# Scientific Session 15

# Caval Filtration and Intervention

Monday, June 13, 2022
3:00 PM–4:30 PM

## Abstract No. 143

### Gunther tulip filter strut penetration: benign long-term follow-up

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**Purpose:** IVC filter strut penetration of the caval wall is often cited as an indication for filter removal (1). Though a common finding on CT images, associated clinical manifestations are reported in $<$ 1% of cases (2–5). Nonetheless, the observation of a conical filter strut that appears to penetrate the caval wall remains a concern long-term because it is common, may be progressive, and there are case reports of serious strut-related symptomatic complications. This study was designed to assess the incidence, magnitude, and natural history of vena cava wall penetration by struts of the Gunther Tulip inferior vena cava filter.

**Materials and Methods:** An IRB-approved retrospective review identified 369 consecutive patients who had Gunther Tulip infrarenal filters placed over a 5-year period. Included were 203 (age 59.1 years, 59.4% male) who had subsequent CT imaging. Most common indication for the filters was venous thromboembolism (VTE) (87%) and either a contraindication to (48.8%), or a complication on anticoagulation (32.5%). Of 482 CT studies, no scans were performed for penetration-related symptoms, although 1.9% were obtained for suspicion of caval thrombosis. Clinical data and images were reviewed for evidence of complications and detailed position of the filter struts. For consistency, the penetration was measured on axial images from the outer caval wall to the inner edge of the distal end of each strut. Filter strut behavior over time was modeled using a Generalized Linear Mixed Model.

**Results:** Penetration was strongly positively correlated with filter dwell time, but the extent of penetration plateaued at 4 mm at 9 years follow-up. 79.2% of patients had at least one strut at least 0.2 mm, and 28% had a strut >3mm from IVC wall at a mean 5.5-year follow-up. There was greater penetration at all time points for women ($P$=.002). Abutment or penetration of adjacent structures were identified in 223 struts in 104 (51.2%) filters; of those, 80 had follow-up CT, and 47% showed progression and 19% regressed. There were no symptoms referable to filter strut penetration.

**Conclusion:** Gunther Tulip filter struts often appear to penetrate progressively through, or remodel, the IVC wall for the first 9 years, with minimal change subsequently. The findings of a high incidence of penetration, limited long-term progression, and a very low incidence of symptomatic complications in this and other unselected series (2-5) together support a non-interventional approach to asymptomatic Gunther Tulip filter strut penetration.

## Abstract No. 144

### Automated IVC filter detection from abdominopelvic CT exams using deep learning

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**Purpose:** IVC filters (IVCF) continue to be placed with regularity, estimated at over 30,000 per year in the USA. IVCF retrieval remains below 25% despite growing awareness of potential complications. “Loss to follow-up” is a common reason they may not be retrieved, especially when patients transition to new healthcare providers. This project aims to develop an automated, deep learning-based, approach to detect IVCF from abdominopelvic CTs performed for any reason. Once detected, this algorithm can automatically notify providers to evaluate the ongoing need for filtration.

**Materials and Methods:** 90 CT scans with IVCF and 90 scans without IVCF were selected randomly from a search of radiology report texts and verified by manual review. Selected scans included those without intravenous contrast and those in various phases after contrast administration. After anonymization they were pre-processed using *a priori* knowledge of IVCF locations. This included spatial cropping to remove 20% of the scan in the AP and left-right dimensions while limiting the craniocaudal extent to 40 cm from the lung bases. Intensity cropping was also performed to limit the Hounsfield units between 1 and 2,500. Finally, the scans were resampled to a matrix of 128 $\times$ 128 $\times$ 64 to allow a constant input size into the neural network.

The deep learning model is a 3D convolutional neural network with 3 convolutional layers. Max-pooling along with batch normalization were used after each layer. A total of 64, 128 and 256 filters were applied in the convolution layers ensuring the model received low and high-level features to create relevant feature maps. The model also performed dynamic image augmentation during training such as image rotation by a few degrees. This augmentation on-the-fly ensured the model would be able to detect IVCF without bias introduced by the image orientation.

**Results:** The model was trained for 100 epochs during which 144 images were used for training and 36 images used for validation. The model recorded its highest accuracy of 97.3% for training and 94.44% for validation.

**Conclusion:** Deep learning techniques can provide accurate detection of IVCF from CT scans that patients may undergo for a variety of reasons. This automated process has the potential to supplement the normal clinical workflow by analyzing scans independent of the interpreting radiologist and notifying the referring provider and/or affiliated interventional radiology service that an IVCF was detected. Future work involves integrating the algorithm with an IVCF tracking database to automatically add or remove patients to ensure appropriate follow-up is provided.

## Abstract No. 145

### Utility of inferior vena cava filters in perioperative prevention of pulmonary embolism in spine surgery patients

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