THROMBO-EMBOLIC DISEASE

Role of vena cava filters in high-risk trauma and elective orthopaedic procedures

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KEYWORDS
Vena cava filters; Thromboembolism; Deep vein thrombosis; Prophylaxis

Summary
Pulmonary embolism (PE) is the leading cause of death after trauma and is the most common cause of death in the immediate post-operative period after lower limb reconstructive procedures. Although, systemic anticoagulation is the corner stone of both prophylaxis and treatment of venous thromboembolism, there is increasing awareness and usage of vena caval filters (VCFs) in high-risk patients. Instead of permanent filters, retrievable filters are predominantly used nowadays by interventional radiologists aiming to avoid long-term complications such as inferior vena caval obstruction and post-phlebitic syndrome. It is evident from the available literature that prophylactic filters do protect against fatal PE in high-risk trauma and patients undergoing complex lower limb reconstructive procedures; however, there is uncertainty about the efficacy of different types of filter designs and clear indications of the high-risk group remain controversial.

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Introduction
Orthopaedic and trauma patients constitute a major group of hospital patients with an increased risk of venous thromboembolism.1 Incidence of deep vein thrombosis (DVT) has been reported to be as high as 35–65% in trauma patients2,3 and up to 84% in the patients undergoing total hip and total knee arthroplasties.4 Incidence of pulmonary embolism (PE) in trauma patients has been reported up to 22% with estimated mortality of 8–35%.5-7 In the United Kingdom, Thromboembolic Risk Factor Consensus Group (THRIFT) and Scottish Intercollegiate Guidelines Network (SIGN) Group have recommended routine thromboprophylaxis to all the patients suffering from major trauma, patients undergoing surgery for a fractured hip, elective total hip and total knee replacement.8,9 However, up to 14% of high-risk trauma patients may not be suitable for routine prophylaxis because of some contraindications to anticoagulation.10,11 In addition, many of the orthopaedic and trauma patients may not be suitable for application of mechanical compression devices because of long bone...
fractures, open wounds, external fixators and plaster casts in situ. In such a scenario, when conventional modalities are contraindicated or have failed, and in patients with a previous history of recurrent DVT or PE, there is a clear indication for the surgical interruption of the emboli propagating from the extremities. Recently, inferior vena cava (IVC) filters are increasingly being used prophylactically in high-risk trauma patients. Historically, these methods have evolved from ligation or plication of the vena cava to permanent or temporary placement of mechanical filters in the IVC. Indications for the insertion of these filters are expanding. This article is aimed at reviewing the indications, contra-indications, current trends and controversies in the use of vena cava filters in the high thromboembolic risk complex trauma and orthopaedic patients.

Types of vena cava filters (VCFs)

An ideal filter should effectively protect against PE, be technically easy to insert, mechanically and biologically stable and should have a low incidence of long-term and short-term complications. None of the present filter designs could be labelled as ideal. However, differences in their mechanical properties may influence the selection of a filter specific to some patients. Early implantable endovascular devices for the treatment of venous thromboembolism were the Mobin–Uddin filter and Kimray–Greenfield filter. Design characteristics of the IVC filters have undergone several changes and many designs are now available for use. Most devices are made up of fatigue resistant stainless steel or titanium alloy. Commonly used filters and their general characteristics are shown in Table 1. There are no studies in the literature that conclusively establish the superiority of one filter design over the others.

Method of insertion of IVC filters

Placement of filters is usually carried out by an interventional radiologist or by a vascular surgeon. Modern filter insertion involves a standard venepuncture and insertion of a filter via a transvenous catheter under fluoroscopic guidance (Figs. 1 and 2). Femoral, jugular and basilic veins have been used in that order of frequency. Bedside application using a portable ultrasound device has also been reported.

Table 1

<table>
<thead>
<tr>
<th>Filters</th>
<th>Material</th>
<th>Year</th>
<th>Maximum IVC size (mm)</th>
<th>Insertion site</th>
<th>MR image compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds nest</td>
<td>Stainless steel</td>
<td>1982</td>
<td>40</td>
<td>Femoral, jugular</td>
<td>No</td>
</tr>
<tr>
<td>Venatech</td>
<td>Phynox</td>
<td>1986</td>
<td>28</td>
<td>Femoral, jugular</td>
<td>Yes</td>
</tr>
<tr>
<td>Titanium Greenfield</td>
<td>Titanium</td>
<td>1988</td>
<td>28</td>
<td>Femoral, jugular</td>
<td>Yes</td>
</tr>
<tr>
<td>Simon Nitinol</td>
<td>Nickel–titanium</td>
<td>1988</td>
<td>28</td>
<td>Femoral, jugular, antecubital</td>
<td>No</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>Stainless steel</td>
<td>1973</td>
<td>28</td>
<td>Femoral, jugular</td>
<td>Yes, but creates minor artefacts</td>
</tr>
<tr>
<td>Greenfield TrapEase filter</td>
<td>Nickel–titanium</td>
<td>2000</td>
<td>30</td>
<td>Femoral, jugular, antecubital</td>
<td>Yes</td>
</tr>
<tr>
<td>Venateck—low profile</td>
<td>Phynox</td>
<td>2001</td>
<td>28</td>
<td>Femoral, jugular, antecubital</td>
<td>Yes</td>
</tr>
<tr>
<td>Gunther Tulip</td>
<td>Eligiloy</td>
<td>2001</td>
<td>28</td>
<td>Femoral, jugular</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Indications

VCFs are used when medical treatment is contraindicated, failed or complicated by a serious adverse effect in a patient with proximal DVT or PE. The Seventh American College of Chest Physicians (ACCP) Consensus Conference on antithrombotic therapy has recommended the following indications:

1. contraindication or complication of anticoagulation in a patient with proximal vein thrombosis of the lower extremity or PE,
2. recurrent thromboembolism despite adequate anticoagulation,
3. chronic PE with pulmonary hypertension,
4. concurrent performance of surgical pulmonary embolectomy or pulmonary endarterectomy and
5. heparin-induced thrombocytopenia.

In a review by Greenfield and Proctor, indications for IVC filter insertions were contraindications to anticoagulant therapy (45%), complication of anticoagulant therapy (20%) and prophylaxis (13%).

Prophylaxis in trauma patients

In some trauma centres, VCFs have been used prophylactically without a documented PE or DVT. Table 2 shows the criteria used by the different authors to identify the high-risk trauma patients for the placement of prophylactic IVC filters. Some of the trauma patients may be at a higher risk for bleeding complications after the injury and hence may not be suitable for routine anticoagulation. This includes patients with associated intracranial haemorrhage,
ocular injury with associated haemorrhage, solid intra-abdominal organ injury (liver, spleen and kidney), or pelvic or retroperitoneal haematoma requiring transfusion. Most authors agree that the risk benefit ratio is in favour of VCFs in high-risk trauma patients.

Prophylaxis in patients undergoing hip and knee surgeries

Patients undergoing revision hip and knee replacements could be the candidates for expanding use of prophylactic VCFs, although there is no supporting evidence in favour of this statement. High-risk patients undergoing primary hip and knee arthroplasties are selected by some authors, although no worldwide consensus has yet been established. Emerson reported the use of Greenfield filters prophylactically in 47 patients undergoing hip and knee arthroplasties and compared the results with 37 patients receiving only anticoagulation. All patients with chronic DVT, prior DVT or PE with major complications of anticoagulation, a major PE or DVT or PE within first 7 post-operative days were considered for a filter insertion. At a follow up of 24–76 months, there was no PE. They encountered two cases of IVC occlusions, one suprarenal placement of filter, one haemothorax and two vagus nerve injuries. Vaughn et al. used Greenfield filters prophylactically in 42 patients undergoing hip or knee arthroplasties who had previous thromboembolic complications and therapeutically in 24 patients because of a contraindication to therapeutic anticoagulation or failed prophylaxis with Coumadin. None of the prophylactic group and one in the therapeutic group developed fatal PE.

Prophylaxis in pathological fractures

Patients with pathological fractures are at higher risk of thromboembolic events because of a hypercoagulable state combined with a fracture and an orthopaedic surgical procedure to stabilise the fracture. Benevenia et al. reported the results of prophylactic IVC filters placed preoperatively in 24 patients with metastatic pathological fractures of long bones who were unable to receive pharmacological prophylaxis. They compared 24 patients who received IVC filters plus mechanical prophylaxis (compression stockings and sequential compression boots) and 23 patients who received only the mechanical prophylaxis. At a mean follow up of 11.5 months, all five PE and all two fatal PE occurred in the non-filter group. They reported four complications, which included groin haematoma, insertion thrombosis, distal placement of filter and filter occlusion in one patient each. However, use of filters in such patients has been criticised for high cost and mortality.

Prophylaxis in spinal cord injuries

Prophylactic use of VCFs in the spinal injury patients is controversial. Leon et al. used VCFs prophylactically in 74 patients undergoing spinal surgeries. Their criteria were (1) history of thromboembolism, (2) diagnosed thrombophilia, (3) malignancy, (4) bed ridden for more than 2 weeks prior to surgery, (5) staged procedures or multiple level surgeries, (6) combined anterior and posterior approaches, (7) expected need for significant iliocaval manipulation during surgical exposure, and (8) single stage anaesthetic time more than 8h. At a mean follow up of 11 months, one patient developed PE and 27 limbs developed DVT. These authors concluded that despite a high incidence of DVT following high-risk spinal surgeries, prophylactic IVC filters
appear to protect patients from PE. However, in a study of 111 patients with spinal cord injury, patients with paraplegia or tetraplegia, Maxwell et al. reported 11.8% and 0.9% incidence of DVT and PE, respectively, which were 9% and 1.8% in general trauma admissions. Incidence of DVT in spinal cord injury patients with long bone fractures was 37.5%. On the basis of low incidence of PE, prophylactic filters in spinal injury patients are only used when it is associated with long bone fractures.

### Complications of IVC filters

Complications associated with filter placement are uncommon and usually non-fatal. However, both fatal and non-fatal complications have been reported. Becker et al. divided non-fatal complications into five groups; technical difficulties during placement of filters, insertion site thrombosis, filter migration, IVC thrombosis and lower extremity DVT. Table 3 shows the reported incidence of common complications in the studies involving the trauma patients. PE in 0.5–5% of patients and fatal pulmonary emboli in about 0.7% cases have been reported subsequent to VCF application. Other complications include insertion site haematoma formation, wound infection, pneumothorax, air embolism, filter malposition and insertion site thrombosis. Movement of VCFs in both cephalad and caudad directions have been noted. In the majority, this migration is minimal and asymptomatic. Occlusion of the IVC has been reported in 2–9% of patients. Post-thrombotic syndrome due to venous insufficiency in the lower limbs seems to be a common problem in studies with long-term follow up (35–44%).

### Retrievable VCFs

Potential long-term risks of permanent VCFs include filter migration, venostasis, infection and vena caval occlusion. However, the true picture in the long-term remains largely

<table>
<thead>
<tr>
<th>Author</th>
<th>Criteria used by different authors to identify the high-risk trauma patients.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rogers et al. (1997)</td>
<td>(1) Complex pelvic fractures (2) Pelvic fractures with long bone fractures or (3) Multiple lower limb fractures or Above injuries with at least one additional risk factor: • Age &gt; 55 • Injury Severity Score &gt; 16 • Immobilisation more than 6 weeks</td>
</tr>
<tr>
<td>Winchell et al. (1994)</td>
<td>Head injury, spinal injury, posterior element pelvic fracture, multiple long bone fractures</td>
</tr>
<tr>
<td>Langan et al. (1999)</td>
<td>Prolonged immobilisation with multiple injuries Closed head injuries Pelvic fracture Spine fracture Multiple long bone fracture</td>
</tr>
<tr>
<td>Rodriguez et al. (1996)</td>
<td>Three or more of the following risk factors: • Age &gt; 55 • ISS &gt; 15 • Automotive injury score &gt; 2 on head chest or abdomen • Multiple lower limb fracture • Pelvic fracture • Spinal trauma • Subclavian vein cannulation</td>
</tr>
<tr>
<td>Khansarinia et al. (1995)</td>
<td>Injury Severity Score &gt; 9 Severe head injury with lower extremity fractures or prolonged ventilator dependence Spinal injury with paralysis Major abdominal or pelvic penetrating venous injury</td>
</tr>
<tr>
<td>Pasquale and Fabian (1998)</td>
<td>Patients who cannot receive anticoagulation and &gt; 45 years of age or poor cardiopulmonary reserve and Patients having one or more of the following risk factors: • Severe closed head injury (Glasgow Coma Scale Score &lt; 8) • Incomplete spinal cord injury with paraplegia or quadriplegia • Complex pelvic fractures with associated long bone fractures • Multiple long bone fractures</td>
</tr>
</tbody>
</table>
unknown. Many of these patients may have only a temporary contraindication for anticoagulation. It is also an important consideration when a permanent filter needs to be placed in a young trauma patient. Retrievable filters are devised with an intention of preventing PE in the short term while eliminating long-term complications associated with permanent filters. Allen et al. placed 53 Gunther Tulip filters in 51 high-risk trauma patients. Retrieval was successful in 24 out of 25 attempts. There were no complications like bleeding, device migration, thrombosis, infection or PE.

From the available literature, it appears that the application of retrievable filters is effective in preventing new or severe PE. Most studies investigating the retrieval of the Gutinther Tulip filter have proposed removal within 15 days of implantation, before the filter struts become incorporated into the caval wall. Retrieval may not be feasible within this time period due to continued contraindication for anticoagulation, recurrent PE or technical difficulties in many patients. However, these filters can be repositioned under angiographic guidance and can be removed within the next 2 weeks.

**Controversies and comments**

PE is a leading cause of delayed deaths after trauma and is the most common cause of death in the immediate postoperative period in patients who underwent reconstructive operations in the lower limbs.

Ongoing bleeding or increased risk of bleeding often precludes the use of anticoagulants at least in the early period after trauma and most centres would not use the anticoagulants in recent cerebral injury, cerebral haemorrhage, active bleeding, significant thrombocytopenia, cerebral metastasis or a recent large embolic stroke.

Skeletal injuries in the lower limbs, wounds and immobilisation devices often prevent the use of mechanical compression devices. Although systemic anticoagulation remains as the corner stone for both prophylaxis and treatment of venous thromboembolism, there is a clear indication for the surgical interruption of the emboli when the anticoagulants are contraindicated or failed.

It is generally clear from the literature that prophylactic filters protect patients from fatal PE, in high-risk patients and in those patients who have a contraindication for anticoagulation. However, there is no agreement in identifying these high-risk patients. Different authors have used diverse criteria to identify high-risk trauma patients. Increasing age, prolonged immobilisation, long bone fractures, increasing injury severity score and pelvic fractures are generally agreed as high-risk factors for venous thromboembolism and hence been used by the various authors to guide the patient selection for placement of prophylactic filters.

In the absence of well-conducted prospective studies, various groups have arrived at some 'consensus' recommendations for their use. Patients undergoing revision hip and knee replacements could be candidates for the expanding use of prophylactic IVC filters because of the high risk of DVT and PE after these procedures and consequences of anticoagulants that may interfere with wound healing. However, the evidence is slim to support generalised prophylactic use in this group of patients.

Concerns have been raised about the increased risk of DVT, IVC thrombosis, and post-phlebitic syndrome after IVC filter insertion. Incidence of subsequent DVT of 35–44% after prophylactic use of IVC filters have been reported in long-term. Decousus et al. in a randomised control study with 8 years of follow up reported similar total number of venous thromboembolic events in patients treated with or

**Table 3 Results of IVC filter placement in trauma patients.**

<table>
<thead>
<tr>
<th>Author</th>
<th>Indications</th>
<th>Cases</th>
<th>Follow up period (months)</th>
<th>PE</th>
<th>Death</th>
<th>DVT</th>
<th>IVCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benevenia et al. (2004)</td>
<td>Pathological fractures</td>
<td>24</td>
<td>11.5</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Duperier et al. (2003)</td>
<td>Prophylactic</td>
<td>133</td>
<td>&lt;12</td>
<td>1</td>
<td>1</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>Wojcik et al. (2000)</td>
<td>Prophylactic in 64 and therapeutic in 41 patients</td>
<td>105</td>
<td>28.9</td>
<td>0</td>
<td>0</td>
<td>28 (44%)*</td>
<td>1 (0.95%)</td>
</tr>
<tr>
<td>Langan et al. (1999)</td>
<td>Prophylactic</td>
<td>160</td>
<td>19.4</td>
<td>1</td>
<td>0</td>
<td>24 (12.8%)</td>
<td>0</td>
</tr>
<tr>
<td>Rogers et al. (1998)</td>
<td>Prophylactic</td>
<td>132</td>
<td>20</td>
<td>3</td>
<td>1 (2.3%)</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>Rogers et al. (1997)</td>
<td>Prophylactic</td>
<td>35</td>
<td>24</td>
<td>1</td>
<td>0 (2.8%)</td>
<td>2 (5.7%)</td>
<td>0</td>
</tr>
<tr>
<td>Khansarinia et al. (1995)</td>
<td>Prophylactic</td>
<td>108</td>
<td>NA</td>
<td>0</td>
<td>0</td>
<td>9%</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA—not available.

*Refers to 64 patients who had prophylactic filters.
without a filter (36.4% vs. 35.45%). However, those patients with VCF experienced a greater cumulative incidence of symptomatic DVT (35.7% vs. 27.5%), but significantly fewer symptomatic emboli (6.2% vs. 15%). The authors concluded that at 8 years, VCFs reduced the risk of PE, but increased that of DVT and had no effect on survival. Although their use may be beneficial in patients at high risk of PE, systematic use in the general population with venous thromboembolism is not recommended (PREPIC trial).

However, other studies in trauma populations have reported no difference in the incidence of DVT in patients with or without VCFs. Attempts to broaden the indications for IVC filter placement have been made since the inception and concerns have been raised about their over use.

A total of 299 trauma patients received filters which included 248 filters placed prophylactically. McMurtry et al. studied the incidence of PE in all the patients admitted to a level-I trauma centre between 1989 and 1997. They compared the two cohorts corresponding to years of high or low prophylactic filter use. Between 1989 and 1997. They compared the two cohorts corresponding to years of high or low prophylactic filter use. A total of 299 trauma patients received filters which included 248 filters placed prophylactically. Overall the incidence of PE was 0.31% and 0.48% during the year of low and high use of filters respectively. Contrary to the findings of others, these authors concluded that increased use of prophylactic filters in trauma patients failed to decrease the overall incidence of PE. Furthermore, indications in spinal injury, joint replacement and pathological fractures remain controversial.

After reviewing the literature, we found a clear lack of randomised studies assessing the efficacy of the filters for orthopaedic and trauma patients. Placement of VCFs in trauma and orthopaedic patients needs fundamental understanding and further assessment of risk-benefit ratio. Many issues remain unclear and carefully designed randomised controlled studies are needed to establish the expanding clinical indications, efficacy and safety of filters. However, long-term safety of permanent filters is not well established and retrievable filters are currently being evaluated for this purpose. Such studies need to identify the high-risk patients in trauma and complex elective orthopaedic patients. It seems from the literature, even in the absence of well-conducted randomised controlled studies that VCFs do protect against fatal PE in high-risk trauma and complex orthopaedic patients with acceptable early complications.

**Practice points**

- VCFs could be either permanent or retrievable, used for the surgical interruption of the emboli propagating from the extremities
- Used in patients with contraindications to anticoagulation and mechanical compression devices
- VCFs tend to protect against fatal PE in high-risk trauma and complex orthopaedic patients with acceptable early complications

**Research directions**

- To obtain consensus in establishing clear indications for VCFs in complex trauma and complex reconstructive procedures
- Long-term efficacy of permanent vs. retrievable filters
- Outcome in different filter design
- Role of VCFs in metal-on-metal hip resurfacing

**References**


