ESC European Society of Cardiology

European Heart Journal - Case Reports (2023) **7**, 1–5
https://doi.org/10.1093/ehjcr/ytad003

CASE REPORT
Cardiovascular imaging

Metal in motion: a case report of inferior vena cava filter migration

Jonathan A. Aun [1,2]*, Edward A. Hulten[1,2], Binh T. Nguyen[3,2], and Eric H. Twerdahl[4,2]

[1]Department of Medicine, Walter Reed National Military Medical Center, Cardiology Service, 4494 Palmer Road North, Bethesda, MD 20814, USA; [2]Department of Medicine, School of Medicine, Uniformed Services University of the Health Sciences, Uniformed Services University of the Health Sciences, 4301 Jones Bridge Road, Bethesda, MD 20814, USA; [3]Department of Radiology, Walter Reed National Military Medical Center, Cardiology Service, 4494 Palmer Road North, Bethesda, MD 20814, USA; and [4]Department of Vascular Surgery, Walter Reed National Military Medical Center, Cardiology Service, 4494 Palmer Road North, Bethesda, MD 20814, USA

Received 23 March 2022; first decision 6 May 2022; accepted 4 January 2023; online publish-ahead-of-print 6 January 2023

Background Inferior vena cava (IVC) filter migration, particularly to the heart, is a rare complication. Small metal fragments may be inadequately characterized on transthoracic echocardiography and may be missed entirely on chest radiograph. Managing the adverse outcomes of IVC filters is a formidable challenge as retrieval carries the risk of arrhythmia, right ventricular perforation, and damage to the tricuspid valve.

Case summary A woman in her fifties underwent routine computed tomography (CT) calcium score screening and was found to have a metallic fragment in the right ventricle of her heart. Subsequent contrast enhanced, ECG-gated cardiac CTA was completed and images were reconstructed to yield cine images on syngo.via (Siemens, Erlangen, Germany) and vitrea workstation (version: 6.6.3; Vital, Toshiba Medical Systems) to guide heart team discussion and clinical management.

Discussion Our case illustrates the benefit of CTA with cineography in characterizing the location, size, and extent of fragment involvement within the myocardium. Moreover, this case serves as a reminder to medical professionals to carefully consider IVC filter placement in the appropriate patient, remain vigilant regarding potential complications, and to aspire follow-up of removable filters.

Keywords IVC filter • vascular complications • filter fracture • cine images • case report

ESC Curriculum 2.1 Imaging modalities • 2.4 Cardiac computed tomography • 9.4 Thromboembolic venous disease

Learning points

- CTA can 3D visualize foreign bodies to guide heart team discussions and management.
- Healthcare professionals should carefully consider selection for IVC filter placement.
- Aspire follow-up of removal filters and review prior imaging as this may diagnose a strut fracture.

Introduction

Inferior Vena Cava (IVC) filter migration, particularly to the heart, is a rare complication that occurs in 0.1–1.2% of procedures, depending on the filter type employed.[1] Thin metallic fragments are difficult to visualize on echocardiogram and are easily missed on chest radiographic studies. The most common procedure-related issues include vascular access concerns such as bleeding, incomplete opening of the filter, migration, and tilt.[2,3] Post-procedurally caval thrombosis and perforation are a potential consequence while late issues may include filter fracture.[2–4] Retrieval may be attained with either endovascular or open surgical approaches.[1] Risk of retrieval includes inducing arrhythmias,

* Corresponding author. Tel: 301-295-4000, Fax: 301-295-6616, Emails: jonathan.a.aun.mil@mail.mil; jon.aun16@gmail.com
Handling Editor: Luca Arcari
Peer-reviewers: Jan Henzel; Ali Nazmi Calik and Amir Idris
Compliance Editor: Franca Morselli
Supplementary Material Editor: Katharine Kott

perforation of the right ventricle, and damage to the tricuspid valve, amongst others.[3,4]

Timeline

2008 (month unknown)
59-year-old female suffered non-traumatic retroperitoneal haematoma. No bleeding aetiology discovered. Patient developed left iliofemoral DVT.

2008 (month unknown)
IVC filter placed for left iliofemoral DVT given ongoing bleeding concerns. Hypercoagulable work-up negative.

2020 (July)
CT calcium score imaging obtained for cardiovascular risk assessment. Linear hyperdensity incidentally within the right ventricle was visualized.

2020 (July)
Transthoracic Echocardiography performed and unable to visualize object.

2020 (August)
Contrast enhanced; ECG-gated cardiac CTA performed. CT images were reconstructed to produce cine images on syngo.via (Siemens, Erlangen, Germany) and vitrea (version: 6.6.3; Vital, Toshiba Medical Systems) to further characterize the fragment and guide clinical management.

2020 (August)
Heart team consultation discussed with the patient to remove part or all of the filter given risk of continued embolization and thrombus vs. no intervention.

2020 (September)
Surgical removal of IVC filter with Cook wire loop snare.

2020 (October)
Follow-up with cardiology and vascular surgery.
Patient remains without procedural complications. Not on oral anticoagulation.

2022 (March)
Patient remains asymptomatic on routine follow-up.

Case Presentation

In 2008, a 59-year-old female suffered a non-traumatic retroperitoneal haematoma. She was not on exogenous anticoagulation at the time and no aetiology of bleeding was discovered. She subsequently developed a left iliofemoral deep venous thrombosis (DVT). It was believed that the intra-abdominal haematoma resulted in compression of the left iliac vein but this was never definitely proven as outside hospital records were not able to be obtained. There was no evidence of May-Thurner syndrome on previous imaging per hospital records. A Bard G2 retrievable IVC filter (formerly C. R. Bard, Inc.) was placed while hypercoagulable work-up was ongoing, which ultimately was unrevealing. Adequate follow-up for potential removal did not occur. In 2020, the patient presented for routine medical evaluation with her primary care physician who advised computed tomography (CT) calcium score imaging as part of cardiovascular risk assessment. She denied any cardiovascular symptoms and was tolerating activities of daily living without complication. Cardiopulmonary examination was unremarkable. Electrocardiogram demonstrated normal sinus rhythm without evidence of underlying hypertrophy, conduction disease, or ischaemia. Family history was without premature coronary artery disease, and there was no history of sudden cardiac death endorsed. Her cholesterol panel revealed a low-density lipoprotein of 103 mg/dL and a total cholesterol of 184 mg/dL. Computed tomography (CT) calcium score imaging as part of cardiovascular risk assessment was obtained by her primary care physician to determine if statin medication would be indicated for primary prevention. A linear hyperdensity in the right ventricle (RV) was incidentally revealed on the CT scan, concerning for embolization of an IVC filter fragment. The patient was asymptomatic. A follow-up contrast enhanced, ECG-gated cardiac CTA was performed in conjunction with a CT, venous phase, of the chest, abdomen, and pelvis. Arterial phase contrast was triggered by bolus tracking with a 200 Hounsfield unit threshold in the ascending aorta. A metallic linear density in the RV papillary muscle, new in comparison to a 2014 CT abdomen/pelvis for renal lithiasis evaluation, was demonstrated (see *Figure 1A–F*). The patient was also found to have a metallic linear density in the anteromedial right middle lobe. CT images were reconstructed using syngo.via (Siemens, Erlangen, Germany) and vitrea workstation (version: 6.6.3; Vital, Toshiba Medical Systems) to further characterize the fragment within the myocardium (*Supplementary material online, Videos S1–S6*). 3D volume rendered imaging allowed visualization of the intracardiac embolized strut, the pulmonary strut, and the fracture IVC filter all in the same image (*Figure 2*). In review of prior imaging, 12 struts of the IVC filter were visible on a virtual colonoscopy in 2009. Subsequent images obtained in 2014 and 2020 revealed 11 and 10 struts, respectively (see *Figure 1A–F*), evidence for two distinct strut fracture embolization events. There was no thrombus adherent to the fractured IVC filter in the IVC. Echocardiography was performed and demonstrated preserved ejection fraction, no pericardial effusion, and normal tricuspid valvular function and pulmonary pressure, but the IVC fragment in the RV papillary muscle from cardiac CT was not directly visualized by echocardiography due to being thin, small metal. Heart team consultation discussed the risks and benefits with the patient and family of removing part or all of the filter due to risk of continued embolization and thrombus vs. no intervention. After shared decision making, the patient consented to remove the filter but leave the embolized RV and lung fragment in place, given the apparent chronicity of the RV and lung embolization per review of prior imaging. The most significant risk was deemed a recurrent embolization or thrombus formation in the suprarenal IVC, heart, or pulmonary arterial circulation.

The procedure was performed in the hybrid operating suite under general anaesthesia. The pararenal IVC was accessed from the right internal jugular vein in standard fashion. A flush venogram was performed to demonstrate patency of the IVC and the absence of thrombus within the filter. The access was then upsized to a 45 cm × 16 Fr Cook Check-Flo Performer introducer sheath (Cook Medical, Bloomington, IN), which was positioned several cm cranial to the hook of the filter. The hook was engaged by a Cook wire loop snare, and the sheath was advanced over the filter. The entire system was then removed and the access site controlled with a single suture. Intraoperative inspection of the filter demonstrated intact removal of the residual 10 struts (see *Figure 3*). The patient tolerated the procedure with no immediate complication and was discharged home following a brief period of recovery.

Discussion

Employment of IVC filters has expanded rapidly since inception in 1973.[5] Overall mortality rates contributed to IVC filter insertion are

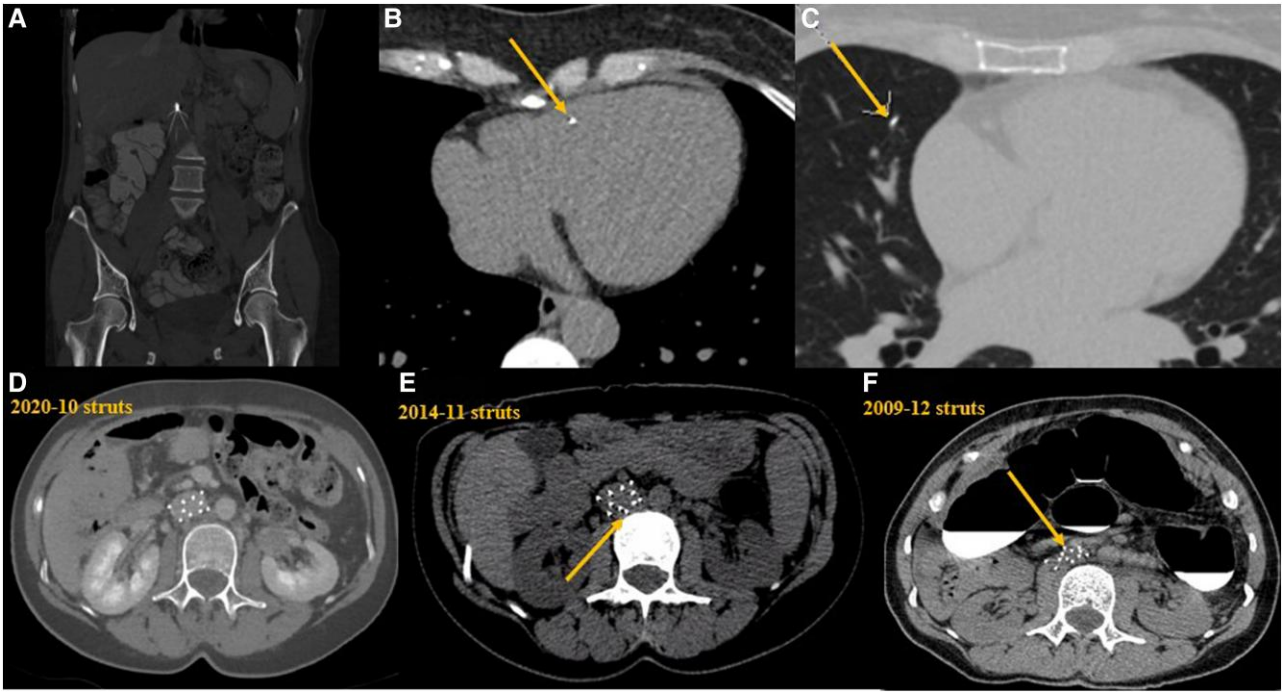

Figure 1 (*A*) CT abdomen and pelvis, June 2009 demonstrating IVC filter. (*B*) Metallic linear density in the right ventricle, new since the CT abdomen/pelvis in 2014. This metallic density is fixed to the right ventricular wall as seen on cine images. (*C*) Metallic linear density in the anteromedial right middle lobe. (*D*/*E*) CT from 2020 showed that a single posterior medial limb of the IVC filter is absent making in total 10 limbs as compared to 11 limbs on comparison of 2014. This likely corresponds to a new fragment seen in the right ventricle. The IVC filter is free of filling defects. IVC distal to the IVC filter was noted to be patent. (*F*) Virtual colonoscopy in 2009 demonstrated 12 struts of the IVC filter.

Figure 2 (Left) 3D anigio view syngo.via still frame allowing visualization of the the intracardiac embolized strut (asterisk), the lung strut (top arrow) and the fracture IVC filter in the same view (bottom arrow). (Right) Embolized right ventricle strut visualized on inverted 3D MIP with vitrea workstation indicated by the arrow.

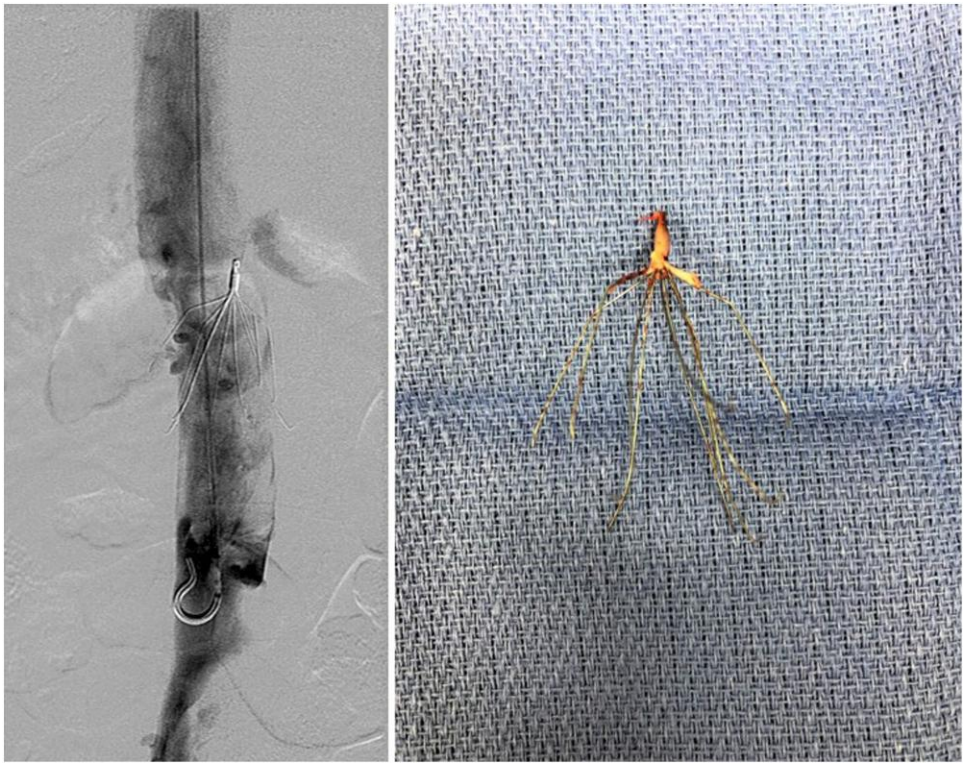

Figure 3 (Left) Initial venogram showing a patent IVC with no intraluminal thrombus. (Right) demonstrating residual filter with some caval endothelium around the top of the filter.

low at approximately 0.12%; nonetheless, it is paramount to understand the spectrum IVC filter outcomes to guide clinical decisions.[4] The undesirable events associated with IVC filters are divided into procedure related, post-procedure, and retrieval complications.[2] The most common procedure-related issues include vascular access concerns such as bleeding, incomplete opening of the filter, migration, and tilt. Post-procedurally caval thrombosis and perforation are a potential consequence while late issues may include filter fracture such as our patient.[2,4] The Society of Interventional Radiology offers specific definitions for these outcomes.[6]

What has remained a continual challenge is determining which subset of patients would benefit most from their use as clinical practice guidelines differ considerably amongst major societies.[7,8] The only universally accepted indication for IVC filter therapy remains patients with an acute thromboembolism who have an absolute contraindication to anticoagulation.[7,8] Uncontrollable bleeding, high risk for bleeding complications, or urgent surgery requiring the cessation of anticoagulation are some of the reasons clinicians may consider employment of these medical devices.[7,8] Moreover, anticoagulation failure is often deemed a potential indication for IVC placement; however, a plethora of cases surrounding recurrent venous thromboembolism (VTE) do not signify a true failure but instead a consequence of inadequate anticoagulation.[8] Health care professionals should have a heightened awareness to assess for medication adherence, underlying medical conditions including thrombophilia or malignancy and if there truly is a recurrent VTE.[8] Patients should be evaluated for underlying hypercoagulable conditions including antiphospholipid syndrome or heparin-induced thrombocytopenia which may lead to recurrent VTE in patients that are therapeutically anticoagulated.[4] Moreover, anatomical anomalies including May-Thurner syndrome must be considered in patients with repeated thrombosis at the same anatomical location.[4]

In 2010, the FDA provided guidance recommending filter removal when protection from pulmonary embolism was no longer required.[4] Despite this measure, annual retrieval rates in the general population remain low at 6.6%.[4] It is important to recognize that longer dwelling times are predictive of retrieval failure.[4] Failure rates at standard retrieval are nearly 40.9% at 7 month indwelling times, and there is an increased complexity with retrieval.[4] There have been several reported cases of IVC filter migrations to various organs including the heart and lungs managed with either observation or various methods of intervention.[1,3,4] Retrieval may be attained with either endovascular or open surgical approaches.[3] Risk of retrieval include inducing arrhythmias, perforation of the right ventricle, and damage to the tricuspid valve, amongst others.[3,4] The degree of cardiac dysfunction, ease of percutaneous removal, the patient's ability to withstand open surgical removal via sternotomy, and operator experience are some of the many avenues of consideration to determine optimal care in a patient centred approach.[1] There has been a growing body of evidence to support the need for an IVC filter retrieval clinic to ensure adequate follow-up and timely removal.[9] Imaging with CT has been demonstrated to be beneficial in identifying complications and offering removal for retrievable IVC filters.[10] Expert reviews have supported that 'retrieval should be attempted for perforating filter and fracture filter fragments when imaging suggests feasibility and favourable risk-to-benefit ratio'.[11] The employment of CTA, specifically cineography, was instrumental to guide clinical decision making for our patient as team members could 3D visualize the foreign body thus helping characterize location, size, and extent of fragment involvement.

Conclusion

Our case illustrates the benefit of CTA to characterize the location, size, and extent of fragment involvement within the myocardium. Moreover, this case highlights the crucial responsibility of health care professionals to ensure timely follow-up for retrievable filters and to remain watchful for potential adverse outcomes.

Outcome and follow-up

The patient did not experience any procedural complications during her hospital stay. Therapeutic oral anticoagulation was not provided following removal of the filter. Follow-up clinic visits with both vascular surgery and cardiology at both 4 and 12 weeks was accomplished. At 2-year follow-up, our patient has not experienced any complications following removal of the IVC filter. She has remained without recurrent embolization or thrombus formation.

Patient experience

'I was very relieved to know that removal of the filter could be achieved through non-invasive measures. I was fearful about having open surgical removal, but I am very appreciative to my team for their coordinated approach. My outcome could not have been better, and I am grateful for the care received. I hope this case serves as a reminder to others regarding potential filter removal if it is no longer necessary. Unfortunately, I did not have discussions regarding this aspect of my care when it was initially placed.'

Lead author biography

Dr. (Major) Jonathan Andrew Aun is a second year cardiology Fellow at Walter Reed National Military Medical Center in Bethesda, MD. He proudly serves in the United States Air Force. As an Assistant Professor of Medicine at the Uniformed Services University of the Health Sciences (USUHS), Dr. Aun teaches both medical students and residents. Jon is passionate about mentoring medical students and sharing his joy of cardiology. His specific interests are advanced cardiovascular imaging and preventative cardiology. Dr. Aun has been selected as an advanced cardiovascular imaging fellow at Brigham and Women's Hospital in Boston, MA. He will begin training in July 2023.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports*.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: The views expressed in this presentation do not reflect the official policy or position of the Department of Defense or the U.S. Government. The identification of specific products or scientific instrumentation is considered an integral part of the scientific endeavour and does not constitute endorsement or implied endorsement on the part of the author(s), DoD, or any component agency. Dr. Edward Hulten has volunteer educational or health policy activity with ASNC, SCCT, SNMMI, SCMR; editorial board contribution to ACC Cardiosmart, SCMR Case of the Week, and Atherosclerosis; volunteer consultation regarding cardiology and cardiovascular imaging with DoD and Defense Health Agency. Dr (s). Aun, Twerdhal and Nguyen have no disclosures.

Funding: None declared.

References

1. Heiraty P, Casasanta M, Gashti M, Wang J. Percutaneous removal of an IVC filter from the right atrium. Endovascular Today [Internet]. 2011 Aug 1 [cited 2021 Jan 20];25–7. https://evtoday.com/articles/2011-aug/percutaneous-removal-of-an-ivc-filter-from-the-right-atrium?c4src=archive:feed
2. Grewal S, Chamarthy MR, Kalva SP. Complications of inferior vena cava filters. *Cardiovasc Diagn Ther* 2016;**6**:632–641.
3. Wakabayashi Y, Takeuchi W, Yamazaki K. Inferior vena cava filter misplacement in the right atrium and migration to the right ventricle followed by successful removal using the endovascular technique: a case report and review of the literature. *SAGE Open MedCase Rep* 2015;**3**:2050313X1559583.
4. Li X, Haddadin I, McLennan G, Farivar B, Staub D, Beck A, *et al.* Inferior vena cava filter—comprehensive overview of current indications, techniques, complications and retrieval rates. *VASA Zeitschrift fur Gefasskrankheiten* 2020;**49**:449–462.
5. Greenfield LJ, McCurdy JR, Brown PP, Elkins RC. A new intracaval filter permitting continued flow and resolution of emboli. *Surgery* 1973;**73**:599–606.
6. Caplin DM, Nikolic B, Kalva SP, Ganguli S, Saad WE, Zuckerman DA. Quality improvement guidelines for the performance of Inferior vena cava filter placement for the prevention of pulmonary embolism. *J Vasc Interv Radiol* 2011;**22**:P1499–1506.
7. DeYoung E, Minocha J. Inferior vena cava filters: guidelines, best practice, and expanding indications. *Semin Intervent Radiol* 2016;**33**:65–70.
8. Kadian-Dodov D. *Who needs an IVC Filter?*. Bethesda, MD: American College of Cardiology; 2020.
9. Schuchardt PA, Yasin JT, Davis RM, Tewari SO, Bhat AP. The role of an IVC filter retrieval clinic—A single center retrospective analysis. *Indian J Radiol Imaging* 2019;**29**:391–396.
10. Jaberi A, Tao MJ, Eisenberg N, Tan K, Roche-Nagle G. IVC Filter removal after extended implantation periods. *Surgeon* 2020;**18**:265–268.
11. Kesselman A, Oo TH, Johnson M, Stecker MS, Kaufman J, Trost D. Current controversies in Inferior vena cava filter placement: AJR expert panel narrative review. *AJR Am J Roentgenol* 2021;**216**:563–569.