

Review Article

Inferior vena cava filters: a review

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ABSTRACT

Venous thromboembolism is an entity that ranges from deep vein thrombosis to pulmonary embolism, both are highly prevalent diseases in our environment and potentially fatal. The intention of this review is to compile information regarding the indications, contraindications, complications and comparison of different therapeutic methods in order to create an algorithm. An exhaustive review was performed with the available literature, using the PubMed, ScienceDirect, Scopus and Cochrane databases from 2004 to 2021. The search criteria were formulated to identify reports related to inferior vena cava filters. Venous thrombosis manifested as deep vein thrombosis or pulmonary embolism is a highly prevalent disease in our setting with high morbidity and mortality. Currently, different therapeutic options have been presented to address this pathology, in this review we focus on the developments regarding the use of vena cava filters. Reviewing the indications for the placement of a vena cava filter, we find absolute indications such as a contraindication to anticoagulation and high risk of massive pulmonary embolism. Pulmonary thromboembolism is a disease with high prevalence and mortality, we have highly effective and novel treatments such as the vena cava filter, patients should be selected carefully always taking into account the absolute and relative indications.

Keywords: Inferior vena cava filter, Venous thromboembolism, Deep venous insufficiency, Pulmonary embolism, Removable filters, Permanent filters

INTRODUCTION

Venous thromboembolism currently represents one of the most common causes of preventable hospitalization, a mortality rate of 5-10% has been calculated, with an increasing prevalence of thromboembolic events, this

entity can manifest as deep vein thrombosis (DVT) or as pulmonary embolism (PE).^{1,2} Pulmonary thromboembolism is a potentially fatal disease, it represents an obstruction of the pulmonary artery or one of its branches by a thrombus that originated in some other part of the body. It has an incidence in Mexico of 40 to 53

per 100,000 people, in Germany from 55.3 to 71.7 per 100,000, in Canada 38 per 100,000 inhabitants, in the United States it is responsible for 100,000 deaths per year and in Europe for 300,000.³⁻⁷ Among its risk factors are genetic alterations, recent surgery, trauma, immobilization, obesity and smoking.⁸

RESULTS

The cornerstone of treatment in people with thromboembolic disease (VTE) is anticoagulation, patients with anticoagulation have lower rates of recurrence of VTE and patients with deep vein thrombosis (DVT) have lower chances of developing a pulmonary embolism (PE).⁹ In most cases of deep vein thrombosis, anticoagulation may suffice, however, thrombolysis or thrombectomy is generally reserved for cases of massive iliofemoral DVT, Phlegmasia Cerulea Dolens (PCD), patients with anticoagulation failure or whom present an extension of the clot, which must be organized, without lysis. Clinically, the onset of symptoms should be less than 14 days with a low risk of bleeding.¹⁰ Thrombolysis can be systemic, catheter-directed, or drug-mechanically driven. Thrombolysis is associated with rapid complete lysis and preserved function of venous valves, but the risk of recurrent DVT, occurrence of PE, and mortality remain the same. There is an increased risk of bleeding when using systemic thrombolysis with recombinant tissue plasminogen activator (rTPA or Alteplase).¹¹ Catheter-directed thrombolysis is considered only as initial treatment in patients with risk of limb loss, since it can reduce the risk of bleeding by breaking the clot faster.⁹ On the other hand, ultrasound-assisted thrombolysis has no benefit over catheter-directed thrombolysis and should not be used.¹² Pharmacomechanical thrombolysis allows the direct administration of fibrinolytic agents through a catheter, combining mechanical fragmentation and aspiration of the thrombus.¹³ This technique proves a lot safer when compared with systemic thrombolysis, presenting a lower risk of bleeding using a lower dose of fibrinolytic agent.¹⁴ Pharmaco-mechanical thrombectomy quickly offers a central flow channel, but has the disadvantage of causing displacement of the thrombus,

which could increase the incidence of pulmonary thromboembolism.¹⁵ Finally, surgical thrombectomy using a Fogarty catheter to extract the clot is used generally in supra-inguinal occlusions, it used to be the treatment of choice in acute ischemia of the lower limb until endovascular therapies evolved, which have been shown to provide better clinical results with lower mortality rates, however, currently it can offer excellent results with certain advantages over endovascular therapy in selected cases, such as in patients with PCD, as it offers faster and safer recanalization with rates of almost 100%, for this reason it continues to be widely used in countries like Mexico as it helps to keep treatment costs low.¹⁶⁻¹⁷

Historically, the interruption of the flow in the vena cava to prevent pulmonary embolism has been practiced for centuries, it was suggested for the first time by Trousseau in 1868, and it was until 1893 that the first successful ligation of the inferior vena cava was performed, recognized the association between deep vein thrombosis and pulmonary embolism, using femoral vein ligation for some time, which eventually fell into disuse due to recurrent thromboembolic events (VTE), especially due to the increased risk of pulmonary embolism in the contralateral limb.¹ These surgical background was fundamental for the development of the currently used vena cava filters, which are implantable devices designed to intercept thrombi that have been released from the lower limbs or pelvis, preventing their migration to the lungs thus preventing PE.¹⁹

INDICATIONS

The main indication for the placement of a vena cava filter will be in patients with deep vein thrombosis or a history of pulmonary embolism who have an absolute contraindication for the use of anticoagulants.¹⁰ Anticoagulation may be contraindicated in patients with active and uncontrollable bleeding, severe thrombocytopenia, recent intracerebral hemorrhage, brain injury with high risk of bleeding, need for urgent surgery, seriously ill patients in the intensive care unit or who present multiple trauma.²⁰

Table 1: Absolute, relative and contraindications for placement of an inferior vena cava filter in patients with pulmonary thromboembolism or chronic venous insufficiency.

Absolute	Relative	Contraindication
Contraindication of anticoagulation	<ul style="list-style-type: none"> • Patients at high risk of massive pulmonary embolism consider filter plus anticoagulation • Recurrent VTE despite anticoagulation • Complication from anticoagulant • Failure of anticoagulants • Impossibility of maintaining adequate anticoagulation • Thrombus progression despite adequate anticoagulation • High-risk or massive PE with residual DVT • Severe cardiopulmonary disease and DVT • Large free-floating proximal DVT 	<ul style="list-style-type: none"> • Patient at risk of non-massive or recurrent pulmonary thromboembolism with adequate hemodynamic status and effective anticoagulation • No Access route to the vena cava • Bacteremia • No location available in vena cava for placement of the filter

Table 2: Types of vena cava filter.

Permanent	Removable	Convertible
<p>They do not have mechanisms to be withdrawn</p> <p>• There has been concern that complications are associated with the length of time the filter is in place</p>	<ul style="list-style-type: none"> • They have mechanisms to be withdrawn • They can be left permanently or removed according to the indications and clinical circumstance • Preferred since complications are related to the filter's residence time in the body 	<ul style="list-style-type: none"> • May alter their structure after implantation to no longer function as filters • Filter and subsequently Stent function

The 2016 CHEST / ACCP guidelines mention that the only absolute indication to place a vena cava filter in patients with venous thromboembolism will be the contraindication of anticoagulation and the placement of a filter can be accepted in patients with high risk of massive PE added to anticoagulation.⁹ There are other guides in which relative indications are postulated. Table 1. Society of Interventional Radiology (SIR) 2011 guidelines suggest the use of a vena cava filter in patients with deep vein thrombosis or pulmonary thromboembolism who have had complications or failure of anticoagulation, inability to maintain adequate coagulation, thrombus progression despite anticoagulation, risk of massive pulmonary embolism with residual deep vein thrombosis and severe cardiovascular diseases with deep vein thrombosis.²¹ The American Heart Association guidelines of 2011 propose the use of a vena cava filter for patients with confirmed pulmonary thromboembolism or DVT with contraindication to anticoagulation or active bleeding, recurrent PE despite anticoagulation and its use may be considered in patients with PE and low cardiopulmonary reserve, as well as patients at risk of massive thromboembolism.²²

CONTRAINDICATIONS

The placement of a vena cava filter is usually safe, there are no absolute contraindications, however, among the relative ones are incorrigible coagulopathies and bacteraemia.²² The risk of bacteremia should always be considered versus the benefit of placing the filter, although infections by vena cava filter are very unusual and fewer have been reported.²³

LOCATION OF THE THROMBUS, TO USE OR NOT TO USE A VENA CAVA FILTER?

Proximal deep vein thrombosis comprises a thrombus located in the popliteal vein towards the proximal section













which includes the femoral vein and iliac vein. Anticoagulation is indicated for all patients, even if they are asymptomatic since proximal DVT has a high risk of embolization, clearly justifying the placement of a filter in the vena cava.⁹

Distal deep vein thrombosis is one that include the territory below the popliteal fossa, in the calf veins such as gastrocnemius, anterior tibial, posterior tibial and peroneal. Most distal DVTs occur in the posterior tibial and peroneal veins. In these patients there is a lower risk of embolization and their pathology can resolve spontaneously.²⁴⁻²⁶ Clinical and ultrasound follow-up should always be given as it is possible for the clot to expand despite having therapeutic doses of anticoagulation, which undoubtedly represents an indication for vena cava filter placement. Patients without previous episodes of DVT or malignancy are considered to be at low risk of extension, and should be treated without anticoagulation or placement of a vena cava filter, using only ultrasound monitoring and compression stockings.^{9,10,27} Patients who are at higher risk for having previous events of venous thromboembolism or cancer should be anticoagulated, but there is no clear indication to place an inferior vena cava filter.⁹

TYPES OF VENA CAVA FILTERS

There are three main groups of vena cava filters, permanent, removable and convertible. Table 2. Permanent filters do not have adaptations to be removed, these were the first to be approved by the FDA, they can be placed only in inferior vena cava with a diameter of 28 mm or less and their intention is to remain in the vein, however, it has been reported that the incidence of complications is directly related to the time the filter remains in the body. The withdrawable ones have mechanical adaptations to be removed once the thromboembolic risk has decreased or once the patient is a candidate for anticoagulation again. They can be used in inferior vena cava up to 30 mm.²⁸ In 2014 the FDA issued an alert on considering the time in which the filters should remain in the body, presuming that they should be removed in the shortest time possible, when the protection for PE is not necessary, it minimizes adverse effects.²⁹ Convertible filters are the newest option, they work as a filter and can later be converted to a configuration similar to that of a vascular stent, when its function as a filter is no longer necessary, this conversion can be done approximately after 60 days. These filters can be placed with or without the intention of being converted, depending on the indication and clinical circumstance, if not converted, it will provide permanent filtration.³⁰ Removable vena cava filters are currently preferred since better results have been seen by extracting them to reduce the possibility of complications once they fulfilled their function.

Table 3: FDA approved vena cava filters.

Filter	Type	Material	Form	Features	Complications	Image
ALN	Removable	Stainless steel	Conical	6 short tips to adhere to the walls of the vena cava and 3 long tips to place it.	Incline 5.7%, success rate removal 92.7% (20) Migration 1%	
Option Elite	Removable	Nickel-titanium	Conical	It can be used in cellars up to 30 mm	Migration range 2.0% -4.9%	
Gunther Tulip	Removable	Cobalt	Conical	4 long legs with anchor and 4 secondary legs around each one.	It presents complications when removing it secondary to an inclination > 15 ° and tissue growth around the legs.	
Permanent Vein Tech	Permanent	Phynox	Conical	Central hooks on the legs.	Firm and flexible to adapt to mega cava.	
Convertible vein tech	Convertible	Cobalt	Conical	8 legs with anchors.	Converts to an open configuration when filtration is no longer needed.	
Trapease	Permanent	Nitinol	Non Conical	Closed cage design	Opposition of cranial and caudal fixation bars to reduce migration.	
OptEase	Removable	Nitinol	Non Conical, double basket	Closed cage with lateral spikes to allow self-centering	Filter fracture range 14.1% - 37.5%	
Bard	Permanent	Nitinol	Conical	6 legs with 6 legs, total of 12 components	Filter fracture at 38%	
Crux	Removable	Nitinol Frame with PTFE net	Nonconical, opposing hélix design		No reported migration cases, 7% thrombi in or near the filter.	
Bird Nest	Permanent	Stainless steel	No Conical	4 long arms ⁵ and a pair of anchors each	Flexible catheter, easy application	
Greenfield	Permanent	Titanium or stainless steel	Conical	6 legs with curved anchors to prevent penetration	0.3% filter fracture 1% migration 1% filter penetration	
Simon	Permanent	Nitinol	Conical bilevel	Conical top tier with 6-leg bottom tier	First approved nitinol vascular implant	

TEMPORARY VENA CAVA FILTERS

Temporary vena cava filters are a subgroup of filters which will be kept only for a short term since they do not have any fixation characteristics to anchor themselves to the vena cava wall, they are usually removed between weeks.^{1,2-6,31-33} In Table 3 we can see some of the vena cava filters that exist in the market approved by the FDA.

Table 4: Complications of the vena cava filter.

Complications	Diagnosis	Treatment
Vena cava thrombosis	Duplex ultrasound	Endovenous techniques to recanalize the inferior vena cava
Vena cava perforation	Duplex ultrasound	Surgery
Filter displacement, migration, or fracture	Ultrasound	Image-guided percutaneous removal
Recurrent pulmonary embolism	Dimer -D, CAT	Thrombolysis

CHOICE OF FILTER, TEMPORARY OR PERMANENT?

Vena cava filters were initially created with the intention of being permanent, however, recent research has indicated that adverse effects are associated with a prolonged time of use (greater than 30 days).³⁴⁻³⁶ The FDA in 2014 recommended their rapid removal once the indications allow it, and suggested that the risk-benefit profile in favor of removing the filters begins between days 29 and 51 after their placement.^{29,37} Patients who have the instruction to remove the filter should ideally do so within a month. It has been seen show that it is safer when it is removed before 3 months. If the filter is not removed within this time, a decision must be made 6 months later to remove it or declare it a permanent filter.^{39,40} Converting a removable filter into a permanent one can be considered one of the advantages that removable filters offer when a patient worsens or their basic condition does not resolve, however, it must be considered that the cost of removable filters is higher than that of the permanent ones, this because they have structural elements for their removal.⁴¹

PLACEMENT

Fluoroscopic-guided angiography is used for jugular or femoral access. Fluoroscopy makes it possible to measure the length and diameter of the inferior vena cava, the location and number of renal veins, as well as the presence of pre-existing thrombi 21 or the absence of anatomical variants such as a retro-aortic or circumaortic left renal vein since it is a variation that occurs in 3% -7% of the population.⁴² The apex of the filter is positioned just below

the level of the lowest renal vein. Regarding placement, one of the complications may be due to the presence of mega cava, which is defined with a diameter greater than 30 or 40 mm where the filter cannot be properly placed.⁴³ To anchor the filter, it will be necessary to penetrate the vena cava limitedly, if it is placed more than 3 mm deep in the wall it is considered a complication, as it can penetrate adjacent organs 21 more frequently seen in conical-shaped filters, with an incidence of perforating ranging from 13% to 100%.⁴⁴

COMPLICATIONS

The vast majority are directly related to the length of time the filter remains in the vena cava. Among the most frequent complications we find: filter fracture, migration, filter thrombosis and post-thrombotic syndrome. (Table 4)⁴⁵

Filter fracture is the most common complication, it occurs when one of the filter components detaches, increasing the risk of embolization or the fragment itself migrating. It occurs more frequently with removable filters.⁴⁶ Filter migration occurs when the filter leaves its original place and can sometimes reach an intracardiac location. Treatment of filter migration, displacement, and fracture is image-guided percutaneous removal, the success rate varies depending on the anatomical location. Vena cava thrombosis can occur when a very large thrombus is retained or by thrombus formation within the filter. However, it is a rare complication with an incidence of 2-8% but may lead to stenosis or occlusion so intravenous techniques to recanalize the inferior vena cava are required.^{47,48} Post-thrombotic syndrome refers to signs and symptoms of chronic venous insufficiency that develop after deep vein thrombosis.⁴⁹ It occurs in 50% of patients within the first year after a thrombosis despite anticoagulation. Treatment includes conservative measures such as exercise, venous hygiene measures, compression stockings and in the case of stenotic iliac vein segments, it can be treated with percutaneous angioplasty with or without stent or venous bypass.^{50,51} Venous valve reconstruction, including valve transplantation and valvuloplasty, has been unsuccessful in treating these patients.

PROPHYLACTIC IVC FILTERS

Prophylactic filters refer to a patient who has not yet developed a venous thromboembolism but is at high risk of doing so, such as immobilized or polytraumatized patients. A randomized controlled study was conducted comparing two groups of patients at high risk of deep vein thrombosis. One group received permanent IVC filter versus the other that received low molecular weight heparin. The filter group showed an initial decrease in pulmonary embolism but there was no difference in long-term mortality; in the two-year follow-up, the incidence of DVT in the inferior vena cava filter group was significantly higher.^{20,52}

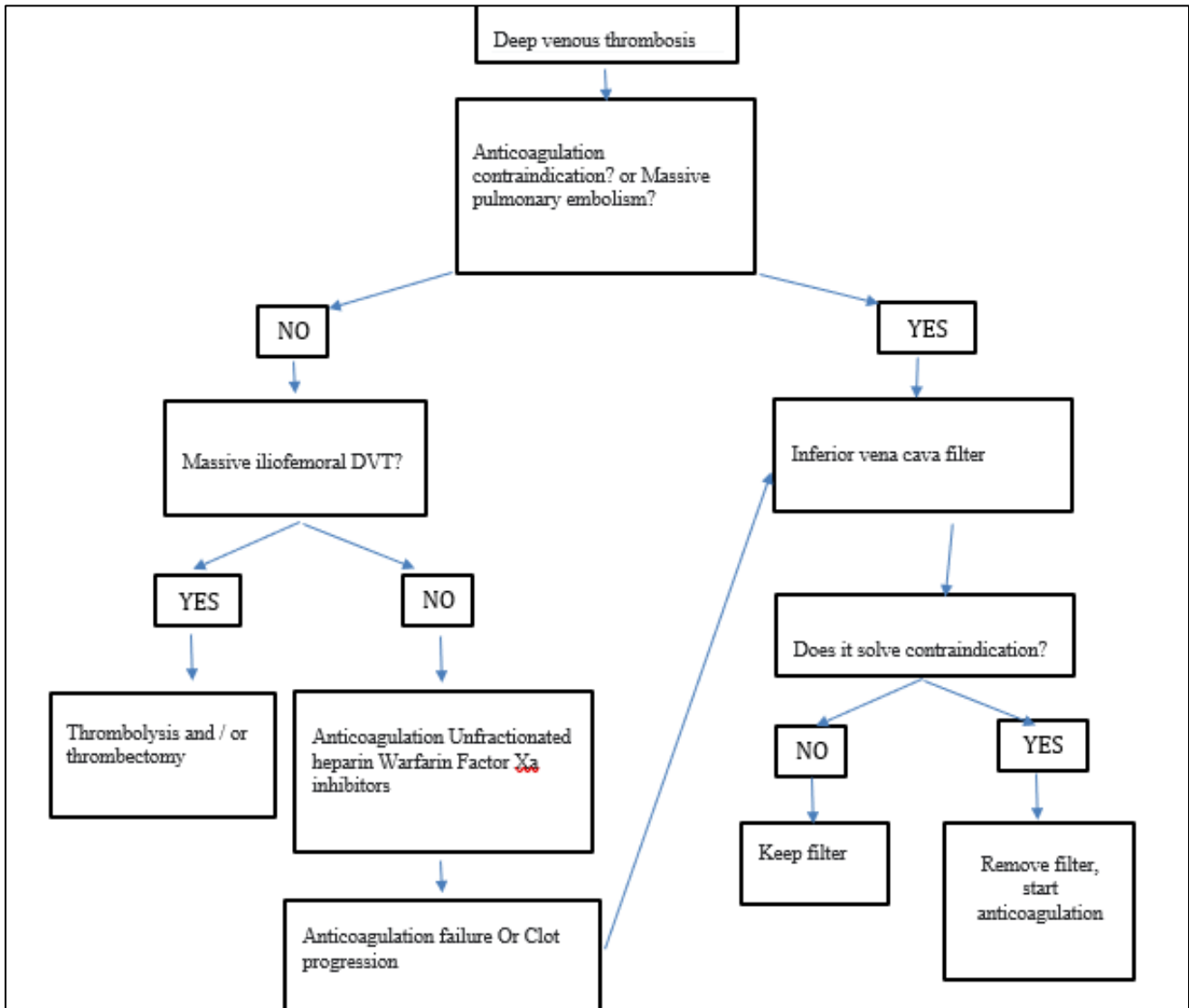


Figure 1: Algorithm for deep venous thrombosis.

Different authors agree that putting a prophylactic vena cava filter has no effect on reducing patient mortality and has a higher risk of DVT than anticoagulation. However, patients in special conditions such as ICU, polytraumatized or with contraindications for anticoagulation, some associations such as the “Eastern Association for the Surgery of Trauma” and societies such as the “Society of Interventional Radiology” recommend the placement of a vena cava filter even without DVT.^{19,21,53-55}

SUPERIOR VENA CAVA FILTERS

Although a thrombus lodged in the veins of the upper limbs may migrate to the pulmonary arterial system, 19 the approximate incidence of PE from the upper limbs is around 2%, and it clinically presents with less deterioration compared to embolized thrombi from the lower extremities.^{56,57} However, various studies have shown that the placement of superior vena cava filters can

be performed safely and effectively to prevent pulmonary embolism in patients with venous thrombosis of the upper extremities.⁵⁸ This procedure will be performed in patients with upper extremity deep vein thrombosis when anticoagulation has failed or is contraindicated.⁵⁹ Complications of inserting this filter include thrombosis, superior vena cava perforation, aortic perforation, cardiac tamponade, and pneumothorax.

SPECIAL SITUATIONS

Since the use of IVC was proposed in 1981 during pregnancy, permanent and temporary filters have been used successfully, the latter being the most used today. Factors such as the temporary elevated risk of VTE in pregnancy, hypercoagulable state caused by the physiological adaptations of the hemostatic system in preparation for birth, the presence of venous stasis, vascular endothelial damage, and an increase in procoagulant factors make it a valuable alternative.^{60,61}

Venous thrombosis is an important cause of morbidity and mortality in pregnancy, however, the indication of a vena cava filter according to the ACCP will be limited only to women with deep vein thrombosis with recurrent pulmonary embolism despite anticoagulation, the benefit of placing the filter should outweigh the risk, since migration is more frequent as a complication, when placed, it has to be removed as soon as possible during the postpartum period.^{62,63} Thromboembolism is the second leading cause of death in cancer patients.⁶⁴ Different studies have analyzed whether it is convenient to routinely place a vena cava filter in cancer patients, Brunson et al. placed vena cava filters routinely in cancer patients and concluded that no benefit in 30-day mortality was shown and a 60% increase in deep vein thrombosis was reported.⁶⁵ The Standardization committee of the International Society of Thrombosis and Haemostasis suggested that the placement of vena cava filter should not be done routinely in cancer patients and its use should be limited to situations where there is a contraindication to anticoagulation and a high risk of pulmonary embolism.⁶⁶

WHEN TO REMOVE THEM?

Ideally, they should be removed between 30 days and 3 months after insertion, once the condition for which anticoagulation was contraindicated has resolved.⁹ However, it has been shown that most removable filters are never removed, the extraction ranges from 12% to 45%.³⁵ Candidate patients to keep the filter are those who have a contraindication to permanent anticoagulation such as hematological disorders. The technical success of the removal is considerable, greater than 95% and depends on factors such as the time and the slope the filter was placed.⁶⁷ The inclination at which the filter is placed modifies its ability to trap emboli, it decreases if it is more than 15° inclined and is more difficult to remove. This complication appears more in conical filters.⁶⁸

DISCUSSION

Venous thrombosis manifested as deep vein thrombosis or pulmonary embolism is a highly prevalent disease in our setting with high morbidity and mortality. Currently, different therapeutic options have been presented to address this pathology. In this review we focus on the developments regarding the use of vena cava filters.

Vena cava filters can be superior or inferior, regarding the upper ones, despite the fact that the incidence of pulmonary thromboembolism from the upper limbs is 2%, there is an indication to place a vena cava filter in patients in whom anticoagulation has failed or is contraindicated, complications in this technique include perforation of the superior vena cava, cardiac tamponade, and pneumothorax.⁵⁶ On the other hand, we have the inferior vena cava filters, which have been studied thoroughly. Depending on the location of the thrombus, it may be from the proximal lower extremity, originating from the popliteal vein, including the femoral and iliac vein, or

distal, deriving from the lower territory of the popliteal vein. When there is proximal thrombosis, the risk of creating pulmonary embolism is much higher, so it should always be accompanied by treatment, whether or not it is symptomatic, the first-choice treatment will be anticoagulation if we are treating an individual who does not have a contraindication to this. or who does not have a massive venous thrombosis, otherwise then the option will be a vena cava filter. When the thrombosis is in the distal lower limb, the risk of thromboembolism is much lower, therefore, although having a symptomatic patient, there is no indication for treatment, nevertheless ultrasound monitoring is suggested.

Reviewing the indications for the placement of a vena cava filter, we find absolute indications such as a contraindication to anticoagulation and high risk of massive pulmonary embolism. Patients who may present a contraindication to anticoagulation are those with thrombocytopenia, active bleeding or cerebral hemorrhage, among others. Regarding the relative indications, we find patients with recurrent deep vein thrombosis despite anticoagulation and all those related to complications or failure of anticoagulation. Placement will be performed by fluoroscopic angiography being relatively safe with few complications. One of the dilemmas that the treating doctor may encounter is what type of filter to use? In this review the preferred filters are those that are temporary, preferably with a following extraction after 1 to 3 months, this because it has been found that vena cava filter complications such as migration, penetration, filter fracture, vena cava thrombosis or post-thrombotic syndrome, increase their incidence depending on the time spent in the body. We analyze situations of special populations such as pregnant women, who are at higher risk of deep vein thrombosis, however, there is no indication to place an inferior vena cava filter prophylactically unless it is a woman with venous thrombosis deep or recurrent pulmonary embolism despite anticoagulation. Regarding cancer patients, although thromboembolism is the second leading cause of death in this group, vena cava filter placement is not routinely recommended. Finally, when dealing with a polytraumatized patient who must undergo multiple surgeries, in case he cannot be anticoagulated, he will benefit from the protection of an inferior vena cava filter. (Figure 1)

CONCLUSION

Pulmonary thromboembolism is a disease with high prevalence and mortality, we have highly effective and novel treatments such as the vena cava filter, patients should be selected carefully always taking into account the absolute and relative indications. Currently, the use of permanent filters has been declining since studies have shown that a longer stay results in a higher rate of complications. Removable filters with a length of stay between 29 and 54 days have reduced the rate of complications after their placement. Anticoagulant therapy

continues to be superior to vena cava filters and the recommendations for its use are increasingly limited to specific clinical conditions. More studies are needed to define the recommendations for the use of vena cava filters especially now that safer anticoagulants are being developed. In this review we present an algorithm that facilitates the therapeutic decision for a patient with deep vein thrombosis.

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