Strategies for prevention of iatrogenic inferior vena cava filter entrapment and dislodgement during central venous catheter placement

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Background: **Iatrogenic migration of inferior vena cava (IVC) filters is a potentially life-threatening complication that can arise during blind insertion of central venous catheters when the guide wire becomes entangled with the filter. In this study, we reviewed the occurrence of iatrogenic migration of IVC filters in the literature and assessed methods for preventing this complication.**

Methods: **A literature search was conducted to identify reports of filter/wire entrapment and subsequent IVC filter migration. Clinical outcomes and complications were identified.**

Results: **A total of 38 cases of filter/wire entrapment were identified. All of these cases involved J-tip guide wires. Filters included 23 Greenfield filters, 14 VenaTech filters, and one TrapEase filter. In 18 cases of filter/wire entrapment, there was migration of the filter to the heart and other central venous structures. Retrieval of the migrated filter was successful in only four of the 18 cases, and all of these cases were complicated by strut fracture and distant embolization of fragments. One patient required resuscitation during retrieval. Successful disengagement was possible in 20 cases without filter migration.**

Conclusions: **Iatrogenic migration of an IVC filter is an uncommon complication related to wire/filter entrapment. This complication can be prevented with knowledge of the patient's history, use of proper techniques when placing a central venous catheter, identification of wire entrapment at an early stage, and use of an appropriate technique to disengage an entrapped wire. (J Vasc Surg 2014;59:255-9.)**

Iatrogenic migration of an inferior vena cava (IVC) filter is an uncommon complication that can be caused by IVC filter/guide wire entrapment. This almost always occurs during central venous catheter (CVC) placement, a procedure often performed "blind," without image guidance. Forceful attempts to free a trapped wire without fluoroscopy can result in filter dislodgement and migration to the heart or other central venous structures.[1-4] Furthermore, filter deformation, strut fracture, fragment embolization, and caval injury have been reported.[1-4]

The complication of filter/wire entrapment was first reported by Loesberg et al[5] in 1993, and a handful of cases have been documented in the literature since. We recently encountered a case of a VenaTech IVC filter migration/displacement to the superior vena cava immediately after deployment; this occurrence was thought to be caused by an unrecognized filter/J-tip guide wire entrapment (Fig).

We conducted this study to review the occurrence of iatrogenic displacement of IVC in the literature and to assess methods for preventing this complication.

METHODS

This literature review did not require Institutional Review Board approval. An extensive Medline and PubMed search was conducted through November 2012 to identify reports of IVC filter/wire entrapment, iatrogenic filter migration, and additional complications (English language; key words: "filter entrapment," "guide wire," "J-tip," "entrapment complications," "IVC filter migration," and "wire entrapment filter"). For each case, the following parameters were identified: filter type, access site, wire type, clinical services involved, filter migration, filter damage, complications, and details of any interventions performed.

RESULTS

In our case, iatrogenic IVC filter displacement occurred immediately after filter placement during wire exchange for the placement of a CVC (Fig) using the same right internal jugular venous access. The filter was severely deformed within the superior vena cava and could not be retrieved.

A total of 38 cases of IVC filter/guide wire entrapment were identified in the literature (Table I). All were related to J-tip guide wires.[1-27] The Greenfield filter (Boston Scientific, Natick, Mass) was the most commonly affected IVC filter (n = 23), followed by the VenaTech filter (Braun, Bethlehem, Pa; n = 14) and the TrapEase filter

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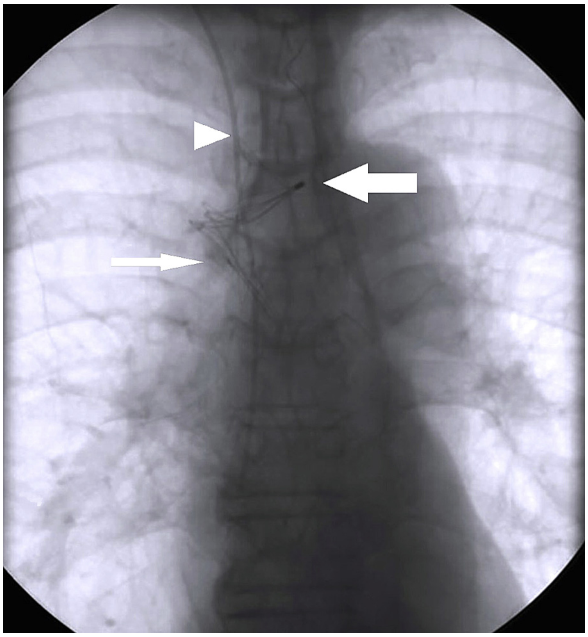

Fig. A filter migration occurred immediately after filter placement during wire exchange for the placement of a central venous catheter (CVC; *arrowhead*) using the same right internal jugular venous access. Severely deformed inferior vena cava (IVC) filter within the superior vena cava (*small arrow*), with the apex (*big arrow*) oriented toward the left brachiocephalic vein.

(Cordis, Bridgewater, NJ; n = 1). Access involved 15 right internal jugular, 21 subclavian (10 left and 11 right), and three femoral veins. One patient had both internal jugular and femoral access. Clinical services involved included surgery (n = 23), medicine and oncology (n = 8), anesthesiology and critical care medicine (n = 5), and radiology (n = 2).

Eighteen of the 38 cases (47%) resulted in iatrogenic filter displacement (Table II). Filter migration sites included the superior vena cava (n = 4), brachiocephalic venous branches (n = 6), right atrium (n = 4), right jugular vein (n = 1), and iliac venous confluence (n = 1); in two cases, the filter was partially dislodged. Among these 18 cases, 11 were conservatively managed, including two cases of filter migration to the right atrium (care was withdrawn from one patient; the other was not a candidate for thoracotomy because of comorbidities, and percutaneous retrieval was deemed too risky because of severe filter deformation).[2,3]

Retrieval of the dislodged filter was attempted in seven of 18 patients but was only successful in four. Among the three cases of failed filter retrieval, the wire was cut ex vivo in two cases (presumably with a length of wire left just under the jugular and femoral access sites, respectively) and was left in place in the remaining case. In these three cases, the wire remained firmly engaged in the venous system despite multiple attempts by the interventionist to disengage the wire from the filter.[5,7,10] Clinical outcome

Table I. Summary of 38 cases of entrapment from 1993 to 2012

Filter type	
Greenfield	23
VenaTech	14
TrapEase	1
Total	38
Access	
Right internal jugular vein	15
Right subclavian vein	11
Left subclavian vein	10
Femoral vein	3
Total	39[a]
Wire type	
J-tip wires	38
Services involved	
Surgery	23
Medicine/oncology	8
Anesthesiology/critical care medicine	5
Radiology	2
Total	38

[a]One case with both jugular and femoral access.

in these cases was as follows: one case was managed conservatively according to family wishes; the second patient died 21 days later from multi-organ failure; and the third patient remained asymptomatic but was found to have additional strut embolization from the brachiocephalic vein to the left lung at 1-year follow-up.[5] For the four cases in which retrieval was successful, all were complicated by strut fracture and fracture fragment embolization to the left lung and brachiocephalic vein.[1,4,10,23] Furthermore, one patient suffered significant blood loss and hemodynamic instability during the procedure, requiring resuscitation and transfusion.[23]

Overall, filter deformity was identified in 12 cases, with strut fractures in 10 cases (four caused by retrieval of the migrated filter). Distant embolization of fractured fragments was reported in nine cases, including embolization to the left lung, hepatic vein, IVC, and brachiocephalic vein. Caval injury from vigorous pulling of the entrapped wire was reported in one case as a visible intimal flap under fluoroscopy.[8]

Of the 38 cases of IVC filter/wire entrapment, operators suspected entrapment in 20 cases and referred the patients to image-guided retrieval, resulting in no displacement of the IVC filter. All 20 entrapped wires were successfully disentangled; 19 were released with endovascular techniques, and one was released through surgical extraction.[6,7,10-15,17-24,26,27] In four cases of successful in situ disengagement, initial forceful pulling of the entrapped wire resulted in unraveling of the wire's outer core, but the wire was subsequently removed under imaging guidance with no evidence of retained wire fragments.[7,18,19,26]

DISCUSSION

Iatrogenic migration of an IVC filter is a serious complication that can arise from the forceful pulling of an entrapped J-tip guide wire, often when the operator is

Table II. Complications and outcomes

Wire entrapment	
Without filter dislodgement	20
With iatrogenic filter dislodgement	18
Total	38
Iatrogenic filter dislodgement	
Superior vena cava	4
Brachiocephalic venous branches	6
Right atrium	4
Right jugular vein	1
Iliac venous confluence	1
Partially dislodged/tilt	2
Total	18
Management	
Entrapment without filter dislodgement	20
Wire disengaged endovascularly	19
Surgical extraction	1
Iatrogenic filter dislodgement	18
Conservative management	11
Retrieval attempted, failed	3
Retrieval attempted, successful	4
Total	38
Filter outcomes	
Filter deformation	12
With strut fracture	10
Distal embolization of struts	9
Strut embolization sites	
Left pulmonary artery/branches/lung	5
IVC	2
Brachiocephalic venous branches	1
Hepatic vein	1
Total	9

IVC, Inferior vena cava.

unaware of the patient's history of IVC filter placement. In most of the reported cases in this study (31/38; 82%), the operators were able to recall significant resistance when attempting to free the entangled wire. This complication occurs most frequently during insertion of a CVC, a common procedure performed by many different clinical services. The guide wire included in current CVC kits usually contains a J-tip on one end and a straight tip on the other.[28] The flexible J-tip is often preferred and thought to reduce the risk of vessel wall perforation during access. However, the J-tip guide wire is likely the cause of entrapment, which can result in filter migration to the heart and other vessels as well as laceration of the cava. Furthermore, filters can become deformed and fractured in the process of disengaging an entrapped wire or even during imaging-guided retrieval of a migrated filter.[3]

It can be extremely difficult to retrieve a severely deformed filter without risking vascular injury and strut fracture and migration to the heart and lung. Once a filter is dislodged, retrieval becomes more complicated and often requires thoughtful planning. Consideration for retrieving dislodged filters should involve risk and benefit analysis of the procedure, experience of the operator, the patient's clinical status, and willingness of the patient and family to proceed. For instance, when a dislodged filter is not deformed and is conical in shape (eg, the Greenfield filter and optional filters), retrieval is possible by passing a wire beyond the filter, snaring the wire, and pulling back to a sheath.[29] In the cases of central filter displacement in this study, most operators decided to leave the dislodged filter in situ because the risks of retrieval outweighed the benefits. However, retrieval was attempted in seven of the 18 cases because of concerns about cardiac arrhythmias or thromboembolic risk; only four of these filters were successfully retrieved, and each of these cases was complicated by filter fractures, distant strut embolization, and vascular perforation.[1,4,10,23] One patient had cardiac arrest and required resuscitation and transfusion. In our case, we decided to leave the displaced filter in situ. However, the long-term safety of leaving a deformed filter in the circulation is unknown.

With the high prevalence of IVC filter and CVC use in an aging population, wire entrapment could occur during any planned or emergent CVC placement or catheter exchange, all of which take place routinely without image guidance.[30-32] However, case reports and studies on the topic have been scarce since 2006. The occurrence of this complication is likely underreported or underpublished in the literature because of possible bias.

Prevention of this complication can be achieved at many levels. First, before insertion of any CVC, the patient's medical history, including information about any previously implanted filters, should be obtained. In the report by Loesberg et al,[5] one patient had a guide wire entangled in the filter on two separate occasions across a span of 2 weeks. This could have been prevented if the operators had been aware of the patient's history and taken due precautions. In this age of electronic medical records, automatic alerts could be triggered to remind practitioners of patients' device history and to advise caution when additional procedures are performed. At our institution, IVC filter is added in the patient's past surgical history in the electronic medical record at the time of placement.

Second, choices about the length and type of wire are important in the prevention of wire entrapment. In a study evaluating 30 commercially available tunneled and nontunneled CVC kits, including seven nontunneled CVC kits made for bedside placement, 18 kits had a guide wire far longer than needed for optimal placement.[28] Normally, the distance to the junction of the right atrium and IVC averages approximately 15 to 20 cm from the medial aspect of clavicle. We suggest that the guide wire should not be advanced more than 25 cm from the right jugular approach or more than 30 cm from the right subclavian approach. Similarly, the distance from the left jugular and the left subclavian approaches should be just a few centimeters more to cross the midline. This will prevent the wire from passing through the right atrium into the IVC and possibly engaging the filter. From a femoral approach, we suggest that the guide wire should not be advanced more than 25 cm, inferior to the L2 level. The 15- and 20-cm guide wires provided in CVC kits are the optimal length for placement. In the previously mentioned study evaluating 30 CVC kits, distance markings of any type on the guide wire were present in only 33% of the kits (10 out of 30).[28] We strongly recommend that guide wires with length markings should be an industry standard for CVC kits, and we advocate the use of guide wires with markings to allow the operator to more accurately assess the length of the wire in vivo during bedside CVC placement. Additionally, in an in vitro study, Kaufman et al[16] found that J-tip guide wires with a diameter of 3 mm or less are prone to entrapment with 12-F stainless steel Greenfield and VenaTech filters. Guide wires in current CVC kits come with two ends: a J-tip on one end and a straight tip on the other. Given that only the J-tip guide wire has been found to become entangled with IVC filters, we strongly encourage operators to consider using the soft straight tip guide wire in patients with an implanted IVC filter or to consider placing the CVC under fluoroscopic guidance.

Third, as a rule of any endovascular procedure, the wire or catheter should never be advanced or pulled against resistance. In the cases we assessed in this study, all iatrogenic filter migrations occurred after vigorous tugging of the wire against obvious resistance. It is recommended that if resistance is encountered in the withdrawal of the guide wire during CVC placement, fluoroscopy should be performed before the operator proceeds.

Finally, the disengagement procedures assessed in this study had a high success rate (19/20; 95%) when image-guided techniques were employed. However, selecting the appropriate disengagement technique depends on anatomy, such as the orientation and location of the entrapment, and the clinical judgment and comfort level of the operator. Many wire disengagement techniques and variations have been described in the literature, such as the monorail technique and "rail and reins" technique.[17,20] For an initial attempt at disengagement, we recommend straightening the J-tip wire by pinching and stretching the wire and advancing it to disengage from the filter. (As the J-tip guide wire tip consists of a flexible central wire wrapped with a smaller coiled wire, the J-tip is straightened by stretching the outer wire.) In general, the easiest technique should be attempted first, such as gently advancing the wire, spinning the wire in situ,[21,24] or advancing a catheter or sheath over the wire to straighten the J-tip.[7,11,19] If there is inadequate length of protruding segment to safely load catheters, the monorail technique and snare/forceps technique can be considered. In the monorail technique, a straight catheter is first modified by cutting a new side hole 1 cm proximal to the end hole and then placing the catheter onto the J-wire so that the wire is passed into the end hole and out of the modified side hole in a monorail fashion. The stiff end of another wire is then advanced through the catheter up to the modified hole to provide additional support to the catheter. The combination of catheter and wire is advanced to the level of the filter up to the entrapped J-tip of the guide wire, where short and rapid thrusts are applied to provide caudally directed force to free the wire.[20] Instead of using the stiff end of a wire to provide support to the modified catheter, operators can use a smaller caliber catheter, advancing this catheter/catheter combination to the level of the IVC at the entrapped J-tip.[6] The snare/forceps technique requires an additional femoral access. In this method, biopsy forceps, alligator forceps, or a snare is advanced through the femoral sheath to grasp the entrapped J-tip directly from below to disengage the wire.[4,7,12,13,23,33] The rail and reins technique requires additional bifemoral access and is technically more challenging.[17]

In summary, iatrogenic filter migration is a serious complication related to filter/wire entrapment. Retrieval of a migrated filter is often unsuccessful and may cause fragmentation, embolization, and significant morbidity to the patient. Awareness of this potential complication is the key to prevention. Knowing the patient's history, using proper technique to insert a CVC, and promptly identifying wire entrapment can reduce the risk of filter disruption and migration.

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