

Can Pre-Retrieval Computed Tomography Predict the Difficult Removal of an Implementing an Inferior Vena Cava Filter?

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Purpose: Implementing an inferior vena cava (IVC) filter is a relatively safe procedure but potential negative long-term effects. The complications for filter retrieval have been noted. We examined filter characteristics on pre-retrieval computed tomography (CT) that were associated with complicated retrieval (CR) of IVC filters.

Materials and Methods: A retrospective review of IVC filter retrievals between January 2008 and June 2014 was performed to identify patients who had undergone a pre-retrieval CT for IVC filter retrieval. CR was defined as the use of nonstandard techniques, procedural time over 30 min, filter fractures, filter tip incorporation into the IVC wall, and retrieval failure. Pre-retrieval CT images were evaluated for tilt angle in the mediolateral and anteroposterior directions, tip embedding into the IVC wall, degree of filter strut perforation, and distance of the filter tip from the nearest renal vein.

Results: Of seventy-six patients, twenty-four patients (31.6%) with CRs and 56 patients (73.7%) with non-CR were evaluated for pre-retrieval CT. For IVC filter retrieval with a dwelling time of over 45 days, a tilt of over 15 degrees, the appearance of tip embedding and grade 2 perforation were associated with CR on multivariate analysis. However, for IVC filter retrievals with a dwelling time of less than 45 days, there were no factors associated with CR.

Conclusion: Pre-retrieval CTs may be more effective for IVC filters with a dwelling time of over 45 days. Therefore, a pre-retrieval CT may be helpful in predicting CR of IVC filters with long dwelling times.

Key Words: Venous thrombosis, Vena cava filters, Device removal

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INTRODUCTION

In the treatment of venous thromboembolism, inferior vena cava (IVC) filters are used in selected cases as an alternative treatment to avoid pulmonary embolism (PE) in patients who cannot receive anticoagulation therapy.

In August 2010, the U.S. Food and Drug Administration (FDA) released a communication on the removal of retrievable IVC filters and issued the following recommendation: “The FDA recommends that implanting physicians and clinicians responsible for the ongoing care of patients with retrievable IVC filters consider removing the filter as soon as protection

from a PE is no longer needed [1].”

There are potential negative effects of permanent use of IVC filters, and thus retrievable IVC filters have been developed. With the development of new generation retrievable IVC filters, the risk of developing long-term complications inherent to the use of older generation filters should become minimal, as long as the filters are retrieved [2]. Actually, difficult IVC retrieval cases have increased up to 10% of the total of all retrieval cases [3]. A systematic literature review of retrievable IVC filters by Angel et al confirmed that most complications (93%) associated with retrievable IVC filters occurred due to long-term use [4]. Thus, it was necessary to evaluate the difficulties of IVC filter retrieval with long dwelling time.

There have been studies that have analyzed factors associated with complicated retrievals (CRs) on pre-retrieval computed tomography (CT). However, there was no analysis between filter characteristics on pre-retrieval CT and dwelling time in CR of IVC filters [5]. The objective of our study was to evaluate the factors in pre-retrieval CT affecting complicated IVC filter retrieval focusing on the differences in dwelling time.

MATERIALS AND METHODS

We retrospectively reviewed patients who had undergone IVC filter retrieval at a single institution between January 2008 and June 2014. We only included patients that underwent retrieval after a CT scan.

We analyzed patient characteristics (age, sex and indication for IVC filter) and procedure (IVC filter type and dwell time). We examined the details of the IVC filter retrieval process and divided them into two groups: a CR group and a non-CR group. A CR was defined by the use of nonstandard techniques (external compression [Fig. 1A,

B], change of catheter to steer the snare [Fig. 1C, D] and IVC filter relining with a balloon), a procedural time over 30 min, and retrieval failure.

We compared the pre-retrieval CT images between the two groups with factors such as tilt angle, CT appearance of tip embedding, degree of filter strut perforation, and distance of filter tip from the nearest renal vein, as well as dwelling time. Tilt angle was determined by measuring the angle between the central longitudinal axis of the filter and the IVC wall, with mediolateral tilt angles measured in the coronal reconstructions and anteroposterior tilt angles measured in the sagittal reconstructions [5]. The perforation degree was divided by relation to the IVC filter tip and wall. Grade 0 was defined as all filter hooks being inside the lumen, grade 1 when the filter hook was inside the IVC wall and grade 2 when the filter hook was outside the IVC outer wall [6].

Our primary endpoint was the difference between the CRgroup and non-CRgroup. The secondary endpoint included factors that were related to CRagainst dwelling time.

To determine the risk factors related with CR, we conducted a multivariate analysis using patient characteristics, IVC filter details and pre-retrieval CT findings against dwelling time (<45 vs. >45 days), based on a post-market trial of Optease[®] (Cordis Corp., Miami, FL, USA) [7].

We compared between CR group and non-CR group with Fisher's exact test and independent t-test. To determine the risk factors related to CR, multivariate analysis was conducted using a logistic regression model.

RESULTS

Among the 149 IVC filter retrievals performed in 341 patients with IVC filter insertion between September 2008 and December 2014, pre-retrieval CTs were performed in 76

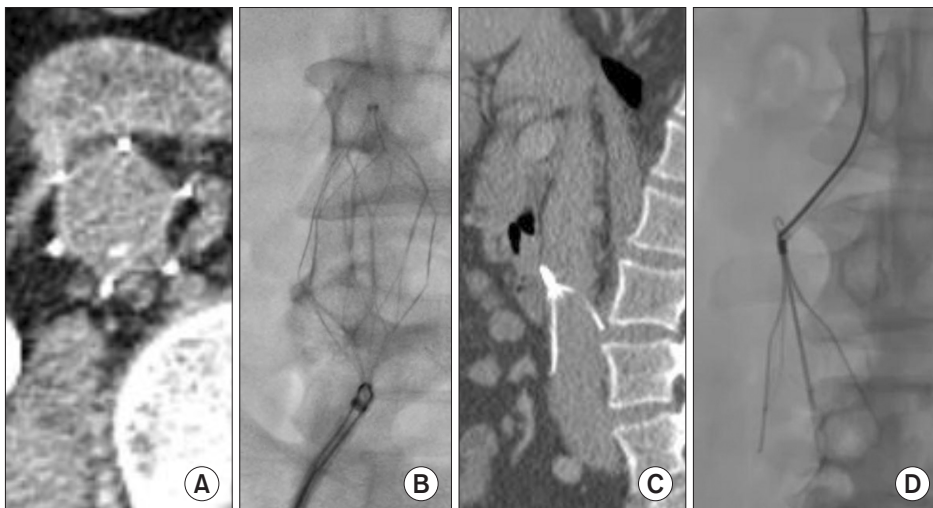


Fig. 1. (A) Axial computed tomography (CT) image shows grade 2 perforation. (B) Inferior vena cava (IVC) filter shape changes due to adhesion and external compression. (C) Sagittal CT image shows embedding to the IVC anterior wall. (D) Catheter-steered snare wire use.

Table 1. A comparison of characteristics between the CR group and the non-CR group

Variable	CR group (n=24)	Non-CR group (n=56)	P-value
Demographics			
Age (y)	53.0±23.2 (39-76)	59.0±29.5 (36-82)	0.652 ^a
Sex, male	16 (66.7)	32 (57.1)	0.749 ^a
Indications for insertion			
Pulmonary embolism	2 (8.3)	5 (8.9)	0.853 ^b
Thrombolysis	16 (66.7)	40 (71.4)	
Contraindications for anticoagulation	6 (25.0)	8 (14.3)	
Dwelling time (d)			
Within 45	50.0±78.1 (15-198)	38.0±42.5 (14-135)	<0.010 ^a
Over 45	10	20	
	14	36	
Type			
Optease®	18 (75.0)	47 (83.9)	0.754 ^b
Tulip®	6 (25.0)	9 (16.1)	

Values are presented as mean±standard deviation (range), number (%), number only. CR, complicated retrieval.

^aIndependent t-test, ^bFisher's exact test.

(51%) patients.

In this study, we only included patients who had undergone a pre-retrieval CT before IVC filter retrieval. Among the 76 cases with a pre-retrieval CT, there were 24 cases (32%) of CR.

There were 20 retrievals with nonstandard techniques (procedural time over 30 min or external compression: 14 cases, change of catheter to steer snare; 4 cases, IVC filter relining with balloon; 2 cases) and 4 retrieval failures.

There were no differences between the CR group and the non-CR regarding age, sex, indication for IVC filter and IVC filter type. However, dwelling time for the CR group was longer than that of the non-CR group ($P<0.01$) (Table 1).

In the pre-retrieval CT scans, there were differences between the two groups regarding tilt angle, tip embedding and perforation degree but there were no differences regarding distance from the renal vein. The total number of tilt angles over 15 degrees was 22 cases (91.7%) in the CR group, and 11 cases (19.6%) in the non-CR group ($P<0.01$). There were 7 cases (29.2%) of tip embedding in the CR group, and 1 case (1.8%) in the non-group ($P<0.01$). There were 15 cases (62.5%) of grade 2 perforation in the CR group, and 4 cases (7.1%) in the non-CR group ($P<0.01$; Table 2).

Additionally, in multivariate analysis, we found that for IVC filter retrieval with a dwelling time of over 45 days, a tilt angle of over 15 degrees (hazard ratio [HR], 6.476; 95% confidence interval [95% CI], 2.194-12.147; $P<0.01$), tip embedding (HR, 7.213; CI, 3.234-11.231; $P<0.01$) and grade 2 perforation (HR, 2.165; CI, 3.193-9.134; $P<0.001$) were associated with CR. However, for IVC filter retrieval with a dwelling time of less than 45 days, there were no factors associated with CR (Table 3).

Table 2. A comparison of computed tomogram findings between the CR group and the non-CR group

Variable	CR group (n=24)	Non-CR group (n=56)	P-value
Tilt angle			
Anteroposterior (mean, °)	15	3	<0.01 ^a
Mediolateral (mean, °)	19	4	<0.01 ^a
Tilt over 15°	22	11	<0.01 ^b
Tip embedding	7	1	<0.01 ^b
Perforation degree			
Grade 0	2	29	<0.01 ^b
Grade 1	8	23	
Grade 2	14	4	
Distance from renal vein (mean, mm)	11.2	12.1	0.87 ^a

CR, complicated retrieval.

^aIndependent t-test, ^bFisher's exact test.

DISCUSSION

In the treatment of venous thromboembolism, IVC filters are as an alternative treatment to avoid PE in patients who cannot receive anticoagulation therapy. Many retrievable IVC filters are available and are safe if retrievals are achieved [8].

However, complicated IVC filter retrievals have increased up to 64% of all IVC filter retrievals [9,10]. In our study, there were 24 CRs (31.5%) from a total of 76 retrievals in patients who had a CT angiogram. Thus, it was necessary to evaluate the factors predicting CR.

CRs caused by fibrosis due to chronically inserted filters can be performed by various methods such as advanced snare techniques and microdissection with endobronchial

Table 3. A multivariate analysis of factors associated with complicated retrieval according to dwelling time

Dwelling time	Over 45 days		Within 45 days	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Tilt over 15°	6.476 (2.194-12.147)	<0.01	4.476 (0.912-11.084)	0.08
Tip embedding	7.213 (3.234-11.231)	<0.01	3.742 (0.845-10.231)	0.15
Perforation degree (grade 2)	2.165 (3.193-9.134)	<0.01	1.165 (0.693-6.267)	0.45

OR, Odd ratio; CI, confidence interval.

*Logistic regression test.

forceps [6,11-13]. Dwelling time is the most important factor associated with CR, with a reported risk of 2-4 times higher for dwelling times longer than 180 days [14,15]. However, others have reported that dwelling time within 90 days was not significant [5].

In our study, dwelling time over 45 days was an important factor associated with CR. There were factors associated with CR in pre-retrieval CTs for dwelling times over 45 days, such as filter tip embedding, high tilt angles and high degree of perforation to the IVC wall, as in other studies [5,10,16].

If dwelling time was less than 45 days, pre-retrieval CT findings were not associated with CR in our study. This may be due to the lower degree of adhesion and fibrosis into the IVC wall with shorter dwelling time. The filter tip embedding, higher tilt angle and higher-grade perforation have been associated with adhesion and fibrosis into the IVC [5]. However, dwelling time was more strongly associated with adhesion and fibrosis into the IVC than pre-retrieval CT findings in our study.

There were some limitations in this retrospective study. The patients were not randomized and we did not control for the indications or choice of treatments. The recorded demographic and clinical characteristics did not differ

between the two groups, so the groups should be compared with caution. Yet, we found that if it was necessary to remove an IVC filter with long dwelling time, a pre-retrieval CT could help predict potentially CRs. For removal of IVC filters with long dwelling time out of the instructions for use, it is necessary to check filter tilting, embedding and perforation on pre-retrieval CT. It is also important to keep with the indications for IVC filter placement, and to remove IVC filters as soon as possible after insertion.

CONCLUSION

In conclusion, if dwelling time is longer than 45 days, pre-retrieval CT findings of tip embedding, increased tilt angle and higher-grade perforation are associated with complicated IVC filter retrieval. Therefore, a pre-retrieval CT may be helpful to predict the CR of an IVC filter with a long dwelling time.

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