Retrieval of the Recovery Filter after Arm Perforation, Fracture, and Migration to the Right Ventricle

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The authors report a case of inferior vena cava filter arm perforation, followed by fracture and migration to the right ventricle causing chest pain and nonsustained ventricular tachycardia. Review of abdominal computed tomographic (CT) scans show the two filter arms that fractured and migrated had perforated the vena cava 2 years previously. Microscopic evaluation of the retrieved filter and limbs revealed bending metal fatigue at the fracture sites. This case and review of the literature suggest a causal relation between Bard Recovery filter arm perforation and subsequent fracture and migration. Percutaneous retrieval of filters with arm fracture or arm migration is recommended.


Abbreviation: IVC = inferior vena cava

THE Recovery filter (Bard Peripheral Vascular, Tempe, Arizona) was designed as both a permanent and temporary filter. The filter first obtained U.S. Food and Drug Administration approval for sale in the United States in 2002 (1) and was sold until replaced by the G2 filter (Bard) in 2005. The Recovery filter has six filter leg wires with hooks in a standard teepee configuration. This filter has a unique set of six additional outward-directed centering arm wires at the top of the filter. All 12 wires are joined together with a nitinol cap. The fracture and migration of individual parts of inferior vena cava (IVC) filters is uncommon, as is migration to the wall of the right ventricle. The causes and management of this problem in one patient are the basis of this brief report.

CASE REPORT

A 62-year-old woman had a Recovery filter placed 2 days before knee replacement surgery. Two months earlier, she had developed a deep venous thrombosis and pulmonary embolus while recovering from gastric bypass surgery. She was initially treated with anticoagulation. The filter was placed at an outside institution as a permanent IVC filter to prevent pulmonary embolus during knee replacement surgery.

The patient had no further problems with thromboembolic disease. Two years later, the patient presented with a history of vague right-sided abdominal and chest pain. Unenhanced computed tomography (CT) of the abdomen demonstrated that three upper arms and one of the lower limbs of the filter had penetrated the IVC (Fig 2). The current CT scan demonstrated that two of the three perforating arms had fractured and migrated. The filter in the IVC was retrieved with the Recovery Cone catheter (Bard Peripheral Vascular) placed through a 12-F sheath. The filter was successfully extracted from the vena cava along with one of the fractured wire arms (Fig 3).

The wire arm fragment in the right ventricle was extracted by using a 7-F interV ENSnare system (Medical Device Technologies, Gainesville, Florida) with a 27–45-mm snare. The snare was positioned co-axially through an 8.3-F steerable sheath (Enpath Medical, Minneapolis, Minnesota). The steerable sheath enabled us to direct the snare catheter directly at the small foreign body in the right ventricle. All the components of the filter were retrieved and accounted for (Fig 4). Completion venography, ventriculography, and thoracic and abdominal CT confirmed successful extraction without complication. The patients’...
chest pain and palpitations resolved and have not returned in 4 months of follow-up. A 24-hour Holter monitor demonstrated the absence of ventricular tachycardia.

**DISCUSSION**

The primary reason for retrieving the IVC filter was that the delayed fracture and migration suggested the possibility of additional fracture and migration. It was believed that the IVC filter should be removed before the right ventricular fragment in case additional filter fragments migrated to the heart or lung during the IVC retrieval.

This possibility was borne out by the unanticipated retrieval of the sec-

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**Figure 1.** Axial contrast-enhanced CT scan demonstrates the migrated arm of the filter in the right ventricle (arrow).

**Figure 2.** (a) Axial CT scan through the top of the filter demonstrates the six intact upper arms of the Recovery filter. (b) A more caudal image shows perforation of three arms on the right side of the vena cava. The two arms that fractured and migrated are indicated by the arrows. (c) A further caudal image below the level of the arms shows only the legs. One leg has perforated the vena cava and extends posterior to the aorta. (d) CT scan obtained at 2 years demonstrates missing arms from the 9 and 7 o’clock positions.
ond fractured arm when the filter was removed from the IVC. The arm was found enclosed in the legs of the filter, having been serendipitously retrieved with the Recovery Cone catheter. It was clear from the abdominal CT scan that two arms were fractured and had migrated. The location of the second arm was initially thought to be the right ventricle attached to the first. In retrospect, the free arm can be seen on the abdominal CT scan (Fig 3a), lying parallel to a leg of the filter.

There was some concern that the filter would be deformed or displaced during an attempted but unsuccessful retrieval, further compromising the filter’s ability to trap thrombus. We were also concerned that the filter retrieval could be hindered by the absence of the two of the filter arms that are the hooked with the Recovery Cone catheter (Fig 3b). Previous reports in the literature suggested that removal of the filter might be possible even though the filter had been in place for 735 days.

One author (2) reported a high (100%) success rate for late (>180 days) retrieval of the Bard Recovery filter. There is also a case report of successful retrieval of a fractured filter (3). Failed retrieval most commonly occurs from the filter cap being imbedded in the vena cava wall (4). Fortunately, our patient’s filter was centered in the vena cava.

The rationale for retrieving the wire fragment in the right ventricle included (a) nonsustained ventricular tachycardia (presumably from ventricular irritation by the wire fragment) and (b) right ventricular perforation and cardiac tamponade reported in another case of filter arm migration to the right ventricle (3). The idea of snaring foreign bodies from the right ventricle is routine. However, the removal of small wire fragments presents unique challenges and risks. In the literature, most cases of small wire or needle fragment retrieval from the right ventricle have required cardiac surgery (3,5–7). In our case, the wire appeared adjacent to the wall but had not perforated the right ventricle. We elected to remove the right ventricular fragment percutaneously to reduce the morbidity of the retrieval. The challenges of percutaneous removal of small fragments from the right ventricle or atrium are being able to get good directional control and catheter stability in a moving cavernous space while trying to direct a snare or biopsy forceps into the needed location and orientation. There are additional concerns of causing dysrhythmia or damaging the heart wall, cordae tendinae, or tricuspid valve. We had a code cart, defibrillator, and transvenous pacemaker ready for use during the procedure, and the cardiac surgery team was on standby. We used an effective combination of a steerable sheath designed for electrophysiology cardiac ablations and a complex multiloop snare.

The Bard Recovery filter is constructed of 0.013-inch nitinol wire, with six inferior legs with hooks and six outward- and then downward-pointing centering arms (Fig 4). In one report, the centering arms had a tendency to perforate the vena cava wall, which occurred in 27.5% of cases (8). That article describes 11 of 40 patients with perforations at an average of 80 days. Three of 11 perforated arms fractured, making the rate of arm fractures

Figure 3. (a) The second fractured arm is tucked in, with the legs of the filter giving a heart shape of two adjacent struts (arrow). Compare this image carefully with Figure 2b, which was obtained at the same cross-sectional level before fracture and migration. (b) Remaining intact filter arms are in the grasp of the Recovery Cone catheter during retrieval. The second fractured arm has migrated into the center of the filter (arrows) and was only appreciated in retrospect. The arm was captured in the legs of the filter and came out with the rest of the filter.

Figure 4. Photograph shows all of the retrieved fragments. From right to left: The arm extracted with the filter, the filter from the IVC, and the arm bent by the snare when extracted from the right ventricle. (Available in color online at www.jvir.org.)
7.5% (three of 40 patients) overall and 27% of arms perforated. Migration occurred in one of three fractured arms. There were no fractures described in arms without vena cava wall perforation or in any filter legs. It is interesting that, in the current case, the filter arm fractures also occurred in arms that had perforated the vena cava. Reported migrations of fractured filter arms in the literature have been to the pancreas in one case (8) and into the right ventricle in another (3). The Manufacturer and User Facility Device Experience (MAUDE) database describes a third case of arm fracture and migration to the pulmonary artery. Filter leg perforation (Fig 2c) is not uncommon, with an accepted rate of 0%–41% (9). Leg fractures of the Bard Recovery filter have not been reported.

We propose that the outward and downward pointing perforated arms develop a more acute angle between the arm and the cap than do nonperforated arms. The perforated arms are also fixed relative to the filter cap and vena cava wall. The fixation of the distal arms in surrounding tissue resists movement. The fixed arms are then subjected to high frequency of bending stress due to vena cava wall and filter movement during the respiratory and cardiac cycles. There are nearly 3.5 million (3,456,000) cardiac cycles at a heart rate of 80 beats per minute in 30 days. Evaluation of the filter with a dissecting microscope suggests a bending metal fatigue just below the filter cap (Fig 5a, b). This is the type of fracture that would occur by bending a paper clip back and forth until it fractures. Metallurgical analysis with scanning electron micrography confirms a bending metal fatigue fracture (Fig 5c).

The Bard Recovery filter described in this case was commercially avail-
able from April 2003 to October 2005, when the modified Bard G2 filter was introduced. The new G2 filter has longer arms. The arms are less angulated and more parallel to the vena cava wall. The tips of the arms are turned away from the vena cava wall (like the tips of skis). These changes may have corrected the problem of perforation and migration.

Vena cava wall perforation of the upper arm of a Bard Recovery filter may lead to filter arm fracture and migration. In our patients, we are recommending imaging with unenhanced abdominal CT to look for arm perforation, fracture, or migration to further evaluate the scope and risk posed by this filter. Removal of migrated arm fragments to the right ventricle and/or fractured filters can be performed percutaneously and should be considered for such patients.

References