Case Report

Removal of an inferior vena cava filter that had migrated to the right ventricle by off-pump ventriculotomy and direct-vision snare capture: a novel hybrid technique

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Abstract
Inferior vena cava filter (IVCF) migration to the right ventricle is a life-threatening condition. Conventionally, on-pump ventriculotomy is required if the endovascular retrieval is compromised. However, for patients in fragile physical condition, the complications of myocardial revascularization are unacceptable. We herein present a case of IVCF migration to the right ventricle in which the hook of the filter was tilted against the anterior wall of the right ventricle. The IVCF was successfully removed via a hybrid technique combining an off-pump microincision of the right ventricle with direct-vision snare capture. This hybrid technique avoided the complication of myocardial revascularization, shortened the operation time, and reduced the amount of blood loss.

Keywords
Inferior vena cava, filter, migration, removal, ventriculotomy, snare capture

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Introduction
Inferior vena cava filters (IVCFs) are used to prevent venous thromboembolism, a highly lethal condition. However, complications...
related to IVCFs have increased during the past two decades with increasing implantation of these filters.1,2 Among these complications, IVCF migration to the right ventricle is one of the most fatal.3 Conventionally, an endovascular technique is performed to retrieve the filter after it has migrated to the right ventricle.4 If this fails, the IVCF can be removed via right ventriculotomy under cardiopulmonary bypass (on-pump).5 Under certain circumstances, however, the IVCF cannot be retrieved by an endovascular approach, and the patient is too fragile to tolerate extracorporeal circulation because of hypoxemia. We herein report a case of successful removal of an IVCF that had migrated to the right ventricle via a novel hybrid technique of off-pump microinvasive right ventriculotomy combined with catheterized snare capture.

Case report
A 54-year-old man presented to our hospital with precordial pain and hemoptysis. Physical examination showed occasional premature ventricular contraction and swelling of the left lower limb. Seven days earlier, the patient had undergone implantation of an IVCF (OPTEASE; Cordis Corporation, Fremont, CA, USA) under the renal veins (Figure 1(a)) in a foreign hospital, but the IVCF had migrated to the right ventricle with the hook tilted against the anterior wall (Figure 1(b) and (c)). The patient also had a long history of silicosis (Figure 1(d)), which resulted in a low arterial oxygen pressure (PaO2 of 62.5 mmHg) and high arterial carbon dioxide pressure (PaCO2 of 39.9 mmHg) preoperatively. An electrocardiogram showed ventricular tachycardia. Echocardiography demonstrated metal artifacts in the right ventricle with significant tricuspid regurgitation and pulmonary hypertension (pulmonary arterial systolic pressure of 38.4 mmHg). Endovascular retrieval of the IVCF failed because the hook was tilted against the anterior wall, which made the hook difficult to capture by the snare. Hence, the filter was removed via midline sternotomy and right ventriculotomy. After opening the pericardium, approximately 100 mL of bloody pericardial effusion gushed out. We directly visualized and confirmed the hook’s location, which was against the anterior wall of the right ventricle (Figure 2(a)). A hybrid technique was used to retrieve the filter. First, a purse-string suture was placed in the ventricular wall about 5 mm around the hook (Figure 2(b)), and a 3-mm microincision was then made to open the right ventricle. Second, the hook was captured with a snare (Figure 2(c)) and the filter was removed through a 10-Fr sheath (Figure 2(d)). A broken filter strut was seen, but it was completely removed without residue (Figure 2(e)). The purse-string suture was then tightened and knotted. The blood loss volume during the procedure was 100 mL. A postoperative chest radiograph confirmed that the IVCF was entirely removed (Figure 2(f)). The patient had an uneventful recovery, and no complications were observed during the 3-year follow-up.

Informed consent was obtained from the patient for the publication of this case report. The study protocol was approved by the ethics review board of Beijing Friendship Hospital.

Discussion
The advantage of the retrievable IVCF is it can be removed in a timely manner once the transient risk factor of venous thromboembolism has disappeared. However, the complications associated with retrievable filters have also increased considerably during the past two decades.6 IVCF migration to the ventricle is one of the most life-threatening complications. In a study of 25 patients in whom the filter migrated to the heart or pulmonary artery, 3 (12%) died of cardiac
shock or arrhythmia and 8 (32%) were converted to open surgery to remove the filter.  

The method most commonly used to remove an IVCF that has migrated to the right ventricle is endovascular retrieval, and if this fails, an on-pump right ventricular incision is mandatory. However, in the present case, the patient had stage III silicosis and hypoxemia. For patients with high risk factors such as low cardiopulmonary reserve, on-pump extracorporeal life support may not be more beneficial than off-pump procedures. Therefore, after the failure of an endovascular approach, we decided to retrieve the IVCF via a hybrid approach in this case. To our knowledge, this is the first report of the extraction of an IVCF that had migrated to the right ventricle via off-pump ventriculotomy and direct-vision snare capture. This hybrid approach avoids the complication of myocardial revascularization, shortens the operation time, and reduces the amount of blood loss. However, the successful retrieval of the IVCF in this case may have been partially due to the position of the hook,

Figure 1. Preoperative status of the migrated inferior vena cava filter (IVCF) and silicosis of the patient. (a) The initial position of the IVCF (yellow arrow) was under the renal veins. (b) A sagittal chest radiograph showed that the IVCF (yellow arrow) had migrated to the right ventricle. (c) Computed tomography showed that the IVCF was in the right ventricle and that the hook was tilted against the anterior wall of the right ventricle (yellow arrow). (d) A chest radiograph demonstrated stage III silicosis (red arrow) of the patient's lung.
which made the microincision feasible. Long-term evaluation and an appropriate hook position are needed for this technique.

Conclusion

The hybrid technique of off-pump ventriculotomy and direct-vision snare capture may be a less invasive and valid approach for IVCF migration to the heart chamber. However, this technique is limited by the appropriate hook position and requires further evaluation of its safety and durability.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Figure 2. Off-pump extraction of the inferior vena cava filter (IVCF). (a) The anterior wall of the right ventricle was nearly perforated by the hook of the IVCF (yellow arrow). (b) A purse-string suture was placed around the hook (yellow arrow). (c) The hook was captured by a snare (yellow arrow) after making a small incision in the right ventricle. (d) The IVCF was retreated and removed via a 10-Fr sheath (yellow arrow). (e) The IVCF was successfully extracted with a thrombus and the broken filter strut (yellow arrow). (f) The postoperative chest radiograph confirmed complete extraction of the IVCF.

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Supplemental Material

Supplemental material for this article is available online.

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