A 16-F Sheath with Endobronchial Forceps Improves Reported Retrieval Success of Long-Dwelling "Closed Cell" Inferior Vena Cava Filter Designs

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ABSTRACT

Purpose: To report results of a 16-F sheath/endobronchial forceps combination in retrieval of "closed cell" inferior vena cava (IVC) filter designs with prolonged dwell times of $\geq$ 60 days.

Materials and Methods: Forceps retrieval of selected IVC filters using a 16-F 45-cm sheath was performed in 35 patients (25 women and 10 men). Patients presented with filters that were no longer needed without (n = 10) or with (n = 21) prior failed retrieval, caval thrombosis before lysis (n = 3), and back pain (n = 1). Filter designs included 19 Günther Tulip (54%), 10 Option (29%), and six OptEase (17%). Mean dwell time was 977 days. Imaging characteristics, technical success, fluoroscopy time, and complications were recorded.

Results: Filters included 20 tip-embedded, 6 tip-adherent, 4 fractured, and 6 containing thrombus. All were strut and wall-embedded. Initial snare failures occurred in 8 filters because of hook straightening (n = 4), adherent material (n = 2), snare breakage (n = 1), and filter tilt (n = 1). The 16-F sheath/forceps combination was 100% successful in removing filters. In 1 patient, 2 extravascular fragments could not be retrieved. Median fluoroscopy time, excluding 3 extended lysis procedures, was 8 minutes. Minor caval abnormalities, including caval spasm and caval defects, were noted in 17 patients, and filter fracture occurred in 2 patients. No major complications occurred.

Conclusions: A high rate of retrieval for closed cell long-dwelling strut and wall-embedded filters may be achieved using a 16-F sheath/endobronchial forceps combination.

ABBREVIATION

IVC = inferior vena cava

Inferior vena cava (IVC) filters with "closed cell" designs have lower retrieval success rates compared with filters with single individual metal elements (1–9). IVC filters with closed cell designs have complete circuits of metal or wire and include Günther Tulip (Cook, Inc, Bloomington, Indiana), Option (Argon Medical Devices, Inc,

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Plano, Texas), and OptEase (Cordis Endovascular, Warren, NJ) filters. Filters with single individual metal elements include Recovery (Bard Peripheral Vascular, Tempe, Arizona), G2 (Bard Peripheral Vascular), G2X (Bard Peripheral Vascular), Eclipse (Bard Peripheral Vascular), Meridian (Bard Peripheral Vascular), ALN (ALN International, Miami, Florida), and Celect (Cook, Inc) filters (Fig 1a, b). These filters, particularly with long dwell times, may be difficult to remove as a result of their closed cell struts, in contrast to their tips, becoming embedded in the IVC wall (Fig 2a, b). Multiple closed cell struts with substantial IVC wall contact and corresponding increased surface area serve as an effective scaffold for aggressive epithelialization, neointimal hyperplasia, and fibrosis, making these filters difficult to remove (7,10).

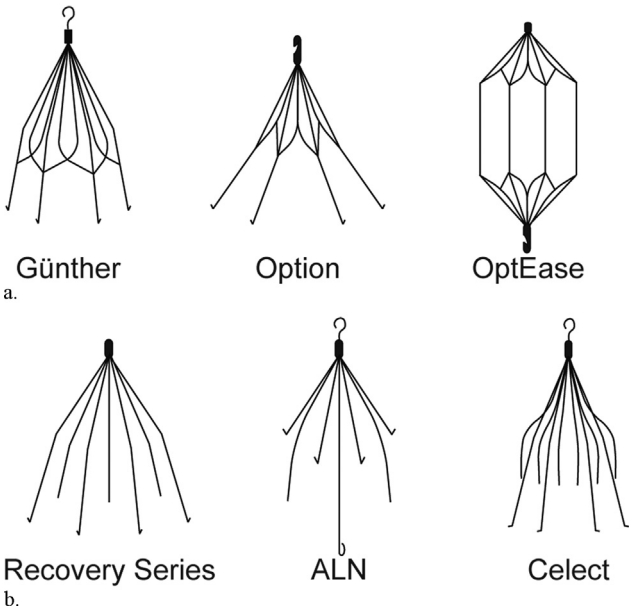


Figure 1. Examples of closed cell versus open cell IVC filters. **(a)** IVC filters with closed cell designs or complete metal circuits and **(b)** IVC filters with open cell designs or single individual metal elements.

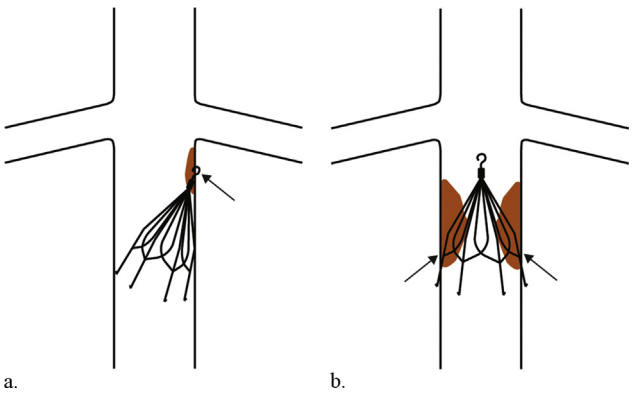


Figure 2. Tip-embedded versus strut and wall-embedded IVC filters. **(a)** Günther Tulip filter with tip embedded in the IVC wall (arrow) and **(b)** Günther Tulip filter with closed cell struts embedded in the IVC wall (arrows). Brown material denotes neointimal hyperplasia.

Modern retrieval techniques, including the use of traditional prepackaged retrieval devices (11,12) and variations on snare removals (13,14), employ pulling-type mechanisms to retrieve these closed cell strut and wall-embedded filters, leading to failed filter removal as well as caval retraction, inversion, intussusception, and dissection (15). A balanced traction technique has been developed using the combination of endobronchial forceps, which allow filter tip access and application of a firm retractile force (16–18), and a large sheath (19), which provides a balanced forward counterforce and serves to accommodate neointimal hyperplasia and fibrosis, for removal of strut and wall-embedded filters with closed cell designs. The aim of this study was to describe the results of using a 16-F Check-Flo Performer introducer sheath (Cook, Inc) in combination with endobronchial forceps (LYMOL Medical, Woburn, Massachusetts) in the retrieval of strut and wall-embedded closed cell IVC filters with extended dwell times of $\geq$ 60 days.

MATERIALS AND METHODS

This study was conducted with institutional review board approval and complied the Health Insurance Portability and Accountability Act. Patients were identified using retrospective review of the division's quality improvement database (HI-IQ; Conexsys, Lincoln, Rhode Island) and other medical and imaging records. During the period from July 2013 until December 2015, all patients presenting for retrieval of closed cell strut and wall-embedded IVC filter designs, including Günther Tulip, Option, and OptEase, with prolonged dwell times of $\geq$ 60 days underwent modified endobronchial forceps removal using a 16-F 45-cm Check-Flo Performer introducer sheath as an alternative to the standard snare technique with a 10-F sheath for non–tip-embedded filters or endobronchial forceps with a 12-F and 14-F sheath combination for tip-embedded filters, as previously described (17,18). Prolonged dwell time was defined as 60 days in accordance with a US Food and Drug Administration decision analysis mathematical model, which concluded that the risk and benefit profile favored unneeded filter removal between 29 and 54 days (20).

Patients consisted of 25 women (71%) and 10 men (29%) with mean and median ages of 50 years and 53 years, respectively (range, 19–81 y) (Table 1). Nine of the patents were included in an earlier description, as their filters were tip-embedded as well (18). Ten patients presented with IVC filters that were no longer needed for protection from pulmonary embolism without prior retrieval attempts (29%), 21 patients presented with filters that were no longer needed with prior unsuccessful retrieval attempts at outside institutions (60%), three patients presented with caval thrombosis

before lysis (8%), and one patient presented with long-standing back pain that developed 3 months after filter placement (3%) (Table 2).

Filter designs included 19 Günther Tulip (54%), 10 Option (nine Option and one Option Elite) (29%), and six OptEase (five OptEase and one Aegisy, a Chinese version of the OptEase) (17%) (Table 2). Composite mean and median dwell times were 977 days and 640 days, respectively (range, 64–3,895 d). Mean dwell times for Günther Tulip, Option, and OptEase filters were 1,321 days (range, 64–3,490 d), 644 days (range, 118–3,895 d), and 438 days (range, 95–1,295 d) (Table 2).

All patients who underwent IVC filter retrieval were seen in the interventional radiology clinic by an attending interventional radiologist before the procedure. All procedures were performed with intravenous moderate sedation with midazolam (Roche; Basel, Switzerland) and fentanyl (Akorn Pharmaceuticals; Lake Forest, Illinois), titrated to effect, by one of eight board-certified attending interventional radiologists with 2–23 years of experience. All procedures were performed using pulsed fluoroscopy at 7.5 pulses/s.

The endobronchial forceps technique has been described elsewhere (17,18). Briefly, spot magnification radiographs were obtained of all filters to evaluate for fracture (Fig 3a). After obtaining right internal jugular vein access for Günther Tulip and Option removals or femoral vein access for OptEase retrievals, rotational venography was performed using a flush catheter and half-strength contrast material (iopamidol [ISOVUE-M 300; Bracco Diagnostics, Monroe Township, New Jersey]) with an injection rate of 15 mL/s for 6 seconds and a 2 second x-ray delay to evaluate for tip embedding (Fig 3b) (21). A snare was used for the first eight tip-centered filters (Fig 3c), whereas 3-mm endobronchial forceps (4162; LYMOL Medical) was used immediately with tip-adherent and tip-embedded filters. In cases of snare malfunction (Fig 3d), endobronchial forceps was subsequently used. After the first eight snare failures, endobronchial forceps was used for all closed cell strut and wall-embedded filters, including tip-centered filters, with prolonged dwell times of $\geq$ 60 days.

A 16-F 45-cm sheath was advanced into the IVC and positioned superior to the tip of the filter. A snare, used for the first eight tip-centered Günther Tulip, Option, and OptEase filters, or 3-mm endobronchial forceps (#4162; LYMOL Medical) was then placed through the 16-F sheath and positioned above the filter. Once the hook was grasped (Fig 3e), either without (tip-centered filters) or with (tip-embedded filters) tip dissection from the wall of the IVC, the filter was over-sheathed (Günther Tulip and OptEase) or over-sheathed and pulled into the sheath (Option) per the manufacturers' recommendations (Fig 3f).

After filter retrieval, repeat venography was performed to evaluate for thrombosis, caval spasm (Fig 3g), caval perforation, fractured fragments, and other potential complications. Caval spasm was defined

Table 1. Patient Demographics

Characteristic	Günther Tulip (n = 19)	Option (n = 10)	OptEase (n = 6)	Total (N = 35)
Age, y				
Mean	52	48	47	50
Median	49	51	53	53
Range	23–81	19–63	32–71	19–81
Sex, n (%)				
Male	5 (26%)	4 (40%)	1 (17%)	10 (29%)
Female	14 (74%)	6 (60%)	5 (83%)	25 (71%)

Table 2. Filter Retrieval Indications, Designs, and Dwell Times

	Tulip Günther (n = 19)	Option (n = 10)	OptEase (n = 6)	Total (N = 35)
Filter retrieval indications, n (%)				
No longer needed without prior retrieval	4 (21%)	2 (20%)	4 (67%)	10 (29%)
No longer needed with prior unsuccessful retrieval	12 (63%)	7 (70%)	2 (33%)	21 (60%)
Caval thrombosis before lysis	2 (11%)	1 (10%)	0	3 (8%)
Long-standing back pain	1 (5%)	0	0	1 (3%)
Filter designs, n (%)	19 (54%)	10 (29%)	6 (17%)	35 (100%)
Filter dwell times, d				
Mean	1,321	644	438	977
Median	842	270	333	640
Range	64–3,490	118–3,895	95–1,297	64–3,895

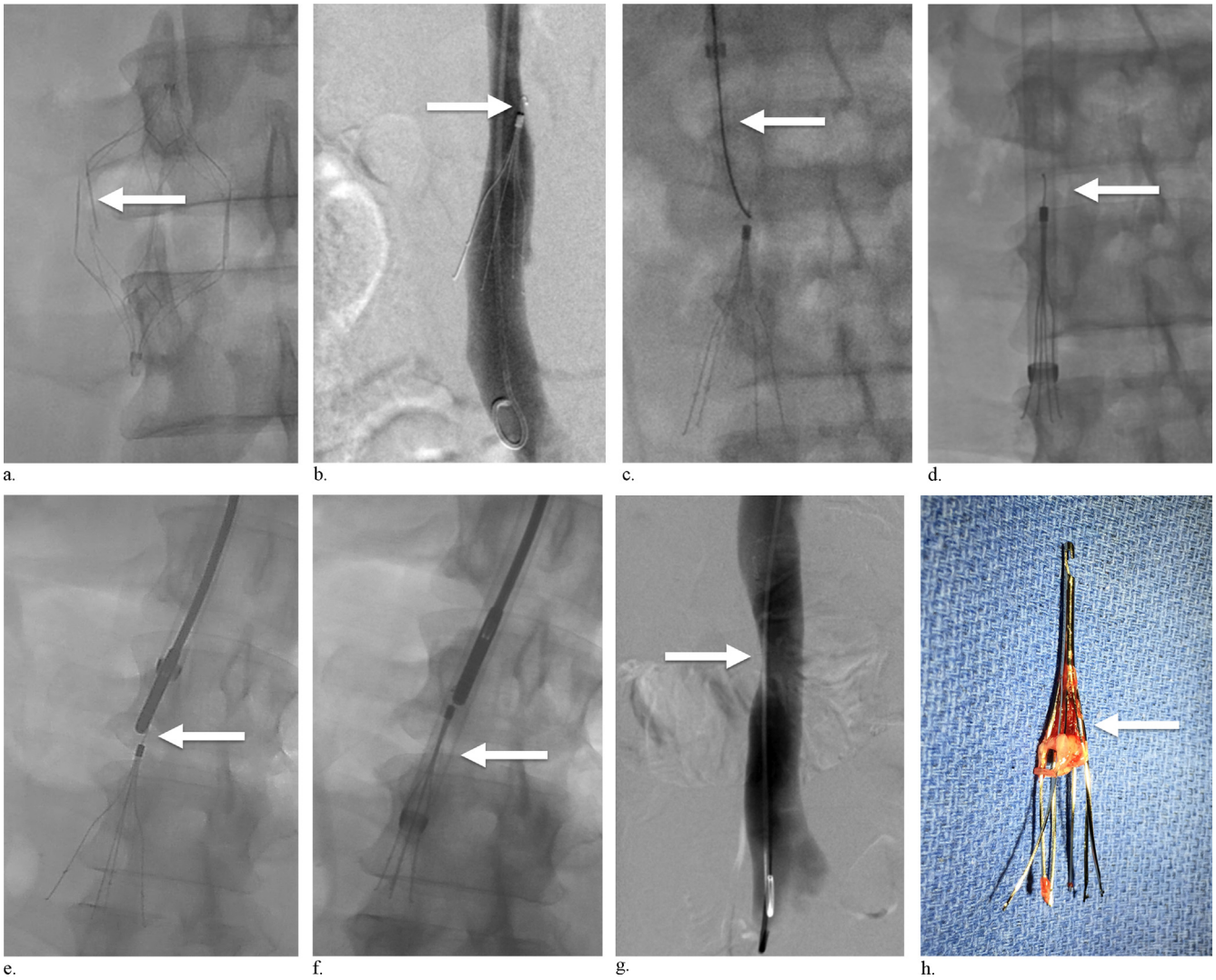


Figure 3. **(a)** Spot magnification radiograph demonstrating a fractured intravascular OptEase filter (arrow shows fractured rail). **(b)** Rotational venogram in a different patient showing a tip-embedded (arrow) and strut and wall-embedded Günther Tulip filter. **(c)** Fluoroscopic image in a third patient demonstrating advancement of a snare (arrow) to grasp the hook of the IVC filter. **(d)** Over-sheathing of the Günther Tulip filter with subsequent straightening of the hook (arrow) resulting in snare failure. Endobronchial forceps was subsequently used to retrieve the filter (not shown). **(e)** Endobronchial forceps in a different patient used to grasp the hook of a Günther Tulip filter (arrow). **(f)** Over-sheathing of the filter (arrow). The filter was retrieved in its entirety. **(g)** Venogram obtained after retrieval showing moderate caval spasm (26%–50%) (arrow). **(h)** Photograph showing a successfully retrieved strut and wall-embedded Option filter with associated neointimal hyperplasia and organized thrombus (arrow).

as none (0%), mild (1%–25%), moderate (26%–50%), or severe (51%–75%). Additional retrieval attempts, if necessary, were made to recover fractured fragments, again using 3-mm and infrequently 1.5-mm endobronchial forceps (#4162 or #4157; LYMOL Medical). After hemostasis was achieved, patients were monitored for 2–4 hours in the interventional radiology recovery area. All retrieved IVC filters were sent for pathologic evaluation to document if the entire intact filter was removed, if the entire broken filter was retrieved, or if only a portion of the filter was recovered (Fig 3h). After the procedure, all patients had a follow-up evaluation in the interventional radiology clinic or by telephone at 1 month. Calculations of percentages, means, medians, and ranges were performed on the data using spreadsheet software (Excel 2010; Microsoft Corporation, Redmond, Washington).

RESULTS

Initial imaging, including spot magnification radiographs and rotational venography, demonstrated six adherent tips, 20 embedded tips, four fractured filters (including one Günther Tulip filter with two extravascular filter fragments), and six filters with a small amount of nonocclusive thrombus that did not interfere with removal. A snare was used initially in eight patients (23%), but was unsuccessful because of straightening of the hook (50%), adherent material (25%), snare breakage

(12.5%), or filter tilt (12.5%). Endobronchial forceps was used initially in 27 (77%) patients and as backup in the eight (23%) patients with snare failure. The 16-F sheath was used initially in 34 patients (97%), and combination of a 12-F and a 16-F sheath was used in one patient (3%) per operator preference.

The 16-F sheath and endobronchial forceps combination was used to successfully retrieve all 35 IVC filters (**Table 3**). One Günther Tulip, one Option, and one OptEase filter required two piecemeal removals, with all associated intravascular fragments ultimately removed. In one patient with a Günther Tulip filter, two extravascular fragments, which were separate from the main body of the filter on initial presentation, could not be removed because of their location.

Mean and median fluoroscopy times for the entire procedure were 14 minutes (range, 3–95 min) and 9 minutes, respectively. Removal of two Günther Tulip filters and one Option filter was part of extended lysis procedures resulting in longer fluoroscopy times of 95 minutes, 54 minutes, and 58 minutes, unrelated to filter removal. When excluded, mean and median fluoroscopy times were 9 minutes (range, 3–21 min) and 8 minutes, respectively.

Minor asymptomatic caval abnormalities after removal were noted in 17 patients (49%), including nine with mild (1%–25%) and six with moderate (26%–50%) IVC spasm and two patients with small caval defects (**Table 3**). Filter fracture occurred during the removal process in two patients (6%), one with a Günther Tulip filter and one with an Option filter, with all fractured fragments completely recovered. No major complications occurred according to the Society of Interventional Radiology (SIR) clinical practice guidelines (22). At 1 month, there were no complications associated with filter removal; however, one patient developed unrelated occlusion of concurrently placed iliofemoral stents.

DISCUSSION

Günther Tulip, Option, and OptEase IVC filters have low published long-term retrieval success rates (1–9) because they become strut and wall-embedded with neointimal hyperplasia and fibrosis secondary to their closed cell designs (7,10). Although Günther Tulip retrieval technical success rates were 100% at 11 days after placement in a multicenter study (1), successful recoveries decreased to 97% at 30 days (2), 84% at 43 days (3), and 90% at 59 days (4). Moreover, Kaplan-Meier product-limit analyses estimated the probability of successful Günther Tulip retrievals to be only 67% and 37% at 182 days and 365 days, respectively (4). Closely mirroring the Günther Tulip experience, the Option filter had 92% retrieval success at 58 days after placement in a single-institution study (5), but only 86% at 67 days in a prospective multicenter clinical trial (6). Moreover, substantially more adjunctive retrieval techniques, including looped guide wires, endobronchial forceps, balloon-assisted displacement, and fibrin cap maceration techniques, were needed to remove Option filters compared with their Celect filter counterparts (5). Likewise, the OptEase filter had 100% retrieval technical success rates at 11 days (7) and 16 days (8) after implantation, but only 92% after 25 days (9).

Multiple methods have been used to address epithelialization, neointimal hyperplasia, and fibrosis and successfully remove IVC filters (17–19,23–25). Use of endobronchial forceps in conjunction with a standard 12-F and 14-F sheath combination was successful in removing 96% of tip-embedded IVC filters (n = 114) with only one major complication (18). A modified loop snare technique, in combination with a 16-F sheath, successfully removed 100% of tip-embedded open cell IVC filters (n = 33), without any complications (19). Photothermal tissue ablation using a xenon chloride excimer laser was used successfully to remove 98% of IVC filters (n = 100), including many strut and wall-embedded Günther Tulip, Option, and OptEase IVC filters, with three major complications (23,24). Despite using substantially less force compared with standard retrievals, excimer laser–assisted retrieval resulted in one case of acute IVC thrombosis and two cases of acute caval disruption requiring urgent endovascular stent graft placement (23,24). Most recently, combinations of in situ snares and endobronchial forceps, together with 14-F, 16-F, or 18-F sheaths, were used successfully to remove five strut and wall-embedded OptEase filters, with one pseudoaneurysm and one retained strut reported after the procedure and a mean fluoroscopy time of 25 minutes (25).

In the present study, all closed cell strut and wall-embedded filters were successfully removed using the 16-F sheath and endobronchial forceps combination, without any major complications and with mean and median fluoroscopy times of 9 minutes and 8 minutes,

Table 3. Successful Filter Removals and Complications

	Günther Tulip (n = 19)	Option (n = 10)	OptEase (n = 6)	Total (N = 35)
Successful filter removals, n (%)	19 (100%)	10 (100%)	6 (100%)	35 (100%)
Complications, n (%)				
Filter fracture	1 (5%)	1 (10%)	0	2 (6%)
Caval spasm	6 (32%)	5 (50%)	4 (67%)	15 (43%)
Intimal wall defect	2 (11%)	0	0	2 (6%)

respectively (excluding extended lysis procedures). The technical success is comparable with the previously described excimer laser–assisted and in situ snares and endobronchial forceps techniques but with fewer complications (23–25) and with substantially less fluoroscopy time (25). Additional advantages of the 16-F sheath and endobronchial forceps combination potentially include lower costs, widespread availability, and no need for specialized laser training.

The theorized balanced traction mechanism for removal of closed cell strut and wall-embedded IVC filters using the endobronchial forceps and 16-F sheath combination may be distilled into several components (**Fig 4a, b**). The endobronchial forceps, which has been previously described to gain filter tip access (17,18), supplies a firm retractile force, more than that generated by the traditional snare; this is validated by the fact that five snare failures were due to hook straightening or snare breakage in this study. In the setting of a steady retractile force, the stiffer 16-F sheath delivers a balanced forward counterforce, dissecting neointimal hyperplasia and fibrosis from the strut and wall-embedded closed cell IVC filters and preventing caval inversion, intussusception, and dissection, as develops in the setting of unbalanced retraction (15). At the same time, the larger 16-F sheath serves to accommodate the entrapped and newly dissected hyperplastic tissue, leading to successful filter removal.

This study has several limitations. It was performed at a single institution and is a retrospective study. The sample size was small, with only 35 patients, as these are the early results of using a 16-F sheath in combination with endobronchial forceps. In addition, the techniques described comprise an advanced filter retrieval technique that requires endovascular skills to perform. Moreover, the 16-F sheath and endobronchial forceps technique was not directly compared, in a randomized fashion, with other advanced techniques for filter removal.

In conclusion, a 16-F sheath in combination with endobronchial forceps offers a more rigid platform to strip filter-associated neointimal hyperplasia and fibrosis, while providing a larger vessel for tissue accommodation. This study demonstrates the successful removal of all closed cell strut and wall-embedded IVC filters with extended mean dwell times of 977 days using the 16-F sheath and endobronchial forceps combination.

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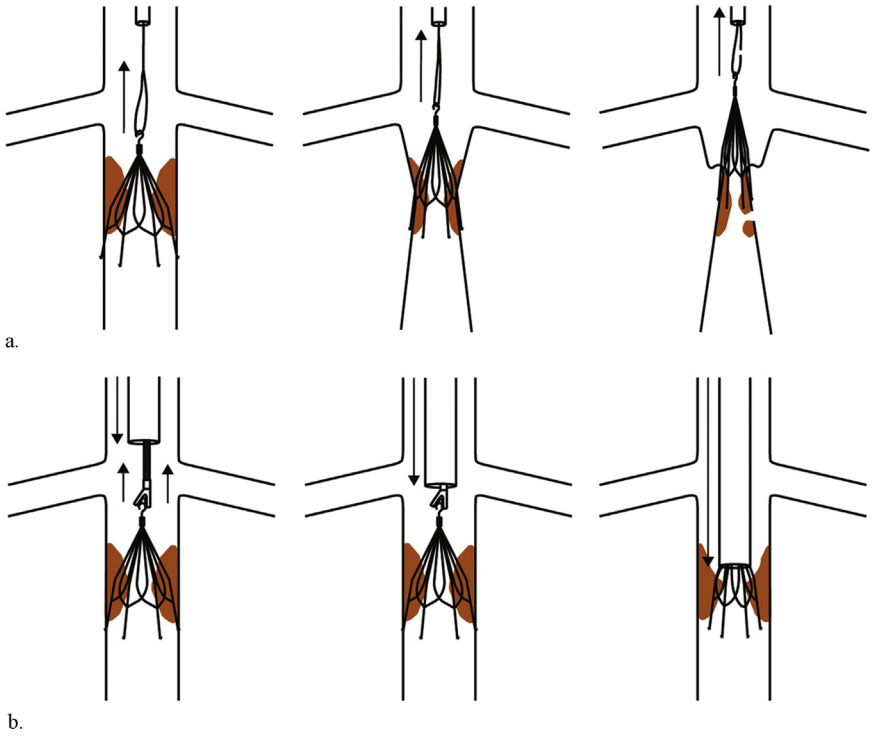


Figure 4. Pulling-type versus balanced traction retrieval mechanisms. **(a)** Pulling closed cell strut and wall-embedded filters results in snare breakage, hook straightening, caval inversion, caval intussusception, caval rupture, and failed removals. Arrows represent the retractile/pulling force of the snare device. **(b)** Endobronchial forceps with a 16-F sheath allows filter tip access and application of a firm retractile force coupled with a firm balanced forward pushing force. Together, this balanced traction results in tissue dissection, while preventing caval inversion and intussusception, leading to successful retrieval of "closed cell" strut and wall-embedded filters with few complications. The 16-F sheath serves as an accommodation vessel for neointimal hyperplasia as well. Brown material denotes neointimal hyperplasia. Upward arrows represent the retractile/pulling force of the endobronchial forceps. Downward arrows represent the pushing force of the 16 French sheath.

REFERENCES

1. Hoppe H, Nutting CW, Smouse HR, et al. Günther Tulip filter retrievability multicenter study including CT follow-up: final report. J Vasc Interv Radiol 2006; 17:1017–1023.
2. De Gregorio MA, Gamboa P, Bonilla DL, et al. Retrieval of Günther Tulip optional vena cava filters 30 days after implantation: a prospective clinical study. J Vasc Interv Radiol 2006; 17:1781–1789.
3. Terhaar OA, Lyon SM, Given MF, Foster AE, McGrath F, Lee MJ. Extended interval for retrieval of Günther Tulip filters. J Vasc Interv Radiol 2004; 15:1257–1262.
4. Smouse HB, Rosenthal D, Thuong VH, et al. Long-term retrieval success rate profile for the Günther Tulip vena cava filter. J Vasc Interv Radiol 2009; 20:871–877.
5. Ryu RK, Desai K, Karp J, et al. A comparison of retrievability: Celect versus Option filter. J Vasc Interv Radiol 2015; 26:865–869.
6. Johnson MS, Nemcek AA Jr, Benenati JF, et al. The safety and effectiveness of the retrievable option inferior vena cava filter: a United States prospective multicenter clinical study. J Vasc Interv Radiol 2010; 21:1173–1184.
7. Oliva VL, Szatmari F, Giroux MF, Flemming BK, Cohen SA, Soulez G. The Jonas study: evaluation of the retrievability of the Cordis OptEase inferior vena cava filter. J Vasc Interv Radiol 2005; 16:1439–1445.
8. Meier C, Keller IS, Pfiffner R, Labler L, Trentz O, Pfammatter T. Early experience with the retrievable OptEase vena cava filter in high-risk trauma patients. Eur J Vasc Endovasc Surg 2006; 32:589–595.
9. Rimon U, Bensaid P, Golan G, et al. Optease vena cava filter optimal indwelling time and retrievability. Cardiovasc Intervent Radiol 2011; 34: 532–535.
10. Kuo WT, Cupp JS, Louie JD, et al. Complex retrieval of embedded IVC filters: alternative techniques and histologic tissue analysis. Cardiovasc Intervent Radiol 2012; 35:588–597.
11. Avgerinos ED, Bath J, Stevens J, et al. Technical and patient-related characteristics associated with challenging retrieval of inferior vena cava filters. Eur J Vasc Endovasc Surg 2013; 46:353–359.
12. Imberti D, Bianchi M, Farina A, Siragusa S, Silingardi M, Ageno W. Clinical experience with retrievable vena cava filters: results of a prospective observational multicenter study. J Thromb Haemost 2005; 3:1370–1375.
13. Foley PJ, Nathan DP, Wang GJ, et al. A "fall-back" technique for difficult inferior vena cava filter retrieval. J Vasc Surg 2012; 56:1629–1633.
14. Al-Hakim R, McWilliams JP, Derry W, Kee ST. The hangman technique: a modified loop snare technique for the retrieval of inferior vena cava filters with embedded hooks. J Vasc Interv Radiol 2015; 26:107–110.
15. Al-Hakim R, Kee ST, Olinger K, Lee EW, Moriarty JM, McWilliams JP. Inferior vena cava filter retrieval: effectiveness and complications of routine and advanced techniques. J Vasc Interv Radiol 2014; 25:933–939.
16. Dinglasan LA, Oh JC, Schmitt JE, Trerotola SO, Shlansky-Goldberg RD, Stavropoulos SW. Complicated inferior vena cava filter retrievals: associated factors identified at preretrieval CT. Radiology 2013; 266: 347–354.
17. Stavropoulos SW, Dixon RG, Burke CT, et al. Embedded inferior vena cava filter removal: use of endobronchial forceps. J Vasc Interv Radiol 2008; 19:1297–1301.
18. Stavropoulos SW, Ge BH, Mondschein JI, Shlansky-Goldberg RD, Sudheendra D, Trerotola SO. Retrieval of tip-embedded inferior vena cava filters by using the endobronchial forceps technique: experience at a single institution. Radiology 2015; 275:900–907.
19. Lynch FC. Modified loop snare technique for the removal of bard recovery, G2, G2 express, and eclipse inferior vena cava filters. J Vasc Interv Radiol 2012; 23:687–690.
20. Morales JP, Li X, Irony TZ, Ibrahim NG, Moynahan M, Cavanaugh KJ. Decision analysis of retrievable inferior vena cava filters in patients without pulmonary embolism. J Vasc Surg Venous Lymphat Disord 2013; 1: 376–384.
21. Kiefer RM, Pandey N, Trerotola SO, Nadolski GJ, Stavropoulos SW. The value of rotational venography versus anterior-posterior venography in 100 consecutive IVC filter retrievals. Cardiovasc Intervent Radiol 2016; 39:394–399.
22. Sacks D, McClenny TE, Cardella JF, Lewis CA. Society of Interventional Radiology clinical practice guidelines. J Vasc Interv Radiol 2003; 14: S199–S202.
23. Kuo WT, Cupp JS. The excimer laser sheath technique for embedded inferior vena cava filter removal. J Vasc Interv Radiol 2010; 21: 1896–1899.
24. Kuo WT, Odegaard JI, Rosenberg JK, Hofmann LV. Excimer laser-assisted removal of embedded inferior vena cava filters: a single-center prospective study. Circ Cardiovasc Interv 2013; 6:560–566.
25. Scher D, Venbrux A, Okapal K, et al. Retrieval of TRAPEASE and OPTEASE inferior vena cava filters with extended dwell times. J Vasc Interv Radiol 2015; 26:1519–1525.