Update on Vena Cava Filters

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Current Treatment Options in Cardiovascular Medicine 2008, 10:101–111
Current Medicine Group LLC ISSN 1092-8464
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Opinion statement
Inferior vena cava (IVC) filter placement has increased dramatically over the past two decades. Filters are indicated to prevent pulmonary embolism in patients with venous thromboembolism (VTE) and a contraindication to anticoagulation or a complication of anticoagulation. Some of this increased use is the result of expanding relative indications for filter placement, including placement for primary prophylaxis. The US Food and Drug Administration has approved 11 filters for permanent deployment, two of which—the Günther-Tulip (Cook Medical, Bloomington, IN) and the OptEase (Cordis Endovascular, Miami Lakes, FL)—are optionally retrievable. Once anticoagulation is deemed safe, all patients should be fully anticoagulated to prevent propagation and recurrent thromboembolism. Complications related to IVC filters include procedure-related issues, device complications, and secondary VTE. Therefore, the decision regarding filter placement and/or retrieval must be individualized.

Introduction
Deep venous thrombosis (DVT) and pulmonary embolism (PE) are part of the spectrum of venous thromboembolism (VTE). Population-based studies estimate the annual rate of VTE at 128 per 100,000 US residents [1]. Thus, there are approximately 360,000 cases of VTE annually in the United States. This number appears to be growing and may be the result of increased recognition of VTE or perhaps the increase in use of medical and surgical services that raise the risk for secondary VTE [2]. VTE recurrence following the initial event is common and has been documented in up to 40% of patients during 10-year follow-up, with more than 10% of recurrent events attributed to documented or suspected fatal PE [2].

Current guidelines recommend anticoagulation as first-line therapy for all cases of VTE [3]. Anticoagulation is indicated to prevent thrombus extension and recurrent VTE. When anticoagulation is contraindicated or complicated, an inferior vena cava (IVC) filter may afford protection against pulmonary embolism. However, IVC filters do not treat VTE but rather help manage the risk for secondary PE. In the absence of anticoagulation, the patient remains vulnerable to thrombus propagation and new thrombus formation. No randomized trials have compared IVC filter placement while withholding anticoagulation versus anticoagulation in patients with underlying VTE to determine outcomes in this population. In many patients, an IVC filter is placed because of firm contraindications to anticoagulation, and outcomes in this population are not well documented. Therefore, once all the issues and concerns regarding anticoagulation have been addressed, current guidelines suggest that therapeutic anticoagulation be instituted despite IVC filter placement.

One reason for this recommendation is the concern regarding increased risk for secondary DVT following IVC filter placement. Décousus et al. [4] randomly assigned 400 patients to anticoagulation with or without IVC filter placement. At 2-year follow-up, patients with an IVC filter had a 20.8% incidence of recurrent DVT compared with 11.6% (P = 0.02) in patients without an IVC filter. At 8-year follow-up, the risk of recurrent DVT was no longer statistically significant but had increased. Recurrent DVT was demonstrated in 35.7% of patients with an IVC filter compared with a 27.5% DVT rate in the control population (P = 0.16) [5•]. Billett et al. [6] retrospectively assessed outcomes in 1628 patients after VTE and compared 251
patients treated with anticoagulation and IVC filter placement with 1377 patients treated with anticoagulation alone. There was no difference in the rate of secondary PE between the groups; hazard ratio at 90 days was 1.02 and at 5 years 0.96 ($P = 0.95$ and 0.88, respectively). There was a trend toward increased risk for recurrent DVT in patients with a filter. Over the 5-year study period, 41.4% of patients with an IVC filter had recurrent DVT compared with 36.2% of patients treated with anticoagulation alone ($P = 0.12$) [6]. Despite these results, it remains unclear whether IVC filter placement should change current recommendations regarding the duration or intensity of anticoagulation. Many authors still suggest that patients be treated with anticoagulation according to the VTE event [7••]. However, these results may serve as part of the impetus for improving filter design and retrievability.

### IVC FILTER PLACEMENT

IVC interruption was initially performed as open surgical ligation or plication. Surgically applied caval clips and intravenous umbrellas or filters followed. These techniques, however, were complicated by a high rate of IVC occlusion, migration, and perioperative complications. The first percutaneously inserted IVC filter, the Kimball-Greenfield, was approved for use in the 1970s. Today, all filters are placed transvenously.

Filter placement typically occurs in the angiography or surgical suite, with fluoroscopy and intravenous contrast to provide optimal visualization of the anatomy before insertion. More recently, some institutions have developed protocols for either bedside duplex ultrasound guidance or intravascular ultrasound (IVUS) to facilitate placement. These techniques limit radiation and contrast exposure. In addition, the bedside procedure protects critically ill intensive care patients or patients with multiple traumas from the rigors of transporting them to the interventional or surgical suite for the procedure. In one of the largest series published, Connors et al. [8] demonstrated successful ultrasound-guided (USG) IVC filter insertion in 284 of 325 patients (87%). Poor visualization, IVC thrombus, or a large vena cava prevented deployment in 12% of the patients. Filter misplacement occurred in six patients, and another six patients developed secondary complications of related thrombosis or filter migration. Hospital charges related to filter placement were $2388 less than filters placed fluoroscopically in the same year. Bedside USG IVC filter insertion is limited by the ability to identify necessary anatomic landmarks and presence of thrombus within the IVC. After the operator identifies the right renal artery posterior to the IVC and the left renal vein as it crosses anterior to the aorta, the filter can be placed in an infrarenal position during “real-time” imaging. The procedure is visualized from initiation until completion. Following deployment, an abdominal radiograph is taken to confirm the placement [9•]. IVUS-guided bedside IVC filter placement is another evolving technique [10•]. Although this procedure may be somewhat more invasive, IVUS overcomes the potential limitations of USG filter insertion, including abdominal wounds and excessive bowel gas. Again, placement confirmation with abdominal radiography is necessary. When feasible, USG or IVUS-assisted bedside IVC filter placement may be a good option for some patients.

### DEVELOPMENT

The Mobin-Uddin filter was the first device designed for intravascular IVC interruption. Because of its large size, venotomy was required for placement. In addition, it was associated with a significant rate of IVC thrombosis. The Mobin-Uddin filter was removed from use in 1986. Many of the design changes and modifications introduced since the earliest filters have been driven by the complications related to the currently available devices. Several characteristics are paramount to developing a successful filter. The ideal filter has good trapping capabilities and affords protection against large and small emboli without increasing the impedance to flow. The device should deploy in a central position and be resistant to tilting. When deployed, the filter should fix securely to the wall of the IVC to avoid migration. However, the anchoring points or struts should also not be prone to IVC wall perforation. The device must be biocompatible. It must resist corrosion and device fatigue/fracture. Limited interaction with the endothelium potentially reduces thrombogenicity as well as resisting endothelialization and facilitating retrieval. A small-caliber introducer is preferred to decrease the risk for procedural complications including insertion site thrombosis. The use of nonferromagnetic compounds allows MRI without excessive artifact from the device [11]. Available filters typically have similar designs. Conical filters, the Greenfield filters (Boston Scientific/Meditech, Natick, MA), and Vena Tech (B. Braun Medical Inc., Evanston, IL) have a central filtering device similar to the original Greenfield filter. Many of the other filters have dual-layer filtering designs with a central embolic capture point as well as a second caudal layer of filtration. These devices include the Simon Nitinol (C. R. Bard, Inc., Covington, GA), Günther-Tulip (Cook Medical, Bloomington, IN), Recovery/G2 (Bard Peripheral Vascular, Tempe, AZ), and Celect (Cook Medical, Bloomington, IN) filters (Fig. 1).

### FILTER TYPES

There are four different types of filters: permanent, optionally retrievable, temporary, and optionally convertible. Permanent filters are intended to be placed within the IVC, and no attempt to retrieve or reposition them is advocated. The optionally retrievable filters are approved for permanent placement but have characteristics that may allow percutaneous retrieval once the risk for PE has passed. Temporary filters remain tethered to the outside of the body by a wire or catheter. Removal is required within several weeks of placement.