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INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

Ten-year experience of retrievable inferior vena cava filters in a tertiary referral center

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PURPOSE
A significant proportion of patients undergoing surgery have an increased incidence of acute pulmonary embolus (PE). We analyzed all patients who had a retrievable inferior vena cava (IVC) filter placed preoperatively for PE prophylaxis and investigated the long-term outcomes of the patients who did not have their filter removed.

METHODS
Patients who underwent retrievable IVC filter insertion and attempted removal were identified from the radiology information systems database in a large tertiary referral university teaching hospital. Results of all clinical investigations (including computed tomography, magnetic resonance imaging, ultrasonography, and plain radiography) while the IVC filters were *in situ* were reviewed.

RESULTS
In total, 393 retrievable IVC filters were inserted, 254 with the indication of preoperative thromboembolic prophylaxis. Recurrent PE was reported in five patients (1.9%) despite the IVC filter. Of the 254 retrievable filters inserted prior to surgery, an attempt at retrieval was made in 168 filters (66.1%). Successful retrieval at the first attempt occurred in 143 cases (85.1%), while 25 cases failed or were aborted (14.9%). No attempt at retrieval was made in 86 (33.9%) patients and a significant proportion of these patients had undergone cancer surgery ($P < 0.0107$). In those patients where there was no attempt at retrieval, there was an association between cancer surgery and a shorter absolute survival time ($P < 0.0001$).

CONCLUSION
The majority of attempted filter retrievals were successful, and a proportion of nonretrieved IVC filters are accounted for in patients who underwent cancer surgery and ultimately died with the filter *in situ*. A departmental protocol is recommended to ensure the filter is removed where appropriate and possible.

Pulmonary embolism (PE) is a common condition occurring both to hospitalized patients and in the community (1). For patients who undergo surgery there is a fivefold increase in the incidence of PE during and after surgery (2). In the postoperative period, PE is a major cause of morbidity and mortality particularly in the critically unwell patient (3). There has been an increasing trend in the use of retrievable inferior vena cava (IVC) filters for those patients undergoing surgery with known recent deep vein thrombosis (DVT) or PE. The indication for insertion of a retrievable IVC is clearly a defining factor for when, and if, a filter will be retrieved (4).

In some clinical circumstances a retrievable filter is left *in situ* as a permanent filter yet little data exists confirming either the efficacy or safety of this. Systematic review of the use of retrievable IVC filters has shown a successful retrieval rate ranging from 12% to 45% (5), although other registry studies show much higher retrieval rates above 90% (6, 7). It is well described that IVC filters have significant complications including vena cava thrombosis or stenosis, wall perforation, filter fracture or migration (5).

We aimed to retrospectively assess the retrieval rate for patients who had a retrievable IVC filter placed preoperatively for PE prophylaxis and what affected the retrieval rate. Furthermore, we aimed to investigate the outcomes of those patients who do not have their filter removed.

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Methods

The data collection was performed in November-December 2014, of all retrievable filters implanted over a ten-year period between November 2004 and October 2014.

Current practice

All procedures were performed in a large tertiary referral university teaching hospital in the United Kingdom. All procedures were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Patients who underwent retrievable IVC filter insertion and attempted removal were identified from the hospital radiology database (CRIS). Four main types of retrievable filters were used throughout the study period including Recovery (CR Bard), Recovery G2 (CR Bard), Denali (Bard Peripheral Vascular) and Gunther Tulip (Cook Medical). A cavogram with iodinated contrast was performed before placement to confirm IVC patency and anatomy. The size was measured using a graduated catheter if no preprocedure measurements, such as recent computed tomography (CT) scan, were available. The infrarenal IVC was the preferred location for IVC placement. Either a femoral or jugular approach was used for deployment depending on the clinical circumstances of the procedure, the device, and at the discretion of the operator. All filter retrievals were performed via an internal jugular vein approach, as dictated by the design of the filters. A cavogram was routinely performed prior to attempted filter removal to assess caval patency, thrombus within the filter, and filter position within the cava. If significant thrombus was found within the filter (>20%–25% filter volume by visual assessment), removal was not attempted at that time but was reconsidered after a period of anticoagulation to allow the thrombus to clear. The insertion procedure is well established and described; in addition, our unit is experienced with advanced retrieval techniques for complicated retrievals such as those described in the published literature (8, 9).

The current practice within the department to ensure filters are removed in a timely manner is to document on the operation note and radiology report that the filter should be removed within three months or as soon after surgery as possible. A further letter is sent out to the referring clinician to remind them to consider referring the patient back for filter retrieval if this has not happened within two months of placement.

Main points

- In our tertiary referral center, retrievable inferior vena cava filters (IVC) were successfully retrieved at a good rate, and filter dwell time was not associated with increased retrieval failure.
- In our cohort over half of the attempts failed due to thrombus, which were resolved or reduced in volume using anticoagulation to allow safe removal. Repeated insertion and removal of retrievable IVC filters was feasible.
- We report that a proportion of non-retrieved IVC filters are accounted for in patients who underwent cancer surgery and ultimately died with the filter *in situ*.

Definitions of outcomes

Records and digital recordings of the studies of the IVC filter insertion and retrieval procedures were analyzed. Retrieval procedures were routinely reported as uncomplicated, filters contained minimal thrombus not precluding retrieval, sufficient thrombus to inhibit retrieval, and failed retrievals (usually due to angulation or legs perforating the IVC wall). Clinical data, such as the reason for filter insertion, was collected from the request form submitted by the clinical team and archived on the hospital radiology information system. Results of all clinical investigations (including CT, magnetic resonance imaging, ultrasonography, and plain radiography while the IVC filters were *in situ*) were reviewed for details such as recurrent PE. Time from filter insertion to removal, to death or to most recent clinical follow-up (i.e., the time of study data collection) was recorded for all patients.

Statistical analysis

Representation of gaussian data was given as mean±standard error of the mean (range) and for non-gaussian data as median (range); D'Agostino and Pearson omnibus normality test performed on datasets prior to analysis. Mann-Whitney U test was performed to compare non-gaussian means. Chi-square test was performed with post-hoc comparison testing each value of one nominal variable versus the sum of all others with Bonferroni correction (i.e., each specialty versus sum of others, P value significance set at <0.05 divided by the sum of the categorical variables [<0.00625]). Log-rank (Mantel-Cox) test was performed to compare Kaplan-Meier survival curves.

Results

Over the study period, 393 retrievable IVC filters were inserted in our unit. For the explicit indication of preoperative thromboembolic prophylaxis 254 filters (64.6%) were inserted in 250 patients; four patients underwent insertion of a second retrievable filter after an interim period from removal of the first filter (for a repeat surgical procedure considered to be at high risk of PE). There were 111 male and 139 female patients with a mean age of 58.7±16.0 years (range, 18.9–86.8 years). The type of filters inserted included: 107 Recovery (42%), 55 Recovery G2 (21.7%), 43 Denali (16.9%), 43 Gunther Tulip (16.9%), 6 not specified (2.4%). Four patients underwent two separate retrievable filter episodes; the first filter dwell time was 70.3±38.4 days (range, 22–104 days). The time between filters was 572.3±400.3 days (range, 56–1009 days) with a second dwell time of 28.3±20.7 days (range, 9–49 days), the second procedure for all patients was uncomplicated. Recurrent PE despite having a filter *in situ* was reported in only five patients (1.9%); these included four females. The time of new PE after filter placement was early in three patients who underwent cancer surgery (7–136 days) and occurred later in two patients who underwent pulmonary endarterectomy (1662–2067 days).

Of the 254 filters inserted, an attempt at retrieval was made in 168 filters (66.1%), with a mean indwell time of 59.5 days (range, 3–537 days). The indication of surgery for a cancer did not have any affect on the filter retrieval rate over time (Log-rank P = 0.3372). A successful retrieval at the first attempt occurred in 143 cases (85.1%), while 25 cases failed or were aborted (14.9%). The filter was removed at the second attempt in seven cases, of note in these patients the initial attempt was aborted due to thrombus in the filter. In total retrieval was performed in 150 filters (59.0%) placed preoperatively and 58.0% of these were removed within three months from insertion (Fig. 1). Taking into account all retrieved filters small amounts of macroscopic thrombus were observed in five filters at extraction (3.3%).

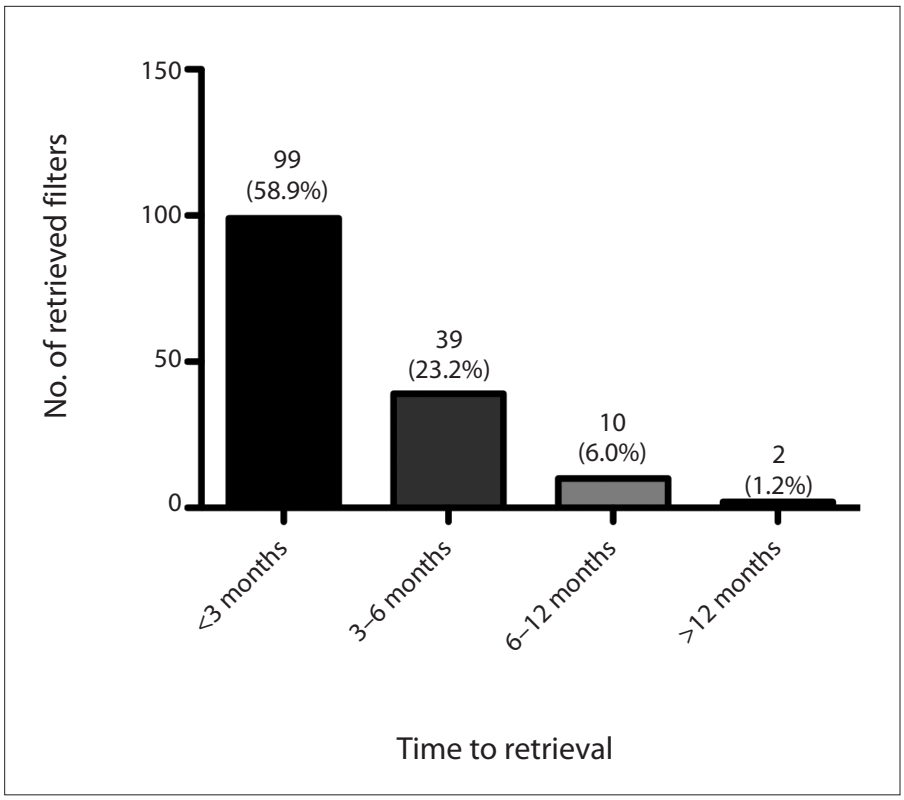

Figure 1. Time from insertion to retrieval categorized (percentage of total attempted retrievals, n=168).

Table. Types of surgery covered by retrievable filter

Type of surgery	Total inserted (n=254)	Indication for cancer surgery (% of inserted)	Retrieved (% of inserted)	*P*
Orthopedics	52 (20.5)	1 (1.9)	35 (67.3)	0.20
Pulmonary endarterectomy	39 (15.4)	0 (0)	9 (23.1)	<0.0001
Gynecology	35 (13.8)	15 (42.9)	24 (68.6)	0.24
Upper gastrointestinal	35 (13.8)	28 (80)	25 (71.4)	0.12
Colorectal	33 (13.0)	28 (84.8)	20 (60.6)	0.88
Urology	17 (6.7)	6 (35.3)	14 (82.4)	0.047
Hepatobiliary	16 (6.3)	9 (56.3)	9 (56.3)	0.79
Others*	27 (10.6)	5 (18.5)	14 (51.9)	0.66

There was a significant variation between the types of surgery and retrieval rate ($\chi^2 = 29.98$ with 11 degrees of freedom, $P < 0.0001$).
*Neurosurgery, n=6; bariatric, n=5; plastic surgery, n=4; not specified, n=4; vascular, n=3; breast, n=2; cardiothoracic, n=1; endoscopic retrograde cholangiopancreatography, n=1; maxillofacial, n=1.

Orthopedic procedures were the most commonly covered surgical group, with multiple surgical subspecialties referred for retrievable IVC filter insertion (Table). There was a significant variation between the types of surgery and retrieval rate ($\chi^2 = 29.98$; degrees of freedom, 11; $P < 0.0001$) with patients undergoing pulmonary endarterectomy identified as an outlier ($P < 0.0001$, Table). Thus, excluding pulmonary endarterectomy patients, overall retrieval rate was 65.6%.

In the 25 cases with an initial failed or aborted attempt no further attempt was made in 15 cases (60%). In the 25 cases of a failed initial attempt the reason for failure were due to thrombus in 13, angled filter in seven (two with leg outside wall also), leg outside wall alone in two, unable to snare in two, while the reason for failure was not reported in one case. A second attempt was made in 10 cases with a failed attempt in three due to an angled filter in two (one with leg outside wall) and thrombus in one case (Fig. 2). Time from filter insertion to retrieval was not significantly different between successful and failed retrieval attempts, 60 days (range, 3–537 days) versus 59 days (range, 5–262 days), respectively (Mann Whitney U, $P = 0.817$, Fig. 3). Two patients had filter dwell times in excess of 500 days, both patients had undergone orthopedic/plastic surgery and had reduced mobility following road traffic accident. At retrieval, snaring of the filter was uncomplicated with no evidence of endothelialization of the filter tips. There was no evidence that a specific filter type had a higher rate of failed retrieval.

No attempt at retrieval was made in 86 patients (33.9%), follow-up 901.2±85.4 days (range, 3–2752 days). In this subgroup, surgery for cancer was included in the indication in 30 patients (34.9%). In the cancer surgery group, 23 patients (77%) had died at follow-up (mean time to death, 351.5±101.3 days) where a terminal diagnosis had been made following surgery and further intervention to remove a filter was deemed superfluous. A large proportion of those filters not retrieved in the 56 patients who underwent noncancer surgery were in patients undergoing pulmonary endarterectomy surgery (n=26, 45.6%). The second largest noncancer surgery group comprised 13 patients (23.2%) who underwent traumatic orthopedic surgery and either had multiple comorbidites or were deemed too frail for further intervention, mean age 65.7±4.90 years (range, 41.0–87.7 years).

Furthermore, in all patients where no attempt at retrieval was made, preoperative cover for cancer surgery was associated with increased mortality; there were 25 deaths out of 92 filter insertions (27.2%) in cancer surgery compared with 18 deaths out of 162 (11.1%) in noncancer surgery (chi-square test, $P < 0.0107$). Absolute survival time was also significantly shorter in those undergoing cancer surgery (Log-rank $P < 0.0001$, Fig. 4) and survival time was limited from when the filter was inserted.

Discussion

In this study, we have reported the long term outcome of retrievable IVC filters inserted in our tertiary referral unit over a ten year period. The majority of retrievable IVC filters inserted in our unit were successfully removed and with a low complication rate. We have identified that many retrievable IVC filters that are inserted are ultimately left in situ in patients with cancer.

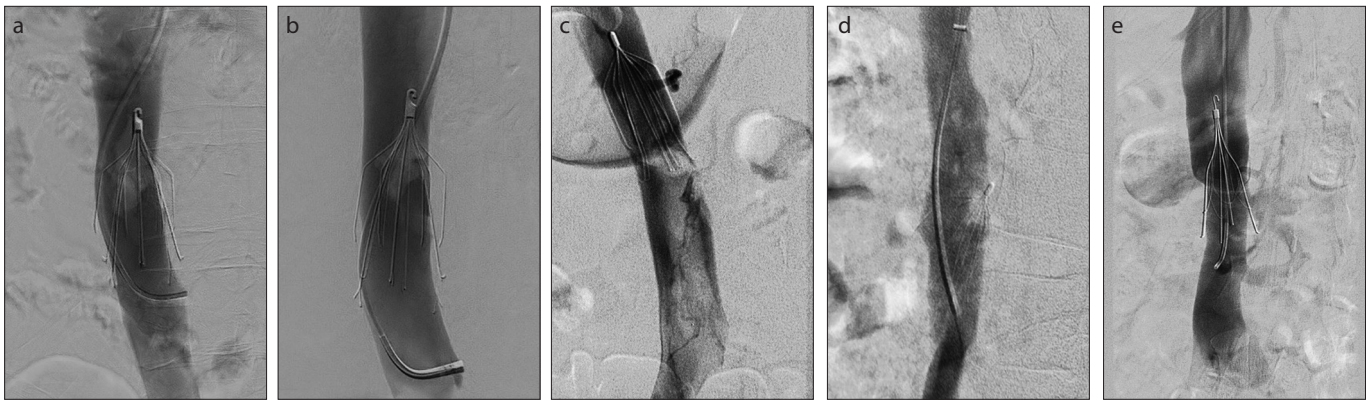

Figure 2. a–e. Reasons for nonretrieval of inferior vena cava (IVC) filter. Digital subtraction images **(a–e)** showing a moderate sized thrombus occluding filter (Denali filter) **(a)**; small thrombus **(b)** in the same patient as in **(a)** after two months of anticoagulation; large occlusive thrombus (recovery filter) **(c)**; angled filter (recovery filter) **(d)**; filter legs penetrating IVC wall (Gunther Tulip filter) **(e)**.

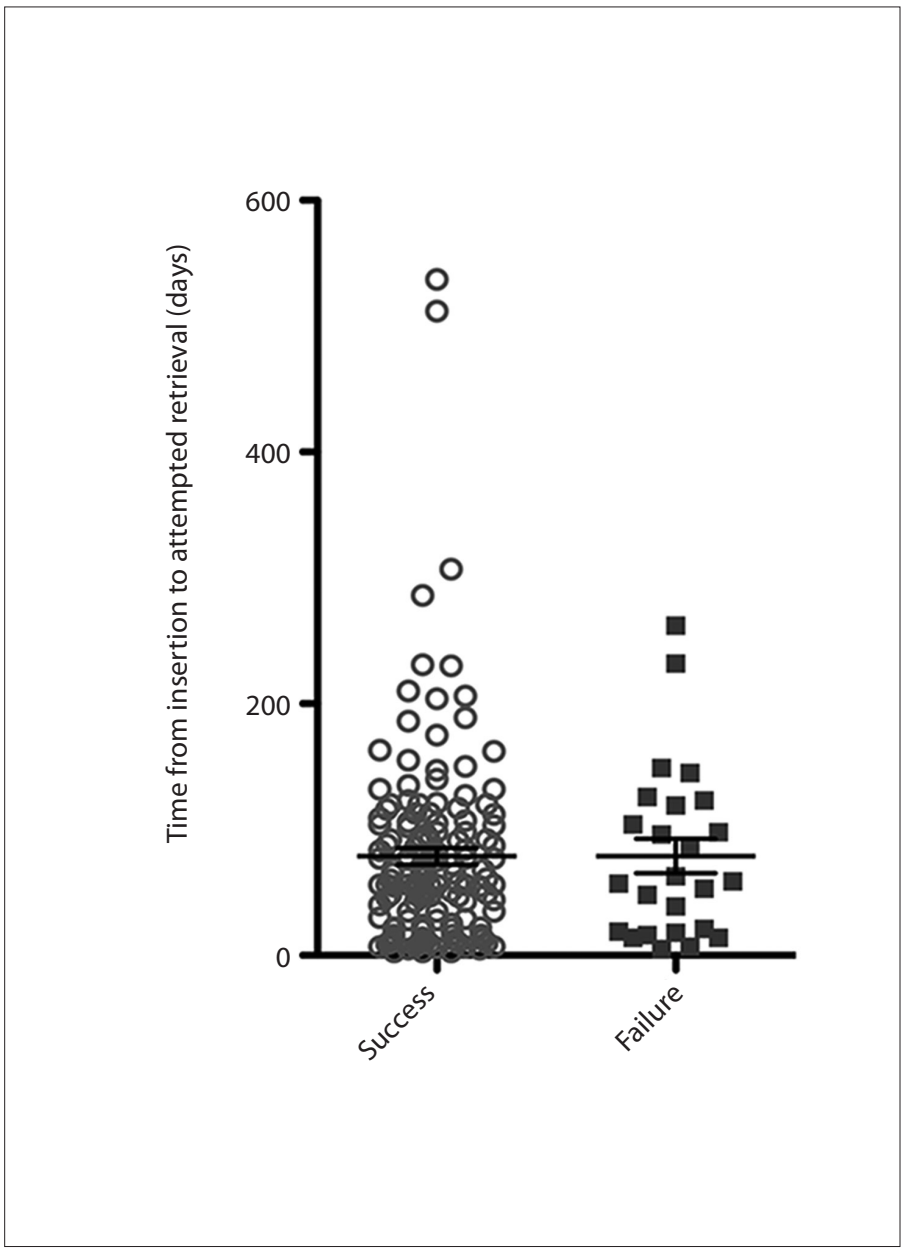

Figure 3. Time from insertion to initial retrieval attempt comparing failed and successful attempts (Mann-Whitney U test, $P = 0.817$).

A mean retrieval rate of 34% of retrievable IVC filters has been found following systematic review of eleven prospective clinical trials (5). Indeed, in the earlier studies, up to 70% of retrievable filters were not removed (10). Similarly retrievable IVC filters prior to surgery following trauma reported a retrieval rate as low as 35% (11).

The overall retrieval rate was 65.6% following preoperative insertion of a retrievable IVC filter and excluding patients undergoing pulmonary endarterectomy. It was considered to be reasonable to exclude this group, as there was little initial intention to retrieve these filters. It was the practice of the center performing the pulmonary endarterectomy surgery for a specific filter type, and the time window for retrieval was well outside that recommended. Thus, these filters were never expected to be retrieved. The decision to treat these retrievable filters as permanent filters was undertaken by the clinical team given the high life-long risk of patients with chronic thromboembolic disease of experiencing further PE. Our rate of attempted retrieval is similar to those reported in the largest series reporting over 200 cases of 60% (12), and 48.5% (13), although these studies were for all patients undergoing filter insertion and not just for PE prophylaxis during a surgical procedure. An increasing attraction of the retrievable filter is that it may be considered a permanent device if circumstances dictate.

Across the world, interventional radiology continues to develop as a separate subspeciality leading to radiology led clinics and independent management of these filter devices. In many centers where direct radiology-led follow-up is undertaken, this has been associated with an improvement in the rate of filter retrieval (14). Similarly,

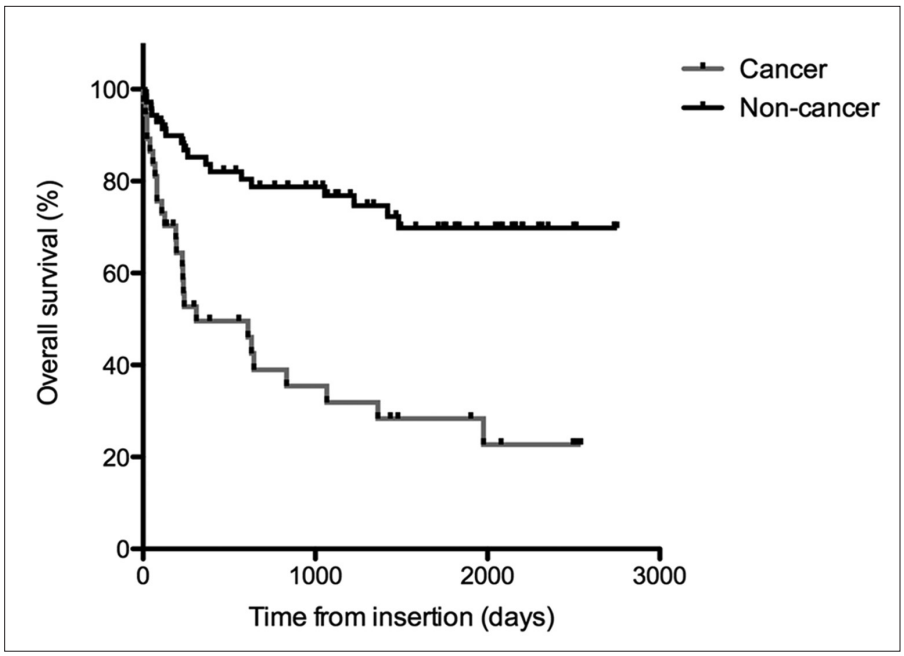

Figure 4. Survival in patients where no retrieval was attempted (Log-rank $P < 0.0001$).

dedicated tracking of patients in a registry was shown to double retrieval rates to 60% in a single center study (15). As such, we have more recently adopted a prospective register to track patients who undergo filter insertion and provisionally schedule patients for a retrieval date at the time of filter insertion. Improved global retrieval rates could be improved with increased provision for radiology-led clinics and dedicated radiology specific follow-up, in collaboration with the referring clinical teams.

In our cohort, those who received a preoperative retrievable filter and did not have the filter removed, were more frequently associated with cancer surgery (endarterectomy group excluded). Furthermore, among patients with nonretrieved filters, those who had it implanted for cancer surgery had a lower survival rate than those who had it for noncancer surgery, 27% vs. 11.1% respectively. We believe this addresses an important issue: the question of appropriateness of inserting a filter into a patient where the long-term prognosis is unknown. If the patient is deemed to have undergone "curative" surgery then the filter can be removed in a normal fashion whereas in those where it becomes apparent that there is more extensive, metastatic or recurrent disease and prognosis is poor the filter can be left *in situ* and deemed "permanent" for the remainder of the patient's life span. We suggest this reflects the clinical scenario in many interventional centers and reflects best practice for patients. Similar to our data, a large single center has reported the presence of metastatic cancer as a predictor of failure to retrieve a filter (12).

Early preclinical animal studies found that prototypes of the retrievable filters were firmly incorporated into the IVC wall three weeks after implantation, and thus retrieval was usually restricted to a two-week window following insertion (4). In our cohort, time from insertion to attempted retrieval was not a factor in failure to retrieve the filter; indeed others have reported a retrieval time up to 2475 days after the initial insertion date (16). In the United Kingdom, national guidelines suggest "a strategy for removing the IVC filter at the earliest possible opportunity" (17); however, no specific timeframe has been defined. In our series, 58% of filters were retrieved within three months, in line with the UK Department of Health Medicines and Healthcare products Regulatory Agency (MHRA) recommendations (18), but time from insertion to attempted retrieval did not appear to be a factor in failure to retrieve. We have found that a second insertion of a retrievable IVC filter is feasible and can be performed without any additional complication risk profile.

Over half of the initial failed filter retrieval attempts were due to thrombus within the filter on cavogram, most of these resolved or reduced to a sufficient size to allow safe removal after a period of anticoagulation. A large study has shown that 6.5% of filters had thrombus on initial cavograms; this is comparable to our study were 7.8% of initial retrieval attempts found clot sufficient to preclude retrieval. This group found that the incidence of filter thrombus decreased with dwell time and also that an additional period of anticoagulation successfully reduced the filter thrombus burden and facilitated later retrieval (19). The second most common reason for failure was due to an angled filter, and no specific filter type appeared to be particularly susceptible to this. Endothelialization has been postulated to play a role by covering the anchors or tip but in our series failure occurred even when performed within the three-month window.

This is a single center study and although the patients have been included in a prospective database, many of the data points have been collected in a retrospective manner. Though this may be thought of as a limitation it reflects the "real world" practice of clinical interventional radiology. Another drawback may be that as a tertiary referral center often patients return to their local hospital for further care, and there is a possibility that new practitioners in those centers could undertake filter retrieval at a later date. However, this is unlikely as the vast majority of specialist vascular procedures are performed in our center for the region. Patients may also move out of our region and have further care in other parts of the country; this can be considered a common universal draw back to all cohort studies and the only way to account for this is to censor those cases if it becomes known that the patient has moved.

In conclusion, insertion of a preoperative retrievable IVC filter for noncancer surgery results in an excellent retrieval rate, as long as there is a plan for retrieval made at the time of placement and close follow-up is maintained. In our unit, filter dwell time was not associated with an increased retrieval failure rate. A relatively large proportion of nonretrieved IVC filters are accounted for in patients who underwent cancer surgery and ultimately died with the filter *in situ*.

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Conflict of interest disclosure

The authors declared no conflicts of interest.

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