A Modified Loop Snare Technique for Difficult Retrievals of Inferior Vena Cava Filter and Migrated Coil

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Summary

The aim of this study was to evaluate the safety and efficacy of a modified loop snare technique for retrieval of difficult inferior vena cava (IVC) filters and migrated coils.

A retrospective review of Günther Tulip filter retrievals between January 2014 and February 2017 was performed. A total of 316 IVC filter retrievals were attempted. In 25 cases, the standard technique had failed and our modified loop snare technique was subsequently attempted in 21 of these patients.

The retrievals were successful in 20 cases (mean dwell time, 42.6 days, range, 14-102 days). The dwell time of the one failure was 46 days. The retrieval rate increased from 92.1% with the standard technique to 98.4% with the combination of the standard and modified loop snare technique. Unsuccessful retrieval was due to migration and endothelialization of the filter. This technique can also be used to remove migrated coils which cannot be captured by standard techniques. There were no complications from the retrievals.

Tilt and endothelialization of filters are the main factors resulting in unsuccessful retrievals with the standard technique. In the present study, we describe an alternative technique for difficult IVC filter retrievals, which can also be used to capture migrated coils and occluders in the aorta and heart.

Key words: Migration, Endothelialization, Complications

Inferior vena cava (IVC) filters are implanted to prevent pulmonary embolisms (PE) in patients with contraindications to anticoagulation or patients which cannot be adequately controlled by anticoagulation.1) Retrievable IVC filters can be left in place as permanent devices or if they are no longer needed by the patients, they can potentially be removed. The potential ability to remove the filters has resulted in increasing placement of IVC filters. However, many retrievable filters cannot be removed with standard techniques. The long dwell time of filters may be associated with severe complications, such as IVC thrombosis, deep venous thrombosis (DVT) recurrence, filter migration and filter fracture.2,3) Successfull retrieval can be disturbed by the incorporation of the struts of the filter or a tilt of the filter, which precludes capture of the hook of the filter with standard retrieval techniques. There are a wide variety of techniques which have been used to remove filters that could not be retrieved by conventional methods.4-8) Among them, one of the most efficient and simplest ways is the loop snare technique. We further modified this method to make it easier to retrieve the filters. This modified method can also be used to capture the migrated coils and occluders in aorta and heart. The present study is a retrospective review of our modified loop snare technique to deal with difficult Günther Tulip filter retrievals.

Methods

Patients: Institutional review board approval was obtained from our hospital for this study. A retrospective review of all patients who underwent a retrieval of a Günther Tulip filter (GTF) (William Cook Europe, Bjaeverskov, Denmark) between January 2014 and February 2017 was performed. During this period, 316 patients had undergone filter retrievals. Among these patients, 304 patients had DVT of a lower extremity, 17 of which were accompanied by inferior vena cava thrombosis. Another 12 patients had renal and inferior vena cava thrombosis or tumor thrombus. The information was documented by duplex sonography and computed tomographic angiography (CTA).

Pre-retrieval preparation: GTFs were implanted using a femoral venous or right jugular access, and retrievals were planned for all patients. Prior to filter retrieval, a CTA for inferior vena cava was performed in all cases to identify possible IVC thrombus entrapment and filter tilt. The examinations were performed no more than 1 week before the retrieval procedure. IVC venography was further performed to detect filter-related thrombi before retrieval. If the filters were free from the clots, or if the clot burdens

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Filter retrieval techniques: All of the filter removals were performed under local anesthesia by two experienced vascular surgeons and filter retrievals started with the right jugular vein. Conventional retrieval techniques were attempted first in all patients with a standard GTF Retrieval Set (Cook, Bjaeverskov, Denmark) which contains an 11-F outer sheath, an 8-F inter sheath, a gooseneck snare, a puncture needle, and a 0.038-inch, 150-cm guide wire.

The modified loop snare technique was performed when the hook could not be captured with a conventional method (Figure 1A). The same right internal jugular access was used. A 5-F Cobra catheter (William Cook, Bjaeverskov, Denmark) was formed below the IVC filter and then pulled back until it was hooked below the filter apex. A 150-cm, 0.035-inch guide wire (Terumo, Somerset, NJ, USA) was passed through this catheter, and a loop was formed around the filter tip. The guide wire was then advanced to the high IVC, where the leading end of the wire was passed through a snare (Figure 1B). The snare was placed through the sheath in the right internal jugular vein. The snare was then closed around the tip of the wire (Figure 1C). The ends of the wire and the snare were tensioned gently and simultaneously by hand, to allow the filter to be straightened and retrieved through the sheath (Figure 1D). The wire could pass through the filter struts or lie between the filter and IVC wall (Figure 1E), and the filter can be retrieved easily (Figure 1F).

After filter removal, venography was performed to evaluate contrast extravasation, intraluminal defects, and narrowing of the IVC. Patients were observed for 12-24 hours after the procedure. Patients with non-retrieved filters were followed with CTA and duplex sonography.

Results

A total of 291 filters (92.1%) were removed with standard techniques. In the 25 unsuccessful cases, 21 filters had tilted severely, leading to a tip-embedding into the IVC wall as assessed by angiographic imaging. Therefore, the hook could not be captured with a gooseneck snare. The retrievals of the 21 tilted filters were subsequently attempted with our modified loop snare technique. This group consisted of 13 men and 8 women and their average age was 41.5 years old (range, 26-73 years old). The mean dwell time of the filters was 42 days (range, 14-102 days). The detailed basic information for these 21 patients is summarized in Table I. This modified technique was successful in 20 cases and the retrieval rate was 95.2% (20/21). The tissue encapsulating the hook was dissected away by the guide wire, and then all of the 21 filters were pulled into the sheath easily. The one failed case was due to tight adhesion between the filter strut and the IVC wall.

After anticoagulation with low molecular weight heparin, thrombus still formed in the IVC and bilateral iliac-femoral vein in a pregnant patient, along with a DVT in the left lower extremity. A GTF filter was then placed in her infrarenal IVC by a right internal jugular vein approach. She appeared transiently uncomfortable and nervous and had chest tightness after 2 hours of induced labor (15 days after the filter placement). A CTA showed an extensive IVC thrombosis (Figure 2A-C) and mild pulmonary embolism. In consideration of contraindications to thrombolysis, anticoagulation therapy performed in this patient consisted of 20 mg qd of rivaroxaban. Fortunately, the IVC thrombus disappeared 1 month later, although the hook was attached against the posterior wall of the IVC (Figure 2D), which hampered the capture of the hook with a standard technique, and the filter strut migrated out of the IVC more than 7 mm (Figure 2E and Figure 3A). This lead to a tight adhesion between the filter strut and
the IVC wall, which may result in the snare becoming unable to separate the filter from the IVC with tugging. The modified loop snare technique was subsequently performed. Interestingly, the neck of the filter was captured by the wire loop, and the filter was pulled into the retrieval sheath (Figure 3B). But the filter was too closely adherent to the IVC wall, and the power of the snare to catch the guide wire was insufficient to separate the filter from the IVC wall (Figure 3C). Furthermore, the snare and the wire were separated in the sheath (Figure 3D). However, the hook could be easily captured by the snare in the 11-F sheath (Figure 3E). The filter could not be removed when the filter hook was straightened (Figure 3F). No further retrieval attempts were made after 50 minutes for safety considerations. The filter was left in place as a permanent device. No complications occurred during this failed attempt. Postoperative angiography showed moderate stenosis of the IVC (Figure 3G). No extravasation of contrast medium was observed.

The technique we described can also be used to retrieve migrated coils and occluders in aorta and heart. An 82-year old patient presented with hoarseness 13 months after endovascular repair of a thoracic aortic aneurysm. The hoarseness was caused by a compression of the recurrent laryngeal nerve by the aneurysm due to a type I endoleak. We attempted to use an Interlock-35 detachable coil (Boston Scientific Corporation, MA, USA) to repair the endoleak with an endovascular technique. The endoleak was resolved successfully, but the coil had migrated into the thoracic aorta during embolization. The coil could not be captured with the standard technique by using a gooseneck snare (Figure 4A). According to the loop snare technique, a guide wire was passed through the coil, and the free end of the wire was ensnared with the gooseneck snare to form a loop (Figure 4B). The coil could then be easily pulled into the sheath (Figure 4C).

For filter retrieval procedures, the mean fluoroscopy time was 12.4 minutes (range, 2.5-38 minutes). Fluoroscopy time was up to 30 minutes for the first patient. Recently the time was reduced to no more than 5 minutes due to increases in proficiency and skill. There were no procedural complications. Following IVC filter removal, IVC venograms were performed in all patients to evaluate the damage to the IVC. There were no contrast extravasations and severe IVC stenosis was identified in all cases. Patients were followed-up 3 to 6 months after filter retrieval in our institution. Also, long-term follow-up is needed for patients whose filters are not removed. All patients remained asymptomatic during follow-up in an outpatient setting. A CTA was performed 6 months later for a patient whose filter was not retrieved by this technique. The results showed that the IVC stenosis was improved significantly compared with that performed by venography during a retrieval attempt (Figure 5). All patients in this study received anticoagulants for at least 3 months, and long-term anticoagulation with warfarin was recommended for patients with unretrieved filters.

Discussion

GTF was one of the first retrievable filters, and its use was started in Europe in 1992, in the United States in 2001, and in China in 2007. Its advantages include experience of placement, low filter-related thrombosis, retrievability, and high filtration efficiency. Since retrievable filters were introduced into China, the number of filter placements has increased rapidly. At present, Chinese physicians perform the most filter implantations in the world. However, many retrievable filters are not actually removed. Previous studies reported that successful filter re-
Figure 3. Venography showed A: the strut of the filter had migrated out of the IVC wall. B: The neck of the filter was captured by the wire loop, and the filter was pulled into the retrieval sheath. C: Significant tension on the snare could not separate the filter from IVC. D: The snare and the wire were separated in the sheath. E: The hook could be easily captured by the snare in the 11-F sheath. F: The filter hook was straightened. G: Postoperative angiography showed moderate stenosis of the IVC.

retrieval was associated with the interval time of placement and endothelialization of struts. The retrieval rate varies for different types of IVC filters. The longer the dwell time, the lower the success rate for retrieval. For GTF, Hoppe, et al. reported a 100% successful retrieval rate in 23 patients at a mean dwell time of 11 days. Rosenthal, et al. reported a 94% successful retrieval rate at a mean dwell time of 51 days. The retrieval rate was decreased to 76% at a mean dwell time of 261 days. The initial window of GTF between implantation and retrieval is 14 days, which was first approved by the FDA in 2003. The manufacturer states the present retrieval interval is 3 months. Our removal rate is as high as 98.4%, which is mainly because most of our filter retrievals did not exceed the retrieval window. However, more and more publications have reported that large numbers of prolonged dwell time filters have been removed successfully. The longest time was 3006 days, as reported by Lynch.

Early on after introduction filter retrieval was abandoned in our institution because it was difficult to capture the tilted hook with the snare. In order to prevent severe complications caused by a permanent filter, we developed this method to retrieve a tilted filter in a young man. Next, we searched the literature and found that it is similar to loop snares and other advanced techniques. Compared with previously reported techniques, our technique has more advantages. Firstly, the loop snare technique reported by Lisa, et al. used a 16-F sheath to remove the filter tip. They reported that a smaller sheath was difficult to advance over the tip or hook of a tilted
filter. However, all of the 21 tilted filters in our study could be easily pulled into the 11-F sheath. The 11-F retrieval sheath is the smallest sheath used in these techniques, which can reduce complications of venous access. Secondly, they reported a 260 cm guide wire was used to pass through the filter struts, and both ends of the wire were outside the sheath, which made this operation difficult to complete with one surgeon. On the contrary, we used a 150 cm guide wire to pass through the filter strut. The end of the wire and snare were pulled simultaneously by one hand, and the sheath was advanced by the other hand. Thus, the operation can be performed by one surgeon. Lastly, compared with traditional techniques, only one additional cobra catheter was used, resulting in only a slight increase in cost.

Tilting during placement, especially via a left femoral approach, is the main disadvantage of GTF filters, which also increased the difficulty for retrieval. The new generation of GTF, the Celect Filter, has an additional 8 thin secondary struts to improve stability. However, filter tilt still frequently occurs in clinical practice.\textsuperscript{17,18} Many techniques have been reported to prevent tilting during filter placement.\textsuperscript{19,20} However, we found that even if the tip hook was located in the center of the IVC, the filter could also tilt and migrate with a longer dwell time (Figure 6). Regardless of tilt angle, the modified loop snare technique can easily capture the tip or hook of the tilted filters. There are also some other advanced techniques that have been described to deal with this problem. These include a balloon-displacement technique,\textsuperscript{21,22} rigid endobronchial forceps,\textsuperscript{7} and the excimer laser sheath technique.\textsuperscript{6} However, the rigid endobronchial forceps may induce filter fracture, and the excimer laser sheath is unavailable in most institutions.

In our experience, once the filter strut has migrated more than 5 mm outside the lumen of the IVC, successful retrieval becomes extremely difficult. There is still controversy over the use of long-term anticoagulation in patients with filters. IVC reduced the risk of pulmonary embolism but increased the recurrence of DVT. After filter implantation, the recurrence rate of DVT was 8.5\% at 1 year, 20.8\% at 2 years, and 35.7\% at 8 years.\textsuperscript{23,24} Anticoagulation following filter placement was responsible for about a 50\% reduction in the incidence of IVC filter thrombosis.\textsuperscript{25}
Therefore, it is our recommendation that all patients with permanent filters undergo long-term anticoagulation with rivaroxaban or warfarin in order to decrease the recurrence of DVT.

Coil migration during endovascular procedures is a common complication, which has been reported to occur in 2%-6% of cases,\textsuperscript{26-29} and the consequences can be catastrophic.\textsuperscript{20} A 20 × 30 cm coil migrated to the descending aorta during type 1 endoleak treatment. The coil moved up and down with the arterial pulse in the aorta so it could not be captured with a 20 mm gooseneck snare (EV3, Cvidien, Plymouth, MA, USA). Due to the advantages of this modified loop snare technique, the migrated coil could be easily removed. To the best of our knowledge, this is the first case reported in China to use a loop snare technique to remove a migrated coil. Furthermore, the authors have witnessed the capture of a migrated occluder in IVC with this loop snare technique in our hospital.

There are several limitations to the present study. We described this method only in cases with GTFs, and we cannot compare the retrieval rate using our method with that using other advanced techniques as this was a retrospective study.

Conclusion

Filter tilt and endothelialization are the main factors resulting in retrieval failures with standard techniques. Even if the tip hook of the filter is located in the center of the IVC during placement, the filter could also tilt and migrate during a long dwell time, which leads to the hook being displaced against the IVC wall. The technique we have described here increases the retrieval rate of the GTFs, and it is a simple, convenient, and safe method, which can be also used to capture the migrated coils and occluders in an aorta and heart.

Disclosures

Conflicts of interest: None.

References

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Figure 6. CTA for IVC was routinely performed before filter retrieval. A: The tip hook was located in the center of the IVC (dwell time: 41 days). B: The filter tilted with a longer dwell time and the hook of the filter was displaced against the anterior wall of the IVC (dwell time: 72 days).