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

Part II CONTINUED...

Santhosh Joseph [a], Deepak Bharathi [a], Senthilnathan [a]

Key words : Interventional Radiology

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 Slowly but inevitably procedures that once required surgeons and surgical incisions have been replaced by percutaneous image guided techniques.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 procedures included acute vascular emergencies, control of acute bleeding, acute stroke, acute limb, several difficult

CORRESPONDING AUTHOR :

Dr. SANTHOSH JOSEPH
Professor and Head
Department of Radiology & Imaging Sciences
Sri Ramachandra Medical College and Research Institute,
Porur, Chennai – 600 116.
email : santosh01@yahoo.co.in
[a] Department of Radiology & Imaging Sciences

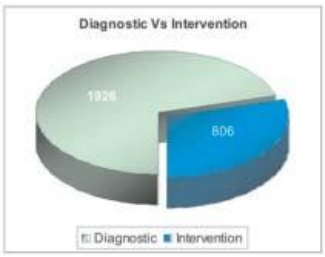


Chart 1: Diagnostic and Interventional procedures

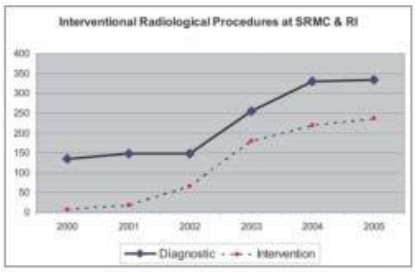


Chart 2: Number of procedures

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.

E) INTERVENTIONS IN CHRONIC PROBLEMS

E.1 Hypertension - Intervention for renal artery stenosis (Fig 15)

There are many causes for obstructive lesions of the renal artery, common ones being atherosclerosis (90%) and fibromuscular dysplasia (FMD). The clinical manifestations of renal artery occlusive disease are hypertension, renal failure or both. Hypertension secondary to renal artery stenosis accounts for 1-5% of patients with hypertension. Angioplasty and stent placement are the percutaneous techniques commonly used in the treatment of obstructive lesion of the renal artery

A B C

Fig. 15 Renal PTA and Stenting.

Renal PTA and Stenting: *Patient presented chronic hypertension.* ***A:*** *Aortogram reveals significant bilateral proximal renal artery stenosis.* ***B:*** *Restoration of flow in both the renal arteries following bilateral stent placement.* ***C:*** *Stents in situ.*

Renal artery angioplasty (Fig.15) and stent placement is a challenging procedure and depends on the types and locations of lesions, the size of the vessels and the angles between the aorta and the renal arteries. Metallic stents improve the technical and clinical outcomes in atherosclerotic disease, particularly for ostial lesions. Unless complicated by a dissection, stents are not necessary for most forms of FMD.

E.2 Claudication / Chronic limb

The prevalence of atherosclerotic peripheral arterial disease increases with age from 3% in individuals aged 40-59 to 20% in older than 70 years. Most common symptom is pain upon ambulation (claudication). A smaller percentage have rest pain, tissue loss or gangrene. A wide variety of technologies have been applied to this vascular bed including angioplasty, stents, stent – grafts, mechanical atherectomy and laser atherectomy. Occlusive disease of the SFA and popliteal artery can be effectively treated with angioplasty when the stenoses or occlusions are focal (Less than 5cm in length). The technical success rate for percutaneous SFA and popliteal interventions is greater than 95% for stenoses and 85-90% for occlusions. Similar interventional techniques are also available for upper limb and visceral arteries. The major advantage of endovascular therapy includes repeatability in primary or secondary failure whereas redo procedures are cumbersome in surgery.

F) INTERVENTIONS FOR THERAPEUTIC COMPLICATIONS

F.1 Intravascular foreign body removal

The most common cause for accidental embolisation is transection of an indwelling polyvinyl or polyethylene catheter when it is withdrawn across a sharp needle bevel. Intravascular foreign bodies can cause serious complications such as death, transient arrhythmia, sepsis, thrombus and pulmonary emboli. These can be successfully removed using retrieval devices such as the loop snare, hooked catheter, helical basket, hook guidewire etc.

G) INTERVENTION IN DIFFICULT CLINICAL SITUATIONS:

G.1 Carotid cavernous fistula (Fig. 16)

These are spontaneous or traumatic connections between the carotid artery and the cavernous sinus and can be classified as direct or indirect. The traumatic carotid cavernous fistula occurs following head injury where there is a tear connecting the carotid artery and cavernous sinus, whereas spontaneous CCF are dural AVM's at the level of the cavernous sinus. Reversal of direction of the flow through the ophthalmic veins and or spheno-parietal sinus is possible if an arterio-venous connection develops in the cavernous sinus. Elevated venous pressure in the veins draining the orbit may produce orbital venous congestion, transudation of interstitial fluid, proptosis, increased intra ocular tension and secondary glaucoma. Less frequently reversal of flow into the sphenoparietal sinus with resultant cortical venous hypertension poses a risk of intra-cerebral hemorrhage and warrants emergent therapy.

Endovascular treatment options available include transarterial balloon embolisation for symptomatic direct CCF and trans arterial or transvenous coil embolisation in case of indirect CCF.

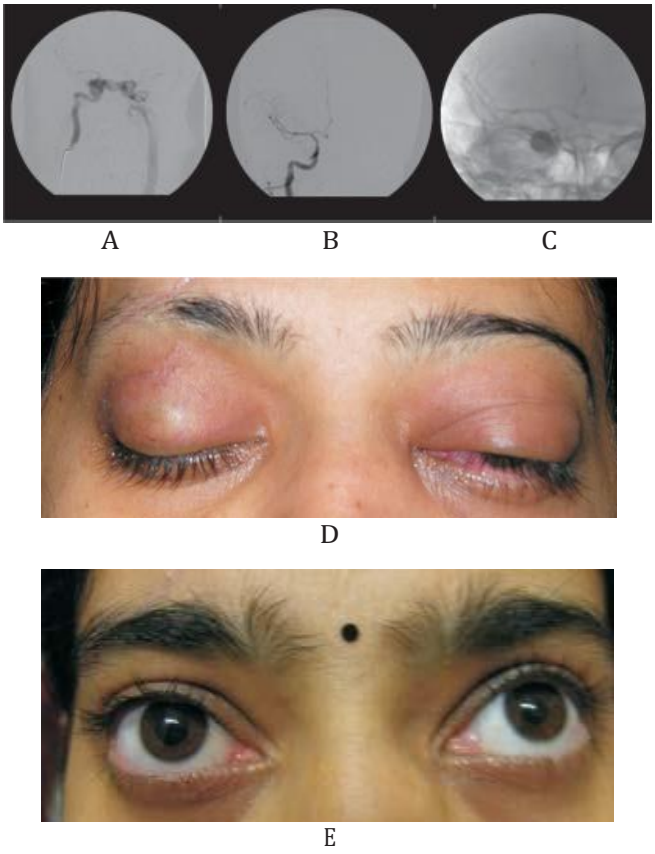
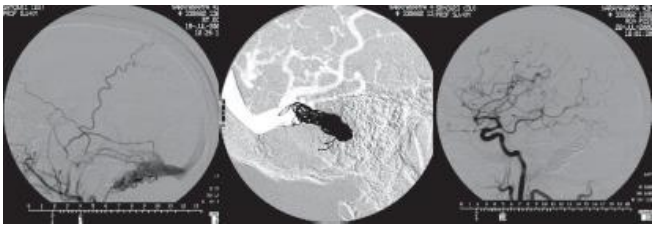


Fig.16: Carotid Cavernous Fistula

Carotid Cavernous Fistula : *A 24year old lady presented with proptosis, chemosis and ptosis of the right eye following RTA. A: Right carotid angiogram showing carotid cavernous fistula. B: Following embolisation of CCF with balloon absence of SOV filling. C: Balloon in situ. D: Pre embolisation clinical picture. E: Post embolisation shows normal appearance.*

G.2 Dural AVM (Fig.17)

Intracranial dural AV Fistulae are acquired arterio venous shunts located inside the duramater. They account for 10-15% of all intracranial arteriovenous lesions. Their presentation and prognosis are variable, symptoms are due to arterialization of the venous system. Endovascular treatment is particularly tricky. The choice of treatment depends on the natural risk of the disease which may be estimated for each patient according to the type of venous drainage. The possible modes of treatment include arterial embolisation with particles or glue, sinus occlusion with coils or even direct puncture and coil embolisation. The major symptoms in patients with dural AV fistulas include tinnitus, proptosis, raised ICP or IOP and mentation changes. The transvenous embolisation or direct puncture embolisation through a burr hole provides a new opportunity to treat these highly complex and challenging problems with good clinical results.



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D

E

Fig. 17: Dural AVM

DURAL AVM: *43 year old gentleman presented with proptosis, chemosis of the right eye with right third nerve palsy.* ***A:*** *Right carotid angiogram showing dural AVM at the level of the right transverse sinus.* ***B:*** *Coil mass in situ in the right transverse sinus.*

C: *Post coil embolisation angiogram showing obliteration of the AVM.* ***D:*** *Pre procedure clinical photograph showing proptosis and chemosis of the left eye.* ***E:*** *Post procedure clinical photograph showing full resolution at three months follow up.*

G.3 Pial AVM (Fig.18 & 19)

Arterio-venous malformations (AVMs) are the most common intracranial vascular malformation. AVM's occur in about 0.02% to 0.05% of the population. In treating AVMs, the nidus of the lesion must be removed or obliterated. The more the nidus of the AVM is occluded, the less collateral supply it will develop. The materials available for embolisation include N-butyl-cyanoacrylate (NBCA) and absolute alcohol or onyx

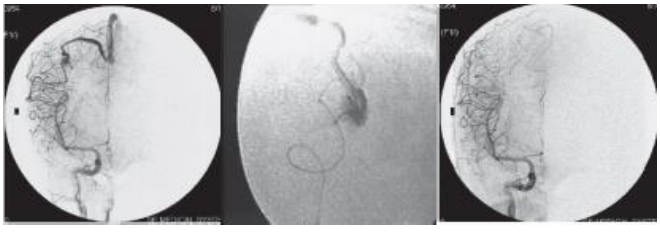

Fig 18: Pial AVM

Pial AVM : *35 year old man presented with sudden onset of hemiplegia and aphasia. CT scan revealed large right intra cerebral hematoma.* ***A:*** *Carotid angiogram AP view shows a motor cortex AVM.* ***B:*** *Microcatheter placed distally within the nidus.* ***C:*** *Following selective catheterization and embolisation with NBCA, total disappearance of the nidus. Patient made a remarkable recovery.*

A B C

Fig. 19: Pial AVM – Onyx embolisation

Onyx embolisation. *20 year old medical student presented with recurrent seizures. CT scan revealed large AVM in the left temporal lobe.* ***A:*** *Carotid angiogram shows left temporal AVM with feeders from MCA.* ***B:*** *Post Embolisation angiogram shows complete occlusion of the AVM.* ***C:*** *X-Ray skull shows onyx cast.*

Absolute alcohol has the ability to penetrate the capillary with destruction of all cells, which makes it a dangerous tool. Patients with AVM present with intractable headache, hemorrhage, seizures or progressive neurologic deficit. Cerebrovascular surgical excision of the AVM of brain is a very good option of treatment in non eloquent parts of the brain which are located superficially. Embolisation is an alternative to surgical technique in several areas that are eloquent.

G.4 Spinal AVM (Fig.20)

In patients with spinal AVM or spinal dural fistula embolisation is the choice of treatment as surgical excision carries high morbidity and mortality

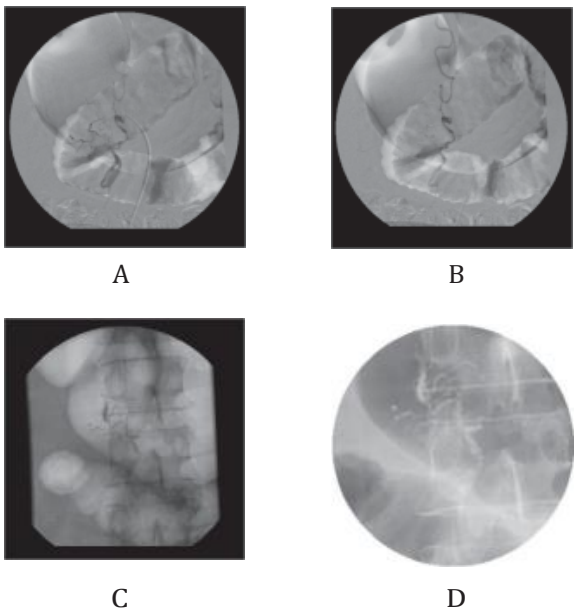

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Fig. 20 : SPINAL AVM

Spinal AVM. *64 year old gentleman presented with sudden onset of paraplegia.* ***A & B:*** *Spinal angiogram reveals spinal dural AVF in the right side of the thoracic spinal cord. C: Post embolisation shows complete occlusion of the AVM. D: Embolic cast.*

Rapid advances in neuroimaging and improvements in neuro angiography have led to better understanding of spinal cord vascular malformation. The clinical presentation of spinal AVM is directly influenced by the location as well as the angioarchitecture. Significant technical improvement in catheters and delivery systems as well as in various embolic materials have led to marked technical improvements in endovascular therapy.

G.5 Tracheo-bronchial stent

Patients with large airway obstruction arising from either benign or malignant processes and those with tracheo oesophageal fistula have a particularly challenging clinical problem. Common causes of local airway obstruction include overgrowth of granulation tissue, fibrosis, tracheomalacia, endoluminal neoplasm and extrinsic neoplasm. The recent development of an endoluminal stent offers a relatively simple and non invasive method of relieving clinical problems due to obstruction[26,27]. Being a simple procedure, the placement of endoluminal tracheo-bronchial stents has been advocated for treating mechanical causes of airway compromise that are not amenable to surgery. After the placement of endoluminal tracheobronchial stents, patients experience quick relief of respiratory symptoms and enjoy a relatively comfortable life. Stents also provide relatively long lasting relief against malignant obstruction.

G.6 Pulmonary AV Fistula

Congenital pulmonary arterio-venous fistulae (AVF) and malformations (AVM) are abnormal direct communications between a pulmonary artery and pulmonary vein. Blood is shunted directly from the right heart to the left, without benefiting from two major functions of the pulmonary capillary bed: oxygenation and filtration. Patients with such lesions may present with symptoms of hypoxia due to shunting, resistant polycythemia, effort intolerance, high output cardiac failure or more seriously paradoxical embolisation. The therapy of pulmonary AVFs is embolisation. Occlusion of the feeding artery can be accomplished with coils or detachable balloons. Recurrence after embolisation is unusual (less than 5%).

G.7 Venous malformation / hemangioma (Fig. 21 & 22)

Vascular malformations are composed of dysplastic vessels with a normal endothelial turnover. These can be categorized into slow flow vascular malformation (capillary, venous and lymphatic and high flow vascular malformation (Arterio venous vascular malformations). These venous malformations are usually diagnosed based on clinical examination and demonstrate phleboliths on X-ray. Therapeutic strategies for these malformation is based on multi disciplinary approach involving dermatologists, vascular surgeons, plastic surgeons and hematologists in addition to interventional radiologists.

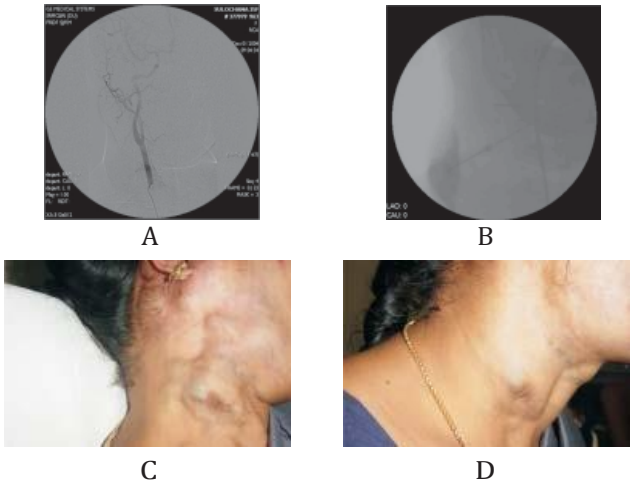

Fig. 21 : Superficial Venous Malformation

SUPERFICIAL VENOUS Malformation: 35 year old lady presented with multiple tortuous swelling in the right side of neck. A: Common carotid angiogram revealed no arterial feeders. B: Direct puncture embolisation was done using ethanol and lipiodol mixture. C: Pre embolisation clinical photograph with turgid neck swelling. D: Post embolisation clinical photograph reveals almost marked reduction of the swelling.

Percutaneous embolisation help us to achieve significant reduction in size there by helping the surgeon to achieve adequate reduction with limited blood loss. Hemangiomas are pediatric vascular lesions which usually manifest within the first month of life. More than 90% show spontaneous regression at 5-7 years of age. Most hemangiomas do not require any treatment. Embolisation is performed in those patients who presents with high output failure to minimize the shunt and in patients who present with cosmetic disfigurement.

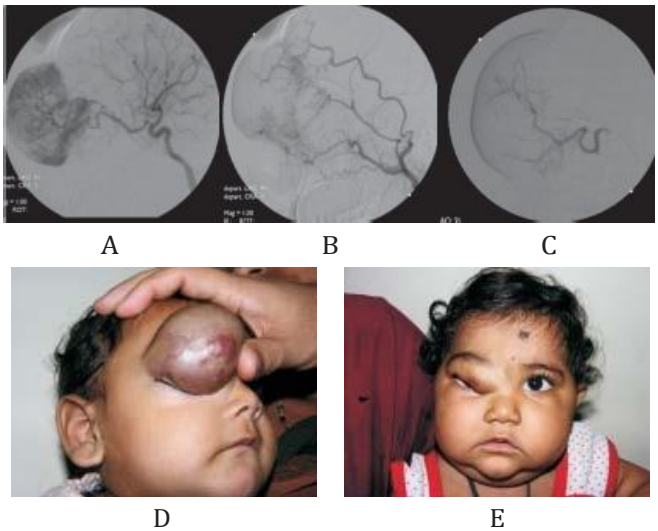

Fig.22 : Upper Eyelid Hemangioma

Upper Eye lid haemangioma. *1 year old child presented with swelling of the right upper eye lid of six months duration. A: Right ICA angiogram reveals haemangioma supplied by ophthalmic artery. B: Right ECA angiogram shows feeders from internal maxillary artery. C: Post embolisation angiogram shows significant reduction in vascularity of the haemangioma. D: Pre embolisation clinical picture with mechanical ptosis. D: Post embolisation clinical picture shows remarkable reduction in size of the haemangioma and improvement of ptosis.*

H) INTERVENTION FOR PAIN RELIEF

H.1 Vertebroplasty (Fig.23)

Vertebroplasty with acrylic glue (polymethyl methacrylate, PMMA) is a procedure aimed at preventing vertebral body collapse and relieving pain in patients with pathologic vertebral bodies / collapse due to benign or malignant disease

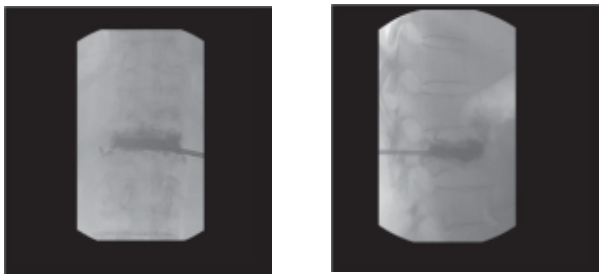

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Fig. 23 : Vertebroplasty

Vertebroplasty. *60 year old female presented with severe back ache. X-ray revealed collapse of the L1 vertebrae.* ***A:*** *AP view shows acrylic glue injection with filling of the entire vertebral body.* ***B:*** *Lateral view showing transpedicular approach.*

The pain reducing effect of cement cannot be explained by the consolidation of the pathologic bone alone. The PMMA is cytotoxic owing to its chemical and thermal effect during polymerization. The temperature during polymerization is high enough to produce coagulation of tumoral cells. The procedure is contraindicated in patients with hemorrhagic diathesis and in the presence of infection. An anterior approach is used in the cervical area, a transpedicular or intercosto vertebral route in the thoracic area and a postero-lateral or transpedicular route in the lumbar area.

H.2 Percutaneous management of Osteoid Osteoma

Osteoid osteoma produces local pain that is worse at night and improves dramatically with aspirin. Effective treatment of this tumor depends on complete removal of the tumor nidus. The conventional treatment is surgical or percutaneous excision. The ability to precisely control the treated area, a high degree of precision, applicability in joints and an excellent dose – response characteristic makes interstitial laser photocoagulation (ILP) a valuable treatment method for Osteoid osteomas. It consists of percutaneous insertion of optical fibers into the tumor. The tumor is coagulated and destroyed by direct heating. The procedure is performed under CT guidance. A single needle and a single laser fibre are sufficient for nidus diameter upto 10mm. Success rates of 60-90% are reported. Other interventions for pain relief include intraarticular injection of corticosteroids in faget syndrome, percutaneous epidural and nerve root block.

H.3 Percutaneous laser disc decompression (PLDD)

Percutaneous removal of the nucleus pulposus has been performed using a variety of chemical and mechanical techniques for the past several years. These techniques consist of percutaneous removal all or part of the nucleus purposes to induce more rapid healing of the abnormal lumbar disc.

H.4 Pelvic congestion syndrome (Fig.24)

Chronic pelvic pain is a perplexing and disturbingly frequent problem. An estimated 10 million women are affected, but a reasonable explanation can be found in fewer than half. A wide variety of gynaecologic conditions can be responsible for chronic pelvic pain. When dilated gonadal and periuterine veins are determined to be the etiology of the pain, the term "pelvic congestion syndrome" is applied. Reflux of blood in gonadal veins is the underlying etiology of pelvic varicosities in the majority of patients. Rarely, pelvic AV malformations or fistulas may be encountered. Gonadal venography remains the definitive diagnostic imaging modality. As most of the patients with pelvic congestion syndrome are relatively young, embolotherapy represents an attractive alternative. Coils are the embolic agents used most often for gonadal vein occlusion. Embolisation reduces or eliminates symptoms in up to 80% of women.

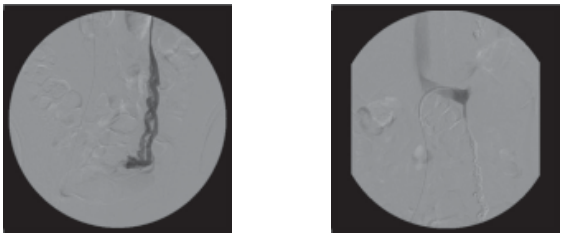

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Fig. 24 : Pelvic Congestion Syndrome

Pelvic Congestion Syndrome. *37 year old doctor presented with severe lower abdominal pain. Doppler revealed multiple venous channels in the pelvis.* ***A:*** *Ovarian venogram reveals multiple dilated tortuous venous channels.* ***B:*** *Post embolisation venogram shows complete occlusion of the dilated venous channels. Patient made a remarkable recovery.*

I) INTERVENTION FOR INFERTILITY

I.1 Varicocele embolisation

Dilatation of the pampiniform plexus termed a "varicocele" results from reflux of blood through incompetent gonadal vein valves in males. These are common lesions, found in 5-17% of males. There is no effective medical treatment for varicoceles. The goal of intervention is to interrupt the internal spermatic vein in order to prevent retrograde flow of blood into the scrotum. Surgical ligation can be performed at multiple levels. The recurrence rate is approximately 10-20% due to collateral

flow. Percutaneous embolisation can be performed and embolisation with coils is preferred. Multiple coils are deposited along the entire length of the vein. Sperm counts improve in 80% of patients following successful embolisation

I.2 VASCULOGENIC impotence

The indications for penile angiography are the evaluation of impotence and trauma. Approximately 50% of males over the age of 40 experience some degree of erectile dysfunction. The least common cause is vasculogenic, and should be pursued only after other etiologies have been excluded. There are two potential vascular causes of impotence, venous leak (inability to trap blood in the corpus cavernosum) and arterial insufficiency. Vasculogenic impotence has a venous etiology in one third of cases and combined arterial and venous in the rest. Patients with venous leak tend to respond well to pharmacologic therapies. Severe arterial insufficiency is more difficult to treat effectively but in an internal iliac artery, angioplasty or microvascular bypass to the penis may be effective.

I.3 Uterine artery embolisation (Fig. 25)

The most common indication for selective uterine artery angiography is for embolisation of symptomatic fibroids. Fibroids are vascular tumors that grow in size and increase in prevalence with age throughout a woman's reproductive life. The indications for intervention are fibroids that cause heavy, prolonged periods, pelvic pain, dyspareunia, miscarriages and pressure symptoms on adjacent structures. Pharmacologic treatment with GnRH analogues, results in temporary reduction in size, but fibroids will enlarge once medication is stopped. Conventional surgical procedures include hysterectomy and myomectomy, using open, laparoscopic or hysteroscopic techniques. Uterine artery embolisation is an alternative approach to management of fibroids

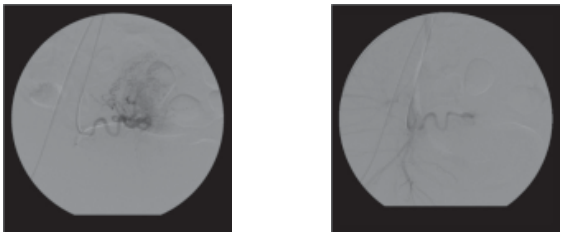

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Fig. 25: Uterine Fibroid Embolisation

Uterine Fibroid Embolisation. *35 year old lady presented with abnormal uterine bleeding. Ultrasound revealed 6 x 4 cms fibroid in the right anterior wall of uterus. A: Selective uterine artery angiogram reveals hypertrophied feeders to the fibroid. B: Post embolisation angiogram reveals significant reduction of flow and disappearance of the abnormal vascularity.*

The basic principle is selective infarction of the fibroids with particulate embolic materials directly delivered into the uterine arteries. The indications are identical to those for surgery, although the procedure is not recommended when the fibroids are pedunculated or largely submucosal. Permanent particles (300-700mm diameter range) are generally used. Embolisation is continued until there is sluggish flow in the uterine artery with elimination of the fibroid blush. Bilateral embolisation is mandatory. Embolised fibroids shrink on average 50-60% in volume, with relief of symptoms in 85-90% of patients.

I.4 Fallopian Tube Recanalisation (Fig.26)

Isolated obstruction of the proximal fallopian tube amenable to transvaginal dilatation and recanalisation is thought to be the cause of infertility in about 20% of the patients.

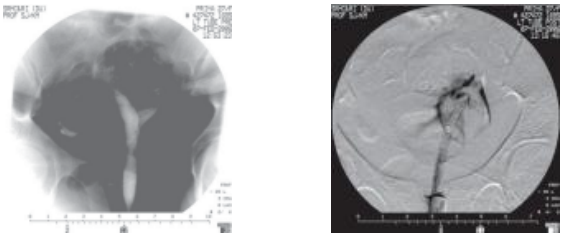

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Fig.26: Fallopian Tube Recanalisation

Fallopian TUBE Recanalisation. *Patient presented with infertility following right salpingectomy for right tubal pregnancy. A: HSG showing left cornual block. B: Balloon dilatation of the left cornu done, contrast injection showing peritoneal spillage*

Women with unilateral or bilateral proximal tubal obstruction confirmed by hysterosalphingography or laparoscopy are candidates for transvaginal recanalisation. Transvaginal fallopian tube recanalisation results in lower patient morbidity and is less expensive than tubal microsurgery. This procedure is recommended as the intervention of first choice in patients with proximal tubal obstruction. The more invasive therapy should be reserved for patients with distal tubal disease and for those in whom fluoroscopic catheterization fails.

J) INTERVENTION FOR PALLIATION

J.1 Percutaneous Transhepatic Biliary Drainage (PTBD) (Fig. 27)

The major purpose of PTBD has been and is still used to drain retained bile for decompression in obstructive jaundice. PTBD route is indispensable for carrying out various procedures of biliary interventional radiology. Another use of the route is to obtain an access for intracavitary radiotherapy. [28] Cholestasis induces biliary infection and protracted hyperbilirubinemia impairs renal function. In the presence of hyperbilirubinemia, both surgical mortality and morbidity are high at 15 to 25% and 40 to 60%[29,30] and

decompression should be done as early as possible in patients with obstructive jaundice. The success rate of PTBD is 90-100%. [31,32] The application of indwelling stents (endoprostheses) in the biliary system has been well established because it provides sufficient antegrade biliary drainage without encumbrance of an external tube that needs catheter flushing, dressing at the skin entry site and periodic catheter exchanges.

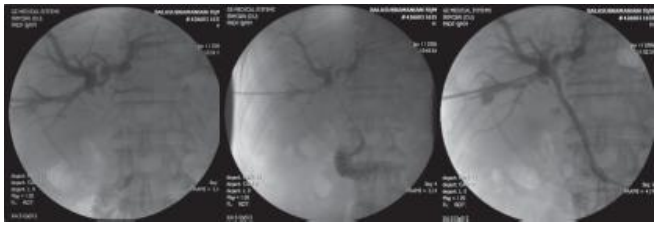

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Fig. 27: Percutaneous Transhepatic Biliary Drainage

*PERCUTANEOUS **Transhepatic Biliary Drainage.** 70 year old male presented with obstructive jaundice. MRI revealed Klatskin tumor. A: Cholangiogram shows obstruction at the level of hepatic duct confluence. B: Guide wire placed in the duodenum across the stricture. C: Following successful stent placement, flow of contrast through the obstructed segment visualized. Patient experienced marked relief following biliary stenting.*

Invention of metallic stents has become a popular procedure of palliative treatment for patients with obstructive jaundice caused by unresectable malignant tumors. The large caliber is associated with a low frequency of occlusion by bile encrustation.

J.2 TUMOR ablation (Fig. 28)

Many solid tissue malignancies are poorly responsive to systemic chemotherapy, surgical resection or local radiation therapy. In situ image guided tumor destruction or ablation has become an attractive option. It offers the possibility of an effective minimally invasive and less costly approach, often achievable in an outpatient sitting. Available ablation techniques can be broadly classified as chemical, embolic or thermal. Chemical ablation is achieved by image – guided instillation of a chemical agent. The most common chemical agent used for tumor ablation is ethanol. Percutaneous ethanol injection (PEI) has been shown to be a safe, inexpensive and effective treatment for small (3-5cms) hepatocellular carcinomas. Tissue functions normally in a narrow range of temperatures. If the local temperature is made sufficiently abnormal, the cells within the environment are permanently damaged. If extremes of temperature are applied, the cells are destroyed and coagulative necrosis ensues. Percutaneous, image – guided therapies using heat have utilized diverse thermal energy sources. Thermal energy sources have included sound (high – intensity focused ultrasound, light (laser photocoagulation), microwaves and radio frequency energy.

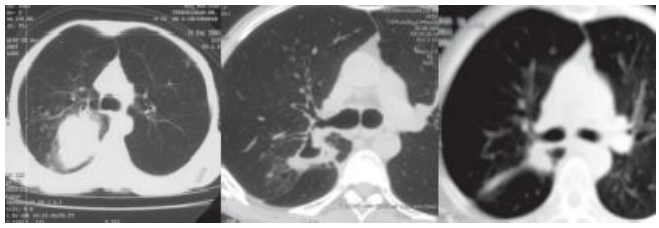

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Fig.28: RadioFrequency Ablation

*RADIOFREQUENCY **Ablation.** 58 year old male known case of adenocarcinoma lung underwent RFA. A: CT Thorax reveals a large tumor in the posterior segment of the right upper lobe. B: Three months follow up reveals cavitation of the tumor with marked reduction of size. C: Six months follow up reveals almost disappearance of the tumor following RFA. Radio frequency energy has been used for surgical electrocautery since the early 1990s. RFA can be achieved with monopolar or bipolar electrode systems.*

COMPLICATIONS

Complication related to interventional radiological procedures include puncture site related, contrast agent related, catheterization related and those related to coagulation. Puncture site related complications include puncture site hematoma, arterial dissection, pseudo aneurysm formation and arterio venous fistula. Contrast agents may lead to nephropathy, allergic reaction, congestive cardiac failure. The use of iso osmolar, non ionic contrast media has reduced the incidence of these complications. Injury to vessels may occur during catheterization and is more common in elderly patients due to pre existent atherosclerosis and in patients with collagen vascular diseases. Thrombo embolic complications may occur due to dislodgement of atheromatous plaques and due to formation of platelet thrombi at the tip of the catheter. The incidence of these complications is variable depending on the procedure performed and the disease for which it is performed.

CONCLUDED

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