European Journal of Radiology Open 5 (2018) 73–78

Contents lists available at ScienceDirect

European Journal of Radiology Open

journal homepage: www.elsevier.com/locate/ejro

Is external compression on the IVC a risk factor for IVC filter abutment? A single center experience of 141 infrarenal celect filter insertions

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ARTICLE INFO

Keywords:
Inferior vena cava filter
Computed tomography
Abutment
Retrieval
External compression
Filter retrieval

ABSTRACT

Objectives: To investigate risk factors for inferior vena cava (IVC) filter abutment, including external compression on the IVC wall, using venous phase computed tomography (CT).

Methods: One-hundred-forty-one cases of Celect IVC filter insertion between January 2009 and April 2017 were retrospectively reviewed. On pre-procedural CT, IVC diameter and morphological classifications were measured. Filter tilt angle, IVC angle, vertical position, and filter tip abutment to the IVC wall were analyzed on post-procedural CT. IVC compression was examined by pre- and post-procedural CT analysis. Multiple logistic regression analysis was conducted to find factors related to IVC filter abutment.

Results: Of 141 IVC filter insertion cases, 52 were classified in the filter tip abutment group and 89 in the non-abutting group. IVC tilt angle (11.7 ± 5.5° vs. 6.4 ± 5.4°), presence of external compression (14/52, 27% vs. 9/89, 9%), and IVC morphology were different between the groups ($p < 0.05$). In multiple logistic regression analysis, filter-tilt angle over 9.25° and external compression on the IVC were found to be independent predictors of filter abutment (odds ratios: 4.56, 10.18, respectively).

Conclusion: IVC filter tilt, external compression on IVC wall, and IVC morphology were significantly different between the filter tip abutment and non-abutment groups. External compression and filter tilt over 9.25° were risk factors for filter tip abutment in multiple logistic regression analysis. By identifying these factors, we may be able to reduce filter tilting by preventing the filter from being deployed in a dangerous area.

1. Introduction

While anticoagulant therapy is the treatment of choice for deep vein thrombosis, inferior vena cava (IVC) filters are becoming increasingly popular as the only option to reduce the incidence of pulmonary embolism when anticoagulation is contraindicated. In addition to therapeutic purpose, prophylactic IVC filter insertion is also performed for patients with severe trauma or immobilization [1,2,3]. Permanent placement of a retrievable IVC filter increases the risk of IVC thrombosis and injury to adjacent organs [4,5]. The main reasons IVC filter retrieval fails are: (1) the filter hook is embedded in the IVC wall due to filter tilting; and (2) the filter limbs penetrate into adjacent organs [5,7]. Reducing IVC filter tilting at the time of insertion is essential for successful subsequent retrieval of the filter. However, despite advancement in IVC filter design and insertion techniques, the conditions leading to IVC filter tilting and abutment to the IVC wall are still unclear. Moreover, some factors, such as the connection between adjacent structures and IVC compression have not yet been investigated. Therefore, the purpose of this study was to investigate whether venous phase CT can reveal factors correlated with IVC filter tilting and abutment, and especially whether compression from adjacent structures affects the likelihood of filter tilting and abutment to the IVC wall.

2. Materials and methods

2.1. Patients and study design

This retrospective study was approved by our institutional review board, and informed consent was waived. We reviewed images in the picture archiving and communication system (PACS) and electronic medical records to identify patients who underwent Celect IVC filter insertion (Cook Medical, Bloomington, Ind, USA) between January 2009 and April 2017. During that period, 221 IVC filters were inserted at our institution. Among 221 filters, 181 were Celect IVC filters, and the remaining were other filters (n = 40). Forty patients were excluded for the following reasons: (1) absence of postprocedural angiography

Abbreviations: IVC, inferior vena cava; PACS, picture archiving and communication system

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https://doi.org/10.1016/j.ejro.2018.05.001
Received 14 February 2018; Received in revised form 18 April 2018; Accepted 2 May 2018

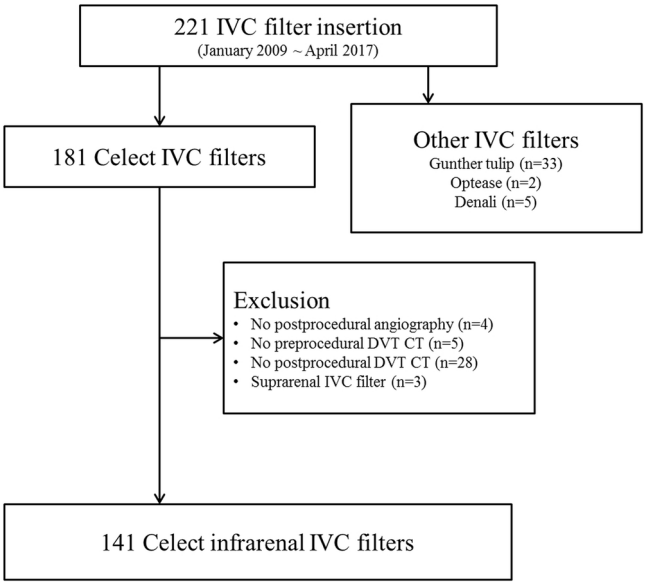

Fig. 1. Flow chart of study enrollment.
IVC, inferior vena cava, DVT, deep vein thrombosis, CT, computed tomography.

(n = 4), (2) absence of preprocedural venous phase CT (n = 5), (3) absence of postprocedural venous phase CT (n = 28), and (3) suprarenal insertion of the IVC filter (n = 3). Exclusion criteria and patient enrollment data are shown in Fig. 1.

2.2. IVC filter insertion and retrieval

All IVC filter insertions and retrievals were performed by one experienced interventional radiologist. After local anesthesia with 2% lidocaine (Jeil Lidocaine, Seoul, Korea), venous access was obtained either through the right internal jugular vein or right common femoral vein. Then inferior vena cavography was performed to identify the levels of renal vein insertion and to check for anatomical variants of the IVC prior to IVC filter deployment. All IVC filters were inserted into the infrarenal IVC. Post-procedure, anteroposterior vena cavography was obtained immediately after IVC filter deployment. Indications for IVC filter insertion are summarized in Table 1 and are categorized according to Society of Interventional Radiology guidelines [3].

IVC filter retrieval was performed using the standard snare technique with a filter retrieval set (Cook Medical, Bloomington, Ind, USA). Complex retrievals (requiring additional devices, such as balloon catheters) or complicated retrievals (resulting in IVC laceration or rupture) were analyzed. Filter retrieval failure was also analyzed.

Table 1
Indications of IVC filter insertion.

Therapeutic indications (evidence of PE or IVC, iliac, or femoropopliteal DVT)	103
Absolute or relative contraindication to anticoagulation	93
Massive PE with residual DVT in a patient at risk for further PE	9
Free-floating iliofemoral or IVC thrombus	1
Prophylactic indications	38
Multiple long-bone and pelvic bone fractures with BTK vein thrombosis	35
Intracranial hemorrhage with BTK vein thrombosis	3

IVC – inferior vena cava.
DVT – deep vein thrombosis.
PE – pulmonary thromboembolism.
BTK – below the knee.

2.3. Filter tilting and image analysis

All enrolled patients had a pre- and post-procedural venous phase CT scan. The post-procedural CT scans were conducted for pre-retrieval evaluation or follow-up of deep vein thrombosis. All CT scans were performed using the deep-inspiration breath-hold technique. The scan range was from the top of the intrahepatic IVC to tip of the toe, and was reconstructed with 5 mm section thicknesses. Various image parameters were measured with pre- and post-procedural venous phase CT. The mean interval between pre-procedural CT and procedure was 6 days (range 0–315) and 77 days between procedure and postprocedural CT (range 1–1035), respectively. Filter tilt angle, IVC angle, and vertical position of the filter were measured on a three dimensional workstation (AquariusNET, Terarecon, San Mateo, Calif, USA) using post-procedural CT data. Filter tilt angle was determined by comparing the long axis of the filter and the long axis of the IVC, and the IVC angle was measured by comparing the long axis of the IVC at the level of renal vein insertion with the long axis of the IVC at the level of IVC filter. The vertical position of the IVC filter was determined by measuring the number of vertebral bodies from the renal vein junction to the lower margin of the IVC filter. Filter tip abutment to the IVC wall was defined as visual abutment of the IVC filter hook against the IVC wall on three dimensional CT data, and was determined by consensus between two readers. Based on these data, enrolled patients were divided between the filter tip abutting and non-abutting group.

Measurement of IVC diameter and morphology were performed using the PACS system (Infinitt PACS, Infinitt Heathcare, Seoul, Korea) based on pre-procedural CT. On axial CT images, IVC long and short transverse diameters were measured at a point 4 cm below the lowest renal vein connection to the IVC. Morphologic characterization of the IVC itself was categorized as oval, round, or crescent shaped by analyzing axial CT images of the IVC at the same position.

After obtaining these data, extrinsic compression factors causing direct indentation and filter tip abutment to the IVC wall were analyzed on pre- and postprocedure CT, and were agreed to by our 2 readers. Subsequently, these factors were analyzed in both the abutting and non-abutting group. Additionally, subgroup analyses of these factors were performed with respect to retrieval rate and failed, complex or complicated retrievals.

2.4. Statistical analysis

For statistical analysis of continuous variables, the averages of our 2 readers' values were used. In univariate analysis, the independent sample *t*-test was applied for comparing continuous variables, and the Chi-square and Fisher's exact tests were used for categorical variables. A filter tilt of 15° was the cutoff used to evaluate both groups, in accordance with a previous study [3]. Finally, correlation between various parameters and filter tip abutment to the IVC wall was investigated with multiple logistic regression analysis. Prior to this analysis, an ROC curve was constructed to determine the best cutoff value for continuous variables. For statistical analysis, continuous variables were dichotomized after ROC analyses. Statistical analysis was performed using MedCalc version 17.5 statistical software (MedCalc Software bvba, Ostend, Belgium) and a P value less than 0.05 was considered statistically significant.

3. Results

One hundred forty-one Celect IVC filter cases were finally enrolled in this study. Seventy-three were men and 68 were women, with a mean age of 63 years ± 15 and range of 20–88 years. Among 141 patients, 52 patients were in the abutting group, and 89 patients were in the non-abutting group. Baseline patient demographic and imaging analysis data are summarized in Table 2.

Retrieval attempts were not statistically different between groups