Heliyon 10 (2024) e33246

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Case report

# Surgical removal of an inferior vena cava filter in the duodenum: A rare case report and literature review

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ARTICLE INFO

*Keywords:*
IVC filter retrieval
Open surgery
IVC filter
IVC filter complication
Duodenal penetration

ABSTRACT

*Background:* Inferior vena cava filters are typically retrieved using endovascular procedures. However, in cases where complications related to the filter arise or when endovascular retrieval becomes challenging, open surgery could be considered.

*Case presentation:* A 65-year-old woman underwent inferior vena cava filter placement surgery for progressive venous thrombosis embolism (VTE). Following an unsuccessful endovascular retrieval attempt at an external hospital two months later, she experienced abdominal pain and was transferred to our facility for further treatment. Examination revealed that she was encountered a complication where the inferior vena cava filter penetrated both the vena cava and the duodenum post-implantation. But fortunately, the patient's blood test results were within normal range. Ultimately, our institution successfully removed the filter through open surgery and the patient was discharged without any complications.

*Conclusions:* This case, along with our literature review, illustrates the viability and safety of duodenal-penetrated filter removal via open surgery, resulting in favorable outcomes and a promising prognosis for the patient.

## 1. Introduction

Inferior vena cava (IVC) filters may be employed in cases of venous thrombosis embolism (VTE) when patients have contraindications or failure to anticoagulation therapy [1]. Current evidence suggests that the placement of IVC filters significantly decreases the risk of subsequent pulmonary embolism (PE) [2]. Nevertheless, the risk of mechanical complications, including filter adhesion, penetration of the caval wall, and filter displacement, notably rises with the filter's duration, significantly when patients surpass the high-risk period for developing pulmonary infarction and the filter is not promptly retrieved. Additionally, if the IVC filter is left in place for an extended period, there is an increased risk that the filter might not be removed, particularly if patients are lost to follow-up [3]. The standard method for IVC filter removal is typically through endovascular retrieval. However, in cases where the filter's position and structure exhibit abnormalities, alternative surgical procedures should be contemplated for the filter's removal. Reed et al. reported a case in which several endovascular attempts to remove the filter failed and were ultimately successfully removed through open surgery. The case revealed that the filter had penetrated the vena cava wall, duodenum, posterior aortic wall, and gallbladder, although the patient remained asymptomatic. The patient was discharged from the hospital 3 days post-operation, with positive results noted during the 3-month follow-up [4]. This study demonstrated an open surgery approach for retrieving the IVC filter

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https://doi.org/10.1016/j.heliyon.2024.e33246
Received 20 January 2024; Received in revised form 14 June 2024; Accepted 18 June 2024
Available online 26 June 2024

in the case of duodenal perforation complication. This case and the accompanying literature review are expected to offer valuable insights and serve as a practical foundation for guiding the selection of surgical strategies to remove IVC filters in future clinical practice.

## 2. Case presentation

A 65-year-old woman with a right ankle fracture received a retrievable IVC filter at an external hospital due to progressive VTE despite low molecular weight heparin therapy. The right femoral vein was utilized for puncture, with routine Cavography performed during the operation. A filter was successfully placed in the inferior vena cava just below the opening of the renal vein. Two months post-placement, she suffered a failed endovascular IVCF removal and subsequently developed upper abdominal pain. This patient was subsequently referred to our institution for further treatment. Abdominal examination revealed deep abdominal tenderness but no rebound tenderness. Nausea and vomiting did not occur simultaneously with abdominal pain, and there was no vomiting of blood. Additionally, the fecal occult blood test result was negative. She had no history of hypertension or diabetes and had previously experienced a urinary tract infection. Upon admission, her laboratory test results showed normal values for D-dimer, platelets, leukocyte count, blood amylase, direct bilirubin, indirect bilirubin, alanine aminotransferase, and aspartate aminotransferase. The patient did not received antibiotic treatment. The angiogram revealed that the supporting leg of the IVCF was outside of the inferior vena cava (Fig. 1A, black arrow) and the filter legs rotated and twisted together (Fig. 1A). Inferior vena cava computed tomography venography (CTV) unveiled an improper filter position, and the tilted IVC filter likely resulted in filter limbs protruding into the nearby duodenum (Fig. 1B). These images were extracted using a 3D software (Fig. 1C). Following a comprehensive assessment of the CTV results and extensive communication with the patient, we conducted a thorough discussion. We determined that surgical removal was the most suitable course of action. The patient was made aware of the surgical risks, primarily the potential for significant bleeding due to filter penetration during the perioperative and intraoperative phases. The patient underwent an exploratory laparotomy with open surgical retrieval, conducted through a midline abdominal incision of 20 cm while under general anesthesia. A retroperitoneal incision was made along the right paracolic sulcus, allowing for the mobilization of the colon and duodenum to expose the infrarenal IVC. One of the legs of the IVC filter was firmly embedded in the duodenal serosa, and extensive tissue adhesions were discovered in this area (Fig. 2A). The strut that had penetrated the duodenum was excised to prevent damage to the IVC wall, and it was subsequently removed after a careful separation of the IVC (Fig. 2B). There was no intestinal content spillage, and the wound surface was closed with a purse-string suture. Later, the IVC was incised after securing vascular control both proximally and distally to the filter. The head of the IVC filter was noted to be wedged into the dorsal lumbar vein, with the filter pillar tightly adhering to the blood vessel wall.

Simultaneously, a small quantity of thrombus was visible within the blood vessel wall and inside the filter. The thrombus was cleared, and the IVC filter was successfully extracted after carefully separating the pillar and recycling hook (Fig. 2C). The patient experienced a blood loss of approximately 500 ml during the operation, with most of the lost blood being collected, filtered, and subsequently transfused back. During the surgery, the patient received 5000U of heparin sodium via intravenous injection. Following the surgery, she was administered 4000IU of low-molecular-weight heparin every 12 hours via subcutaneous injection for a duration of 7 days. The patient's postoperative recovery progressed satisfactorily. She was dismissed on postoperative day 7. She was advised to take 20mg of rivaroxaban orally daily for a period of three months after discharge. One month into the follow-up, the patient was in good health, and there were no notable abnormalities detected in the follow-up inferior vena cava CTV (Fig. 2D). The timeline of this case was presented in Table 1.

## 3. Discussion and literature review

We presented a successful surgical removal of an inferior vena cava filter in the duodenum. Due to the benefits of using IVC filters in preventing PE, many patients have been opting for IVC filter placement surgery. In contrast to permanent filters, an escalating trend shows that retrievable filters were utilized in a larger population, the data shows that their removal rate remained low. A retrospective

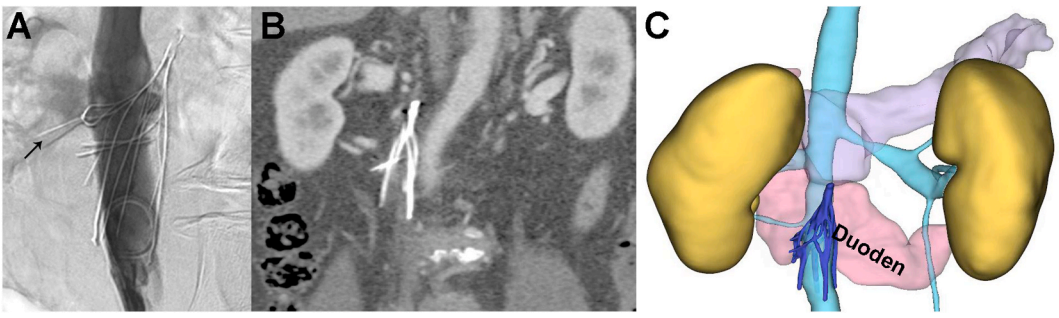


**Fig. 1.** The manifestation of ectopic inferior vena cava filter in imaging. (A) Intraoperative angiographic display of filter pillar penetrated the lateral posterior wall of the inferior vena cava. (B) Shifted IVC filter displayed on CT images. The arrow points to the filter pillar that penetrated the wall of the IVC, suspected to have penetrated the intestinal wall. (C) CTV imaging data was extracted using a 3D software called DetecModeling developed by boea wisdom, displaying the relationship between the abnormal filter and the surrounding duodenum.

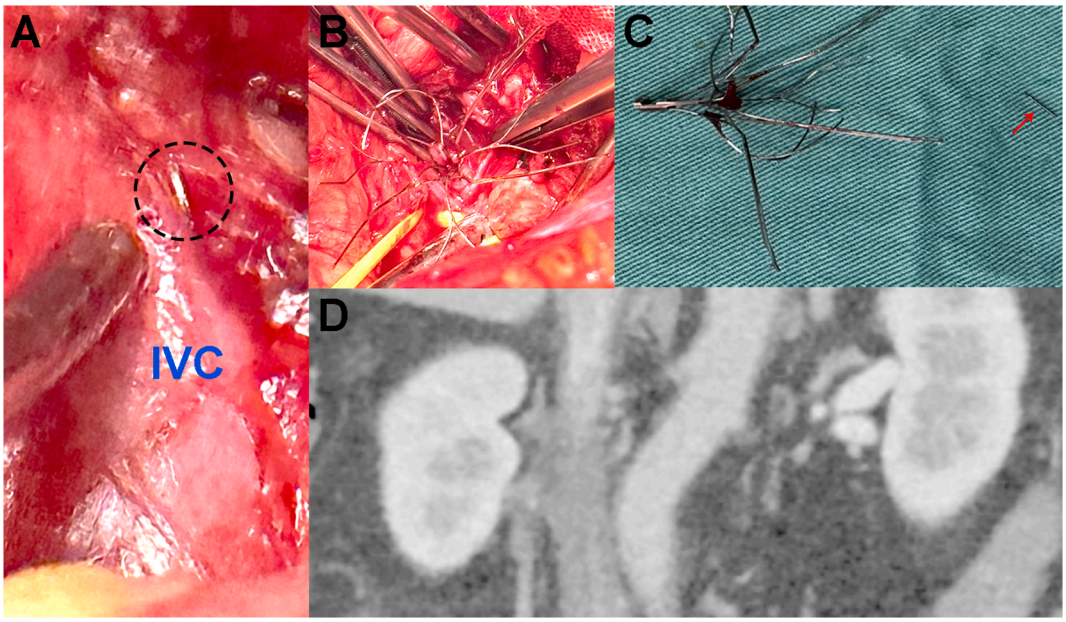


**Fig. 2.** Successful removal of ectopic IVC filter through abdominal median incision. (A) Abnormal filter detected during surgery. The arrow represents a filter strut that penetrated the intestinal wall. (B) Ectopic filter successfully removed through open surgery. (C) Abnormal filter completely removed. The arrow represents the removed filter pillar that penetrated the intestinal wall. (D) Normal inferior vena cava displayed on CT images after filter removal.

medical record review examined patients who had retrievable IVC filters placed between 2006 and 2011, and the findings showed that only 7 % of patients had undergone filter removal [5]. Furthermore, the persistently low rates of follow-up and filter removal have resulted in the majority of filters being left in place, potentially leading to various postoperative complications. Distinct complications following filter placement surgery encompass VTE, filter displacement, rupture, and adjacent blood vessels and tissue perforation. These complications are typically identified during imaging examinations or scheduled retrieval procedures, with the incidence of complications due to insertion problems ranging from 5 % to 23 % [6]. Filter displacement can be accompanied by caval penetration, and the filter pillar can damage surrounding tissues and blood vessels, including duodenal penetration, liver and kidney penetration, and lumbar arteriovenous penetration. Retrievable filters were typically extracted through an endovascular approach.However, in cases where complications related to the filter, such as displacement, perforation, or unsuccessful endovascular retrieval, arose, surgeons opted for open surgery to remove the challenging filter.

Out of an 80 observed patients who had undergone filter implantation, 16 % experienced broken filter struts; of these, 11 % had tissue embolism as a consequence [7]. Retrievable filters should be promptly removed when there are no indications for their insertion. The likelihood of complications occurring within 30 days after the placement of IVC filters was lower, but with extended use of the filter, the frequency of reported events increased [8]. Furthermore, a recent study indicated that only 2 % of patients with indwelling filters had PE as the cause of death [9].

We conducted a systematic review of all cases in the PubMed and Embase database involving the retrieval of IVC filters through open surgery from January 2002 to July 2023. This review encompassed 35 patients from 19 studies (**Table 2**). We observed a man-to-woman ratio of approximately 0.5 among the 35 patients, with the average age at which the patients underwent open surgery being 50 $\pm$ 16 years (n = 35). All patients experienced filter-related complications, including caval penetration, duodenal penetration, aortic wall penetration, renal vein penetration, filter infection, etc. Among these patients, 20 % (n = 7) were asymptomatic, whereas 69 % (n = 24) presented with symptoms resulting from the penetration of the vena cava filter into the surrounding blood vessels and tissues,

**Table 1**
Timeline.

| Timeline | Events |
|---|---|
| Case | |
| Day 1 | A 65-year-old woman underwent an unsuccessful endovascular retrieval attempt at an external hospital. Subsequently, she experienced abdominal pain and was transferred to our institution for further treatment. |
| Day 4 | Inferior vena cava computed tomography venography (CTV) unveiled an improper filter position, and the tilted IVC filter likely resulted in filter limbs protruding into the nearby duodenum. |
| Day 6 | The patient underwent an exploratory laparotomy with open surgical retrieval. |
| Day 14 | She was discharged. |
| Day 41 | The patient was in good health, and there were no notable abnormalities detected in the follow-up inferior vena cava CTV. |

**Table 2**
Summary of the findings in reported open removal of inferior vena cava filters.

| Author | case number | Age (years or mean ± SD years) | Gender | Length of implant | Problems with the IVC filter | Sumptoms cause by IVC filter | Attempts of endovascular retrieval | Transfusion/ Blood loss | Postoperative hospital stay | Follow up | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atik, F. A [10]. | 1 | 42 | Man | Unknown | Caval and hepatic penetration | Abdominal pain | None | _ | _ | Good | |
| Lee, J. S [11]. | 1 | 63 | Woman | > a year and a half | Caval and duodenal penetration | None | None | 300ml | > 3 days | Good | |
| Kim, K. Y [12]. | 1 | 61 | Woman | 7 years | Caval and duodenal penetration | Abdominal pain | had attempt | no transfusion | 5 days | Good | |
| Reed, N. R [4]. | 1 | 60 | Woman | 7 months | Penetration of caval wall, duodenum, aortic wall, gallbladder; the head of filter in lumbar vein | None | had attempt | _ | 3 days | Good | |
| Dagenais, F [13]. | 1 | 24 | Man | Unknown | Inverted filter; caval and hepatic penetration; infection of the filter | None | 3 attempts | _ | _ | Good | Inverted filter, the device barbs facing caudally |
| Chassin-Trubert, L [14]. | 1 | 37 | Woman | 1 year | Penetration of caval wall, duodenum, periosteum | None | None | _ | 6 days | Good | |
| Veroux, M [15]. | 1 | 46 | Woman | 2 years | Penetration of caval wall, duodenum, aortic wall | Aortic mural thrombosis, leg swelling | None | _ | 10 days | Good | |
| Park, H. O [16]. | 1 | 74 | Woman | 8 years | Caval and duodenal penetration | Abdominal and back pain with nausea and vomiting | 1 attempt | _ | 12 days ( hospital day ) | Good | |
| Malgor, R. D [17]. | 1 | 61 | Woman | 5 and a half years | Penetration of caval wall, duodenum, aortic wall | Abdominal pain | None | 100ml | 3 days | Good | Conservative treatment of pain for 2 years |
| Bathla, L [18]. | 1 | 76 | Woman | 14 months | Penetration of caval wall, duodenum, lumbar vertebra, ureter and adventitia of gonadal vein | dizziness and black tarry stools | None | _ | 6 days | Unknown | good after operation |
| Woodward, E. B [19]. | 1 | 31 | Woman | 8 days | Retroperitoneal hemorrhage, lacerated lumbar artery, pseudoaneurysm | abdominal pain | None | Preoperative blood transfusion | 10 days | Unknown | The filter punctured the artery during deployment, causing a pseudoaneurysm to rupture and causing a retroperitoneal hematoma |
| Feezor, R. J [20]. | 1 | 40 | Man | > 4 months | Caval and duodenal penetration | abdominal pain , nausea, anorexia, | None | _ | _ | Good | |

(*continued on next page*)

**Table 2** (*continued*)

| Author | case number | Age (years or mean ± SD years) | Gender | Length of implant | Problems with the IVC filter | Sumptoms cause by IVC filter | Attempts of endovascular retrieval | Transfusion/ Blood loss | Postoperative hospital stay | Follow up | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | intermittent constipation, and weight loss | | | | | |
| Charlton-Ouw, K. M [21]. | 7 | 44 ± 16 | Men/ Women ( 0.4 , n = 7 ) | 1 patient was implanted with three filters 10 and 25 years ago; 3 patients were placed 72,12, and 5 months ago; 3 patients, unknown | All patients, IVC penetration; 4 patients, duodenal penetration; 2 patients, aortic penetration; 1 patient, penetration of renal vein; 1 patient, penetration of anterior spinal ligament; 1 patient, penetration of gonadal vein; 1 patient, periosteal penetration | 5 patient, abdominal pain (two of the patients with right groin pain); 1 patient, back pain and leg swelling; 1 patient, unknown | 5 patient, had attempts (one of the patients had 3 attempts); 1 patient, none; 1 patient, unknown | _ | 7 ± 4 days | 3 patient, good; 1 patient have leg sewlling; 1 patient had postoperative ileus; 2 patients, unknown | |
| Chauhan, Y [22]. | 1 | 77 | Man | 5 years | Caval and aortic penetration, aortic dissection | abdominal and back pain | None | _ | 10 days | Unknown | |
| Nelson, W. K [23]. | 1 | 47 | Woman | 3 years | Penetration of caval wall, aorta, vertebra | None | had attempt | _ | _ | Good | |
| Taylor, S. G [24]. | 1 | 48 | Woman | 4 years | Caval and renal penetration | abdominal pain and hematuresis | 2 attempts | blood transfusion | 4 days | Good | Renal parenchymal penetration leads to hematuria and requires blood transfusion |
| Kuo, W. T [25]. | 1 | 46 | Woman | 6 months | Fractured strut in right ventricle, penetration of right ventricle | chest pain | had attempt | extracorporeal circulation | 6 days | a sternal wound dehiscence after postoperative week 6 | IVC filter placement for bariatric surgery |
| Connolly, P. H [26]. | 6 | 50 ± 18 | Men/ Women ( 0.2 , n = 6 ) | 2 patients,2 years; 2 patients,8 months; 1 patient,3 years; 1 patient,5 months | All patients, IVC penetration; 4 patients, duodenal penetration; 1 patient, colonic penetration; 1 patient, penetration of aortic wall | 4 patients, abdominal pain (one of the patients with back pain); 2 patients, asymptomatic | Unknown | no transfusion | _ | Unknown | |
| Rana, M. A [27]. | 6 | 54 ± 15 | Men/ Women ( 2 , n = 6 ) | 6 patients were placed 6,7,9,23,33 and 35 months ago | All patients, IVC penetration; 3 patients, duodenal penetration (one of the patients had enteric hemorrhage); 2 patients, aortic | 2 patients, back pain; 1 patient, abdominal pain; 3 patients, unknown | 4 patient, had attempts (two of the patients had 2 and 3 attempts, respectively); 2 patients, none | _ | 3.6 days | Good | |

(*continued on next page*)

**Table 2** (*continued*)

| Author | case number | Age (years or mean ± SD years) | Gender | Length of implant | Problems with the IVC filter | Sumptoms cause by IVC filter | Attempts of endovascular retrieval | Transfusion/ Blood loss | Postoperative hospital stay | Follow up | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | penetration; 2 patients, renal vein penetration (one of the patients had fractured tines in lung and vertebral body); 1 patient, gallbladder penetration; 1 patient, ileum and vertebral body penetration with psoas abscess | | | | | | |

such as abdominal pain, swelling of lower limbs, back pain, nausea, vomiting, and dizziness. Abdominal pain was the most prevalent symptom, with a few patients exhibiting back pain and a minimal number experiencing black stools or hematuria. Duodenal penetration accounted for 57 % (n = 20) of all patients, which was the most common complication. Among these, 60 % presented with abdominal pain, while 10 % experienced back pain. Of the 30 patients with known filter implant durations, 97 % (n = 29) had their filters in place for more than 30 days. The shortest duration was over four months, and the most extended recorded instance involved a filter remaining in place for 25 years. Among 33 patients, 36 % (n = 12) had not undergone any attempt at endovascular retrieval, whereas 64 % (n = 21) had. Notably, 9 % (n = 3) of these patients had experienced as many as three retrieval attempts. Open surgery treatment was ultimately chosen in all reported cases. Follow-up results for 24 patients indicated that 88 % (n = 21) experienced a successful recovery after open surgery. In contrast, 12 % (n = 3) encountered issues such as leg swelling, intestinal obstruction, and chest wound dehiscence following the surgery. Prolonged retention of filters in place may offer limited benefits in reducing the harm caused by PE and raise the likelihood of complications over time. The occurrence of complications may be insidious, but for patients presented with abdominal pain, duodenal penetration should be highly suspected, and a CT or MR scan would be recommended. Open surgery appears to be a more favorable choice for these patients.

But the risk of complications, such as intraoperative bleeding, cannot be ignored when opting for open surgery. The comparison between it and endovascular removal of filters was reflected in Table 3. The larger incision required for open surgery increases the risk of postoperative wound infection and wound rupture. Furthermore, the lumbar vein that is closely attached to the posterior wall of the vena cava is difficult to separate during surgery and is prone to damage, leading to bleeding. Open surgery may also affect gastrointestinal function. To fully expose the inferior vena cava, the intestine often needs to be moved, which poses a risk of postoperative gastrointestinal dysfunction and even intestinal obstruction. Additionally, some opinions suggest that if there are no symptoms or other complications, removing the filter through open surgery may not be necessary. It has been observed that asymptomatic patients, who experienced failed percutaneous removal of filters, showed a lower incidence of complications during midterm follow-up, despite significant penetration of the filter strut [28].A study reported 21 cases where filters were successfully removed through open surgery after failed endovascular attempts. They either experienced rupture of the filter pillar, abdominal pain, or other reasons, but no postoperative complications occurred after undergoing open surgery [29]. Therefore, the decision to opt for open surgery for filter removal after unsuccessful intracavitary attempts should be informed by a broader spectrum of real-world cases. In our case, laparoscopic surgery was not considered primarily due to its suitability for conical filters that adhere to the venous wall. Difficulty arises in dissecting the filter during surgery if the retrieval hook of the filter has not penetrated the vena cava wall. Moreover, if the posterior wall of the vena cava is penetrated, it will be difficult to separate it under laparoscopic surgery [29].

While some literatures suggest that in cases where postoperative complications like filter perforation occur, the filter may not be retrieved immediately if the patient remains asymptomatic. However, considering the findings of the earlier retrievable filter outcomes, it is important to note that for these patients, the risk of pulmonary embolism (PE) persists, regardless of their ability to continue anticoagulation. For patients whose CT imaging examinations did not reveal severe rupture or perforation of the filter, temporary conservative treatment can be considered, but it is essential to maintain close follow-up for these patients. Furthermore, the time window for filter retrieval is crucial. The findings from a prospective multicenter study revealed that filters implanted for over three months have a 50 % likelihood of removal failure [30]. Unfortunately, no literature has been found to compile the failure rate of endovascular removal in patients with filter related complications. At one institution, the initial approach involved percutaneous retrieval for patients scheduled to have their filters removed, and this method resulted in a successful removal rate of 84 %. Open surgery was conducted in the case of symptomatic patients and those with complications resulting from a failed initial attempt at percutaneous removal. Following the surgical intervention, the patients' symptoms completely disappeared [28]. In our literature review, it was observed that 64 % of patients who had experienced complications had previously attempted one or more removals through endoluminal procedures, but they exhibited a satisfactory recovery after undergoing open surgery. Hence, open surgery represents a meaningful and viable choice for patients experiencing symptoms or facing failed endovascular removal attempts. In addition, we also observed that the duodenum may be the most commonly affected surrounding tissue, and abdominal pain may be the main symptom in these patients. Hence, patients who experienced abdominal pain after IVC filter placement should be alert to the possibility of duodenal penetration. In addition, in the cases we reviewed, four cases were clearly described as strut fractures, with two cases being informed of two missing arms [25,27]. The case of the broken strut penetrating the right ventricle ultimately underwent a median sternotomy [25]. In our case, only one pillar was fractured, and it was wrapped in the duodenal tissue without floating to other

**Table 3**
Comparison between open surgery removal of filters and endovascular removal of filters.

| | Advantages | | Disadvantages | |
|---|---|---|---|---|
| | Open surgery | endovascular removal | Open surgery | endovascular removal |
| Operating time | | ✓ | longer time | |
| Intraoperative blood loss | | ✓ | could be fatal bleeding | – |
| Length of incision | | ✓ | bigger incision | – |
| Hospital stay (days) | | ✓ | longer | – |
| Overall complication | | ✓ | vary depend on surgery process | – |
| The use of antibiotics | | ✓ | depending on laboratory testing | – |
| Start of eating | | ✓ | after anal exhaust | – |
| Total cost | | ✓ | more expensive | – |
| Challenging filter retrieval | ✓ | | | Fail to retrieve under specific conditions |

surrounding tissues. After laparotomy was performed, the filter and its arm fragment were successfully removed. Open surgery seems to be a more meaningful choice for these challenging filters, as endoluminal procedures may cause unnecessary damage to patients.

## 4. Limitations

This study is a single case report, although we have conducted relevant literature reviews. In addition, the advantages of open surgery for patients require thorough evaluation, particularly weighing the risks of leaving the filter in place following unsuccessful endovascular attempts against the postoperative complication risks associated with open surgical removal of the Inferior Vena Cava Filter (IVCF). The procedure in our case was executed smoothly, and the patient exhibited no adverse outcomes or unforeseen incidents post-surgery. However, this outcome does not imply the absence of risks or complications associated with open surgery for filter removal, such as postoperative wound dehiscence and intestinal obstruction, as mentioned in our literature review. Furthermore, no clear indications have been found in existing studies for transitioning from endovascular attempts to open surgical intervention. Therefore, additional research and case analyses are crucial to develop more explicit guidelines.

## 5. Conclusion

Open surgery has a greater trauma and a higher risk of intraoperative bleeding to patients compared to the endoluminal procedure, so open surgery shouldnot be the first choice for IVC filter retrieval. Duodenal penetration would be considered for IVCF implantation patients with abdominal pain. When this complication is confirmed, endovascular retrieval may need to be carefully selected. Open surgery can be an effective and viable strategy in cases where IVC filters have penetrated surrounding tissues or blood vessels and endovascular attempts have proven unsuccessful.

## Ethics statement

Ethical review and approval were waived for this study due to the single one case presented. All imaging materials, clinical images, and other data included in the manuscript were published with the informed consent of the patients.

## Fundings

This work was supported by National Natural Science Foundation of China (No. 82270520 to Qin Li, NO.82000729 to C·C., and No. 82100518 to Yunfei Chen).

## Data availability statement

The datasets used and analyzed during the current study are available from the corresponding authors (C.C. and Q.L.) and B.Z. on reasonable request.

## CRediT authorship contribution statement

**Bingjie Zhu:** Writing – original draft, Visualization, Formal analysis, Data curation. **Peng Zhou:** Resources. **Yunfei Chen:** Data curation. **Chuanqi Cai:** Writing – review & editing, Visualization, Formal analysis. **Qin Li:** Writing – review & editing, Resources.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

None.

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