ORIGINAL ARTICLE

INTRAVASCULAR FOREIGN BODY RETRIEVAL

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Abstract

Introduction: *Intravascular foreign body (IFB) embolization is a potential complication of any vascular procedure. Intravascular foreign body retrieval (IFBR) can be achieved using percutaneous techniques, open surgery, or both combined.*

Methods: *We completed a retrospective review of patients who underwent endovascular or open IFBR since 2011 on our institution. Primary end-point was technical retrieval success, and secondary end-points were procedure-related complications and 30-days survival.*

Results: *Twenty-seven patients underwent IFBR. Median time from intravascular device loss and retrieval was less than one day. 67% were non-endovascular guidewires and sheath fragments (N=28). 59% of IFBs were lost during their deployment (N=16); 41% during their removal attempts (N=11). 44% were lost in the arterial system (N=12) and 52% in the venous system (N=14). An endovascular procedure was used as the first approach in IFBR in 56% of patients (N=15) and open procedure in 44% (N=12). In the presence of IFB on the thoracic or abdominal cavity, it was always tried a first-endo approach; if IFB was present on the neck or limbs, 75% were retrieved by open surgery (N=20; p<0.001). Success rates were 100% for open and 87% for endovascular procedures. IFB caused five acute complications: one IJV thrombosis, two strokes and three acute limb ischemia. There were no IFBR-related complications. 30 days-survival was 100%.*

Conclusion: *Embolization of IFBs can be minimized with proper device selection, deployment and removal. In this study, open and endovascular retrieval had high success rates and minimal morbidity. Its choice is surgeon-dependent and restrained by devices availability.*

INTRODUCTION

Intravascular foreign body (IFB) malpositioning or embolization is a potential complication of any vascular procedure and can cause severe morbidity. It is increasing as endovascular procedures become ubiquitous.

Migration of devices in the venous system constitutes the bulk of reports, with embolized central line fragments being the most frequently retrieved device; The rate of broken venous catheters has been estimated at 0.1%. However, arterial losses are increasingly reported. In the exponentially increasing cardiac catheterization procedures, IFB malpositioning or embolization incidence is about 0.1%–0.9%.[1-4]

The higher number of patients under dialysis or chemotherapy has increased the use of intravascular devices. Accordingly, most cases of IFBR occur in dialysis and oncology patients.[5]

Technique, device and patient factors contribute to the misplacement of various intravascular devices. The technical error remains a significant source of IFBs during venous procedures; the retention of device fragments during CVC insertion is often due to inexperience, inattention, poor fixation or loss of control of guidewires. The excessive traction force sometimes required to remove the CVC may

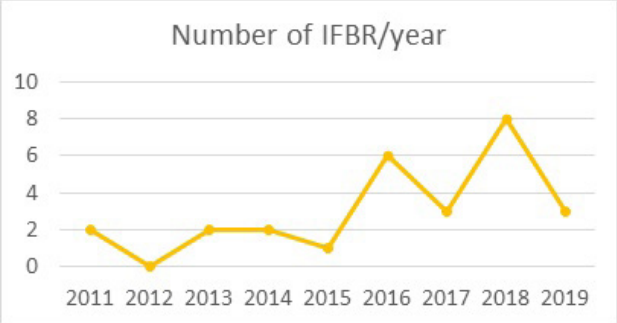

Figure 1 *The pattern of intravascular foreign body retrieval evolution.*

cause catheter fragmentation due to the formation of a fibrin sheath around the catheter. In the venous circulation, the device often floats unimpeded to the heart.[2,6]

On the arterial system, maldeployment in a more peripheral location than was initially intended is often the problem; a balloon-expandable stent may fall off the balloon, or an undersized stent can be displaced peripherally. Reported issues with embolization coils usually occur when the delivery catheter or the undersized coil positions are not stable.[1,2]

Intravascular foreign body retrieval (IFBR) can be achieved using percutaneous techniques, open surgery, or both combined.

The earlier technique of retrieval of displaced foreign bodies implied open surgery, which increased the patient morbidity and mortality. In 1964, Thomas et al. used a rigid bronchoscope forceps through a sheath to remove a fragment of a broken guidewire from a patient's right atrium. In 1967, Edelstein described retrieval of a displaced catheter from the superior vena cava using a ureteral stone basket. Since then, percutaneous techniques have dramatically altered the management of foreign bodies. The technique refinement and device developments made the endovascular option using the snare the mainstay for IFBR.[3,4]

Because such instances are unusual and only occasionally encountered by anyone practitioner, this study aims to characterize the malpositioned or embolized devices and the strategies used for their retrieval.

METHODS

We completed a retrospective observational study after patient clinical folder consultation and local ethics committee approval. We identified all patients who underwent endovascular or open IFBR by a vascular surgeon on a central tertiary university hospital from October 2011 to October 2019 (8 years).

We reviewed our experience and evaluated the cause, symptoms, management, and outcomes of IFB misplacement and retrieval.

Patients undergoing routine endovascular retrieval of temporary vena cava filters were excluded.

The retrieval method was left to the surgeon's discretion as, currently, there is no standard retrieval algorithm at our institution. If an endovascular approach is taken, we use a loop snare, if available off-the-shelf, from a femoral vessel sheath, if possible.

In all patients, heparin was given during the procedure, and intravenous antibiotics were administered.

The primary end-point was retrieval procedure success, defined as complete removal of the foreign body.

The secondary end-points were procedure-related complications, time of vascular department observation and 30-days survival. Complications of the intravascular device misplacement were not considered procedure-related complications but IFB symptoms.

Statistical analysis

Statistical analysis was performed using the software IBM SPSS Statistics 24®. Categorical variables were expressed as frequencies and compared using the Qui-Square test or Fisher exact test. Continuous variables with normal distribution were expressed as mean±standard deviation (SD), and they were compared using the t-Student test. Continuous variables with non-normal distribution were expressed as median±interquartil interval, and they were compared using the Mann-Whitney test. Survival analysis was performed using the Kaplan-Meier method. $p<0.05$ was considered statistically significant.

RESULTS

Twenty-seven patients underwent IFBR.

IFBR increased in recent years (Fig.1). 74% of these procedures were performed from 2016 to 2019.

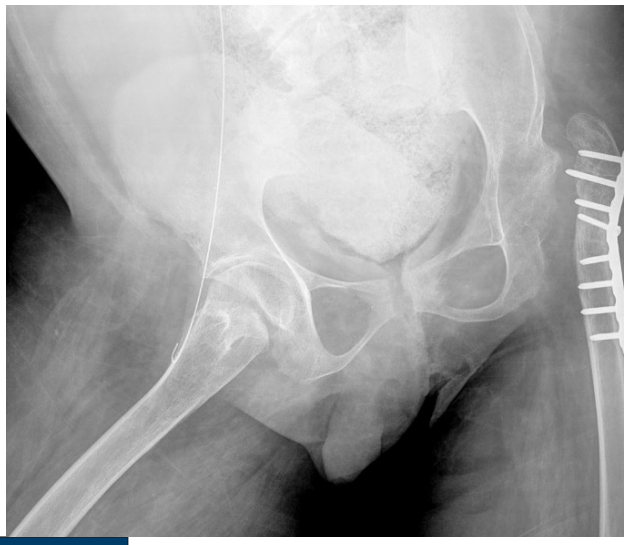

Figure 2 *Migrated central venous cateter guidewire on the inferior vena cava with one end on the right femoral vein.*

Figure 3 *Misplaced coils on the left internal jugular vein (arrow).*

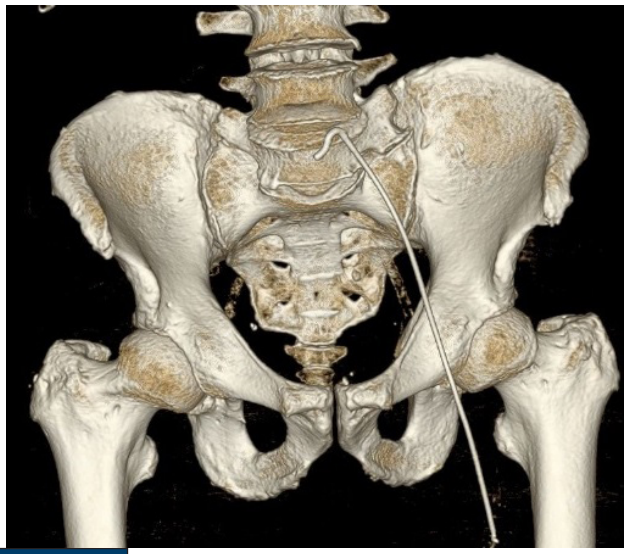

Figure 4 *Migrated diagnostic catheter on the left iliac vein.*

Median time from intravascular device loss and retrieval was less than one day: 55% of the devices were retrieved on the same day they were lost. In three patients, the IFB had been lost more than two weeks before.

The IFB retrieved was a guidewire or guidewire fragment in 30% (N=8, Fig.2), a sheath or sheath fragment in 44% (N=12). The remaining were endovascular-specific devices themselves or fragments of their delivery systems (Table 1).

59% of IFBs were lost during their deployment (N=16, Fig.3); 41% during their removal attempts (N=11).

44% were lost in the arterial system (N=12), 52% in the venous system (N=14, Fig.4), and 4% in the heart (N=1). The vessels where the devices were lodged are depicted in Table 2.

An endovascular procedure was selected as the first option in IFBR in 56% of patients (N=15) and an open procedure in 44% (N=12). There was a statistically significant association between the target vessel and the first treatment option taken ($p<0.001$). In the presence of IFB on the thoracic or abdominal cavity, it was always tried a first-endo approach; if IFB was present on the neck or limbs, 75% were retrieved by open surgery.

Success rates were 100% for open and 87% for endovascular procedures. We used a snare on 67% of endovascular IFBR (Fig.5). In two patients, thoracic IFB was endovascularly displaced to a reachable location for open retrieval. These were considered successful endovascular IFBR.

There were two unsuccessful endovascular IFBR: one CVC guidewire on the internal jugular vein was not able to

Table 1 **Intravascular foreign body**

	n(%)
Guidewire or guidewire tip	**8 (30)**
Central venous cateter guidewire	7 (26)
Endovascular guidewire tip	1 (4)
Sheath or sheath fragment	**12 (44)**
Chemotherapy port catheter	5 (19
Central venous cateter sheath	4 (15)
Introducer arterial sheath	1 (4)
Arterial pressure monitoring sheath	1 (4)
Hemodialysis catheter	1 (4)
Others	**7 (26)**
Pigtail	1 (4)
Balloon	1 (4)
Stent	1 (4)
Coil	1 (4)
Occluder	1 (4)
Penumbra aspiration device tip	1 (4)
Stent delivery system tip	1 (4)

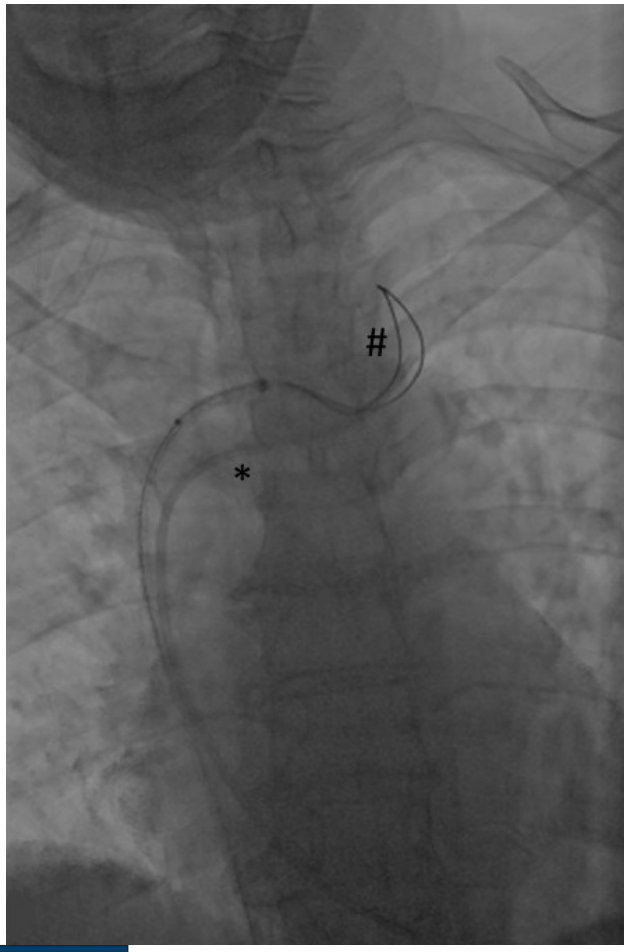

Figure 5 *Superior vena cava central venous cateter fragment (*) retrieval using a snare (≠).*

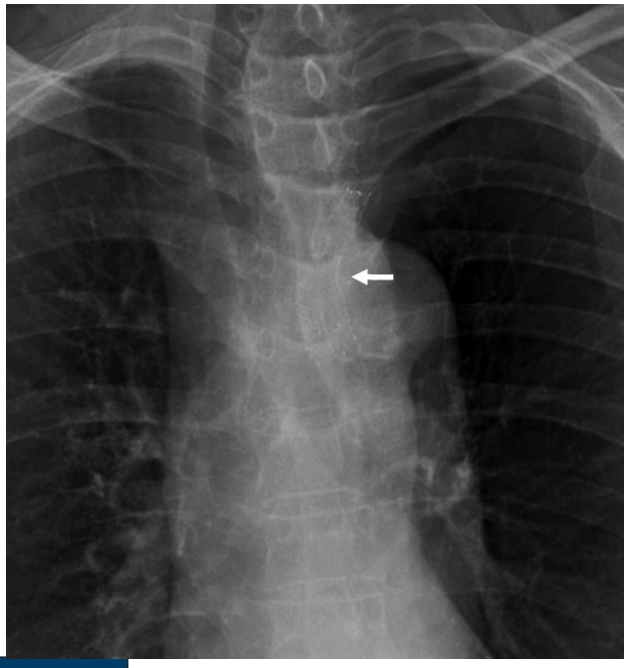

Figure 6 *Misplaced bare metal stent on the left subclavian artery origin (arrow).*

be snared and was retrieved by open vein exposure; one misplaced bare-metal stent on the left subclavian artery crossing the aortic arch was fragmented during endovascular IFBR and left collapsed against the aortic wall (Fig.6).

IFB caused five acute complications. A migrated CVC guidewire caused an IJV thrombosis. Two strokes were caused by a carotid artery CVC sheath and a chemotherapy port catheter. Fragments of an introducer arterial sheath and a hemodialysis catheter on a femoral artery provoked two acute episodes of lower limb ischemia. A CVC guidewire migrated to a brachial artery a month before caused acute upper limb ischemia that led to upper limb major amputation (Fig.7).

There were no IFBR-related complications.

The median time of inward vascular surveillance was less than 24hours. Most patients were discharged to the precedent ward immediately after the procedure. The patient that underwent upper limb major amputation had the most prolonged vascular ward hospitalization (43 days).

At 1-month, the survival rate was 100%.

DISCUSSION

The decision to retrieve a foreign body must be made on a case-by-case basis, considering the patient's overall life expectancy, the hazards involved with retrieval, the current symptoms, and the likelihood of serious complications or further migration.

Only 5.6% of intravascular foreign bodies produce symptoms.[4] However, foreign bodies left unattended in the vascular system have been associated with a 71% major complication rate and 24% to 60% mortality rate. Those located within the cardio-pulmonary system pose the most significant risk.[1,7] Infectious complications are high in broken catheter fragments; it arises from bacterial contamination. Misplaced coils cause local thrombogenicity, ischemia, and perforation. Guidewires and endovascular stents can lead to perforation, vascular wall injury, and thrombosis. Endovascular stents are prone to perforation.[3] This suggests that IFBs' removal must be done as soon as possible.[5]

However, leaving some types of foreign bodies in place is reasonable, particularly if firmly adherent to the vessel wall and in asymptomatic patients with a limited life expectancy. The exception is a device displaced to the heart due to the risk of arrhythmias or occlusion of the pulmonary outflow.[6,8]

The first crucial step in successfully retrieving a lost IFB is to obtain an accurate history, including the object's size, shape, and current location.[2]

Conventional X-ray is the first-line imaging technique, but it gives only a projective localization of the IFB (not its exact location); moreover, it can be used only for radiopaque materials. Catheter fragments are generally poorly visible fluoroscopically. Some authors consider mandatory an accurate preoperative planning with CT scan imaging.[5] We only require a preoperative CT scan if the clinical

Table 2 **Vessel where the foreign body was lodged**

	n(%)
Superior vena cava	7
Femoral artery	5
Inferior vena cava	2
Internal jugular vein	2
Subclavian artery	2
Aorta	1
Femoral vein	1
Umeral artery	1
Popliteal artery	1
Subclavian vein	1
Great saphenous vein	1
Carotid artery	1
Below-the-knee artery	1
Heart	1

scenario and conventional X-ray do not highly suggest the IFB location.

Another reason to remove a device as soon as possible is that intravascular objects become covered by endothelium surprisingly quickly. If it becomes incorporated with the vessel wall, it may not be possible to engage or remove it without causing significant endothelial damage.[9] Most of the IFB in this sample were retrieved on the same day they migrated.

Making general recommendations for foreign body retrieval based on the literature is difficult, as each incidence tends to be unique.

There are various retrieval devices available for endovascular IFBR: snares, Dormia baskets, biopsy forceps, tip-deflecting wires, pincher devices, oversized sheaths or balloon catheters.[1] However, like in our series, the large majority of endovascular IFBR uses a snare. In one series, only 8.7% of displaced devices were retrieved with a device other than a snare.[4] The only prerequisite for using loop snares is that the device should have a free edge to grasp. If not, it may be obtained using various dislodgement techniques using pigtail or double-curve catheter or angioplasty balloons.[1,2,4,7] When using a snare, it is also essential to predict how the object will bend when captured.9 The resulted kinked device should be loaded into an introducer with a lumen at least twice the original diameter of the IFB, particularly if arterial access.[5] Moreover, to decrease capture time, the loop snare size has to be equal to or slightly smaller than the vessel diameter and larger than the IFB diameter.[5]

Misplaced stents can either be retrieved or implanted in another vascular site. Frequently it is easier, safer, and quicker to identify a suitable vascular bed within which the lost stent can be safely and permanently parked.[2,8] Stent retrieval attempts could lead to vascular trauma.[3] If complete removal is the goal, maintaining a guidewire through the lumen of a lost stent is critical. The snare is opened around the proximal-most end of the lost stent and is then cinched down, drawing the constrained end of the stent out through the sheath.[7]

For venous access, like other authors, we advocate the femoral vein due to ease of access, large-caliber, easier handling, and good postprocedure compression.[2] We also

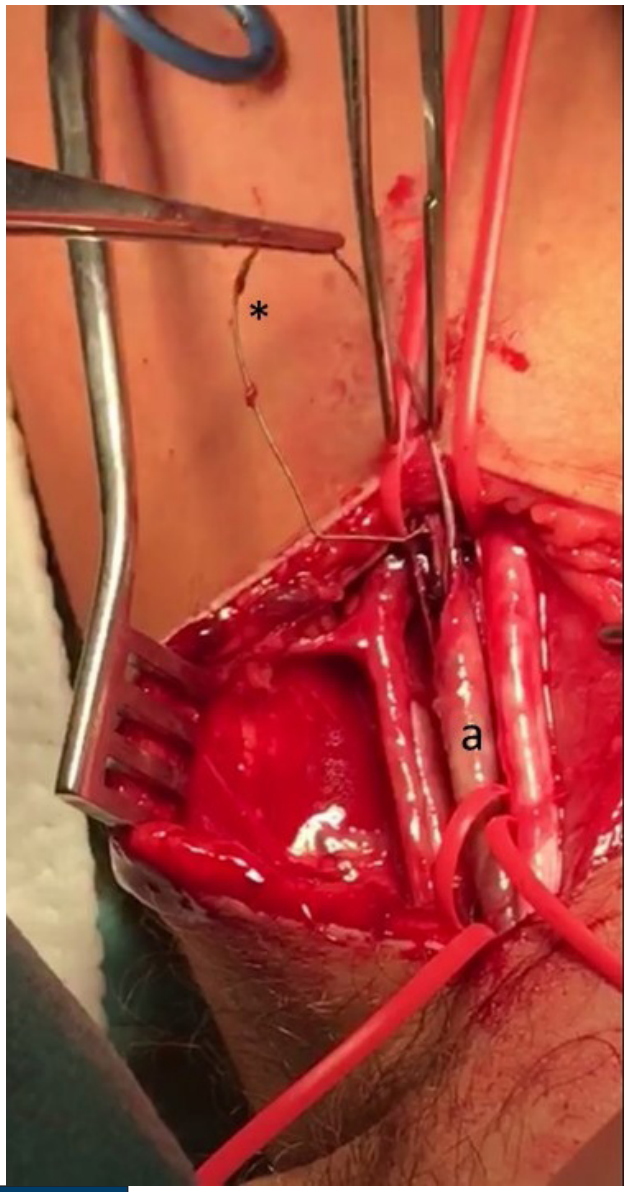

Figure 7 *Brachial artery (a) guidewire (*) open retrieval.*

prefer long and >7Fr sheaths to provide greater support and stability for the snare and engage the snare-bended IFB.[7]

An underappreciated and occasionally reported maneuver is the endovascular repositioning of an object to facilitate a less morbid open retrieval, performed in two patients of this sample. Most commonly, it is used to displace a larger device down to the femoral artery or vein, where it can be removed by a small cutdown.[4]

Nowadays, the endovascular approach is considered the first-line method for retrieving IFBs. It offers a high success rate with low associated morbidity. Skills in endovascular procedures and good knowledge of materials are mandatory to approach these challenging clinical situations. However, the endovascular approach may not always be appropriate or possible in retrieving IFBs in up to 6% of the cases. So open surgery retrieval will continue to be helpful in some instances.[5] In our department, IFB in accessible locations like limbs and neck continue to be frequently removed by open surgery.

In literature, the procedural success rate of IFBR described is above 90%.[1,3] The loop snare is frequently the first choice of device used to attempt the removal of an IFB. It is simple to use and effectively achieves a good success rate of IFB retrieval, even in inexperienced hands.[2,7] Like other series[6], a loop snare catheter was the preferred method of retrieval of IFB by the authors, especially when the IFB is early found and does not appear adherent to the vessel wall. When the object is adherent to a vessel wall or does not have an obvious free edge, basket snares are a practical 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. When foreign bodies are firmly adherent to the vessel wall, grasping forceps can be a helpful tool in extracting the object. The choice of device for retrieval is ultimately surgeon-dependent and restricted by off-the-shelf availability. In our department, the loop snare is the only off-the-shelf endovascular device for IFBR.

Although no complications related to the endovascular retrieval procedure were reported in our study, complications previously stated include artery spasm, thrombosis, and injury to the vessel at the puncture site or vessel perforation. Foreign bodies trapped within the heart pose the greatest risk for capture. Attempts at their removal may cause dysrhythmia or myocardial perforation and damage to chordae tendinae or tricuspid valve.[5,6]

Undoubtedly, primary prevention of IFB is ideal. Good training and knowledge of the devices being used are vital to avoid this complication. Good case planning with appropriate equipment in the range of the operator's experience and adequate staff training in the manipulation of percutaneous intravascular devices will avoid the majority of lost IFBs2.

Limitations

This is a retrospective study, and it relies on a proper registry. It is possible that some IFB were lost and were not retrieved due to uncomplicated locations, lack of referral or critical patient status; these devices were not identified. The IFBR is dependent on surgeon experience, particularly endovascular. This study did not include IFBR performed by non-vascular medical staff, including cardiologists or interventional radiologists.

CONCLUSION

Embolization of IFBs is a growing problem that can be minimized with proper device selection, deployment and removal.

When an intravascular foreign body is identified, careful planning and a working knowledge of the tools available will allow its removal in the safest and the most expedient manner.

In this study, open and endovascular retrieval had high success rates and minimal morbidity. However, its choice is surgeon-dependent and restrained by devices availability.

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