



Excimer laser assisted complex inferior vena cava filter retrieval: a single institution's experience over 6 years

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AIM: To investigate inferior vena cava (IVC) filter retrievals and the use of the excimer laser sheath to assist in complex cases.

MATERIALS AND METHODS: Retrospective analysis was undertaken of 181 attempted filter retrievals over a 6 year period. Pre- and perioperative imaging was analysed from both standard retrieval and complex retrieval techniques.

RESULTS: One hundred and eighty-one IVC filter retrievals were attempted: 130 (72%) standard retrievals were successful and 51 (28%) failed due to device endothelialisation. Forty (23%) cases then had subsequent successful complex retrieval under general anaesthetic. Eighteen (45%) cases were removed with the sling technique and 22 (55%) cases using the excimer laser dissection technique. Where preoperative venography/computed tomography (CT) demonstrated embedding of the filter feet versus filter apex, this was predictive of requiring dissection techniques versus sling technique (13/18 patients; $p < 0.05$ chi-squared test). The difference in device indwelling time was statistically significant between the successful standard retrieval group (134 days) versus patients who failed standard retrieval and required complex techniques (243 days; $p = 0.00018$).

CONCLUSION: Standard retrieval techniques failed in 28% of cases. This correlated with devices that were indwelling for longer. When imaging demonstrated filter-feet endothelialisation/perforation, this was predictive of requiring dissection techniques with the excimer laser.

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Introduction

Inferior vena cava (IVC) filters are deployed to prevent thrombus in the legs and pelvis, which would subsequently cause an embolism in the pulmonary circulation. IVC filters are commonly used in patients with deep vein thrombosis (DVT) or as prophylaxis in patients with an

increased risk of clotting but with contraindications to standard anticoagulation therapy. Optional “temporary” IVC filters are the preferred choice as they are designed to be retrieved.¹ Prompt device retrieval is advised once the risk of pulmonary embolism has returned to baseline or the contraindication to anticoagulation is no longer present, in order to prevent the significant morbidity associated with retained filters. The US Food and Drug Administration (FDA) recommends retrieval at 4–8 weeks from implantation.²

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Complications of IVC filters include venous thrombosis and occlusion³ which increase with the time the device remains *in situ*.^{4,5} Rates of IVC thrombus and DVT are approximately 3% and 5%, respectively, with long-term filter retention⁶ and IVC occlusion seen in as high as 22% of cases at 5 years despite the use of anticoagulation.⁴ There is an increase in the rate of failure of retrieval proportional to the length of time the filter remains *in situ*, with published device dwell times of >9–12 weeks predictive of retrieval failure.^{5,7} Standard retrieval with a jugular approach and loop-snare fails in between 9–26% of attempts.^{5,8,9} This is usually secondary to tilting and/or endothelialisation of device components such as the apex retrieval hook and or the feet.¹⁰ In these cases, complex filter retrieval techniques have been described in the literature. Normally these procedures require sedation or general anaesthetic and require larger sized sheaths and take longer than standard retrieval techniques; examples include, the wire-loop-snare or “sling” technique¹¹ where a sheath is inserted in the internal jugular vein and a reverse-curve catheter is manipulated past the filter; this allows a guidewire to be looped through the legs of the filter and then snared from above by a para-axial loop-snare passed through the same sheath. This forms a sling around the legs of the filter and gives purchase to disengage the filter apex and retrieval into a 16 F sheath.

When the “sling” or similar techniques fails to disengage the filter, further, more advanced procedures to dissect free the filter components have been described including the use of photothermal laser ablation sheaths, intravascular endoscopic forceps to disengage the tines from a common femoral vein approach,¹² and endobronchial forceps manipulation from a jugular and/or femoral sheath approach.¹³ In all these cases, the aim is to free and manipulate an embedded filter into a position where it can be retrieved into a sheath. Excimer laser sheaths have a metallic tip with a ring of laser-emitting optical fibres; on activation of the generator these generate photothermal energy that allows focal targetable tissue ablation. This is used in the dissection of endothelialised tissue, and is frequently used by cardiologists in aiding extraction of pacemaker leads. Kuo *et al.* described the use of a 14 F excimer laser sheath to dissect free endothelialised IVC filter feet. The laser sheath is passed over the guide wire sling inside a 16 F parent sheath in the jugular vein resulting in a coaxial sheath system. The filter can then be collapsed and safely retrieved into the coaxial sheaths from a single access found in the jugular vein.¹⁴

The present study is a single institution review of IVC filter retrieval techniques, including endovascular dissection, and it aims to investigate the reasons for complex techniques being required.

Ethical consideration

This study was a retrospective service evaluation and participants underwent interventions according to the standard service being delivered with no randomisation of patients. This did not require ethical approval according to the local research ethics committee guidelines. Informed written consent was obtained for all procedures in all cases.

Materials and methods

The present study was a retrospective review all IVC filter removals between 2010–2016 at a single institution. IVC filter retrieval is attempted under local anaesthetic using standard retrieval techniques via a right internal jugular (RIJV) approach with an 8–12 F sheath and loop-snare. When simple techniques fail due to the device being embedded in the wall of the IVC, patients are routinely booked for a repeat procedure in a hybrid vascular theatre for a complex retrieval with general anaesthesia within 2 weeks.

Technique for complex retrieval

All patients were treated in a hybrid theatre under general anaesthetic with a vascular surgeon available and a covered stent on standby in case of IVC rupture. All IVC filter retrievals were carried out by one or more of three consultant interventional radiologists with a subspecialty interest in vascular intervention. Computed tomography (CT) venography is carried out prior to retrieval to assess the position of the filter if there is concern of feet perforation or device migration/fracture.

A 16 F sheath passed into the IVC via RIJV access. A preprocedural cavogram is obtained to ensure no venous stenosis/clot in the device. A step-wise approach is employed. Initially the sling technique is attempted. In cases where the feet of the filter do not disengage, an excimer laser sheath is used (14 F sheath, Spectranetics, Colorado Springs, CO, USA) with the laser tip calibrated to 60 mJ/mm² to dissect the tines away from the wall of the IVC. The filter is then retrieved into the 16 F sheath (Fig 1).

In cases where the filter is tilted and the sling technique is not achievable, a 10 F sheath is inserted in the common femoral vein and endoscopic forceps are used to manipulate the filter enough to allow successful sling technique and laser sheath removal from the jugular. A final post-procedure cavogram is performed in all patients to ensure there was no IVC extravasation or “candy wrapping” stenosis. The time of procedure and dose–area product (DAP) were recorded, and any complications reviewed.

Results

One hundred and eighty-one filter retrieval attempts included the following filter types: four Günther Tulip filters (Cook, Bloomington, IN, USA), 75 Option filters (%; Argon Medical Devices, Athens, TX, USA), 66 G2X filters (%; Bard Peripheral Vascular, Tempe, AZ, USA), and 36 Celect filters (%; Cook). Indications for filter insertion included lower-limb DVT and/or pulmonary embolism with either contraindication to starting or continuing anticoagulation due to concurrent surgery or complications of anticoagulation. The use of a particular brand of device was secondary to local procurement during the 6 year study period and was not secondary to patient factors.

One hundred and seventy patients had successful device retrieval, and 51 (28%) standard retrievals failed

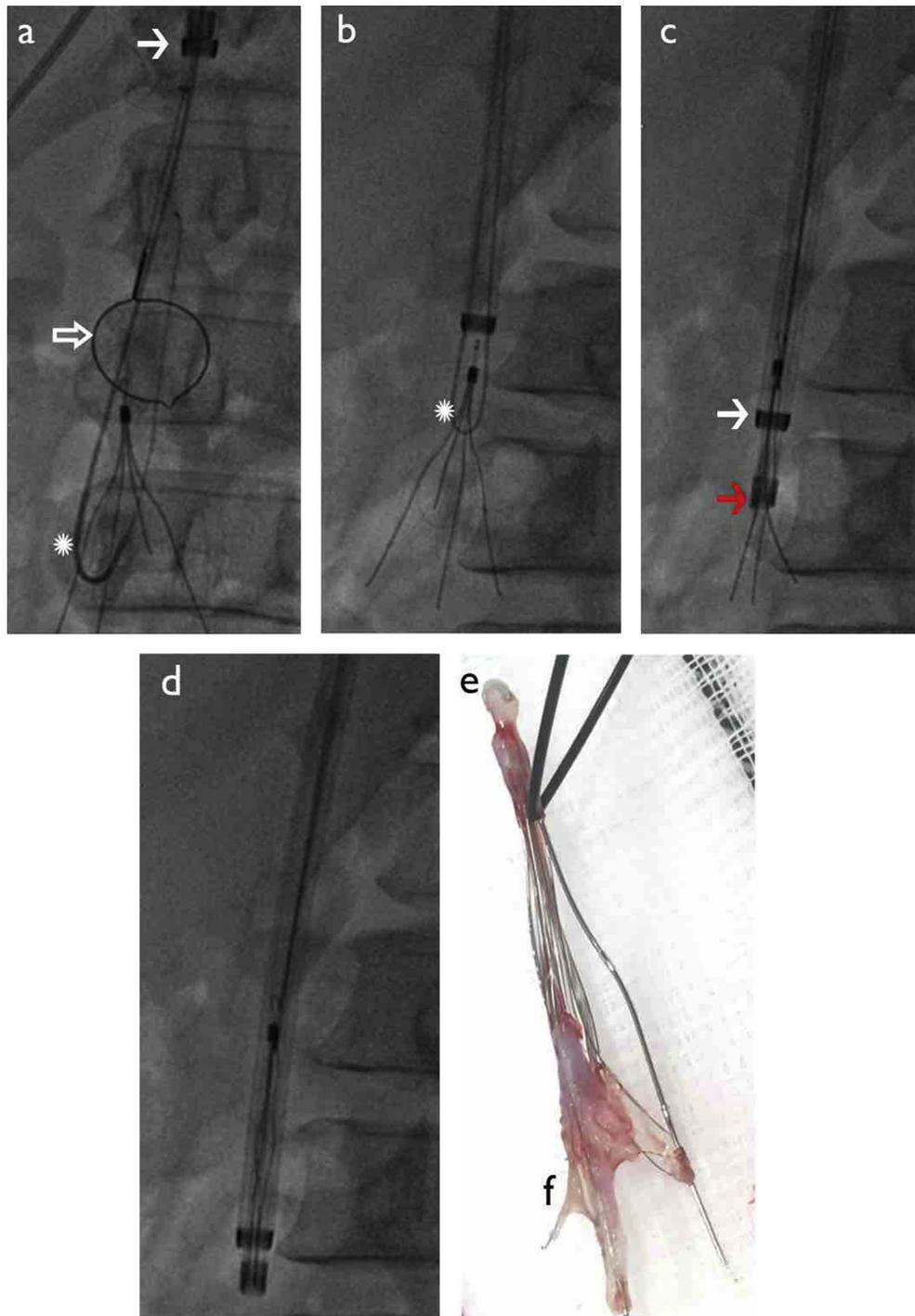


Figure 1 Fluoroscopic images from complex filter retrieval. (a) A 16 F sheath in the IVC (white arrow) with reverse curve catheter and exchange length guidewire (asterisk) is passed through the legs of the filter and snared in a paraxial loop-snare (solid white arrow) to make a sling. (b) Guide wire sling (asterisk) in position. (c) The laser sheath (red arrow) is passed over guide wire sling, through the 16 F sheath giving a coaxial system used to collapse and dissect free the legs, which have become embedded f. (d) The device is retrieved into the laser sheath. (e) Photograph of the device. The guidewire sling is seen at the top of the image (black wire). A layer of endothelialisation is seen covering the apical hook and the legs f, explaining the difficulties in retrieving the device with standard techniques.

(130 [72%] successful attempts). After failed standard attempts in 11 cases, further complex techniques were not attempted due to advanced comorbidities and treatment with life-long anticoagulation favoured after discussion in the haematology/vascular multidisciplinary team (MDT); seven (7/11) cases had significant IVC stenosis so retrieval

attempts were abandoned and four (4/11) cases were lost-to-follow up.

In all cases standard technique failed because of presumed combination of fibrous scar tissue formation and neointimal hyperplasia causing endothelialisation of the device components.

Forty (23%) cases had subsequent removal under general anaesthetic. In 18/40 (45%) cases, combination with a large-bore sheath and sling technique allowed sufficient purchase to retrieve the devices. In 22/40 (55%) cases, excimer laser dissection technique extraction was used. In three cases, a joint technique with access from above with an excimer laser sheath and addition of endoscopic forceps manipulating the filter from access in the right common femoral vein.

No instances of IVC rupture or post procedural bleeding was demonstrated. All filters were removed completely, and there were no documented cases of post-procedural IVC stenosis/structuring.

In the cases of successful standard retrieval, the mean time devices were indwelling was 134 days (range 1–958 days). In patients with failed standard retrieval and requirement for complex techniques, the device indwelling time ranged from 30 days up to >5 years (mean 243 days). The difference was statistically significant (Mann–Whitney *U*-test, $p=0.00018$; Fig 2).

The screening time and DAP for successful standard retrievals ranged between 10 seconds and 21 minutes (median 2 minutes 45 seconds), and median DAP (681 mGy/cm²). Complex procedure screening times ranged from 3 minutes to 51 minutes (median 13 minutes 30 seconds) and median DAP was 1,536 mGy/cm². The difference was significantly different ($p<0.0001$; Fig 3).

Within the complex retrieval groups, three subgroups were identified with different components becoming embedded (demonstrated on either CT or fluoroscopy): (1) in 20 cases, this was due to tilting of the filter and the retrieval hook embedding in the IVC wall; (2) in 18 cases one or more of the filter feet were protruding through the IVC wall/scar tissue embedding the feet; and (3) in two cases there were multiple points of embedding at both the apex and feet.

Of the 18 cases where preoperative imaging demonstrated embedding of the filter feet, 13 cases required laser with or without endoscopic forceps dissection techniques. In the 20 cases where just the hook was embedded, 12 were retrievable with the sling technique and did not require dissection techniques. Embedding or perforation of filter feet on preoperative imaging was predictive of requiring dissection techniques (either laser and/or endoscopic forceps techniques; 13/18 patients, $p<0.05$, chi squared test).

There was a significantly higher proportion of Option Elite filters that required complex techniques to remove them compared with the other filter types (chi-squared test $p<0.002$). The reasons for this are unclear and the difference in mean indwelling time for each brand of device was not significantly different (between 156–160 days for the three main most commonly used devices).

Discussion

Optional IVC filters should be retrieved promptly, but inevitably despite robust local databases and mechanisms to prevent loss-to-follow up, filters are still being retained for several months and years. This institution is a tertiary referral centre, so several of these devices were placed in

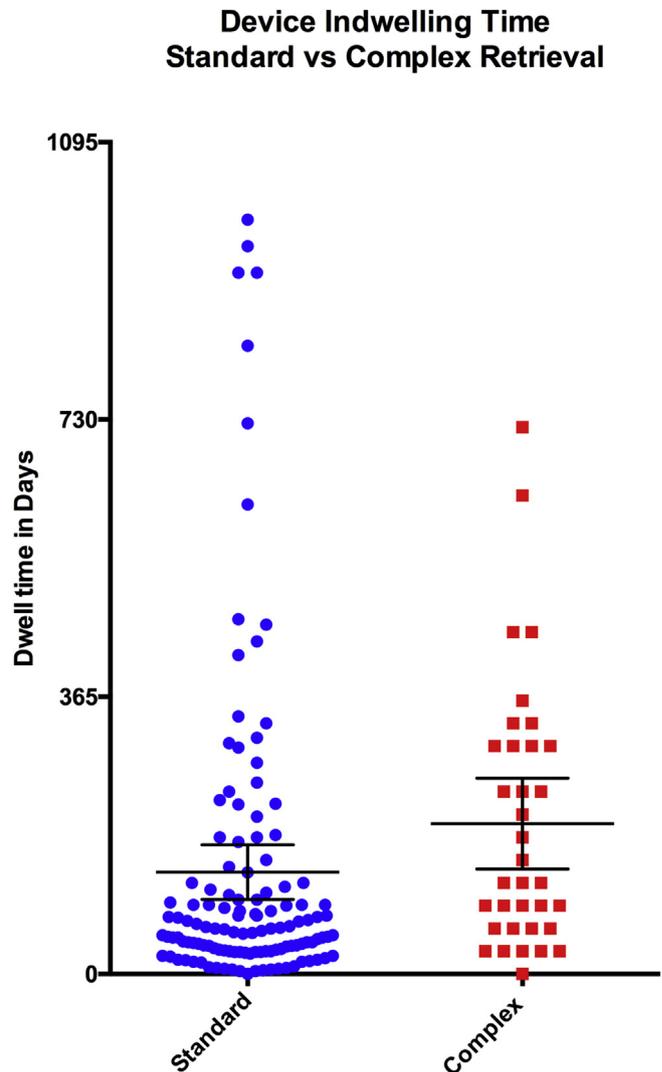


Figure 2 Grouped scatter plot with the indwelling times of the filter in the successful standard retrievals and those requiring further complex retrieval techniques.

outside hospitals. IVC filter registries have been developed to try and reduce the incidence of this occurring, such as those set up by British Society Of Interventional Radiology and Cardiovascular and Interventional Radiological Society of Europe.⁷ The complications of IVC filters being left in long term can result in severe morbidity including chronic leg swelling from IVC thrombosis and/or occlusion.^{4,6}

Standard filter retrieval techniques are typically performed under local anaesthetic and employ a relatively small sheath (12 F) and a loop snare. This has a fairly high failure rate (in up to 26% of reported series) due to tilting of the device making snaring the retrieval point at the apex impossible, and/or complicated by elements of the device becoming embedded within the IVC wall. Kuo *et al.* in 2012 demonstrated that a combination of neointimal hyperplasia and fibrous tissues surrounded the legs of explanted embedded filters causes some devices to become embedded. The extent of endothelialisation is thought to be proportional to the length of the time the device is *in situ*.⁸

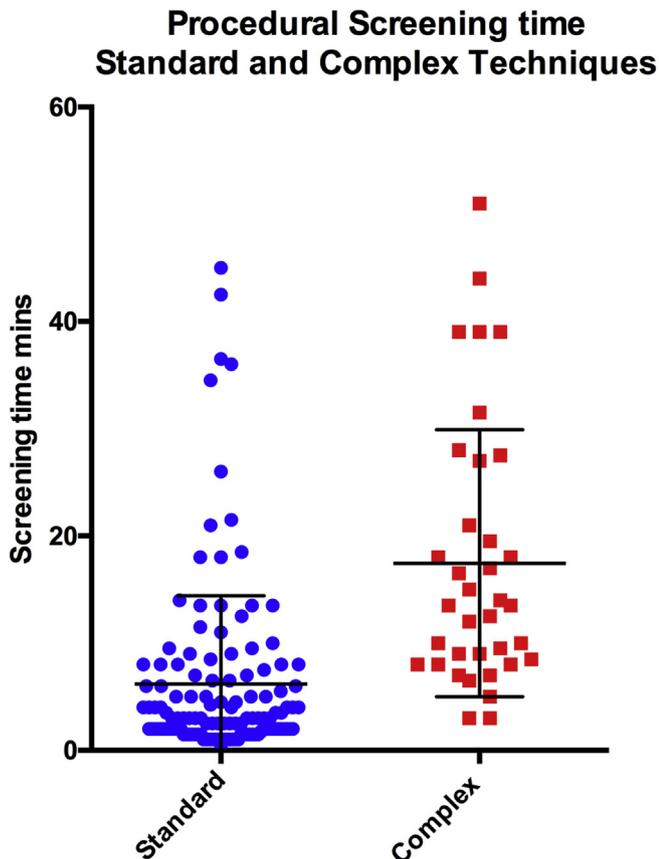


Figure 3 Grouped scatter plot with the procedural screening times of standard and complex retrievals.

In addition, device components can perforate the bowel, aorta, and other intra-abdominal structures, adding further complexity to device retrieval.

The present study found the standard retrieval technique failed in 28% of initial attempts, which is in keeping with published series, and correlated with longer device indwelling time ($p=0.00018$). Conversely, the standard technique was successful in 11 (8%) cases where filters had been *in situ* for over a year. Despite the retrospective nature of this study and small sample size, the authors recommend a standard retrieval technique should be attempted in all cases of filter removal; with complex techniques only considered after a multidisciplinary discussion with haematology, vascular surgery, and interventional radiology as to the appropriate management on a case-by-case basis. Where patients have a poor life expectancy, the morbidity of complications of a retained IVC filter must be weighed up against the risks of a complex retrieval attempt. Complex filter retrieval techniques have high success rates but are reported to have significantly higher complication rates than simple loop-snare techniques,⁹ although no instances of IVC rupture/bleeding/post-procedural stenosis were seen in this cohort. In addition, general anaesthetic or at least anaesthetist-led deep sedation is recommended for complex filter retrieval, firstly due to the potential longer duration of such cases, and secondly, the discomfort of a large bore sheath in the neck.

The sling technique was successful in approximately 50% of cases. This is broadly similar to published data, which found the sling technique to be successful in up to 63% of cases.⁹ The sling technique was particularly useful when filters were tilted or endothelialised meaning the loop-snare could not engage with the filter-retrieval hook.

In the majority of cases (22/40), the sling technique alone was insufficient to dislodge the device and intravascular dissection techniques were required either with laser sheath or intravascular forceps. The laser sheath was most frequently employed when the filter feet were found to be embedded.

A published series of 251 cases of complex IVC filter retrievals assisted by intravascular dissection with an excimer laser sheath, demonstrated high success (>99%) and low complication rates.¹⁴ Kuo *et al.* described two main benefits of the laser sheath: (a) provision of targeted dissection of endothelialised tissue, and (b) the combination of a laser sheath inside a large-bore sheath provides a coaxial system; this significantly reduces the measured traction force required to disengage the IVC filter compared with standard single-sheath techniques.¹⁴

The authors found a similar experience with the coaxial platform giving a high level of control to collapse the filter like an umbrella, rather than a less predictable force required when snaring and pulling. Furthermore, the laser-assisted technique only requires a single puncture site, which is a further benefit over techniques such as forceps dissection, which require dual access from both the jugular and femoral vein.

The present study is limited due the study being a retrospective review of practices. There was no randomisation or standardisation of groups of patients and the study serves to demonstrate the experience of a single institution with complex filter removal; however, this does reflect the heterogeneity of real-life practices in interventional radiology.

In conclusion, for IVC filters that have been retained for long periods of time, a step-wise approach to retrieval is recommended with standard loop-snare approach tried initially. Standard techniques can be successful even after filters have been *in situ* for >12 months, but was found more likely to fail in these patients. Complex techniques can then be considered to prevent morbidity of retained devices. Using a combination of the sling technique and dissection with excimer laser sheath, IVC filters that have been left *in situ* for several years can be retrieved safely.

Conflicts of interest

None declared.

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