Inferior Vena Cava Filters

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Venous thromboembolism is common. Most pulmonary emboli arise as thromboses in the deep veins of the lower extremities and may result in serious complications. Inferior vena cava filters (IVCF) are intended to prevent the passage of deep vein thrombosis to the pulmonary arteries. Accepted indications for IVCF placement include the presence of acute venous thromboembolism with inability to administer anticoagulation medication or failure of anticoagulation. Despite these clear indications, IVCF have been commonly placed in patients for primary prevention of pulmonary emboli in patients deemed to be at high risk, along with several other “soft” indications. As a result, IVCF use has been rising over the past 2 decades, especially given the retrievable nature of modern devices. Nonetheless, IVCF are not free of complications, which may occur during implantation and retrieval and while retained in the body. Despite this increase in use, the long-term efficacy remains unclear, and the management of patients with retained filters is often controversial. Finally, filter retrieval in eligible patients is relatively infrequent, suggesting that systems must be in place to improve appropriate filter use and to increase retrieval. (J Am Coll Cardiol Intv 2013;6:539–47) © 2013 by the American College of Cardiology Foundation

Venous thromboembolism (VTE) is common, with a reported incidence of 422 of 100,000 people in the United States (1). Left untreated, pulmonary embolism (PE) will occur in as many as 40% of all proximal deep vein thrombosis (DVT) (2). Whereas first-line treatment for VTE is anticoagulation medication, some patients will experience treatment failure, and anticoagulation is contraindicated in others. Inferior vena cava filters (IVCF), which represent an evolution of earlier techniques, have been gaining popularity (3). A review of trends over 21 years in the U.S. National Discharge Survey (1979 to 1999) and a Medicare survey citing trends between 1999 and 2008, reported a marked increase in the use of IVCF (4,5). Hospitalization rates for VTE have risen during the same period, although the rate of rise has flattened (1,6), especially when compared with prophylactic (7) and retrievable IVCF (rIVCF) use (8).

Indications for IVCF Implantation

There is significant controversy regarding the appropriate indications for IVCF placement. Recommendations have been suggested as part of several professional medical society consensus documents; however, the body of literature is generally lacking. There are significant differences among these guidelines (Table 1) (9–13). It is noteworthy that whereas the Society for Interventional Radiology’s guidelines delineate more instances in which filter deployment may be considered appropriate, the American College of Chest Physicians’ guidelines are actually less prescriptive, particularly given their recommendation to consider a subjective assessment of bleeding risk as a modifier of several indications (9).

Although all published guidelines agree that IVCF are indicated in patients who have an acute VTE and who cannot receive anticoagulation medications or in whom adequate anticoagulation has clearly failed despite evidence of appropriate use and effect, some indications are more...
controversial. Retrievable inferior vena cava filters (rIVCF) are inserted perioperatively in patients undergoing surgical pulmonary embolectomy with the intent of reducing the effect of post-surgical PE in this unstable population (14). In a retrospective analysis of mortality in 520 patients who were unstable secondary to PE and who underwent embolectomy, all of whom received an IVCF, mortality was lower than in 430 patients who did not receive a filter (25% to 58%, \( p < 0.0001 \)) (15). Furthermore, IVCF placement in patients with poor cardiopulmonary reserve is considered a relative indication by most guidelines (Table 1). The data to support this, however, are poor (9,16). Another relative indication for IVCF in several guidelines are free-floating ilio caval DVT; however, data are conflicting (17,18). Nevertheless, this subset of DVT still appears in the Society for Interventional Radiology guidelines and ACR appropriateness criteria as a relative indication for an IVCF (Table 1).

IVCF have been advocated for patients undergoing pharmacologic and pharmacomechanical thrombolysis of DVT due to the risk of “breakaway” pulmonary embolization (19). In a prospective analysis of 174 patients being treated with streptokinase for DVT via a temporary filter catheter, emboli were detected within the filter in 31.1%, 1 of which was as large as 6.5 cm (20). In an analysis of 17 patients who received rIVCF prior to treatment with catheter-directed thrombolysis or pharmacomechanical thrombolysis for DVT, a trapped thrombus was observed in 8 (47.1%) (19). Conversely, other studies have not shown a clinical benefit of filters during thrombolysis. Filter use and symptomatic PE were very low in a retrospective case-controlled study of catheter-directed thrombolysis in 303 limbs, where PE occurred in 6 patients (21).

IVCF are advocated for high-risk populations without VTE as a prophylactic measure, such as in trauma patients. However, there are several points of controversy regarding this practice. First, deployment-related complications, although uncommon and usually mild, can add morbidity (22). Second, patients will be at risk for long-term complications related to the device if the filter is not removed. Third, the reported incidence of lethal PE in trauma patients varies widely in the literature. In a review of 16 case series concerning trauma patients, PE occurred in 0% to 10% without a filter; however, information regarding patient characteristics and outcomes was limited (23). Fourth, there are alternatives to IVCF for thromboprophylaxis in many of these patients. In a randomized controlled trial of 442 trauma patients randomized to intermittent pneumatic compression or low-molecular-weight heparin, both treatments seemed effective (24). However, in a meta-analysis pooling data regarding 4,093 subjects in 73 studies that examined reported VTE incidence in trauma patients, the overall incidence for DVT and PE were 11.8% and 1.5%, respectively, and were not shown to be reduced by pharmacological or mechanical prophylaxis (25). Despite these uncertainties, prophylactic IVCF are commonly inserted in trauma patients in some institutions (26–29).

Another patient group that is at high risk for VTE is patients undergoing spine surgery. Over a 6-month follow-up period, 129 patients who underwent spine surgery and received a prophylactic IVCF did not develop VTE, whereas a matched cohort of 193 patients who received only mechanical thromboprophylaxis developed 8 PE over the same period (30). However, in another series in which 74 prophylactic IVCF were inserted, whereas the median time-to-event was not available, 23 patients developed DVT and 1 developed PE after 11 months (31).

IVCF as an alternative to anticoagulation have been suggested in patients with brain tumors and VTE. A retrospective analysis compared survival of 136 patients with brain cancer or intracranial hemorrhage and VTE who were treated with an IVCF and 39 patients who received anticoagulation treatment (32). In an adjusted model, the study showed a decrease in hospital mortality (8.8% vs. 12.8%) and an increase in total survival time (21 weeks vs. 11 weeks) in patients who received filters; however, both were not statistically significant, possibly due to lack of sufficient power.

Prophylactic IVCF have been advocated for chronically immobilized patients, although many of them can safely receive anticoagulation or be fitted with intermittent pneumatic devices. In a retrospective imaging-based report of a single-center experience of 371 patients with stroke who received an IVCF, most commonly for contraindications to anticoagulation (68%) and as prophylaxis (22%), PE occurred in 54 (15%) within a median of 3 weeks, DVT in 60 (16%), and symptomatic inferior vena cava (IVC) thrombosis in 5 (1.3%) (33).

Prophylactic IVCF are also being used in patients undergoing elective open gastric bypass surgery. These patients have a 1% to 4% chance of PE despite anticoagulation, most commonly within 1 month of surgery (34,35). Nonetheless, the quality of literature to support this practice is poor. A systematic review of IVCF use in bariatric surgery identified 11 studies, none of which were randomized. Four studies compared an IVCF to a non-IVCF group and 7 were case series (36). Most filters were implanted in high-risk patients; however, the definition for high risk differed between studies and little information was available regarding filter retrieval.

### Abbreviations and Acronyms

- **CI**: confidence interval(s)
- **DVT**: deep vein thrombosis
- **IVC**: inferior vena cava
- **IVCF**: inferior vena cava filter(s)
- **rIVCF**: retrievable inferior vena cava filter
- **PE**: pulmonary embolism
- **VTE**: venous thromboembolism
Filters are occasionally used in high-risk patients in conjunction with anticoagulation, recognizing the imperfection of standard anticoagulant therapy. In a comparison of outcomes of 251 patients who received both an IVCF and anticoagulation medications, most commonly for massive PE or VTE and failure of anticoagulation, and 1,377 patients receiving anticoagulation therapy alone for various indications, there was no difference in the incidence of PE at 90 days and 5 years and a nonsignificant trend toward more DVT in the IVCF group at 5 years (41.4% vs. 36.2%, p = 0.12) (37). In the PREPIC (Prévention du Risque d’Embolie Pulmonaire par Interruption Cave) trial, among 24 patients without a filter who developed PE, 46% were receiving anticoagulation medications (38). It is noteworthy that a Cochrane review of combined intermittent compression and anticoagulation for VTE prevention in high-risk patients showed the combination to be effective and safe (39).

Cancer patients being treated with anticoagulation for VTE are at particularly increased risk for recurrent VTE and bleeding (40). Consequently, IVCF are often indicated in this patient population in the setting of VTE. Mortality is increased in patients with malignancy regardless of IVCF use (41). Another concern in the cancer patient receiving an IVCF is caval thrombosis. A retrospective analysis of outcomes of 308 patients with cancer who had IVCF inserted for various indications reported IVC thrombosis in 14 (4.5%), PE in 4 (1.3%), and retroperitoneal hemorrhage in 2 (0.7%) (42). Most patients (248 [80.5%]) had either locally advanced or metastatic cancer. Also, in a multivariable analysis of the 8-year follow-up of the PREPIC trial, cancer was associated with increased risk for recurrent DVT.

### Table 1. Societal Guidelines for IVC Use

<table>
<thead>
<tr>
<th>ACCP (9)</th>
<th>SIR (10,12)</th>
<th>Appropriateness Criteria (13)</th>
<th>AHA (11)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Therapy for Acute VTE is Pharmacologic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Absolute Indications/Evidence Level I or Level IIa or High Appropriateness</strong></td>
<td>VTE and contraindication to anticoagulation</td>
<td>Chronic symptomatic PE</td>
<td>Adult patients with any confirmed VTE with contraindications to anticoagulation or with active bleeding complication</td>
</tr>
<tr>
<td>Acute VTE and contraindication to anticoagulation</td>
<td>Failure of anticoagulation in patients with VTE including recurrent VTE, complication of anticoagulation, and inability to achieve or maintain therapeutic anticoagulation</td>
<td></td>
<td>Recurrent acute PE despite therapeutic anticoagulation, it is reasonable to place an IVC filter</td>
</tr>
<tr>
<td><strong>Relative Indications/Evidence Level IIb or Mid-Level Appropriateness</strong></td>
<td>VTE with limited cardiopulmonary reserve</td>
<td>Acute PE and/or iliofemoral DVT</td>
<td>Patients with acute PE and very poor cardiopulmonary reserve, including those with massive PE</td>
</tr>
<tr>
<td>Unstable patients with PE may benefit from IVCF in conjunction with anticoagulation therapy</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Massive PE treated with thrombolysis/thrombectomy or chronic PE treated with thromboendarterectomy</td>
<td>Large, free-floating proximal DVT</td>
<td>Free-floating iliopelvical DVT</td>
<td></td>
</tr>
<tr>
<td>Thrombolysis for ilio caval DVT</td>
<td>Thrombolysis for iliocaval DVT</td>
<td>rIVCF for phlegmasia cerulea dolens undergoing endovascular treatment</td>
<td></td>
</tr>
<tr>
<td>Iliocaval DVT</td>
<td></td>
<td></td>
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<tr>
<td>Recurrent PE with a filter in place</td>
<td>Difficulty achieving anticoagulation or poor compliance to anticoagulation treatment</td>
<td>rIVCF as prophylaxis in high-risk patients</td>
<td></td>
</tr>
<tr>
<td>High risk of complications of anticoagulation (e.g., fall risk)</td>
<td>Prophylaxis for patients with severe trauma, closed head injury, spinal cord injury, multiple long bone injuries, prolonged immobilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Not Indicated/Not Appropriate</strong></td>
<td>Prophylaxis</td>
<td>Calf vein thrombosis and upper extremity DVT</td>
<td>Routinely as an adjuvant to anticoagulation and systemic fibrinolysis in the treatment of acute PE</td>
</tr>
<tr>
<td>Prophylaxis for patients with severe trauma, closed head injury, spinal cord injury, multiple long bone injuries, prolonged immobilization</td>
<td></td>
<td></td>
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</tbody>
</table>

*The appropriateness criteria are not clear in their scoring of acute VTE and contraindication to anticoagulation.

ACCP = American College of Chest Physicians; AHA = American Heart Association; DVT = deep vein thrombosis; IVC = inferior vena cava; IVCF = inferior vena cava filter; PE = pulmonary embolism; rIVCF = retrievable inferior vena cava filter; SIR = Society of Interventional Radiology; VTE = venous thromboembolism.
from 1991 to 1995 to Do They Prevent Pulmonary Emboli?

(hazard ratio: 2.46, 95% confidence interval [CI]: 1.27 to 4.73, p = 0.007) (38).

A population-based study analyzed hospitalization records from 1991 to 1995 to find that the rate of rehospitalization for PE did not decrease with the use of IVCF, whereas rehospitalization for DVT increased (43). Furthermore, the investigators of a Cochrane database review could not draw firm conclusions regarding the effectiveness of PE reduction with IVCF use (44). There are no studies that randomized patients to receive either an IVCF or anticoagulation treatment. The PREPIC trial was a prospective, randomized, controlled study of 400 patients with DVT who were assessed to be at high risk for PE to receive anticoagulation medications with or without 1 of 3 types of permanent IVCF: VenaTech LGM (B. Braun, Woburn, Massachusetts), titanium Greenfield (Boston Scientific, Natick, Massachusetts), or Bird’s Nest (Cook Medical, Bloomington, Indiana) (45). Patients were actively screened for PE at baseline and after 8 to 12 days, but DVT was defined only with associated symptoms. At 12 days, there was a significant reduction in PE in the IVCF group (4.8% vs. 1.1%, p = 0.03). Many patients died of causes unrelated to VTE, and IVCF did not show a mortality benefit. By 2 years, more patients in the filter group developed a symptomatic DVT (20.8% vs. 11.6%, p = 0.02) and mortality remained similar between groups (21.6% vs. 20.1%, p = 0.65). Furthermore, only a nonsignificant decrease in PE in the IVCF group was noted (3.4% vs. 6.3%, p = 0.16). At 8 years of follow-up, there was still no mortality benefit, despite a persistent significant reduction in PE, and DVT rate was still increased in the IVCF group (38). Unstable patients with PE have the greatest potential to appreciate a mortality benefit from IVCF. A retrospective analysis of outcomes in 38,000 patients who were unstable as a result of PE revealed a 35% mortality benefit for patients who had an IVCF in place compared with those who did not (33% vs. 51%, respectively, p < 0.001) (46).

Some studies actually showed worse outcomes for patients who received an IVCF. A retrospective, population-based study examined the outcomes of 1,547 patients, 203 of whom had a permanent IVCF placed for various indications. At a median of 926 days, all-cause mortality was higher in the filter group (p < 0.001) and more patients in this group had DVT (21% vs. 14.9%, p = 0.009), whereas the incidence of PE was no different (1.7% vs. 5.3%, p = 0.18) (47). Nonetheless, patients who received filters were more likely to be more severely ill than were those who did not.

A direct comparison of efficacy and complications between permanent IVCF and rIVCF is complicated as these are 2 heterogeneous groups of devices. However, a retrospective series comparing 427 rIVCF and 275 permanent IVCF over a mean of 11.4 months reported PE, DVT, and IVC thrombosis rates to be similar (4% vs. 4.7%, p = 0.67; 11.3% vs. 12.6%, p = 0.59; and 1.1% vs. 0.5%, p = 0.39, respectively) (48). Patients with permanent IVCF were older and more likely to have an intercurrent malignancy; however, rIVCF were inserted more often in patients with proximal DVT and in patients undergoing catheter-directed thrombolysis. Similarly, a systematic review of 9,659 permanent IVCF and 860 rIVCF reported PE in 1.1% to 3.2% and DVT in 11.4% of the cohort (49).

Technical Aspects of IVCF Placement and Removal

Placement of an IVCF should be preceded by an assessment of the patient’s duration of risk of PE and life expectancy. Currently, a choice should be made between permanent and retrievable IVCF (Table 2) (50–52). In the future, these patients will also be candidates for convertible devices (53).

Prior to the insertion procedure, any available cross-sectional imaging should be reviewed for IVC and access site anatomy, patency, and anomalies. The majority of filters are placed using fluoroscopic guidance in interventional suites, but intravascular ultrasound can be used for bedside placement in unstable patients or immovable patients (Fig. 1). Depending upon the design of the filter and diameter of the delivery sheath, filters can be inserted from the femoral, jugular, or antecubital veins. The IVC is imaged to assess diameter, patency, presence of congenital anomalies, and the location of the renal veins (Fig. 2A). The usual target-landing zone for IVCF is the infrarenal IVC, close to the level of the renal veins (Fig. 2B). The diameter of the IVC in the target-landing zone is important, as each filter is rated for a maximum IVC diameter, above which the likelihood of embolization of the filter itself is increased (Table 2). The maximum IVC diameter that can be treated is 40 mm (Bird’s Nest filter), with most devices intended for cavae up to 28 to 31 mm in diameter. Some devices require minimum caval diameters in order to open or fixate properly. This information is provided in each device’s instructions for use. In patients with certain IVC anomalies, pregnancy (or likelihood of future pregnancy), extensive IVC thrombus, or renal vein thrombosis, the filter can be placed in the suprarenal IVC (55). Outcomes of filters in this location appear to be similar to those placed in the infrarenal IVC.

The filter is then inserted according to the instructions for use. Confirmation of complete IVCF deployment, placement in the intended location, and correct orientation are important. Operator errors include misplacement of the filter in nontarget veins such as renal, gonadal, and ascending lumbar. Many filters are packaged in universal delivery sets, so that there is potential for the device to be inadvertently placed upside down.
Filter removal is performed with local anesthesia and intravenous sedation in most cases. Patients on therapeutic anticoagulation should be maintained in the therapeutic anticoagulant range at the time of the procedure (56). The presence of trapped thrombus is excluded with caval venography. When a large or fresh-appearing thrombus is found, the procedure is terminated, and the patient maintained on anticoagulation medications. In most cases, the thrombus will resolve in 4 weeks and the filter will subsequently be removed (57).

Each IVCF is designed for removal from a venous-specific access: in most cases, the jugular vein. A few devices can be removed from the femoral venous approach. The procedure requires fluoroscopic imaging, either single or bi-plane. After the vena cavogram is performed, a sheath capable of receiving the filter is positioned close to the device. A variety of devices and techniques with escalating aggressiveness can be used to remove a filter. When filters are centered in the IVC and not firmly attached to the walls of the cava, simple snares or dedicated filter-grasping devices are often effective. In some cases, the filter is not easily engaged, and shaped catheters are necessary to pass a guidewire around the filter. The guidewire tip is then snared and externalized through the sheath, effectively constructing an in situ snare (58). After securely engaging the filter, the sheath is advanced over the device to collapse it and/or the device is pulled into the sheath. Common sheath sizes range from 8- to 12-F. The filter should be inspected for missing elements after removal, and a repeat IVC venogram should be obtained to document integrity and patency of the IVC. Adherent or tilted filters may require advanced retrieval techniques including dissection away from the wall of the IVC.

Table 2. FDA Approved rIVCF Main Characteristics

<table>
<thead>
<tr>
<th>Filter</th>
<th>Recommended Time-to-Retrieval</th>
<th>Introducer Size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celect (Cook Medical, Bloomington, Indiana)</td>
<td>Retrieval was 97% at 179 days and reported up to 466 days (50)</td>
<td>7-F</td>
<td>Can be used up to a maximal IVC size of 30 mm</td>
</tr>
<tr>
<td>Gunther Tulip (Cook Medical, Bloomington, Indiana)</td>
<td>Retrieval success rate was 94% at 12 weeks and reported up to 494 days (51)</td>
<td>11-F</td>
<td>Can be used up to a maximal IVC size of 30 mm</td>
</tr>
<tr>
<td>G2 (Bard Peripheral Vascular, Tempe, Arizona)</td>
<td>Retrieval was 86.9% at 131 days and reported up to 602 days (52)</td>
<td>7-F</td>
<td>Can be used up to a maximal IVC size of 28 mm. High rates of tilting that precludes retrieval, fracture, and migration have been reported</td>
</tr>
<tr>
<td>Optease (Cordis, Miami Lakes, Florida)</td>
<td>23 days</td>
<td>Can be used up to a maximal IVC size of 30 mm</td>
<td></td>
</tr>
<tr>
<td>ALN Filter (ALN Implants Chirurgicaux, Ghisonaccia, France)</td>
<td>“Unlimited”</td>
<td>6-F</td>
<td>Approved for IVC up to 28 mm in the United States and 32 mm in Europe</td>
</tr>
<tr>
<td>SafeFlo (Rafael Medical Technologies, Caesarea, Israel)</td>
<td>N/A</td>
<td>6-F</td>
<td>Available for IVC 16-25 mm</td>
</tr>
<tr>
<td>Option (Rex Medical, distributed by Argen Medical Devices, Plano, Texas)</td>
<td>175 days</td>
<td>5-F</td>
<td>Can be used up to a maximal IVC size of 32 mm</td>
</tr>
<tr>
<td>Crux (Crux Biomedical, Menlo Park, California)</td>
<td>In a multinational study, 98% of filters were retrieved within 84 ± 57 days</td>
<td>6-F</td>
<td>Can be retrieved from the jugular or the femoral approach. Two sizes offer protection for IVC sizes 17-28 mm</td>
</tr>
</tbody>
</table>

FDA = U.S. Food and Drug Administration; N/A = not available; other abbreviations as in Table 1.
IVC with endobronchial forceps or laser-rimmed lead extraction sheaths (59). In extreme cases, open surgical removal can be performed. Whenever advanced techniques are required, the risk of a complication is increased, and leaving the filter in place permanently should be considered as an important option.

Complications Associated With IVCF

Most of the IVCF complication-related literature is composed of case reports. It is likely that the complication rate is under-reported (60). The MAUDE (Manufacturer and User Facility Device Experience) database, a Food and Drug Administration voluntary registry, has accumulated only 842 IVCF-related complications in 10 years between 2000 and 2010 (61). In this database, most complications were reported 30 days or later after implantation. Different filters seem to vary in their complication profile, but comparisons are scarce. Complications may occur during implantation or retrieval or when a filter is retained. Insertion-related complications have been reported in 4% to 15% of patients and include puncture site-related problems, misplacement, migration, filters failing to deploy properly, and vena cava perforation (22,62). An uncommon complication is symptomatic access site DVT (3%); however, asymptomatic thrombi that can be detected by ultrasound are of questionable clinical significance and much more common (35%) (63,64). Complications of retained filters and their reported incidence, when available, include filter migration or embolization (3% to 69%), strut fracture and penetration (9% to 24%), IVC thrombosis (6% to 30%), lower extremity edema, post-thrombotic syndrome (5% to 70%), DVT (0% to 20%) (23), and recurrent PE (3% to 7%) (4,16,48,62) (Fig. 3). It is noteworthy that retained thrombus within the filter is often cited as proof of filter effectiveness, and, indeed, some breakthrough PE are fatal. Also of note is that IVC thrombosis can sometimes be asymptomatic, such as when discovered on imaging performed for other indications (65).

Management of Patients With IVCF

It is believed that many of the thrombotic complications of IVC filters can be avoided by prompt removal of rIVCF. As time from implantation elapses, the chances for VTE persist (38), but contraindications to anticoagulation may have resolved (66). Furthermore, most available data points to the fact that as filters are retained, more long-term complications may occur (38,66). In a series of 140 rIVCF inserted in trauma patients, complications occurred in 13.3% despite a median dwell time of only 21 days (67). Accordingly, guidelines suggest that rIVCF should be retrieved (9,11) and the U.S. Food and Drug Administration issued a statement to this effect (68). Manufacturers typically state that retrieval is more likely to be successful if attempted within several weeks to months (69). In most reported series, upward of 85% of rIVCF could theoretically be retrieved (62). However, the aforementioned reviews of rIVCF use reported retrieval in only 33.6% and 34% of over 10,000 cases (60,70). The most commonly cited reasons for nonretrieval include patient loss to follow-up (28) and lack of follow-up (71), as well as patient noncompliance (72). In response to this data, various systems have been devised to improve the rIVCF retrieval rate. Another still-experimental approach is to develop absorbable IVCF that will disappear from the body, preferably after the acute indication has passed (73). Duration of anticoagulation administration is another filter-related management issue. Patients with VTE should be treated with anticoagulation medication according to their underlying condition, as retained IVCF are not specific indications for anticoagulation therapy (9). If an IVCF has been deployed because of a contraindication to anticoagulation, treatment should resume once the contraindication has subsided (11). Prolonging anticoagulation administration in patients with retained filters
has potential advantages such as reducing filter-related IVC thrombosis and minimizing recurrent PE, but it also carries an increased risk of bleeding (74). The presence of an IVCF as an indication for anticoagulation is still a matter of debate suffering from a paucity of high-quality data. Most reports of IVCF-related thrombotic complications lack information about whether patients were receiving anticoagulation medications and about the quality and intensity of anticoagulation treatment (37). A nonrandomized prospective cohort of 121 patients with permanent IVCF who were given long-term anticoagulation treatment reported 6 (5%) recurrent PE and 24 (19.8%) new DVT during a median follow-up of 3.1 years, which corresponded to an incidence rate for PE of 1.6 per 100 patient-years (95% CI: 0.7 to 3.5) and for DVT of 7.0 per 100 patient-years (95% CI: 4.8 to 10.0) (74). IVCF thrombosis that was not clinically evident was detected by routine ultrasonography in 7 (5.8%) patients. These were all resolved within 8 weeks of oral anticoagulation being substituted by low-molecular-weight heparin. Major bleeding occurred in 8 (6.6%) patients.

**Future Issues**

As stated throughout this review, several publications in the field of IVCF are of suboptimal quality. Accordingly, a committee within the Society for Interventional Radiology convened in 2009 recommended a randomized trial of IVCF prophylaxis and a comparison between IVCF and anticoagulation therapy in patients who have an indication for anticoagulation (53). Furthermore, a national IVCF registry has been developed to collect data regarding patients with IVCF for 48 months (NCT01367184). Also, a second version of the PREPIC trial (PREPIC 2), a multicenter randomized study comparing outcomes of patients with VTE being treated with anticoagulation therapy with or without rIVCF, has completed recruitment (NCT00457158).

**Conclusions**

The increased use of IVCF is not supported by high-quality evidence. The only indications for IVCF that are widely accepted are in patients with acute VTE and absolute contraindications to anticoagulation or in patients who have failed adequate anticoagulation. Notwithstanding, IVCF likely have a role in the treatment of some high-risk patient populations. Further research is needed to ascertain specifically, which patient populations outside these strict criteria actually benefit from filter implantation. Finally, prompt filter retrieval is crucial as complications may accrue soon after implantation, and dedicated surveillance must be in place in centers that perform IVCF implantation.

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72. Silberzweig JE. Successful clinical follow-up for trauma patients with retrievable inferior vena cava filters (IVC) filters can be challenging to achieve. J Trauma 2007;63:1193, reply 1193.

Key Words: deep vein thrombosis • inferior vena cava filter • pulmonary embolism • venous thromboembolism.