamponade. The patient was observed overnight in the hospital. Imaging and clinical follow-up with CT 2 months later revealed resolution, with no further complication. This pseudoaneurysm did not involve the area of the IVC where the forceps were used to remove the hook of the filter from the wall. No patients required stent grafting, surgery, or other intervention.

Discussion

When retrievable IVC filters were approved for use in the United States in 2003, it was logical to think that most of these filters would be removed and that complications related to IVC filters would decrease. Unfortunately, although the number of IVC filters placed in the past decade has increased dramatically, many retrievable filters are not removed (16,17). Retrievable IVC filters that are not removed can have complications, including leg perforation, fracture, migration, and thrombosis (14,18–21). Such complications led to a release of a U.S. Food and Drug Administration safety alert in 2010 urging physicians who place retrievable filters to be responsible for the ongoing

Table 1

Patient Demographic and Clinical Characteristics

Characteristic	Data (n =114)
Mean age (y)*	43 (18–79)
No. of men†	37 (32.1)
No. of women†	77 (67.9)
Filter dwell time (d)*	465 (24–2976)
No. of symptomatic patients†	29 (25)
No. of patients with prior removal attempts†	79 (69)
No. of patients with extraluminal struts†	100 (88)
No. of patients with filter fracture†	32 (28)
No. of patients with embolized fragment†	9 (8)
Mean fluoroscopic time (min)*	24 (3.2–88)
No. of patients with complications†	4 (3.5)
Minor	3
Major	1

* Numbers in parentheses are the range.

† Numbers in parentheses are percentages.

Table 2

Indications for Filter Placement

Clinical History	Data (n = 114)
Pulmonary embolism and/or deep-venous thrombosis with contraindication to anticoagulation	44 (39)
Trauma with prolonged immobilization	20 (17)
Prophylaxis before bariatric surgery	12 (10)
Anticoagulation stopped before other surgical intervention	27 (24)
Failed anticoagulation	11 (10)
Placed at outside institution	101 (89)
Placed at study institution	13 (11)

Note.—Values are expressed as number of patients, with percentages in parentheses.

care of their patients and consider removing the filters as soon as they are no longer needed to protect against pulmonary embolism.

One result of this attention has been an increased vigilance in the follow-up of patients with IVC filters and the formation of IVC filter clinics and other strategies to improve follow-up (22,23). Despite this closer follow-up and more patients returning to be evaluated for filter retrieval, standard techniques can fail (17). The most common reason for a failed IVC filter retrieval is tilting of the filter, with the tip of the filter becoming embedded in the wall of the IVC (11). When this occurs, it is impossible for a snare or cone device to be placed over the tip of the IVC filter. Therefore, a widely applicable and cost-effective technique is needed to retrieve these filters.

The need for nonstandard techniques to retrieve tip-embedded filters has led to the development of the loop-snare, laser-assisted removal, balloon displacement, and endobronchial forceps techniques (12,17,24–26). The endobronchial forceps technique was initially described in 2006 in a small group of patients (12,13). It was initially developed upon discovery that standard techniques with snare or retrieval cones were not successful in removing filters whose tips were embedded in the wall of the IVC. Our study now shows the value of the forceps technique during a longer period in a much larger unselected group of patients with tip-embedded filters.

This technique has been successful in 95% of patients who presented with a tip-embedded filter on an intention-to-treat basis because the endobronchial forceps were first used at our institution. Three of the four attempted retrieval failures occurred in the first 15 patients, suggesting a learning curve for the technique. The loop-snare technique was unsuccessfully attempted in two of the four failures. All four of these patients have had their filters left in place as permanent devices. All 13 Günther Tulip filters in this series were successfully retrieved by using the endobronchial forceps. Laser-assisted retrieval, which has been used to remove leg-embedded Günther Tulip filters, was not required in any of these patients (27,28).

Other investigators have shown success with use of endobronchial forceps to retrieve embedded IVC filters. For example, Kuo et al (11) recently reported on a series of 50 patients with IVC filters requiring complex retrieval techniques for removal. The endobronchial forceps technique facilitated 40 of these 50 removals, in which the tip was embedded. Such use of forceps for filter retrieval at another institution demonstrates the transferability of the technique, a key element of our procedure. The filters in that series were classified as tip embedded if standard techniques failed; in contrast, in our trial, we used venographic findings.

In a recently published modification of our technique (29), the authors described the use of a snare, flexible forceps, and laser to retrieve tip-embedded IVC filters. Their technique was successful in the three cases in which it was used. However, their approach required expensive equipment that is not needed with our technique. In addition, the mean fluoroscopy time for those three patients was 150 minutes, compared with 24 minutes in our study.

The forceps technique for filter retrieval involves more than just the use of forceps. We believe the steps of clinic visit, CT venography, spot radiograph acquisition, and rotational venography are essential to the success of the procedure (30). The spot radiographs often depict fractures unsuspected at CT or new fractures that have developed since the most recent imaging examination. The preretrieval rotational venogram allows determination of whether conventional techniques even apply. If the filter is tilted but not tip embedded, standard retrieval techniques can be used to remove the filter. If a filter is shown to be tip embedded, standard techniques are not used. This is important because using standard techniques with a snare or retrieval cone will not be successful in tip-embedded filters and can lead to further complications, such as filter fracture, further malposition, or migration; substantial cost; prolonged procedure time; fluoroscopy time; and use of contrast material. Indeed, as evidenced by the one patient

Table 3

IVC Filters according to Type

Filter Type and Manufacturer	No. of Patients	Mean Dwell Time (d)*	No. of Patients with Extraluminal Strut	No. of Patients with Fracture	No. of Symptomatic Patients
G2, Bard PV	33	631 (101–2731)	31	12	8
Celect, Cook Medical	31	297 (25–2014)	27	8	10
Günther Tulip, Cook Medical	13	624 (93–1966)	9	2	5
Eclipse, Bard PV	11	278 (66–638)	12	3	2
Recovery, Bard PV	10	710 (24–2976)	10	5	1
G2X, Bard PV	8	458 (149–1571)	6	1	1
Option, Argon	6	154 (92–211)	4	1	
OptEase, Cordis	1	338	1	0	
ALN Filter, ALN International	1	92	0	0	

* Numbers in parentheses are ranges.

in whom we did not attempt to retrieve the filter, such techniques can turn a readily retrievable, tip-embedded filter into an irretrievable one. The rotational venogram also helps guide the dissection of the filter tip. When the forceps are being used to dissect the tip of the filter free, the fluoroscopy tube is rotated to the angle that best profiles the tip of the embedded filter in relation to the wall of the IVC.

Although this study shows that the endobronchial forceps can be used to safely retrieve tip-embedded filters in a large group of patients, three minor complications and one major complication occurred. One minor complication (small venous pseudoaneurysm) was probably attributable to the forceps dissection itself. However, the one major complication was not due directly to the forceps dissection of the tip-embedded portion of the filter but rather to the removal of a filter with wall-embedded struts.

Our study had important limitations. This is a retrospective study, although all patients who presented to our center with tip-embedded filters were offered this treatment and the data were collected prospectively as part of our quality assurance program. This is an advanced technique for filter retrieval, and endovascular skills are needed to perform this procedure safely. The endobronchial forceps technique was not compared with other advanced techniques for filter removal. Although using advanced techniques to remove IVC filters provides intuitive benefits, no prospective randomized study, to our knowledge, has demonstrated a definite benefit to removing a retrievable IVC filter compared with leaving the filter in place as a permanent device.

In conclusion, our study results show that, in a relatively large number of patients, the endovascular forceps technique can be used safely to remove tip-embedded IVC filters, including those for which prior attempts at removal have failed.

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