

A Review of the use of Inferior Vena Cava Filters for the Prevention of Pulmonary Embolism

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Received date: February 07, 2023; Accepted date: February 17, 2023; Published date: February 27, 2023

Citation: Sotonye T Dodiya-Manuel., Emmanuel Auchi Edafe., (2023), A Review of the use of Inferior Vena Cava Filters for the Prevention of Pulmonary Embolism, *International Journal of Cardiovascular Medicine*, 2(1); DOI:10.31579/2834-796X/017

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Abstract

The management of patients with venous thromboembolism (VTE) is very tasking and may involve a multi-disciplinary approach. The main treatment modality for VTE still remains anticoagulation. There are situations in which anticoagulation may not be sufficient or is contraindicated. The placement of filter devices in the inferior vena cava (IVC) to prevent embolization of deep venous thrombosis (DVT), a well-established secondary treatment option thus becomes necessary. This review discusses, we discuss the indications, contraindications and commonly used filters in the inferior vena cava.

Keywords: IVC filters; indication; contra-indication; procedure

Introduction

Pulmonary embolism (PE) is a cause of significant morbidity and mortality in both low- and high-income countries of the world. [1] It is estimated to be among the leading cardiovascular causes of mortality, with an estimated 3-month mortality rate ranging from 15% to 18%. [1] When PE is not treated properly, it may lead to chronic pulmonary hypertension and right heart strain. A major source of PE is deep venous thrombosis that is formed in the lower limbs and pelvic veins. [1] Once the diagnosis of deep vein thrombosis (DVT) is made, urgent treatment with anticoagulation is paramount to prevent severe and life-threatening complications such as PE and the post-thrombotic state (pain, heaviness, leg swelling, and ulceration). [2] Medical remedies for DVT include low-molecular-weight heparin, unfractionated heparin and oral anticoagulants such as vitamin K and non-vitamin K antagonists. [2] In situations where anticoagulation is not feasible or is shown to be ineffective, inferior vena cava (IVC) filters may be used to prevent pulmonary embolism.

The implantable IVC filter was first introduced by Mobin-Uddin in 1969 and Greenfield in 1973, and the use of IVC filters has grown tremendously since the 1990s. [3] An IVC filter is a metallic filter placed endovascularly into the IVC to prevent lower extremity blood clots from embolizing to the right side of the heart and the pulmonary arterial circulation. Blood clots that are trapped in the IVC filter are then dissolved by the body's own natural thrombolytic mechanisms. [4] Retrievable IVC filters are those that may be removed percutaneously or may be left in place permanently. Permanent IVC filters stay in place and are not removed. Permanent filters are rarely indicated nowadays. Most filters implanted nowadays are the temporary filters which can be removed when the indication for use ceases.

A retrievable IVC filter can be removed by capturing the hook on the IVC filter tip with a snare and removing the filter through a sheath. This radiopaque hook may often be seen on plain radiographs to determine whether the IVC filter is the type that may be retrievable or is better left. Other integral components of an IVC filter include the tip and the arms (shorter struts) and legs (longer struts). The tip of the filter should always point in the direction of blood flow toward the heart so that clots may be captured within the filter legs. The objective of this review is to evaluate the techniques and indications for the IVC filters which would be beneficial especially in low- and middle-income countries.

Characteristics of ideal IVC filters.⁵

The features of ideal IVC filters include the following: [5] 1. Non-thrombogenic, biocompatible, long-life material, 2. High filtering efficiency for large and small emboli without impedance of flow. 3. Secure fixation within the vena cava. 4. Rapid percutaneous insertion with good release mechanism simple and controlled and amenable to repositioning. 5. MR imaging compatibility e.g., nonferromagnetic. 6. Low cost 8. Retrievability should be easy and very simple.

There is however no filter that meets all the above criteria up till date. [5]

Commonly placed IVC filters. [6] The table 1 below shows the commonly used IVC filters worldwide. The various sizes are shown.

In Nigeria, the commonly used IVC filter is ALN filters. The reason may be due to cost.

Name	Manufacturer	MRI compatibility	Permanent/Retrievable	Approved caval diameter (mm)
ALN vena cava filter	ALN	Conditional to 3T	Yes	32
OptionElite	Argon	Conditional to 3T	Yes	30
Denali	Bard	Conditional to 3T	Yes	28
Recovery G2	Bard	Conditional to 3T	Yes	28
Sentry	Boston Scientific	Conditional to 3T	No (Bio convertible)	28
Greenfield	Boston Scientific	Safe to 1.5T	No	28
VenaTech LP	B.Braun	Conditional to 3T	No	28
VenaTech	B.Braun	Conditional to 3T	No (Convertible)	28
Celect	Cook	Conditional to 3T	Yes	30
Gunther Tulip	Cook	Conditional to 3T	Yes	30
Bird's Nest	Cook	Conditional to 3T	No	40
OptEase	Cordis	Conditional to 3T	Yes	40

Table 1: Commonly used IVC filters

Indications for Use of Ivc Filters

There are many indications for the use of IVC filters, however, only a few are recommended in the guidelines. The Society of Interventional Radiology (SIR) published guidelines in 2020 in collaboration with the American College of Cardiology, American College of Chest Physicians, American College of Surgeons Committee on Trauma, American Heart Association, Society for Vascular Surgery (SVS), and Society for Vascular Medicine (SVM) in the Treatment of Patients with Venous Thromboembolic Disease recommend the following: [7]

1. In patients with acute pulmonary embolism, with a contraindication to anticoagulation therapy, the use of IVC filter be considered based on various clinical risk factors. [the strength of recommendation: Limited]

2. In patients with acute DVT without PE and with a contraindication to anticoagulation therapy, an IVC filter could be considered based on various clinical risk factors. [Strength of recommendation: Consensus]

3a. In patients undergoing anticoagulation for acute VTE (DVT, PE) in whom a contraindication to anticoagulation develops, an IVC filter be considered in the setting of ongoing significant clinical risk for PE. The Strength of recommendation is Consensus.

3b. In patients undergoing extended anticoagulation for VTE (DVT, PE) and have completed the acute phase of treatment in whom a contraindication to anticoagulation develops, an IVC filter should not be placed, with rare exceptions. The Strength of recommendation is Consensus

4. In patients who are receiving therapeutic anticoagulation for VTE (DVT, PE) who experience a recurrent VTE, we suggest that a filter not be placed, with few exceptions. Reasons for anticoagulation failure should always be addressed. The Strength of recommendation: Consensus

5. In patients with acute VTE (DVT, PE) who are being treated with therapeutic anticoagulation, there is recommend against routine placement of an IVC filter. The Strength of recommendation is Moderate.

6. In patients with acute PE who are undergoing advanced therapies, we suggest considering the placement of IVC filters only in select patients. The Strength of recommendation is Limited

DVT with Advanced Therapies.

7. In patients with DVT who are undergoing advanced therapies, suggest to considering the placement of IVC filters only in select patients. The Strength of recommendation: Limited.

8. In trauma patients without known acute VTE, there is a recommendation against the routine placement of IVC filters for primary VTE prophylaxis. The Strength of recommendation is Moderate

9. In patients without known acute VTE who are undergoing major surgery, we suggest against the routine placement of IVC filters. The strength of recommendation is Consensus

10. In patients who have indwelling IVC filters with no other indication for anticoagulation, the recommendation is against anticoagulation. The strength of the recommendation is consensus.

11a. In patients with indwelling retrievable/convertible IVC filters whose risk of PE has been mitigated or who are no longer at risk for PE, there is a suggestion that filters be routinely removed/converted unless the risk outweighs the benefit. The strength of recommendation is consensus

11b. In patients with indwelling permanent IVC filters whose risk of PE has been mitigated or who are no longer at risk for PE, there is a suggestion against routine removal of filters. The strength of recommendation is Consensus.

12. In patients with complications attributed to indwelling IVC filters, there is the suggestion that filter removal be considered after weighing filter-versus procedure-related risks and the likelihood that filter removal will alleviate the complications. The strength of recommendation is consensus.

13. In patients who have an IVC filter, the recommendation is to use structured follow-up program to increase retrieval rates and detect complications. Strength of recommendation is limited.

14. In patients undergoing IVC filter placement, there is recommendation against any specific placement technique.

Typical indication for IVCF placement

The typical indication for placement of an IVC filter is the existence of VTE with an absolute contraindication to anticoagulation, a complication of anticoagulation, or failure of anticoagulation. [8] The advantage of IVC filter insertion in the setting of acute PE is the prevention of morbidity and mortality from hemodynamic effects of PE recurrence. However, limited low-quality observational studies support this practice. [9,10] Routine use of IVC filters is not recommended (Class IIIa evidence) in patients with VTE treated with therapeutic anticoagulation. [7,12] IVC filter placement should be considered when anticoagulation needs to be stopped due to the occurrence of significant bleeding. [12] A cohort study of patients with significant bleeding risk and VTE

Insertion and Retrieval Techniques

IVC filter placement is best for the IVC from the hepatic veins to the level of the iliac vein bifurcation. This can be grouped into infra-renal and supra-renal position. There are two common well established endovascular approaches which are the trans jugular (neck) and transfemoral (groin). [3] The most practiced method is the trans femoral vein route in sub-Saharan

Africa. [13] Most of the IVC filter positioned in the region is commonly in the infra-renal vein level.

Anatomy

The internal jugular vein (IJV) is located anterior and lateral to the carotid artery. A low puncture increases the risk of pneumothorax, and a high puncture increases the risk of arterial puncture because the artery lies more

directly posterior to the vein higher up in the neck. The common femoral vein lies medial to the artery. It is advisable to use ultrasonography (US) during the puncture. In sub-Saharan Africa, where ultrasound is not available in most centers, one may use blind puncture from the femoral using the inguinal ligament and directing the puncture more medial to the most medial femoral artery pulsation as landmarks. The anatomic site of the internal jugular and the femoral veins are demonstrated in figures 1 and 2.

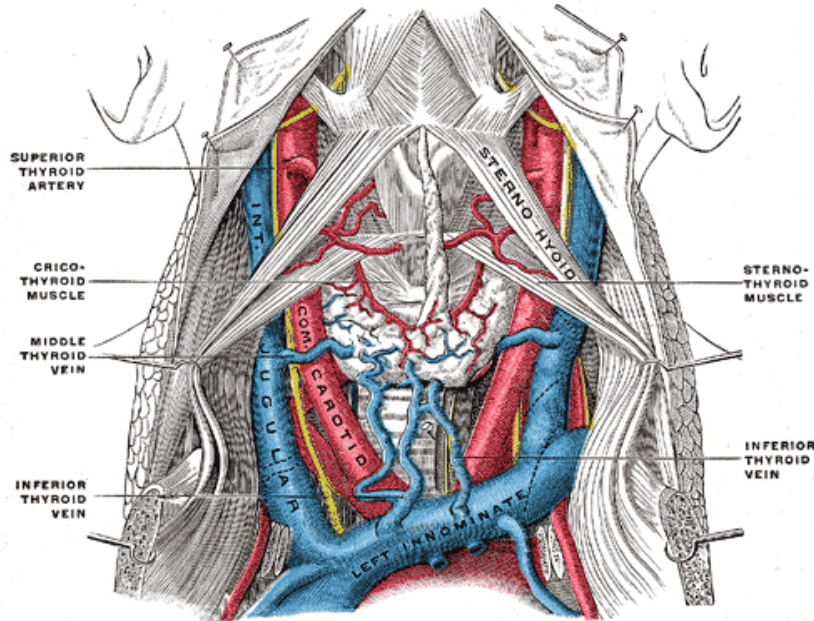


Figure 1: anatomy of the internal jugular vein.^{14, 15, 16}

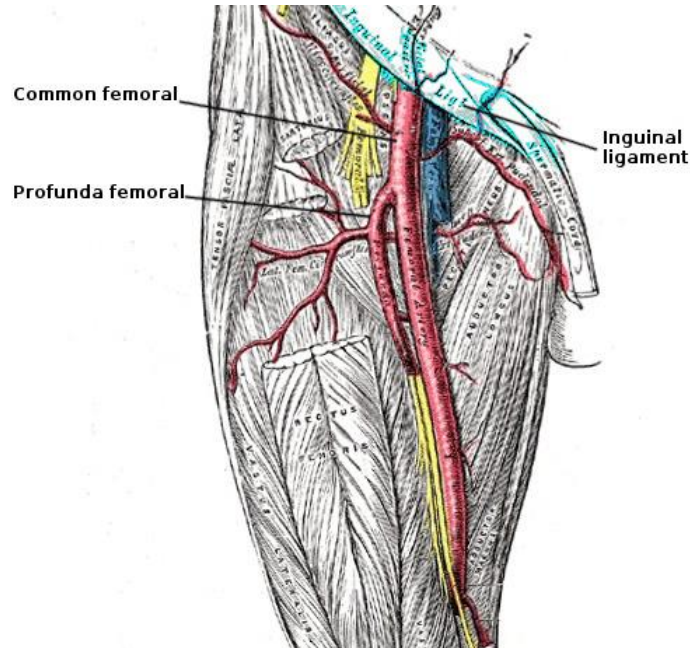


Figure 2: Anatomy of the femoral artery. From medial to lateral are the vein, artery and the nerve.^{17,18}

Procedural planning

Filter types

While planning the procedure, it is important to take a decision on the type of filter to be used. There are two different types of IVC filters; permanent (non-retrievable) and temporary (retrievable). [19] Permanent filters cannot be removed or repositioned. Temporary filters (optional filters) can be retrieved or removed. With time, the filter becomes incorporated into the

caval wall and may not be removable or surgical techniques may be used to remove it. [20-23]

The implanting physicians are responsible for the ongoing care of patients with retrievable IVC filters and should consider removing the filter as soon as the indication for PE prevention is resolved. [21,22] All physicians involved in the treatment and follow-up of patients receiving IVC filters should consider the risks and benefits of filter removal for each patient; a

patient should be referred for IVC filter removal when the risk-benefit profile favors removal and the procedure is feasible in light of the patient's health status. IVC filter placement is associated with a significant risk of malpractice litigation. [24]

Methods of Insertion. [25-28]

There are two methods of insertion. This is via a jugular or a femoral approach. The jugular approach is referable if an iliofemoral thrombus is present. ALN filters are commonly used in Nigeria. The insertion route is written on the filter either via the jugular or femoral. But their retrieval is via the side with the hook i.e jugular approach. The insertion could be carried out under fluoroscopy guided or ultrasound.

Inferior Vena Cava Filter placement

Explain the procedure to the patient and relations. Get informed consent. Evaluate the patient for contrast allergy. Place the patient on nil per oral (nothing by mouth) for 4-6 hours before the procedure. Clean the skin on the groin or neck with chlorhexidine or povidone-iodine solution depending on the access route. Puncture could be done blindly with palpation of the femoral artery as a guide or the use of an ultrasound device (with a sterile cover) to choose a point on the skin above the vein. Infiltrate 5-10mls of local anesthesia under the access skin.

Using an 18-gauge or micro puncture needle, puncture the anterior wall of the vein and enter the vein. Aspirate venous blood to confirm correct positioning. Evaluate the path of the wire on fluoroscopy to ensure an appropriate venous course. If using a micro puncture kit, convert to 0.035-in. wire.

Advance the 0.035 guide wire into the inferior vena cava (IVC). Advance the catheter into the iliac vein and take the venogram to identify the renal vein. The placement could be infra-renal or supra-renal position. The venogram also helps to measure the following:

1. Patency of the IVC
2. Size of the IVC
3. Ensure that no left-side IVC is present

The next step is to deploy the IVC filter if the venogram accepted. Position the catheter (7F catheter) and remove the dilator. Upload the filter in the 7F catheter and use the dilator to deploy it at the right position. Remove the dilation after deployment and take the final fluoroscopy post-deployment. Then remove the catheter and manually compress for 10 to 20 minutes to ensure no bleeding. Then move the patient to the ward for about 4 hours before discharge from the hospital.

Complications

Immediate Complications

Complication	Occurrence rate
Filter migration and embolization (i.e. >2 cm change from original position)	This occurs in less than 1%. ³⁷ More than 90% occur after 30 days.
Filter fracture	This occurs in 2–10% of filter inserted. ³⁸ About 40% risk of fracture at 5.5 years
IVC perforation: of the filter head or strut >3mm beyond the wall of the IVC or within an adjacent structure	The incidence is about 0–41%. ³⁹ About 20% of IVC filter complications reported as IVC perforation. ³⁷
DVT	Incidence at 2 years is about 21% and at 8 years about 36%. ⁴⁰
Filter-related thrombosis	This occurs at a rate of 2–30%. ³⁸

Table 2: IVC filter insertion complication

Contraindications to the filter insertion

The absolute contraindication for IVC placement is lack of access to the IVC and patient refusal of consent. The relative contraindications may include the following:

1. Deranged coagulation

There are several immediate complications that may occur during the procedure. During the initial placement of IVC filters, there is a small chance of mal-positioning where the filter is not placed in the infrarenal IVC.

This may be avoided using a careful deployment technique and a properly performed IVC venogram. In addition, the filter itself may not deploy correctly with all its struts not fully expanded. Other immediate complications include those related to access, such as arterial puncture, with major complications occurring in 11%. [29] There is a small chance of hematoma or bleeding, more commonly in groin access. Access site thrombosis may occur.

Filter Migration and Fracture

Filter migration and fracture are feared long-term complications that may cause serious harm. As venous flow is directed upward toward the heart, fractured elements or the filter itself may embolize more centrally. There have been cases of filter migration to the pulmonary artery and right ventricle, occurring from 0.1 % to 1.25%, with the of risk cardiac tamponade. [30] Struts that fracture and embolize to the cardiac wall and causes perforation are treated with open-heart surgery or percutaneously in select cases. Retrieval of intracardiac filters and fragments or those within the pulmonary arteries are quite challenging and require a complex armamentarium of foreign body retrieval devices. [31]

Filter Strut/Leg Perforations

One of the most common complications seen with IVC filters is penetration and perforation of the struts outside the confines of the IVC wall, occurring in 9%-24% of cases, which may represent a natural progression from IVC wall tenting to frank perforation. [32] Perforated struts may interact with adjacent organs, commonly the aorta, bone, ureter, and bowel. Symptomatic aortic and bowel injuries are unusual but have occurred and required surgical repair. [33] There have been rare case reports of penetrating IVC filters causing aortic pseudoaneurysms, retroperitoneal hemorrhage, hydronephrosis, and pancreatitis. Therefore, as advised by the FDA, retrievable IVC filters should be removed as soon as they are no longer needed to avoid these complications. [34]

Inferior Vena Cava Filter Thrombosis

IVC filter placement has been associated with an increased risk of DVTs and IVC thrombosis. According to the literature, IVC thrombosis occurs in 7.7%-30% of patients with IVC filters. [35] In patients without prior DVTs, new DVT may occur. In these cases, if not contraindicated, oral anticoagulation may be initiated to treat the DVT. If the patient is symptomatic, some centers advocate mechanical thrombectomy. A chronically occluded IVC, seen only in 2% of patients, has undergone angioplasty and stented open in some instances. [36]

The table 2 showed the common complications of IVC filter placement.

2. Total thrombosis of the IVC
3. Bacteremia, sepsis, or both
4. Caval diameter less than 15 mm

Conclusion

IVC filters are placed for the prevention of pulmonary embolism in patients with contraindications for anticoagulation or those with clear evidence of failed anticoagulation. The advantage of IVC filter insertion in the setting of acute PE is the prevention of morbidity and mortality from hemodynamic effects of PE recurrence. Complications are low and may arise during filter insertion or months after the procedure.

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