

How I do it: robotic approach to the vena cava removal of the IVC filter strut extruding through the cava to the right ureter

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The gold standard of managing the retrieval of inferior vena cava (IVC) filters has been an endovascular approach with snare techniques. At times, complete removal cannot be performed, and an open surgical approach has been undertaken. Robotic technology allows for an alternative approach to a retained IVC filter retrieval. There are only a few documented cases of

this approach in the literature to date, and we present a novel approach utilizing the lower abdominal retroperitoneal approach. We describe the approach, as well as provide some suggestions, which may facilitate both the higher and lower approaches to the IVC utilizing the robotic technique. The purpose is to share our experience in managing the vena cava to support urologists handling pathology related to the venous system, utilizing minimally invasive techniques.

Key Words: inferior vena cava filter, robotic surgery, inferior vena cava robotic surgery

Introduction

Recent data indicate that approximately 40,000 inferior vena cava (IVC) filters are placed annually in the US.¹ It has been estimated that over 30% of the IVC filters placed are not removed in a timely manner.² This leads to a high incidence of IVC occlusion and risk of filter erosion, which can lead to chronic pain or injury of surrounding structures. A systematic review of the literature found that caval penetration was noted in 19% of patients with retained IVC filters, with organ involvement in nearly 20% of those cases.³ Patients with symptomatic filter remnants require removal of the retained or remnant IVC filter. The gold standard of managing the retrieval of IVC filters has been an endovascular approach with snare techniques.

Erosion through the vena cava and/or filter fracture makes endovascular approaches challenging,

and full retrieval may be impossible, as evident in this case report. The other option with a retained IVC filter, which has fractured or penetrated an adjacent organ, is laparotomy and vena caval reconstruction, with associated morbidity. Robotic technology allows for an alternative approach to a retained IVC filter retrieval.

There are only a few documented cases of this approach in the literature to date, and we present a novel approach. The first documented cases of robotic IVC filter removal are from 2017 and 2019^{4,5} and describe the lateral approach to the vena cava with the patient in the flank position. Here, we discuss a case of a 29-year-old male with a retained IVC filter who failed an endovascular attempt at retrieval. The patient underwent a robotic IVC filter retrieval utilizing the lower abdominal retroperitoneal approach.

The approach to the vena cava is something commonly encountered by the urologic surgeon. Any surgery on the right kidney requires exposure of the vena cava, allowing the renal vein to be skeletonized. This is commonly done in the flank position, with a lateral approach. Alternatively, a midline incision

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or thoracoabdominal incision allows excellent exposure when open surgery is utilized. Less commonly used, but very effective, is the lower abdominal retroperitoneal approach. This technique has been utilized effectively for years by laparoscopic surgeons to approach the great vessels when doing laparoscopic or robotic retroperitoneal lymph node dissection. We demonstrate that this technique provides excellent exposure to the IVC and positions the urologic surgeon to collaborate with vascular surgery colleagues, providing minimally invasive options to treat relatively unusual problems.

Method and Technique

A 29-year-old otherwise healthy male was referred to St. Peter's Health Partners Urologic Oncology for possible removal of a retained IVC filter due to our extensive familiarity with robotic IVC surgery.

The patient survived a severe motor vehicle accident 10 years ago, where he sustained multiple injuries requiring admission to the critical care unit with prolonged intubation. At that time, he underwent prophylactic placement of an IVC filter. The patient has since fully recovered.

Over the last few years, the patient had been experiencing intermittent sharp, stabbing, burning right flank pain. He was seen by his primary care physician and found to have microscopic hematuria and thus referred to an outside urologist for further evaluation.

Urology workup was essentially negative, other than persistent microhematuria and a retained IVC filter. The CT findings included a penetrating strut visualized abutting the wall of the mid-right ureter, potentially contributing to the cause of hematuria as seen in [Figure 1A](#).

He was referred to vascular surgery for evaluation and ultimately underwent endovascular removal of the filter. A bilateral jugular vein approach was used to snare the filter. Two out of 3 struts were successfully removed. The third strut could not be removed and was seen on venogram protruding through the wall of the IVC into the retroperitoneum.

The patient was seen in follow-up by vascular surgery, reporting ongoing, persistent right flank pain. A repeat CT was performed, confirming the presence of the remaining strut fragment. No inflammatory changes or hematoma were seen. [Figure 1B](#) clearly demonstrates the remaining stent strut extruding from the IVC abutting the right ureter.

Collaboration between surgeons from vascular surgery and urologic oncology led to a planned

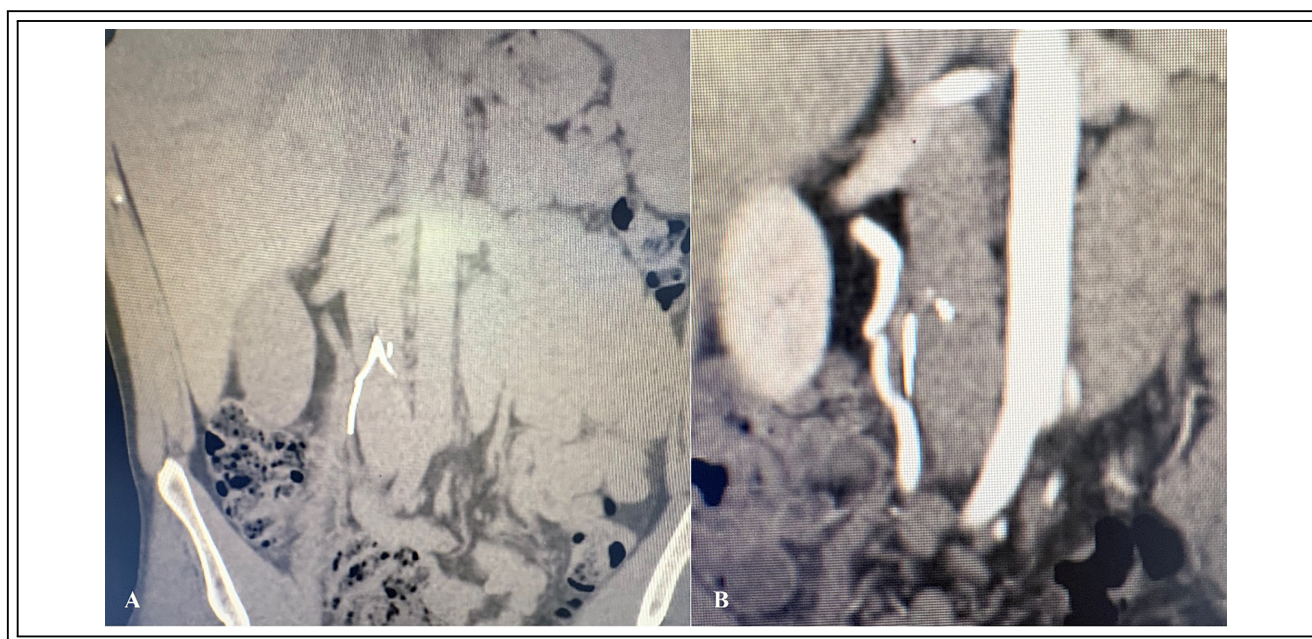


FIGURE 1. Preoperative imaging. (A). Noncontrast CT scan demonstrating the retained IVC filter struts in the vena cava. (B). CT abdomen and pelvis with IV contrast and delayed views. Note that the aorta has contrast, while the IVC has not yet filled. Images show a single IVC filter strut extruding through the vena cava and in contact with the right ureter, which fills on delayed imaging.

robotic-assisted approach for foreign body retrieval, similar to a retroperitoneal lymph node dissection. A statement of informed consent was obtained from the patient prior to surgery. A St. Peter's Hospital Ethics Consultation, the institutional standard for ethics approval, was obtained on 01 October 2023 for this minimally invasive approach, and no number was assigned as this was considered within the standard of care. The patient subsequently underwent a robotic-assisted removal of the IVC filter and reconstruction of the vena cava using the robotic lower abdominal retroperitoneal approach.

The patient was placed in a steep Trendelenburg position, and an incision was made in the posterior peritoneum medial to the cecum and appendix. Left and right common iliac veins were dissected up to the confluence of the vena cava. A significant inflammatory reaction was noted at the confluence of the vena cava. The vena cava was carefully dissected more superiorly up to the level of the right renal vein. The vena cava was then completely mobilized. Multiple small vessels feeding into the vena cava were controlled with bipolar cautery. Large lumbar vessels were controlled with silk ties. Just proximal to the bifurcation of the vena cava, a large metal tine was visualized protruding through the vena cava and into the psoas muscle. This was identified as the stent strut fragment abutting the right ureter. As the ureteral lumen was not compromised, no ureteral stent was placed.

Prior to pulling the metal tine out of the vena cava, the cava was completely controlled (see [Figure 2](#)). Similar techniques were utilized when removing an IVC tumor. The proximal vena cava was encircled

with a vessel loop below the renal veins and again distally below the filter, above the confluence of the common iliac veins. Bulldog clamps were introduced into the operative field. The inferior aspect of the vena cava was secured with the vessel loop and a bulldog clamp.

Initial attempts at vena cava control earlier in robotic practice utilized Rommel tourniquets, then the double loop vessel loop was cinched with a hemalok clip. Unfortunately, both of these techniques ultimately led to loosening of the occlusion device and bleeding from the caudal vena cava. Combining the vessel loop/hemalok with a single bulldog has become the reliable standard and can provide a bloodless field for meticulous dissection.

At this stage, the vena cava should be soft and nondistended prior to cavotomy. If there is blood engorgement, care is undertaken to identify and control any missed lumbar veins.

A combination of vessel loops and laparoscopic bulldogs was used for proximal and distal control of the vena cava. This completely excluded the portion of the vena cava with the retained IVC filter fragment. At this point, the metallic piece coming through the wall of the IVC filter was carefully mobilized and cut away from the IVC, as it was embedded in the psoas muscle. Surprisingly, there was minimal bleeding when the tine was pulled out from the caval wall.

Placement of a Prolene stitch above the cavotomy prior to incision of the vena cava was performed. A small cavotomy allowed for assurance of expedited control and repair if bleeding had been encountered from uncontrolled lumbar vein(s).

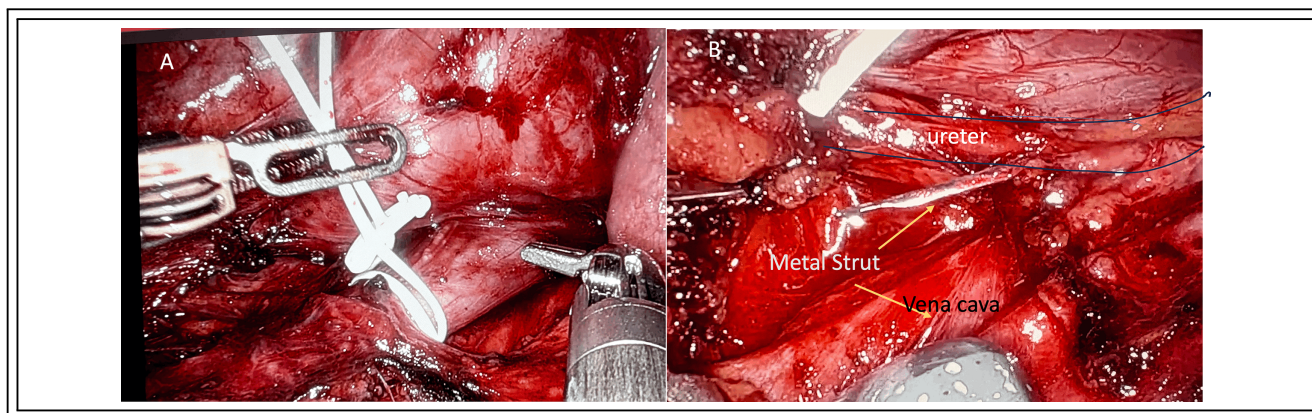


FIGURE 2. Intraoperative photos—initial dissection. (A). Complete control of the vena cava with a combined double looped vessel loop (white) and hemalok clip on the vessel loop acting as a tourniquet. (B). A clear view of the IVC filter strut is clearly outside the vena cava, with the right ureter highlighted. It was in contact with the psoas and ureter, but had not invaded the ureter

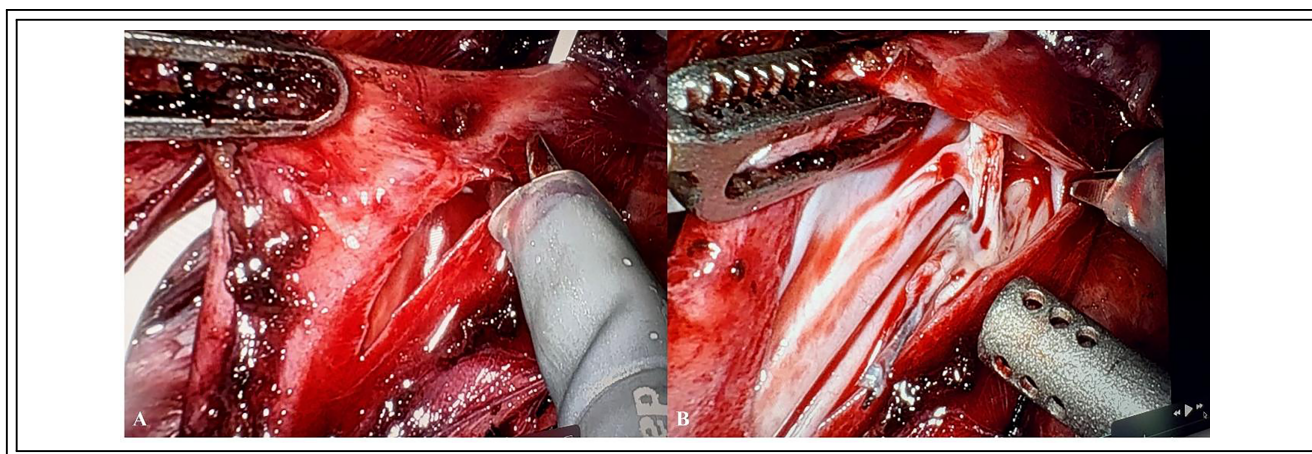


FIGURE 3. Intraoperative photos—opening the vena cava. (A). With the vena cava completely controlled after cinching the tourniquet and placing bulldogs, sharp dissection is used to open the vena cava. (B). Opening the vena cava shows the retained IVC struts completely epithelialized. This tissue was opened, the hardware removed, and the excess tissue excised from the caval lumen

Sharp dissection was used to make a 2 cm linear cavotomy, and blood was aspirated from within the vena cava. There was no further bleeding (see [Figure 3A](#)). Two additional metallic tines were visualized inside the vena cava. Some of these were completely endothelialized, as seen in [Figure 3B](#). Tissue was cut away from the metallic tines. Residual endothelialized tissue within the vena cava was excised, leaving a wide-open channel. All retained metal was removed from inside the vena cava. A total of 3 tine fragments were removed from the operative field.

At the conclusion of the procedure, all metal tines had been removed, and the lumen was repaired under direct vision with 3-0 Prolene suture without compromising the luminal diameter of the vena cava ([Figure 4A](#)). Prior to completing the closure, the inferior bulldog and vessel loops were released to flush out any possible CO₂ or debris (see [Figure 4B](#)). Total clamp time for the vena cava was 18 min. Once the lumen was filled, the closure was completed. There was minimal blood loss throughout the case (100cc total). The abdomen was desufflated, and no further bleeding was noted (see [Figure 4C](#)). The trocars were removed, and the patient was brought to the recovery room. Operative time was 150 min. The patient was started on Aspirin 81 mg daily for 30 days, and ultimately sent home after 12 h of observation.

In summary, [Table 1](#) lists our steps, which allow for safe exposure, control, and repair of the vena cava when using robotic assistance.

Brief discussion of the result

The patient recovered very well and was seen in the urology oncology clinic for a post-operative follow-up visit one week after the procedure, with complete resolution of his right flank pain. The patient returned to work three weeks after surgery. Ultrasound done at 6 months demonstrated full recovery and patent flow of the IVC. At his one-year follow-up appointment, he had maintained complete resolution of all symptoms and was back to all normal activities.

IVC filters are extremely common, and retrieval rates are >90% if removed within 12 months of placement.¹ However, follow-up is not uniform, and the retained IVC filter is a relatively common event. Although endovascular approaches are often successful, there are rare occasions when retained tines from the IVC filter cannot be removed.³ As seen in the images shown here, the IVC filter apparatus becomes completely covered by endothelium, making it difficult, and potentially life-threatening, to remove with the snare technique. This is clearly seen in [Figure 3](#). Open surgery with laparotomy and direct exposure of the vena cava is the gold standard approach for treating this issue, which is likely to become increasingly common as 40,000 IVC filters are placed annually in the US alone.³ This case demonstrates a minimally invasive approach utilizing the DaVinci robot. Although laparoscopic techniques are available, they require extensive training and have not been widely adopted for complex vascular procedures.

The robotic approach allows for a minimally invasive approach to retained IVC filters that fail endoscopic retrieval. This approach is particularly

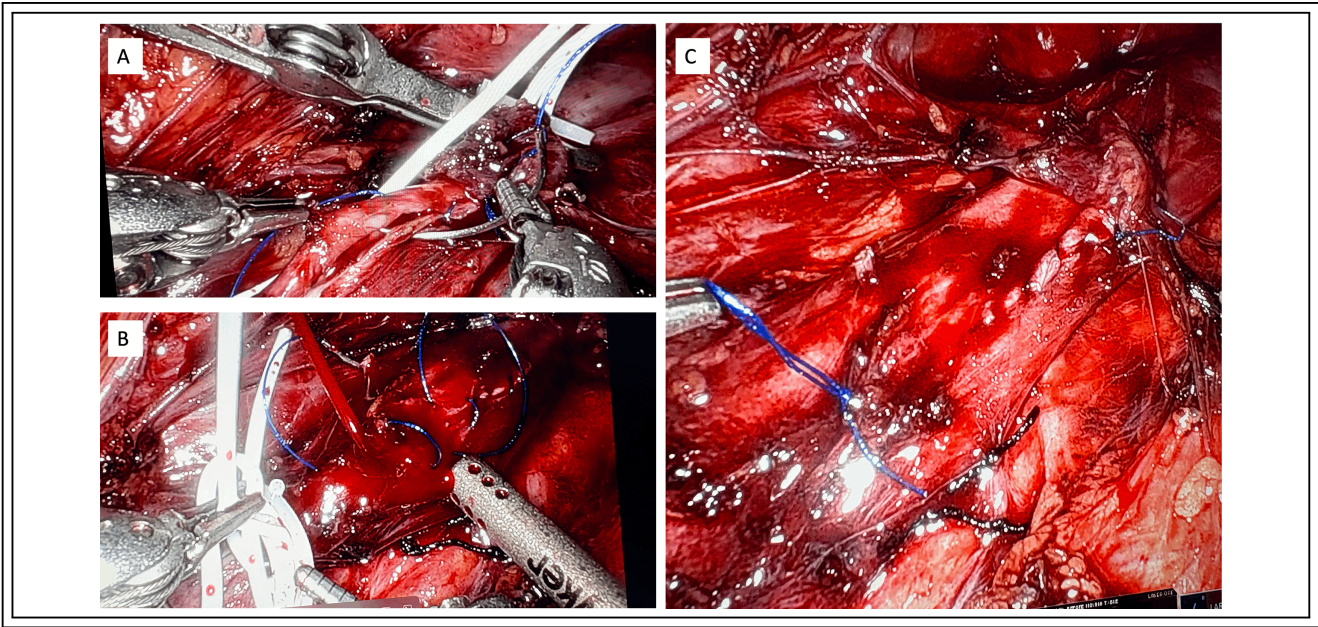


FIGURE 4. Intraoperative images. (A). Completing the reconstruction of the vena cava with 3-0 Prolene with bulldog clamps in place. (B). Removal of the lower bulldog and relaxing the tourniquet, letting the vena cava fill, and any residual gas flush out. (C). Completed reconstruction with flow restored to the vena cava and no appreciable narrowing

TABLE 1. Steps for robotic control of the vena cava		
Order	Step	Brief description
1	Expose IVC	Incise the peritoneum along the medial aspect of the cecum to the inferior mesenteric vein. Tack up the peritoneum to the anterior abdominal wall with a W-configuration barbed suture
2	Dissect IVC	Control all lumbar vessels with 4-0 silk ties or bipolar cautery to prevent back bleeding
3	Encircle IVC	Using a vessel loop, cut 15 cm. Double loop-use tip-up grasper or prograsp
4	Stepwise clamping	IVC first, caudal end, then contralateral renal vein if needed, then superior aspect—cranial end. IVC should be soft!
5	Incise	Check to ensure suction is working, then make a longitudinal incision, remove all hardware
6	Close IVC	Begin closure, release the inferior clamp first to burp out air bubbles, then complete closure using permanent suture (Prolene or Gore-Tex)
7	Completion	Remove all bulldogs, cut all vessel loops and remove pressure to 5 mmHg and observe for signs of bleeding

useful in the setting of filter struts that have punctured the vena cava. Complete mobilization of the vena cava with proximal and distal control is performed regularly in the urologic oncology setting when treating renal tumors with vena cava involvement. This has been utilized over the last 12 years successfully with the DaVinci robot.

Various approaches to the vena cava are available to the robotic surgeon. The approach most commonly used during renal surgery, and the one which has been previously described to address this issue, is the trans abdominal lateral approach.⁴⁻⁷ This approach requires the lateral decubitus position and involves mobilization of the ascending colon and duodenum

to access the vena cava. This approach has significant advantages when the goal is to completely skeletonize the renal veins.

Site selection is key when approaching the vena cava. It is crucial to understand the area of pathology involving the inferior vena cava (suprahepatic, infrahepatic, or infrarenal) when determining the approach. In this case, the IVC filter was in the lower third of the vena cava with strut extrusion just above the right common iliac vein. The lower abdominal approach, utilizing tenting of the posterior peritoneum to retract the abdominal contents, was developed for robotic retroperitoneal lymph node dissection.⁸ This approach was well-suited for dealing with pathology in the lower third of the vena cava and involved minimal dissection or mobilization of bowel. This proved to be a safe, effective, and relatively expeditious approach to treat this complication of a retained vena cava stent.

As seen in [Figures 1](#) and [2](#), a portion of the IVC filter had partially migrated out of the vena cava and was abutting the ilioinguinal nerve, psoas muscle, and, in this case, the right ureter. Removal of this foreign body led to the resolution of pain. The ureter was inflamed, but not perforated, and no further surgery on the ureter was required. To date, this is the first report of robotic repair of an IVC filter affecting a ureter.

[Figure 3](#) also shows complete endothelialization of one of the struts. The metallic strut was covered by a fingerlike projection of endothelial tissue, which persisted after removal of the metal piece. This inflammatory response to the retained piece explains why endovascular retrieval was not possible. Furthermore, the robotic approach allowed for direct visualization of the lumen, full removal and excision of the epithelial tissue, and uneventful repair of the vena cava. This was crucial; leaving this behind may have resulted in a thrombogenic surface. The patient avoided a laparotomy and blood transfusion, resulting in a very rapid and full recovery following this robotic surgery. This was a successful example of the minimally invasive approach to a retained IVC filter, utilizing a robotic surgical system to remove retained fragments in a symptomatic patient.

Conclusions

The urologist is well-equipped to manage the vena cava. Extensive experience gained from removing renal masses with extension into the vena cava has made cava dissection and vena cava reconstruction a common occurrence. Renal vein transposition for

nutcracker syndrome and removal of retained IVC filters also falls well within the expertise of the experienced urologic oncologist.^{9,10} Robotic removal of IVC filters has been described before with similar success and outcomes.^{11,12} Working together collaboratively with the vascular surgeons allows for the safest delivery of care for the patients.

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Author Contributions

The authors confirm contribution to the paper as follows: Endovascular approach and conception of the robotic surgery were done by Yaron Sternbach. The robotic surgery and all final revisions were performed by Jonah Marshall. The original manuscript and many essential contributions were made by Olga Kirk. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials

All data is available by request, emailing the primary author—jonah.marshall@sphp.com.

Ethics Approval

A statement of informed consent was obtained from the patient prior to surgery. A St. Peter's Hospital Ethics Consultation, the institutional standard for ethics approval, was obtained for this minimally invasive approach was obtained 01 October 2023 for this minimally invasive approach, and no number was assigned as this was considered within standard of care.

Conflicts of Interest

The authors declare no conflicts of interest.

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