PERCUTANEOUS PLACEMENT OF INFERIOR VENA CAVA FILTERS

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SUMMARY

Pulmonary embolism is a serious and difficult problem. Many approaches for the prevention of recurrent pulmonary embolism have been tried. Percutaneous placement of inferior vena cava filters is an easy, safe, avalaible and well established procedure for the prevention of pulmonary embolism. The authors review the indications for use of IVC filters, and they review the main filters available in terms of ease of use, the physical characteristics, the technique of introduction, the efficacy and morbidity, and the potential complications associated with their use. Insertion of IVC filters by precutaneous approach was successfully performed in 6 patients with recurrent pulmonary embolism. Following the intervention procedure without complication there were no further pulmonary emboli.

RESUMO

Colocação Percutânea de filtros na veia cava inferior

A aplicação de filtro na veia cava inferior foi efectuada em 6 doentes com embolias pulmonares de repetição. Após a realização da técnica sem complicações não houve repetição de embolia pulmonar. A embolia pulmonar é um problema grave e difícil. A sua profilaxia tem sido feita de formas diversas. A colocação percutânea de filtros na veia cava inferior como prevenção da embolia pulmonar é uma técnica acessível, fácil e praticamente sem complicações. Revêem-se as indicações para o uso de filtros da veia cava inferior, as características, a técnica de introdução, eficácia e eventuais complicações dos principais filtros disponíveis.

INTRODUCTION

Most of the patients with venous thrombosis and pulmonary thromboembolism are generally treated with anticoagulants. However in patients in whom the anticoagulants are contraindicated, if there is a failure of anticoagulant therapy or complications from anticoagulant therapy, IVC interruption should be performed. This major operation needs general anesthesia and may have longterm sequela due to venous stasis.

Ligation of the inferior vena cava (IVC) was first performed as a treatment for recurrent pulmonary embolism by Trousseau in 1968[1]. Since then, ligation of the inferior vena cava has been an alternative therapy in patients with thromboembolic disease when anticoagulation fails or is contraindicated.

The inferior vena cava is interrupted because in 75% to 90% of the cases pulmonar emboli originate in the legs and pelvis. Surgical ligation has a mortality rate of 10% to 15% and emboli recurrence in 5,9% of patients[2]. To decrease the mortality rate and avoid general anesthesia, a percutaneous approach is used.

Inferior vena cava filters are devices to be introduced in the inferior vena cava in order to prevent major pulmonar embolism. For several years they were inserted via a surgical venous cut down. During the last 6 years, as some changes were introduced, caval filter placement has been accomplished mainly by percutaneous approach and their application increased. In the meantime new devices were developed.

The original Kimray-Greenfield vena cava filter and the Mobin-Uddin-umbrella were not simple percutaneous delivery devices, because they were bulky and cumbersome and required a special applicator and colaboration of surgery and radiology teams for placement.

The ideal filter should have a high filtering efficiency (large and small emboli) without impedance of blood flow, should not be associated with a high frequency of vena cava thrombosis, should have stability of positioning and a low rate of associated morbidity, and rapid percutaneous insertion[3,4]. The vena caval filters should trap emboli, and at the same time caval patency should be maintained and should have biologic and mechanical stability as well as safety and ease in placement.

As angicoagulation does not provide immediate protection from significant emboli, filters can be used as a therapeutic adjunct to anticoagulation[5].

Vena cava filters have become the method of choice for the prevention of pulmonary embolism for patients who cannot be given anticoagulant or thrombolytic drugs or for whom these drugs have failed.

Other indications, that are relative, are prophylaxis from pulmonary embolism in patients at high risk such as massive pelvic or extremities trauma, before neurologic, spine or hip surgery, patients with cor pulmonale and severe pulmonar hypertension or in combination with thrombolitic therapy. The filter can be used as perioperative prevention of pulmonary embolism in very high risk operations of pulmonary emboli as in total hip replacement that carries a 25% risk[3]. In this situation the IVC filter is also indicated in patients with pulmonary embolism and deep vein thrombosis of the lower extremities suficient in size and extent to be detected by Doppler ultrasound.

One contraindication to percutaneous filter placement is severe blood coagulapathy that predisposes to bleeding from the puncture site. In young patients filter placement should not be done.

Types of filters: Mobin-Uddin Umbrella filter – The first IVC filter was the Mobin-Uddin Umbrella filter introduced in 1970[6]. This filter was withdrawn from the market in 1986 because of the high frequency of caval occlusion and its sequela[5]. It was designed for introduction through a venotomy under local anesthesia.

Greenfield filter – The Greenfield filter, that was developed in 1976[7], was originally inserted through an internal jugular vein venotomy and later by percutaneous approach. It consists of six stainless steel legs attached to a central hub and radiating out to form a cone. The hip of each leg has a hook to anchor it to the caval wall. The apex filter is oriented with its apex pointed cephalad. The emboli accumulate in the central cone tip. The body's natural thrombolytic system tends to lyse the clots captured by the filter.

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Originally the Greenfield filter was inserted via a surgical venotomy of either the femoral or internal jugular vein using a carrier capsule mounted on a catheter. The jugular approach has a straighter course into the IVC, it therefore keeps the filter better centered during insertion. On other hand, it avoids the possibility of dislodging any thrombus that might be present within the pelvic veins.

Nowadays, it is introduced percutaneously through an introducer sheath with an inside diameter of 24 F and an outside diameter of 29 F. The introducing tract is made with either Teflon dilators of increasing diameter or with an angioplasty balloon catheter (7 mm diameter, 3 cm length).

The Greenfield vena cava filter is the most widely used of the current available filters[8,9]. However, it has some disadvantages that led to the development of several new IVC filters. One disadvantage is the need to create a large-bore tract, which is responsable for the prevalence of thrombosis at the insertion site. A second disadvantage is the occurrence of filter tilt which reduces filter capability[10]. Malposition of the filter into the renal veins, hepatic veins or right atrium has been reported. Misplacement of the Greenfield filter into other veins or even migration can occur[11]. Even small migrations can have serious consequences. If, for example, some of the filter leg enters a renal vein, the filter will tilt, therefore there is a decrease in clotting efficiency[12].

With continued flow maintained at the periphery of the caval lumen, the rate of caval thrombosis is only 3-5 percent[8]. Recurrent emboli occur only in 2%[9]. However, with the development of other new generation filters that can be inserted through smaller caliber sheaths, the Greenfield filter is less used.

The principal advantage of the Greenfield filter is that, even with 80% of the cone filled with clot, the cross-sectional area is reduced only 64%. However, if the filter is off center, large clots can bypass the filter through the wider spaces between the limbs.

Titanium Greenfield filter – The Titanium Greenfield filter is a modified design of the stainless steel Greenfield filter. It does not have an apical hole for guidewire insertion[4].

It comes in a 12 F carrier and is introduced through a 14 F catheter. It can be used for cava with a diameter not exceeding 28 mm. There is a 4% rate of embolism migration in 30%, tilting in 40% and suspected penetration of the caval wall in 30%[13]. At the base it is broader than the Greenfield filter and it exerts a force of fixation on the wall of the IVC.

Bird's Nest filter – It is made of four stainless steel wires bent several times and preshaped in such a way that upon insertion into the IVC it has a shape like a bird's nest. There is a hook at the end of each wire to anchor the filter. It comes in an 11 F carrier and is inserted through a 14 F sheath by femoral or jugular approach.

The filter is pushed with a detachable wire. As it advances it resumes its configuration and fixes to the vessel wall[14]. At the end the wire pusher is detached and the Teflon catheter and sheath are removed together. It is the only filter suitable for vena cana sizes between 20 and 40 mm in diameter. All the others can only be up to 28 mm.

The second generation devices have a cava occlusion of 1,4% and recurrent embolism of 0,5%. It is a very effective filter and the rate of embolization is only 1%[5]. Due to its form, it is not subject to the need for centering.

Vena Tech filter – This filter is a cone with six flat metallic diagonal limbs. Welded to each limb of the filter, there is a straight side rail parallel to the walls of the IVC, for stabilization in the center of IVC, with small barbs that hold the filter in place. It comes prepacked in a 10-French carrier and requires a 12-French outer diameter sheath.

Follow-up at 1 year showed migration of the filter in 13%, recurrent pulmonary embolism in 2% and vena cava occlusion in 7%[4].

Basket filter – The Basket filter, designed by Gunther et al in 1986, consists of a basket like structure of 12 stainless steel wires with a caudal hook to allow percutaneous retrieval[15].

For introduction, the Gunther filter is inserted into a loading cartridge and then advanced with a guidewire through a 10 - F catheter, from either the femoral or the jugular approach. It can be retrieved within 1-2 weeks without damage to the vessel wall. There is caval thrombosis in 7% of patients.

It has the advantages of easy insertion into the IVC without tilting, effective filtration, stability in remaining parallel to the central areas of the cava and possible percutaneous retrieval.

Nitiol filters – These are made of Nitiol wire preshaped in a mushroom-like configuration. Nitiol is an alloy of nickel and titanium and has thermal memory properties. The nitiol wires are preshaped at a high temperature. When cooled on ice they become soft, but when rewarmed at body temperature they resume their initial shape[15].

Upon insertion through an 8-F introducer, the filter assumes its original shape.

a. Palestran filter – The Palestran filter is a Nitiol filter that has two components, one is a filter mesh and the other a component with six anchoring limbs with terminal hooks that penetrate the vena cava wall up to 1 mm[15].

b. Cragg filter – The Cragg filter is a spiral Nitiol filter, that can be introduced through an 8 - F catheter. It can be repositioned easily. It can be adjusted to every size of the vena cava by tightening or loosening the spiral. The apex is oriented superiorly and can hold emboli[16].

c. Simon Nitiol filter – The Simon Nitiol filter is made of Nitiol. The filter has an umbrella made of seven pedal loops which provide the major filtering and six legs for fixation to the caval wall. It is inserted through a 7 - F carrier with a 9 - F diameter sheath. It has a recurrent pulmonary embolism of 1,1%, and a vena cava occlusion of 7,8%[4]. It is only 3 cm in length therefore it is preferable where the longitudinal distance between the renal veins and iliac bifurcation is reduced or when the smaller 9-F percutaneous puncture is advantageous.

Amplatz filter – The Amplatz filter is made of an inert alloy formed into a spider configuration with its apex directed caudal.

The caudal hook allows percutaneous retrieval of the filter through a 14 - F Teflon catheter from femoral approach. Therefore the filter can be used for short-term profilaxis of pulmonar embolism. The clottrapping efficiency is not significantly affected by tilting[17]. Misplacement can occur in 2% of the cases. It is introduced through a 14 - F catheter.

Technique of introduction – Before the placement of the filter, the patient should be informed that the filter is a permanent implant.

The filters may be introduced through a femoral or an internal jugular vein or even the external jugular vein for small filters. The right femoral vein is most commonly used. The left femoral vein can also be used with the new, smaller systems of introduction , in spite of the fact that there is greater resistance in filter passage. The presence of iliac or low IVC trombi is a contraindication to the placement of the filter by the femoral approach. The internal jugular vein should be punctured just lateral to the carotid artery, midway between the sternal notch and the angle of the jaw, with the needle parallel to the spine.

To puncture the femoral or jugular vein, a single wall puncture technique should be performed. For the purpose, during the insertion of the needle, a continuous suction is applied with an attached syringe.

An inferior vena cavogram is performed in order to check IVC patency and the extent of thrombus, if any, to measure the transverse diameter of the vessel below the renal veins and the susceptibility to the intended filter device, to delineate the IVC anatomy, to determine the level of the renal veins and possible IVC, anomalies[6]. Cavography is also performed to visualize collateral vessels, to choose the delivery site and approach of insertion and to choose the type of filter.

A diameter of the filter should be greater than that of the IVC. In the event of a large IVC, if there is no large filter available, a filter can be placed in each iliac vein.

A better level of placement of the filter is immediately below the renal veins. This is to maintain patency of the renal veins if IVC thrombose occurs and if there is any significant collateral vessel. The filter should be close to the renal veins in order to avoid a large stagnant dead space between the filter and the renal veins, in which clots can be formed if the cava thrombosis occurs[12].

Using the applicator, the filter is introduced under fluoroscopy and positioned just below the renal veins. After that, the cavography is repeated in order to confirm patency of the IVC and for diagnosis of complications such as perforation or filter migration. The applicator and the sheath are then removed.

For a basiline, a plain radiograph of the abdomen is obtained of anteroposterior and lateral views. The radiograph can show integrity, angulation and migration of the filter. Cavography and CT may be needed for further evaluation of the filter.

MATERIAL AND METHODS

A vena cava filter was placed in 6 patients, all females between the ages of 41 and 65, mean 58. All patients had several episodes of pulmonary embolism documented by scintigraphy as multiple segmental defects. Four patients were treated with heparine, the remaining two had contraindication to heparine, one had an active duodenal ulcer and the other had had a stroke 6 months earlier. All patients were considered high risk for pulmonary embolism.

All patients had venograms that revealed extensive deep vein thrombosis in the lower extremities and two had thrombus in the iliac veins and inferior vena cava below the renals.

In one patient a Greenfield filter was placed and in another a Palestran filter was introduced, both by femoral approach.

In four patients a Gunther filter was placed percutaneously in the inferior vena cava, two by femoral approach and two by interna jugular vein approach. In two patients a Bird's nest filter was placed percutaneously by femoral approach.

RESULTS

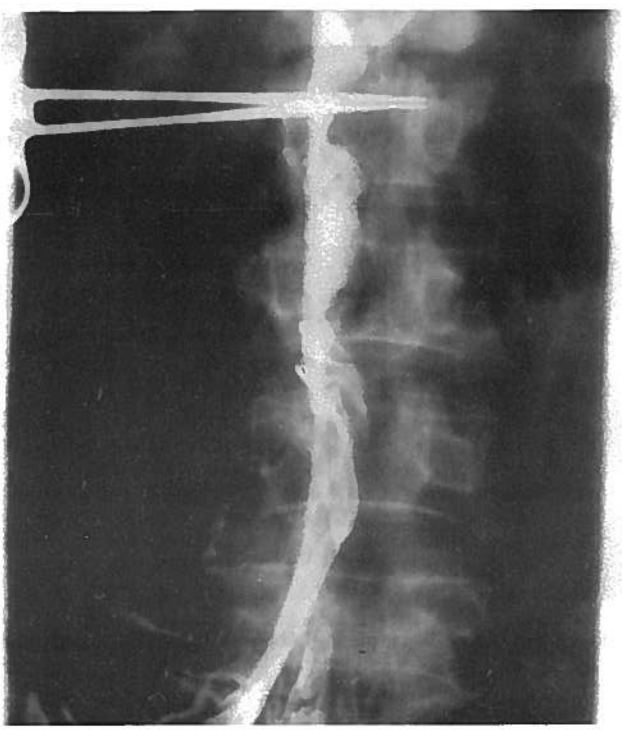
The filters were correctly placed below the renal veins, without complication.

Following the inferior vena cava placement, neither of the patients had any further episodes of pulmonary embolism.

Representative cases:

Case 1: PN, white female, 43 years of age, with severe ischemia of both lower limbs due to severe occlusive disease of both femoral arteries. An aorto-bifemoral bypass was performed.

One month later the patient had several episodes of sudden onset of left chest pain. A venogram revealed extensive thrombus in the calf veins, femoral veins and IVC. The ventilation perfusion demonstrated multiple segmental defects in the right lung base. The patient was considered a high risk for pulmonary embolism due to a duodenal ulcer and a Gunther IVC filter was placed percutaneously through the right interna jugular vein (*Fig. 1*). The patient did not have any further pulmonary embolisms.



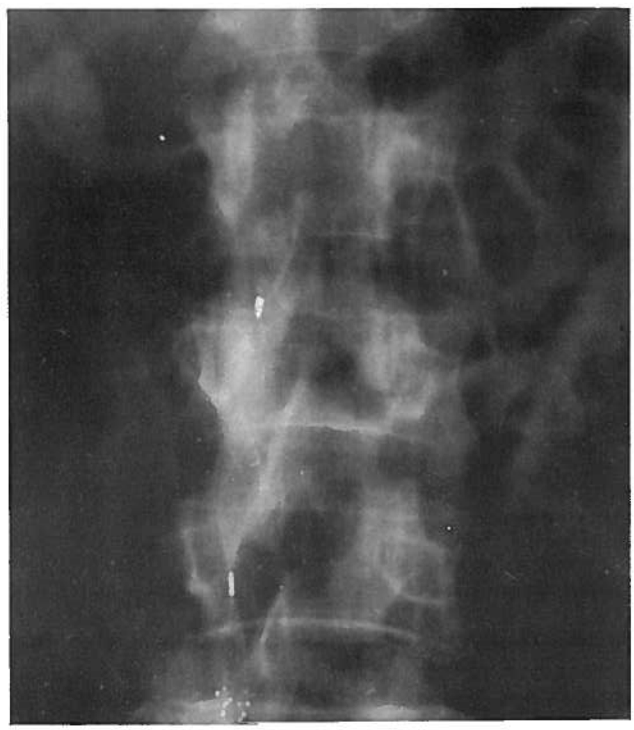


Fig. 1 – a) **Inferior venacavography performed through jugular vein-extensive iliofemural thrombosis up to renal vein level (metallic marker).** ***b)*** **Abdomen plain film-Gunther filter in place.**

Case 2: L.S. 63 year old white female with three episodes of pulmonary emboli, documented by scintigraphy, and treated with heparine. Thrombosis of the left iliac vein and of the right femoral and popliteal vein. Due to a recent stroke, heparine was contraindicated. A Gunther filter was placed percutaneously by right femural approach (*Fig. 2*). The patient did not have any further pulmonary embolisms.

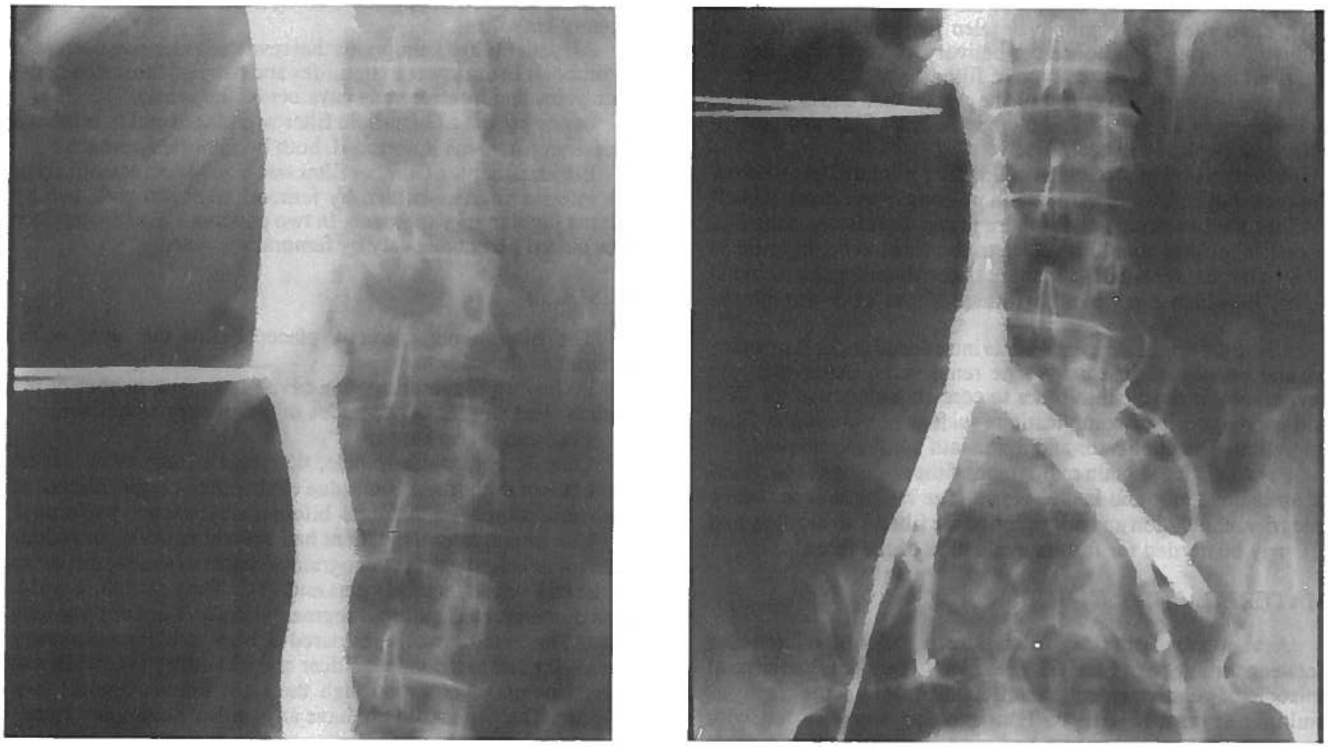
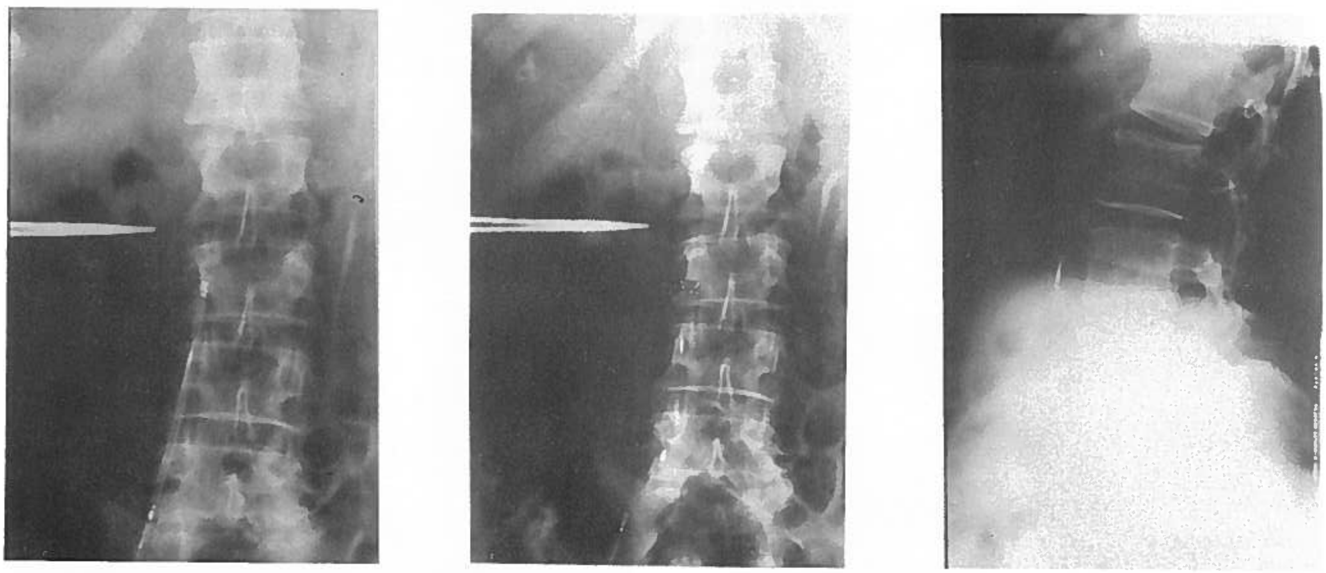


Fig. 2 – a) Inferior venacavography performed of right femoral vein. Metallic mark at the level of renal veins. *b)* Inferior vena cavography after placement of Gunther filter.



c) Filter inside the introducer before delivering. *d)* Abdominal plain film anteroposterior view – Gunther filter in place. *e)* Abdominal plain film, lateral view: Gunther filter in place.

Case 3: L.M. 63 year old, white female with a large uterine fibromyoma, who had several episodes of left chest pain, in spite of treatment with heparine. Venography documented bilateral deep vein thrombosis in the lower extremities and IVC. A scintigraphy performed showed a perfusion defect in the left lung. A Bird's nest filter was placed percutaneously by right interna jugular vein approach (*Fig. 3*). There were no further pulmonary embolisms and the patient was operated to the uterine tumor 3 days later.

Case 4: MAS – 43 year old female who had several episodes of pulmonary embolus, documented by scintography, in spite of being treated with heparine. Thrombosis of the right iliac vein. After a Bird's nest filter was introduced by left femoral approach, there were no further pulmonary embolisms (*Fig. 4*).

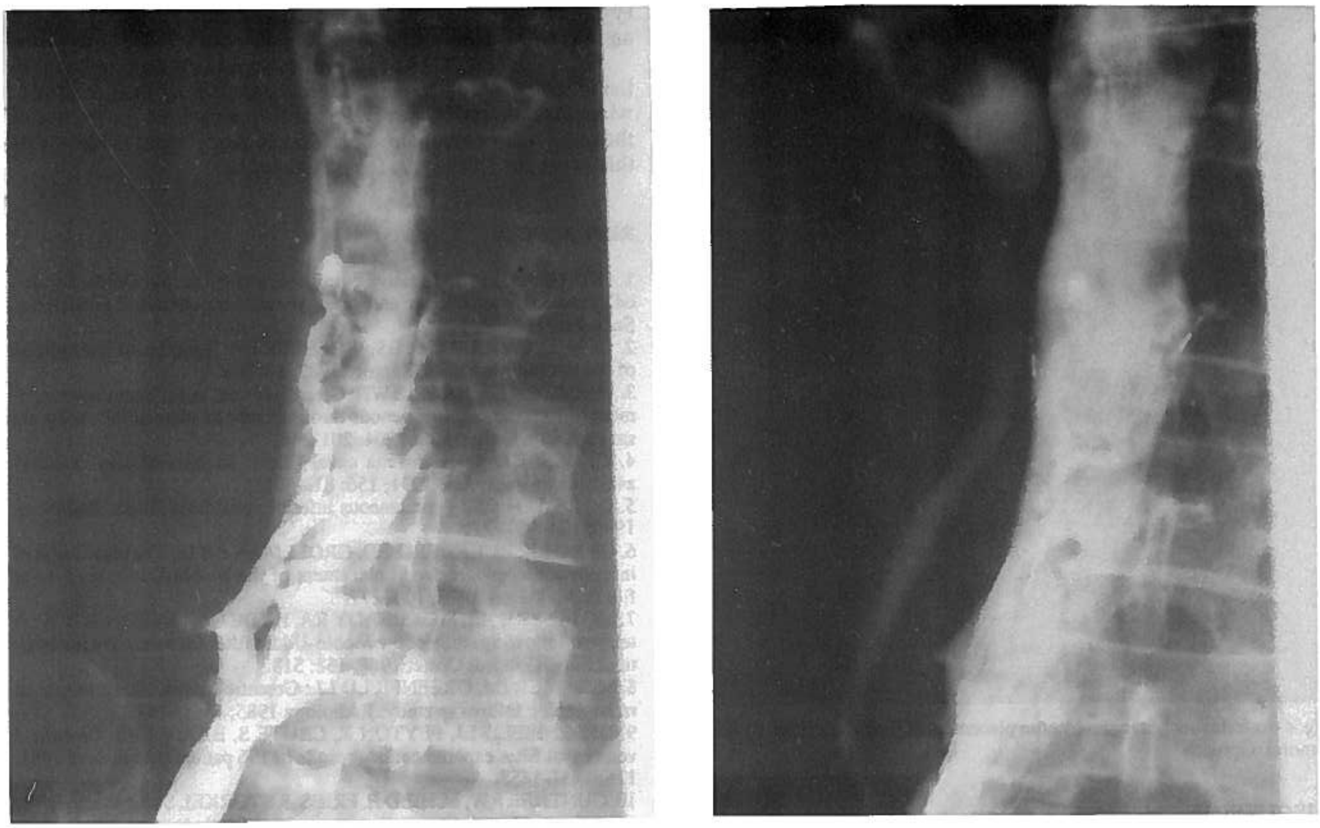
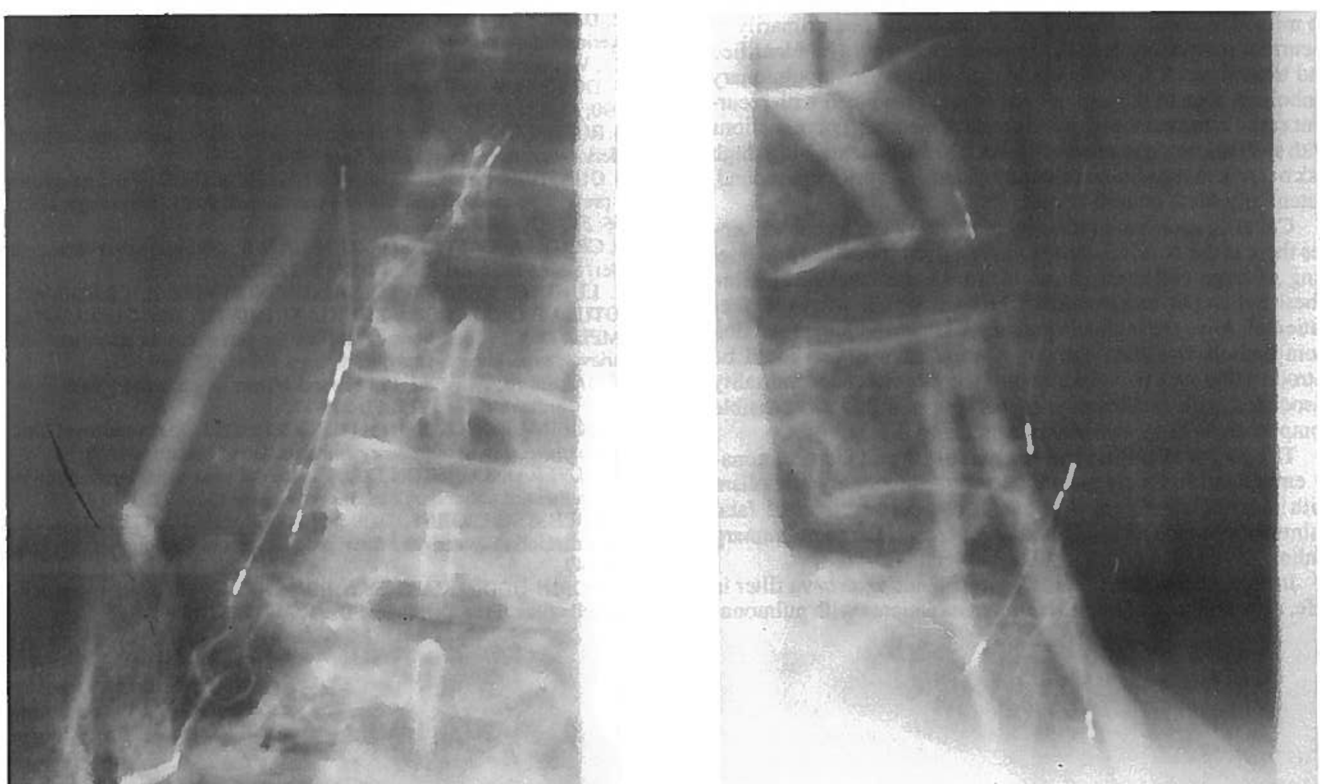


Fig. 3 – a) Inferior venacavography – thrombus in IVC. *b)* Inferior venacavography after Bird's nest filter



c) Plain film of the abdomen shows the filter. *d)* Lateral film of the abdomen shows the filter. Dilated ureters due to compression by uterine tumor.

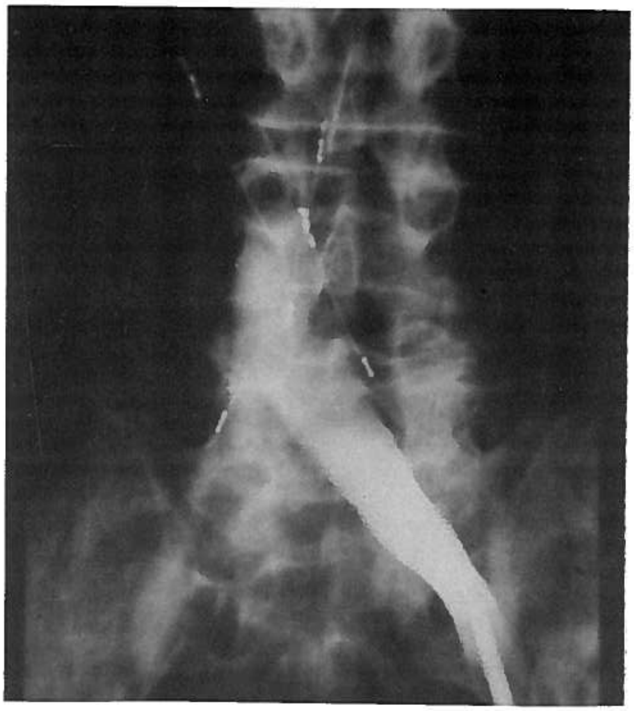


Fig. 4 – Inferior venacavography after placement of Bird's nest filter, by left femoral approach

DISCUSSION

There are about 630,000 symptomatic cases of pulmonary embolism per year in the United States with an immediate mortality of 11%[18]. Of the remaining 563,000, the diagnosis would be missed in about 71%, 30% of whom would die, primarily of recurrent pulmonary emboli. Another 29% would be identified and treated, yet 8% to 9% would die with recurrent pulmonary embolism. Due to the high mortality rate associated with recurrent embolism, and the high incidence of bleeding complications with systemic anticoagulations (about 20%), patients with a high risk of recurrent embolism should be identified prior to a second, potentially fatal, embolic event.

Caval ligation has a mortality of about 12%[3]. As consequences there is the development of lower extremity edema and opening of large collateral channels around the level of ligation. These collaterals can eventually bring emboli in 4% to 50% of patients[3]. A way to maintain patency while providing protection from emboli was then sought. A vena cava filter should be introduced in such patients avoiding the morbidity and mortality associated with recurrent pulmonary emboli and the possible complications of systemic anticoagulation therapy.

The goal of IVC filter placement is to prevent fatal pulmonary embolism: the incidence of recurrent pulmonary embolism with most of the filters is about 5 to 6 percent, and of fatal pulmonary embolism is about 2 to 3 percent. Large pulmonary emboli are trapped by all available filters.

In spite of that, the use of a percutaneous vena cava filter is safe, easy and curcial in the treatment of patients with pulmonary embolism or deep venous thrombosis, we were asked to place an IVC filter in only 6 patients.

Every patient had had several episodes of pulmonary embolism before IVC placement. There were no complications following this intervention procedure and there was no recurrence of the pulmonary embolism. Therefore it is important to know that this procedure is easy, safe and available.

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