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## ORIGINAL ARTICLE

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# Factors Affecting Inferior Vena Cava Filter Retrieval Success Rate

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### ABSTRACT

**Objective:** To evaluate potential factors that may affect technical success rate in inferior vena cava filter attempts.

**Methods:** All inferior vena cava retrieval attempts from 2012 to 2016 at a single institution were reviewed. Patient demographics, indications for procedure, inferior vena cava filter type, presence of angulation, filter dwell time were compared between successful retrieval group and unsuccessful retrieval group. Statistical analysis was performed by using unpaired t test, Mann-Whitney U test, or Fisher's exact test, depending on the variables being evaluated.

**Results:** A total of 29 patients with 30 inferior vena cava filter retrieval attempts were included. Overall retrieval success rate was 83% (25 of 30). Inferior vena cava filter angulation of  $>15^\circ$  was observed in 3 of 5 (60%) unsuccessful retrievals compared with none of 25 (0%) successful retrievals ( $p = 0.002$ ). Mean filter dwell time was 61 days (median, 57 days) in unsuccessful retrievals compared with 51 days (median, 13 days) in successful retrievals. However, the difference was not statistically significant.

**Conclusion:** Inferior vena cava filter with an angulation of  $>15^\circ$  is associated with unsuccessful retrieval attempts.

**Key Words:** Vena cava, inferior; Venous thrombosis

## 中文摘要

### 取出下腔靜脈濾器成功率的影響因素

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**目的：**評估影響取出下腔靜脈濾器成功率的潛在因素。

**方法：**回顧2012年至2016年期間在一所分區醫院進行的所有下腔靜脈濾器取出的病例。將成功取出下腔靜脈濾器和失敗兩組間的患者性別年齡、手術指徵、下腔靜脈濾器類型、濾器有否傾斜，以及

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**Contributors:** All authors (HCL, WYW, FHN, CSC, and KLL) designed the study. HCL was responsible for acquisition of data. HCL and WYW contributed to the analysis of data. HCL and WYW wrote the article. All authors (HCL, WYW, FHN, CSC, and KLL) had critical revision for important intellectual content of this article. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

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濾器停留時間作比較。根據所評估的變量，使用非配對 $t$ 檢驗、Mann-Whitney  $U$ 檢驗或Fisher精確檢驗進行統計分析。

**結果：**共納入29名患者（涉及30例下腔靜脈濾器取出）。整體成功率為83%（25例）。在失敗的5例中（60%）有3例下腔靜脈濾器傾斜大於15°，而所有成功個案則無此情況（ $p = 0.002$ ）。不能取出的濾器的平均停留時間為61天（中位數，57天），而成功取出的濾器平均停留時間為51天（中位數，13天），兩組無統計學差異。

**結論：**下腔靜脈濾器的傾斜角度大於15°與不能成功取出相關。

## INTRODUCTION

Inferior vena cava (IVC) filters have been demonstrated to protect against pulmonary embolism in patients with deep venous thrombosis.<sup>1</sup> Common indications for IVC filter use include patients with acute venous thromboembolic event who cannot receive or have failed anticoagulation.<sup>2</sup> However, the use of IVC filters is not without complications. Long-term risks may include filter migration, embolisation, fracture, caval penetration, and thrombosis.<sup>3</sup> These complications can be avoided by removing the filters when their indications resolve.

The overall IVC filter retrieval rate varies across different centres and can range from 12% to 45%.<sup>4</sup> Technical success rate also varies. Data from the British Society of Interventional Radiology IVC Filter Registry showed an overall 83% technical success rate in attempted IVC filter retrievals.<sup>5</sup> Limited data are available regarding factors that affect technical success rate in IVC filter retrieval attempts. The aim of this study was to retrospectively review attempted IVC filter retrievals at our hospital and to evaluate factors that may affect technical success rate.

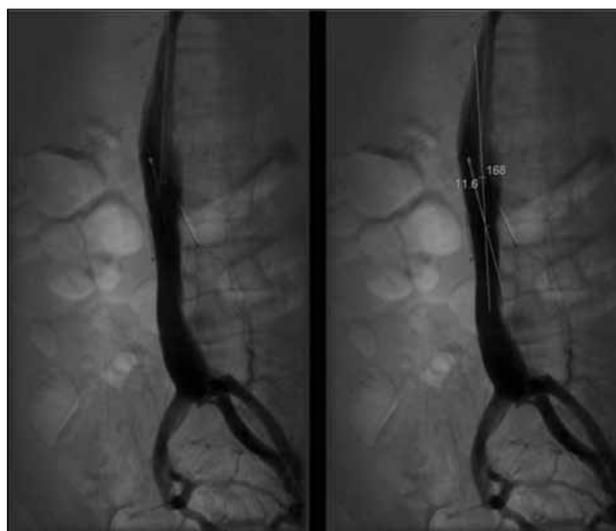
## METHODS

All patients with IVC filter retrieval attempt between January 2012 and December 2016 at a single hospital were identified by searching in the picture archiving and communications system database. No patient was excluded from the study.

Individual electronic medical records were retrospectively reviewed. Data regarding patient demographic information, co-morbidity, indication for IVC filter insertion, brand of IVC filter, dates of insertion and retrieval, procedural details from filter placement and retrieval, and presence of filter angulation were obtained. Filter angulation was determined by reviewing images in the picture archiving and communications system software (IMPAX; Agfa, Mortsels, Belgium) and using the angle markup tool. Two lines were drawn,

the first line paralleling the long-axis of the IVC at the level of the filter, and the second line passing through the apex of the filter bisecting the filter. Degree of filter angulation was defined by the angle formed by the two lines (Figure). Significant IVC filter angulation was considered present when the angle was  $>15^\circ$ . The  $15^\circ$  cut-off was determined by US Society of Interventional Radiology quality improvement guidelines.<sup>6</sup>

Two brands of IVC filter were used: the Celec™ Platinum Vena Cava Filter (Cook, Bloomington [IN], US) and the OPTEASE® Retrievable Vena Cava Filter (Cordis Endovascular, Miami Lakes [FL], US). The IVC filter retrieval attempts were performed via a right jugular vein or right or left femoral veins approach. An



**Figure.** Image from inferior vena cavogram performed before retrieval of a Celec Platinum Vena Cava Filter (Cook, Bloomington [IN], US). Using the angle mark-up tool, with one line paralleling the long-axis of the inferior vena cava at the level of the filter and the second line passing through the apex of the filter bisecting the filter, the degree of filter angulation was determined to be  $11.6^\circ$ . The filter was subsequently retrieved successfully using a conventional retrieval technique.

inferior vena cavogram was first performed to look for any significant thrombus within the IVC filter which would preclude its retrieval. The IVC filter retrieval was then performed with Günther Tulip® Vena Cava Filter Retrieval Set (Cook), or with OPTEASE Retrieval Catheter (Cordis) and Amplatz Goose Neck Snare (ev3/ Covidien, Plymouth [MN], US). The IVC filter was retrieved with the conventional retrieval technique, where hook of the filter was engaged by the snare, followed by advancement of the sheath over the filter, separating the filter from the IVC wall. Alternative retrieval technique was used at the attending radiologists' discretion when conventional technique was unsuccessful. Retrieval was considered unsuccessful if filter could not be retrieved. Abandoned procedure due to significant thrombus within the filter after inferior vena cavogram was not considered retrieval attempt or failure.

An unpaired *t* test was used to compare the difference in age of patients in successful and unsuccessful attempts. The Mann-Whitney *U* test was used to compare the difference in filter dwell time in successful and unsuccessful attempts. Fisher's exact test was used to compare the difference in sex, brand of filter, presence of angulation between successful and unsuccessful attempts.

**RESULTS**

Results are summarised in the Table. A total of 29 patients were identified, including nine men and 20 women, with a mean age of 67 years (range, 41-89 years). One of the patients had duplicated IVC with bilateral IVC filter placement. There were 30 IVC filter retrieval attempts, of which 25 (83%) were successful and five (17%) were unsuccessful. Indications for placement included deep venous thrombosis with contraindication to anticoagulation due to surgical operation (n = 20; 67%), and bleeding (n = 10; 33%). A total of 13 (43%) Celect (Cook) IVC filter and 17 (57%) OPTEASE (Cordis) IVC filter were placed. The reason for all five

cases of unsuccessful retrieval was inability to engage the hook of filter with snare by conventional technique. Loop snare technique was also used in one case but was unsuccessful. The IVC filters were retrieved by conventional techniques in all successful cases.

Angulation of >15° was present in 3 of 5 unsuccessful attempts (60%) and was absent in all cases of successful retrievals. This difference was statistically significant (p = 0.002). When the degree of angulation was compared as continuous variables, degree of angulation in unsuccessful attempts (mean, 13.8°; median, 18; range, 0-24) and successful attempts (mean, 3.4°; median, 2; range, 0-12) remained significantly different (p = 0.02; Mann-Whitney *U* test).

**DISCUSSION**

Pulmonary embolism is an important clinical condition associated with considerable mortality. The most common cause of pulmonary embolism is deep venous thrombosis in the lower limbs. The first-line treatment for deep venous thrombosis is anticoagulation. However, some patients may be contraindicated for anticoagulation medication. In these patients, IVC filters may be considered. These IVC filters are designed to be placed in the IVC and trap thrombi while preserving caval patency, thus preventing lower limb thrombi from embolising to the pulmonary arteries. In the PREPIC (Prevention du Risque d'Embolie Pulmonaire par Interruption Cave) study, IVC filters were shown to protect patients with deep venous thrombosis against development of pulmonary embolism.<sup>1</sup> Although a reduction of risk of pulmonary embolism was observed in the study, there was no demonstrable effect on survival.

Recommended indications for IVC filter insertion differ among different guidelines.<sup>2</sup> One indication generally recommended by all guidelines is patients with acute venous thromboembolism and contraindication to anticoagulation therapy. In addition, IVC filter insertion

**Table.** Patient and filter characteristics of patients with unsuccessful and successful inferior vena cava filter retrieval attempts.

	Unsuccessful attempts (n = 5)	Successful attempts (n = 25)	p Value
Age, mean (range)	75 (60-83)	65 (41-89)	0.18
Sex (men:women)	0:5	9:16	0.29
Underlying malignancy	2 (40%)	7 (28%)	0.62
Brand of inferior vena cava filters	Celect (n = 3) OPTEASE (n = 2)	Celect (n = 10) OPTEASE (n = 15)	0.63
Mean filter dwell time (days)	61 (median, 57; range, 9-158)	51 (median, 13; range, 8-308)	0.25
Angulation >15°	3 (60%)	0	0.002

is recommended in haemodynamically unstable patients as an adjunct to anticoagulation by several guidelines. In one retrospective study of 21095 unstable patients with pulmonary embolism, IVC filters were associated with a reduced in-hospital all-cause case fatality rate in all ages.<sup>7</sup> However, in the PREPIC II randomised controlled trial, it was found that the use of anticoagulant treatment in combination with a retrievable IVC filter did not reduce the risk of symptomatic recurrent pulmonary embolism at 3 months when compared with anticoagulation treatment alone in adult hospitalised patients with acute symptomatic pulmonary embolism and at least one severity criterion.<sup>8</sup>

The use of IVC filters is not without risks.<sup>9</sup> Periprocedural complications include venous access site bleeding, thrombosis, and rarely arteriovenous malformation. In the long-term, filter migration, fracture, or caval perforation may occur. Although IVC filters have been shown to protect against pulmonary embolism, these filters are associated with an increase in the occurrence of deep-vein thrombosis.<sup>1</sup> Caval thrombosis is also a common complication with published rates ranging from 2% to 30%. Some of these complications can be prevented by removal of filters when they are no longer needed. Thus, optional IVC filters were developed, allowing retrieval of the filter when its indication expires, reducing the long-term risk. These filters can also be left in place and function as permanent IVC filters. In fact, the US Food and Drug Administration has published a safety communication recommending that a patient should be referred for IVC filter removal when risk/benefit profile favours removal and procedure is feasible given patient's health status.

Technical success rates in IVC filter retrieval vary in the literature. Our success rate of 83% is similar to that reported in the British Society of Interventional Radiology IVC Filter Registry.<sup>5</sup> In a study by Glocker et al<sup>10</sup> where 121 IVC filter retrieval attempts were included, they found that mean time since IVC filter placement was significantly different between successful (median, 105 days) and unsuccessful (median, 162 days) retrieval groups, and that 90% of successful IVC filter retrievals occurred at or before 117 days following placement. Filter angulation of  $>20^\circ$  on anteroposterior radiograph was also found to be associated with unsuccessful retrieval attempts. In another study by Marquess et al<sup>11</sup> where 166 cases were assessed, the relation between degree of filter angulation and retrieval success was not significant. They found that prolonged dwell time and increasing patient

age were associated with failed filter retrieval. In a study by Dinglasan et al<sup>12</sup> in which preretrieval computed tomography (CT) images were reviewed, it was found that tip embedding has the strongest association with complicated retrieval (odds ratio=129), followed by a closely related parameter, angulation of more than  $15^\circ$  in any direction (odds ratio = 33). Filter dwell time also increased risk of a complicated retrieval by an odds ratio of 2.3.<sup>12</sup>

In the present study, although limited by a small sample size, filter angulation of  $>15^\circ$  was found to be significantly associated with retrieval failure. Filter angulation results in closer apposition of the filter tip to the IVC wall and greater difficulty in snaring the tip with devices.<sup>12</sup> Retrieval is also made more difficult by embedment and endothelialisation of the tip of angled filters.<sup>12</sup> We assessed IVC filter angulation on an anteroposterior radiograph taken during inferior vena cavogram performed before retrieval. This method of assessment is similar to that employed in the studies by Glocker et al<sup>10</sup> and Marquess et al.<sup>11</sup> The limitation of this assessment is the inability to assess anteroposterior angulation of IVC filters. According to the study by Dinglasan et al,<sup>12</sup> 46% of filters in their study showed normal angulation in one direction and angulation of  $>15^\circ$  in the orthogonal plane. In one of our patients with failed retrieval and filter angulation of  $<15^\circ$ , review of a CT study performed close to the time of retrieval showed anteroposterior angulation of the filter. Assessment in two orthogonal planes would give a more accurate picture on the actual degree of filter angulation. However, preretrieval CT was not routinely performed in our institution to allow for such assessment.

Although longer filter dwell time was reported to be associated with difficult retrieval by several studies, our study failed to show a statistically significant relationship between retrieval success rate and filter dwell time.<sup>10-12</sup> Failed filter retrieval occurred in one case with IVC filter angulation of  $24^\circ$  at only 9 days after placement. The longest time since placement in the successful retrieval group was 308 days. However, we did observe a higher dwell time in the unsuccessful group (mean, 61 days; median 57), compared with the successful group (mean, 51; median, 13). In fact, 52% (13 of 25) of the successful retrieval attempts occurred within 2 weeks of placement, compared with 20% (1 of 5) in the unsuccessful retrieval group. There is a chance that failure to show statistically significant difference could be due to the small sample size in our series.

Our study is limited by its retrospective nature and a relatively small sample size from a single institution. Conventional retrieval techniques were generally uniform, but different radiologists may have different degree of experience in IVC filter retrieval. The time spent during retrieval and the thresholds of using alternative techniques were at the discretion of the radiologists and not standardised. Only two different types of IVC filter were included in the study as other types of IVC filter were not available in our institution.

In conclusion, our study demonstrated that an IVC filter angulation of  $>15^\circ$  was associated with unsuccessful retrieval attempts. Radiologists should be prepared that difficult retrieval may occur with potential need for alternative retrieval techniques when significant IVC filter angulation is encountered.

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