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 CR group and non-CR group. The secondary endpoint included factors that were related to CR against 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

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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.
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 [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).

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