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Pan Arab Interventional Radiology Society

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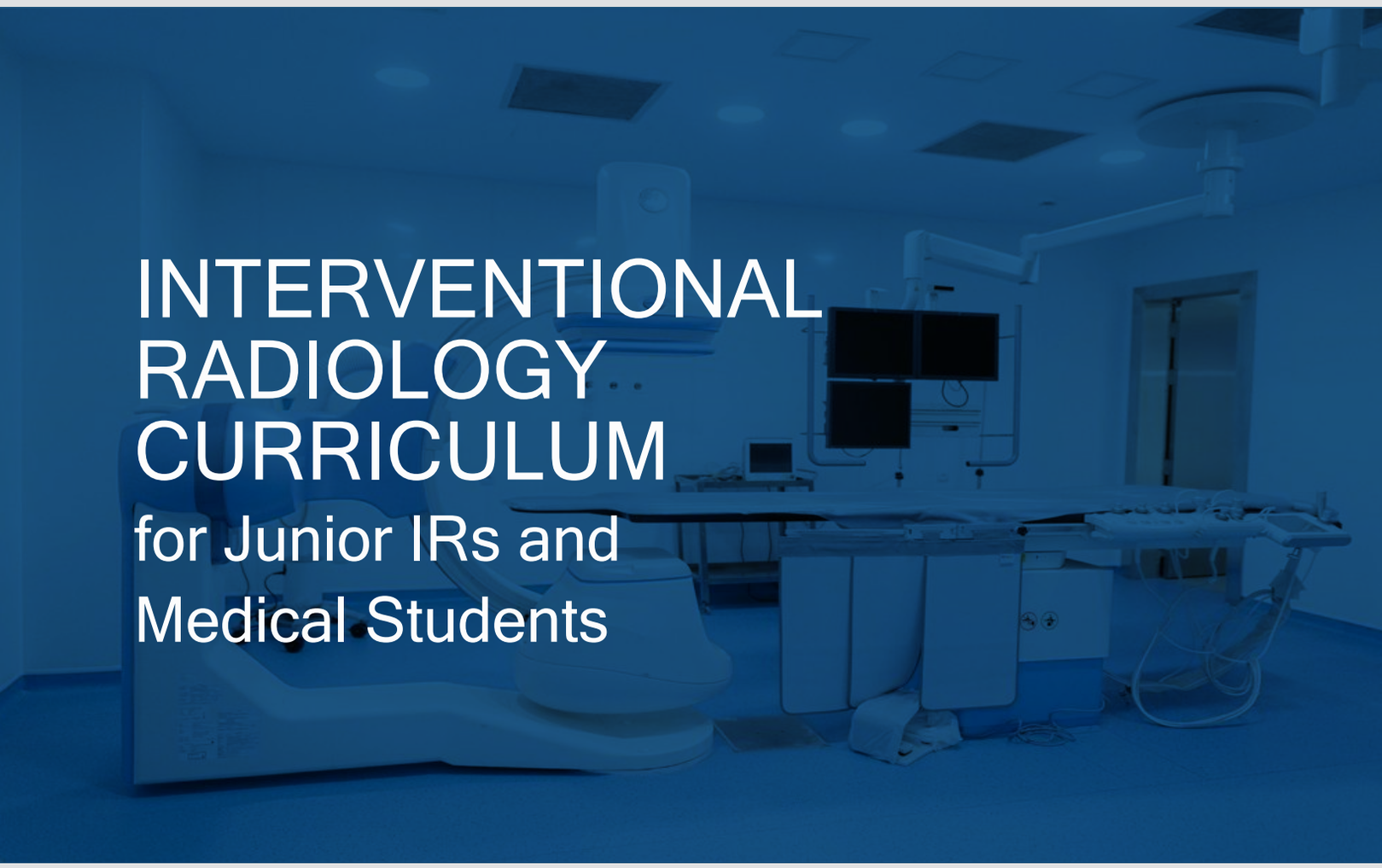

INTERVENTIONAL RADIOLOGY CURRICULUM

for Junior IRs and Medical Students

Edition 2.0

April 2025

INTRODUCTION OF THE FIRST EDITION

In the past few decades, Interventional Radiology has evolved as one of the fastest growing medical specialties; presenting a unique combination of high-end technological advances and competent operator skills with least possible complications and almost no recovery time.

These advantages made Interventional Radiology one of the most attractive specialties for medical students all around the world.

Being the largest Interventional Radiology Society in the Middle East, PAIRS has an increasing role in spreading awareness about our magical specialty among medical students and young IRs starting their career which mandates providing a concise simple guide to introduce them to the world of IR.

Hereby it gives me utmost pleasure to introduce the preliminary edition of PAIRS INTERVENTIONAL RADIOLOGY CURRICULUM FOR JUNIOR IRs AND MEDICAL STUDENTS, a comprehensive condensed guide where you can learn about the most important currently available Interventional Radiology procedures.

Ayman Al Sibaie
PAIRS PRESIDENT 2019-2024

INTRODUCTION OF THE SECOND EDITION

It is my honor to introduce the second edition of the PAIRS INTERVENTIONAL RADIOLOGY CURRICULUM FOR JUNIOR IRs AND MEDICALSTUDENTS.

Interventional Radiology has become one of the most competitive specialties to join due to its marvelous clinical results, with minimal complications, owing to the use of robust, small-caliber tools and a heavy reliance on technology.

This new edition offers a refined, quick, interesting, easy-to-read, and evidence-based guide to the various interventional radiology procedures. More cases have been added, including QR codes to access educational videos.

Through this guide, we invite you to glimpse the future shaping modern medicine. It will help those who want to join this specialty or those who have just started an IR fellowship. It will also give any clinician an understanding of the interesting treatments that our specialty can provide.

Mohammad Farouq Badran
PAIRS PRESIDENT 2024–2026

Since the PAIRS board assigned the PAIRS "Residents, Fellows, and Students (RFS)" team to develop a PAIRS curriculum for medical students and junior interventional radiologists, we adopted a different approach from traditional IR sources.

This booklet presents IR procedures within the framework of medical school curricula taking a disease-oriented rather than a procedure-oriented approach.

For each body system, you will find relevant diseases categorized as traumatic, inflammatory, neoplastic, etc., followed by the potential IR solutions for each condition. Most procedures are illustrated with actual procedural images.

In this edition, we have added more figures, expanded the list of procedures, and included QR code links to the PAIRS RFS: Was_Once_a_Beginner educational video series on PAIRS Academy. These videos, freely accessible to PAIRS members, provide detailed illustrations of many procedures.

So, whether you are a radiology resident, intern, medical student, or a physician from another specialty seeking to learn more about IR procedures, this curriculum is highly recommended for you.

PAIRS Residents, Fellows, and Students Team,
Head of the PAIRS RFS Committee:
Rana Khafagy, MD, FPAIRS

Interventional Radiology Curriculum for Junior IRs & Medical Students

Edition (2), April. 2025

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Introductory Videos, Basic IR procedures

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Introduction to Embolization

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Introduction to Basic IR: Procedures
(Embolization/Ablation/U.S Guided Procedures)

Peripheral and Aortic Vascular Diseases and Interventions

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Venous Access

Overview:

Venous access is obtaining access to venous circulation for several indications (see below)

Types:

- Peripheral venous access:

Peripheral venous cannulation is the most common type of venous access usually through veins of the hands, forearms, and occasionally feet.

It is appropriate for short term therapies (less than 3-5 days)

- Central venous access:

A procedure in which access to large central veins is obtained through placement of a catheter percutaneously under ultrasound and fluoroscopic guidance, usually done under local anaesthesia or sedation.

General indications:

1. Failure of peripheral cannulation
2. Need to measure the central venous pressure.
3. Total parenteral nutrition or need for rapid high volume blood or fluid transfusion
4. Need to administer drugs that otherwise can't be administered in a peripheral vein (e.g. chemotherapeutics)
5. Need for long term therapies.
6. Hemodialysis or plasmapheresis which require a high flow volume that can only be obtained in the right atrium or large central veins.

Commonly used catheters for central venous access include:

- **Non-Tunneled:**
  Central line, Quniton (acute temporary hemodialysis catheters)
- **Tunneled hemodialysis catheters (THDCs)**
- **Peripherally Inserted Central Catheter (PICC line)**
- **Totally implantable venous access devices (TIVADs)** commonly known as Port-a-cath

Access:

- Central venous catheters (CVCs) are commonly inserted through jugular or subclavian vein access. Common femoral vein access is the last resort as it is associated with highest risk of infection and deep venous thrombosis.
- TIVADs, commonly for chemotherapy administration, are best to be placed through jugular access.
- Quinton lines for hemodialysis or plasmapheresis through jugular vein or common femoral vein are used for short term use (less than 2 weeks) as they carry higher risk of infection and DVT. They should be only used in emergency setting.
- THDCs should be used if dialysis catheter is expected to be needed for more than two weeks.
  Subclavian venous access should be preserved as the last option for THDCs to decrease the risk of central venous stenosis as it could hinder future AV access creation. Conversely, femoral access should be avoided in patients planning for kidney transplantation, as the external iliac vein is usually used for venous anastomosis with the transplanted kidney vein. Iliac DVT and its sequelae could complicate future transplantation.
  Last resort is direct access to IVC through a transhepatic or trans lumbar approach.
  Dialysis arteriovenous (AV) access (fistula or graft) should be
  created as soon as possible as they are more durable and carry less risk of infection than THDCs.
  If AV access is contraindicated e.g., patients with heart failure and very poor cardiac function, THDCs can be used as a long-term dialysis access instead of AV access.
- Peripherally Inserted Central Catheter (PICC) lines: basilic and brachial veins are most used as access, the tip of the catheter is placed at the cavo-atrial junction. It is used for long-term IV administration of medication (e.g. antibiotics) or parenteral nutrition.

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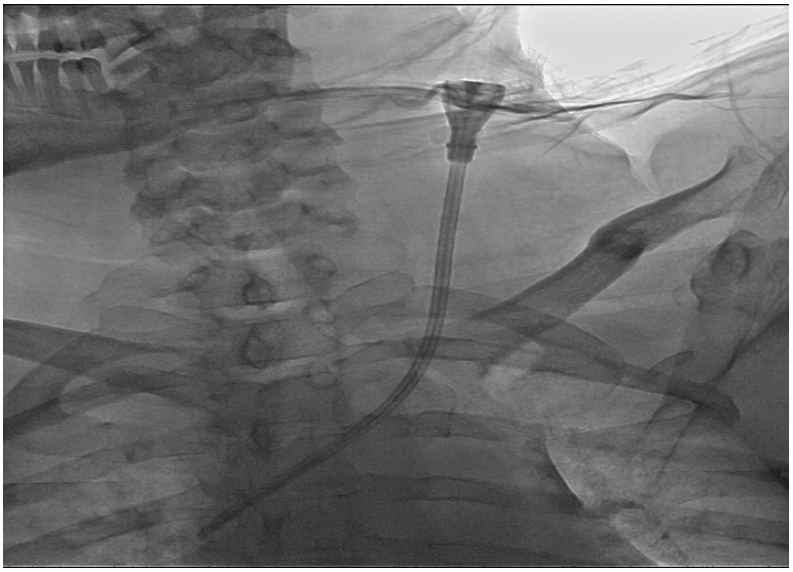
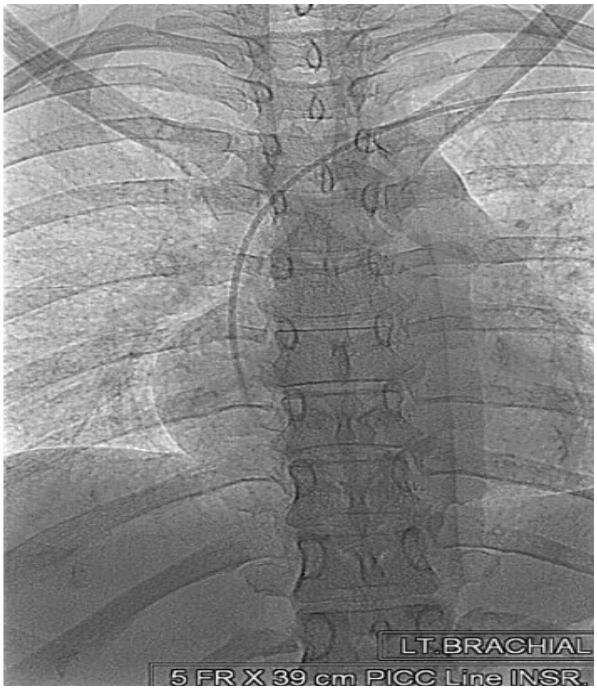
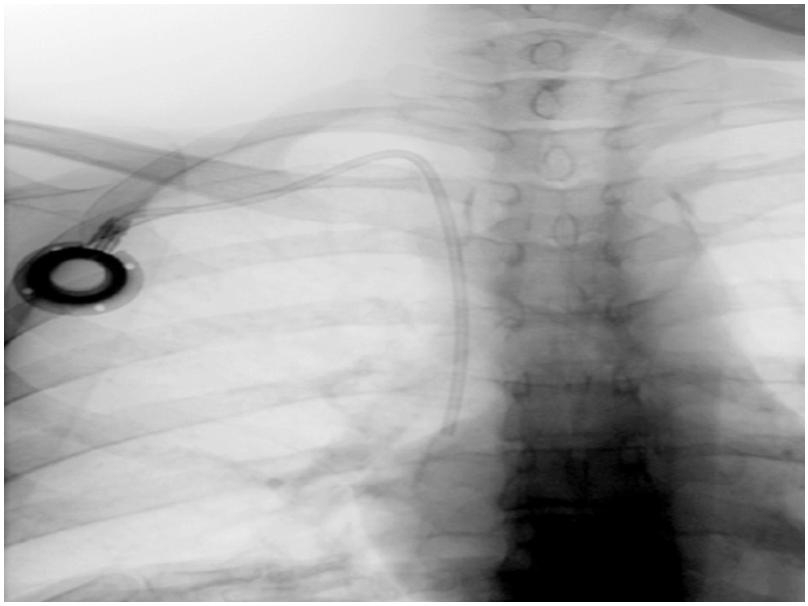


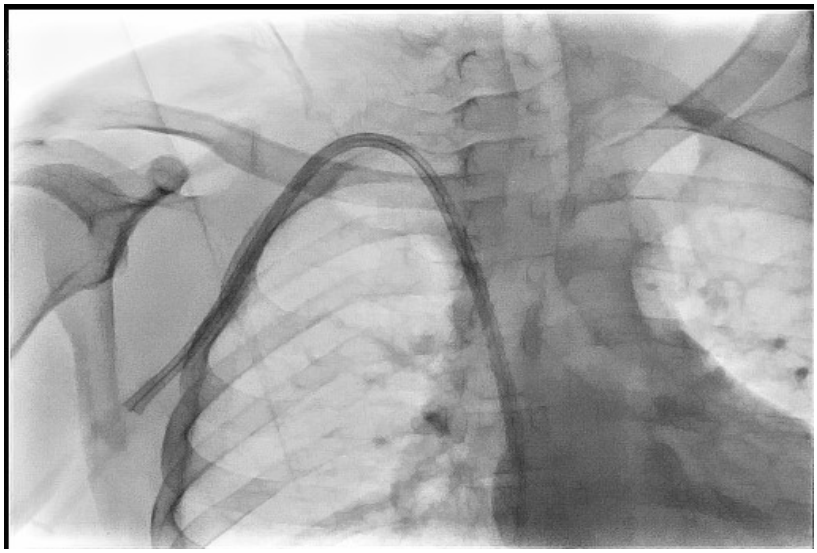
Left Mahurker Insertion. Case Courtesy of Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo, Egypt



PICC Line Insertion. Case Courtesy of Omar Basheir,
King Abdulaziz Medical City, Riyadh KSA



Port A Cath Insertion. Case Courtesy of Khaled Aly/ Lama Elkassas,
Ain Shams University Hospitals, Cairo, Egypt



Right IJV permiacath insertion. Case Courtesy of Karim Abd El Tawab,MD, Ain Shams University Hospitals, Cairo, Egypt

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Central Venous Access. A General Overview

Varicose veins

Overview:

Varicose veins are enlarged, tortuous veins in the subcutaneous tissue connected to the superficial veins of the lower limbs. They are primarily caused by valvular dysfunction, which results in superficial venous reflux. Other contributing factors include weakened venous walls or ineffective perforators.
Leg and ankle edema, itchiness, pain, cramping, hyperpigmentation and venous ulcers are among the symptoms. Chronic venous illness is classified according to CEAP (clinical, etiologic, anatomic, and pathophysiologic) criteria.

Radiological diagnosis and findings:

Additional imaging and a functional evaluation are required before therapy since the anatomic source(s) of reflux are not well associated with the location of the apparent varicosities.
Doppler ultrasonography can determine the existence and distribution of subcutaneous varicosities. It is the preferred approach for determining whether the saphenofemoral and sapheno-popliteal connections are refluxing. The location of the perforators may also be found and detected.

Treatment options and indications of IR:

Depending on the cause and the severity of the condition, various techniques for treating varicose veins are available, ranging from conservative (compression stockings) to surgical (vein stripping).
Interventional methods, such as foam sclerotherapy, endovenous laser ablation, or radiofrequency catheter ablation, are used when conservative therapy fails.

IR treatment options:

Radiofrequency ablation (RFA):
The RFA catheter is inserted under US guidance into the vein. RFA uses high frequency alternating current to heat the venous lumen. The ionic agitation and local heating generated by the current produce venous spasm and irreparable intimal damage and ultimately venous fibrosis.
Endo-venous laser ablation (EVLA):
EVLA destroys the vein by delivering light energy using a laser fiber inserted intra-luminally while using ultrasound guidance. Blood in the lumen produces steam bubbles that heat up the vein wall and permanently destroy the intima.

In both RFA and EVLA, the commonly targeted veins of the lower extremity are:

- Greater saphenous vein (GSV)
- Small saphenous vein (SSV)

Sclerotherapy:
Injects the varicose veins and spider veins directly with a sclerosant solution or foam causing intimal irritation and veins sclerosis.

Others: Mechanical and Chemical Endovenous Ablation (MOCA), Mechanical Only Ablation (MOA), Endovenous glue ablation

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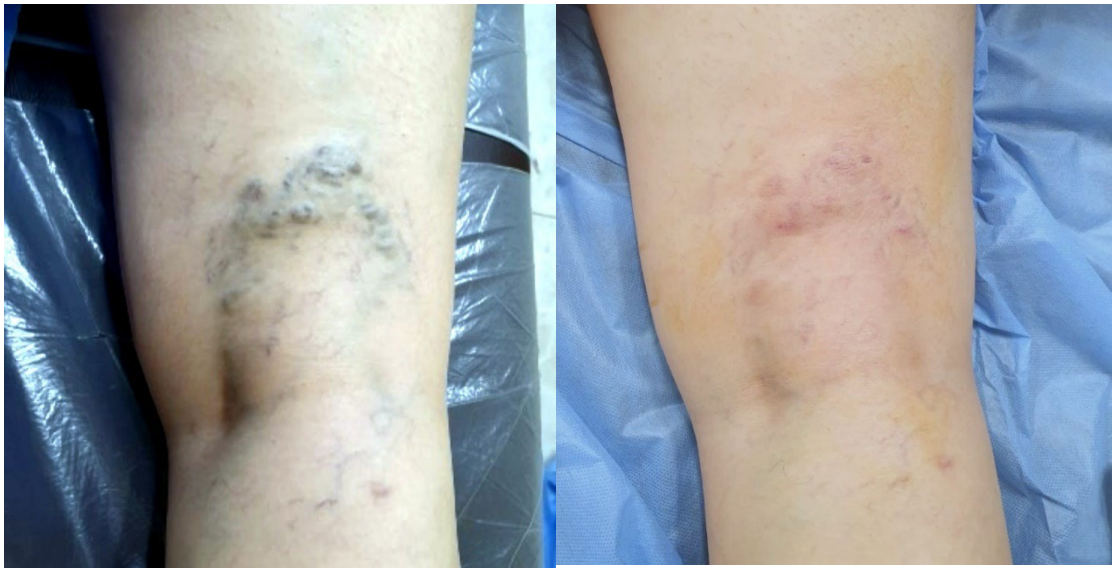


A case of popliteal area superficial varicose veins that were treated with Sclerotherapy; Case Courtesy of Karim Abdel Tawab, MD, Rana Khafagy, MD, , Ain Shams University Hospitals, Egypt

DVT Thrombolysis/Thrombectomy/Stenting

Overview:

Deep venous thrombosis (DVT) is a global health problem. DVT typically occurs in the deep veins of the lower limbs and pelvis. DVT can develop into a pulmonary embolism (PE), a life-threatening condition that occurs when the clot breaks free and becomes lodged in the pulmonary arteries.

Patients present with signs of leg swelling, pain, tenderness on deep palpation, erythema, and pain on dorsiflexion of the foot.
Risk factors for developing acute DVT are included in Virchow's triad: stasis, endothelial damage, and hypercoagulability.

Radiological diagnosis and findings:

Ultrasound is used to visualize the lower extremity venous system:

- **Acute/Subacute thrombus:**
  Expanded vein, anechoic or hypoechoic lumen, noncompressible vein, in addition to the lack of flow or flow along the margins of a filling defect.

- **Chronic thrombus:**
  Narrowed vein; lumen partially or entirely filled with hyperechoic material; flow may occur through the lumen's center or minor channels.

Treatment options and indications of IR:

- Medical treatment options:

Anticoagulation: is the primary treatment of acute DVT

- Initial treatment: therapeutic doses of either unfractionated heparin or LMW heparin.
- Long-term treatment: Oral therapy with direct oral anticoagulant (DOACs) such as rivaroxaban or apixaban; or vitamin K antagonists (e.g., warfarin) are very effective for long-term prevention of recurrent thrombosis.

Systemic thrombolytic therapy:

- A fibrinolytic drug is given via an intravenous line distant from the affected limb.

- The major disadvantage is the increased risk of serious bleeding complications, with intracranial hemorrhage carrying the highest mortality.
- Not used for DVT treatment in current practice.

- Surgical treatment options:
  - Surgical thrombectomy (for failed thrombolysis or mechanical thrombectomy and in patients with contraindications to thrombolysis).
  - Valvuloplasty/venous valve reconstruction surgery.

- IR treatment options:

The objectives of endovascular therapy for DVT include treatment of acute symptoms and minimizing the risk of post thrombotic syndrome by preventing thrombus propagation, recurrence, and degradation of vessel valves.

Catheter-Directed Thrombolysis (CDT):

Through percutaneous insertion of a catheter into the venous system, a thrombolytic drug, such as tPA, is slowly infused directly into the thrombus. This procedure is called catheter-directed thrombolysis.

Indications:

- First episode of acute (14 to 21 days) iliofemoral deep venous thrombosis in a functional patient presenting with moderate to severe symptoms.
- Phlegmasia cerulea dolens.
- Ineffectiveness of standard therapy (recurrence of symptoms or clot extension).
- Intolerance to future pulmonary embolism.
- Severe inferior vena cava thrombosis with symptoms.

Technique:

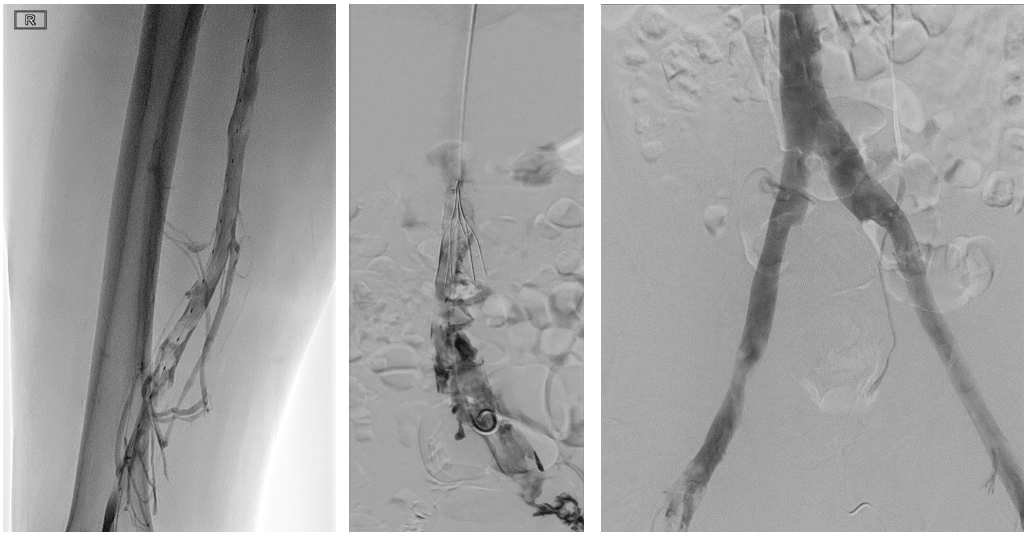
- Access into a non-thrombosed deep venous system of the affected limb below the thrombosed venous segment, using US-guidance.
- Venography to define the extent of the thrombus.
- Embed a multi-side-hole catheter attached to an infusion of a dilute solution of a thrombolytic drug (typical infusion: tPA 0.5-1.0mg/h)

- The infusion lasts for six to twenty-four hours, during which the patient is closely watched for bleeding through clinical observation and laboratory tests.
- Repeat venography is performed.
- The catheter is repositioned to span the remaining thrombus, and the infusion is continued.
- May need additional interventions after CDT (thrombectomy; angioplasty, stenting).

Percutaneous Mechanical Thrombectomy (PMT):

Direct thrombus extraction and clot burden reduction using percutaneous mechanical thrombectomy devices.
This is often preceded by thrombolytic infusion to soften the clot and reduce the burden of thrombosis.
Multiple techniques can be used:

- Aspiration: application of suction through a guiding catheter or continuous aspiration catheter (CAT) or Large Bore Aspiration thrombectomy (LBAT) devices.
- Rotational: removal of the thrombus by breaking the thrombus into microscopic particles with the help of high-speed rotating helix or spiral-shaped wires. Endothelial damage may occur when these devices get in contact with the vessel wall.
- Rheolytic: The mechanism of action for rheolytic devices is to drag and remove the thrombus inside the device using a "vortex" generated by spraying high-speed fluid onto the thrombus.
- Ultrasound-facilitated: the use of low-power ultrasound energy to disperse the thrombolytic drug within the thrombus using an ultrasound-emitting thrombolytic infusion catheter.



Acute filter related ilio-caval and femoral DVT, Pre (left, middle) and post thrombolysis and thrombectomy (right); Case courtesy of: Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

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Angio Jet Thrombolysis for Lower Extremity Acute DVT

Endovascular reconstruction with metallic stents:

If there is still a venous occlusion after thrombolysis, venous stenting and balloon angioplasty, are performed as an additional therapy in patients who have acute iliofemoral DVT to re-establish vein patency.

Indications

Acute DVT

- Iliofemoral DVT
- Evidence of residual thrombus or obstruction following thrombolysis

Chronic DVT

- Established post-thrombotic syndrome (PTS) with significant moderate to severe symptoms using validated clinical assessment score (eg, Villalta or CEAP).
- Symptomatic iliofemoral stenosis or obstruction confirmed on imaging amenable to stent placement

Technique

- Retrograde or antegrade access into deep venous system so DVT stenting can be done.
- Venography to define the extent of the stenosis or the thrombus.
- Pre-dilation to facilitate the delivery of a larger stent that is required to restore venous outflow
- Insertion of a large-diameter stents is recommended with stent sizes 18–24 mm in the cava, 14–18 mm in the common iliacs, and 12–16 mm in the external iliacs.
- Multiple stents may be used to cover the entire diseased segment, self-expanding dedicated venous stents are most commonly used.

IVC filter (IVCF) placement:

There is a lack of consensus among societal guidelines, however, there is agreement on the "classic" indications for IVF in patients with PE or IVC, iliac, or femoral-popliteal DVT.

Indications

- Contraindication to anticoagulation.
- Complications of anticoagulation.
- Failure of anticoagulation (recurrent PE despite adequate therapy or an inability to achieve adequate anticoagulation)

Technique

- Access into femoral or jugular vein.
- Inferior vena cavography to determine IVC caliber, patency, and anatomic variation; to demonstrate the level of the renal veins; and to determine whether caval thrombus is present.
- IVCF is deployed with fluoroscopic guidance immediately inferior to the origin of the lowest renal vein.
- When placement of an infrarenal filter is impossible or unlikely to prevent PE (Renal vein thrombosis /IVC thrombus extending to the level of the renal veins or above, / Gonadal vein thrombosis/ IVC duplication, /Low insertion of the renal veins/ Thrombus extended above an existing infrarenal filter), suprarenal filter insertion may be done.

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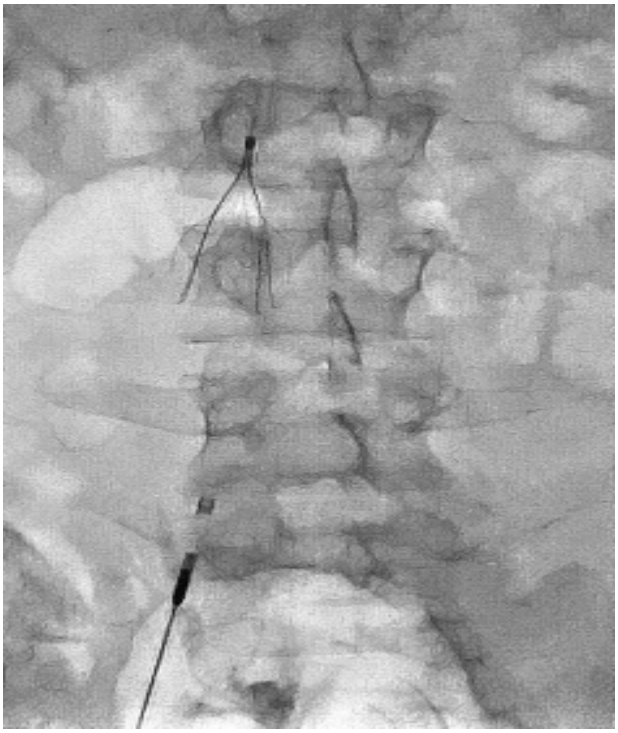
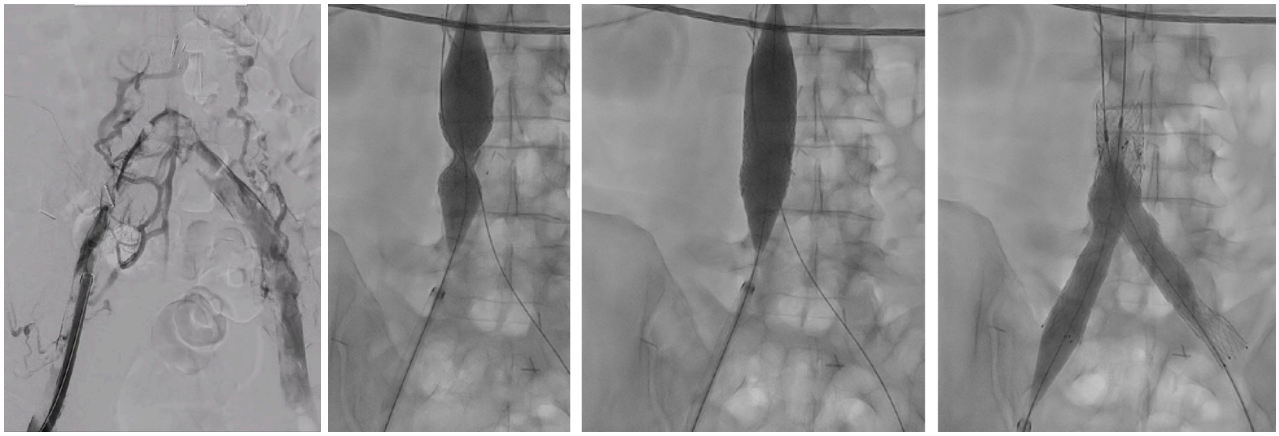


IVC Filter Placement; Case Courtesy: Karim Abd El Tawab,MD
Ain Shams University Hospitals, Cairo Egypt



1st (left image): Venography shows extensive acute DVT in the iliac veins and left femoral vein. 2nd, 3rd and 4th image: Stent placement and angioplasty of the stenotic IVC with bilateral iliac stenting Case courtesy of: Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

Aortic Aneurysms

Overview:

Aneurysm is defined as dilatation of a blood vessel more than 50% of its original diameter due to weakness in its wall.

Aneurysms can be classified according to site as aortic aneurysms, visceral aneurysms, cerebral aneurysms, and peripheral arterial aneurysms.

They can also be classified according to shape into saccular and fusiform aneurysms.

Pseudoaneurysms should be differentiated from true aneurysms as pseudoaneurysm have no true wall. They result from trauma to vessel wall or infection and are considered a contained hemorrhage surrounded with a hematoma which forms its wall.

Abdominal aortic aneurysms (AAAs) are linked to atherosclerosis and are thought to be due to weakness in the atherosclerotic aortic wall.

Most thoracic aneurysms and AAAs are asymptomatic and are incidentally discovered. The most feared complication of AAAs is spontaneous rupture and fatal hemorrhage. Distal ischemic manifestations can occur due to embolization from its mural thrombus. It may also present as compression on the surrounding structures.

Radiological diagnosis and findings:

- Ultrasound is most used for screening and initial assessment.
- Computed tomography angiography (CTA) is the gold standard, it gives information regarding the aneurysm site, size along with preoperative planning by assessing important parameters including the aneurysm length, landing zones (which are the healthy areas of the aorta proximal and distal to the aneurysm), tortuosity and angulation of the aorta. The type of endograft and its size is chosen according to the aneurysm morphology and extent.
- Xray can show widening of the mediastinum in cases of thoracic aneurysm

Lines of treatment and Indications of IR:

Unruptured descending thoracic aortic aneurysm and AAAs are recommended to be treated if:

1. Symptomatic.
2. Asymptomatic, measuring 4 cm in diameter, and has grown more than 1 cm during a year.
3. Aneurysm larger than 5.5 cm.

Surgery:

Surgical approach is the first option for ascending aortic aneurysms.

It can also be used in descending aortic aneurysms, especially the complex ones. Although open surgical repair of AAA remains the gold standard, Endovascular Abdominal Aortic Aneurysm Repair is increasingly being used in lieu of open repair.
IR options:
Minimally invasive Endo Vascular Aortic Repair (EVAR) is a good alternative to open surgical repair.

Indications:

- In unruptured descending thoracic aortic aneurysm or AAA, EVAR is considered in patients who are unfit for surgery.
- EVAR is considered to be the first line management for ruptured AAAs with suitable anatomy (infrarenal AAA) as it provides better outcome.

Technique:

(EVAR) is commonly done under general anaesthesia to ensure immobilization of the patient. Percutaneous EVAR (PEVAR) can be done under local anaesthesia/moderate sedation, particularly with the use of percutaneous arterial closure devices.

Femoral arterial access is obtained percutaneously or by surgical cutdown with insertion of a vascular sheath. Contralateral access is also obtained to introduce flush catheter which will be used for contrast injection during the procedure.

Aortography is done to assess the aorta, its branches, and the aneurysm. The stent graft is deployed to cover the whole length of the aneurysm with appropriate landing. The contralateral limb is then cannulated, and the contralateral graft limb is then deployed over guidewire. Next, the ipsilateral graft limb is deployed. A balloon is then inflated to oppose the ends of the endograft and junction zones to

ensure good sealing. Final angiography is done to exclude endoleak. Hemostasis is achieved at access sites via surgical repair or closure devices.

Fenestrated endografts are also available to treat aneurysms with challenging anatomy that requires coverage of renal arteries or other important vessels.

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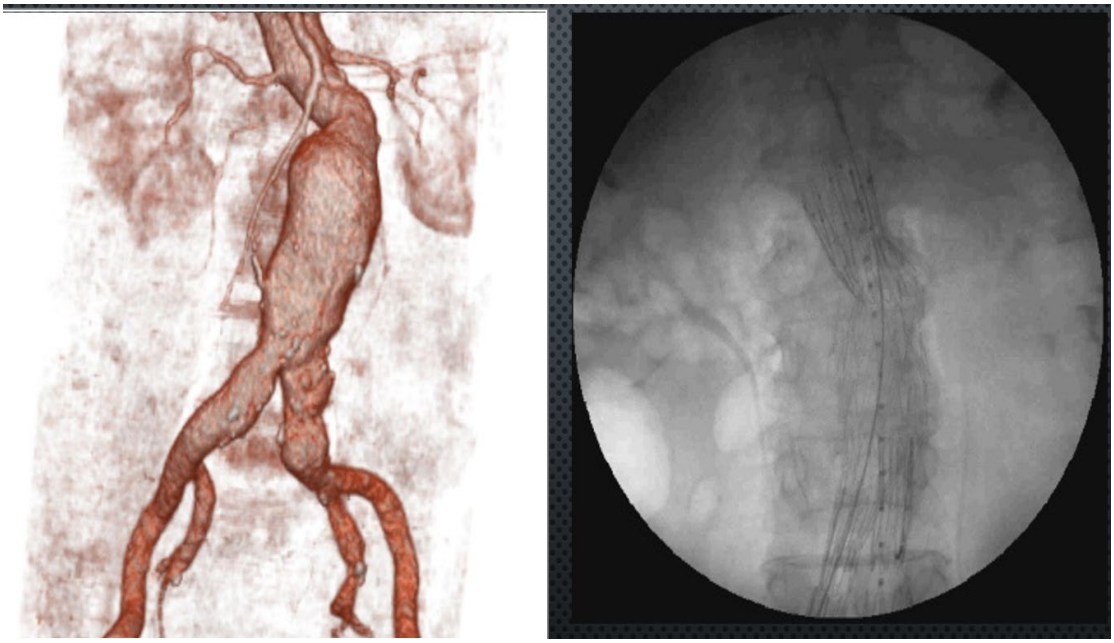

Left image: CT 3D volume rendering image showing an infra-renal fusiform aortic aneurysm extending to both CIAs, Right image: post EVAR placement bypassing the aneurysm.
Case courtesy of Ayman El Sibaie, IR consultant, Rashid hospital, UAE

Left image: an infra-renal fusiform aortic aneurysm, Right image: post EVAR placement bypassing the aneurysm. Case courtesy of Ayman El Sibaie, IR consultant, Rashid hospital, UAE

Traumatic Aortic Injury

Overview:

Traumatic aortic injury (TAI) is a blunt or less commonly penetrating injury to the aorta resulting in disruption of its wall, pseudoaneurysm formation, or complete transection. It is a common cause of death in polytrauma patients.

TAI commonly occurs at the thoracic aortic isthmus as a result of deceleration injuries like road traffic accidents or falling from height.

TAI is classified into 4 grades: grade I (intimal tear), grade II (intramural hematoma), grade III (pseudoaneurysm), and grade IV (rupture).

Radiological diagnosis and findings:

Computed tomography angiography (CTA) is the gold standard for detection of TAI. Direct signs of thoracic TAI in CTA include intimal flap, pseudoaneurysm, contour irregularity, and extravasation. The presence of periaortic or mediastinal hematoma is an indirect sign of underlying TAI. CTA also helps in planning for endovascular management and determining the required graft size.

Lines of treatment and Indications for IR:

Control of blood pressure and heart rate is the initial step as it decreases the risk of fatal rupture of the aorta and should be initiated in all patients.

Grade I TAI is managed conservatively with close follow up by serial imaging,

Types II, III and IV should be repaired urgently after other life-threatening traumatic injuries are managed. Thoracic TAIs can be repaired by an open surgical approach or endovascular approach.

Conventional surgical repair is associated with 28% mortality and 16% paraplegia rate.

The IR treatment option is Thoracic endovascular aortic repair (TEVAR) which carries less complication risk and better outcome compared to traditional surgical approach and is recommended for all patients with grade II to IV thoracic TAI with favorable anatomy.

Technique:

The procedure (TEVAR) is done under general anaesthesia to ensure immobilization of the patient. Femoral arterial access is obtained by surgical cutdown or percutaneously with deployment of a vascular sheath. Aortography by a pigtail catheter is done to assess the aorta, its branches, and the aneurysm. The relationship of the aneurysm to the major arch vessels, specifically the left subclavian and left carotid arteries, should be clearly defined.

The stent graft is introduced over a stiff guidewire and deployed carefully to avoid inadvertent coverage of the major arch vessels. A compliant balloon is usually inflated to oppose the ends of the endograft against the aortic wall to ensure good sealing. Final angiography is done to ensure good sealing with no endoleak and good arterial flow in the arch vessels.

Hemostasis is achieved at access site via surgical repair or closure devices.

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Acute Aortic Syndromes:

Overview:

Acute aortic syndromes (AAS) are medical emergencies caused by disruption or compromise of aortic wall integrity.

AAS include thoracic aortic dissection, intramural hematoma (IMH) and penetrating atherosclerotic ulcer (PAU).

Aortic dissection is separation of the aortic wall layers due to an intimal tear, the flow of blood through the intimal tear separates the aortic intima from the media and creates a false lumen and a true lumen.

Aortic dissection is classified by two classification systems, the DeBakey classification system and the Stanford classification system.

Stanford type A dissection involves the ascending thoracic aorta, while **Stanford type B** dissection doesn't involve ascending thoracic aorta (all dissections originating distal to left subclavian artery).

DeBakey type I dissection involves both ascending and descending thoracic aorta

DeBakey type II dissection involves only ascending aorta.

DeBakey type III dissection is similar to Stanford B dissections, which involves only the descending thoracic aorta.

IMH is thought to occur due to spontaneous rupture of Vasa vasorum. Blood leaks into aortic wall media forming a contained hematoma; if the intima is disrupted, IMH will progress into aortic dissection. IMH is classified similar to aortic dissection.

PAU is a confined dissection or pseudoaneurysm of the aorta that results from blood entering the aortic media but without propagation due to surrounding atherosclerosis.

AAS present with sudden, severe chest pain usually described as (tearing pain) radiating to the back. Patients with AAS typically present with increased blood pressure measurements. A classical finding is the presence of discrepancy of blood pressure measurement between both upper limbs, however it is not always present.

Other symptoms include dysphagia, dyspnea, or signs of malperfusion of major branch vessels, these include bowel ischemia, oliguria due to renal ischemia, myocardial ischemia, stroke and lower limb ischemia.

Radiological diagnosis and findings:
Computed Tomography Angiography (CTA) of the aorta is the gold standard for diagnosis and planning for open surgical or endovascular repair.

Other useful diagnostic modalities are magnetic resonance imaging, echocardiography, and transesophageal echocardiography.

Lines of treatment and Indications of IR:

- All patients should receive medical management with beta blockers, to decrease systolic blood pressure, and pain management medications.
- *Aortic dissection:*
- Type A dissections are mainly managed by open surgery. Endovascular fenestrated and/or target vessel stenting can be done prior to or after open surgical repair to improve end organ perfusion in patients with mesenteric or renal ischemia.
- Uncomplicated type B dissections are primarily managed medically

Indications:

Endovascular aortic repair (EVAR) is considered in:

1- Uncomplicated type B dissections if they show high risk features.
2- Complicated type B dissections: those with uncontrolled hypertension despite medical treatment, early aortic expansion, end organ ischemia due to involvement of aortic branch vessel, and signs of aortic rupture.

IMH:

- Patients with complicated and uncomplicated type A IMH should undergo open surgery.
- Patients with uncomplicated type B IMH can be managed conservatively.
- Complicated type B IMH is best managed with EVAR when anatomy is favorable.

PAU:

- In patients with persistent pain due to PAU or have risk features, elective repair is considered. Type A lesions are managed by open surgery while type B lesions are best managed with EVAR when possible.

Technique:

The procedure (EVAR) is done under general anaesthesia to ensure immobilization of the patient. Femoral arterial access is gained, a vascular sheath is then secured. Aortography by a pigtail catheter is done to assess the aorta, its branches, and the entry tear. A stent graft is deployed to seal the entry tear eliminating blood flow to false lumen. A compliant balloon is usually inflated to oppose the ends of the endograft against the aortic wall to ensure good sealing. Angiography is done after that to ensure good sealing with no endo-leak points and good arterial flow in the nearby branches.

Hemostasis is achieved at access site via surgical repair or closure device.

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Peripheral Arterial diseases and Acute Limb Ischemia

Overview:

Peripheral artery disease (PAD) is an atherosclerotic disease which affects peripheral arteries, more commonly lower limb arteries.

Risk factors include smoking, diabetes, hypertension, and dyslipidemia.

PAD is classified according to the clinical presentation and severity:

The **Fontaine Classification** is the most used classification system, PAD is classified into 5 stages:

Stage I: Asymptomatic.

Stage IIa: Mild claudication.

Stage IIb: Moderate-severe claudication.

Stage III: Rest pain.

Stage IV: Ulceration or gangrene.

Another commonly used classification system is the **Rutherford classification** of chronic limb ischemia; it is classified into 7 stages:

0—Asymptomatic.

1—Mild claudication.

2—Moderate claudication.

3—Severe claudication.

4—Rest pain.

5—Ischemic ulceration not exceeding ulcer of the digits of the foot.

6—Severe ischemic ulcers or frank gangrene.

Acute limb ischemia (ALI) is defined as an acute and severe decrease in blood supply to a limb. It classically presents with "6 Ps": pain, pallor, pulselessness, poikilothermia (cold), paresthesia and paralysis. ALI is classified into:

- Viable: The limb is not at immediate risk, no significant sensory or motor affection with detectable arterial and venous doppler signal.
- Threatened: limb is at immediate risk of amputation if no intervention is done, and no detectable arterial doppler signal but detectable venous signal, this group of patients are further subcategorized into IIa (marginally threatened: slow to intact capillary refilling, intact sensation

or defective sensation limited to toes, and intact motor power), and IIb (immediately threatened: slow to absent capillary refilling, defective sensation affecting more than toes with rest pain and mild to moderate motor affection).

- Irreversible: Non salvageable limb with permeant tissue damage, no detectable doppler arterial or venous signal, profound anaesthesia, and profound paralysis (rigor).

Radiological diagnosis and findings:

- History taking and clinical examination including blood pressure measurement and assessment for risk factors and comorbidities.
- Assessment of resting ankle brachial index (ABI). Normal resting ABI is 0.9-1.1, PAD is diagnosed if ABI is less than 0.9. Patients with Critical Limb ischemia (CLI) have an ABI of less than 0.3. An ABI higher than 1.4 is due to noncompressible rigid vessels and is nondiagnostic, this is associated with diabetes and chronic kidney disease. In these patients, Toe brachial index (TBI) should be used instead, and PAD is diagnosed if TBI is 0.70 or less.

Noninvasive imaging provides information regarding exact site of the lesion, degree of stenosis and disease extent. It also helps in decision making regarding the appropriate type of intervention (e.g., surgical bypass vs endovascular recanalization). Duplex ultrasound study, computed tomography angiography (CTA) or magnetic resonance angiography (MRA) can be used. Duplex study is usually the first step in radiologic assessment.

- Invasive assessment with catheter angiography is considered if intervention is planned in the same session e.g., balloon angioplasty or stenting for critical limb ischemia (CLI).

Lines of treatment and Indications of IR:

Patients with PAD are either managed medically, endovascularly, or surgically.

The choice of whether to treat a patient medically or with invasive procedures depends on the presentation, severity of symptoms (according to Fontaine and Rutherford classification), and failure of medical treatment.

- Medical management includes lifestyle modification, management of risk factors, and antithrombotic medications.
- Surgical options include endarterectomy, surgical thrombo-embolectomy, bypass graft, and/or amputation for non salvageable gangrenous tissue.
- IR treatment options include balloon angioplasty, drug coated balloons (DCB), bare metal stents, drug eluting stents, covered stents, atherectomy

for heavily calcific lesions, and chronic total occlusion recanalization procedures.
- A combination of all these technologies is often required.

Indications of IR treatment:

When both endovascular and surgical interventions have similar risk and expected outcome, endovascular approach should be the first option.

In general, endovascular management is the preferred modality in limited lesions (stenosis or occlusion less than 10 cm in length), and for patients not fit for surgery.

Technique:

The most used method for stenotic lesions is balloon angioplasty.

The procedure is done under local anaesthesia. Digital subtraction angiography (DSA) is done to define the stenosis or occlusion. The guidewire is then navigated across the stenosis or occlusion, and an angioplasty balloon is advanced to the site of stenosis. Angioplasty is performed and the guidewire is kept in place. Residual stenosis, immediate recoil or flow limiting dissection can be treated with self-expandable stent.

The vascular access sheath is removed at the end of the procedure, hemostasis is achieved via a vascular closure device or manual compression.

Regarding ALI

- All patients should be anticoagulated unless contraindicated. Rapid revascularization is the mainstay of management to prevent limb loss. Amputation is reserved for category III ALI (non-salvageable ischemic limb).
- Endovascular revascularization options include catheter directed thrombolysis (CDT), aspiration thrombectomy and mechanical thrombectomy, this is accompanied by balloon angioplasty or stenting of residual stenotic lesions to avoid recurrence of thrombotic occlusion.
- Open surgical balloon catheter thrombo-embolectomy or surgical bypass is appropriate for patients with ALI due to large embolus or patients with category IIb ALI. Surgical revascularization is thought to restore blood flow faster than endovascular approach.

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Chronic total occlusion of the SFA (left) treated with balloon angioplasty (middle), patent SFA (right). Case courtesy of: Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

Scan me

Angioplasty & Stenting of Superficial Femoral Artery in Peripheral Arterial Disease part ١

Scan me

Angioplasty & Stenting of Superficial Femoral Artery in Peripheral Arterial Disease part ٢

Traumatic Peripheral Arterial Injuries

Overview:

Trauma may damage the vascular system of limbs' arteries and veins.

Vasospasm, contusion, intimal flaps, intimal disruption or hematoma, external compression, laceration, transection, localized wall defects, pseudo aneurysm, arteriovenous fistulas (AVFs), ischemia, and gangrene are possible vascular complications of trauma to the limbs.

Limb gangrene due to tissue and organ ischemia and shock following major bleeding are the predominant clinical symptoms of vascular injuries.

Radiological diagnosis and findings

Duplex ultrasonography is the first-line imaging modality in most patients. It can detect pseudoaneurysms, AV fistula, vein wall irregularity, and hematoma.

CT and MRI angiography help diagnose vascular disease, identify the type and location of vascular injury, lesion size and extent, and any problem with the collateral circulation; treatment can then be planned. CTA is less invasive than conventional arteriography and has similar high sensitivity and specificity.

CT angiographic signs of arterial injuries in the extremities:

- Active extravasation of contrast material.
- Pseudoaneurysm formation.
- Abrupt narrowing of an artery.
- Loss of opacification of a segment of artery.
- Arteriovenous fistula formation.
- Dissection

Angiography remains the gold standard for diagnosing vascular trauma, yet it is more invasive than CTA.

Treatment options and indications of IR:

Surgical options include exploration with primary vessel repair, patch, bypass, ligation, fasciotomy, tissue debridement and amputation.

IR Indications:

In patients with low-velocity injuries (such as a stab wound or handgun blast):

- In anatomical territories where surgical exposure might prolong ischemia or increase risk of bleeding complications
- In regions where there is a higher risk of iatrogenic nerve injury during vessel exposure, such as the subclavian artery.

IR Treatment Options:

Endovascular interventions such as stent graft placement and embolization are well established alternatives in the management of vascular injuries. The choice depends on the location and type of injury.

Active extravasation from traumatic injuries can be treated with superselective embolization of the injured vessel or by proximal embolization. The choice of embolic materials depends on the level of injury, vascular territory and operator experience.

Isolated pseudoaneurysms originating from branches or main vessel injury with narrow necks can be treated with US guided thrombin injection.

Pseudoaneurysms associated with arteriovenous fistulas are treated with covered stents depending on site of injury.

Dissections can be managed with balloons, bare metal stents, or covered stents.

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Peripheral vascular malformations

Overview:

Malformations can be classified into arterial malformations (AMs), venous malformations (VMs), arteriovenous malformations (AVMs), lymphatic malformations (LMs), capillary malformations (CMs), and combined vascular defects.

Arterio-venous malformations (AVM) and arterio-venous fistulas (AVF) are aberrant blood shunts that develop when arteries and veins directly communicate with one another, bypassing the normal capillary bed and typically leading to venous dilatation and congestion.

AVM and AVF can both be idiopathic, and AVF can also develop after trauma.
AVMs are characterized by the presence of a "nidus" while AVFs are direct communications between arteries and veins with no intervening nidus.
According to their anatomical placements and flow characteristics of the abnormality, vascular malformations can induce a range of symptoms. Peripheral AVMs often manifest as a palpable mass on the outside, with overlaying crimson color, as well as a perceptible thrill and bruit.
AVMs can be clinically classified according to the Schobinger staging for AVMs, beginning with stage 1, quiescent, and progressing to stage 4, decompensation, based on their behavior and clinical consequence.

(I) Quiescence	Pink-bluish stain, warmth and arteriovenous shunting are revealed by Doppler scanning. The arteriovenous malformation mimics a capillary malformation or involuting hemangioma
(II) Expansion	Same as Stage I plus enlargement, pulsation, thrill, bruit and tortuous/tense veins
(III) Destruction	Same as Stage II plus dystrophic skin changes, ulceration, bleeding, persistent pain or tissue necrosis. Osteolytic lesions may occur
(IV) Decompensation	Same as Stage III plus high-output congestive heart failure and left ventricular hypertrophy

Schobinger Staging of Arteriovenous Malformations

VMs and LMs can also cause problems including bleeding or lymphatic fluid leaking through the skin, discomfort, infection, and aesthetic deformity.
Diagnosis of vascular malformations is primarily clinical.

Radiological diagnosis and findings:

Venous malformation:

US:

- hypoechoic lesion, with no flow, or monophasic low-velocity flow, doppler flow is difficult to obtain due to low flow or thrombosis
- Valsalva or manual compression may help to generate flow during US imaging.
- Phleboliths are regions of calcification within a lesion.

MRI:

- The best method for determining the complete anatomic extent of VMs is MRI.
- T2 hyperintense serpiginous lesions that frequently exhibit phleboliths.
- Phleboliths are well-defined, round or oval spots with a dark signal on T2W imaging and a high T2 signal surrounding them.
- Variable levels of T1 hyperintensity may be seen in hemorrhage, thrombosis, or phleboliths.
- The greatest diagnostic indicator is the presence of phleboliths and internal enhancement in the venous phase of Dynamic Contrast Enhanced (DCE) MRA.

CT, X ray:

CT and X ray can identify phleboliths, but they are insufficient because of their lack the soft-tissue resolution.

Lymphatic malformation:

US:

- A cystic mass with lobulations and septations is seen on ultrasound. Even though these are slow-flow lesions, Doppler US may show tiny arteries at the level of septations.

MRI:

- T1 hypointense, T2 hyperintense spaces that may be macrocystic, microcystic, or mixed in size.
- Hyper T1 signal can be found in the context of internal hemorrhage/high protein content.
- Fluid-fluid level; can be seen due to inflammation or hemorrhage; but it can be seen also in VMs as well.

- The most important observation on MR in the distinction from other vascular anomalies is that the lymphatic cysts have no internal enhancement but septal or wall enlargement is frequently seen.

Capillary malformation:

- They are diagnosed based on clinical criteria.
- US can be used to define the lesions
- MRI has limited use.

Arteriovenous malformation:

US:

Ultrasonography is preferred in the assessment of superficial lesions.

Lesions show hypoechoic tortuous feeding arteries without a soft tissue mass associated, enhanced (arterialized) diastolic flow, and unhindered connection between arteries and veins due to aberrant vascular channels. The draining veins that relate to them show arterialized high-velocity flow.

MRI:

MRI assists in treatment planning by determining the complete extent, anatomic involvement, and proximity to important structures.

Arteriovenous fistula

US:

Low-resistance waveforms with high velocity on the arterial side close to the fistula. Arterialized flow will be visible in the draining vein.

MRI:

Magnetic resonance angiography (MRA) is useful to visualize early arterialized vein compatible with an AVF

<u>Treatment options and indications of IR:</u>

Venous Malformation:

Medical treatment options:

- Elastic compression garments.

- Aspirin can be used on a daily basis to prevent local thrombosis.

LMWH is used to treat painful recurrent thromboses and improve coagulation profile, when Localized Intravascular Coagulation (LIC) is a complicating feature of VMs.LIC is the elevation of D-dimer levels, with variable decrease in both fibrinogen and platelet levels.

Surgery: Rarely done alone, and it usually preceded or combined with sclerotherapy.

IR treatment options:

Sclerotherapy is the first-line therapy for VMs.

Indications:

- Bleeding under the skin (hematuria, rectal bleeding, hematemesis, hemoptysis, or intracerebral or intraspinal bleeding, as well as bleeding into the muscles or retroperitoneum).
- Lesions are located in potentially fatal or highly complication-prone regions or obstruct inflow and outflow of important structures.
- Pain and thrombosis.
- Functional impairment.
- Excessive cosmetic implications.

Technique:

- Needle or cannula such as an angiocath (usually 20–25 gauge) is inserted into the VM under direct vision or ultrasound guidance.
- When blood return is noted, a syringe/tubing combination is attached to the needle.
- Digital subtraction angiography (DSA) is performed to see the accessed portion of the VM, to estimate the capacity, and to assess the associated draining veins If such a communication occurs, it can often be prevented by manual compression of the communicating normal vein; rarely, it may be necessary to place a platinum or fibre coil to block the venous communication.
- Once a proper needle location is confirmed, the sclerosing agent is injected under fluoroscopy.
- The sclerotic agent that can be used: concentrated ethanol, sodium tetra-decyl sulfate (STS) or polidocanol.

Lymphatic malformation: Medical treatment options:

- Compression can reduce inflammation and pain while lowering the risk of infection.

- Steroids.
- Antibiotics: when the infection involves the LM.

Surgery: challenging treatment with high risk of recurrence and frequently infiltrative lesions.

IR treatment options:

Indications:

- Lesions in potentially life-threatening regions.
- LM that has hemorrhagic or infectious complications.
- Patient discomfort, decreased mobility, aesthetic dissatisfaction, or any other condition that significantly reduces quality of life.

Technique

- A 21to 25-gauge needle is used to enter the LM under ultrasound guidance
- To confirm access into the LM, the fluid that is returned should be chylous, or hemorrhagic if intralesional bleeding occurred.
- To limit dilution of the supplied sclerosant and increase sclerosant effectiveness, the LM should be completely aspirated before sclerosant delivery.
- LMs have been treated with a variety of sclerosants, including doxycycline, STS, bleomycin, and 100% ethanol.

Arterio-venous malformations (AVM): Surgical excision, embolization techniques, or a combination of both may be used to treat AVMs.

IR treatment options:

The general principle of embolization is that occlusion is performed at the site of the abnormal arteriovenous shunts.

AVMs may be treated percutaneously into the shunt site, from the venous side, or from the arterial side.

Indications:

- Patients with Schobinger stage I and II AVMs are usually handled conservatively, with an initial diagnostic work-up followed by an annual follow-up evaluation.

- In most cases, definitive therapy for AVMs is reserved for stage III and IV lesions

Technique:

From the arterial side:

- Obtain arterial vascular access (femoral or radial artery are preferred).
- Catheterize the main feeder of the AVM with 5Fr catheter through which a microcatheter is advanced distally.
- The aim is to place the microcatheter in a very distal feeder close to the arteriovenous site of shunting, beyond any normal arteries.
- The embolic agent should ideally be inserted into the nidus up to the point where the draining veins are.

From the venous side:

- For obstructing outflow and introducing liquid embolic into the AV shunt site, a balloon occlusion catheter may be helpful. You can inject ethanol into the venous side. In a more saccular AVM. Coils are frequently utilized to occlude the venous sac or reduce the flow on the venous side.

If there is insufficient arterial or venous access, which is frequently brought on by a difficult intravascular path or clogged proximal arterial feeders, direct percutaneous access into the AVM can be conducted.

In order to reduce the flow or to occlude the nidus, liquid embolic agents such as n-butyl cyanoacrylate, Onyx, 100% ethanol, or coils are employed.

Arteriovenous fistula:Most acquired AVFs spontaneously resolve within a few months, hence conservative therapy with interval imaging and clinical care is recommended for AVF management.

Early therapy is needed when there are clinical consequences or a significant fistulous connection. The fistula can be repaired surgically.

<u>IR treatment options:</u>
A covered stent can be used for endovascular repair to cover the fistula and stop the arteriovenous shunt while maintaining distal arterial flow.
As an alternative, embolization or coils, may be used to obliterate the fistula when it is long enough to connect the artery and vein.

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1. Geschwind JFH, Dake MD. Abrams' angiography: interventional radiology. 3rd ed. Philadelphia: Wolters Kluwer health - Lippincott Williams & Wilkins; 2014
2. Bertino F, Trofimova AV, Gilyard SN, Hawkins CM. Vascular anomalies of the head and neck: diagnosis and treatment. Pediatr Radiol. juin 2021;51(7):1162-84.
3. Mulligan PR, Prajapati HJS, Martin LG, Patel TH. Vascular anomalies: classification, imaging characteristics and implications for interventional radiology treatment approaches. Br J Radiol. mars 2014;87(1035):20130392.
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Cardiothoracic Diseases and Interventions

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Pleural / pericardial effusion

Overview:

Collection of serous or purulent fluids in the pleural or pericardial spaces due to inflammatory, infectious, malignant, traumatic, volume overloading diseases, or idiopathic causes. Patients usually present with dyspnea, fever (in case of empyema), or circulatory collapse (in case of cardiac tamponade).

Radiological findings and diagnosis:

Chest Xray shows meniscus sign or blunting of the costophrenic angle in pleural effusion, and flask shaped opacity in chronic pericardial effusion (acute pericardial effusion can be normal in Xray). Transudate pleural effusion appears on US as anechoic (black) fluid displacing the lung parenchyma. Increased echogenicity and presence of internal echoes may indicate transudate nature, of hemorrhagic or infectious consistency. CT helps in measuring the quantity and fluid CT density, which can be high in infectious or hemorrhagic effusions.

Lines of treatment and Indications of IR:

- Medical treatment:
  Medical treatments depend on the cause of the pleural effusion. It can be diuretics in case of congestive heart failure, chemotherapy for malignant etiology and antibiotics for empyema.
- Pleurodesis:
  Used to prevent recurrence of rapidly recurring pleural effusion. It is done by administering a sclerosing agent like talc in the pleural space.
- Surgical treatment:
  Pleural effusion can be managed surgically like thoracotomy for inadequate drainage and decortication for persistent or recurrent effusions not responding to other measures.

IR treatment options:

- Aspiration and Thoracentesis:

US or CT can be used to obtain a sample of the fluid collection for cytology, fluid analysis, or culture and sensitivity. Thoracentesis is done to relieve acute respiratory or cardiac distress. US is the preferred modality of guidance as it allows live needle tracking.

- Insertion of drainage catheters:

Pigtail catheter insertion by image guidance is indicated in case of reaccumulating effusion despite repeated attempts of aspiration. Placement of drainage catheters is associated with increased risk of infection.

References:

1. Chand R, Eltorai A, Healey T, Ahn S, editors. Essential Interventional Radiology Review: A Question and Answer Guide. Cham: Springer; 2022.
2. Kok HK, Ryan E, Asadi H, Lee M, editors. Interventional Radiology for Medical Students. Cham: Springer; 2018.
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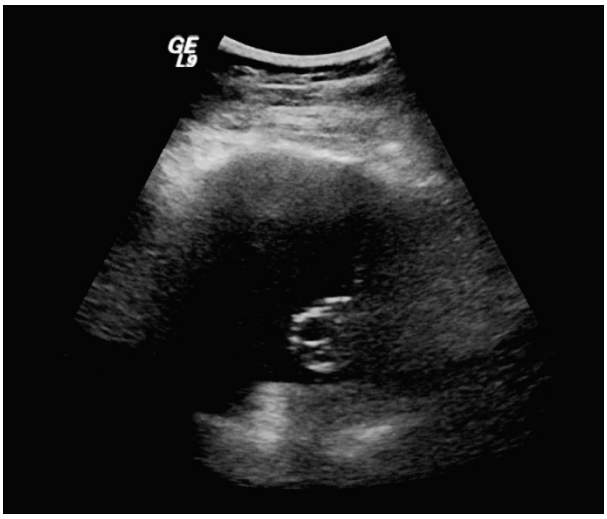

Pigtail Catheter in Pleural Effusion. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo Egypt

Chylothorax

Overview:

Lymphatic pleural effusion which can present with dyspnea, fever, or fatigue. It results from thoracic duct and lymphatic vessels injuries that can be traumatic or non-traumatic secondary to malignancies, infections, or systemic diseases.

Radiological diagnosis and findings:

Chylous effusion appears radiologically as other types of pleural effusion. It is usually confirmed by chemical composition and cytology of an aspirate.

Lines of treatment and Indications of IR:

- Conservative measures: Aim to decrease the amount of chyle produced from the digestive system by placing the patient on total parenteral nutrition. Octreotide, a somatostatin analog, may be tried.
- Surgical measures: By ligation of the thoracic duct surgically or by pleurodesis in which the pleural potential space is obliterated preventing the chyle accumulation.
- Percutaneous US guided drainage: to relieve distressing effusions.
- Thoracic duct embolization +/- stenting: in case of persistent chylous effusion for more than two weeks, with high daily output more than 500 mL/day or when conservative measures fail, as an alternative to surgical thoracic duct ligation or pleurodesis.

IR technique:

Nodal lymphangiography is performed by bilateral US guided puncture of inguinal lymph nodes followed by slow and continuous injection of lipiodol contrast to outline the lymphatic channels. Lipiodol progression is intermittently monitored under fluoroscopy until the cisterna chyli is identified. Using fluoroscopic guidance and under local anaesthesia, a Chiba needle is introduced through the anterior abdominal wall. the needle is passed to the vertebral body, targeting the spinous process of D12/L1 or where the cisternal chyli is identified. An 0.018” or 0.014” hydrophilic wire is advanced into the thoracic duct followed by insertion of a microcatheter. Contrast injection through the catheter is done to visualize the site of leakage followed by embolization using coils and glue proximal to the leak site +/- stenting.

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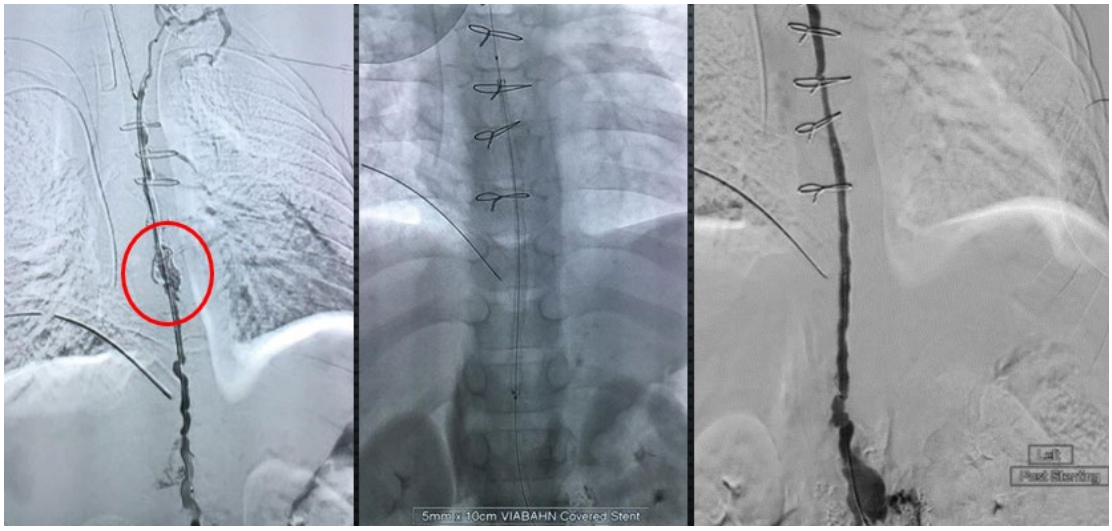
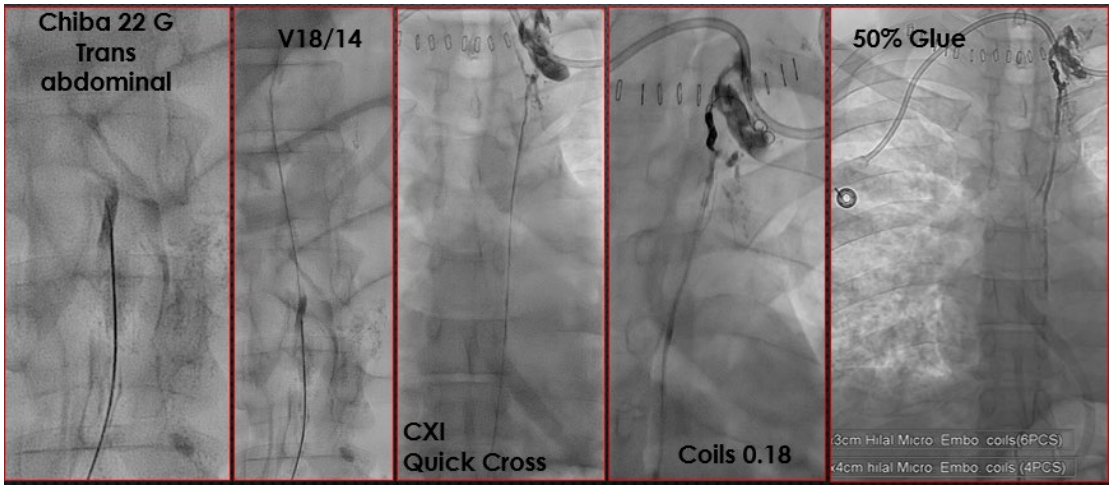
1. Chand R, Eltorai A, Healey T, Ahn S, editors. Essential Interventional Radiology Review: A Question and Answer Guide. Cham: Springer; 2022.
2. Chen E, Itkin M. Thoracic duct embolization for chylous leaks. Semin Intervent Radiol. 2011 Mar;28(1):63-74. doi: 10.1055/s-0031-1273941. PMID: 22379277; PMCID: PMC3140251.



A case of chylothorax post open-heart surgery. Left image shows Antegrade / reterograde access. Middle image shows Retrograde covered stent placement. Right image: Post stent image where chylothorax is seen stopped. Case courtesy of Mohammad Badran, King Faisal Specialist Hospital and Research Center, Riyadh, KSA



Thoracic duct embolization with micro-coils and glue through antegrade access.
Case courtesy of Mohammad Badran, King Faisal Specialist Hospital and Research Center, Riyadh, KSA

Pulmonary Nodules

Overview:

Focal lesions in the pulmonary parenchyma that could be either asymptomatic and incidentally discovered or symptomatic presenting with symptoms as hemoptysis, dyspnea, weight loss or other symptoms of different para-malignant syndromes.

Radiological diagnosis and findings:

- CT is gold standard. Large size, rapid growth, or suspicious features as spiculated border indicates high risk of malignancy. It can be used for disease staging thus dictating management.
- Positron Emission Tomography (PET) can assess the activity of the pulmonary nodules and associated metastasis.

Lines of treatment and Indications of IR:

- Centrally situated nodules can be biopsied through endobronchial approach via a bronchoscope. More peripheral and subpleural lesions can be sampled by CT guided biopsy.
- For treatment of malignant lesion, different modalities including surgical resection, chemotherapy, radiotherapy, and percutaneous ablation can be used depending on the type and stage of cancer.

IR options:

- **CT guided biopsy:**
  Indicated when nodules are found on CT, yet they are indeterminate even after PET assessment and no safer route through bronchoscopy (endobronchial approach) is available. CT guided core biopsy is typically better for peripherally situated nodules and can be done under local anaesthesia where the biopsy needle is introduced into the target pulmonary nodule.
- **Percutaneous ablation:**

  CT guided ablation by different modalities (microwave, cryoablation, radiofrequency) offers a good alternative to surgery in patients who are not candidates for surgery. Ablation can be used with either curative or palliative intents for primary or metastatic lesions. The needle is guided by CT to its target to ablate it under general anaesthesia.

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1. Chand R, Eltorai A, Healey T, Ahn S, editors. Essential Interventional Radiology Review: A Question and Answer Guide. Cham: Springer; 2022.
2. Turner, Jr. JF, Jain P, Yasufuku K, Mehta AC, editors. From Thoracic Surgery to Interventional Pulmonology: A Clinical Guide. Cham: Springer; 2021.

Acute pulmonary embolism

Overview:

Pulmonary embolism (PE) is defined as the presence of embolus in the pulmonary arterial system. PE commonly originates from deep venous thrombosis of the lower limbs. Peripheral and segmental PE may be asymptomatic; However, patients may present with various symptoms such as dyspnea, tachypnea, hypoxia and/or circulatory collapse.

It is graded by right ventricular (RV) dysfunction and hypotension into low, intermediate, and high-risk pulmonary embolism (PE). Low risk PE corresponds to normal RV function and blood pressure. Intermediate risk/submassive PE corresponds to RV dysfunction yet with normal blood pressure. High risk/massive PE corresponds to RV dysfunction that results in hypotension.

Radiological diagnosis and findings:

Diagnosis depends on a low threshold of suspicion by the clinical symptoms in accordance with rest of the clinical history, vital signs, and oxygen saturation.
It is confirmed by CT pulmonary angiography, which can locate the site of the embolus.
Ventilation/perfusion (V/Q) scan shows ventilation-perfusion mismatch, and it is typically used when CT is contraindicated.
Chest radiography is used to exclude other causes such as pneumonia.
Echo can be done to exclude RV strain and RV dysfunction.

Lines of treatment and Indications of IR:

- Cardiopulmonary support is the initial treatment.
- In the absence of any contraindications, all patients with acute PE should receive appropriate anticoagulation therapy.
- For a massive PE there are three different treatments options: (1) systemic thrombolysis; (2) Surgical pulmonary embolectomy; (3) Endovascular techniques
- Implanting an inferior vena cava filter (IVCF) may be considered in the management plan, in cases of massive PE to prevent further thrombus migration.
- Endovascular IR treatment (Catheter-directed therapy) includes mechanical clot thrombectomy or catheter-directed thrombolysis (CDT). According to the clinical guidelines of the American College of Chest Physicians (ACCP), CDT is considered in acute massive PE when systemic thrombolysis therapy fails or is contraindicated. Pulmonary Embolism Response Team (PERT) is an emerging concept that aims to facilitate decision making process in multidisciplinary approach that

includes members from critical care, interventional radiology, cardiology, anaesthesia, cardiac surgery, hematology and clinical pharmacy.

IR technique:

Venous access is obtained, usually through the femoral vein, then a long sheath is inserted. A pigtail catheter or a balloon-tipped catheter is navigated through the right heart to reach the pulmonary outflow tract.

After identifying the pulmonary artery branches with the highest thrombus burden and correlating these findings with prior imaging, the thrombus can be traversed with a guidewire to facilitate placement of mechanical thrombectomy devices or infusion catheters to start clot fragmentation and aspiration.

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1. Goldhaber SZ, Visani L, De Rosa M. Acute pulmonary embolism: clinical outcomes in the International Cooperative Pulmonary Embolism Registry (ICOPER) Lancet. 1999;353:1386–1389
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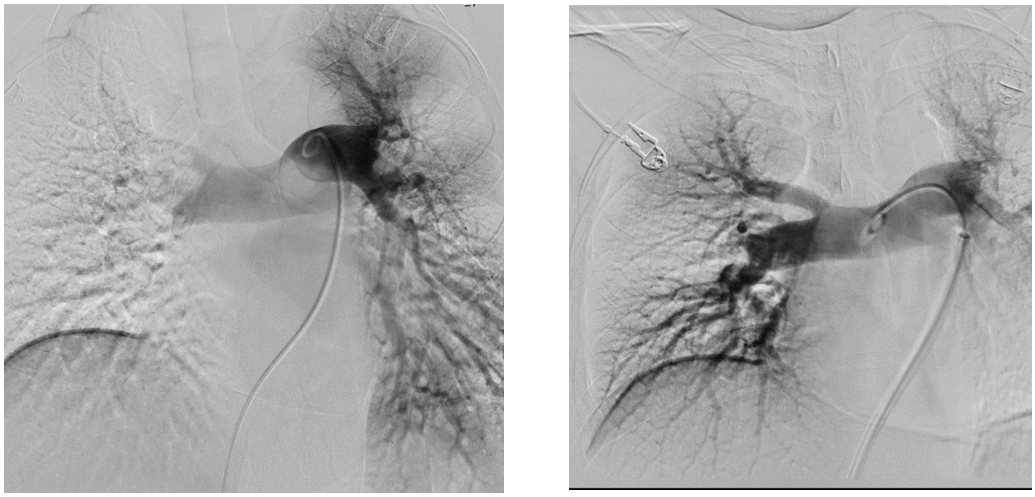

Acute pulmonary embolism with non-filling of contrast of the right upper and lower lung lobes' pulmonary branches (left image), Post recanalization of the right pulmonary artery branches (right image). Case courtesy of Ayman El Sibaie, IR consultant, Rashid Hospital, UAE.

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IR Role in Management of Pulmonary Embolism

Hemoptysis

Overview:

Expectoration of blood or blood-tinged sputum from the lungs or tracheobronchial tree. It can be graded as massive when the amount exceeds 200-250 ml per day.

It could be due to infectious (e.g. T.B.), malignant, traumatic, or parenchymal lung diseases.

Radiological diagnosis and findings:

CT angiography detects the bleeder origin, its laterality, and its underlying cause. It is also used in the preoperative assessment to assess the origin of the bronchial artery which has multiple anatomic variations. Hemoptysis is mostly of bronchial arterial source rather than of a pulmonary arterial source.

Lines of treatment and Indications of IR:

- Bronchoscopy is the first line in non-massive hemoptysis which can help in the diagnosis, localization of source and treatment.
- Surgical resection is the last option.
- Bronchial artery embolization (BAE) is the first line for massive hemoptysis. Also, it is indicated for lesser amounts if bronchoscopy fails to stop it.

IR technique:

Femoral or radial arterial access is gained. Catheter is introduced to the aorta and angiography is done to determine origin of bronchial arteries and to visualize any possible nearby spinal branches. Once the bronchial artery is cannulated, a microcatheter is advanced and angiography is done to exclude filling of the anterior spinal artery and to avoid non-target embolization. Bleeding bronchial artery appears hypertrophied and/or tortuous with hyper vascular background, aneurysmal dilatation, or pseudoaneurysms. Active contrast extravasation is rarely seen. The embolizing agent used differs according to the bronchial artery size and the required site of embolization, either proximal or distal near the bed. Embolizing agents that are commonly used include embolic particles and/or glue.

References:

1. Chand R, Eltorai A, Healey T, Ahn S, editors. Essential Interventional Radiology Review: A Question and Answer Guide. Cham: Springer; 2022.
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A patient with cystic bronchiectasis and fibrosis (left image: CT chest) presented with hemoptysis. Catheterization of the pathological right bronchial artery revealed abnormal lung parenchymal blush (middle image) that was successfully embolized (right image). Case courtesy of Rana Khafagy, IR consultant, Ain Shams University Hospitals, Egypt

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Bronchial Artery Embolization part ١

Scan me

Bronchial Artery Embolization part ٢

Pulmonary Arteriovenous Malformation (PAVM)

Overview:

Arteriovenous miscommunication between pulmonary arteries and veins. PAVMs could be asymptomatic and diagnosed incidentally, or patients may present with dyspnea, cyanosis, high output heart failure, paradoxical systemic emboli, stroke or brain abscesses. It is one of the manifestations of hereditary hemorrhagic telangiectasia (HHT).

Radiological diagnosis and findings:

CT angiography is used to confirm diagnosis and study related anatomical considerations. Study of feeding arterioles, draining venules, and intervening fistula (direct communication between the artery and vein) or nidus (communicating capillaries) is mandatory to plan for the procedure.

Lines of treatment and Indications of IR:

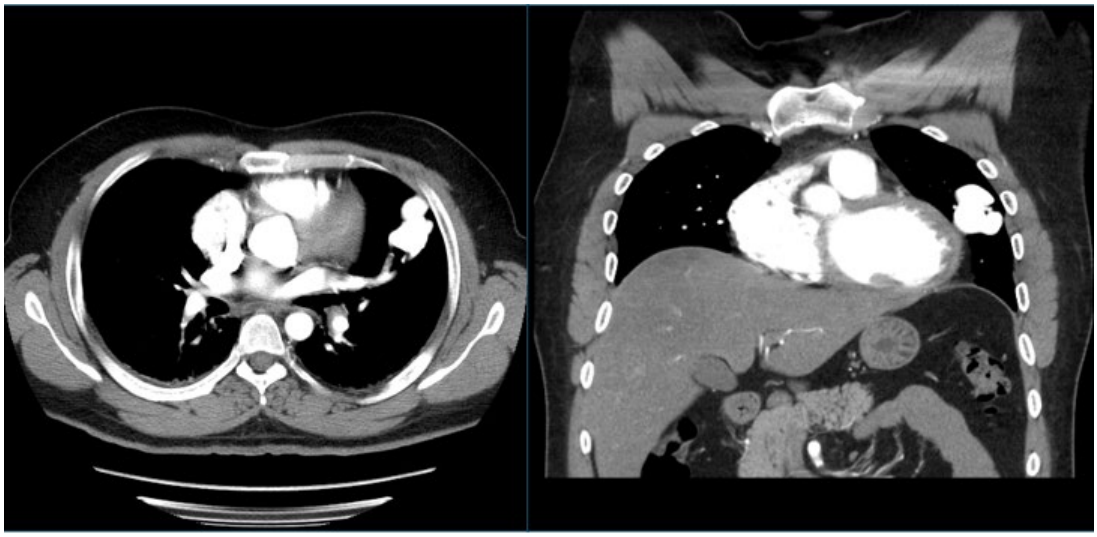
- Surgical resection is preferred if the PAVM is small and confined within a pulmonary segment.
- PAVM embolization is preferred in symptomatic patients where the PAVM is extensive, affecting different pulmonary segments or lobes.

IR technique:

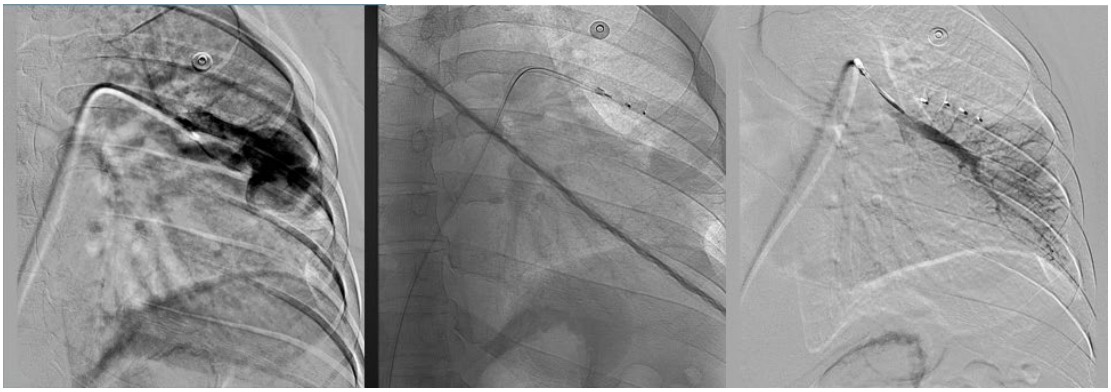
Venous access is gained followed by catheterization of the pulmonary arteries. Embolization of the distal part of the feeder(s) is done preferably with coils or vascular plugs. The use of liquid or particulate embolics is contraindicated due to the high risk of systemic embolization. Extreme caution should be taken during the procedure to avoid air bubbles or clot formation to minimize the risk of systemic embolization.

References:

1. Chand R, Eltorai A, Healey T, Ahn S, editors. Essential Interventional Radiology Review: A Question and Answer Guide. Cham: Springer; 2022.
2. Hsu CCT, Kwan GNC, Evans-Barns H, van Driel ML. Embolisation for pulmonary arteriovenous malformation. Cochrane Database of Systematic Reviews 2018, Issue 1. Art. No.: CD008017. DOI: 10.1002/14651858.CD008017.pub5.



CT pulmonary angiography showing left lingular lobe AVM



A) Selective pulmonary angioagrpahy shows filling of the lingular AVM. B) Post embolization with Amplatzer plugs. C) Final Angiography shows complete isolation of the AVM, Case Courtesy Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

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Management of Pulmonary AVM

Gastrointestinal Diseases and Interventions

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Gastrointestinal (GI) Bleeding

Overview:

Any form of bleeding throughout the gastrointestinal tract. Clinical presentation can vary according to origin and severity. It can be either hidden (occult) or clear (overt).

Most common clinical presentations**:**

- **Upper GI bleeding**: hematemesis (fresh blood vomiting), coffee ground emesis (dark gastric acid mixed with blood) and melena (black tarry stool).
- **Lower GI bleeding**: hematochezia (fresh blood in feces).
- **Non-specific GI bleeding symptoms** include hemodynamic instability, epigastric pain, fatigue, lethargy, syncope, and anemia.

Causes**:**

Upper GI bleeding

- **Medical conditions:** Peptic ulcer (most common), Helicobacter pylori infection, Esophageal Tears, Esophageal varices, Esophagitis, Malignancy and Trauma.
- **Medications:** Nonsteroidal anti-inflammatory drugs (NSAIDS) and anticoagulants.

Lower GI bleeding

- **Vascular:**
  - **Hemorrhoids** also known as piles, are vascular structures or distended blood vessels in the anal canal.
  - **Angiodysplasia:** Abnormal, tortuous, dilated small vessels in gastrointestinal tract`s mucosal and submucosal layers. It is the most common vascular abnormality of GIT.
  - **Ischemic**
  - **Traumatic:** Post Biopsy or polypectomy or accident.
- **Infections or Inflammatory bowel disease (IBD)** or other causes as diverticulitis.
- **Neoplastic**

Radiological diagnosis and findings:

to detect the cause and origin of bleeding:

- **Ultrasound examination**
- **CT Angiography**
- **Upper and lower GI endoscopy** (not only diagnostic but also therapeutic).
- **Nuclear scintigraphy:** is a sensitive test that detects occult gastrointestinal bleeding using radioactive substance when other modalities are inconclusive.
- **Trans arterial catheter angiography**

Lines of treatment and Indications of IR:

- **Supportive measures:** Fluid resuscitation and blood products support.
- **Nasogastric tube lavage:** In case of Upper GI bleeding.
- **Upper and lower GI endoscopy**: bleeding control can be done after direct visualization of the source using adrenaline injection, thermal or clip application. Varices can be controlled by injection of glue or sclerosing agents or by application of bands. Acute variceal bleeding can be temporarily tamponaded by Sengstaken-Blakemore balloon or placement of esophageal stents until patient is stabilized and definitive treatment is completed.
- **Peptic ulcer**: Proton pump inhibitors.
- **Variceal bleeding**: Octreotide, Vasopressin in addition to albumin support in case of liver cirrhosis
- **Open surgical laparotomy in cases of:**
    - Failure of all previous conservative measures and patient is candidate for surgery.
    - Failure of detection of bleeding origin with continued bleeding.
    - In advanced grades of visceral organs trauma.
- **IR:** Transcatheter arterial angiography and embolization, TIPS, BRTO

IR Options and Indications:

- Transcatheter arterial angiography and embolization procedure using femoral or radial artery. Catheters and microcatheters are then navigated to the bleeding artery to close them with embolizing materials such as coils, glue or gelfoam. It is recommended in all GI bleeding patients who fail conservative and endoscopic measures.
- Trans jugular intrahepatic portosystemic shunt (TIPS): in cases of variceal bleeding refractory to endoscopic procedures.
- Balloon-occluded Retrograde Transverse Obliteration (BRTO): Plays a role in controlling gastric variceal bleeding.

References:

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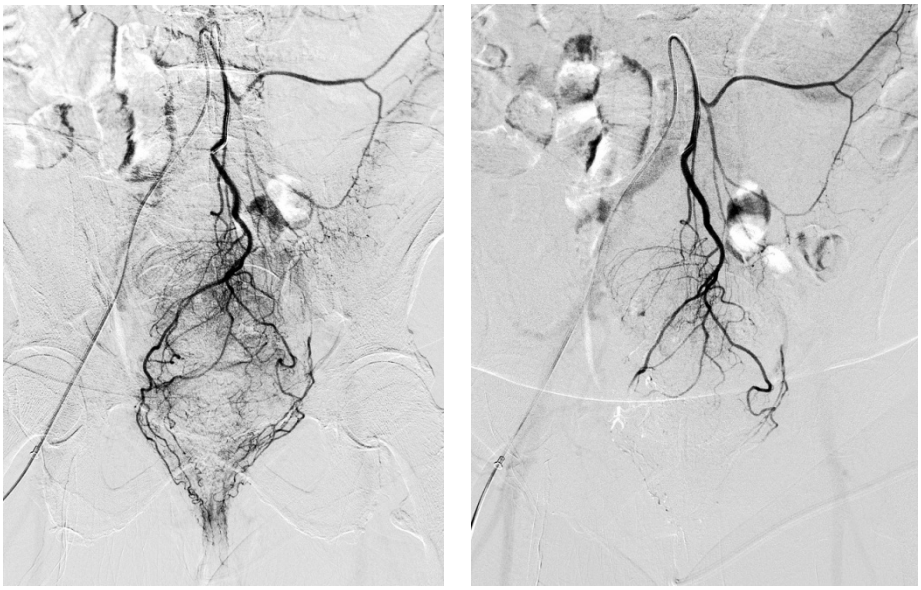
2. Rockey DC. Gastrointestinal bleeding. Gastroenterology Clinics. 2005 Dec 1;34(4):581-8.



Hemorrhoidal arterial embolization before (left) and after (Right) particles embolization. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo Egypt

Iatrogenic post Laparoscopic Cholecystectomy traumatic cystic artery bleeder embolization before (left) and after (Right) particles embolization. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo Egypt

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Splenic Artery Embolization

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Acute GI Bleeding and Embolization

Nutritional Enteral Feeding

Overview:

Malnutrition is a common problem affecting up to 40% of hospitalized patients, increasing their morbidity and mortality. Nutritional support can be given either **enterally** (through a tube placed into the stomach or small intestine) or **parenterally** (through a tube inserted into a vein whereby nutrients enter the bloodstream directly) due to some long-term special conditions.
Enteral feeding through **gastrostomy or gastrojejunostomy** can be recommended due to higher complications rate of parenteral route.

Types:

1. **Open** surgical Gastrostomy.
2. **Percutaneous** Gastrostomy: Fluoroscopic (X-RAY) guided, Computed Tomography (CT) guided, or Endoscopic.

Role of Interventional Radiology:

Fluoroscopic (X-ray) and CT guided Percutaneous Gastrostomy and gastro-jejunostomy.

Indications**:**

- Head, neck, and esophageal tumors.
- Swallowing problems of neurological origin.
- Nutritional support for chronically ill patients or after extensive surgeries.
- Severe GERD or recurrent aspiration of variable causes.
- Gastric outlet obstruction.

Procedure**:**

Direct puncture under fluoroscopic and US guidance from the skin through the gastric or jejunal wall and inserting the tube for direct nutrition delivery to the stomach and duodenum.

Contraindications**:**

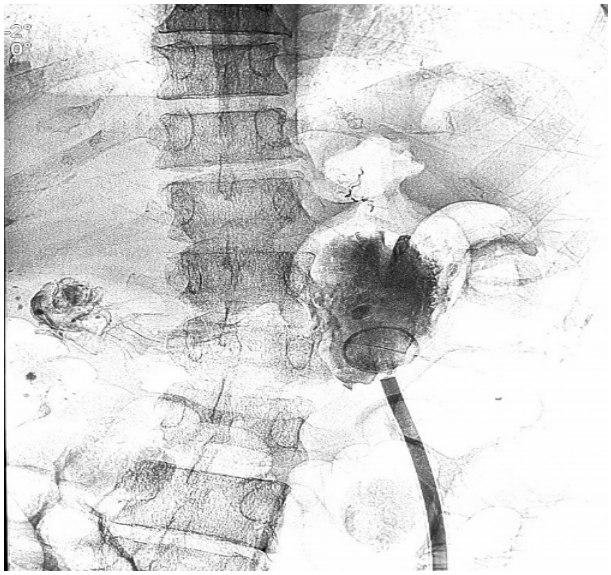
- Uncorrectable Coagulopathy.
- Acute gastritis or peptic ulcer.
- History of total gastrectomy.
- Severe ascites.
- Active peritonitis.

Clinical Follow-up protocol**:**

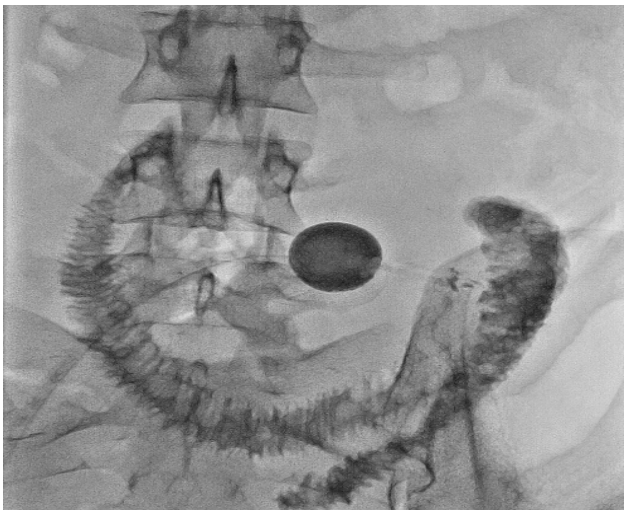
- Patient should fast for 24 hours post procedure with close monitoring for periprocedural complications (Abdominal pain, distention, and bleeding).
- Then, it could be normally used, and the patient is given the usage and care instructions.

References:

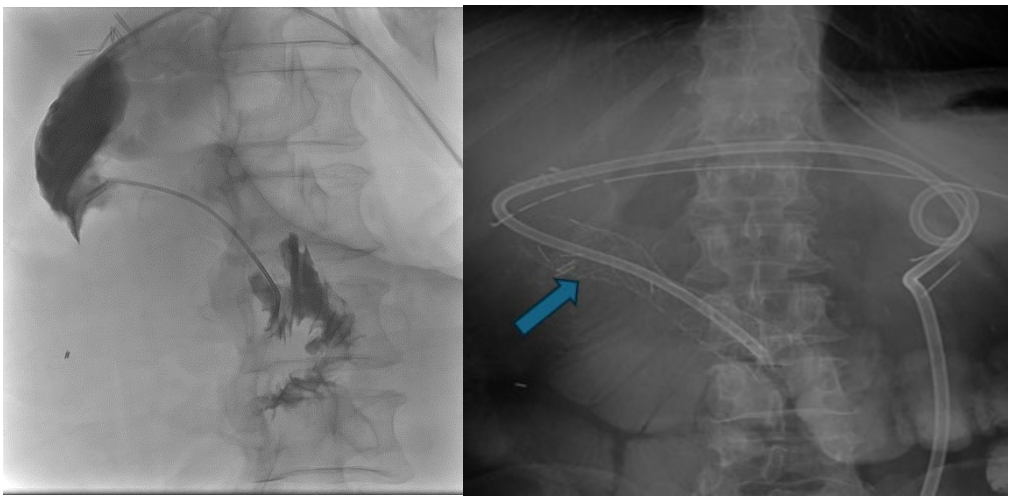
1. Valji K. The Practice of Interventional Radiology, with Online Cases and Video E-Book: Expert Consult Premium Edition-Enhanced Online Features. Elsevier Health Sciences; 2011 Nov 8.



Percutaneous Gastrostomy tube insertion (Pull Technique).
Case courtesy of Rana Khafagy, IR consultant, Ain Shams University Hospitals, Egypt



Percutaneous Jejunostomy tube insertion. Case courtesy of Karim Abdel Tawab, IR consultant, Ain Shams University Hospitals, Egypt.



Right image: Trans gastric access to cross the duodenal obstruction, left image: Post duodenal stent placement and insertion of GJ insertion. Case Courtesy Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

Esophageal strictures

Overview:

Benign or malignant esophageal narrowing which results in dysphagia.

Causes of benign strictures:

Peptic ulcer, pseudo-diverticulosis, caustic insult, esophagitis, Schatzki ring, heterotopic gastric mucosa, mucous membrane pemphigoid, spondylotic induced stenosis, diverticulum, post radiation, extrinsic compression, and post tracheostomy.

Diagnosis:

- **Clinical presentation:** heart burning sensation, bitter mouth taste, choking, cough, dyspnea, hematemesis, and loss of weight.
- **Imaging:** Barium study, CT, Endoscopy with biopsy if needed.

Lines of treatment and Indications of IR:

Medical therapy: treatment of the cause mainly:

- Antibiotics for infection.
- H2 blockers or PPI in GERD.
- Chemotherapy and radiotherapy for malignancy.

Surgical excision and anastomosis if tumor is resectable.

Role of Interventional Radiology:

Esophageal stricture dilation:

- Can be done endoscopically or fluoroscopically (X-ray) guided.
- Using specialized balloon catheters and wire, dilation of the stricture is done.
- For benign esophageal strictures: success rate reaches 90%. Repeated dilatation is often required.
- Malignant stricture and external compression causes often require stent placement to maintain luminal patency.

Esophageal stent indications:

- Palliative treatment of malignant esophageal dysphagia, fistulas, or perforations.
- Refractory Benign strictures in poor surgical candidates.

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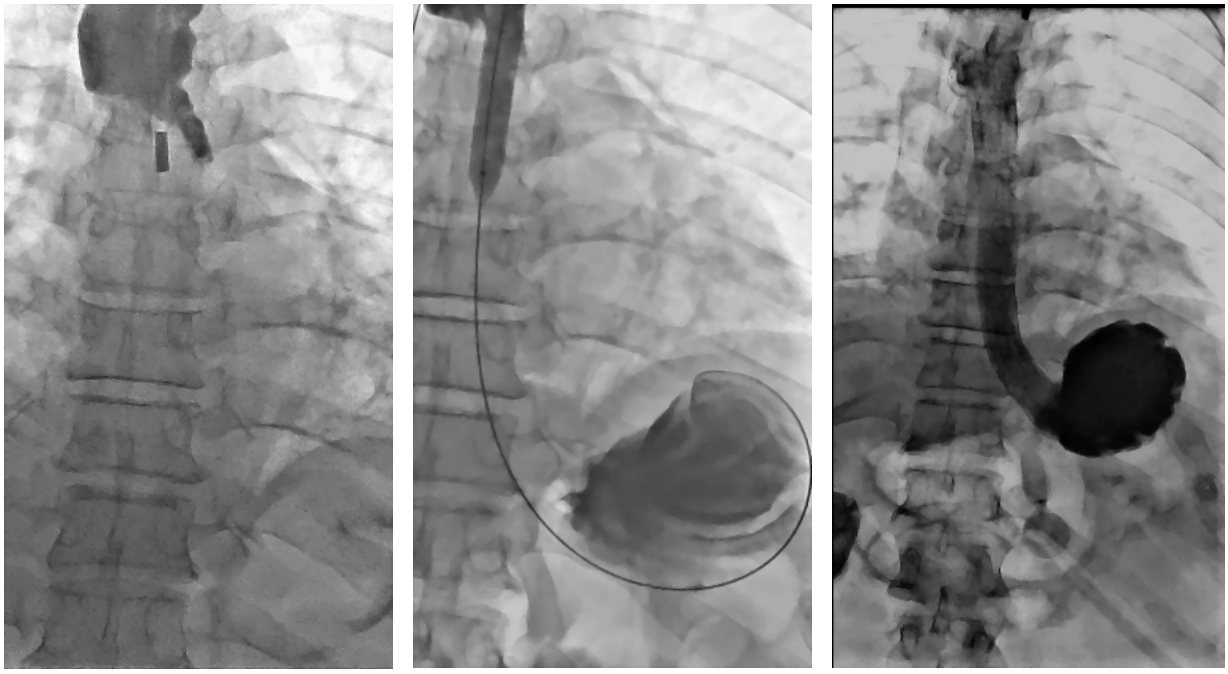

Esophageal cancer pre intervention causing severe stricture (left), balloon dilatation of the stricture (middle), post dilatation and stenting of the esophagus (right). Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo Egypt.

Scan me

Gastrostomy Insertion, IR Pull technique

Gastrointestinal Obstruction due to gastroduodenal or colorectal cancers

Overview:

Malignant obstruction can manifest depending on the tumor location.

Gastroesophageal junction obstruction due to gastric or distal esophageal cancer can present with dysphagia, recurrent vomiting and aspiration.

Duodenal obstruction due to duodenal or pancreatic cancer or extrinsic compression by lymph nodes or masses. Patients may present with gastric outlet obstruction, gastric distension, bilious vomiting and malnutrition.

Colorectal cancer same as gastric cancer with progressive constipation with stool caliber narrowing and rectal bleeding.

Diagnosis:

- Endoscopy with biopsy is the **gold standard.**
- Upper GI contrast media studies (Barium meal or enema).
- CT abdomen.

Lines of treatment and Indications of IR:

- **Medical therapy:** Chemotherapy, immunotherapy, and radiotherapy.
- **Surgical** excision and anastomosis if the tumor is resectable.
- **IR Stent placement** as palliative management.
-

IR option:

Gastrointestinal or colonic stent:
Palliative treatment to provide relief for cases of inoperable cancers with inability to tolerate food, vomiting and cachexia. Endoscopic and/or percutaneous treatment is preferable to surgery due to lower morbidity and mortality, shorter hospitalization, rapid symptom relief and low to none anaesthesia risk.

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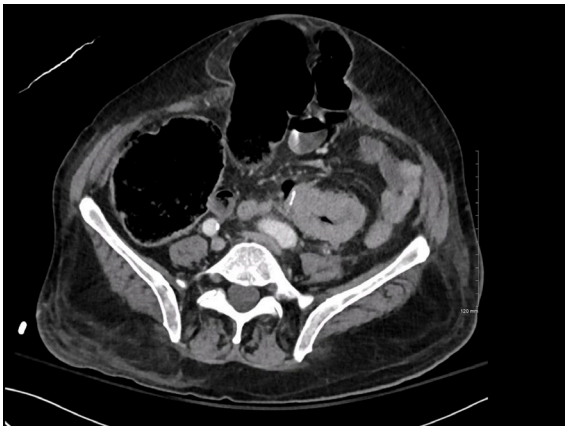
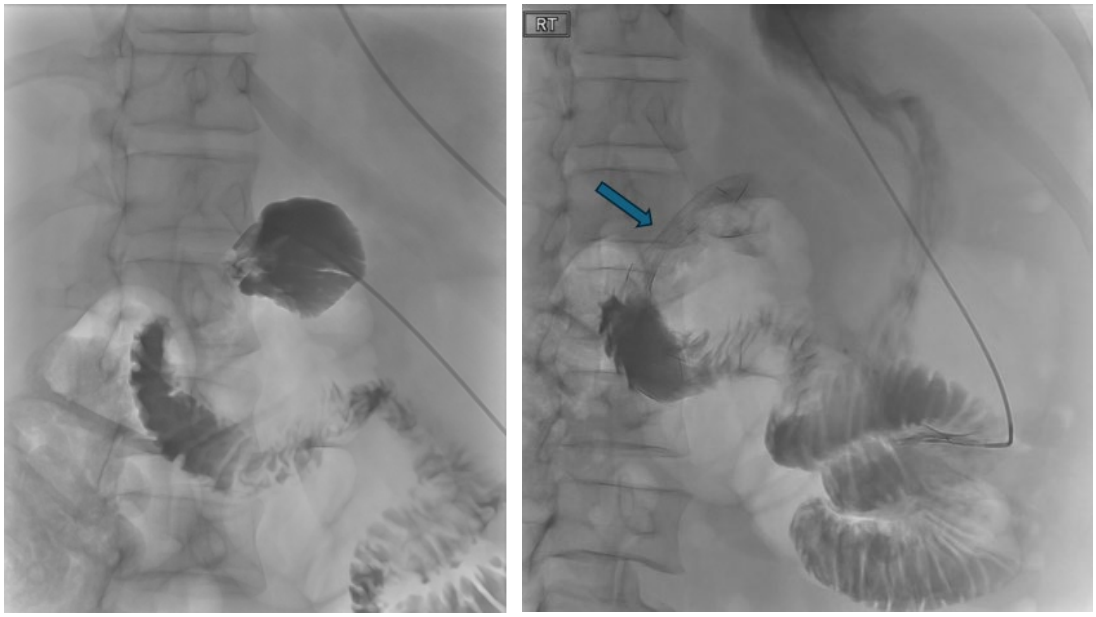


Recurrent sigmoid cancer resulting in large bowel obstruction

Colonic stent placement to alleviate obstruction, Case Courtesy Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia



A case of metastatic gastric outlet obstruction. Left image: duodenal obstruction. Right image: duodenal stent placement (arrow) to alleviate obstruction, Case Courtesy Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

Intra-abdominal Abscess or Ascites

Overview:

Intra-abdominal abscess: a capsulated cavity of pus, or a localized collection of pus surrounded by inflamed tissues in the abdominal cavity of the human body. It can occur post-surgery or trauma or in cases of immunocompromised patients. Patients usually present with abdominal pain, fever, tachycardia, ileus, abnormal weight loss, and loss of appetite.

Ascites: abnormal fluid collection (>25 ml of fluid in the peritoneal cavity). It can be mild, moderate, or marked in amount. It occurs in cases of liver cirrhosis, heart failure or due to visceral inflammation and malignancy. Thus, diagnosis of the cause depends on clinical history, fluid analysis and cytology. Patients present with increased abdominal girth, abdominal distension, progressive abdominal heaviness and pressure, and dyspnea.

Diagnosis:

- **Laboratory tests:**

Abdominal abscess: CBC (↑TLC), ↑ ESR and CRP (Increased inflammatory markers).

- **Imaging:** Ultrasound, CT, and MRI may distinguish abdominal collections from free ascitic fluid

Management measures of abscess:

- Mainly **percutaneous drainage and antibiotics** coverage.
- **Take samples** for culture, sensitivity, and fluid analysis.
- **Surgical laparotomy** and direct drainage if failed conservative and minimally invasive measures. Surgical incision and drainage are reserved for deep inaccessible collections.

Role of Interventional Radiology:

- **Intra-abdominal abscess or ascites:**
  - **U/S or CT guided drainage catheter**
  - **U/S or CT guided fluid sampling:** For culture, sensitivity, and fluid analysis.
- **Refractory Ascites:**
  - **Trans jugular intrahepatic portosystemic shunt (TIPS):** its efficacy is proved in cases of portal hypertension and liver cirrhosis.

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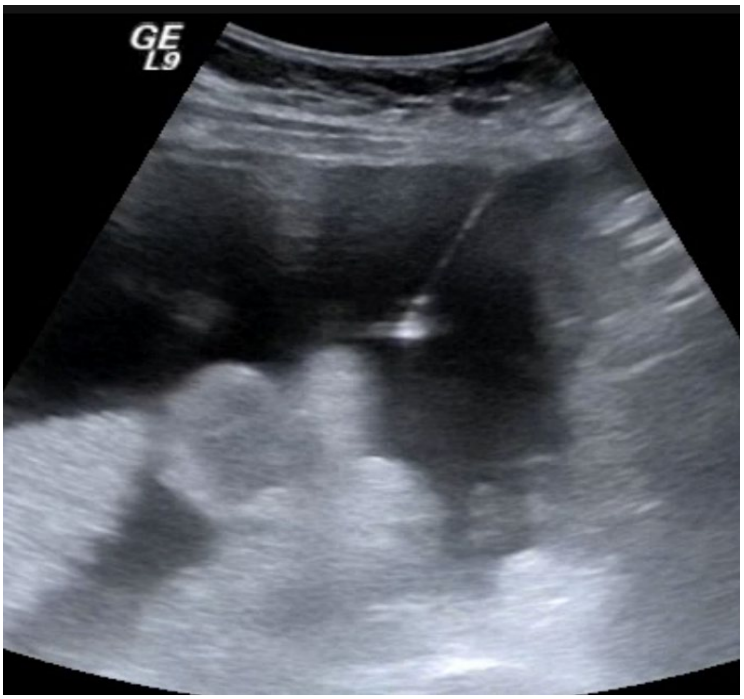

US guided Ascites tapping with needle seen within the ascites. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo Egypt.

Hepato-Pancreatico-Biliairy Diseases and Interventions

Back To TOC

Obstructive Jaundice:

Overview:

Jaundice refers to the clinical status of hyperbilirubinemia, which has a lot of causes. It is often the clue of the diagnosis. It can be widely divided into two types. Non-obstructive and obstructive.

Obstructive jaundice can be due to intrahepatic or extrahepatic obstruction and a wide variety of benign and malignant causes are identified. Common presentations include jaundice, fatigue, pruritus, pale/colored stools and xanthoma. If the obstruction is unrelieved, it may lead to secondary biliary cirrhosis.

Diagnosis and radiological findings:

Labs show elevated bilirubin level and/or elevated tumor markers in malignant conditions. Liver enzymes, specifically alkaline phosphatase, may be elevated.

Transabdominal ultrasound is the initial modality of choice to assess the biliary tree.

The etiology of obstruction and its level may be detected with MR or CT examination. MRCP or CT cholangiography has replaced diagnostic percutaneous transhepatic cholangiography (PTC) or Endoscopic retrograde cholangiopancreatography (ERCP) in most patients as a diagnostic examination.

Biliary drainage options and indications:

- Endoscopic retrograde cholangiography (**ERC**) and endoscopic retrograde cholangiopancreatography (**ERCP**) with stent placement.
- Percutaneous transhepatic biliary drainage (**PTBD**).
- Surgical biliary bypass

Generally, if a patient can undergo retrograde cannulation of biliary system, **ERCP** is the method of choice to drain the biliary system.

However, if ERCP is unsuccessful or not feasible as in cases of papillary distortion from tumor or any anatomical variations, **PTBD** should be considered as a minimally invasive alternative procedure.

Surgical biliary bypass is reserved for situations in which ERCP or PTBD cannot be performed, or if the patient requires biliary drainage or diversion which will require a bypass for long-term durability.

IR treatment options:

PTBD is placement of drainage catheter into biliary system tracts:

- External drainage: percutaneous biliary drain with catheter tip placed in the biliary system.
- Internal/external drainage: percutaneous biliary drain with catheter tip in bowel.

PTBD technique:

The procedure is performed under general anaesthesia or moderate sedation. The patient should be NPO for 6 hours prior to the procedure. Although it is possible to perform the procedure under fluoroscopy guidance, most interventional radiologists use real time ultrasound for needle puncture and entry site selection. After that the needle is guided by real time ultrasound and inserted into a biliary radicle. When the needle is successfully confirmed in the biliary system, a guide wire is advanced, and the needle is removed. After that, the catheter is advanced into an appropriate position within the biliary system or the bowel and is secured by placing anchoring sutures at the catheter site and a sterile dressing is placed over the site closely.

PTBD followed by angioplasty and or stenting can be done for benign or malignant biliary strictures.

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PTD Internal External catheter is inserted through right approach into the CBD for a case of communicating obstructive jaundice due to pancreatic head tumor. Case courtesy of Rana Khafagy, MD, Karim Abdel Tawab, MD, Ain Shams University Hospitals, Egypt.

Liver tumors:

Overview:

Liver tumors are classified into primary and secondary tumors. Primary tumors are further divided into benign or malignant. The most common primary hepatic tumor is hepatocellular carcinoma (HCC). Secondary tumors or liver metastases are more common than primary tumors and the most common source is colorectal cancer (CRC).

Diagnosis and radiological findings:

- HCC: Once a liver lesion is detected on screening US, diagnosis is confirmed by multiphase computed tomography CT or dynamic magnetic resonance (MR). HCC typically shows arterial hyperenhancement and rapid contrast washout.
- Patients with liver metastases must obtain abdominal ultrasound and CT or MR. Chest CT and positron emission tomography PET may be required for staging and for detection of the source of the metastases.

Biopsy:

- Patients with typical imaging features of HCC don't need biopsy, while atypical liver HCC or metastases need to undergo an imaging guided biopsy.
- Biopsy guided by US is adequate in most cases. CT may be required in obese patients.

  Procedure:
  - Under local anaesthesia and using ultrasound or CT guidance, the biopsy needle is advanced through the liver into the target lesions then a core biopsy is obtained.

Lines of treatment:

- **Surgery** plays a vital role in the management of primary and metastatic hepatic tumors. **Surgical resection** such as a wedge resection or segmentectomy can be performed in patients without evidence of vascular invasion and in those patients able to maintain adequate liver reserve post-resection. **Liver transplantation** is the only curative treatment for HCC with candidacy based on the Milan criteria.
- IR procedures
  - Tumor ablation
  - TACE
  - TARE

IR treatment options:

Locoregional liver-directed therapies include trans arterial chemoembolization (TACE), radio embolization (TARE), and percutaneous thermal or alcohol ablation.

Tumor ablation:

Ablative therapy can be done for primary and metastatic lesions as a standalone treatment but may also be combined with transarterial or systemic treatment.

Thermal ablations including radiofrequency ablation (RFA), microwave ablation (MWA), and cryoablation are utilized more than alcohol ablation.

Radiofrequency ablation (RFA):

- Consists of a generator creating rapid and high frequency electrical currents emitted through a needle which is inserted into targeted lesion or tissue. The alternating electrical currents agitate ions, resulting in friction and subsequent heating of the tissue.
- RFA is basically used in patients with small or early HCC tumors and for metastatic lesions, with up to 3 lesions each measuring less than 3 cm.

Microwave ablations (MWA): Similar to RFA in terms of procedural technique (see below). However, MWAs mechanism differs significantly from RFA. MWA propagates microwaves energy from an antenna into the surrounding tissue releasing heat and resulting in tissue destruction. MWA can be used with multiple probes simultaneously, treating multiple target areas or large areas concurrently resulting in shorter procedure times.

- In both RFA & MWA, the patient will be in supine or left lateral decubitus position. The procedure is done under general anaesthesia or conscious sedation as the positioning and ablation may cause pain or discomfort.
- US or CT is used for needle positioning and RFA pads should be put on patient's thighs.
- Imaging, as US, CT, or CBCT, is typically performed at the time of procedure alone or in combination for ablation guidance; for HCC, contrast enhanced arterial phase images may be needed to visualize the tumor.

Tumors embolization:

- Trans arterial embolization is a minimally invasive procedure where embolic agents, with or without chemotherapy or radioactive material, are injected into the feeding artery of the liver tumor in cases not fit for ablative therapy or surgical resection.

- Trans arterial chemoembolization (TACE) is generally administrated in two ways:
  - Conventional TACE in which chemotherapy is mixed with oil-based contrast agent and injected into the feeding vessel followed by permanent or temporary embolizing agents.
  - Drug Eluting beads DEB-TACE where the chemotherapy (typically doxorubicin) is loaded on the microspheres, then injected into the feeding vessel. These beads embolize the lesion and release the drug slowly over 2 weeks minimizing the systemic side effects associated with conventional TACE.
- TARE: See below

TACE technique:

At most oncology centers, the patient's imaging will be reviewed in a multidisciplinary tumor board with collaborative efforts between many specialists from IR, oncology, hepatobiliary surgery to set the best treatment plan for the patient.

Femoral artery approach is usually obtained (radial artery access can be used) under fluoroscopy guidance, a sheath is inserted through which a guide wire and curved catheter are advanced through to catheterize the celiac artery. Celiac and hepatic angiography is performed to delineate the arterial anatomy. A coaxial microcatheter and wire are then advanced through the catheter into the desired arteries supplying the tumor. Then the embolic drugs are slowly injected under fluoroscopic guidance until near stasis is seen. Some IRs may inject permanent or temporary embolic agents after injecting the chemotherapy.

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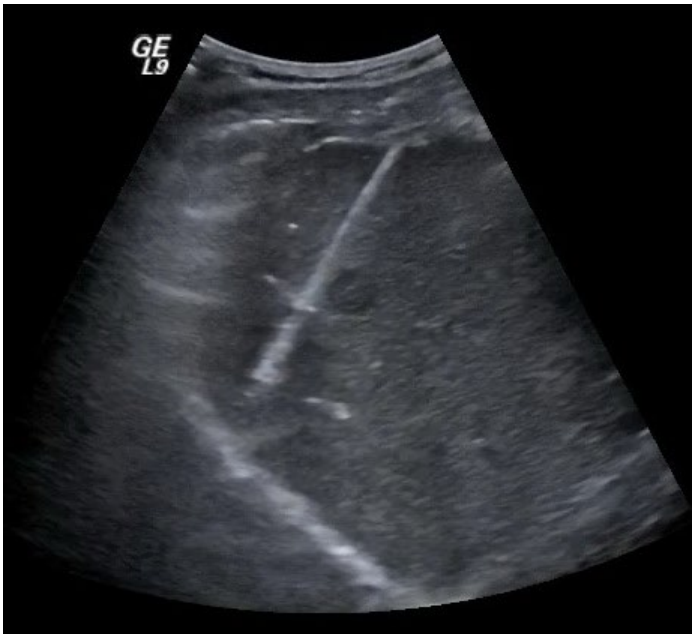

Percutaneous biopsy from right hepatic lobe focal lesion.
Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo Egypt

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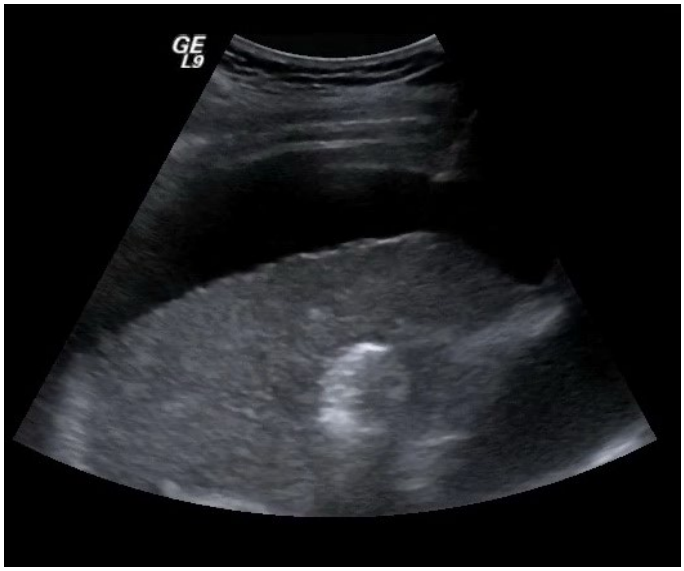
HCC Management, General Overview



During RF ablation of hepatic lobe focal lesion.
Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo Egypt

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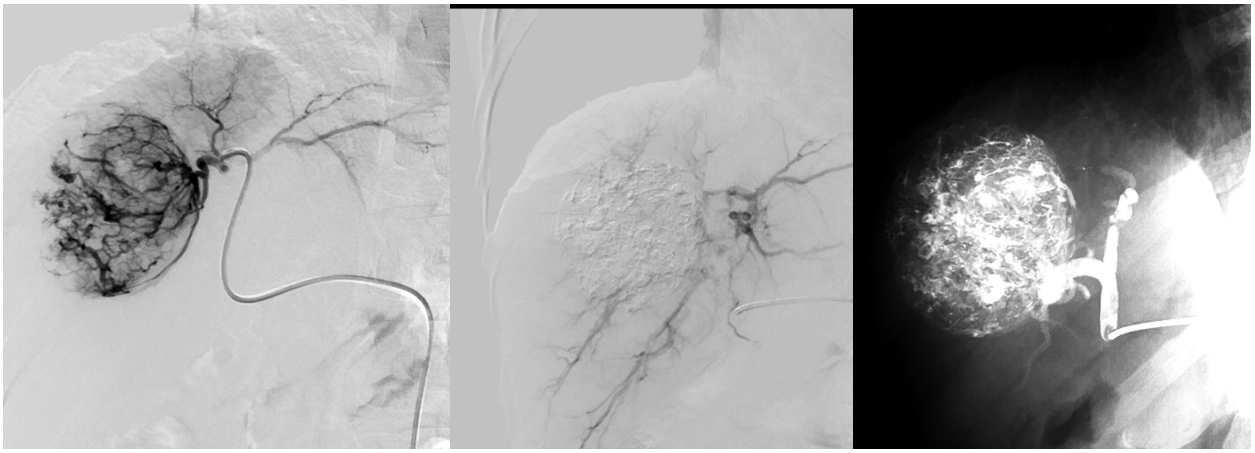
HCC Ablation Procedures



A case of HCC: Catheterization of the hepatic a. supplying the tumor with tumoral blush (left),post chemo-embolization with disappearance of the tumoral blush (middle), Lipiodolconcentrated within the tumor in non subtracted image (right). Case Courtesy of Rana Khafagy, MD, Karim Abd El Tawab, MD,
Ain Shams University Hospitals, Egypt.

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Trans Arterial Chemo Embolization (TACE)

Trans arterial radioembolization (TARE)

Overview:

Trans arterial radioembolization (TARE) refers to the delivery of radioactive microspheres directly into an artery that perfuses a tumor or tumor-bearing tissue. In current clinical practice, radioembolization is employed almost exclusively for liver tumors. The radioactive microspheres become lodged within and around the tumor and cause tumor cell death through the effects of radiation.

TARE eligibility criteria:

Eligibility for TARE requires assessment of the patient's disease burden, biochemical parameters of liver function, and performance status. Patients should have liver-only or liver-dominant primary or metastatic disease with a tumor burden involving less than 50% of the liver. A bilirubin level ≤ 2 mg/dL, albumin >3 g/dL, and normal international normalized ratio (INR) have been used as indicators of adequate hepatic reserve and synthetic function.

Portal vein thrombus (PVT) includes portal vein tumor thrombus (PVTT) due to direct tumor invasion into the portal vein and bland thrombus, which can occur in patients with cirrhosis. Because hepatic arterial embolization procedures typically occlude the arterial supply to a portion of liver, the presence of PVT has been considered a relative contraindication to hepatic arterial embolization procedures due to the higher risk of liver infarction or decompensation resulting from the loss of both arterial and portal venous inflow. Patients who have had an intervention or surgery involving the ampulla of Vater, as patients with biliary stents, sphincterotomies, or direct biliary-enteric anastomoses, have an increased risk of hepatic abscesses following TARE. These patients require special consideration including unique antibiotic protocols to reduce this risk.

Indications for TARE:

- Unresectable hepatocellular carcinoma (HCC): Only 10-15% of HCC patients are candidates for potentially curative therapy such as liver transplant, resection, or ablation.
- Unresectable hepatic metastatic disease: Colorectal cancer (CRC):
    - 60% CRC patients present with liver-dominant metastatic disease.
    - Primary treatment of CRC metastases is resection if possible (plus neo- or adjuvant chemotherapy ± biologic agent).
    - If unresectable, standard of care is systemic chemotherapy ± biologic agent.

- TARE can be used in combination with systemic chemotherapy or alone if systemic chemotherapy fails.

- Other secondary neoplasms treated: carcinoid, breast, sarcomas,ocular melanoma, etc.
- Cholangiocarcinoma.
- Transplant eligible HCC.

TARE technique:

- All patients receiving TARE first undergo a mapping angiogram and calculation of the lung shunt fraction (LSF). Based on the information acquired from the mapping angiogram and LSF, a treatment plan is established.
- A mapping angiogram is important, as it allows determination of an individual's hepatic arterial anatomy and tumor perfusion and identification of extra-hepatic collaterals or variants that could lead to sub optimal treatment.
- Macro-aggregated albumin (99mTc-MAA) is infused into a hepatic artery to mimic the distribution and shunting of the 90Y microspheres.
- Immediately after the mapping angiogram, the patient is taken to the nuclear medicine department in which additional imaging is performed to calculate the percent of pulmonary 99mTc-MAA, and to check for extrahepatic uptake such as in the stomach or small bowel.
- Radioembolization may be planned for infusion in a hepatic artery perfusing an entire hepatic lobe (lobar infusion), to a particular Couinaud segment (segmental infusion), or to a portion of a hepatic segment (sub-segmental infusion).
- Patients return for the treatment angiogram approximately 1–2 weeks after the mapping angiogram, once the prescribed doses of ^{90}Y have been received from the manufacturer:
  - Catheters, microcatheters, and wires are advanced to the intended location for microsphere infusion determined at the mapping angiogram.
  - The radioactive microspheres are injected via the microcatheter.
  - Following dose administration, the catheters used, as well as the components of the administration kit, are carefully collected for radiation survey and proper disposal or storage according to radiation safety protocols.
- Patients undergo post therapy scan using PET-CT or SPECT-CT to determine proper deposition of infused radioactive microspheres in the desired hepatic distribution and possibly assess post infusion dosimetry of target perfused tissue dose.

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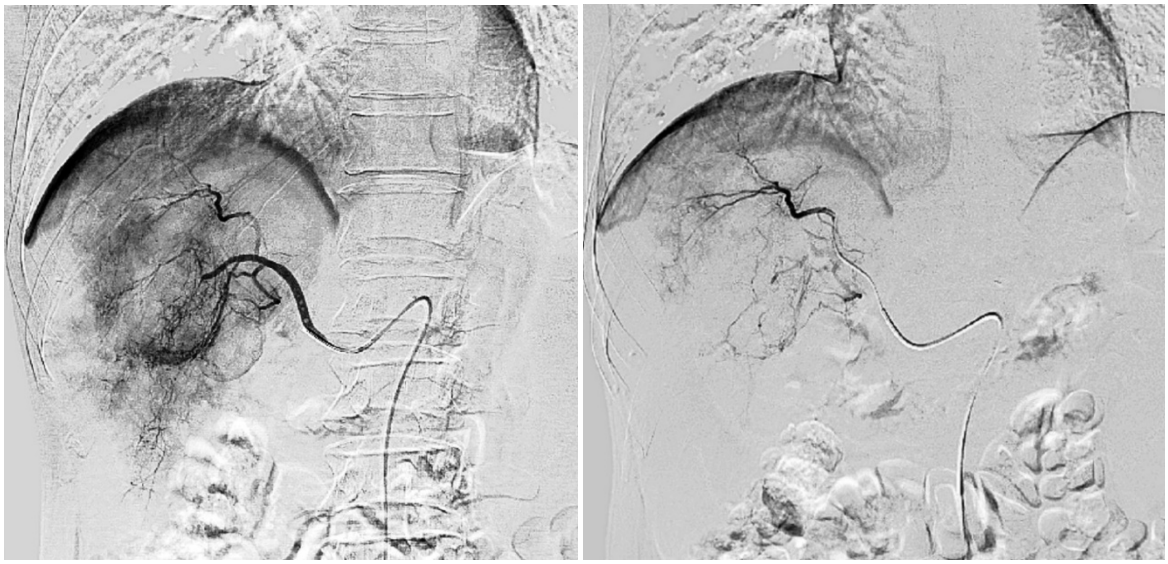

A case of HCC: pre (left) and post (right) TARE. Case courtesy of Karim Abdel Tawab, IR consultant, Ain Shams University Hospitals, Egypt

Portal Vein Embolization:

Overview:

A technique used before hepatic resection to increase the size of liver segments that will remain after surgery by redirecting portal blood to segments of the future liver remnant (FLR) resulting in hypertrophy. Portal Vein Embolization (PVE) is indicated when the FLR is either too small or marginal in size to support essential liver function.

Clinical indications for PVE:

Patients who are candidates for surgical management of primary or metastatic hepatic tumors yet would not have sufficient remaining liver after resection.

- Colorectal cancer is the most common primary malignancy that commonly includes hepatic resection in its management.
- Management of HCC following TACE in order to decrease tumor burden while awaiting surgical resection
- Complex hepatectomy as part of pancreatectomy
- Prior to resection of sclerosing cholangitis

Pre procedure imaging:

Preoperative measurement of FLR is important in ensuring adequate postoperative functional liver. 3D CT volumetry has become standard for measuring liver volume.

Technique:

- Percutaneous access may be obtained from:
  - Contralateral approach: access on the side that is opposite of embolization target, usually left side, anterior subxyphoid area.
  - Ipsilateral approach: access on side of embolization target, usually right side, right mid-axillary line. It may be difficult to catheterize the right portal vein due to its anatomical angulation.
  - Trans-splenic approach: Access of portal system through spleen instead of liver.
- Introduce selective catheters via sheath and perform selective portograms
  - Reverse-curve catheter (ipsilateral approach)
  - Forward-facing catheter (contralateral access)
- Deliver embolic agent, typically glue, until stasis is achieved
- Consider prophylactic tract embolization

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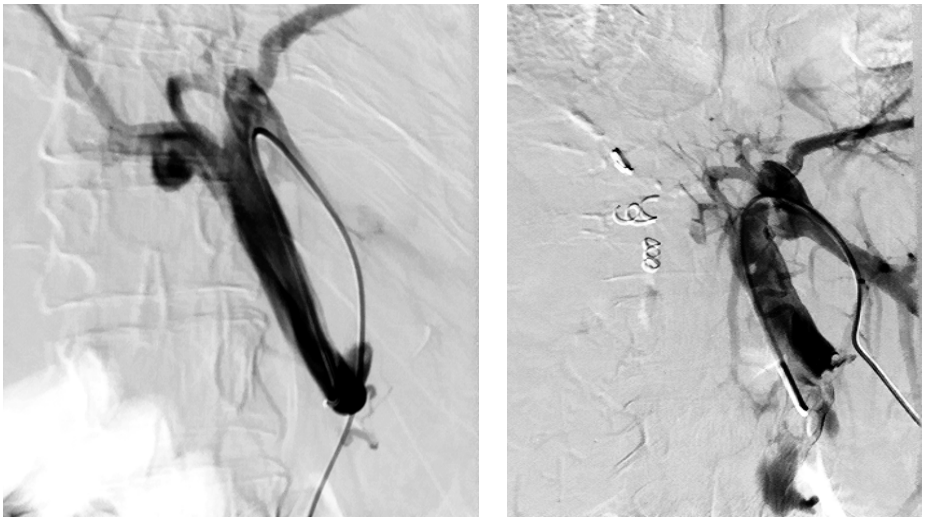

Right portal vein embolization pre (Left) and post (Right) coils and glue embolization
Case Courtesy Karim Abd El Tawab, MD. Ain Shams University Hospitals, Cairo, Egypt

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Portal Vein Embolization

Cirrhosis

Overview:

Cirrhosis is the end stage of hepatic fibrosis which is characterized by the formation of regenerative nodules and distortion of the hepatic architecture. Patients with cirrhosis are prone to a variety of complications, and their life expectancy is greatly reduced. Clinical manifestations of cirrhosis include nonspecific symptoms such as (e.g., anorexia, weight loss, weakness, fatigue) or signs and symptoms of hepatic failure (jaundice, pruritus, signs of upper gastrointestinal bleeding, abdominal distension from ascites and portosystemic encephalopathy). Physical examination findings can include jaundice, spider angiomas, gynecomastia, ascites, splenomegaly, asterixis, digital clubbing, and palmar erythema.

Diagnosis and radiological findings:

- Ultrasound may show heterogenous hepatic echotexture with nodular contour and shrunken liver in advanced disease.
- Diagnosis can be confirmed, if needed, with liver biopsy.

IR management options, indications, and techniques:

Liver biopsy indications (commonly percutaneous US guided):

- Diagnostic evaluation of:
  - Focal or diffuse abnormalities on imaging studies
  - Parenchymal liver disease
  - Chronically (i.e., greater than six months) abnormal liver tests of unknown etiology after a thorough, noninvasive evaluation
  - Fever of unknown origin
- Staging of known parenchymal liver disease
- Development of treatment plans based on histologic analysis

Trans jugular liver biopsy is indicated for:

- Patients with diffuse liver disease.
- Patients with coagulation disorder, ascites or morbid obesity.
- Patients with hemodynamic instability

References:

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Portal hypertension

Overview:

Portal hypertension is the pathologic increase of the portal venous system pressure with portosystemic gradient (PSG > 5 mmHg). Clinically significant portal hypertension (CSPH) is defined when the PSG exceeds 10 mmHg. The most common etiology of portal hypertension is liver cirrhosis. It is usually asymptomatic until the patient develops complications. The clinical presentation of portal hypertension includes splenomegaly, ascites, and variceal hemorrhage.

Diagnosis and radiological findings

- The imaging modality of choice for the diagnosis of portal hypertension is ultrasound which shows signs of cirrhosis, dilated or even thrombosed portal vein. Other signs include splenomegaly and ascites.

Treatment Options:

- Medications to decrease the portal hypertension including beta blockers
- Endoscopic therapy for the management of portal hypertension complications such as variceal bleeding from esophageal or gastric varices.
- Shunting procedures as Trans jugular intrahepatic portosystemic shunts (TIPS)
- Liver transplantation

IR management option:

Trans jugular intrahepatic portosystemic shunt (TIPS):

A method of decreasing portal vein pressure and treating its complications by making a decompressive channel/stent between the portal and hepatic veins to re-route the blood from the high-pressure portal circulation to the low-pressure systemic circulation.

The procedure is done through an internal jugular vein access under general anaesthesia.

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Trans Jugular Intrahepatic Portosystemic Shunt (TIPS)

Variceal bleeding

Overview:

A medical emergency and one of the major causes of death in cirrhotic patients. Patients with bleeding gastric varices may present with vomiting of blood (hematemesis), dark stool (melena). In case of brisk bleeding, the patient can quickly develop hemorrhagic shock.

Diagnosis and radiological findings:

- Diagnosis is often made with upper endoscopy.
- CT with intravenous contrast enhancement can confirm the presence of gastric varices which appear as well-defined clusters of rounded enhancing vessels.

IR management options, indications, and technique:

Trans jugular intrahepatic portosystemic shunt (TIPS): (discussed in portal hypertension above)

Balloon-occluded retrograde transvenous obliteration (BRTO):

Indications:

- Acute gastric variceal hemorrhage
- Secondary prevention of recurrent gastric variceal hemorrhage
- Bleeding ectopic varices (e.g., duodenal)
- Refractory hepatic encephalopathy
- Primary prophylaxis in cases of high-risk gastric varices

Technique:

- Balloon-occluded retrograde transvenous obliteration is a minimally invasive procedure used to treat gastric varices using sclerosants and/or embolic solutions.
- Access is usually through the internal jugular or femoral veins. Afterwards, the appropriate sheath is placed followed by catheterization of gastrorenal shunt through the left renal vein with a balloon catheter and subsequent balloon occlusion.
- A microcatheter is advanced through the lumen of the balloon into the varix as far as possible to prevent reflux to the splenic vein. The sclerosant agent of choice is then injected.
- PARTO (Plug-assisted) and CARTO (Coil-assisted) are variants of the procedure.
- When compared to endoscopic management, BRTO showed a higher bleed-free rate at 1 and 2 years with fewer hospitalizations, inpatient

stays, and lower medical costs. However, there is no difference in survival rates, frequency of complications, or worsening of esophageal varices.

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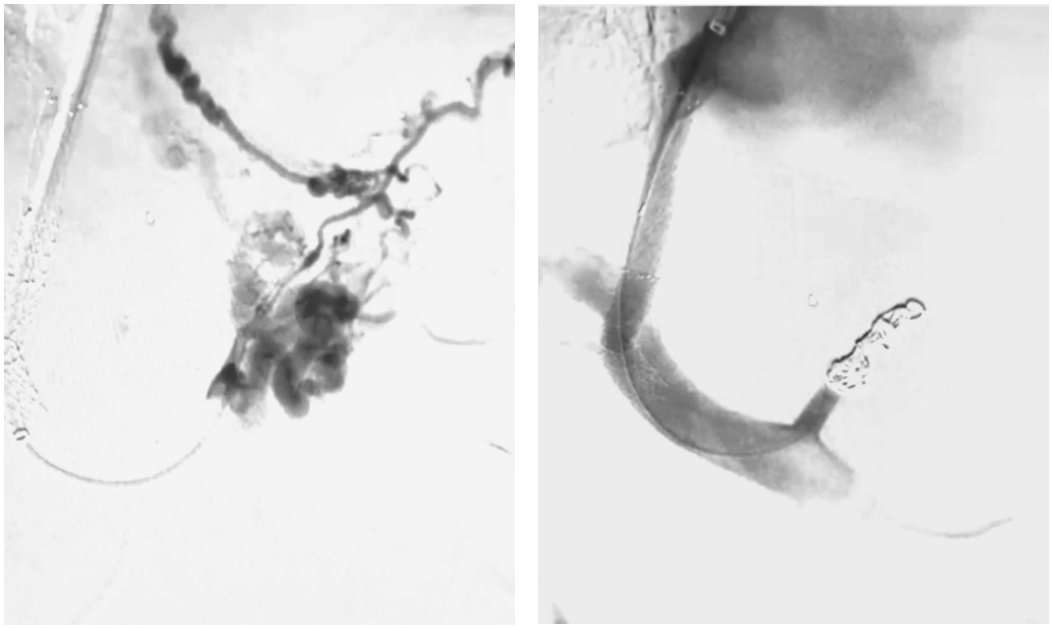

Significant filling of gastroesophageal varices (Left) Post TIPS and variceal embolization (Right). Case Courtesy Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

Plug Assisted retrograde occlusion of Gastric Varix. Case Courtesy Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

Budd-Chiari syndrome

Overview:

Primary Budd-Chiari syndrome is hepatic venous outflow obstruction due to thrombosis or phlebitis. While secondary Budd-Chiari occurs due to invasion or compression of the hepatic veins by a lesion that originates from outside of the vein such as malignancy.

Diagnosis and radiological findings:

- Diagnosis is established with doppler ultrasonography.
- Ultrasound findings include thrombosed echogenic hepatic veins, intrahepatic collaterals, hepatomegaly with heterogenous liver parenchyma and enlargement of the caudate lobe, ascites.
- CT or MRI can be used to confirm the diagnosis.

Treatment options:

- Anticoagulation therapy
- Angioplasty
- Trans jugular intrahepatic portosystemic shunt (TIPS) or Direct intrahepatic portosystemic shunt (DIPS)
- Liver transplantation

IR management options, and technique:

- **Angioplasty**
  Recanalization of venous stenosis by angioplasty, with or without hepatic vein stenting is considered the first line therapy for relieving obstruction and establishing hepatic blood flow.

- **TIPS**
  TIPS can be used in the treatment of BCS, especially for patients who are not eligible for liver transplantation. DIPS is an alternative interventional procedure for decompression of portal hypertension, which usually involves direct puncture to connect the IVC to the portal vein.
  TIPS or DIPS are used as a bridge for liver transplantation.

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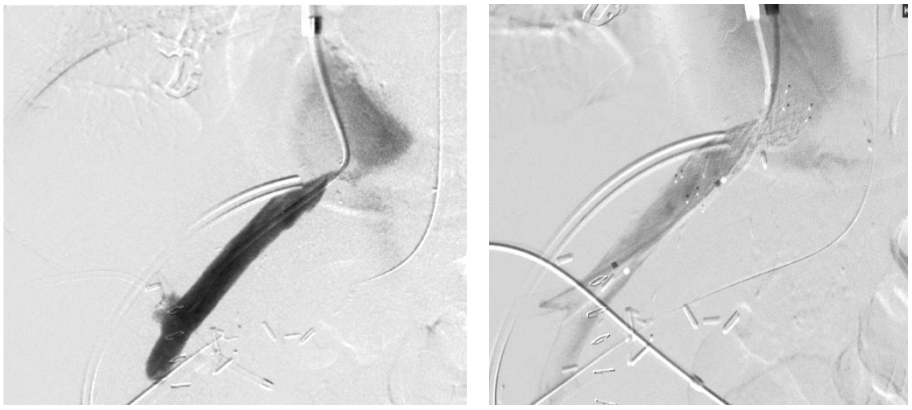

Hepatic vein stenosis pre (Left) and post (Right) stenting. Case Courtesy Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

TIPS in a case of Budd Chiari Syndrome. Case Courtesy Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

Liver transplantation:

Overview:

Interventional radiology plays an integral role in the management of post liver transplantation vascular and non-vascular complications.

Liver transplantation complications:

- **Hepatic artery complications:** most common post transplantation vascular complication (5-25%)
  - Thrombosis
  - Stenosis
  - Pseudoaneurysm
  - Splenic steal syndrome
- **Inferior vena cava IVC and hepatic veins complications**
  - Anastomotic strictures or kinking
- **Portal vein complications**
  - Stenosis and thrombosis
- **Biliary complications**
  - Strictures and bile leak

Imaging and IR treatment options for post transplantation complications:

- **Hepatic artery complications**: Color doppler ultrasound, CTA, or MRA are obtained to confirm the diagnosis.
  Understanding the surgical anatomy of the hepatic artery anastomosis is essential to plan the management. Access can be obtained from femoral or brachial access. Percutaneous transluminal angioplasty and possible stent placement can be done for hepatic artery stenosis. Acute post-operative hepatic artery thrombosis represents an emergency and requires either surgical revision or catheter directed thrombolysis to restore graft perfusion. Hepatic artery thrombosis may result in biliary necrosis, strictures and graft failure.

- **IVC and hepatic veins complications**:
  Post transplant hepatic veins or IVC stenosis may present with liver congestion, deranged liver enzymes, ascites or lower extremity swelling. US or CT venography serve as the main diagnostic imaging modalities. IR options include angioplasty with or without stenting.
  The right internal jugular vein is accessed (some operators prefer the femoral vein access). IVC pressure measurements should be obtained to evaluate infra- & supra- hepatic vein gradient. If IVC or hepatic veins

stenosis is identified, treatment with balloon angioplasty is performed. If residual stenosis is present, stent placement is the next step.

- **Portal vein complications:** Doppler US is typically done when suspected. CT portography or transhepatic photography are the confirmatory diagnostic modality.
  IR treatment options for portal vein stenosis include angioplasty with or without stenting, while portal vein thrombosis treatment options include CDT, thrombectomy and stenting, along with systemic anticoagulation.
  Obtaining percutaneous access (typically right mid axillary line for percutaneous transhepatic access) into portal vein is performed under US or fluoroscopy guidance. A vascular access sheath is inserted over a guide wire into the portal vein. After that, an angioplasty balloon is introduced and positioned at the site of stenosis. Stenting is considered when stenosis is persistent.
- **Biliary complications:** Strictures are diagnosed by MRCP, or cholangiogram can be treated by endoscopic or percutaneous biliary drainage or balloon dilatation and stenting, or surgical intervention. Bile leakage mostly occurs at anastomotic sites. It is diagnosed by nuclear scintigraphy, cholangiography, or by the presence of biloma on US, CT, or MRI. Management includes surgical percutaneous or drainage (under US or CT guidance).

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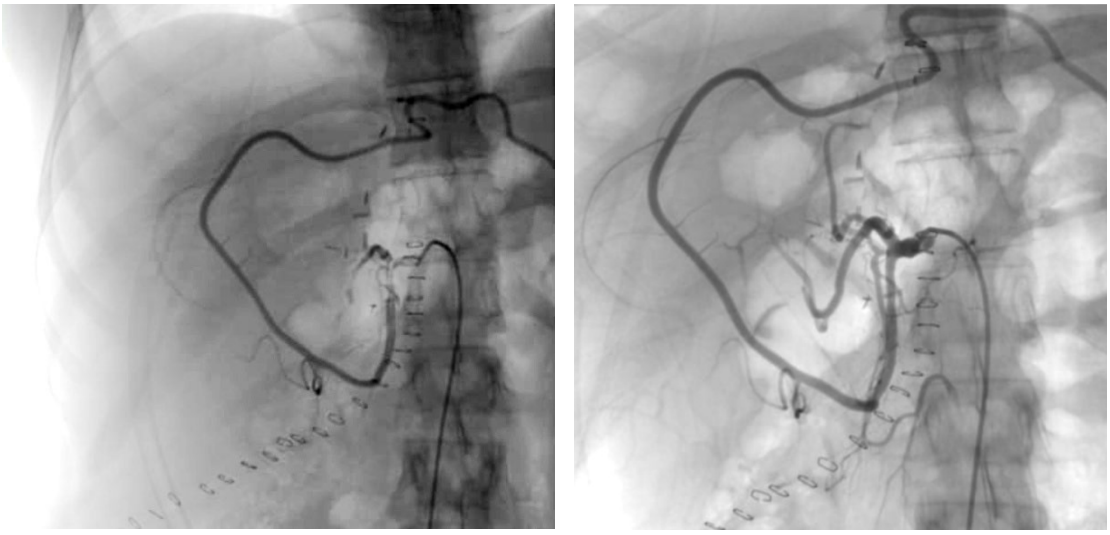
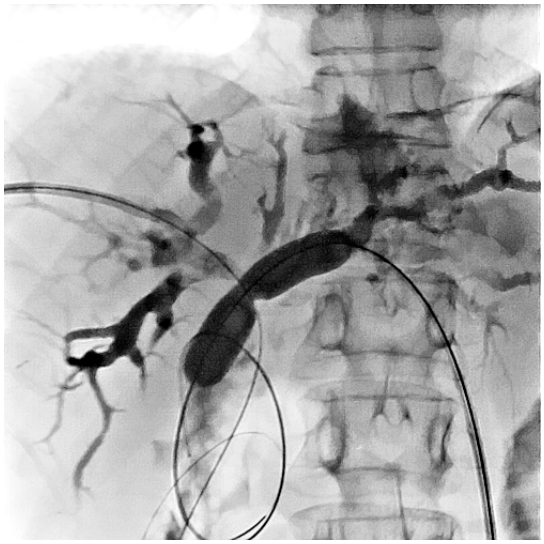


Post liver transplant hepatic artery stenosis pra (left) and post (Right) balloon dilatation. Case Courtesy : Mohamed Sobhi, MD, Ain Shams University Hospitals, Cairo, Egypt



Post Choledochojejunostomy biliary balloon dilatation. Case Courtesy: Karim Abd El Tawab, MD. Cairo, Egypt.

Pancreatic Cancer

Overview:

Patients with pancreatic cancer can be asymptomatic. The most common symptoms of pancreatic cancer are jaundice, abdominal pain, and weight loss.

Diagnosis and radiological findings:

- On ultrasound, a pancreatic carcinoma usually shows a focal hypoechoic mass with ill-defined margins. Dilated bile ducts can also be seen.
- Contrast enhanced CT scan shows ill-defined hypoattenuating mass within the pancreas.

IR management option, indications, and technique:

Irreversible electroporation

- Indications:
  - IRE can be done to increase the success rate of surgical resection or in some patients with locally advanced disease.
  - Palliative treatment for unresectable tumors.
- Technique:
  - Irreversible electroporation (IRE) is a non-thermal ablation technique.
  - IRE for pancreatic cancer can be done percutaneously by an interventional radiologist.
  - The electrodes release ultrashort electrical fields to create lethal nanopores in the cell membrane disrupting cellular homeostasis. Cells die by apoptosis, necroptosis and pyroptosis which are unique to this ablation technique.

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Liver abscess and liver cysts

Overview:

The finding of one or more space-occupying liver lesions identified on abdominal imaging raises the possibility of pyogenic liver abscess. Symptoms that prompt radiologic investigation for a liver abscess include fever, right upper quadrant pain and elevated liver enzymes.
Simple cysts of the liver are cystic formations containing clear fluid that do not communicate with the biliary tract. They vary in size, from very small (a few millimeters) to very large (>10 cm).

Diagnosis and radiological findings:

- **Liver abscess:** Certain imaging features favor the diagnosis of liver abscess over other lesions, such as cysts or tumor. CT is slightly more sensitive than ultrasound but ultrasound is more readily available. On ultrasound, pyogenic abscesses can range from hypoechoic to hyperechoic lesions. Ultrasound may also show internal echoes reflecting debris or septation.
- **Simple liver cyst:** Ultrasonography is the best initial test, because it can often differentiate a simple cyst from other cystic lesions. Simple cysts appear as an anechoic unilocular fluid-filled space with indistinguishable walls.

IR Management options, indications and technique:

Liver abscess drainage and catheter placement

- Drainage is strongly recommended whenever practical and feasible; it is both diagnostic and therapeutic. Percutaneous drainage should be CT or ultrasound-guided under local anesthesia or sedation. Simple aspiration may be sufficient for some small abscesses but, where possible, placement of a drainage catheter is favored.

Liver cyst drainage

- Asymptomatic patients can be managed conservatively while patients with large, symptomatic simple liver cysts may require intervention.
- Percutaneous Aspiration and Sclerotherapy (PAS), done by needle aspiration of the cyst followed by sclerotherapy (often with ethanol), is a reasonable alternative to surgery for symptomatic patients who require intervention.
- In case of hydatid cysts, PAIR technique is usually performed. It involves 4 sequential steps that can be done under local anestheisa or sedation:

1- **P**uncture the cyst via a needle via US guidance (or CT guidance), preferably using the intercostal space through the liver tissue.
2- **A**spiration of the cyst components
3- **I**nstillation of scolicidal agents (as hypertonic saline) into the cyst cavity and left for 20 minutes
4- **R**e-aspiration of the cyst fluid under US monitoring.

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US guided Pig tail tube insertion in a liver abscess. Case courtesy of Karim Abdel Tawab, MD, Ain Shams University Hospitals, Egypt

Liver Trauma

Overview:

Liver is the most commonly injured organ in blunt abdominal trauma. Given its large size in the abdominal cavity, it can also be frequently injured with penetrating abdominal injuries. Most hepatic injuries are minor and can be graded with the American Association for the Surgery of Trauma Hepatic Injury Scale. Interventional radiological procedures can be used to treat traumatic hepatic injuries. More severe hepatic trauma can cause severe bleeding, and thus necessitate massive resuscitation efforts, operative interventions, and damage control laparotomy. Patients can present with right upper quadrant pain, right shoulder tip pain (from diaphragmatic irritation), hypotension, and shock. For patients with hepatic injury, the primary survey should identify the presence of hypovolemic shock from liver bleeding. Vital sign changes present in hemorrhagic shock include a narrow pulse pressure, hypotension, and tachycardia.

Liver trauma evaluation:

Laboratory Evaluation:
This includes complete blood count, coagulation parameters, and lactate level. In addition, liver function tests may be abnormal, although this may not be seen until several hours to days after injury.

Radiologic Evaluation:
Radiologic assessment can also begin in the trauma bay with a focused assessment with sonography for trauma (FAST) exam. The FAST exam is used to identify the presence of blood in the abdominal cavity or pericardial sac. It does not identify the degree of organ injury.

CT scan of the abdomen and pelvis with intravenous (IV) contrast has become standard of care in the hemodynamically stable abdominal trauma patient. It is the best modality for identifying hepatic injuries. CT allows for the identification of hepatic injury and grading of severity. It also allows the clinician to identify other abdominal injuries and quantify hemoperitoneum. Administering IV contrast with CT scan allows for identification of patients with active extravasation of blood as evidenced by a blush on the CT from the liver.

Treatment options and Management:

Non-Operative Management:
Non-operative management for blunt hepatic injury is the treatment of choice in hemodynamically stable patients as specified by the Eastern Association for the

Surgery of Trauma Practice Management Guidelines. Non-operative therapy is appropriate only at a facility capable of hemodynamic monitoring, serial abdominal examinations, and an operating room that is immediately available for emergency laparotomy. Patients with blunt hepatic injury undergoing non-operative therapy must be monitored in the intensive care unit (ICU) for a period with serial hematocrits, abdominal examinations, and bed rest.

Angiography and Embolization:
Angiography with selective embolization is an effective treatment for patients undergoing non-operative therapy of bleeding liver injuries, especially those with blunt hepatic injuries. Success rates for angiography and embolization are as high as 83%. No clear consensus guidelines exist as to when and in which patients to perform angiography with embolization. Some trauma surgeons prefer to do angiography and embolization in any blunt hepatic injury higher than grade III. In contrast, others will only do so if there is contrast extravasation on a CT scan.

Operative Management:
Hemodynamically unstable patients, not responsive to resuscitation, should go directly from the trauma bay to the operating room for laparotomy. In addition, patients with peritoneal signs should go to the operating room. Patients that fail non-operative therapy must undergo laparotomy.

IR options and techniques:

- Management of hepatic trauma has shifted toward non-operative measures over the past several decades, with success of nonsurgical intervention approximately 90%.
- Angiography with embolization is considered in hemodynamically stable patients with arterial contrast extravasation on CT, evidence of ongoing bleeding despite resuscitation, hemobilia, or high-grade liver injuries.
- Trans-arterial embolization (TAE) is also utilized for hemorrhage control following laparotomy in the setting of hepatic trauma.
- The primary embolic materials utilized in hepatic trauma are **Gelfoam** and **metallic coils**. Gel foam is often preferred for multifocal injury due to its temporary occlusive effect with the potential to preserve normal hepatic parenchyma, while metallic coils are often chosen in the setting of injury to a single larger vessel, including arteriovenous fistula, arterio-biliary fistula, and pseudoaneurysm.

IR technique**:**

- Depending upon the availability of anaesthesia, resources, and the condition of the patient, TAE is performed with either IV conscious sedation or general anaesthesia, and a dose of antibiotics should be

administered including skin pathogens and enteric flora due to infection possibility.

- Hepatic trauma embolization is typically performed through femoral artery approach. An 18 to 21-gauge needle is selected to access the artery with or without US guidance.
- Aortic angiogram is performed especially if the hepatic artery is not characterized on CT scan due to anatomical variations.
- In case of normal anatomy; celiac axis is catheterized by 5 Fr catheter, then the common hepatic artery is selected with 5Fr catheter or coaxial microcatheter.
- Depending on the type and extent of the injury, embolization is performed with embolic agents.
- Some important findings may be seen and evaluated such as active contrast extravasation, AVF, pseudoaneurysm and arteriobiliary fistula.
- Post-embolization angiography is performed initially to verify absence of additional angiographic abnormalities warranting treatment.

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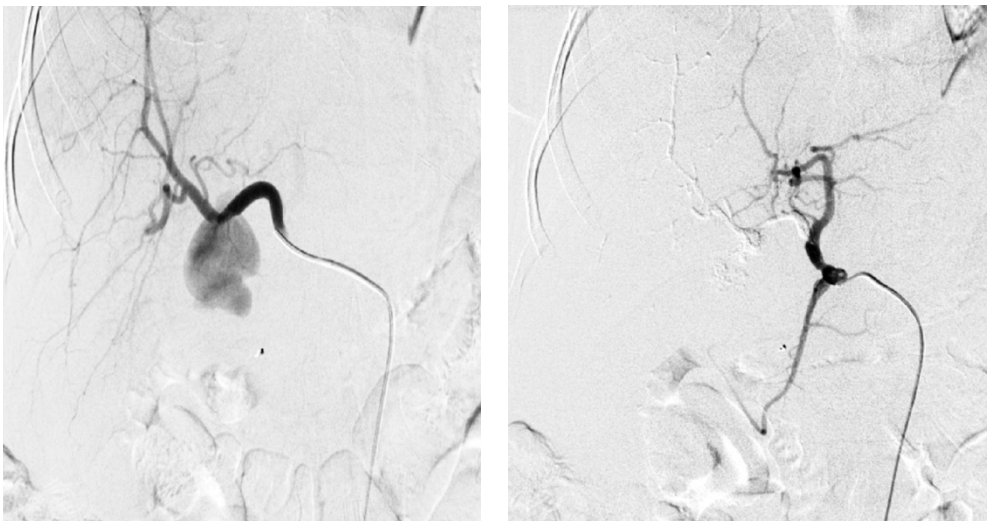

Traumatic right hepatic artery pseudoaneurysm prehepatectomy embolization pre (Left) and post (Right) glue embolization. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University, Cairo, Egypt

Nephrology and Urinary Tract Diseases and Interventions

Back To TOC

Chronic Kidney Disease

Overview:

Chronic kidney disease, or chronic kidney failure, involves a progressive loss of kidney function. The clinical presentation of CKD depends on the underlying disorder and the severity of renal impairment. Patients with early stages of CKD (G1–G2) are usually asymptomatic, but from CKD G3 onwards, patients may experience weakness related to anemia, polyuria, hypertension, dyslipidemia, or mineral bone disorders.

Diagnosis and Radiological findings:

The assessment begins with measuring serum creatinine concentration and estimating GFR [Simplified MDRD formula]. A diagnosis requires persistence or progression of the defining abnormality for more than 3 months.

Imaging tools, such as US, CT, or MRI, are the clue of etiological diagnosis because of the information they provide on kidney size, shape, location, and density, as well as the anatomy of the urinary drainage system (renal pelvis, ureters, and bladder). Cysts, dilation of the ureters or pelvis, calcification, masses, and scars can tell the cause of CKD or confirm a specific diagnosis (such as autosomal dominant polycystic kidney disease or obstructive uropathy).

IR options for diagnosis:

For unexplained, fast-progressing loss of kidney function, chronic hematuria, and low-grade proteinuria or isolated proteinuria, renal US-guided biopsies are frequently advised.

Technique:

The US-guided biopsy is done under local anaesthesia. The patient lies prone and under US guidance the core biopsy needle is advanced targeting the renal cortex to take renal tissue samples.

Lines of treatment and IR options:

The purpose of CKD management is to stop the progression of kidney failure, often by treating the underlying cause with diet, lifestyle, and pharmaceutical interventions. However, even treating the cause of kidney disease might not stop the damage from getting worse. Without dialysis or a kidney transplant, end-stage renal failure is fatal.

- Hemodialysis: A procedure that uses pumps, membranes, and dialysates to clear uremic toxins from the blood. Preparing patients for hemodialysis involves referral for vascular access placement.

- The types of access include:
  1. Direct arteriovenous fistulae: performed by surgery or minimally invasive endovascular access. The anatomical changes in the draining vein based on the anastomosis of a peripheral artery with a bigger subcutaneous vein improve flow and perfusion pressure, allowing for repeated venous punctures for hemodialysis.
  2. Arteriovenous grafts: when the patient's vascular anatomy does not allow for the formation of a fistula. The most common type of graft used for hemodialysis is a polytetrafluoroethylene (PTFE) graft that may be punctured repeatedly.
  3. Central venous catheters or CVCs: Only for short-term use which are inserted under local anaesthesia using US and or fluoroscopic guidance.
- Peritoneal dialysis: Allows the elimination of uremic toxins from the circulation by using the peritoneal membrane as an exchange interface. To do this, a transcutaneous catheter is inserted into the peritoneal cavity, which may then be used to drain and refill dialysate fluid daily.
- Renal transplant.

IR treatment options:

- Endo-AVF creation, which avoids open surgery, involves utilizing special devices under US or fluoroscopic guidance to join a vein and an artery, typically in the forearm, .
- Percutaneous image-guided Peritoneal dialysis catheter placement is done using combination of US and fluoroscopy under local or moderate sedation.
- Complications of fistula treatment:
  - Venous outflow stenoses are frequently treated with angioplasty, which may need high-pressure or cutting balloons to overcome the fibrotic lesions.
  - Thrombosis: PTFE grafts and arteriovenous fistulae are both susceptible to thrombosis. To restore the fistula's patency, angioplasty or endovascular thrombectomy and thrombolysis might be used.

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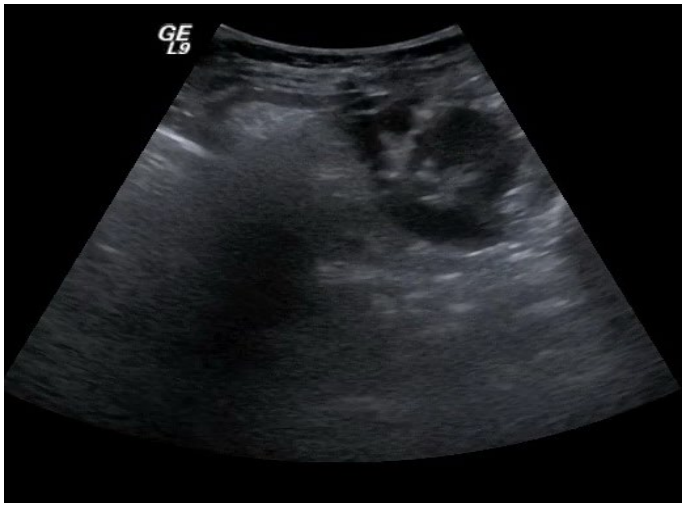
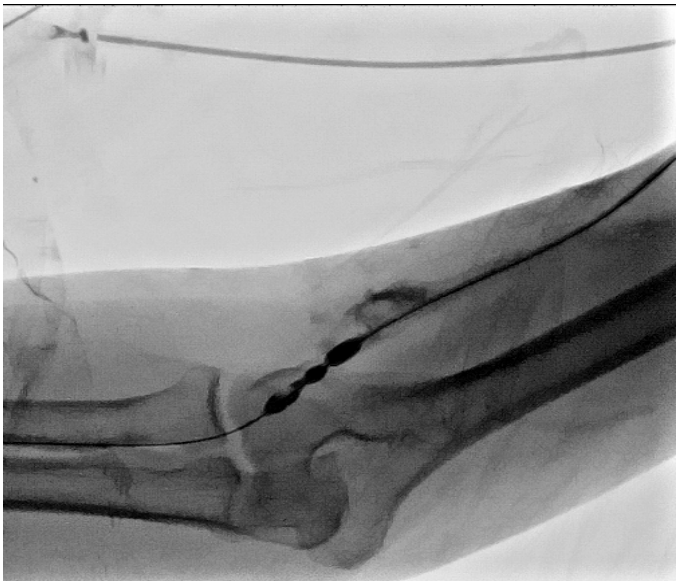


Percutaneous renal biopsy. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo, Egypt



Percutaneous balloon dilatation of blocked dialysis AVF. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo, Egypt

Renal Transplant Dysfunction

Overview:

Renal transplantation is the treatment of choice for patients with end-stage renal disease. Renal transplant dysfunction can be due to vascular complications, acute tubular necrosis, subacute and/or acute rejection, infections, toxicity from immunosuppressive medicines, ureteric strictures and urine leak, and chronic rejection.

Radiological findings and diagnosis:

Doppler-US: First-line imaging method.
Many complications may occur in the acute, subacute, and chronic phases that can be detected using the doppler US as:

- Renal arterial stenosis, renal Arteriovenous fistula, and pseudoaneurysm.
- Renal artery thrombosis: Lack of main or intra-renal artery flow.
- Renal Vein thrombosis: Lack of renal venous flow within an enlarged kidney.
- Ureteral obstruction: Hydronephrosis, Empty bladder.
- Peri-graft fluid collection: Hematoma, abscess, urinoma, lymphocele.
- Graft rejection: Hypoechoic parenchyma.

CT: Good for evaluating hydronephrosis.
MRA: May demonstrate the exact location of stenosis with or without contrast injection.
Nuclear medicine: Provides qualitative and quantitative evaluation of allograft function.

Lines of treatment and IR options:

Surgical: Surgical revision for immediate post-transplant vascular complication is the first line in therapy to restore renal perfusion and preserve the graft.
Urine leak or ureteric strictures may require surgical revision or native ureter reimplantation when minimally invasive percutaneous or urologic interventions do not resolve the leak or strictures.

IR treatment Options:

- Percutaneous nephrostomy (PCN) or nephroureteral stent (NUS) implantation for urinary leak/urinoma.
- Angioplasty and stent for renal artery stenosis after transplant. Stent placement for aortoiliac inflow disease.
- Coil embolization for AV fistula/pseudoaneurysm.
- Urinary obstruction: ureteral balloon dilatation, PCN/NUS.
- Perigraft collection: drainage, sclerosis, and aspiration.

- Percutaneous biopsy for graft rejection.
- Trans arterial embolization or ethanol ablation for graft intolerance syndrome.

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Obstructive Uropathy (Pelvicalyceal and Ureteric Obstruction)

Overview:

Obstructive uropathy refers to any cause of urinary tract blockage, whether whole or partial, permanent, or intermittent.
Depending on the degree and extent of the obstruction, it may cause permanent changes in both the collecting system and renal parenchyma.
Symptoms include flank discomfort and reduced urine output.
Urolithiasis, tumors, infections, post-traumatic stenosis, congenital malformations, or surgical procedures are the most prevalent causes of ureteral blockage.

Radiological findings and diagnosis:

X-rays: 90% of calculi are radio-opaque.
US: is used to assess
- Hydronephrosis severity grading.
- Renal parenchyma and perirenal regions.
CT: Useful for determining the quantity, location, size, and density of renal stones.
MRI: Without the use of contrast, MRI may identify hydronephrosis and the level of obstruction.

Lines of treatment and IR options:

Analgesic therapy for flank pain. Hydronephrosis is generally treated by managing the underlying etiology, such as stone removal by Shock wave lithotripsy or ureteroscopy, or surgical excision of an underlying tumor.
In patients with tiny stones and mild to severe hydronephrosis, a retrograde double J catheter joining the kidney pelvis to the urinary bladder is placed using a cystoscope or ureteroscope to bypass the stenosis site/stone through the ureter.

IR treatment options:

- Percutaneous nephrostomy: for critical patients with hydronephrosis and big stones, urine tract infection, or pyonephrosis.
- Antegrade double J ureteric stenting: for patients with malignant obstruction as a palliative treatment or in cases of ureteric stones.
- Ureteral balloon dilation: for patients with benign ureteric strictures.

IR technique:

Percutaneous Nephrostomy:
Under local anaesthesia and/or sedation, a Chiba needle is used under US guidance to have percutaneous access to the relatively avascular Brödel zone (the plane

between the ventral and dorsal renal artery branches), then a pyelogram by contrast injection is acquired under fluoroscopy.
The nephrostomy catheter is then inserted under fluoroscopic guidance over a guide wire.

Antegrade Ureteric Stenting:
US-guided percutaneous access is obtained then a guide wire is advanced under fluoroscopic guidance down to the urinary bladder bypassing the site of stenosis. Double J Ureter stent is advanced over the wire to the bladder under fluoroscopic guidance.
Ureteral balloon dilation: A balloon can be advanced to the ureteric stenosis and inflated to overcome the stenosis.

Reference:

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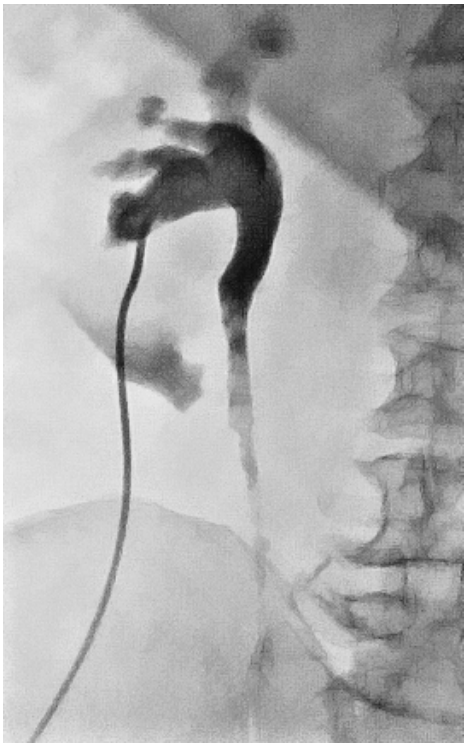
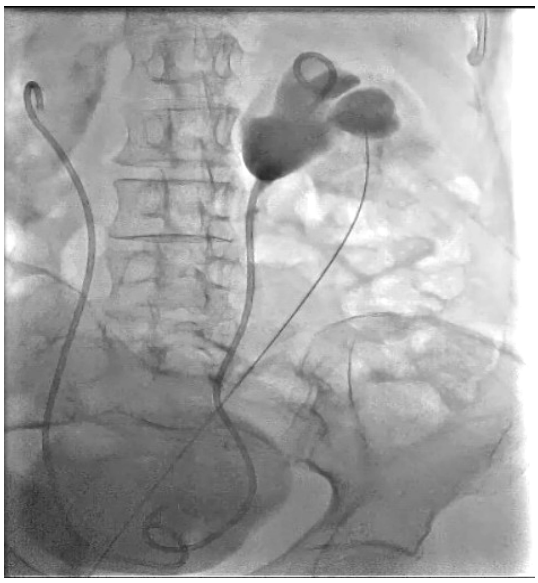


Percutaneous Nephrostomy Tube Application. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo, Egypt



Percutaneous Antegrade Double J stents Application. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo, Egypt

Acute Urinary Retention (AUR)

Overview:

Acute urine retention (AUR) is a sudden inability to urinate and is frequently accompanied by lower abdomen discomfort. Benign prostatic hyperplasia (BPH) is the most prevalent reason. Other causes of AUR include infectious, neurological, and tumoral disorders.
The physical examination may demonstrate suprapubic distension and percussion dullness.

Radiological findings and diagnosis:

US: Confirms urine retention by measuring the post-voiding bladder volume [>300 ccs] and assesses the possibility of suprapubic cystostomy.
It also assesses possible causes by assessing the prostate and its volume.
CT/MRI:
Determine the cause of AUR.

Lines of treatment and IR options:

Treatment of all types of retention aims to decompress the bladder and treat the underlying cause of retention.

- Urethral catheterization.
- Suprapubic cystostomy catheter insertion:

Suprapubic catheterization refers to the placement of a drainage tube into the urinary bladder just above the pubic symphysis in cases where urethral catheterization is either contraindicated or unsuccessful.
It can be inserted surgically or percutaneously under ultrasound or under fluoroscopy guidance.

IR technique:

A large bore needle is inserted into the bladder using ultrasound guidance until urine returns. Contrast injection is performed to conform location. The needle is then used to insert a guide wire into the urine bladder. This tract is then mechanically dilated using dilators. The suprapubic catheter is then inserted into the bladder through the access sheath.

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1. Billet, M., & Windsor, T. A. (2019). Urinary Retention. Emergency Medicine Clinics of North America. doi:10.1016/j.emc.2019.07.005
2. Negro CL, Muir GH. Chronic urinary retention in men: how we define it, and how does it affect treatment outcome. BJU Int 2012;110(11):1590–4.
3. Kessler CS, Bauml J. Non-traumatic urologic emergencies in men: a clinical review. West J Emerg Med 2009;10(4):281–7.

Malignant and Benign Renal Tumors

Overview and clinical presentation:

Renal masses are usually asymptomatic or present with back pain and hematuria.

Radiological findings and diagnosis:

US: Determines the size, structure, and local tumoral extension (eg. vascular invasion).
CT: Renal masses are typically hypervascular and tend to invade the renal vein. CT characterizes renal mass density, enhancement, invasion, and metastasis.
MRI: Higher characterization of the lesions.

Renal biopsy:
Under US or CT guidance usually with local anaesthesia a core needle biopsy can be obtained for tissue sampling.

Lines of treatment and IR options:

Surgery, total or partial nephrectomy, is the first line of treatment.
Percutaneous US/ CT guided thermal ablation is indicated for small tumors or patients with surgical contraindications. Preoperative trans arterial embolization can be used to reduce the risk of intra operative bleeding.

IR Technique:

1. Radiofrequency ablation: A generator is used to send alternating electrical current to the target tissue, causing coagulative necrosis.
2. Microwave ablation: Heat-based ablation in which energy is delivered into the microwave probe through electromagnetic waves, resulting in cell death and coagulative necrosis.
3. Cryoablation: Cold ablation is performed by releasing highly compressed argon gas to spread in the distal end of the cryoprobe, resulting in severe cooling and the formation of an ice ball within the target tissue. Similarly, helium is utilized to melt the ice ball, resulting in tissue necrosis.
4. Irreversible electroporation: The ablation is generally nonthermal and electric, with the electroporation phenomena causing cell membrane breakdown and, as a result, cellular death.
5. Trans arterial embolization: Hyper vascular renal tumors with a high bleeding risk are embolized prior to the planned surgery.

References:

1. Mohamed E. Abdelsalam, Surena F. Matin, Kamran Ahrar Ablation of Renal Cell Carcinoma, Image-guided interventions book, Chapter 101, pages 823-840.
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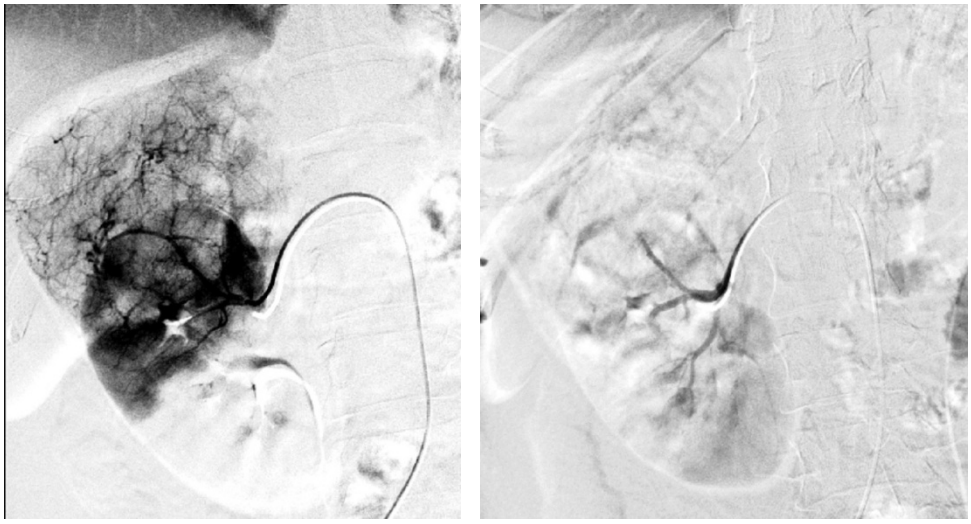

Renal Angiomyolipoma pre (Left) and post (Right) particles embolization. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo, Egypt

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IR Role in RCC Management

Renal Artery Stenosis

Overview:

Renal artery stenosis is the narrowing of one or more arteries carrying blood to the kidneys causing renal hypoperfusion and ischemia.
It can be asymptomatic, or patients may present with high blood pressure resistant to medications, kidney dysfunction, treatment-resistant heart failure or flash pulmonary edema.
Atherosclerosis is the most prevalent cause of renal artery stenosis in the elderly usually affecting renal arteries ostia. Other causes include fibromuscular dysplasia, dissection, vasculitis, neurofibromatosis, developmental problems, and kidney compression by a tumor or hematoma.

Radiological findings and diagnosis:

- Doppler US: allows assessment of renal size and waveforms in the renal artery. Increased peak systolic velocity and reduced resistive indices may indicate more than 60% luminal reduction.
- MR/ CT Angiography have excellent sensitivity and specificity for ostial and proximal renal artery stenosis. Reduction in luminal diameter greater than 75%, post-stenotic dilatation, and decrease in renal mass are indicative of hemodynamically significant stenosis.
- Conventional Angiography can detect stenosis along arteries and its severity.

Lines of treatment and IR options:

- Medical treatment is the first line of management.
- IR treatment options include percutaneous transluminal renal angioplasty and renal artery stenting.

IR Technique:

- Percutaneous Transluminal Renal Angioplasty: Renal angiography identifies the location and severity of the stenosis followed by balloon angioplasty. This is typically done in cases of fibromuscular dysplasia.
- Stenting: Stent placement is often used in atherosclerotic ostial lesions. Balloon expandable stents are typically used to allow precise deployment.

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1. A. ALHADAD, MANAGEMENT OF RENAL ARTERY STENOSIS: AN UPDATE, Libyan J. Med 2008; 3(2): 91–100. Published online 2008 Jun DOI: 10.4176/071226.

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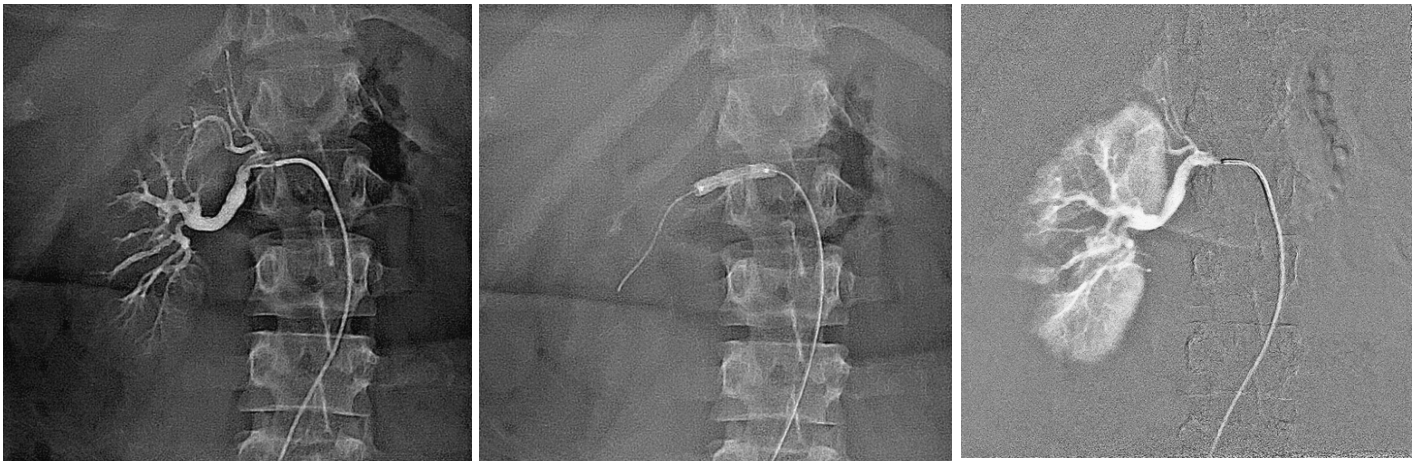

Right renal a. stenosis pre angioplasty (left), right renal a. angioplasty (middle), post right renal a. angioplasty with good flow (right). Case courtesy of Karim Abdel Tawab, MD, Ain Shams University Hospitals,Cairo Egypt

Renal Trauma

Overview:

Renal trauma can be blunt, penetrating, or iatrogenic and range from minor lacerations or capsular hematomas with minimal morbidity and mortality to renal avulsion with high mortality. Patients present with flank pain, hematuria, hypotension, and shock.

Diagnosis and radiological findings:

Laboratory evaluation include complete blood count, coagulation parameters, and lactate level. Furthermore, renal function tests may be abnormal, however, this may not be apparent for several hours to days after the damage.
Focused Assessment with Sonography in Trauma (FAST) can detect free blood in the abdominal cavity as well as peri-renal and/or subcapsular hemorrhage.
Contrast-enhanced computed tomography (CT), the mainstay of renal trauma diagnosis, is recommended in all stable patients with gross hematuria as well as those with microscopic hematuria and hypotension. CT should be conducted if the mechanism of trauma suggests renal injury.

Lines of treatment and indications of IR:

Management ranges from conservative in mild trauma to surgery in severe cases.
IR options include endovascular coil embolization as a trial to preserve the kidney and is indicated in hemodynamically stable patients with IV contrast extravasation on CT, active bleeding despite resuscitation, and gross hematuria.

IR technique:

Renal angiography and embolization via femoral or radial artery access. Renal angiography is used to locate the bleeder (active contrast extravasation, arteriovenous fistula, and pseudoaneurysm). Selective cannulation is done using microcatheter and embolization is done using either coils, gelfoam or glue. Post-embolization angiography is performed to verify the absence of additional angiographic abnormalities warranting treatment.

References:

1. Ines Anselmo da Costa, Bastian Amend, Arnulf Stenzl, Jens Bedke, Department of Urology, Eberhard Karls University, Tubingen, Germany, CONTEMPORARY MANAGEMENT OF ACUTE KIDNEY TRAUMA, Journal of Acute Disease 2016; 5(1): 29–3630.
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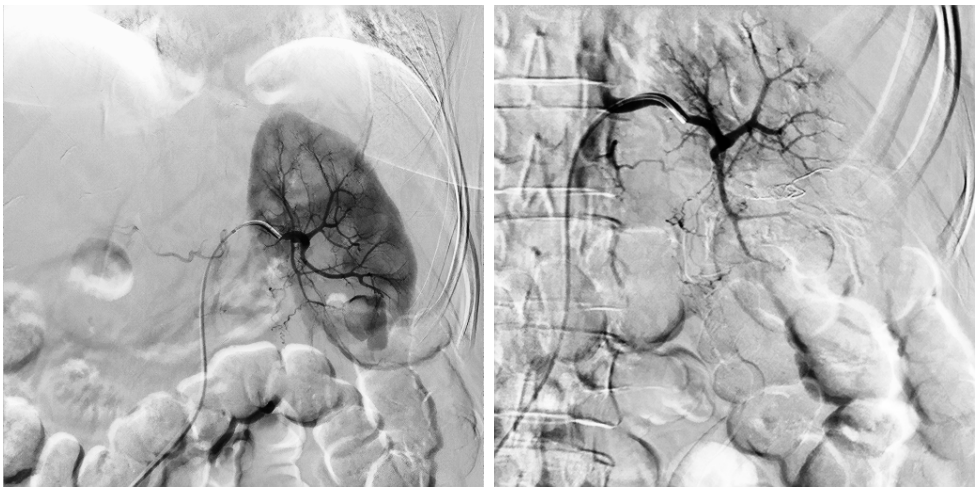

Post PCNL traumatic lower pole pseudoaneurysm pre (Left) and post (Right) Coils embolization. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo, Egypt

Renal Abscess

Overview:

Renal abscess is the accumulation of pus inside the kidney parenchyma. Ascending urinary tract infections with gram-negative bacteria is the most common cause of adult renal abscesses. Hematogenous seeding also occurs. Patients usually present with fever, flank or abdominal discomfort, and leukocytosis.

Radiological findings and diagnosis:

- US shows an echogenic well-defined collection in the renal parenchyma, containing air hyperechoic foci within it.
- CT shows a well-defined, low-attenuation lesion with a thick regular wall or pseudo capsule. The lesion may also include gas bubbles and presents pseudo capsule post-contrast enhancement.
- MRI is the modality of choice for patients allergic to CT contrast media and can be an alternative to avoid radiation exposure in younger patients. Abscess shows typically regular wall contrast enhancement.

Lines of treatment and IR options:

- Small-sized abscess is treated with intravenous antibiotic therapy first.
- Drainage, surgically or percutaneously, is done when medical treatment fails.

IR Technique:

- Percutaneous external drainage: Needle puncture with subsequent guidewire introduction under radiological US/CT guidance is done then a pigtail catheter is inserted over the guidewire and fixed for abscess drainage.

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2. Dielubanza, E. J., Matulewicz, R. S., & Schaeffer, A. J. (2017). Pyelonephritis and Abscesses of the Kidney. Infectious Diseases, 547–554.e1. doi:10.1016/b978-0-7020- 6285-8.00060-5
3. Yen DH, Hu SC, Tsai J, et al. Renal abscess: early diagnosis and treatment. Am J Emerg Med 1999; 17:192.

US guided needle aspiration of a renal abscess. Case courtesy of Karim Abdel Tawab, IR consultant, Ain Shams University Hospitals, Egypt

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Interventional Nephrology

Genital Tract Diseases and Interventions

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Pelvic Venous Congestion Syndrome (PCS)/ Pelvic Venous Disorders

Overview:

Pelvic congestion syndrome causes chronic noncyclic pelvic pain usually in multiparous women where pelvic varices develop around the uterus and the ovaries with or without the development of atypical lower limb varicose veins (VVs) and vulvar varices.

Classifications**:**

Primary:

Most pelvic varicosities are primary and result from incompetent or congenitally absent valves in the gonadal vein (ovarian vein).

Secondary:

Secondary pelvic varicosities are much less common and result from increased pressure in the ovarian vein due to compression e.g. extrinsic mass such as retroperitoneal lymphadenopathy or tumors, compression of the left renal vein (LRV) between the superior mesenteric artery and aorta (nutcracker syndrome) or May-Thurner syndrome (Extrinsic compression of left common iliac vein by right common iliac artery against bony structures) leading to focal venous stenosis with subsequent venous outflow obstruction on the same side

Radiological findings and diagnosis:

- Trans Vaginal Ultrasound and doppler is the diagnostic modality of choice showing:
    - Dilatation of the ovarian veins >4-5 mm in diameter
    - ± flow reversal with the Valsalva maneuver
- CT/MRI venography shows the dilated gonadal veins and pelvic varices and detect the presence of supra-pelvic obstruction, stenosis, or masses.
- Digital subtraction Angiography (DSA) only performed during endovascular treatment, can demonstrate:
    - Dilated ovarian veins
    - Retrograde flow of contrast towards the pelvis

Lines of treatment and Indications for IR:

- Medical treatment includes hormonal therapies to decrease pelvic congestion and analgesics.
- Surgical management includes ventro-suspension of the retroverted uterus (in case the uterus is compressing the ovarian veins), hysterectomy with oopherectomy, or ovarian vein ligation (can be done via laparoscopy).

- IR options include ovarian veins embolization after failed medical management and is increasingly being used as the primary treatment for PCS.

In patients with May-Thurner syndrome, endovascular treatment using venous stents via a femoral approach is performed. In patients with Nutcracker syndrome, surgical option is considered, or less invasive endovascular venous stenting can be performed.

IR technique of ovarian veins embolization:

The ovarian and internal iliac veins may be approached from a jugular, antecubital or femoral approach under local anaesthesia. Right jugular access is usually preferred. Sheath is placed in the accessed vein and a curved catheter is used to catheterize the left ovarian vein arising from the left renal vein.

Embolization of the vein is done subsequently using coils, glue, sclerosants or combined embolics can be used, Then, the right ovarian vein, that drains directly into the IVC, is selectively catheterized and advanced into the right pelvic varices. The embolization procedure is then repeated. If refluxing internal iliac veins are noted, they should be catheterized and selectively embolized.

Patient is discharged on the same day on low dose analgesics. Follow up of the patient is done after 2-4 weeks post embolization.

References:

1. Koo S, Fan CM. Pelvic congestion syndrome and pelvic varicosities. Tech Vasc Interv Radiol. 2014 Jun;17(2):90-5.
2. Daniels J, Gray R, Hills RK, Latthe P, Buckley L, Gupta J, Selman T, Adey E, Xiong T, Champaneria R, Lilford R, Khan KS., LUNA Trial Collaboration. Laparoscopic uterosacral nerve ablation for alleviating chronic pelvic pain: a randomized controlled trial. JAMA. 2009 Sep 02;302(9):955-61.
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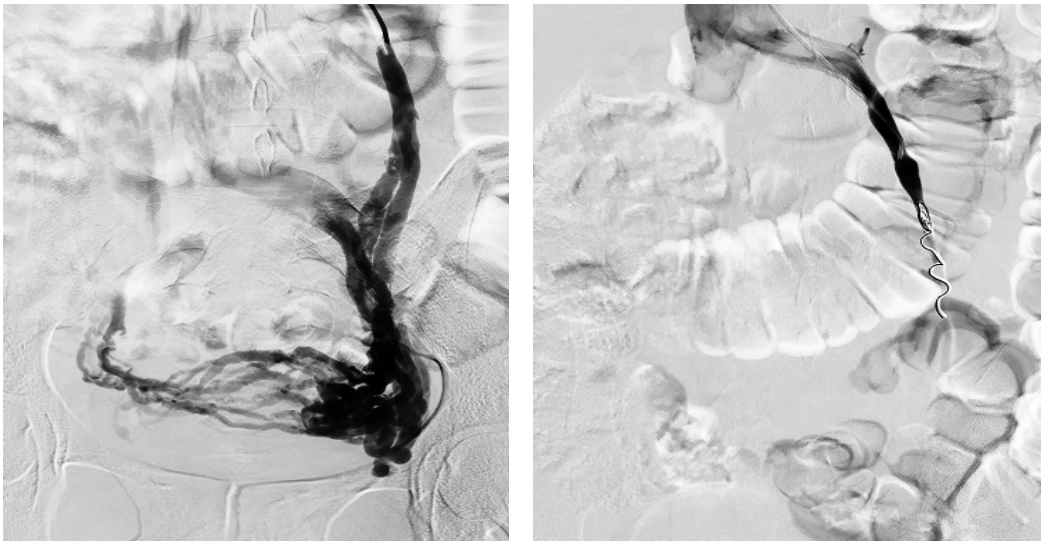

Left ovarian vein embolization with foam sclerotherapy and coils, pre embolization (left) and post embolization (right). Case courtesy of: Karim Abdel Tawab, MD, Rana Khafagy , MD Ain Shams University Hospitals, Egypt

Uterine Fibroids

Overview:

Fibroids (Leiomyomas) are muscular tumors that grow in the wall of the uterus. Fibroids are almost always benign. They can be asymptomatic or present with pelvic pain, menstrual bleeding disorders, infertility, or compression symptoms as frequent micturition.

Radiological findings and diagnosis:

- Transvaginal or transabdominal US and doppler with or without intra-uterine saline infusion assess fibroids number and locations. Most commonly, fibroids are heterogeneous/ iso to hypoechoic compared to the normal uterus showing circumferential vascularity with or without necrotic cystic areas.
- Hysterosalpingography assesses fallopian tubes in infertility cases, where submucosal fibroids may appear incidentally as filling defects.
- Contrast CT scan shows iso to hypodense uterine masses.
- Contrast MRI provides more accurate information compared to ultrasonography regarding number and location of fibroids which makes it better for pre-embolization assessment and prediction of prognosis along with assessment of the fibroid's vascularity.

Lines of treatment and Indications for IR:

- Most common scenario is conservative treatment in asymptomatic and accidentally discovered cases.
- Medical treatment includes hormonal therapy or progestin-releasing intrauterine device (IUD) inducing amenorrhea with a rapid reduction in the size of the tumor. Analgesics, oral contraceptives, and iron help in symptomatic treatment.
- Surgical options include endoscopic/surgical myomectomy or hysterectomy.

Interventional options include the following:

- Uterine Artery Embolization (UAE):
    - Symptomatic fibroids: heavy menstrual bleeding, dysmenorrhea, pain, dyspareunia, or pressure effects on urinary or gastrointestinal tract.
    - Contraindication to surgery.

- Previous unsuccessful surgery for fibroids.
- Coexisting adenomyosis and fibroids.
- Infertility (UAE in this situation should be considered with caution)

- High-Intensity Focused Ultrasound (HIFU):
  - US/MR guided -HIFU is a new, image-guided, non-invasive technique which enables treatment of tumors by thermal-ablation by ultrasound waves.

IR technique: (see below in Post-Partum Haemorrhage)

References:

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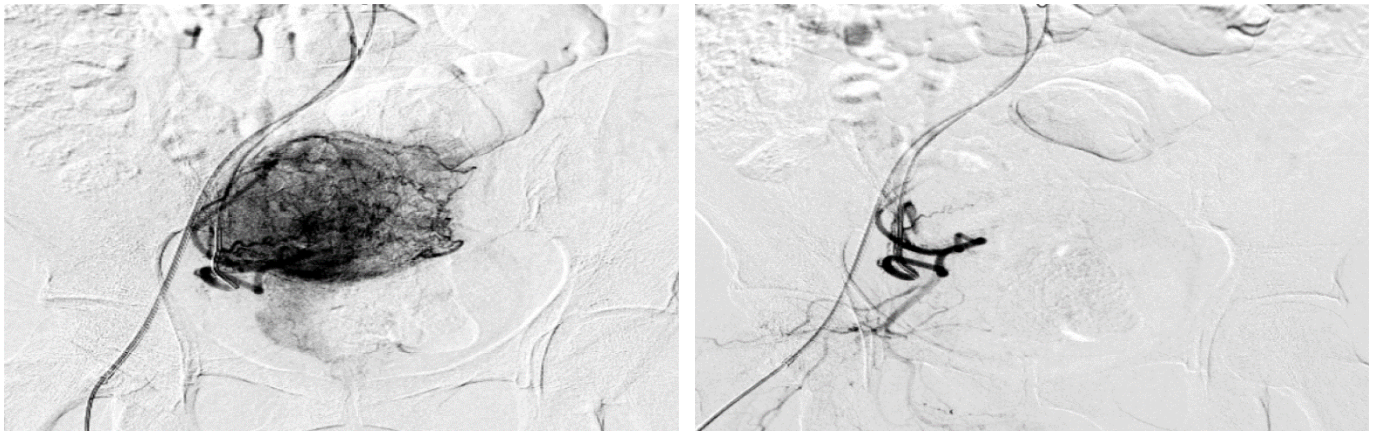

Catheterization and embolization of the right uterine artery supplying a fibroid. Pre-embolization with fibroid blush (left), post embolization (right), the left uterine artery was embolized in the same way. Case Courtesy of Rana Khafagy, IR consultant, Ain Shams University Hospitals, Egypt

Uterine Adenomyosis

Overview:

A benign, non-neoplastic process characterized by the ectopic proliferation of endometrial tissue into the myometrium with smooth muscle hypertrophy. It is endometriosis of the myometrium. 35% of patients with adenomyosis are asymptomatic.

Symptoms include menorrhagia, dysmenorrhea, metrorrhagia and dyspareunia.

Radiological findings and diagnosis:

- Ultrasound: Transvaginal is always preferred to trans abdominal showing:
  - Ectopic endometrial glands and stroma: echogenic nodules and striations, radiating from the endometrium into the myometrium with thickened cystic myometrium and bulky uterus along with increased vascularity using color doppler.
  - Focal adenomyosis resembling a leiomyoma is called adenomyoma.
- MRI is the most definitive noninvasive means of diagnosing adenomyosis, where thickening of the junctional zone ≥12 mm, either diffusely or focally.

Lines of treatment and Indications for IR:

- Medical treatment (as uterine fibroids, see above)
- Surgical hysterectomy is the only definitive therapy for adenomyosis.
- IR options include Uterine Artery Embolization in cases with symptomatic adenomyosis, refusing hysterectomy, and patients with coexisting adenomyosis and fibroids.

IR technique: (see below in Post-Partum Hemorrhage)

References:

1. Atri M, Reinhold C, Mehio A, Chapman W, Bret P. Adenomyosis: US Features with Histologic Correlation in an In-Vitro Study. Radiology.2000;215(3):783-90 doi:10.1148/radiology.215.3.r00jn06783
2. Togashi K, Nishimura K, Itoh K et al. Adenomyosis: Diagnosis with MR Imaging. Radiology. 1988;166(1 Pt 1):111-4 doi:10.1148/radiology.166.1.3336669

3. Popovic M, Puchner S, Berzaczy D, Lammer J, Bucek RA. Uterine artery embolization for the treatment of adenomyosis: a review. J Vasc Interv Radiol. 2011 Jul;22(7):901-9; quiz 909.
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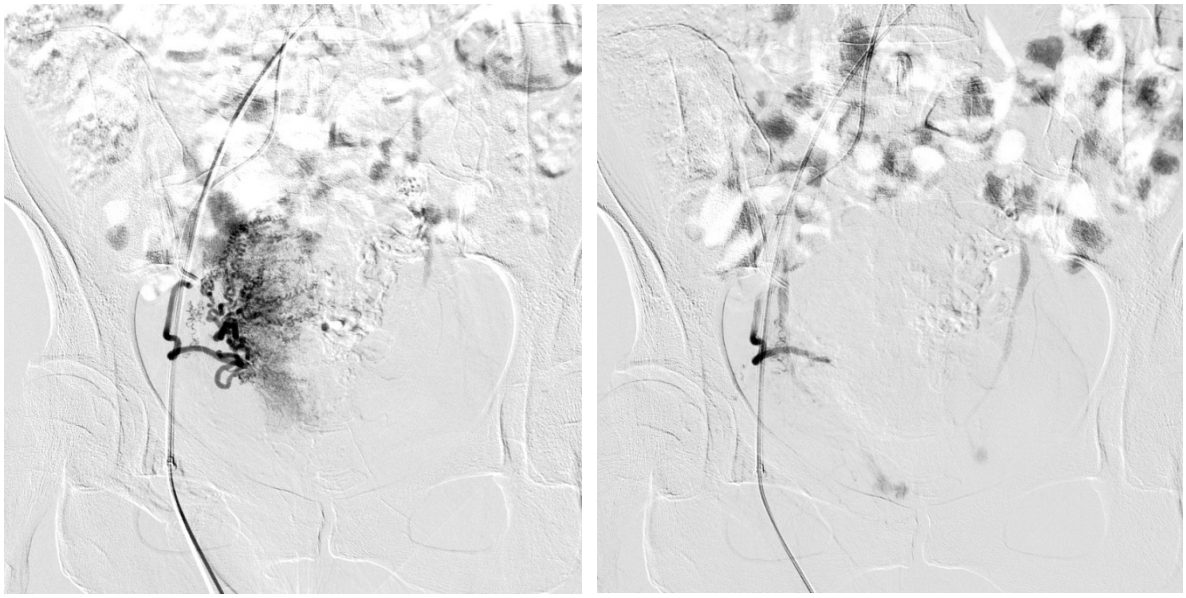

Catheterization and embolization of right uterine artery for case of uterine adenomyosis with tortuous vessels. Pre embolization (left), post embolization (right). Case Courtesy of Rana Khafagy, IR consultant, Ain Shams University Hospitals, Egypt

Post-Partum Hemorrhage

Overview:

According to the WHO, PPH corresponds to loss of more than 500 ml of blood after vaginal or CS delivery.
Primary Post-Partum Hemorrhage (PPH) occurs within the first 24 hours of delivery.
Secondary PPH occurs between 24 hours and 6-12 weeks after delivery and is less common.

Causes:
Uterine atony: accounts for about 80% of primary postpartum hemorrhage.
Endometritis: the commonest cause of secondary postpartum hemorrhage presenting up to 12 weeks after delivery
Others as uterine AVM, uterine artery pseudoaneurysm formation

Radiological findings and diagnosis:

Diagnostic procedures are almost entirely limited to a physical examination to assess uterine tone, retained placenta products or the presence of genital tract lacerations.
Ultrasonography/ MRI to exclude retained products of conception (RPOC):

- US and Doppler assessment show a heterogeneously echogenic material within the uterine canal with internal flow (to differentiate from intra-luminal thrombus). US doppler can also diagnose uterine AVM or uterine artery pseudoaneurysm formation
- Ultrasonography to diagnose endometritis in cases of secondary PPH.
- CT and angiography can see if there's active extravasation of contrast.
- MR imaging to detect RPOC with raised B-HCG.

Lines of treatment and Indications for IR:

- Hemostasis and Conservative treatment:
    - Resuscitation
    - Uterotonic agents
    - Fundal massage
    - Removal of any retained placental parts or membranes
    - Vaginal or uterine packing or uterine balloon tamponade

- Broad spectrum antibiotics in women with secondary postpartum hemorrhage due to endometritis
- Correction of coagulopathies.

- Uterine Artery Embolization (UAE)

IR technique:

Uterine artery embolization can be done under local anaesthesia. Femoral or radial artery access can be used. The catheter is then navigated to the internal iliac artery then to the uterine arteries bilaterally then embolization using embolic particles is done. In cases of post-partum haemorrhage in hemodynamically unstable patients with non-visualized uterine arteries, embolization of the anterior divisions of the internal iliac arteries using gelfoam pledgets is a valid technique.

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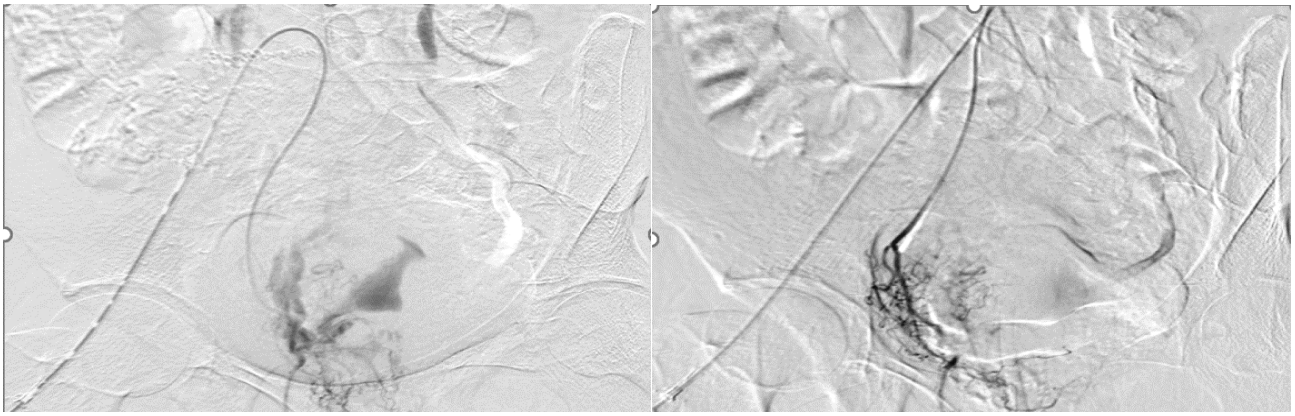
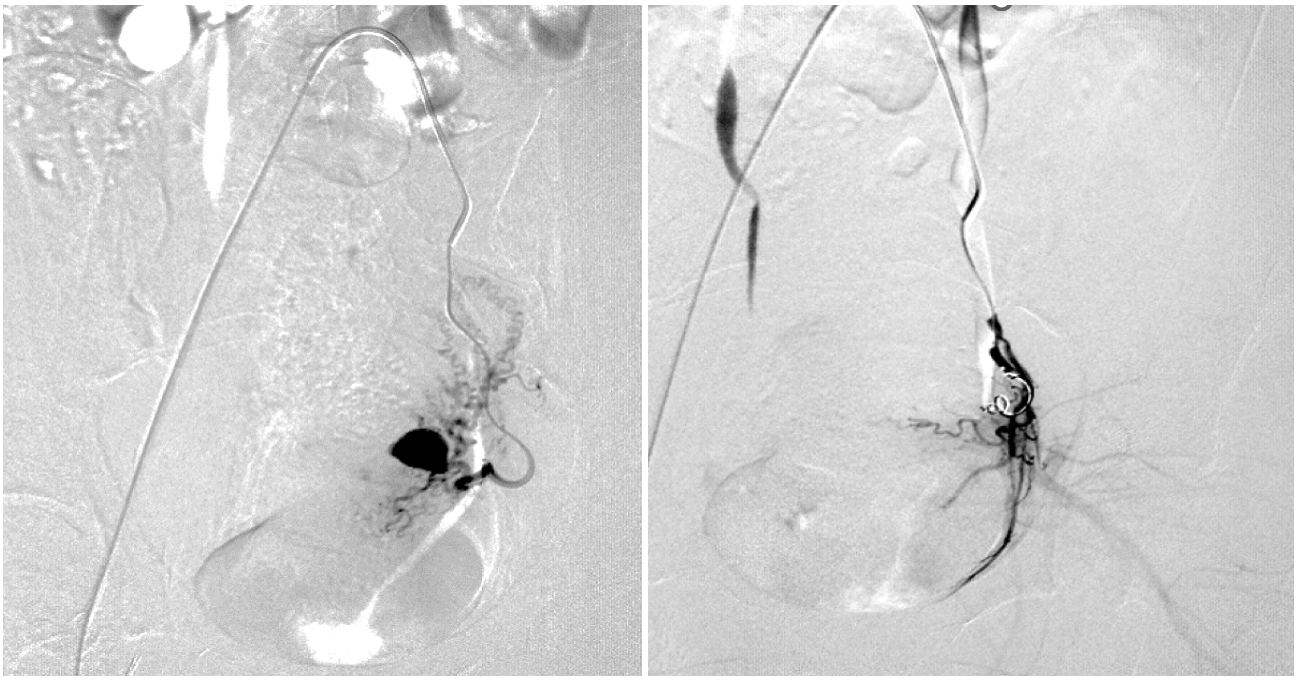
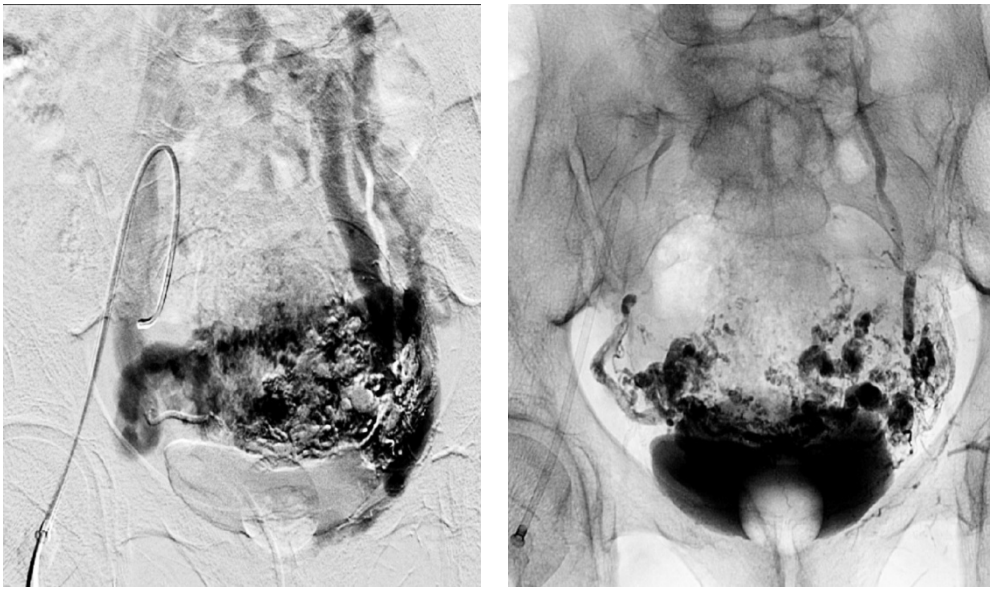


A case of 1ry PPH. Catheterization of the left uterine artery revealed extravasation of the contrast into the uterine cavity, a direct sign of bleeding (left) that was embolized using glue (right) with no evidence of bleeding. Case Courtesy of Karim Abdel Tawab, MD, Ain Shams University Hospitals,Cairo, Egypt



A case of late 2ry PPH. Catheterization of the left uterine artery revealed a pseudoaneurysm (left) that was embolized using coils (right). Case Courtesy of Karim Abdel Tawab, MD, Rana Khafagy, MD, Ain Shams University Hospitals, Egypt



Glue embolization by NBCA for an intrauterine AVM. Case Courtesy: Karim Abd El Tawab, MD, Ain Shams University Hospitals, Cairo, Egypt

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Uterine Artery Embolization

Invasive Placenta

Overview:

Placental invasion into the myometrium results from chorionic villi invasion through a defect in the decidua basalis.

Classified according to the degree of invasion into:

- Placenta accreta: No myometrial invasion
- Placenta increta: partial myometrial invasion
- Placenta percreta: Invasion up to or beyond the uterine serosa

Radiological findings and diagnosis:

U/S, Doppler and MR Findings:

- Focal interruptions in myometrial border
- Reduced myometrial thickness (<1 mm)
- Irregular bladder wall with extensive associated vascularity.
- Focal uterine bulge
- Assessment of depths invasion e.g.: direct invasion, bladder tenting

Lines of treatment and Indications for IR:

- Operative ligation of the internal iliac or uterine arteries is an option.
- Pre-operative balloon occlusion of the internal iliac arteries may be considered to reduce intra operative bleeding. Balloons are inserted in the internal iliac arteries pre operatively and inflated after delivery of the fetus to control bleeding.

IR technique:

Under Local anaesthesia bilateral femoral arteries puncture is done. Catheters are navigated to the internal iliac arteries then balloon catheters are inserted. Balloons are positioned in the contralateral internal iliac artery and inflated to obtain occlusion of the artery then deflated.
The size of the balloon should be optimally tailored to the vessel caliber.
Both balloon catheters are securely fastened in position. The patient is transferred to the operating room for cesarean delivery. Both occlusion balloon catheters are inflated intraoperatively to their previously measured amounts.

Some patients may need further embolization of the uterine arteries after balloon occlusion using gelfoam injection through the balloon catheter.

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Deflated iliac arteries balloons in a twin pregnancy placenta accreta case. Case Courtesy of Karim Abdel Tawab, MD, Rana Khafagy, MD, Ain Shams University Hospitals, Cairo, Egypt

- **Additional Procedures:**

Scan me

Fallopian Tube Recanalization

Varicocele Embolization

Overview:

Varicocele consists of abnormally dilated and tortuous veins within the pampiniform plexus of the spermatic cord. Most cases are asymptomatic, yet some may experience scrotal swelling, pain, heaviness and/or infertility. Primary varicocele is more common and results from incompetent or congenitally absent valves in the testicular vein (internal spermatic vein). Secondary varicocele results from increased pressure in the testicular vein due to compression (e.g. extrinsic mass such as retroperitoneal lymphadenopathy or renal mass), obstruction (e.g. renal vein thrombus), or splenorenal shunting (portal hypertension).

Radiological findings and diagnosis:

Ultrasound is the diagnostic modality of choice that can show dilatation of pampiniform plexus veins >2-3 mm in diameter with or without flow reversal on Valsalva.

CT/MRI with contrast may show dilated cluster of enhancing serpiginous veins and can detect the presence of supra-pelvic obstruction or stenosis and detect any associated masses.

Digital subtraction Angiography (DSA), performed during endovascular treatment, may demonstrate dilated testicular veins and retrograde flow of contrast towards the scrotum.

Lines of treatment and Indications for IR:

- Surgical or laparoscopic option is ligation of the internal spermatic veins.
- IR option by gonadal veins embolization performed in cases of symptomatic varicocele.

  In patients with May thurner syndrome or Nutcracker syndrome, treatment can be surgical, or left renal vein bypass. Less invasive endovascular treatment using venous stents via a femoral approach can be the alternative.

IR technique of embolization:

The gonadal veins may be approached from a jugular, antecubital or femoral approach under local anaesthesia. Right jugular access is preferred. Sheath is placed in the access vein and a curved headhunter catheter is used to catheterize

the left gonadal vein arising from the left renal vein. Embolization of the vein is done subsequently using coils, glue or sclerosants. The right gonadal vein is selectively catheterized from the IVC then the embolization procedure is repeated.

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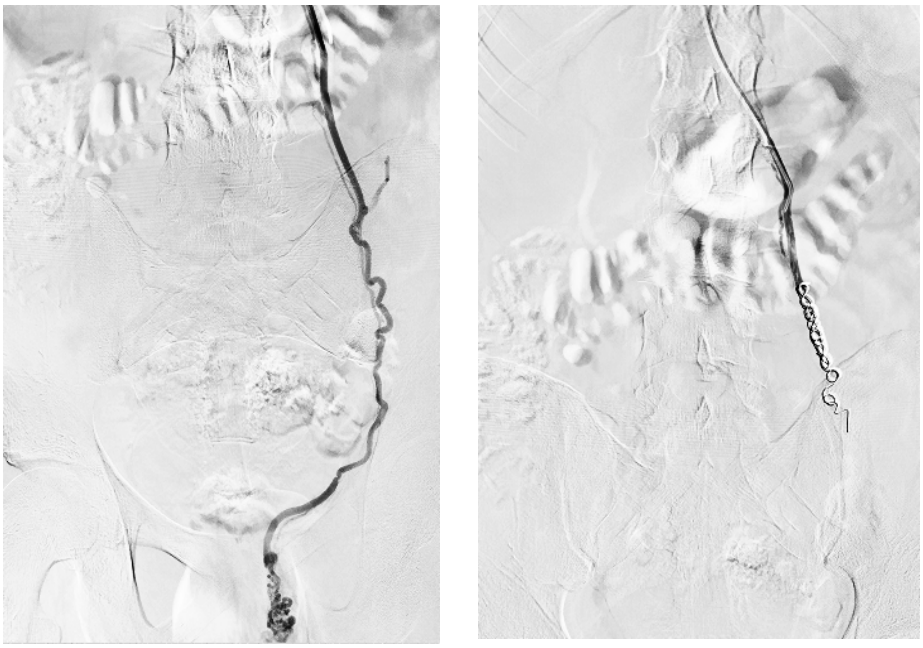

Left varicocele embolization with coils. Pre-embolization (left), post-embolization (right). Case Courtesy of Karim Abdel Tawab, MD, Rana Khafagy, MD, Ain Shams University Hospitals, Cairo, Egypt

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Gonadal Veins Embolization

Benign Prostatic Hyperplasia (BPH)

Overview:

Benign prostatic hyperplasia (BPH) is an age-related pathological enlargement of the prostate that affects about 65% of males in their 60s and the incidence increases with aging. It is due to increase of the glandular cells and stromal tissue in the transitional zone of the prostate. Enlargement and nodularity of the prostatic tissue in the periurethral region causes lower urinary tract symptoms (LUTS) and/or urinary retention. This is more evident in patients with prostatic volume >50 ml.

Radiological findings and diagnosis:

- Pelvic and trans-rectal US helps with measurement of prostatic volume and post voiding urine residue.
- MRI helps in better visualization of prostatic tissue and localization of lesions.
- Prostatic biopsy in patients with suspected prostatic malignancy based on a PSA level greater than 4 ng/mL and a suspicious focal lesion detected with MRI, transrectal ultrasonography, or digital rectal examination. The procedure is done under local anaesthesia via trans-rectal US guidance using 16-18G biopsy needle. 6-12 cores are usually taken including the suspicious prostatic area.

Lines of treatment and Indications for IR:

- Medical management as alpha blockers and 5-alpha reductase inhibitors is used for mild to moderate symptoms of prostate enlargement.
- Surgical options include radical prostatectomy and other minimally invasive surgical therapies such as:

- Transurethral resection of the prostate (TURP)
- Transurethral incision of the prostate (TUIP)
- Transurethral microwave thermotherapy (TUMT)
- Transurethral needle ablation (TUNA)
- Laser therapy
- Prostatic urethral lift (PUL

IR options:

1) prostatic artery embolization (PAE) with indications as follows:

- BPH (Prostate volumes of more than 30 cm^3) and moderate to severe lower urinary tract symptoms (LUTS). No maximum prostate size for PAE.
- BPH and urinary flow peak rate of less than 5 mL/s or urinary retention.
- Poor surgical candidates due to advanced age, multiple comorbidities, coagulopathy and inability to stop anticoagulation or antiplatelet therapy.
- Patients who refuse surgery for fear of retrograde ejaculation, erectile dysfunction or urinary incontinence.
- Hematuria of prostatic origin to stop bleeding.

IR Technique:

It is usually done under local anaesthesia. Common femoral artery or radial artery puncture is the usual access point. Catheters and microcatheters are then navigated to the prostatic arteries followed by embolization using embolic particles or glue with or without coiling the prostatic arteries.

2) Another IR option that is recently proposed as a minimally invasive procedure is the Trans perineal Laser Ablation (TPLA) for benign prostatic hyperplasia with promising results.

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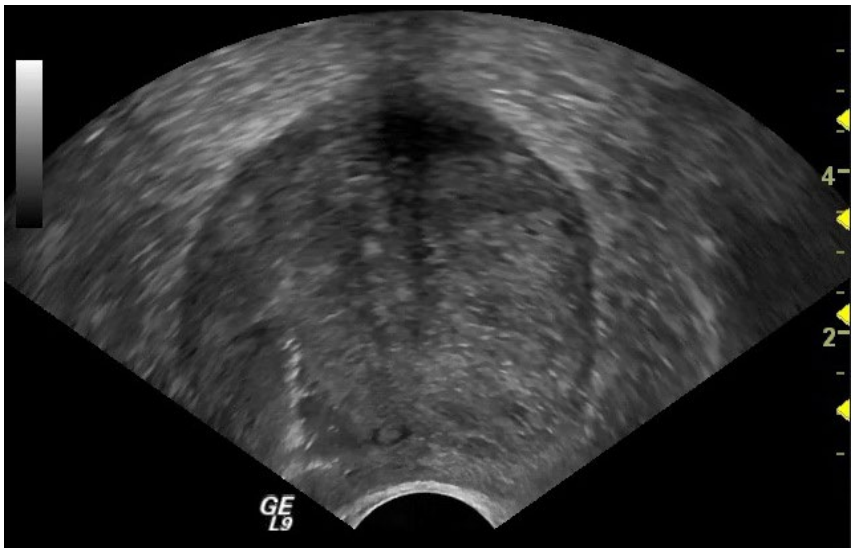
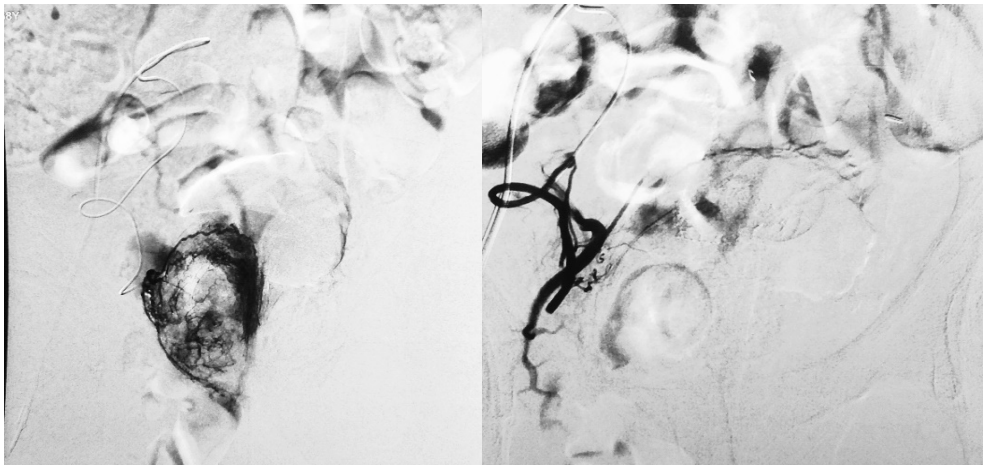


Transrectal prostatic biopsy. Case Courtesy of Karim Abdel Tawab, MD, Ain Shams University Hospitals, Cairo Egypt



Right prostatic artery catheterization (left) and postembolization (right). Case Courtesy of Karim Abdel Tawab, MD, Ain Shams University Hospitals, Egypt

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Prostatic Artery Embolization part ١

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Prostatic Artery Embolization part ٢

Neurological Diseases and Interventions

Back To TOC

Subarachnoid Hemorrhage (SAH)

Overview:

SAH is the leakage of blood into the subarachnoid space. Spontaneous non-traumatic SAH is caused by ruptured cerebral aneurysms in most cases. It represents about 3% of all strokes and usually presents with sudden severe headache. This may be associated with vomiting, coma, or even death.

Radiological findings and diagnosis:

CT scan is highly accurate for diagnosing SAH in the acute presentation;
it is also very useful in demonstrating the aneurysms (by CT angiography) and providing insight as to which treatment modality is most ideal depending on the anatomy. CT scan can also show other rare causes for intracranial hemorrhage such as arteriovenous malformations (AVM) and infective/mycotic aneurysms.
If a CT scan is inconclusive but a high index of suspicion remains, a lumbar puncture may be required to detect abnormal blood products within the cerebrospinal fluid.

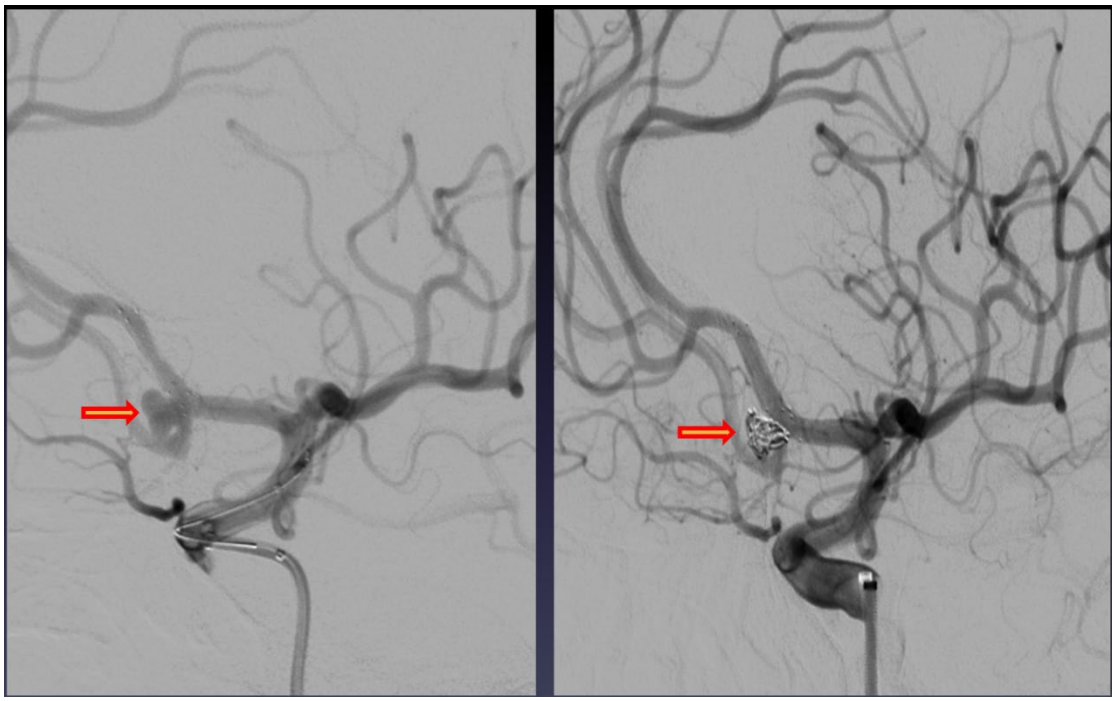
Lines of treatment and Indications for IR:

The primary purpose of treatment is prevention of rebleeding by excluding the ruptured aneurysm from the circulation, with or without brain decompression and evacuation of the hematoma.
Historically, the only treatment was open surgical clipping by the neurosurgeons, by placing metal clips to seal the aneurysm neck to prevent rebleeding.
IR options include coiling of cerebral aneurysms, placing flow-diverters or using Glue.
Ideally, a ruptured aneurysm should be treated within 24 hours of presentation.

IR Technique:

The classic endovascular treatment of cerebral aneurysms is coiling. This is usually done under general anaesthesia to achieve full immobilization. Like most IR procedures, femoral or radial arteries can be used for access. Catheters and microcatheters are then navigated to the aneurysm. 3D angiography is then performed for accurate procedural planning. Coils are fine metallic filaments used to fill the aneurysm sac to exclude it from circulation and prevent rebleeding. Simple coiling can be unsuitable if the anatomy is complex. Other endovascular techniques have been developed to tackle these challenges, such as flow diverters.

On the other hand, AVMs are usually occluded by liquid glue-like materials to penetrate deep into their abnormal vasculature.



Cerebral aneurysm [arrow] before (left) and post coiling (right). Case Courtesy of Ayman El Sebaie, IR consultant, Rashid hospital, UAE

Acute Ischemic Stroke (AIS)

Overview:

Acute ischemic stroke is a sudden neurological deficit caused by decreased blood flow resulting in ischemic insult to brain cells because of an embolus or a thrombus that eventually occluded the cerebral artery. It is the commonest type of stroke and is a major cause of morbidity and mortality. Common presentations include limb numbness or weakness, facial droop, dysphasia, ataxia, loss of vision, or coma.

Radiological findings and diagnosis:

After a full clinical assessment by the neurology or stroke team, a CT brain is requested to exclude intracranial hemorrhage, because this is an absolute contraindication to the most crucial lines of treatment. Additionally, CT can demonstrate early signs of AIS such as subtle hypodensity (dark area) corresponding to a vascular territory.

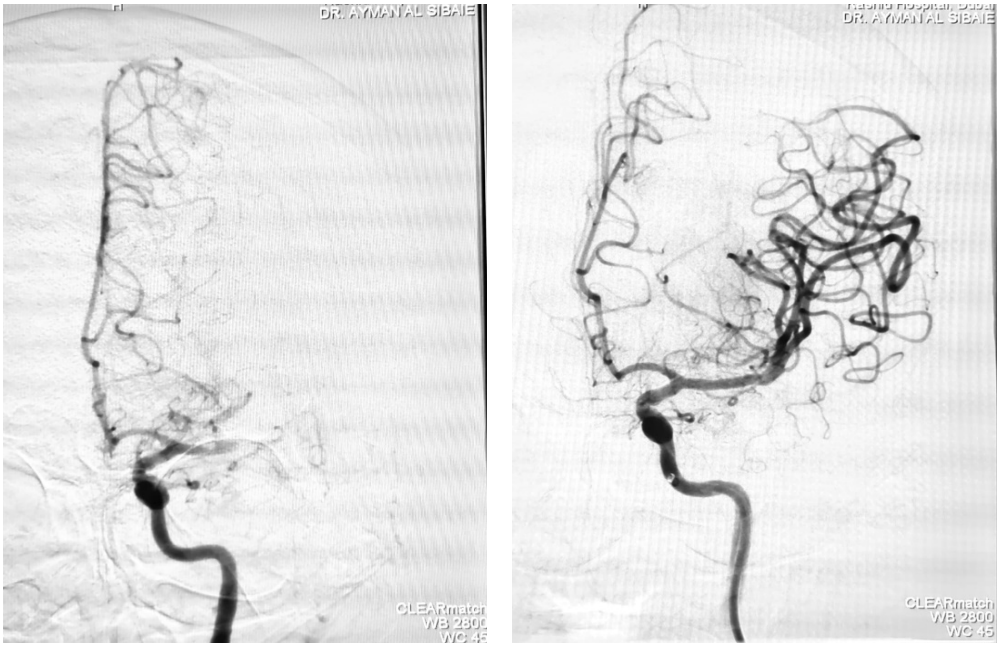
CT angiography is also crucial, as it can accurately show if major vessels are occluded, which has major implications as you will find out in the next section. Brain MRI can be time-consuming, so its use is limited to centers that have certain arrangements in place. Other advanced imaging techniques such as CT perfusion can be useful in case of relatively delayed presentations, to check if there is still salvageable brain tissue that may potentially benefit from acute treatment.

Lines of treatment and Indications for IR:

After excluding hemorrhage, the mainstay of treatment is reperfusion as soon as possible, ideally within 6 hours of onset, but this can be extended in selected cases.
Stroke centers have protocols in place to streamline patient management (e.g., a dedicated anaesthetic team and dedicated porters).
Reperfusion can be achieved by either IV thrombolysis, endovascular mechanical thrombectomy (MT), or both. In case of major vessel occlusion, IV thrombolysis alone is inadequate and mechanical thrombectomy is indicated. MT is particularly valuable when IV thrombolysis is contraindicated (e.g., recent surgery).

IR technique:

MT may be performed without general anaesthesia if the patient is cooperative. Femoral or radial artery access may be utilized. Catheters and microcatheters are then navigated to the occluded artery. To achieve reperfusion, several MT techniques exist, the main two are aspiration thrombectomy (AT) and stent-retriever (ST). An AT catheter evacuates the thrombus simply through suction. On the other hand, ST consists of a metal mesh that entangles the thrombus and retrieves it outside the body.



A case of acute stroke. Middle cerebral artery (MCA) before (left) and after (right) recanalization. Case courtesy of Ayman ElSibaie, IR consultant, Rashid hospital, UAE

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Neuro Interventions

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Neuro Embolization, Cerebral Aneurysms

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Arteriovenous Malformation and Dural Arteriovenous Fistula

Carotid Atherosclerosis and Stenosis

Overview:

Carotid artery atherosclerotic stenosis is an important risk factor for stroke because significant vascular narrowing reduces blood flow to the brain. Mild stenosis is usually asymptomatic. The symptomatic disease manifests as stroke (see acute ischaemic stroke section) or transient ischemic attack (TIA).

Radiological findings and diagnosis:

Asymptomatic carotid stenosis might be incidentally detected during work-up for another problem e.g., ischaemic heart disease. Symptomatic stenosis should be investigated by imaging. Either by CT angiography, MRI angiography, or Ultrasound Duplex. Imaging is very important for quantifying the severity of stenosis. Generally, more than 60% stenosis of the lumen is considered significant.

Lines of treatment and Indications for IR:

Patients with asymptomatic mild stenosis should receive the best medical treatment only.
Surgical treatment (carotid endarterectomy - CEA) is the main treatment for most symptomatic cases with significant stenosis. Significant stenosis requires intervention even if it is asymptomatic, due to increased risk of stroke. Endovascular treatment (carotid artery stenting - CAS) is usually reserved for younger patients with moderate disease.

IR technique:

CAS is usually performed under general anaesthesia under the cover of an antiplatelet to reduce the risks of thromboembolic events during the procedure. Femoral artery access is preferred given its wide caliber. A catheter is then navigated to the aortic arch. A guidewire is then carefully used for crossing the stenosis, followed by balloon angioplasty to dilate the stenosis. Finally, a metal stent is deployed across the stenosis to maintain the new dilated lumen.

Stroke due to distal embolism is a possible peri-operative complication, this risk can be reduced by using an embolism protection device to filter the blood.

Proximal ICA significant stenosis (arrow), treated by balloon angioplasty and stenting.
Case courtesy of Ayman ElSibaie, IR consultant, Rashid hospital, UAE

Carotid-Cavernous Fistula (CCF)

Overview:

CCF is a rare condition due to abnormal communication between the carotid circulation and cavernous sinus. This abnormal communication can be spontaneous or post-traumatic. The main clinical presentation is pulsatile proptosis. Clinical presentation is secondary to increased venous pressure and impaired venous drainage within the head, especially within the structures directly communicating with the cavernous sinus. It can present with progressive visual loss, pulsatile proptosis, pulsatile tinnitus, epistaxis, cranial nerve palsy, raised intracranial pressure, or intracranial haemorrhage.

Radiological findings and diagnosis:

Contrast-enhanced CT scan is usually sufficient to diagnose CCF, showing dilated tortuous superior ophthalmic vein and cavernous sinus. Due to its superior resolution, DSA is the best modality to confirm the diagnosis, map the exact anatomy, and plan the treatment.

Lines of treatment and Indications for IR:

Small, mildly symptomatic CCF can be treated conservatively as spontaneous resolution is possible. Otherwise, IR is the main treatment modality if conservative management fails or in case of significant clinical concern (e.g., loss of vision). Surgery is indicated if IR treatment fails, usually in the form of arterial ligation.

IR technique:

Various IR approaches are available depending on the anatomical details including trans-arterial embolization and/or trans-venous embolization using various materials to occlude the abnormal communication (e.g., coils).

Epistaxis

Overview:
Spontaneous idiopathic epistaxis is very common; hypertension is an important risk factor.

Radiological findings and diagnosis:

After the exclusion of systemic causes of epistaxis, CT or MRI scanning are very useful adjuncts to clinical examination and endoscopy in diagnosing nasal or nasopharyngeal tumors. Nasal endoscopy is very useful in determining the exact side and site of bleeding, which can guide a potential embolization procedure. The main culprit usually branches from the internal maxillary artery (branch of the external carotid artery).

Lines of treatment and Indications for IR:

Epistaxis can be controlled by nasal packing and/or cautery in most cases, which are more successful in anterior rather than posterior epistaxis. However, if these measures fail and bleeding becomes intractable with hemoglobin drop, embolization becomes indicated. Surgical control by ligation of the internal maxillary artery can be attempted as an adjunct to embolization or if embolization fails. For epistaxis secondary to tumours (e.g., juvenile nasopharyngeal angiofibroma), in addition to emergency control of bleeding, pre-surgical embolization can be very useful in facilitating the eventual surgical resection, by reducing tumour vascularity. Full collaboration with the ENT team is key to successful management.

IR technique:

The procedure can be performed without general anaesthesia if the patient can tolerate lying flat, otherwise, general anaesthesia would be more suitable. Femoral or radial artery access can be used. The catheter and microcatheter are then navigated to the internal maxillary artery. Angiography is then performed to identify the abnormal bleeding point and to exclude potentially dangerous anastomosis. Polyvinyl alcohol (PVA) particles are usually the embolic agent of choice, as they can penetrate deep into and block small abnormal arterioles.

Cerebral Venous Thrombosis (CVT)

Overview:

CVT is a rare cause of stroke, due to in situ thrombosis of venous sinuses or cerebral veins. It commonly presents with headache, vomiting, altered vision, papilledema, seizures, and coma. Focal neurological deficits are less common compared to AIS. Systemic hypercoagulable state is an important risk factor.

Radiological findings and diagnosis:

Given the non-specific clinical presentation, imaging is crucial to make the diagnosis. Superior sagittal, transverse, and sigmoid venous sinuses are the most affected structures. CT scan is the usual initial study, and it can show abnormally dense sinuses (bright), with or without brain edema and hemorrhage due to venous congestion. Thrombosis can then be demonstrated on a CT venogram as a dark filling defect within the venous sinus. MRI and MR venogram are also very useful to confirm the diagnosis, demonstrate parenchymal abnormality, and identify more subtle cases.

Lines of treatment and Indications for IR:

The underlying risk factors should be dealt with. Initial medical treatment includes steroids and anticoagulation to reduce brain edema and the progression of thrombosis, respectively. Anticoagulation is usually given even if CVT is complicated by hemorrhage. Recanalization of the occluded vein would relieve venous pressure, reducing the risk of cerebral venous infarction and haemorrhage. Endovascular thrombectomy and thrombolysis are reserved for more severe cases for whom conservative management had failed. Surgical thrombectomy is rarely required, it is indicated for deterioration after the failure of endovascular treatment.

IR technique:

Endovascular thrombectomy and thrombolysis can be performed without general anaesthesia if the patient is cooperative. Venous access is secured via the femoral or internal jugular vein. Catheters are then navigated into the affected vein where thrombolytic infusion is delivered and/or mechanical thrombectomy (e.g., aspiration).

Thrombolytic infusion is usually left to run for 24 hours, after which a check DSA is performed to check for a response. The earlier endovascular treatment is initiated, the more successful it is.

Spinal Arteriovenous Fistula (AVF) and Arteriovenous Malformation (AVM)

Overview:

AVM and AVF are abnormal shunting of blood due to direct communication between arteries and veins, bypassing the normal capillary bed, usually causing venous dilatation and congestion. They usually present in young adults and middle age. Both AVM and AVF can be idiopathic, AVF can also be encountered post-trauma. Classically, AVM is differentiated from AVF by the presence of a 'nidus'. Clinical presentation can be dramatic in case of acute bleeding, but presentation secondary to subacute/chronic myelopathy is usually insidious in the form of slowly progressive back pain, paraparesis, sensory abnormalities as well as sphincter dysfunction.

Radiological findings and diagnosis:

Diagnosis is usually made on an MRI of the spine that shows signs of long-segment myelopathy (edema/congestion) as well as abnormally dilated tortuous blood vessels. DSA is then performed to plan the treatment depending on the exact anatomy.

Lines of treatment and Indications for IR:

Endovascular embolization is the first line of treatment if it is deemed safe on the planning DSA. Because surgery is more invasive, it is usually reserved for cases with a high-risk non-target embolization that may cause iatrogenic collateral damage to the spinal cord. Outcomes are better with earlier treatment.

IR technique:

These procedures are performed under general anaesthesia to maintain patients' comfort because they are usually prolonged and to achieve full immobilization to maximize precision. Femoral artery access is preferred. Catheters and microcatheters are then navigated to the culprit vessel(s). The embolic agents of choice are liquid (e.g., glue) to penetrate deep into abnormal vasculature.

Pre-operative Embolization for Tumors

Overview:

Clinical presentations vary greatly depending on tumor location, size, and vascularity. General non-localizing manifestations of mass effect and increased intra-cranial tension include headache, blurred vision, and seizures.
By devascularizing the tumor, we can reduce peri-operative blood loss, shorten operating time, reduce surgical complications, down-stage large tumors, and/or reduce the risk of residual tumors.

Radiological findings and diagnosis of tumors:

Contrast-enhanced CT or MRI are the imaging modalities of choice providing key information. Highly vascular arterialized tumors respond best to embolization. Exact tumor location helps identify culprit feeding arteries, which makes the actual embolization procedure easier and shorter.

Pre-operative embolization aims:

A multidisciplinary approach and real-time collaboration with neurosurgery are key to achieving optimum outcomes, in general, and particularly in these scenarios.
Embolization can be performed any time between a few hours to a few weeks before surgery, depending on the aim and logistical arrangements.

IR technique:

These procedures are preferably performed under general anaesthesia to maintain patients' comfort because they can be prolonged and to achieve full immobilization to maximize precision. Femoral or radial artery access can be used. Catheters and microcatheters are then navigated to the feeding vessel(s). The embolic agent of choice is usually particles (e.g., polyvinyl alcohol particles - PVA) to penetrate deep into the tumor and induce ischemia. Larger vessels can then be occluded using coils.
Great care is taken to avoid non-target embolization to nearby normal tissues (e.g., stroke and cranial nerve palsy). Patients may experience post-embolization syndrome (as discussed in the interventional oncology section), therefore prophylactic anti-inflammatory medications are recommended.

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Chronic Subdural Hemorrhage (CSDH)

Overview:

Chronic subdural hematoma (CSDH) is a common condition, especially among older individuals. It is defined as a collection of blood breakdown products in the subdural space, located between the brain's surface and the dura mater.

CSDH results from repeated microbleeds and fluid leakage from inflammatory neovascular membranes. Elderly individuals, particularly those over 60, are more susceptible to CSDH due to factors such as cerebral atrophy, which increases the space within the subdural area, and the fragility of blood vessels. Furthermore, the use of anticoagulants and antiplatelet drugs, which are common in this age group, further raises the risk of bleeding.

CSDH has a broad and somewhat vague range of symptoms, primarily including headache and confusion, and, in a few cases, seizures. As CSDH tends to develop gradually with a slow onset, it can be challenging to diagnose and may be mistaken for other age-related conditions, such as dementia.

Radiological Findings and Diagnosis:

Non-contrast CT continues to be the mainstay for evaluating CSDH due to its cost-effectiveness, quick accessibility, and high diagnostic sensitivity. Preoperative radiological factors linked to the recurrence of CSDH include the thickness and volume of the hematoma, its density, whether it is unilateral or bilateral, and the internal structure of the hematoma.

Pathophysiology, Lines of Treatment, and Indications for IR:

Treatment has primarily involved surgical intervention to remove the hematoma, which can be done through burr hole drainage or craniotomy. Although the procedure is relatively simple, the frailty of older patients, who often have several comorbidities, coupled with the high recurrence rate, increases the risk of complications. The development of a neovascular membrane around chronic subdural hematoma (CSDH) is a key element in the pathophysiology of this condition. In addition to the simple rupture of superficial veins, processes such as angiogenesis, fibrinolysis, and inflammation contribute to sustaining the formation of this membrane. The arterial supply from the middle meningeal artery (MMA) to the neo membranes in CSDH suggests that embolizing the MMA could interrupt the ongoing cycle of micro bleeding and inflammation.
Thus, MMA embolization has become an emerging technique, either as an adjunct to or a substitute for surgical drainage. Embolic material has been shown

to infiltrate the neovascular membranes, and MMA embolization seems to accelerate the rate of hematoma reabsorption, likely due to a reduction in membrane bleeding.

IR Technique:

It can be trans radial or femoral access using a 6F radial sheath, which has proven safe and effective for MMA embolization.

After performing branch vessel angiography from the common carotid artery, selective catheterization of the external carotid artery is achieved.

Once access to the external carotid artery is established, the middle meningeal artery (MMA) is selectively catheterized with a microcatheter and microwire. If feasible, distal penetration of the embolizing material into the neo membranes is preferred. The embolic materials commonly used include ethylene vinyl alcohol copolymer or n-butyl cyanoacrylate in the majority of cases.

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Idiopathic Intracranial Hypertension (IIH)

Overview:

Idiopathic intracranial hypertension (IIH), formerly referred to as pseudotumor cerebri, is a condition characterized by increased intracranial pressure without a known underlying cause.

Patients commonly present with symptoms such as headaches, visual disturbances, pulsatile tinnitus, and papilledema. While IIH is most seen in overweight women of childbearing age, several hypotheses have been proposed to explain the mechanisms behind the elevated intracranial pressure. The theory suggesting obstruction in the cerebral venous outflow has gained considerable attention in recent decades. Elevated venous pressure, as confirmed through manometry during cerebral venography in IIH patients, supports the idea that stenosis of the cerebral venous sinuses could be associated with the condition.

Radiological Findings and Diagnosis:

Magnetic resonance imaging (MRI) and venography via MRI or venous MR angiography (MRA) are essential for diagnosing IIH. The diagnosis is based on identifying at least three key neuroimaging findings: an empty sella turcica, posterior flattening of the globe/sclera, transverse sinus stenosis (either bilateral or in the dominant sinus), and/or distension of the perioptic cerebrospinal fluid (CSF) space, with or without optic nerve tortuosity.

Treatment Options and Indications for Interventional Radiology:

IIH is typically managed conservatively with acetazolamide, a carbonic anhydrase inhibitor that reduces intracranial and intraocular pressure, or topiramate, which also promotes weight loss.

Surgical intervention is considered for patients who do not respond to conservative treatment, with cerebrospinal fluid shunting being a common procedure. In rare cases, fenestration of the optic nerve may be performed prophylactically to prevent vision loss.

The recognition of cerebral venous outflow obstruction as a possible underlying cause of IIH has led to the exploration of endovascular treatments for patients with refractory cases who show evidence of transverse sinus stenosis. Stenting of the stenotic dural sinuses can help improve cerebral venous drainage. Although venous sinus stenting (VSS) has shown positive responses in treating acute and subacute IIH, recurrence is still possible, especially if patients experi-ence venous stenosis at the site of the stent or develop new stenosis elsewhere.

IR Technique**:**

During this procedure, cerebral angiography is performed using coaxial arterial catheterization along with concurrent venous catheterization, where a catheter is also introduced into the internal jugular vein. The pressure across the stenotic venous sinus is then measured, and stenting is performed if the pre- and post-stenotic gradients exceed 8 mm Hg.

A self-expanding stent, tailored to fit the length and diameter of the stenotic segment, is deployed. After stenting, manometry is typically repeated to confirm proper placement.

References:

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MSK Diseases and Interventions

Back To TOC

Osteoid Osteoma (OO)

Overview:

Osteoid osteoma is a benign osseous tumor, which is commonly seen in males in the 2nd and 3rd decades of life. Most common site is femoral and tibial metaphysis (50%). Patients usually present with nocturnal pain that is improved by non-steroidal anti-inflammatory drugs (NSAIDs).

Diagnosis and radiological findings:

Best imaging modality is non-enhanced computed tomography (CT), where a solitary hypodense nidus (center) is present with variable degree of surrounding sclerosis. The most important imaging finding is identification of the nidus, its size and location, for it will be targeted for treatment. Magnetic resonance imaging (MRI) can also be useful.
Nuclear medicine Technetium (Tc) 99 bone scintigraphy is highly sensitive showing double density sign of the nidus.

Lines of treatment and Indications for IR:

Conservative: NSAIDs.
Surgical: excision of the nidus is essential for symptomatic relief. However, intraoperative nidus localization is challenging, surgeons tend to invariably resect adjacent sclerotic bone, leading to bone weakening which may necessitate bone graft.
IR: thermal ablative procedures including radiofrequency (RFA), microwave, and laser are available options as well as cryoablation, under image-guidance. CT is superior to MRI, fluoroscopy, or ultrasound. CT-guided RFA is the preferred treatment approach.

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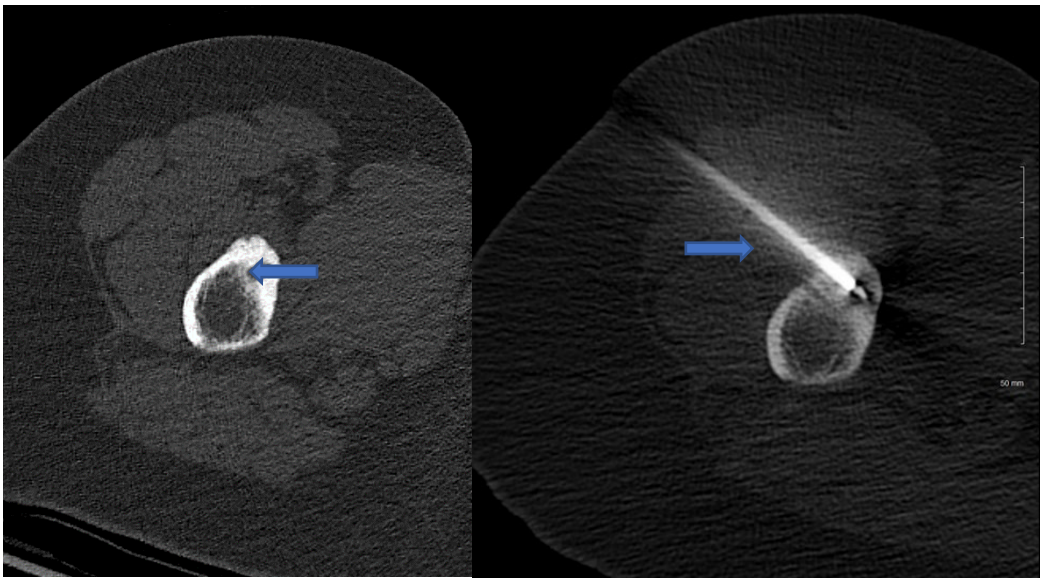

15 years old with osteoid osteoma. Osteoid osteoma seen in the femur (arrow in left image). RFA needle within the lesion (right). Case courtesy of: Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

Aneurysmal Bone Cysts (ABC)

Overview:

Aneurysmal bone cysts (ABCs) are benign, yet locally aggressive bone tumours of an expansile nature. They typically arise within the metaphysis of long bones and the posterior elements of the vertebral bodies, primarily affecting young adolescents.
Due to their expansile nature, ABCs can cause pain, swelling, and potentially lead to pathological fractures. ABCs occurring in the metaphysis of long bones may cause leg length discrepancies and result in gait impairments, while spinal ABCs can lead to neurological deficits due to mass effect. None the less, even in the absence of complications such as fractures, their neoplastic nature necessitates treatment, as they do not resolve on their own.

Diagnosis and Radiological findings:

The chief imaging modality for diagnosis of ABC's includes the plain radiograph where they appear as ballooned out lucent or lytic trabeculated lesions epi-centered eccentrically on the metaphysis of long bones near unfused growth plates causing thinning and erosion of the overlying cortex. The trabeculae in the cyst may give it a characteristic soap-bubble appearance on plain radiographs.
For spinal lesions, cross- sectional imaging may aid in defining the extent of the lesion. On CT, they appear as lucent lesions with density higher than that of fat. Characteristic fluid -fluid levels may be appreciable but will not be as evident as on MRI imaging.
Additionally, MRI can aid in detection of features such as solid components that will differentiate ABCS from other tumour entities masquerading as an ABC. Although fluid -fluid levels are characteristic of ABCS, they are not pathognomonic and can be seen in other tumours such as Giant Cell Tumours (GCTS) and telangiectatic osteosarcoma.

Lines of treatment and Indications for IR:

Traditionally, the treatment of aneurysmal bone cysts has primarily involved surgical curettage and packing, with or without adjunctive treatments such as phenolization, denosumab therapy, or polidocanol injections, aimed at reducing the relatively high recurrence rates associated with this approach. Referral to the interventional radiology (IR) unit by orthopaedic surgeons is typically considered for cases of recurrence, lesions located in anatomically challenging

areas for surgical access, lesions near open growth plates, or patients preferring minimally invasive alternatives to surgery.

Minimally invasive procedures include arterial embolization of feeding vessels, percutaneous injection of doxycycline or polidocanol sclerotherapy, percutaneous injection of calcitonin and steroids, and percutaneous thermal ablation techniques such as microwave ablation and cryoablation. These procedures are generally performed under CT guidance, with complications rarely reported.

Follow-up of treated lesions is conducted using either CT or MRI. Successful treatment is defined by clinical improvement, such as pain reduction or cessation, along with imaging findings that demonstrate sclerosis, reduction in lesion size, absence of residual cysts, and normal new bone growth.

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Vertebral Compression Fracture (VCF)

Overview:

Vertebral compression fractures (VCF) are fractures compressing the anterior cortex with sparing of the middle and posterior columns, secondary to osteoporosis, trauma, or tumors. Patients usually present with acute focal pain, sudden pain in elderlies with or without radiculopathy or kyphotic deformity.

Diagnosis and radiological findings:

- Radiographs: loss of vertebral body height anteriorly with intact posterior body cortex. Paraspinal hematoma could be seen.
- MRI: useful in cases of equivocality such as determining acuity vs. chronicity of fractures or in cases of pathological fractures. If acute, edema is usually present.
- Nuclear medicine Technetium (Tc) 99 bone scintigraphy is highly sensitive for acute fractures.

Lines of treatment and Indications for IR:

Medical management includes analgesics for pain and bisphosphonates for osteoporosis.
IR options include percutaneous vertebral augmentation with cement by vertebroplasty or kyphoplasty in patients with painful acute/ subacute compression fracture (CF), sacral insufficiency fractures refractory to conservative therapy, CF associated with neoplastic disease and traumatic VCF.

IR Technique:

A combination of local analgesics and moderate sedation is used in majority of cases. Starting with the patient's position, prone or oblique is best utilized for thoracic and lumbar CFs. Cement is injected under image guidance, through transpedicular or parapedicular approach, with the former being a safer route. In kyphoplasty, a balloon catheter is used to create space within vertebra prior to cement injection.

References:

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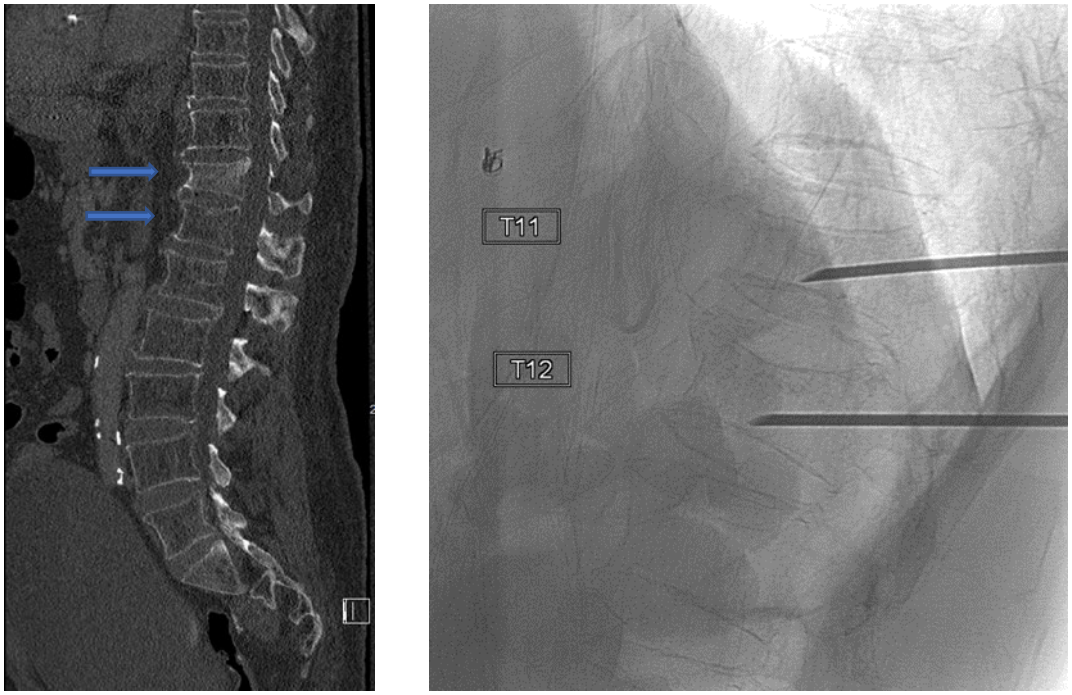
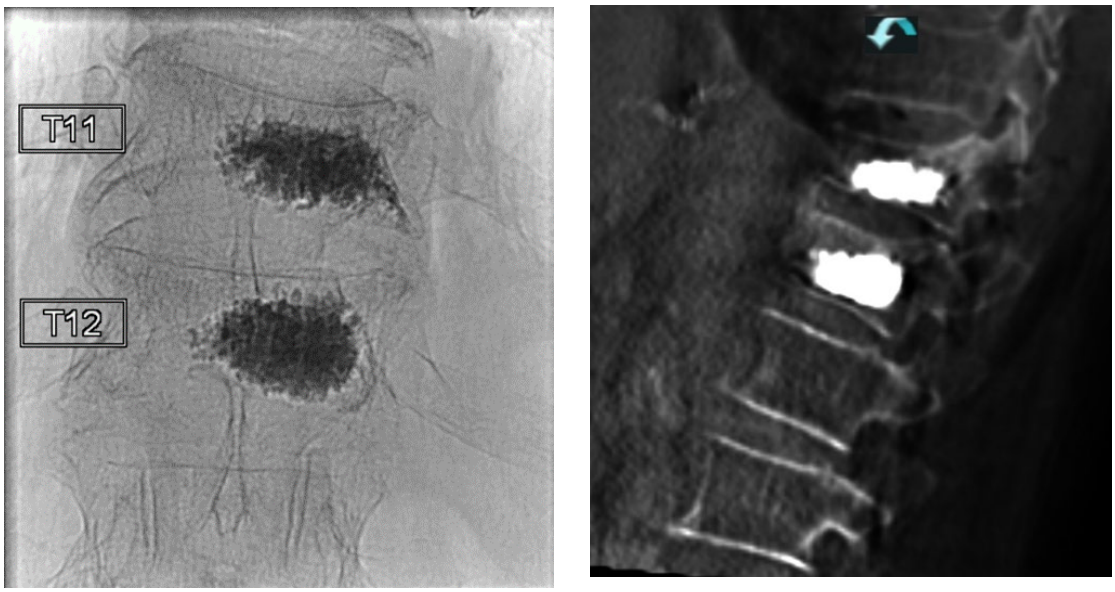


70 years old male with osteoporotic T11 and T12 vertebral bodies compression fracture seen in CT image (left). Cementoplasty needles through transpedicular approach are inserted into the affected vertebrae under fluoroscopic guidance (right).



4 mL of cement was infused at each level, achieving adequate filling of the vertebral body (left). Post cementoplasty CT images (right). Case courtesy of: Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

Metastatic Bone Tumors

Overview:

Bone metastases are the most common bone tumors. Lung, breast, and prostate cancers are common malignancies which tend to metastasize to bone. The most frequent site for metastases is the spine (especially the lumbar segments). Patients usually present with pain, limb weakness and sensory loss, bladder and bowel dysfunction, bone fractures, or may be asymptomatic.

Radiological findings and diagnosis:

CT scan is used more often than plain X-rays to detect the osteolytic (lucent foci) or osteoblastic lesions.
Skeletal scintigraphy (bone scan) allows the visualization of the metastatic bony lesions.

CT-guided biopsy is done under local or moderate sedation, differentiates between cancerous and noncancerous causes (e.g., osteomyelitis), and provides histological evidence of the primary origin of the metastases. Bone biopsy needle is introduced into the target lesion for obtaining core biopsy.

Treatment options and indications of IR:

Medical management with analgesics and surgery are available options.
IR options are palliative or curative. Palliative procedures such as pre-procedural embolization are indicated to decrease pain, tumoral bleeding, or severity of symptoms. Curative procedures include thermal ablation and are indicated in patients with low number of metastases (i.e., < 3 bone metastases measuring <3 cm in diameter each) and favorable profile.

IR Technique:

- Embolization:

Under local anaesthesia, arterial access -usually femoral artery- is obtained. Catheter is navigated to the feeding artery of the tumor and embolic particles are injected.

- Thermal ablation:

Under general anaesthesia, image guided percutaneous ablation needle is inserted targeting the bone lesion. Radiofrequency ablation (RFA) that uses electrical current and microwave ablation (MWA) that uses electromagnetic field are examples of thermal ablation techniques.

References:

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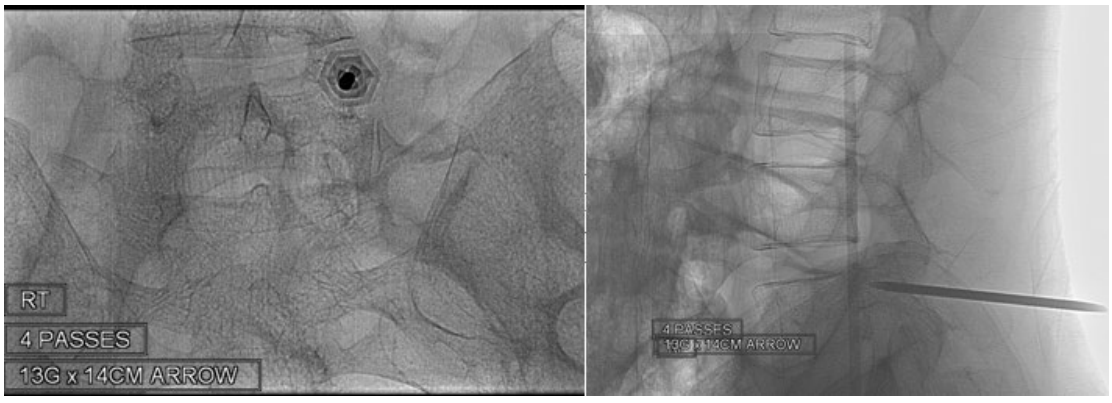

A case of metastatic colon cancer. L5 Biospy via transpedicular access is noted. Case courtesy of: Mohammad Arabi, Consultant Vascular Interventional Radiology, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabi

Soft Tissue Tumors

Overview:

Most soft tissue tumors arise from mesenchymal origins (e.g., fibrous tissue, skeletal and smooth muscle, adipose tissue, etc.). Benign soft tissue tumors occur ten times more frequently than malignant tumors. Large (> 5 cm), painful, and increasing in size soft tissue tumors are red flags that warrant further evaluation to rule out sarcomas. The lower extremities (especially the thighs) are the most common location for sarcomas (malignant soft tissue tumors). Patients mostly present with painless swelling. Other presentations include pain, neurological manifestations, or gastrointestinal bleeding.

Radiological findings and diagnosis:

- MRI is the modality of choice to diagnose most soft tissue masses. It defines the tumor characteristics, assess the tumor extent, and monitor the neoplasm response to treatment.
- Biopsy is essential to specifically diagnose the lesion, stage the disease, and guide the management. Percutaneous core needle biopsy under US, CT, or MRI guidance is performed usually under local anaesthesia.

Treatment options and indications of IR:

Surgical excision with safe margins remains the principal treatment for most soft tissue tumors. Other adjuvant and neoadjuvant therapies such as chemotherapy and radiotherapy depend on each patient's case.
IR treatment options include preoperative embolization (especially in hyper-vascular lesions) to decrease the risk of intraoperative bleeding and thermal ablation in relapses to decrease the frequency of subsequent surgeries.

IR Technique (see above, Metastaic Bone Tumors)

References:

1. WHO Classification of Tumours Editorial Board. Soft tissue and bone tumours. Lyon (France): International Agency for Research on Cancer; 2020. (WHO classification of tumours series, 5th ed.; vol. 3). https://publications.iarc.fr/588.
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Arthrocentesis ± therapeutic injection

Overview:

Diagnostic and/or therapeutic removal of accumulated joint space fluid guided by imaging techniques such as ultrasound, fluoroscopy, or CT. Patient usually presents with joint pain with or without hotness, tenderness, swelling, and limited range of motion depending on the pathology itself.

Diagnosis and radiological findings:

Definitive diagnosis is by arthrocentesis.

Ultrasound, besides being used in guidance and quantification, gives real-time visualization of the joint space showing joint effusion, extent of involvement, ± increased vascularity in case of inflammation and septic arthritis.

CT and MRI both show joint effusion and further periarticular involvement whether bony or cartilaginous.

Lines of treatment:

Depending on the cause of effusion, medical treatment could be tailored yet arthrocentesis plays both a therapeutic and palliative role in almost all cases.

IR management option, indications, and technique:

- Indications:

- Septic arthritis for diagnosis and treatment
- Confirming the diagnosis of crystal arthropathy
- Hemarthrosis aspiration

In case of long-standing, non-specific, undiagnosed articular and peri-articular pain not diagnosed with conventional imaging, MR and to less extent CT arthrography procedure as arthrocentesis could be done with injection of contrast into the designated space to diagnose tendinopathy and further PRP or injection in case of confirmed diagnosis.

References:

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Genicular Artery Embolization (GAE)

Overview:

GAE is a new safe and effective minimally invasive, trans arterial nonsurgical procedure which selectively targets the hyper vascular geniculate arteries supplying the joint synovium.

Indications:

- Patients with symptomatic knee osteoarthritis (OA) who are non-responsive to the conservative medical treatment and ineligible for knee replacement therapy.
- Hemarthrosis of the knee not responding to medical treatment.

IR technique:

Arterial access is obtained likely through femoral access, and an angiography is performed to select the targeted genicular branches. Embolic materials are injected to decrease the blood perfusion and abort the inflammatory cycle and neo-angiogenesis that are associated with the pathophysiology of OA. Consequently, the procedure reduces pain symptoms.

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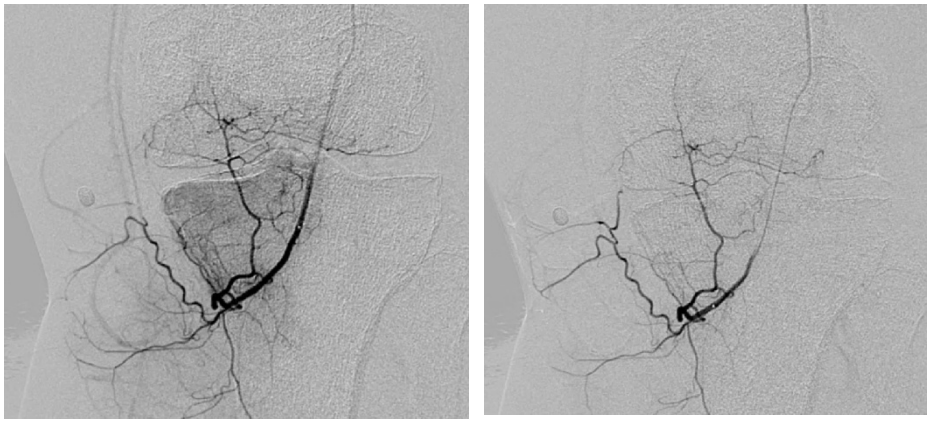


Genicular artery embolization pre (Left) and post (Right) particles embolization. Case Courtesy of Yuji Okuno, Ocuno Clinic, Japan

Scan me

MSK Interventions

Scan me

Genicular Artery Embolization

Back To TOC

Endocrine Diseases and Interventions

Back To TOC

Thyroid nodules

Overview:

Thyroid nodules are abnormal lumps that develop within the thyroid gland. They are a common problem, despite the fact that most of them are benign; malignant cells were found in 10-15%.[1] Patients are usually asymptomatic yet those with large nodule may complain of dysphagia and shortness of breath or simply neck swelling.

Radiological findings and diagnosis:

Ultrasound is used as the primary imaging study. Nodules are classified using Thyroid Imaging Reporting and Data System (TI-RADS) developed by the American College of Radiology (ACR).[2]

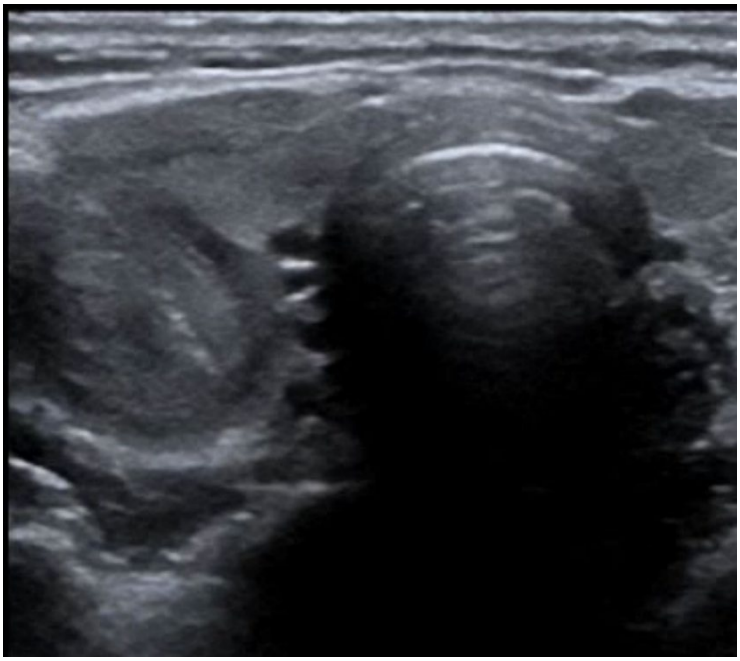
Thyroid nuclear scan detects the site and the activity of the thyroid gland whether hot or cold nodules along with detecting whether the activity is thyrotoxic or not.

Biopsy specimens are obtained usually via fine needle aspiration (FNA). The core biopsy can be useful when the FNA is inconclusive, or lymphoma is suspected.

IR Technique of FNA:

Fine Needle Aspiration (FNA):

- Review the prior imaging to pick out the nodule that meets the criteria for biopsy.
- Localize the lesion under the US, then mark the entry site on the skin.
- Use an antiseptic to cleanse the area and drape the area.
- A sterile probe cover is applied.
- Inject one ML of lidocaine 1% into the superficial area of interest.
- Be sure the patient is stable, do not move or speak.
- Use a 25–27-gauge needle, afterward, advance into the nodules under US guidance. The needle may be attached to a syringe as a holder. Use to-and-fro action to obtain an FNA sample.
- Place the aspirated material on the slide, which can be checked by cytotechnologists for diagnostic quality.



US guided FNAC of a right lobe thyroid nodule with needle seen within thyroid nodule. Case courtesy of Karim Abdel Tawab, IR consultant, Ain Shams University hospitals, Egypt

IR Treatment options and indications:

Thermal Ablation:

Thermal ablation is a minimally invasive procedure performed by an IR as an alternative to surgical treatment in some patients with benign thyroid nodules.

Types of thermal ablation for thyroid nodules:

- Radiofrequency Ablation (RFA): uses high-frequency electrical currents that generate heat destroying the thyroid nodule tissue
- Microwave Ablation (MWA): uses microwave energy to generate heat that destroys the thyroid nodule tissue
- Laser Ablation (LA): uses laser energy that generates heat destroying the thyroid nodule tissue
- High-Intensity Focused Ultrasound (HIFU): uses ultrasound waves to generate heat that destroys the nodule tissue

Indications:

- Treatment of benign solid or predominantly solid nodules in symptomatic patients.
- Treatment of autonomously functioning thyroid nodules as the second choice to surgery or radioiodine treatment.

IR Technique:

The IR uses a small needle electrode or laser fiber to be inserted into the thyroid nodule under ultrasound guidance. the thermal warmness generated at the needle tip destroys the targeted tissue. While surgical resection results in a seen scar, the ablation process is minimally invasive and allows patients to resume normal day-by-day activities with minimum recovery time. Whilst the surgical procedure involves cutting off part of the thyroid which may result in hypoparathyroidism, ablation maintains thyroid integrity.

Alcohol ablation technique can be used in patients with cystic or fluid-filled nodules.

US guided RFA thyroid nodule ablation with RFA needle seen within thyroid nodule. Case courtesy of Karim Abdel Tawab, IR consultant, Ain Shams University hospitals, Egypt

Thyroid Artery Embolization (TAE):

Indications:

This is an emerging minimally invasive technique that has gained popularity over its more invasive surgical counterpart in the treatment of diffuse toxic goitre and large multi-nodular goitre (MNG), where percutaneous ablation has proven impractical. For instance, in a large plunging goitre, where anaesthesia may prove difficult and may also require a chest surgical incision, embolization may successfully lead to the goitre becoming smaller with improvement of compressive symptoms and cosmesis. In cases of Hyperthyroidism whether due to Graves' disease or the presence of one or more toxic nodules on a background of MNG, embolization may aid in the normalization of thyroid hormone levels in addition to a reduction in size of goitre. TAE can also be more effective than percutaneous RFA in patients with very large solitary nodules exceeding 6 cm in diameter.

Technique:

The procedure can be performed via a trans-radial or femoral arterial approach using the Seldinger technique performed under local anaesthesia. A 5F-angiographic catheter such as a vertebral catheter is then advanced over a hydrophilic guide wire through the arterial access gained under fluoroscopic guidance. The superior and inferior thyroid arteries must be accurately identified by contrast injection and Digital Subtraction Angiography (DSA)is performed of the four vessels. This step is crucial to assess which portions of the thyroid gland each branch supplies and to accurately identify those vessels which feed the nodules and those primarily supplying the healthy parenchyma. This information is used for determining which vessels will need to be embolized. Out of the four main vessels, usually a maximum of 2 or 3 vessels are embolized leaving at least one vessel patent to prevent hypoparathyroidism and potentially hypothyroidism.

After the feeding arteries are identified, super selective catheterization with subsequent DSA of these arteries is performed using a microcatheter. Embolization is then performed using particles such as diluted Polyvinyl Alcohol ranging from 150–300 mm in diameter, small enough to occlude the smallest vessel whilst minimizing the risk of particles migrating into the systemic circulation and causing distant embolization elsewhere. Some interventionalists may add a coil to occlude the proximal segment of the vessel after particle embolization. Others however may choose to abort this step owing to both its cost and the fact that it may hinder repeated embolization if the need to do so arises.

Selective angiography is routinely performed post-embolization to ensure the targeted arteries are completely occluded. The patients may be kept under observation overnight.

Post-procedural medication including a corticosteroid and prophylactic antibiotic is usually given in the week following the procedure. After the embolization, patients may experience some neck pain and temporary hyperthyroidism for some weeks. Follow-up of thyroid hormone levels and imaging such as US is done at regular intervals.

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Thyroid Interventions, first part

Pituitary Adenomas

Overview:

Pituitary adenomas are tumors that arise from the anterior pituitary gland. Most adenomas are benign. Functioning adenomas can secrete different hormones depending on the type of cell they are raised from. Non-functioning adenomas do not secrete hormones, yet they can compress the adjacent structures leading to hormonal deficiencies.

Role of IR In diagnosis:

Inferior petrosal vein sampling (IPSS)

It is a minimally invasive procedure used to take samples from veins that drain the pituitary gland, afterward adrenocorticotropic hormone (ACTH) levels are analyzed and compared to ACTH levels in the blood to distinguish the source of hypercortisolism (Cushing syndrome). Pituitary-dependent Cushing syndrome leads to meaningful levels of ACTH in venous samples from the pituitary veins compared to peripheral blood, at the exact contrary, a high level of ACTH in the peripheral blood compared to pituitary veins suggests optic ACTH secretion. Moreover, this procedure also can determine the exact location of the tumor in the pituitary gland.

Indications:

- For patients with biochemical evidence of ACTH-dependent hypercortisolism who had MRI with no detectable tumor, and no other cause of Cushing syndrome is found.
- For cases with discrepancies between imaging studies and biomedical findings, or who do not respond to hormonal tests.
- For patients with post-hypophysectomy with persistent Cushing syndrome.[3]

IR technique:

- Review prior imaging to identify the inferior petrosal sinus anatomy.
- General anaesthesia is required for the procedure.
- Obtain bilateral trans-femoral venous access using a vascular sheath.
- Administer IV heparin dose, if the procedure takes more than one hour, re-administer another dose of heparin.
- Vertebral catheters are advanced bilaterally under fluoroscopic guidance to the internal jugular veins. Thereafter, injection of the contrast is done once

the catheter is in the jugular bulb, and the reflux of contrast into the inferior petrosal sinus guides the placement of the micro-catheter.

- Perform digital subtraction venography to confirm the placement of the micro-catheter.
- Use one micro-catheter for each sinus.
- Before taking the sample, progress micro-catheters concurrently, as close as possible to the cavernous sinus through the petrosal sinus.
- Collect blood samples from both catheters simultaneously and a peripheral vein.
- Administer corticotrophin-releasing hormone (CRH).
- Concurrent, sequential samples should be obtained.
- Submit samples for laboratory assays.

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Primary hyperaldosteronism

Overview:

Primary hyperaldosteronism, or Conn's syndrome, is a cause of unexplained resistant hypertension due to either unilateral, mostly adrenal adenoma, or bilateral idiopathic adrenal hyperplasia. Patients usually present with drug resistant hypertension, especially in young age, and hypokalemia. Symptoms include muscle cramps, paresthesia, palpitations and frequent urination.

While adrenal adenomas could be detected on cross sectional imaging, the majority of them are non-functional. Functioning adrenal adenoma does not necessarily appear on imaging making the management decision hard due to inability to localize the cause. Adrenal venous sampling localizes the causative gland aiding the endocrinologists and surgeons in the management and sparing the normal gland surgically.

Diagnosis and radiological findings:

After excluding secondary causes and narrowing down the differentials to primary adrenal etiologies by lab work, CT and MRI can be used to visualize adrenal causes as congenital adrenal hyperplasia and adrenal adenomas.

Catheter directed adrenal venous sampling localizes the causative gland.

Lines of treatment:

Includes medical treatment with spironolactone or eplerenone ± management of hypokalemia or surgical treatment in medically indicated patients and those with unilateral etiology.

IR indications and technique:

Adrenal venous sampling plays a crucial role in determining a definitive diagnosis and eventually guiding the surgery for unilateral adrenalectomy.

Under local anaesthesia and preferably through CFV access, catheters are advanced to the IVC and selective catheterization of left adrenal veins is obtained. Based on the lab requirements and after being sure that the catheters are placed in the right position, sufficient blood samples are collected from both

veins and the IVC/femoral veins with proper labeling of each sample to the side obtained from. The procedure can be done before and after administrating ACTH to stimulate the adrenal glands. Tests are then run to determine the aldosterone and cortisol levels from each sample, hence determining the site of the etiology and guiding the management.

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Breast Diseases and Interventions

Breast Lumps

Overview:

Breast lumps are concerning symptom for women, they can be of benign nature as breast cysts, benign tumors as fibroadenoma, inflammatory as breast abscess, or of malignant nature. Breast cancer is the most common cancer diagnosed in women, accounting for more than 1 in 10 new cancer diagnoses each year worldwide.

Diagnosis:

Assessment of breast lumps needs a triple assessment including clinical evaluation, imaging (Ultrasound, mammography and/or MRI), and tissue biopsy.

Treatment options and indications of IR:

- Treatment of breast cancer includes surgery with or without radiotherapy for local control. Systemic therapy is indicated for patients with metastatic disease or for palliation.
- Treatment options for benign fibroadenomas include serial observation, excision by minimally invasive image guided large bore needle core biopsy, ablation commonly cryoablation, and surgical excision.
- Treatment of breast abscess includes surgical drainage or minimally invasive US guided drainage with proper antibiotics administration and treatment of the risk factors.

Role of IR in management of Breast tumors:

- Based on the imaging features, the Breast Imaging and Reporting System (BIRADS) published by the American College of Radiology (ACR), provided a classification system for breast masses and biopsy criteria. It ranges from 1 through 6, the greater the classification, the higher the likelihood of cancer.

(1) Core biopsy procedures which can be:

- **US guided biopsy**
- **Stereotactic biopsy**
- **MR guided biopsy**

- Breast biopsy is indicated for suspicious breast lesions according to the BIRADS scoring system (BI-RADS 4 or 5) for diagnostic values.

- There are different ways to take tissue samples, and these include US guided fine-needle aspiration cytology (FNAC), Tru-cut core needle biopsy (CNB), Vacuum Assisted Biopsy (VAB), and incisional or excisional biopsy.
- The role of fine-needle aspiration biopsy has been reduced lately due to its low sensitivity and specificity as well as a high rate of non-diagnostic, suspicious and false negative results. This method does not enable one to differentiate between in situ and invasive disease. Currently, fine-needle biopsy is recommended only for cystic lesions.
- Compared to VAB, CNB is less invasive, yields smaller specimens. VAB uses a suction system, which allows a larger tissue sample to be obtained from a single insertion.
- US-guided VAB under local anaesthesia can be used to remove benign pathologically proven lesions such as fibroadenomas as an alternative to the surgical excision.

US guided Biopsy

Ultrasound is used to guide the needle to obtain biopsy from a suspicious lesion based on the (BIRADS) system.

Technique:

While the patient lies in the supine or lateral decubitus position and under aseptic conditions, US guided infiltration of local analgesic in the subcutaneous, intradermal and breast tissue is done to provide adequate local anaesthesia for the patient. The needle is then advanced, under US guidance, through the breast tissue toward the lesion and a core biopsy is obtained.

Stereotactic Biopsy

In lesions seen only or most clearly on mammograms such as suspicious microcalcifications, asymmetries, masses, or areas of architectural distortion that are not recognized on US, X ray guidance is used to advance a needle and obtain biopsies from the suspicious lesion indicated by the BI-RADS.

Technique:

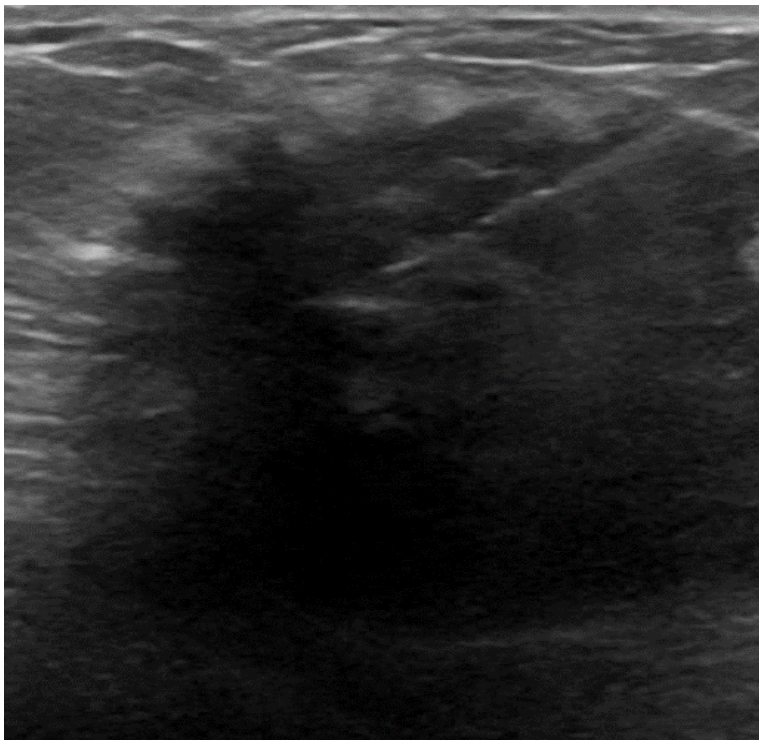
Under aseptic condition, infiltration of local anaesthesia is done while the patient is either in a prone or standing position with the breast firmly compressed between two plates, the mammogram is used to highlight the lesion, then the biopsy is obtained.

MR guided Biopsy

It is used for lesions that can't be identified using the conventional imaging modalities, including ultrasound and mammography.

Technique:

The lateral approach is the standard approach using a co-axial needle. Using a 1.5 or 3T MRI and an open breast coil, the patient lies in prone position while the breast is stabilized between a plastic plate and the grid providing moderate compression. Under aseptic technique, adequate infiltration of local anesthetic to the skin and within the breast tissue is done, the co-axial introducer is introduced through the mini grid within the target lesion and then a plastic obturator is used to replace the metallic stylet to re-image patient prior to sampling to ensure adequate positioning of the needle before biopsy. Once adequate position is confirmed the biopsy needle can be placed in position and the sample is obtained.



US guided breast biopsy in a suspicious breast lesion. Case courtesy of Karim Abdel Tawab, IR consultant, Ain Shams University Hospitals, Egypt

(2) Breast localization for the tumors

Many Patients undergoing breast conservative surgery requires preoperative localization of the lesion under image-guidance, during which a certain device is localized within or adjacent to the target lesion to guide the surgeon intraoperatively for an adequate safety margin.

The localization technique is used for localization of either small nonpalpable tumors detected during screening mammography or in patients with adequate shrinkage of the tumor after neoadjuvant chemotherapy.

There is either wire or non-wire localization technique.

Wire localization:

Mostly done 24 hours prior to surgery. It is considered the standard for pre-operative tumor localization.

Technique:
The procedure is done under local anaesthesia. While the patient lies in the supine or lateral decubitus position and under US guidance, the wire is introduced within the breast tissue to the target lesion with the proximal end of the wire advanced adjacent to the lesion while the distal end of the wire is kept outside of the breast tissue.

Non-wire localization (NWL):

NWL devices are also used for preoperative localization. These devices include radioactive seeds, magnetic seeds, radar reflectors, clip marker and radiofrequency identification tag localizers (RFIDs)
The intramammary clip serves as a mark for pre-operative guidance or for radiologists to later monitor cases where there is a risk that the tumor may not be clearly visible on imaging after chemotherapy or tumor ablation.

Technique:
The procedure is done under local anaesthesia, while the patient lies in the supine or lateral decubitus position. NWL device is introduced through the breast tissue and inserted within the lesion under image guidance, commonly US guidance.

(3) Breast Tumor ablation:

Image guided percutaneous ablation is a minimally invasive procedure that has been recently considered alternative/adjacent to surgery in the management of breast tumors whether benign or malignant.

Ablation procedures include:

1- **Cryoablation:** a cryoprobe (with high pressure, closed loop gas expansion system) is introduced percutaneously to the center of the tumor under US or CT guidance (preferable since it provides more anatomical details). Tumor cells are killed due to direct injury from freezing and thawing of tissue as well as from damage to the micro-circulation.

Indications for cryoablation includes:

- Symptomatic benign fibroadenoma (less than 4 cm)
- Primary (< 2cm), invasive ductal tumor or ductal carcinoma in situ, where there is no or little in situ lesion, located at least 1 cm from the skin surface
- Patients with contraindication to surgery under GA or patients with personal preferences not to perform surgery.

2- **Radiofrequency ablation (RFA):** for small malignant tumors and fibroadenoma, reported to be of high success rate and low complication rate. However, in malignant lesions, standard adjacent surgery may be needed after the procedure.
RFA use both electrical energy and heat to destroy tumor cells. it is commonly done under US guidance where the electrical tip is inserted percutaneously to be placed within the breast tumor. The tumor is, then, ablated under live US monitoring.

3- **Other minimally invasive procedures** that may help in the treatment of early breast cancers or benign fibroadenoma includes:

- Microwave ablation that uses electromagnetic waves for heat ablation
- High intensity focused Ultrasound (HIFU) causing heat and tissue coagulative necrosis.
- Laser ablation where a portable diode laser is used to generate heat within the tissue.

(4) Role of US in Axillary lump management

Lymph node ultrasonography with image guided lymph node biopsy from suspicious looking lymph nodes play an important role in defining the extent of breast cancer hence aids in staging the disease before neoadjuvant chemotherapy. Also, under image guidance like breast tumor localization, a clip can be inserted within the suspicious lymph node to demarcate lymph nodes with documented metastases.

Technique:

Under local anaesthesia, while the patient lies in a supine position, the lesion is localized using US, then an US guided lymph node core needle biopsy is obtained with or without insertion of a clip for localization of the affected lymph node.

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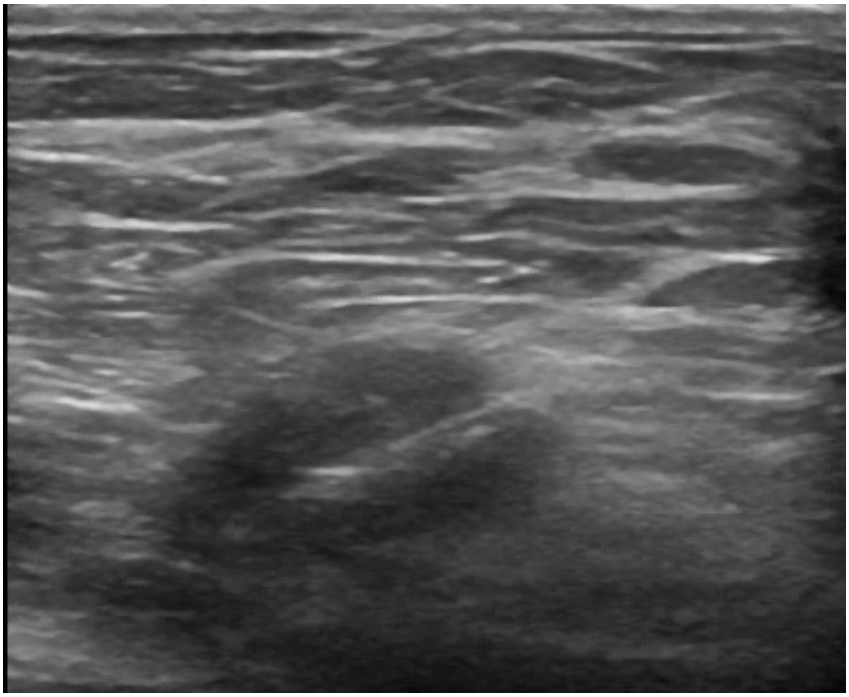
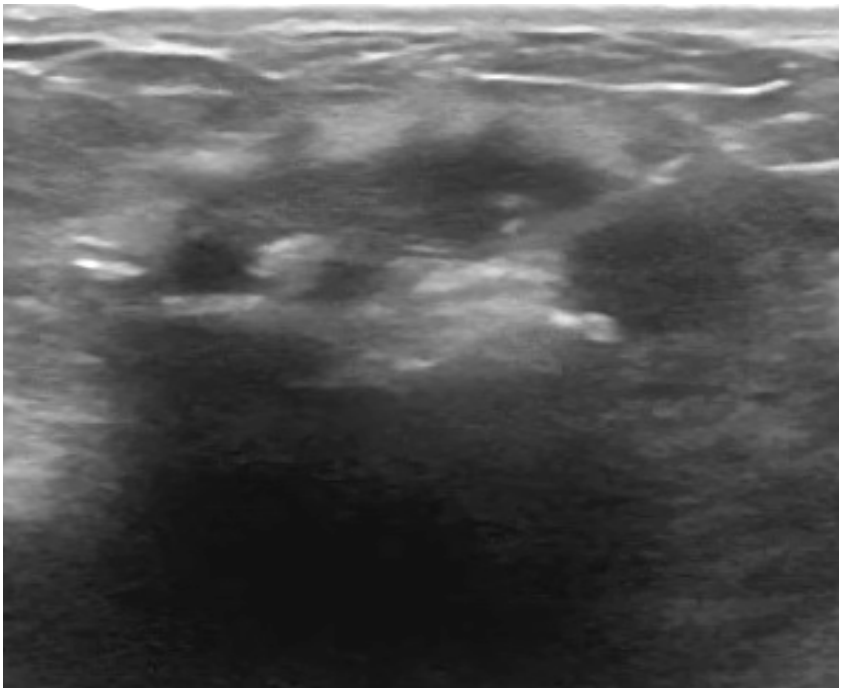
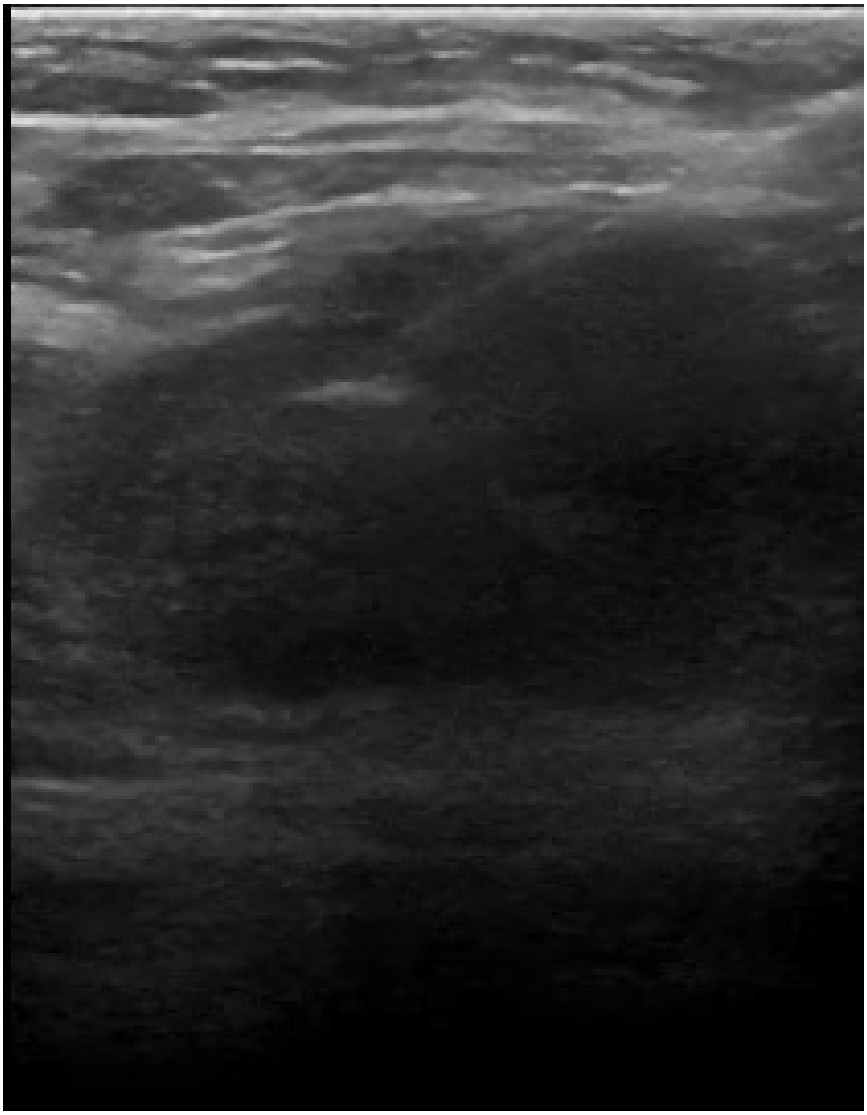


US guided breast wire localization in a non palpable breast mass. Case courtesy of Karim Abdel Tawab, IR consultant, Ain Shams University Hospitals, Egypt



RF ablation of small breast fibroadenoma. Case courtesy of Karim Abdel Tawab, IR consultant, Ain Shams University Hospitals, Egypt



US guided suspicious Lymph Node biopsy. Case courtesy of Karim Abdel Tawab, IR consultant, Ain Shams University Hospitals, Egypt

PAIRS