Endovascular foreign body retrieval

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Objective: **The number of endovascular procedures performed is increasing exponentially as technology improves. A serious complication of endovascular therapy is loss of a foreign body in the vasculature. We reviewed our experience and evaluated the cause, management, and outcomes of intravascular foreign body (IVFB) misplacement.**

Methods: **We completed a retrospective review of patients who underwent endovascular retrieval of IVFBs between 2005 and 2010. Patients were identified by current procedural terminology code or by our hospital's risk management team. Patients undergoing routine endovascular retrieval of temporary vena cava filters were excluded.**

Results: **Twenty-seven IVFBs were identified in 26 patients. Twenty patients were asymptomatic (76.9%). Six patients were symptomatic (22.2%) with either pain (n = 4) or abnormal physical findings (n = 2). There were 13 (48.1%) catheter fragments, six (22.2%) guidewires, five (18.5%) inferior vena cava (IVC) filter (embolisms), two (7.4%) stents, and one (3.7%) sheath fragment. There were five (15.6%) embolizations of an IVFB into the right heart, three (9.4%) into a pulmonary artery, eight (25%) into the vena cava, eight (25%) into peripheral veins, five (15.6%) into peripheral arteries, one (3.1%) into a coronary artery, one (3.1%) into a hepatic vein, and one (3.1%) into adjacent soft tissue. The mechanism of endovascular loss was device fracture in 16 (59.3%) cases, loss of control in six cases (22.2%), migration in four (14.8%) cases, and incorrect device deployment in one case (3.7%). The probable cause of foreign body loss was technical error in eight (29.6%) cases. In three cases, IVFB retrieval was not attempted. The misplacement and retrieval were completed during the same procedure in 13 (48%) cases. Twenty-four endovascular retrievals were performed. Fifteen (62.5%) procedures used a snare to remove the IVFB and two (8.2%) used balloon catheters. Three IVFBs could not be removed and two cases were converted to open procedures. Technical success was achieved in 19/24 cases (79.2%). There were no immediate complications related to the retrieval of the IVFB; however, there was a single late complication of pulmonary embolism after failed endovascular retrieval (1/24, 4.2%). Thirty-day survival was 100%.**

Conclusions: **Intravascular foreign bodies are a serious complication of endovascular therapy that can be minimized with proper device selection and deployment. When an intravascular foreign body is identified, endovascular retrieval should be attempted due to its high success rate and minimal morbidity. (J Vasc Surg 2013;57:459-63.)**

The dangers of intravascular foreign bodies (IVFB) were formally recognized by the Federal Drug Administration (FDA) in a 2008 public health notification.[1] The purpose of the notification as stated was to advise health care providers of serious adverse events associated with unretrieved device fragments and provide recommendations to mitigate these events.[1] This warning was in response to an article by Fisher entitled "Danger: Beware of unretrieved device fragments," which described the case of a fragmented guidewire causing coronary artery perforation and death.[2] In this report, it is mentioned that a coronary guidewire was manipulated into "a shape for which it wasn't designed" causing weakening of the guidewire and causing fracture, which lead to cardiac tamponade during the procedure.[2] The potential for embolization of an IVFB to the heart and pulmonary arteries is a danger that should be a major concern to interventionalists. Bernhardt et al reviewed the complications associated with intracardiac catheter embolization in the1970s showing that mortality of untreated embolization approached 60% due to cardiopulmonary complications. At the same time, all patients in whom the embolized catheter was successfully removed were alive and asymptomatic.[3] Intravascular foreign body embolization is a potential complication of any angiographic procedure. Accordingly, the cause and treatment of IVFB misplacement remains a topic of interest for all interventionalists. Although there have been multiple series published in the interventional cardiology and radiology literature,[4,5] this is the largest series of endovascular retrieval of IVFBs published in the vascular surgery literature to date. Thus, we evaluate our experience with the cause, management, and outcomes of intravascular device misplacement.

METHODS

A retrospective review was performed on patients in whom endovascular retrieval of a foreign body was attempted between November 1, 2005 and April 30, 2010. Current procedural terminology (CPT) codes on hospital charge sheets (CPT # 37203) were used to identify the majority of patients. Those not identified by CPT codes were identified by using the records of our hospital's risk management team. Institutional Review Board approval was obtained and patient demographics, hospital progress notes, clinic notes, operative reports, noninvasive vascular studies, angiograms, and any other available imaging were reviewed. Patients undergoing planned, routine endovas-

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Author conflict of interest: none.

Presented at the Thirty-ninth Annual Symposium of the Society for Clinical Vascular Surgery, Orlando, Fla, March 16-19, 2011.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214/$36.00

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http://dx.doi.org/10.1016/j.jvs.2012.01.092

Table. Type, location, and mechanism of foreign body loss and retrieval in 27 cases

Case	*FB*	*Symptom*	*Location*	*Mechanism*	*Technical error*	*Retrieval device*	*Success*	*Open retrieval success*
1	7F sheath	A	Periph. a.	F	No	Unknown	Yes	—
2	Stent	A	Periph. a.	M	No	Unknown	Yes	—
3	CVC segment	A	Heart	F	Yes	15 mm snare	Yes	—
4	Guidewire	A	Pulmonary a.	F	No	Trilooped snare	Yes	—
5	Swan-Gantz catheter	A	Periph. v.	LOC	Yes	Unknown	Yes	—
6	CVC segment	A	Heart	F	No	Snare	Yes	—
7	Mediport tip	A	SVC	F	No	20 mm snare	Yes	—
8	HD reliable outflow catheter	A	Heart	F	No	Snare	Yes	—
9	HD reliable outflow catheter	A	Heart	M	No	6 × 10 mm balloon catheter	Yes	—
10	Mediport tip	A	Pulmonary a.	F	No	25 mm snare	Yes	—
11	Guidewire	A	Coronary a.	F	No	Microsnare	No	NA
12	Arterial catheter	Difficult flush	Periph. a.	F	No	Balloon	Yes	—
13	CVC tip	A	Soft tissue	F	No	None	—	NA
14	IVC filter struts	ACS	Heart, periph. v.	F	No	Unknown	Yes	—
15	Tunneled dialysis catheter[a]	A	Periph. v., SVC	F	No	4 × 10 mm balloon	No	Unsuccessful
16	Guidewire	A	Periph. v.	LOC	Yes	Unknown	Yes	—
17	IVC filter	A	IVC	LOC	Yes	None	—	NA
18	Stent	A	Periph. a.	M	No	Gooseneck snare	No	Successful
19	Arterial catheter	UE swelling	Periph. v.	F	No	Snare	No	NA
20	IVC filter struts	Abd pain	IVC, hepatic v.	F	No	Snare	Yes	—
21	Guidewire	A	IVC, SVC, periph. v.	LOC	Yes	Trilobed snare	Yes	—
22	Guidewire	A	IVC, periph. v.	LOC	Yes	Snare	Yes	—
23	IVC filter	A	IVC	WD	Yes	Snare	Yes	—
24	Mediport tip	A	Pulmonary a.	F	No	Gooseneck snare	Yes	—
25	Stent delivery catheter	A	Periph. a.	F	No	Snare	No	Successful
26	Guidewire	RP hematoma	Periph. v.	LOC	Yes	Unknown	Yes	—
27	IVC filter	A	SVC	M	No	None	—	Not attempted

a, Artery; *A*, asymptomatic; *Abd*, abdominal; *ACS*, acute coronary syndrome; *CVC*, central venous catheter; *F*, fracture; *FB*, foreign body; *HD*, hemodialysis; *IVC*, inferior vena cava; *LOC*, loss of control; *M*, migration; *NA*, not attempted; *Periph*, peripheral; *RP*, retroperitoneal; *SVC*, superior vena cava; *UE*, upper extremity; *v*, vein; *WD*, wrong device; —, not applicable.

[a]Device related to pulmonary embolism.

cular retrieval of temporary vena cava filters were excluded from this study. The method of retrieval was left to the discretion of the surgeon as currently there is no standard retrieval algorithm at our institution. As summarized in the Table, a variety of snare devices were used for this purpose, including gooseneck snares, trilobed snares, single lobed snares, microsnares, as well as other unconventional retrieval devices such as standard balloon catheters. Standard statistical methods, including averages and standard deviation were applied.

RESULTS

Twenty-seven IVFBs were identified in 26 patients (see Table 1). Twenty patients were asymptomatic (76.9%). Four patients (15.4%) presented with pain as their diagnostic feature, including chest pain from a myocardial infarction, flank pain from a retroperitoneal hematoma, and two patients with vague abdominal pain after minor trauma, which led to imaging showing a foreign body. In the case of myocardial infarction, the patient was admitted for acute coronary syndrome secondary to perforation of the interventricular septum of the heart by a fractured inferior vena cava (IVC) filter strut (Fig 1). Additionally there were two patients with abnormal physical findings, a single case each of arm swelling and arterial line malfunction. Thirteen (48.1%) IVFBs were catheter fragments, six (22.2%) were guidewires, five (18.5%) were IVC filters, two (7.4%) were stents, and one (3.7%) was a fractured sheath.

There were five (15.6%) misplacements of an IVFB into the right heart, three (9.4%) into the pulmonary artery, eight (25%) into the vena cava, eight (25%) into peripheral veins, five (15.6%) into peripheral arteries, one (3.7%) in a coronary artery, one (3.7%) in a hepatic vein, and one (3.7%) into adjacent soft tissue. The mechanism of endovascular IVFB loss was device fracture in 16 (59.3%) cases, loss of control in six cases (22.2%), migration in four (14.8%) cases, and incorrect device deployment in one case (3.7%). The probable cause of foreign body loss was technical error in eight (29.6%) cases, which included loss of control in six (22.2%) cases and one case of incorrect device selection (3.7%) in which a nonretrievable superior vena cava (SVC) filter was mistakenly placed in the IVC, and one

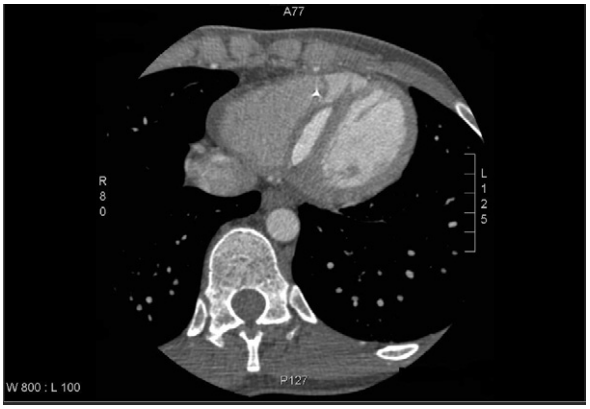

Fig 1. A septal hematoma from an embolized inferior vena cava (IVC) filter strut.

case in which a central venous catheter was fragmented during abdominal surgery by erroneous division. For the six cases of loss of control included in the category of technical errors, four were guidewires lost during central venous catheter (CVC) placement, one was a Swan-Gantz catheter which was placed into an occluded vein causing the catheter to form a knot preventing retrieval at bedside, and one was a malpositioned (angulated) nonretrievable IVC filter. The IVFB misplacement and retrieval were completed in the same procedure in 13 (48%) cases. The remaining cases were late identification of foreign bodies. Twenty-four endovascular retrieval procedures were performed. Fifteen (62.5%) procedures used a snare to remove the IVFB; two (8.2%) used balloon catheters. In the remaining cases, the type of device used to retrieve the IVFB was not identified in the operative note.

Technical success was achieved in 19 of 24 cases (79.2%). Two cases needed to be converted to open procedures in order to retrieve the IVFB. One of these cases involved a self expanding stent that dislodged from the delivery device as it came over the aortic bifurcation causing the femoral sheath to be pulled back unexpectedly and causing the stent to dislodge from the delivery system itself into the distal aorta. The deformed stent was successfully snared and brought into a 7F sheath; however, the stent could not be removed through the sheath and the patient was taken to the operating room for definitive retrieval. The other case converted to open retrieval was after the fracture of the delivery system of a 6×40 mm stent. After successful stent delivery, on removal of the delivery system, it was noted that the inner core had broken and that the outer sheath and proximal portion of the sheath were intact. On further radiologic interpretation, it was apparent that this sheath was free-floating in the left superficial femoral artery. Attempts were made to pass a snare, but this could not be accomplished. Given the fact that this was quite fragile and the catheter continued to fracture, a cut down was made on the left groin. A transverse arteriotomy was made just proximal to the profunda femoris takeoff, allowing extraction of the fragmented catheter.

Alternatively, three attempts at IVFB retrieval were abandoned and the IVFB was left in place. One case involved the removal of a tunneled dialysis catheter in which endovascular techniques were attempted to facilitate a difficult open retrieval which caused fracture of the tunneled dialysis catheter from excessive traction forces. The fragment extended from the subclavian vein into the innominate vein and SVC. In this case, a 4×10 balloon was inflated into the end of the catheter to attempt retrieval. After realization that the catheter was firmly attached, the decision was made to leave the fragment in place.

In one case of attempted IVFB retrieval, endovascular attempts were abandoned after a microsnare catheter could not be passed over the wire to retrieve a portion of guidewire which fragmented during coronary catheterization. After multiple snare attempts, it was not felt that open retrieval would significantly improve outcomes and the foreign body was left in place. The remaining case was a retained catheter that was found in the right subclavian vein of a patient during an ultrasound study to rule out a possible deep venous thrombosis of the patient's right upper extremity. The patient had had arm swelling after peripheral inserted central catheter (PICC) placement, and her arm had remained swollen after PICC removal. After several unsuccessful attempts at snaring the catheter, the surgeon noted that the catheter did not move as if it was scarred in with a fibrinous sheath around it. After multiple attempts at snare retrieval, it was believed that the catheter was truly immobile, and therefore the likelihood of this embolizing was very low. Furthermore, the chances of causing harm would be greater with open retrieval, and the decision was made to abandon the procedure.

Of all records reviewed by case management and by CPT code, there were three cases where IVFB was identified, however, retrieval was not attempted. In one case, the IVFB, a central venous catheter tip, was found to be extravascular on imaging, within the surrounding subcutaneous tissue. Retrieval was not attempted since the IVFB was not causing any symptoms and was believed to be extravascular. In the remaining two cases, displaced IVC filters were stable and it was believed that retention would not cause harm to the patient. One of these IVC filters was placed in the suprarenal vena cava at a significant angle. A second filter was subsequently placed above the displaced filter. An intraprocedural ultrasound showed good flow through the vena cava, and open conversion was not attempted due to concern that removal of the filter would be a significant operation, which was not believed to be warranted in the setting of a patent vena cava. The second case was an IVC filter with migration to the SVC/right atrium junction. All of the radiographs and computed tomography scans during the 3-year period after placement were mistakenly reporting the filter as an "SVC filter," which was stable in position and at the cavoatrial junction. Since the migration was not identified immediately, and it was evident that the IVC filter had been in this position for >3 years (Fig 2), it was decided that attempted retrieval of this stable IVC filter, which was likely held in place by years of fibrosis would be

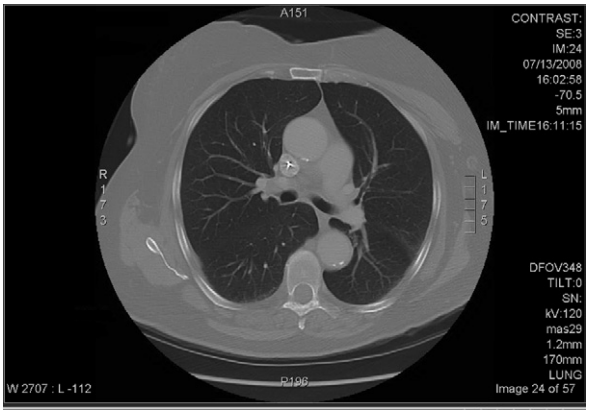

Fig 2. Inferior vena cava (IVC) filter at the cavoatrial junction.

a significant risk to the patient, who was already on lifelong anticoagulation, and was unwarranted in the setting of evidence to its stability over the years.

There were no immediate procedural complications related to IVFB retrieval. Pulmonary embolism from thrombotic debris around a retained catheter fragment was a late complication of failed endovascular retrieval in one case, resulting in an overall complication rate of 1/24 (4.2%). Thirty-day survival was 100%.

DISCUSSION

Intravascular foreign bodies are a serious complication of endovascular therapy. The first report of an endovascular foreign body was in 1954 after an autopsy which showed a dislodged catheter embolized from a cubital vein into the right atrium.[6] Since then, there have been hundreds of reports of central venous catheter-related incidents with reports of fractured guidewires in the literature since 1962.[7,8] In 1964, Thomas et al reported the first successful intravascular retrieval of a steel spring that had migrated to the right atrium and IVC using bronchoscopic forceps.[9] Since then a variety of catheters, including loop and basket snares have been developed for the retrieval of foreign bodies.[10] Reports of intravascular foreign bodies include a variety of objects: endovascular stents, balloon catheters, IVC filters, embolization coils, intravascular ultrasound (IVUS) catheters, cardiac valve fragments, sheaths, temporary pacing wires, pacemaker wires, and atrial septal defect closure devices.[10-14]

Technical, device, and patient factors contribute to misplacement of various intravascular devices. In our study, we had both technical and deployment errors contribute to the loss of a foreign body. Technical error remains a major source of IVFBs during venous procedures in our study and in the literature. In the United States alone, more than 5 million CVCs are inserted annually and the retention of device fragments during CVC insertion is often due to inexperience, inattention, or loss of control of guidewires.[10,15-17] Additionally, guidewire loss is often due to the inadequate tension on the guidewire during insertion of the CVC.[16,17] Alternatively, Tateishi et al suggest that "insertion with excessive force or unnatural resistance also causes breakage of medical devices. Guidewires sometimes stray into the extravascular space or intrude into the vessel wall, and consequently may become entrapped or stuck."[10] This was the case in one patient in our study in whom IVFB was diagnosed by pain from retroperitoneal hemorrhage with a guidewire fragment retained in the common femoral vein. The inadvertent cutting of a CVC during abdominal surgery for small bowel obstruction in our study highlights the fact that special attention and care must be taken when dealing with these endovascular devices.

Another cause of CVC fracture includes the excessive traction force sometimes required to remove the CVC due to the formation of a fibrin sheath around the catheter. First described in 1971 by Hoshal et al, the fibrin sheath is a type of scar tissue, which forms around the catheter secondary to the endothelial damage that is the result of CVC insertion.[18] This scar may explain why long-term catheter removal is often difficult, occasionally causing the CVC to fracture with foreign body retention. This was apparent in our study with seven cases of catheter/mediport fracture which was likely caused from excessive traction force used during CVC removal, as well as one sheath fracture on attempted removal. The long-term risk of thrombosis or migration of adherent fragmented catheters left in place is unknown; however, it has been reported in the literature that leaving these fragments in place when they are firmly adherent to the vessel wall is safe.[19-21] Determining whether the foreign body is firmly adherent to the tissue is not well established but relies on a combination of time since implantation and radiographic evidence of surrounding tissue enveloping the fragment.

Unfortunately, our study did highlight the risk of thrombosis around retained IVFBs, as seen in our single late complication of a pulmonary embolism. This event was likely because of thrombus formation around a retained catheter fragment.

Device failure is another contributing factor in intravascular foreign bodies. We had two cases where the delivery system failed causing dislodgement of a device into the vascular system. In these delivery systems, stent dislodgement can occur with inadequate balloon dilation or stent balloon catheter rupture causing the stent to drop into the vessel.[10] In one of our cases, neither of these occurred; however, the femoral sheath pulled back unexpectedly on insertion and caused the stent to dislodge from the delivery system itself. An alternative to retrieval in these cases of stent embolization is repositioning of the device. This option has been reported successfully by Gabelmann et al in the retrieval of endovascular stents and should be considered when possible.[12]

Based on our experience, it appears that if an IVFB is discovered acutely and does not appear adherent, it can usually be retrieved safely. In our study, a snare catheter was the preferred method of retrieval of IVFBs. Loop snares (ie, Goose-neck) are widely available and have the advantage of being flexible enough to follow the intravascular curvature into the heart, great vessels, or peripheral vessels as neces-

sary. The advent of nitinol loop snares has been advantageous in retrievals as they have the added capability of maintaining their shape within the vessel.[22] Unfortunately, these snares do not have strong gripping capabilities, which can sometimes cause difficulties in retrieving objects without an obvious free edge. When an object is adherent to a vessel wall or does not have an obvious free edge, basket snares are a useful option due to their powerful grasping capabilities and the ability to adjust their size based on the vessel diameter. They can also retrieve relatively large foreign bodies. Care must be taken not to damage the vessel wall or disrupt intramural thrombus within the vessel because of the stiff nature of the basket. When foreign bodies are strongly adherent to the vessel wall, grasping forceps can be a helpful tool in extracting the object.[10,12] The choice of device for retrieval is ultimately surgeon dependent, and various tools and techniques have been found to be useful in the retrieval of lost objects. However, it is clear from the literature that when removing an IVFB, the free edge should be secured followed by catheter extraction of the IVFB. When extraction is not possible, surgical retrieval may be necessary. Repositioning of large fragments to the femoral vein can facilitate retrieval by surgical cut down. This method was used in one of our cases and has been shown to be effective in other cases in the literature.[11] Conversely, when the risks of endovascular or surgical retrieval outweigh the perceived benefits and the IVFB is found to be stable and/or firmly adherent to the vessel wall, leaving the IVFB in place is an option.

Although no complications related to the endovascular retrieval procedure were reported in our study, complications that have previously been reported include cardiac arrhythmias, ventricular perforation, artery spasm, thrombosis, and injury to the vessel at the puncture site or other vessel perforation.[10]

In conclusion, while endovascular procedures seem innocuous, safe, and simple, they can have dangerous and devastating complications. The loss of endovascular foreign bodies is a growing problem, which can be minimized with proper device selection and deployment. When an intravascular foreign body is identified, endovascular retrieval should be attempted due to its high success rate and minimal morbidity and mortality.

AUTHOR CONTRIBUTIONS

Conception and design: MC, SA, JP
Analysis and interpretation: MC, SA, JK, JP
Data collection: MC, JK
Writing the article: MC, SA
Critical revision of the article: MC, SA, JK, JP
Final approval of the article: MC, SA, JK, JP
Statistical analysis: MC, JK
Obtained funding: JP
Overall responsibility: JP

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Submitted Nov 8, 2011; accepted Jan 8, 2012.