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Caval pseudoaneurysms following complex inferior vena cava filter removal: Clinical significance and patient outcomes

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Abstract

Objectives: To investigate the incidence and clinical significance of caval pseudoaneurysm and extravasation post-complex inferior vena cava filter retrieval.

Methods: A total of 83 patients (70% female, average age 56) underwent complex inferior vena cava filter retrieval between January 2015 and December 2019 utilizing either rigid endobronchial forceps ($n = 69$, 83%) and/or excimer laser ($n = 20$, 24%). Procedural variables were recorded. The incidence and size of caval pseudoaneurysms and extravasation along with treatment type and clinical outcomes were analyzed.

Results: Technical success in all cases was 96% (n = 80). Average fluoroscopy time was 23 min (median: 20.2, range: 0.9–129.5). Average filter dwell time was 85 months (range: 2–316 months). Caval pseudoaneurysm was detected on post-retrieval venography in 10 patients (12%) and frank extravasation occurred in 1 case (1%). Average pseudoaneurysm length and width was 20.4 mm (range: 5–45 mm) and 12.9 mm (range: 4–24 mm), respectively. Pseudoaneurysms occurred most frequently during the removal of Optease ($n = 5$) and Celect ($n = 2$) filters. The pseudoaneurysms completely resolved with prolonged (>5 min) balloon angioplasty in all but one instance where a small portion of the pseudoaneurysm persisted. This patient was admitted and observed overnight before being discharged without complication. The solitary case of significant extravasation was effectively managed with immediate stent placement and the patient remained hemodynamically stable.

Conclusions: Radiographically detectable caval pseudoaneurysm and extravasation is not uncommon in complex inferior vena cava filter retrieval and, despite being considered a major complication by Society of Interventional Radiology guidelines, can often be managed without stenting or other invasive treatment.

Keywords

Complex inferior vena cava filter removal, inferior vena cava filter, caval pseudoaneurysm, caval injury

Introduction

Inferior vena cava (IVC) filter retrievals have increased dramatically over the past decade and are employed in several clinical scenarios.[1,2] This increase in utilization is directly related to the ubiquity of IVC filters: approximately 65,000 IVC filters are placed in the United States annually, and roughly 35% are subsequently removed.[3] Routinely placed in patients with venous thromboembolic disease for which standard anticoagulation has failed or is contraindicated, IVC filters can result in complications when not retrieved in a timely

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manner. These include, but are not limited to, strut fracture with or without embolization, migration, caval thrombosis, and/or caval penetration.[3]

Multiple mechanisms exist to retrieve IVC filters with reported high rates of technical success.[4] Among the reasons for retrieval failure include extended dwell times, endothelization of filter components, embedded hooks, and fracture of filter components which have given rise to increasingly complex filter retrieval procedures.[5,6] While such complications are well documented, there is a paucity in current literature detailing complications that occur during complex IVC filter retrieval procedures. An understanding of such complications is important when analyzing the risk benefit ratio of using more advanced retrieval techniques. Among these complications, the incidence and clinical significance of caval pseudoaneurysms following these procedures are specifically not well described. Moreover, for patients in whom caval pseudoaneurysms do occur, current professional guidelines do not make recommendations for appropriate management, nor do they provide physicians with a framework to clinically stratify patients who may be treated conservatively with intra-procedural measures alone versus those who require more invasive management and hospital admission.

The purpose of this retrospective study was to assess the occurrence of caval pseudoaneurysms in a population of patients who underwent complex IVC filter retrieval as well as to characterize management options based on the clinical status of the post-retrieval pseudoaneurysm patient. The incidence and risk factors associated with the formation of caval pseudoaneurysms as well as the treatment options and clinical outcomes are described. This paper serves to aid those who employ complex IVC filter retrieval techniques and aims to describe the clinical relevance and treatment options for caval pseudoaneurysms following IVC filter removal.

Methods

This Institutional Review Board-approved study is a retrospective analysis that examined the incidence and clinical significance of caval pseudoaneurysm with or without extravasation following complex IVC filter retrieval.

An automated data extraction of the electronic medical record (EPIC®; Vernoa, WI) was conducted to identify individuals who underwent complex IVC filter retrieval at a single academic center between January 2015 and December 2019. Complex IVC filter retrieval was defined as interventions that required the use of either excimer laser, rigid endobronchial forceps, or both laser/forceps during the procedure to assist in caval filter extraction.

Procedure technique

All procedures were performed by one of two board certified interventional radiologists with at least five years' experience performing a high volume of complex IVC filter retrievals at a tertiary care referral center. General anesthesia was obtained for patients in whom a prolonged procedure time was anticipated or in those with an elevated anesthetic risk from comorbidities (n = 17). Patients in whom standard filter retrieval with endovascular snare and/or wire-loop techniques failed, complex filter retrieval with rigid forceps (Lymol Medical, Woburn, MA) or excimer laser (GlideLight™ Laser Sheath; Philips Medical, Amsterdam, Netherlands) was utilized. If applicable, pre-procedure anticoagulation was held prior to the procedure. All patients received weight-based periprocedure anticoagulation with intravenous unfractionated heparin.

The preferred approach to retrieval of tip-embedded filters was with rigid endobronchial forceps through a 16 or 18 Fr sheath (Flexor®; Cook Medical, Bloomington, IN). Forceps were utilized to dissect fibrous tissue away from the filter apex and capture it.[7] For filters unable to be collapsed due to intimal reaction and endothelization of the filter struts, photothermal ablation with excimer laser was used. In this scenario, the 16 Fr laser sheath size was selected for all cases. Some instances required the use of both forceps and laser for retrieval due to tip-embedment and hyperplastic tissue of filter struts, respectively.

For biconical filters such as Optease® or Trapease® (Cordis; Hialeah, FL), standard retrieval technique included common femoral venous access and placement of a 26 Fr sheath (DrySeal, Gore, Newark, DE). Retrieval was performed with coaxial placement of the 16 Fr laser sheath and outer dissector device included with the laser. Forceps were not typically used.

Caval injury assessment

Pre- and post-procedure venography with power injection (20 ml/s for total 30 ml volume) was performed for all complex filter retrievals. Post-procedure venography was performed in AP and oblique projections to visualize any evidence of post-filter retrieval caval injury including pseudoaneurysm, extravasation/rupture, or caval vasospasm. Pseudoaneurysm was defined by a contained rupture with contrast extending outside the expected contour of the IVC (as compared to pre-procedure venogram). The width of pseudoaneurysm was measured fluoroscopically from its apex to the

base (i.e. where the expected lumen of the IVC was), and length defined by its craniocaudal extent outside of the normal IVC lumen.

General management of caval pseudoaneurysms was to attempt prolonged (>5 min) compliant balloon angioplasty (Boston Scientific Equalizer balloon, 23–30 mm) to assist in tamponade of the caval wall at the site of pseudoaneurysm. In rare instances, when there was residual stenosis, non-compliant angioplasty up to 20 mm (Atlas Balloon, Bard) was used for treatment following compliant angioplasty. Peri-procedural anticoagulation was continued along with post-procedure anticoagulation to prevent caval thrombosis. Post-procedure observation was variable and operator dependent but did not typically persist beyond overnight observation.

Objectives

Chart review was conducted to determine filter type, indwell time of filter, fluoroscopic procedural time to retrieve filter, technical success, incidence of caval pseudoaneurysms following retrieval, and associated procedural complications such as extravasation. In the event of pseudoaneurysm formation, the size of the pseudoaneurysm, treatment type, treatment time, and clinical outcomes were recorded.

Categorical variables were summarized by counts and percentages of non-missing values. Quantitative variables were summarized by means and range of values.

Results

A total of 83 patients (70% female, average age 56) underwent complex retrieval during the specified study interval. IVC filters were retrieved utilizing rigid forceps in 69 patients (83%), excimer laser in 20 (24%), and both laser/forceps in 4 patients (4.8%). The technical success of all cases, defined as complete retrieval of IVC filter, was 96% (n = 80). The average and median fluoroscopy time was 23 and 20.2 min, respectively (range: 0.9–129.5, standard deviation: ± 20.5 min). The average filter dwell time was 85 months (range: 2–316 months).

Of the 83 total cases, the complication of caval pseudoaneurysm formation was detected on post-retrieval venography in 10 patients (12%). Use of excimer laser was seen in nine of these 10 cases (45% overall, Table 1). Frank extravasation occurred in one case (1%). The average length of pseudoaneurysm was 20.4 mm, with a range from 5 to 45 mm, and the average width was 12.9 mm, with a range from 4 to 24 mm, respectively. Pseudoaneurysms occurred most frequently during the removal of Optease (n = 5) and Celect

Table 1. Descriptive values for each of the 10 patients in which caval pseudoaneurysm occurred following complex IVC filter removal.

Patient	Filter type	Filter complications	Removal technique	Procedure time	PA dimensions (mm)	Dwell time (mo)	Balloon width	Treatment	Post-retrieval course
1	Celect IVC filter	Tilt and perforation	Wire loop and excimer laser	17.7 m	7 × 10 mm	18	27 mm	Balloon	None
2	Optease filter	Perforation, partial fracture on removal	Wire loop and excimer laser	2 h 27 m	8 × 15 mm	121	27 mm	Balloon	Admission
3	Optease filter	Severe tilt	Wire loop and excimer laser	1 h 12 m	21 × 45 mm	12	27 mm	Balloon	None
4	Optease filter	Tilt	Wire loop and excimer laser	3 h 17 m	24 × 29 mm	71	27 mm	Balloon	None
5	Simon nitinol filter	Tilt and mild penetration	Forceps, snare, and excimer laser	2 h 43 m	16 × 26 mm	190	27 mm	Balloon	None
6	Optease filter	Severe tilt	Wire loop and excimer laser	2 h 25 m	7 × 8 mm	3	27 mm	Balloon	Normal 1 month F/U CT
7	Cook Gunther Tulip filter	Tilt	Wire loop and excimer laser	10 m	11 × 25 mm	176	27 mm	Balloon	None
8	Option IVC filter	None	Wire loop and excimer laser	2 h 04 m	24 × 5 mm	20	N/A	None	None
9	Birds Nest filter	Fracture and embedding	Forceps, snare single loop	1 h 17 m	N/A (extravasation)	316	N/A	Stent	Small mural thrombus on F/U CT
10	Optease filter	Thrombosed	Wire loop and excimer laser	41 m	7 × 27 mm	2	20 mm	Balloon + stent	None

IVC: inferior vena cava; CT: Computed tomography; F/u: Follow-up.

(n = 2) filters. Of the 10 cases in which pseudoaneurysm formation was detected, compliant balloon angioplasty (23–30 mm) was utilized for treatment in eight of the 10 cases. In one case, there was residual stenosis, non-compliant angioplasty up to 20 mm (Atlas balloon, Bard) was used for treatment following compliant angioplasty. One of the 10 pseudoaneurysm cases (patient #8) did not require treatment via balloon angioplasty and resolved without treatment. Balloon angioplasty treatment was prolonged (>5 min) in all eight cases in which it was utilized (Figure 1). In those eight cases, the pseudoaneurysms completely resolved with prolonged balloon angioplasty with the exception of one case. In that case (patient #2), a small portion of the pseudoaneurysm persisted despite prolonged angioplasty, and this patient was admitted and observed overnight before being discharged without complication. In another case (patient #6), the pseudoaneurysm (7 × 8 mm) was felt to warrant a one-month follow-up CT due to post-procedural pain out of proportion of normal which showed no evidence of persistent caval abnormality. The solitary case of frank extravasation was effectively managed with immediate stent placement and the patient remained hemodynamically stable throughout the procedure. A follow-up CT demonstrated minimal mural thrombus adjacent to the stent but no persistent extravasation (Figure 2).

Discussion

The rising utilization of retrievable IVC filters, particularly in young patients, carries an increased risk for filter failure that is directly correlated with implantation time. Prolonged dwell times may lead to filter migration, tilt, perforation, or fracture.[8] This may in turn necessitate the use of complex retrieval methods such as rigid endobronchial forceps and/or excimer laser. Among these complications, filter tilt and embedment within the caval wall are most often associated with failure of conventional retrieval methods.[3]

Complex filter retrieval, though routinely safe and effective, carries with it its own set of possible complications, including pseudoaneurysm of the IVC and adjacent vascular structures such as the renal artery.[9] In the case of caval pseudoaneurysm, it is believed that this complication arises from caval wall compromise as a result of increased tractional forces required to free the embedded and fibrosed elements of the filter, or from thermal injury to the caval intima in the case of excimer laser-assisted retrieval.[7] The exact incidence of pseudoaneurysm following complex filter retrieval is not yet well described, though a 2015 single-center retrospective study by Stavropoulos et al. found caval pseudoaneurysm occurred in 2 of 114 patients undergoing complex retrieval with rigid endobronchial forceps, and a 2017 prospective study by Kuo et al. found 25 of 251 patients developed small pseudoaneurysms following excimer laser-assisted retrieval.[7,10]

The incidence and management of complications due to erroneous filter placement and filter failure (i.e. migration, tilt, fracture, perforation) have been well described in the literature and within professional guidelines, but procedural complications following complex retrieval, and their clinical significance and management, have not yet been characterized extensively, and the incidence and classification of complex retrieval-related complications are not currently discussed in either the Society of Interventional Radiology (SIR) or Cardiovascular and Interventional Radiological Society of Europe

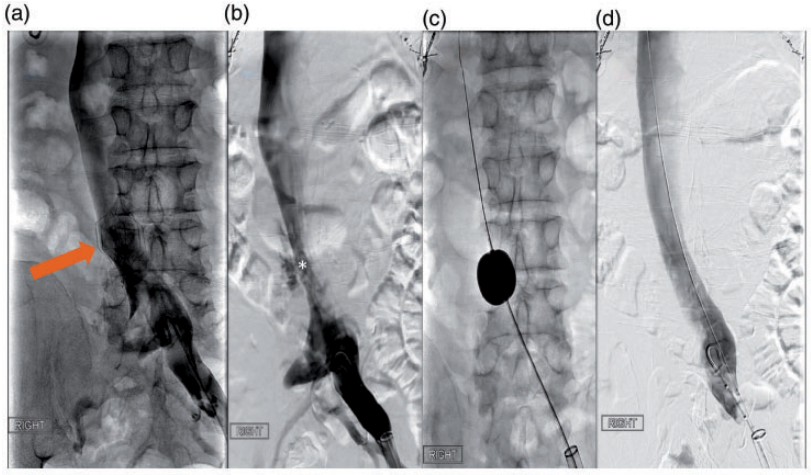

Figure 1. IVC filter removal in a patient with an Optease filter (orange arrow) in place (a). Post-procedural venogram demonstrates a caval wall abnormality in the region of the previously seen IVC filter (b) with pseudoaneurysm formation (asterisk). Prolonged balloon angioplasty was done (c) with resolution of previously seen pseudoaneurysm on final procedural venogram (d).

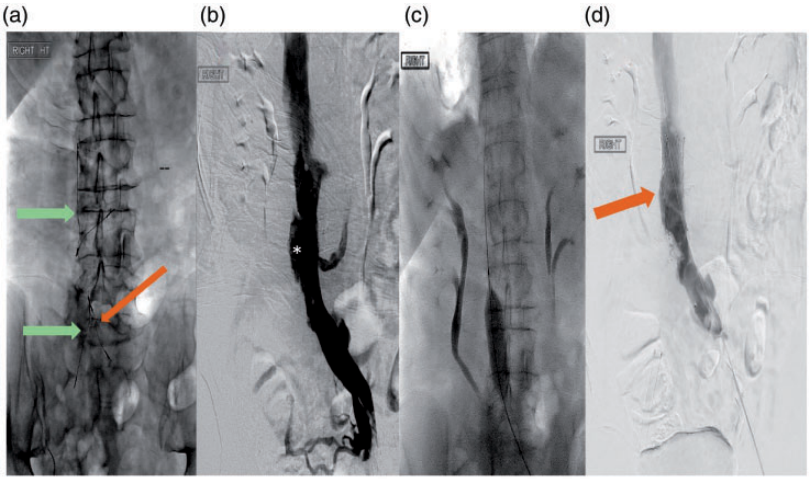

Figure 2. IVC filter removal in the sole case of extravasation; this patient presented with a Birds Nest filter as well as the longest filter indwell time of 316 months. The filter's main components had fractured apart with the inferior component imbedded within the iliac veins (green arrows). Fracture of the inferior strut had also occurred (a, orange arrow). Following retrieval of the fractured components and as much wire mesh as possible, post-procedural venogram demonstrated caval pseudoaneurysm and frank extravasation of contrast (b, white asterisk). Prolonged balloon angioplasty (c) followed by stent placement was performed (d), and no extravasation or caval wall defect was detected on final post-procedural venogram.

(CIRSE) filter retrieval guidelines. In the present study, we have described the occurrence and resolution of 10 caval pseudoaneurysms and one incidence of frank extravasation through conservative methods alone in 11 patients who underwent complex filter retrieval following failure of conventional retrieval methods. Of the 10 patients who developed post-retrieval pseudoaneurysms, eight were treated with prolonged (>5 min) balloon angioplasty and did not experience hemodynamic instability, and only one patient required admission for additional observation. The remaining two patients' pseudoaneurysms were self-limited, requiring no additional treatment or admission. In the case of the patient who experienced frank extravasation, stenting was employed, and the patient remained hemodynamically stable and was not admitted.

These findings suggest that retrieval-related caval pseudoaneurysm and even minor extravasation in the hemodynamically stable and otherwise uncomplicated patient constitutes a minor complication as defined by current SIR clinical practice guidelines.[11] In this case, conservative treatment, such as prolonged balloon angioplasty or stenting without the need for admission or more invasive methods may be the most appropriate management in the majority of patients. Although none of the patients in this study can be classified as having experienced major complications, both Kuo et al.[12] and Kuo et al.[10] described patients who experienced major complications after complex excimer laser-assisted retrieval. None of these major complications were associated with or resulted from caval pseudoaneurysm, and instead these patients exhibited hemodynamic instability and frank extravasation as a result of major caval injury and were treated with immediate stent-graft placement with or without balloon tamponade.[7,12] This delineation between the clinical profiles of patients experiencing major and minor complications is in contrast to a 2015 study by Stavropoulos et al. who described the occurrence of a small IVC pseudoaneurysm after endobronchial forceps retrieval as a minor complication if no treatment was required and a major complication, including 48-h hospital admission, if balloon angioplasty was employed.[7] Additionally, the incidence of caval pseudoaneurysm seen in the present study occurring after excimer laser-assisted retrieval was 45% (9/20) versus 3.3% (2/60) in patients who underwent rigid endobronchial forceps-assisted removal, potentially implicating this retrieval method in pseudoaneurysm formation.

Limitations of the present study include it being a single-center retrospective analysis and its small sample size of patients who experienced retrieval-related complications. Additional work to characterize various associations between causes of complex retrieval necessitation (i.e. tilt, perforation, etc.), retrieval methods, filter make and model, dwell time, and the incidence and severity of pseudoaneurysm formation. Specifically in the case of excimer laser-assisted removal, a 16 Fr system was used on all patients in this study, and correlation between sheath caliber (16 Fr vs. 12 Fr or 14 Fr) and the incidence of pseudoaneurysm formation may be useful to explain the discordance between the minor complication rate associated with excimer laser-assisted retrieval in this study (45%) and that of Kuo

et al.,[10] which reported a minor complication rate of 11.1%. Reproduction at other institutions with larger sample sizes will also be useful to help establish generalizability and validity. Correlation between the patients' clinical picture at time of presentation (i.e. age, sex, comorbidities, symptomatic vs. asymptomatic, etc.) and the rate of caval injury as well as pathologic analysis of tissue samples from patients who underwent uncomplicated complex retrieval vs. those who did experience major or minor complications may also prove to be the useful predictive information for pseudoaneurysm formation. Finally, it is not immediately clear from this study what, if anything, can be done intra-procedurally to prevent the occurrence of pseudoaneurysms during complex retrieval.

Conclusion

Uncomplicated cases of caval pseudoaneurysm can typically be classified as a minor complication according to current SIR guidelines and may be successfully managed with conservative treatment such as with balloon angioplasty alone, and pseudoaneurysm following complex filter retrieval may be more common with excimer laser-assisted retrieval.

Declaration of conflicting interests

The author(s) declared following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Ahmed is an advisory board member for Boston Scientific and Genentech, he is also a speaker for Spectranetics, Cook, Cardiva, Canon, Argon, and Boston Scientific. All other authors state that they have no conflict of interest related to the material discussed in this article.

Ethical approval

Institutional Review Board (IRB) approval was obtained for this type of study and formal consent is not required.

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Informed consent

This study has obtained IRB approval at the corresponding author's institution and the need for informed consent was waived.

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