INTERVENTIONAL RADIOLOGY – SPECIALITY OF THE CURRENT CENTURY: INITIAL EXPERIENCE AT SRMC & RI

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INTRODUCTION:

Radiology remained a diagnostic science ever since its inception following the discovery of X-rays by Roentgen in 1895. The speciality has grown with contrast studies, fluoroscopy and invasive access to blood vessels by Seldinger's technique which have paved a new way to approach clinical diagnosis. The term "interventional radiology" was coined by Alexander Margulis in 1960 to denote a group of procedures done with the help of imaging. Initially it began with simple image guided biopsy or abscess drainage with the help of fluoroscopy. The addition of cross sectional imaging in the last two decades such as CT, Ultrasound and MRI has provided a new dimension in understanding disease process. The innovation of angioplasty (PTA) by Charles Dotter in 1964 was a break through in interventional radiology. Slowly but inevitably procedures that once required surgeons and surgical incisions have been replaced by percutaneous image guided techniques. With the addition of technological innovation and micro devices, the scope, and the number of procedures have increased with a separate speciality being started for each organ/system of the body. The addition of 3D rotational angiography was a boon to the interventional neuroradiologist. Basically interventional procedures aim at opening or closing, ie., opening of a blocked duct or blood vessel and closing of an abnormal or leaking duct or vessel by introduction of various devices. This article aims at the scope of interventional radiological procedures, including those performed at SRMC & RI.

MATERIALS AND METHODS:

Invasive angiography and interventions performed by the interventional radiologist has been analyzed. A total of 2732 angiographic / interventional procedures were performed (M=1737: F=995; Age range=1day to 87years, N = 48years). The procedures were performed using Biplane DSA 3D rotational angiography system (LCN+ GE Milwaukee). The indications for interventional

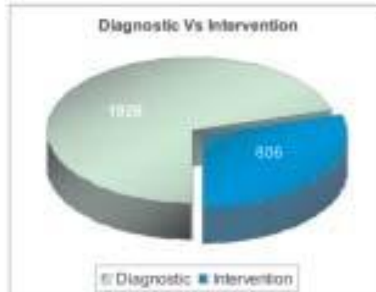

Chart 1: Diagnostic and Interventional procedures

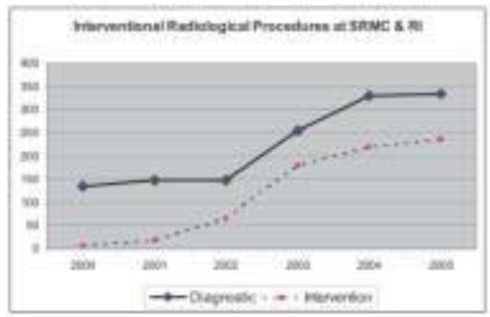

Chart 2: Number of procedures

procedures included acute vascular emergencies, control of acute bleeding, acute stroke, acute limb, several difficult clinical problems such as AVM, aneurysms etc. and for preventive measures, to manage therapeutic complications, as an aid to palliative care, pain management and infertility. This article aims to highlight the variety and the scope of these procedures in patient care.

A) INTERVENTION IN ACUTE VASCULAR EMERGENCIES

A.1 Aortic dissection (Fig. 1)

Aortic dissection typically originates in the ascending aorta (Type A) or post left subclavian artery (Type B). Both are surgical emergencies and cause high degree of morbidity and mortality due to co-morbid conditions. Branch vessel occlusion with end organ ischemia complicates approximately 1/3 of cases of aortic dissection [1, 2]. Mortality for aortic dissection is 15-25% but exceeds 50% when the dissection is complicated by paraplegia due to renal or mesenteric ischemia [1,2]. Several percutaneous options for management of acute and chronic dissection are available. Placement of a stent – graft over the entry tear has been shown to lead to depressurization of the false lumen and restoration of normal flow dynamics in the true lumen. Percutaneous fenestration of the aortic flap (intentional creation of a large distal exit tear) can decompress the false lumen and relieve obstruction of the true lumen.

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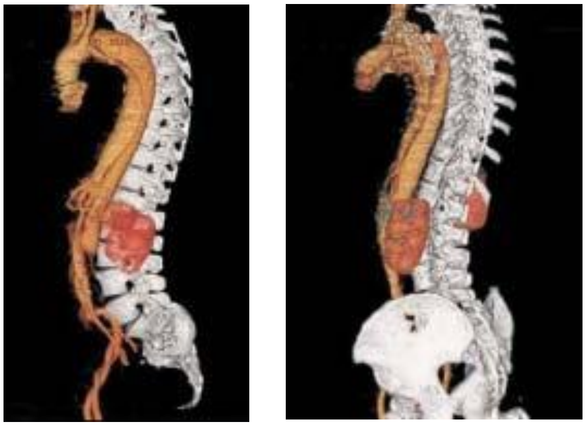

Fig.1 Aortic dissection

Aortic dissection. *Patient presented with sudden onset of chest pain and hypotension. ECG and Troponin T was negative.* ***A:*** *3D CT Reconstruction shows Type B aortic dissection. Stent graft was deployed to seal the entry point.* ***B:*** *3D CT reconstruction after stent graft deployment site shows disappearance of the false lumen.*

A.2 Aortic injury

Aortic injury may result from rapid deceleration and crush injuries, penetrating wounds or instrumentation during surgical or angiographic procedures. The majority of thoracic aortic injuries are due to blunt trauma. Transections of the ascending aorta are almost uniformly fatal. Survival beyond the initial injury occurs only when a pseudoaneurysm forms that is contained by adventitial or periadventitial mediastinal tissues. Mortality from untreated aneurysm rupture exceeds 90% within a month. The conventional therapy for aortic transection is surgery with placement of a short tube graft. This surgery has a 5-10% risk of spinal cord ischemia but otherwise has excellent long term results. Endovascular stent grafts can be used to exclude the traumatic aortic pseudoaneurysm. This may be the preferred initial management in a multitrauma patient, followed later by elective surgical repair.

A.3 Aortic aneurysm (Fig. 2)

Infra renal abdominal aortic aneurysm (AAA) is the

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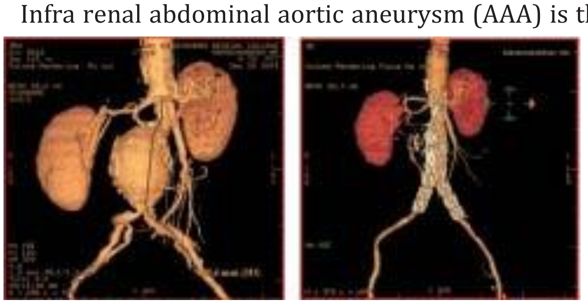


B

Fig.2 Aortic aneurysm

Infra renal aortic ANEURYSM with impending RUPTURE. *Patient presented with severe abdominal pain and hypotension.* ***A:*** *3D CTA showing infra renal aortic aneurysm.* ***B:*** *CT Angiogram after stent graft deployment showing exclusion for the aneurysm from circulation with preservation of flow in the renal arteries. Patient had a remarkable recovery.*

most common aneurysm of the aorta. The natural course of AAA is expansion and rupture. Estes reported that 1- , 3- and 5- year survival rates of untreated patients were 67%, 49.2% and 18.9% respectively [4]. In his series, the cause of death was aneurysm rupture in 63.3%. The current standard of treatment for AAA is open surgical repair, which carries a low overall risk mortality of 1.4 to 6.5% [3]. In high risk patients with co- morbid medical conditions or in patients with impending rupture, the operative mortality is considerably higher (5.7 to 31%) [5]. Endovascular stent graft repair may provide a suitable alternative for the high risk patient. Aortic stent grafts are available in three basic configurations. Patients must meet anatomic criteria involving the proximal and distal attachment sites, angulation and tortuosity of the aorta and pelvis, the presence of calcification and occlusive disease in the access arteries.

A.4 Acute Limb Ischemia (Fig. 3)

The acute, profoundly ischemic limb is a surgical emergency. Cell death begins after 4 hours of total ischemia and is irreversible after 6 hours. Hence, urgent revascularization is necessary. The mortality of patients with acute limb ischemia is almost 25% despite aggressive intervention, with amputation in 20% of those that survive. Surgical intervention remains the choice of therapy.

A B C

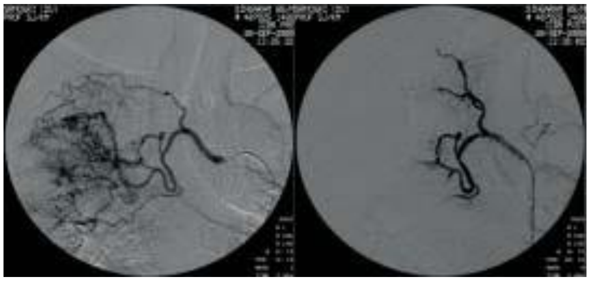
Fig.3 Acute Limb Ischemia

ACUTE right UPPER limb ischemia. *11 year old boy presented with history of acute pain and swelling of the right upper limb with previous history of cricket ball injury.* ***A:*** *Brachial angiogram shows embolic occlusion of brachial, ulnar and radial arteries.* ***B:*** *Traumatic pseudo aneurysm of right subclavian artery.* ***C:*** *Angiogram following stent graft placement reveals complete exclusion of the pseudoaneurysm from circulation. Patient underwent surgical embolectomy through the brachial arteriotomy. Limb function improved and became normal.*

Percutaneous interventions in appropriate patients are indicated when emergent revascularization is not required. Pharmacologic, mechanical and aspiration thrombectomy are useful techniques in both embolic and thrombotic occlusion. Occlusions less than 14 days old are amenable to pharmacologic and mechanical thrombolysis [6,7]. Aspiration thrombectomy should be considered for acute (<48 hours) occlusions. Thrombolysis and mechanical thrombectomy successfully restore antegrade flow in over 95% of patients provided that the occlusion can be crossed with an infusion catheter or thrombectomy device. Often a combination of intervention and surgical procedures may be helpful to achieve the optimal results.

B) CONTROL OF HEMORRHAGE

B.1 Bronchial arterial embolisation (Fig. 4)



A B

Fig.4 Bronchial arterial embolisation

Hemoptysis. *65 year old patient presented with intractable hemoptysis.* ***A:*** *Right bronchial angiogram shows hypertrophied right bronchial artery with abnormal lung vascularity.* ***B:*** *Post embolisation angiogram shows reduction of flow. Patient had no hemoptysis on follow up.*

The most common cause of hemoptysis in our country is infective lung disease such as Tuberculosis or Bronchiectasis; malignant disease, sequestration and AVM being the other causes. Massive hemoptysis is defined as hemorrhage > 300mL in 24 hours. A single episode of hemoptysis carries the risk of asphyxiation if it approaches the volume of the tracheo-bronchial tree (approximately 150ml)[8] Massive hemoptysis has a high mortality rate (>50%) when treated conservatively. Surgery has been considered the standard therapy in patients with adequate lung function and localized hemorrhage. However it may not be feasible in patients with poor pulmonary reserve and carries high morbidity and mortality in an emergent situation[9,10,11]. BAE is a well accepted procedure in the management of massive or recurrent hemoptysis in a patient who is a non surgical candidate. The purpose of BAE is defined as: first, to achieve immediate control of bleeding in all patients, second to obtain continuous bleeding control in patients without surgery; and third, to improve clinical conditions for a prospective surgery.[10]

B.2 Upper GI bleed (Fig. 5 & 6)

The causes for GI bleed include gastritis, bleeding ulcer, benign or malignant tumors or angiodysplasias. Most of the patients are in an unstable state and surgical correction carries significant morbidity and mortality. Because the risk of post embolic ischemia is minimal due to rich collateral circulation in the upper GI tract, transcatheter embolotherapy is more preferred method compared to pharmacotherapy. The goal of embolotherapy is to reduce the pressure in the bleeding artery while maintaining enough collateral flow to preserve viability. Bleeding gastric and duodenal ulcers and hemobilia can be effectively managed by embolotherapy with gelfoam, polyvinyl alchohol particles

A B C

Fig.5 Upper GI bleed

Upper GI Bleed. *25 year old male presented with severe hemetamesis with drop in hemoglobin (Hb – 4gm%).* ***A:*** *Selective gastro duodenal angiogram showing angioma in the first part of the duodenum.* ***B:*** *Catheter advanced selectively into the feeder and embolised using particulate agents.* ***C:*** *Post embolisation angiogram shows disappearance of angioma and the patient did not have further hemetamesis*

(Ivalon) and coils. Gelfoam powder, extremely small Ivalon particles and absolute alcohol should not be used because of the risk of mucosal ischemia or necrosis.[12] In patients with upper GI bleed due to varices, the TIPS procedure is of documented benefit in case of failed medical management. The transjugular Intrahepatic portosystemic shunt (TIPS) procedure decompresses the portal venous system by the percutaneous creation of a low resistance tract in the liver between the portal and hepatic venous systems. The availability of stent grafts has vastly improved the primary patency of these shunts. TIPS is also of documented benefit in intractable ascites due to portal hypertension. The technical success rate for TIPS for variceal bleeding averages about 97% with hemostasis obtained in approximately 98%.

A B C

Fig.6 TIPSS

TIPS. *48year old gentleman presented with intractable ascites due to hepatitis B related cirrhosis.* ***A:*** *Right hepatic venogram.* ***B:*** *Right portal vein access obtained through the liver parenchyma.* ***C:*** *Following successful stent graft placement forward flow noted from the portal vein into the IVC through the stent. Following stent placement portal pressure gradient drop from 40 to 22mm. Significant reduction in ascites after TIPSS*

B.3 Lower GI bleed (Fig. 7)

The common causes of major lower GI bleeding are diverticular disease, angiodysplasia tumors, ischemic enteritis, Meckel's diverticulum, inflammatory bowel disease and post polypectomy bleed.[13,14] Embolotherapy is safer in the small intestine than in the colon because of relative spare vascularity and poorer collateral pathways in the colon.[15] Embolisation should be performed at a level distal enough to maintain some collateral perfusion with a caution of preserving vasa recta.[16] Although embolotherapy for colonic bleeding presents a considerable risk of acute mucosal necrosis, the risk is less than for surgery.

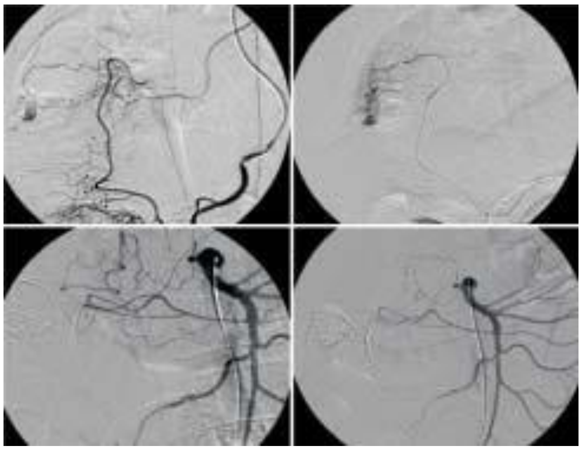


Fig.7 Lower GI bleed

Lower GI Bleed. *64 year old male known CAD underwent CABG on anticoagulants presented with intractable bleeding per rectum.* ***A:*** *Selective superior mesentric artery angiogram revealed bleeding angioma in the ascending colon.* ***B:*** *Microcatheter placed just proximal to the bleeding point and embolised with NBCA.* ***C & D:*** *Post embolisation shows complete occlusion of the bleeding point. Patient hematocrit improved with no further episodes of bleeding*

B.4 Trauma

The diagnostic angiographic examination in trauma patients is focused on the injured limb segment. The range of vascular injuries include spasm, intimal tears, pseudoaneurysm, extravasation, occlusion and arteriovenous fistula. Branch vessel pseudoaneurysms and arteriovenous fistulas can be easily treated by transcatheter embolisation. Similar injuries to the major arteries can be effectively stabilized with stent grafts.

B.5 Postpartum and gynaecologic bleeding (Fig. 8)

Pelvic embolisation is sometimes required in women with vaginal bleeding following vaginal delivery, obstetric or gynecologic surgery or from unresectable gynaecologic tumors. A pelvic angiogram followed by selective internal iliac injections should be obtained. Post partum bleeding from uterine atony or placental abnormalities can be managed with selective catheterization of the uterine artery and embolisation with PVA particles or gel foam. Small permanent particles, such as 300-500mm are usually used to devascularize tumors. The procedure is simple and can preserve the uterus and reduce the number of blood transfusions. Post partum hemorrhage may at times be resistant to medical management and destructive

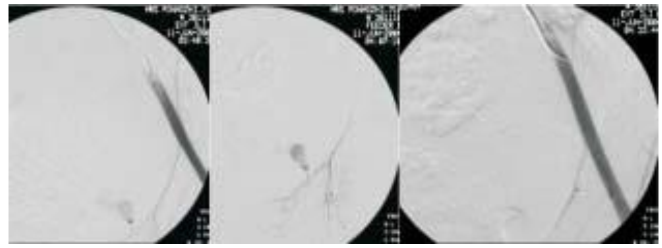


Fig.8 Postpartum and gynaecologic bleeding

Post PARTUM haemorrhage. *27 year old lady presented with profuse bleeding following delivery.* ***A:*** *Selective angiogram of the external iliac artery shows pseudo aneurysm from a small tip.* ***B:*** *Micro catheter placed distally within the pseudo aneurysm, embolised with NBCA.* ***C:*** *Post embolisation angiogram showing total Embolisation of the pseudo aneurysm*

surgical techniques such as hysterectomy or internal iliac artery ligation with its complications may have to be performed.

B.6 Epistaxis (Fig. 9)

Causes of nose bleed include spontaneous anterior or posterior epistaxis conventionally treated by nasal packing. Bleeding may be intractable when it is due to defective vascular disease such as carotid aneurysm or AVM. Nose bleeds are common and usually due to source in the anterior portion of the nose. These bleeds can be controlled easily by surgical packing. Posterior epistaxis is much more difficult to control by post nasal packing. In cases where conventional management fails, surgical ligation or clipping

Fig.9 Epistaxis

Epistaxis. *This 54 year old male presented with intractable epistaxis.* ***A:*** *Right internal carotid angiogram shows pseudoaneurysm in the petrous segment of ICA.* ***B:*** *Following stent graft placement the pseudo aneurysm was completely excluded from the circulation. Patient recovered with no episodes of bleeding*

of internal maxillary artery is done which has a 10-30% failure rate. Selective catheterization of the internal maxillary artery and embolisation with particles (Ivalon) and gel foam successfully controls bleeding in 75-95% of the cases. Adjunctive coil embolisation can be considered in patients with intractable epistaxis.

C) PRIMARY INTERVENTIONS IN STROKE

Stroke is the third leading cause of death in the United States and perhaps the greatest cause of morbidity. There are 150,000 deaths from stroke per year, and about 550,000 new strokes per year. Lingering terminal existences and morbidity is the rule and causes a high disease burden for the community.

C.1 Ischemic Stroke (Fig 10)

In most ischemic insults, there is an area of irreversible tissue damage surrounded by a region that may be viable and teetering on the brink of cell death - the ischemic penumbra.[17,18] It is this potentially salvageable ischemic penumbra that results in clinical improvement in many cases and that is the true target of therapy. The choice of treatment of an intracerebral arterial occlusion is revascularization by intra-arterial thrombolysis by superselective catheterization of the involved vessel. The occluded vessel can be opened

Fig.10 Ischemic Stroke

Ishcemic Stroke. *40 year old lady presented with sudden onset of left hemiplegia. On examination, power on the left side was 0/5.* ***A:*** *Right ICA angiogram shows occlusion of the superior trunk of right MCA.* ***B:*** *Micro catheter was placed distally in the occluded artery and thrombolysis was performed.* ***C:*** *Post thrombolysis ICA angiogram shows restoration of flow in the superior trunk of MCA. Following thrombolysis, her power improved to 4/5.*

using varying strategies which include infusion of pharmacologic agents, aspiration of thrombus and mechanical thrombolysis with catheters. Several recent studies give encouraging results using these techniques.

C.2 Aneurysmal hemorrhage (Fig 11 & 12)

The incidence of intracranial aneurysm in the general population is between 1.5 to 8%.[19,20] The peak age for rupture is 40-70 years. The mean being 50 years.[21] Patients with acute sub-arachonoid haemorrhage secondary to aneurysm had a 36.2% mortality rates and an additional 17.9% morbidity rate; only 46% of patients had a favorable outcome at 90 days.[22] The ideal treatment of an aneurysm is total exclusion from the circulation by open surgical clipping. As an alternative, endovascular non-operative techniques with platinum micro coils are becoming increasingly popular. In addition complex aneurysm with irregular/wide neck can be treated by stent assisted / balloon assisted coiling technique making a new opportunity for treatment in several situations. The GDC (Guglielmi detachable coil) is a platinum coil soldered to the end of an insulated stainless steel introducing guidewire. A low voltage current employs electrolysis to detach the coil (dissolve the solder) when the coil is accurately positioned within the aneurysm. Regardless of aneurysm location, GDC coiling is today applicable for most intracranial

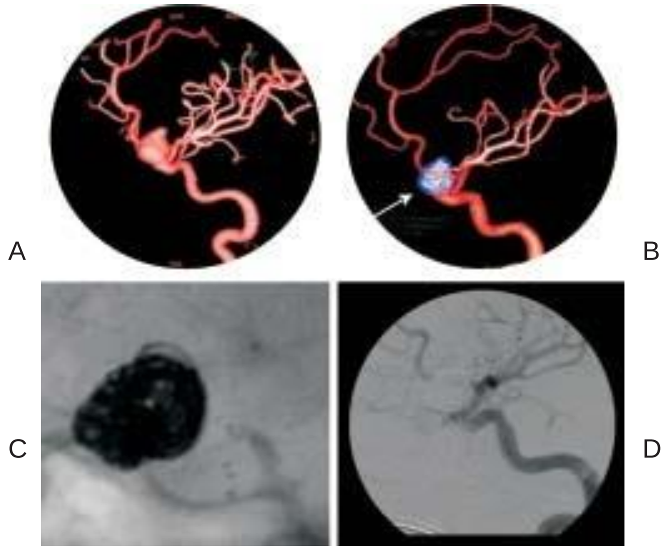


Fig.11 Aneurysmal hemorrhage - Case 1

Aneurysmal hemorrhage. *Patient presented with headache, vomiting and unconsciousness, CT scan showed Subarachnoid hemorrhage.* ***A:*** *Left carotid angiogram 3D DSA – VR image, showing large left carotid ophthalmic segment aneurysm.* ***B:*** *Stent assisted coiling done, 3D DSA VR shows exclusion of the aneurysm fromcirculation.* ***C:*** *Coiling was performed through the stent struts.* ***D:*** *Post procedure DSA Angiogram showing exclusion of the aneurysm from circulation*

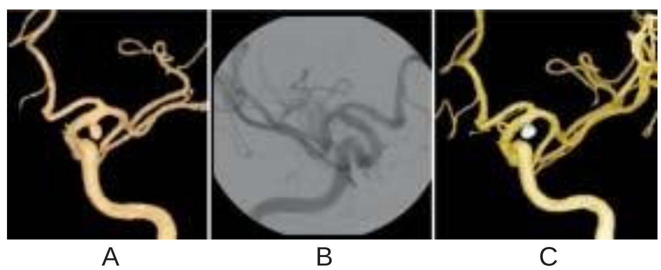


Fig.12 Aneurysmal hemorrhage - Case 2

Aneurysmal hemorrhage. *43 year old female presented with severe headache and unconsciousness. CT scan showed Subarachnoid hemorrhage.* ***A:*** *Right carotid angiogram 3D DSA – VR image, showing small PCom aneurysm.* ***B:*** *Post coil embolisation angiogram shows complete exclusion of the aneurysm from circulation.* ***C:*** *3D DSA VR image shows coils in situ. Patient recovered without any neurological deficits*

aneurysms.[23] Aneurysm size and RSN (Ratio – Sac / Neck) are the main factors critical to the success of endovascular therapy. Further, aneurysms that are difficult for surgical access such as basilar top, carotid ophthalmic or infraclinoid locations can be effectively managed using endovascular technique.

D) INTERVENTION AS A PREVENTIVE MEASURE

D.1 Stroke Prevention - Carotid Angioplasty and Stenting (Fig. 13)

Patients who have 70% or greater stenosis involving the ICA have a 30% risk of stroke during the next two years.

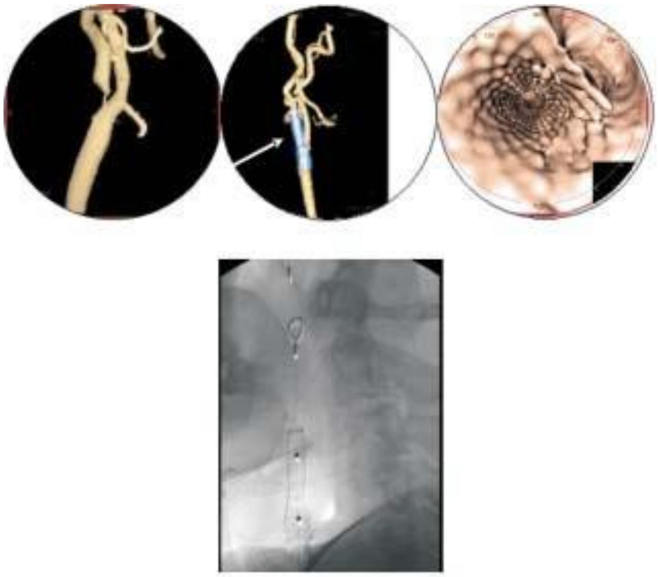


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Fig.13- Carotid PTA and Stenting

Carotid PTA and Stenting. *Senior Insurance Officer presented with transient loss of consciousness.* ***A:*** *Angiogram revealed significant narrowing of left carotid artery. Conventionally treated by surgical endarterectomy. This patient was treated by angioplasty and stenting with distal protection with filter.* ***B:*** *Stent in situ.* ***C:*** *3D Rotational Angiogram with endoscopic view showing the opened stenosis and stent struts.* ***D:*** *Distal EPI filter was placed prior to deployment of the stent*

Ulceration of the plaque increases the subsequent risk of stroke to about 7.5% per year.[24] Carotid angioplasty has the following advantages over carotid endarterectomy-
a) there is no cervical incision. Cranial nerve palsies by manipulation are uncommon.[25] Cerebral ischemia due to clamp occlusion of the carotid artery is not a problem with angioplasty. Lesions that are surgically inaccessible can be treated with angioplasty. With angioplasty, there is no need for general anaesthesia and the patient's clinical status during the procedure can be monitored. Post operative recuperation is shorter and less intensive than for endarterectomy. Cerebral protection during angioplasty can be achieved by two mechanisms: mechanical or pharmacologic. Mechanical means are intended to prevent emboli from arising at the site of the angioplasty and can be achieved using embolic protection filters. Pharmacologic cerebral protection can be achieved by using agents such as Nimodipine. The NASCET Trial has conclusively proved the superiority of endarterectomy in preventing stroke and reducing the stroke rate to 19%. As an alternative to endarterectomy, carotid PTA and stenting is increasingly being employed to prevent stroke.

D.2 Pulmonary embolism prevention - Vena cava filter placement (Fig. 14)

Pulmonary embolism due to Deep venous thrombosis(DVT) is a dreaded complication of prolonged immobilization.

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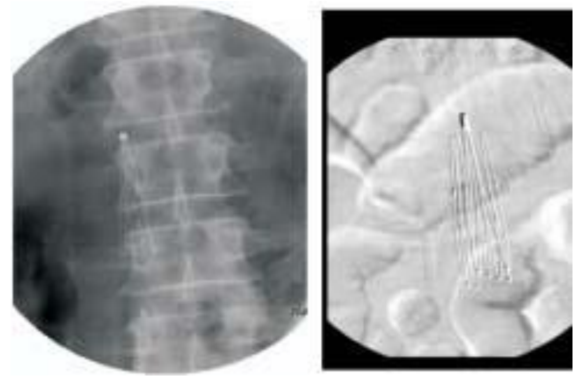

B

Fig.14 Vena Cava filter placement

Vena Cava filter placement. ***A:*** *Patient presented with recurrent episodes of pulmonary embolism due to DVT. Greenfield filter in the IVC.* ***B:*** *Known case of recurrent DVT underwent Venatech filter placement in the IVC*

Vena cava filters prevent thrombus from embolising to the pulmonary circulation by trapping the thrombus in the vena cava. When patients with thrombo-embolic disease cannot be anticoagulated or patients at high risk of developing DVT cannot be screened, monitored or receive prophylaxis, filters are indicated. There are a large number of permanent vena cava filters available. Temporary filters are designed to be removed once the venous thrombus resolves in patients with high risk disease.

To be continued in the next issue...

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