Interventional radiology

Basic anatomy

The following tunics are encountered in arterial vessels from the inside out:

- the intima (internal tunic composed of a single layer of epithelial cells lining the vascular lumen);
- the media (contains collagen and elastin fibers, as well as smooth muscle fibers, with longitudinal and circumferential disposition, with direct involvement in carrying the blood from the heart towards the periphery, but also in adjusting the volume of blood based on the nutrients necessity);
- adenticea (external tunic with collagen and elastin fibers, as well as fibroblasts).

The vascularization of the intima and media comes from the arterial lumen by diffusion, while the external tunic has its own arterial vascularization, called vasa vasorum, found in the large arterial type vessels.

The same 3 tunics are encountered in venous vessels from the inside out also, but differentiating them is difficult compared to the arterial vessels. Also, the wall of the venous vessels is subjected to a lower pressure than the arterial vessels and has a thinner and less elastic wall. In addition, the veins located below the heart have bicuspid valves that move the volume of blood from the periphery to the heart in an anti-gravitational sense and prevent blood regurgitation.

Arterial puncture – Seldinger technique

In most cases, the femoral artery puncture is preferred due to the increased size, superficial disposition and possibility to perform manual hemostasis by compressing it on the femoral head. The femoral artery can be identified in the Scarpa triangle along with the other two similar anatomical elements (femoral vein and femoral nerve). ***Their disposition from medial to lateral in the Scarpa triangle, in the femoral sheath, is: femoral vein, femoral artery and femoral nerve***. The puncture of the femoral artery is made at the level of the inguinal plica, where the arterial pulse with maximum intensity is felt. In order to perform a femoral vein puncture, the femoral vein is located on the inner part of the femoral artery, at about 1 cm inside the Scarpa triangle.

Arterial puncture – Seldinger technique

The Seldinger technique involves the following steps:

- local anesthesia with Xylin 1-2% is performed;
- penetration with the Seldinger needle in the middle of the vessel at 45 °;
- when the needle is in the lumen of the vessel, the short guide is inserted;
- the short guide stays in place, while the puncture needle initially introduced is removed;
- the introductory sheath provided with a system that does not allow blood to flow is advanced on the previously introduced guide;
- the introductory sheath remains in place and serves as a tool to insert and use the rest of the instruments, while the previously introduced short guide is removed.

Alternative arteries for puncture

When the femoral artery is not accessible for various reasons, the axillary, brachial or radial arteries can be used.

The axillary or brachial approach can be practiced in the presence of the following indications:

- treatment of lesions affecting the arterial vessels of the upper limbs;
- lack of pulse in the femoral arteries (bilateral);
- occlusion of the abdominal aorta.

The axillary or brachial approach involves a number of complications and is rarely used. Also, the radial approach is difficult to achieve for the operator due to the low caliber of the radial artery.

Digital subtraction angiography

The technique of digital subtraction angiography involves obtaining an initial radiological image, in the absence of intravascular administration of a contrast agent. Subsequently, the contrast substance is administered intravascularly and a new radiological image is acquired. This technique involves a subtraction between the initial image (without intravascular contrast) and the one obtained subsequently (with the presence of intravascular contrast). The final image resulting from this process is the vascular lumen filled with contrast.

This angiography technique involves keeping the patient in a fixed position, still, in apnea, and offers a number of advantages, including:

- a smaller volume of intravascular contrast agent is used;
- decreased irradiation of the medical staff and patient.

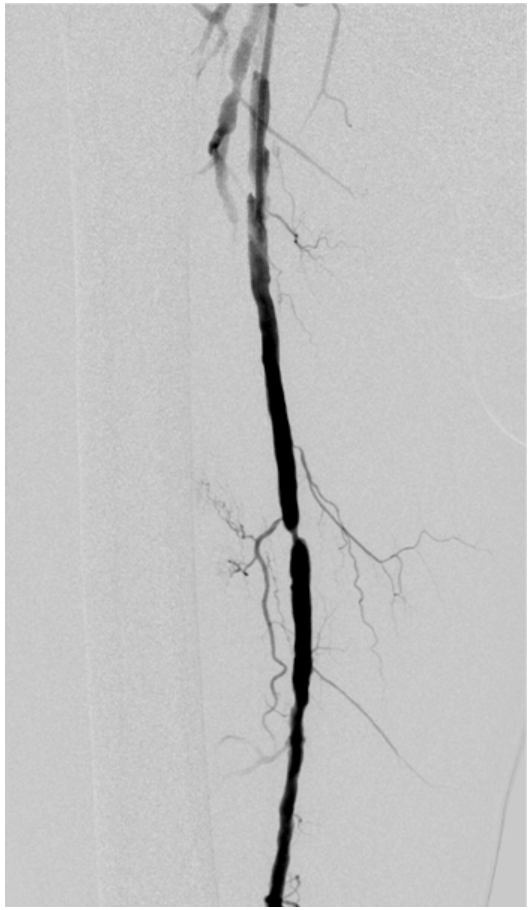
Upper limbs arteriography

- involves an inguinal approach;
- the brachial approach can be used to investigate the contralateral upper limb;
- with regard to the contrast substance administered intravascularly, a volume of up to 20 ml may be used;
- oblique incidences are used;
- this technique provides information on the size and walls of the vessel, the presence of lesions such as aneurysms or arteriovenous fistulas, stenosis with proper evaluation of the stenotic degree, specify the type of occlusion (caused by thrombus, embolus or extrinsic compression).

Lower limbs arteriography

- begins by examining the pulse in the femoral arteries bilaterally and establishing the inguinal approach path on the side where the pulse is felt more strongly;
- the brachial approach can also be used;
- with regard to the contrast substance administered intravascularly, a volume of up to 40 ml may be used;
- oblique incidences are used;
- this technique provides information on the size and walls of the vessel, the presence of lesions such as aneurysms or arteriovenous fistulas, stenosis with proper evaluation of the stenotic degree, specify the type of occlusion (caused by thrombus, embolus or extrinsic compression).

Lower limbs arteriography



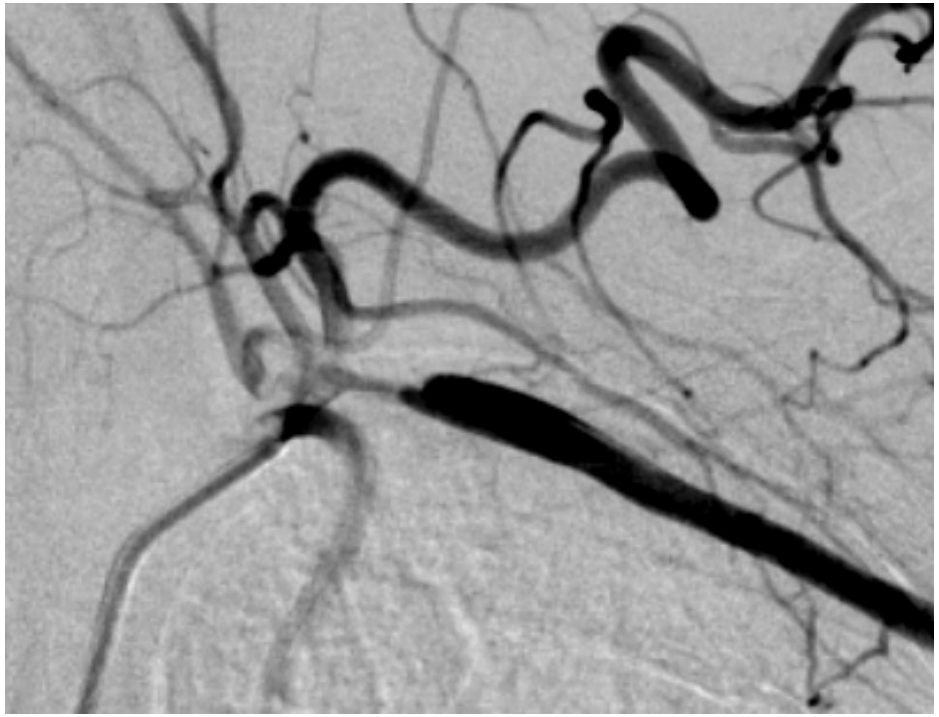
Femoral artery critical stenosis

Occlusion of the femoral artery

Subclavia, carotid and vertebral arteriography

- usually, the inguinal approach is preferred;
- with regard to the contrast substance administered intravascularly, a volume of up to 20 ml may be used;
- oblique incidences are used;
- this technique provides information on the size and walls of the vessel, the presence of lesions such as aneurysms or arteriovenous fistulas, stenosis with proper evaluation of the stenotic degree, specify the type of occlusion (caused by thrombus, embolus or extrinsic compression).

Subclavia, carotid and vertebral arteriography



Stenosis of the subclavian and vertebral arteries

Thoracic aortography

- mainly, the femoral approach is used;
- the brachial approach can also be used when the femoral pulse is absent bilaterally or when there is suspicion of aortic lesions in a posttraumatic context or aortic dissection;
- initially, the right posterior oblique incidence is used and then other types of incidences are used for a correct evaluation of the lesions;
- this technique visualizes the ascending aorta, the aortic cross together with the emerging branches and the descending aorta in the intrathoracic portion;
- this technique provides information on the size and walls of the vessel, the presence of lesions such as aneurysms or arteriovenous fistulas, stenosis with proper evaluation of the stenotic degree, specify the type of occlusion (caused by thrombus, embolus or extrinsic compression).

Abdominal aortography

- in the absence of contraindications, the femoral approach is used;
- initially, the antero-posterior incidence is used and then other types of incidences are used for a correct evaluation of the lesions;
- next to the T12, L1 and L2 vertebral bodies, on the anterior wall of the abdominal aorta, the emergence of the celiac trunk and the superior mesenteric artery are located;
- the emergence of the inferior mesenteric artery is located on the left antero-lateral wall of the abdominal aorta, near the L3 and L4 vertebral bodies;
- this technique provides information on the size and walls of the vessel, the presence of lesions such as aneurysms or arteriovenous fistulas, stenosis with proper evaluation of the stenotic degree, specify the type of occlusion (caused by thrombus, embolus or extrinsic compression).

Upper limb flebography

- involves catheterization of a vein located at the forearm level;
- visualization of the superior vena cava can be achieved by intravascular administration of the contrast substance on the catheter inserted in the femoral vein or internal jugular vein.

Lower limb flebography

- the patient is positioned in dorsal decubitus with the lower limb in a declining position to allow the superficial venous system to be filled;

- a dorsal vein is catheterized as superficial and as lateral as possible;

- the contrast substance administered intravenously moves from the ankle to the thigh through the superficial and deep venous systems;

- to facilitate the filling and visualization of the iliac veins and the inferior vena cava, respectively, compression maneuvers can be performed on the calf and thigh.

Flebography complications

- in an allergic patient, they may develop an allergic reaction, the severity of which depends on the response of the individual immune system and the amount of contrast substance administered intravascularly;

- in the context of renal impairment, the patient may develop nephropathy following the administration of contrast agent, the severity of which depends on the degree of renal impairment and the amount of contrast substance administered intravascularly;

- the possibility of developing a venous thrombosis;

- possibility of extravasation at the injection site.

Diagnosing atherosclerotic disease using angiography

- angiography is the gold standard for diagnosing arterial lesions;
- atherosclerotic disease is a disorder with a slow evolution over time, which allows multiple collateral branches to develop in order to shortcircuit the affected area;
- changes that suggest atherosclerotic disease: the presence of multiple collateral branches, filling defects (occlusions, stenoses);
- to correctly and completely characterize an injury, it is necessary to measure the length of the lesion, as well as the diameter of the vessel before and after the lesion;
- after the diagnosis is established, endovascular therapeutic methods can be applied (stent implantation).

Diagnosing aneurysms using angiography

- the aneurysm implies a focal or diffuse enlargement of the arterial diameter by more than 50%;

- most commonly, the aneurysms are located in the abdominal aorta, inferior to the emergence of the renal arteries;

- there are several types of aneurysms:

a. fusiform aneurysms - in which the entire circumference of the vessel is affected, and all 3 tunics remain intact;

b. saccular aneurysms - in which the rupture of one or more vascular tunics occurs and has a saccular shape (this type of aneurysm resembles the diverticula developed in the digestive tract);

- as a rule, fusiform aneurysms appear in a degenerative context, and saccular aneurysms appear in a post-traumatic or infectious context.

Diagnosing thrombosis using angiography

- thrombosis development involves the pathogenic mechanisms described by the Virchow triad: venous stasis, vascular wall injury and hypercoagulant status;
- the arterial approach is performed remotely or contralaterally;
- in angiography, thrombosis is seen as an intraluminal filling defect;
- if the thrombosis developed slowly, over time, there is a possibility to highlight a well-represented collateral circulation;
- if there is an acute episode of thrombosis, the network of collateral vessels is missing or insufficiently developed and thus raises problems of differential diagnosis with pulmonary embolism;
- after establishing the diagnosis with certainty, endovascular therapeutic methods (thrombolysis, thrombo-aspiration, stent implantation) can be applied.

Diagnosing embolism using angiography

- embolus refers to any free material in the bloodstream that can cause an obstructed blood flow inside a vessel and can be represented by blood clots formed in the heart cavities, endocardial vegetations, gas bubbles or foreign bodies;

- just like in thrombosis, the arterial approach is performed remotely or contralaterally;

- the collateral circulation is insufficiently developed in relation to the need for oxygen and nutrients;

- it is important to accurately locate the occlusion, as well as to evaluate the circulation in the portion located distally to the occlusion area;

- after establishing the diagnosis with certainty, endovascular therapeutic methods (aspiration) can be applied.

Indications for endovascular treatment in atherosclerotic disease

- patients who have resting pain and moderate or severe claudication;
- ideally, a lesion that requires endovascular treatment:

a. is unique;

b. has small dimensions;

c. is concentric;

d. does not present calcifications;

e. is not occlusive;

f. affects a high caliber vessel;

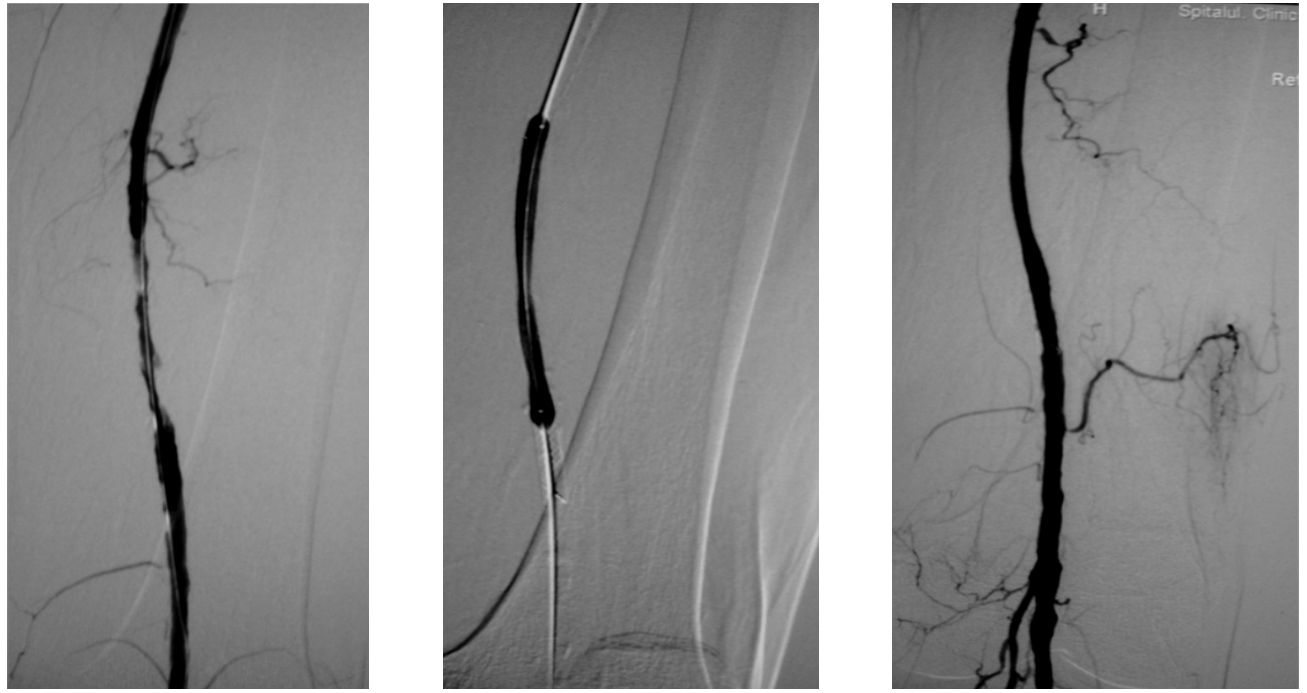
g. the patient presents with intermittent claudication.

Percutaneous transluminal balloon angioplasty

The technique of percutaneous transluminal balloon angioplasty (PTA) involves the following stages:

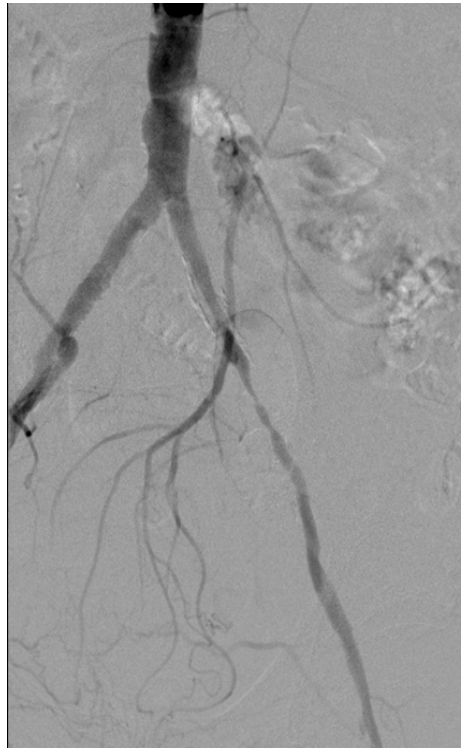
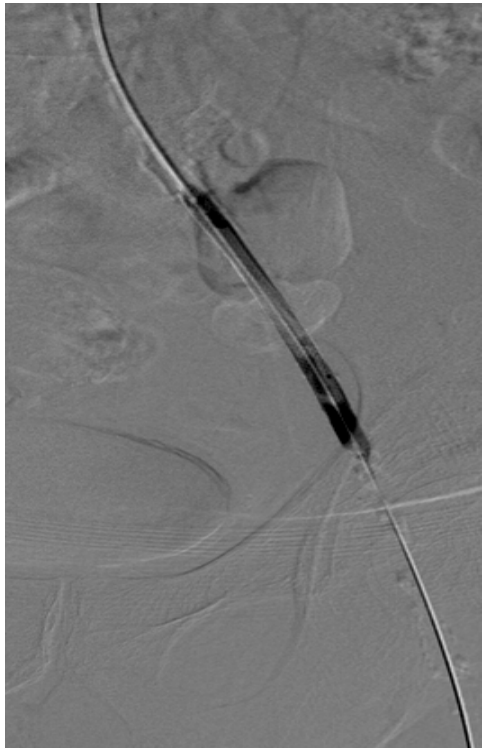
- initially, the introductory sheath is introduced in an area proximal to the stenosis and an angiography is performed to establish the diagnosis with certainty;
- subsequently, the lesion is bypassed with a guide on which the catheter with the balloon will be inserted;
- at the beginning, the balloon with the smallest diameter is chosen, able to cross the lesion and, afterwards, through progressive inflation of the balloon in the stenotic area, endothelial cells peel off and generate dissection of the atheroma plate and the intima of the affected area, so that the arterial lumen is enlarged and the atheroma plate no longer manifests a compressive effect;
- the healing of the denuded endothelium is performed in a period of several weeks;
- the affected area of the vessel is dilated with the help of the balloon until it reaches a diameter similar to the rest of the vessel;
- during balloon inflation, most patients experience local discomfort, but if the pain is significant, then the doctor will opt for deflating the balloon and replacing it with a smaller one;
- in the event that the patient continues to feel pain even after the balloon deflates, then an arterial rupture is suspected.

Percutaneous transluminal balloon angioplasty



Occlusion of the femoral artery + PTA

Percutaneous transluminal balloon angioplasty


Occlusion of the left common iliac artery + PTA

PTA complications

- arterial perforation;
- vascular rupture;
- limited arterial dissection;
- thrombosis;
- embolization;
- acute renal failure;
- complications where the arterial puncture was performed (perforation, bleeding or hematoma, obstruction by thrombosis or embolism, arteriovenous fistula).

Stent implantation

- initially, the introductive sheath is introduced in an area proximal to the stenosis ;
- in the event that the stent is premounted on the balloon, then it is inserted until it reaches the lesion, and then the balloon is inflated for 30 minutes according to the specifications indicated by the manufacturer;
- if a self-expanding stent is used, then it is inserted until it reaches the lesion and it self-expandes through a memory device.

Indications for stent implantation

- in case of PTA failure;
- in case of acute / subacute restenosis after PTA;
- in case of a residual stenosis of more than 30% after PTA.

Filters placed inside the vena cava

- regarding the route of approach, the femoral vein or the internal jugular vein is preferred;
- a venography is performed for diagnostic purpose in order to evaluate the venous lumen for the detection of thrombi;
- most often, the filter is mounted at the level of the inferior vena cava, under the emergence of the renal veins;
- in case of renal or gonadal veins thrombosis, as well as thrombosis in the inferior vena cava, the filter is usually placed in the inferior vena cava, superior to the emergence of the renal veins.

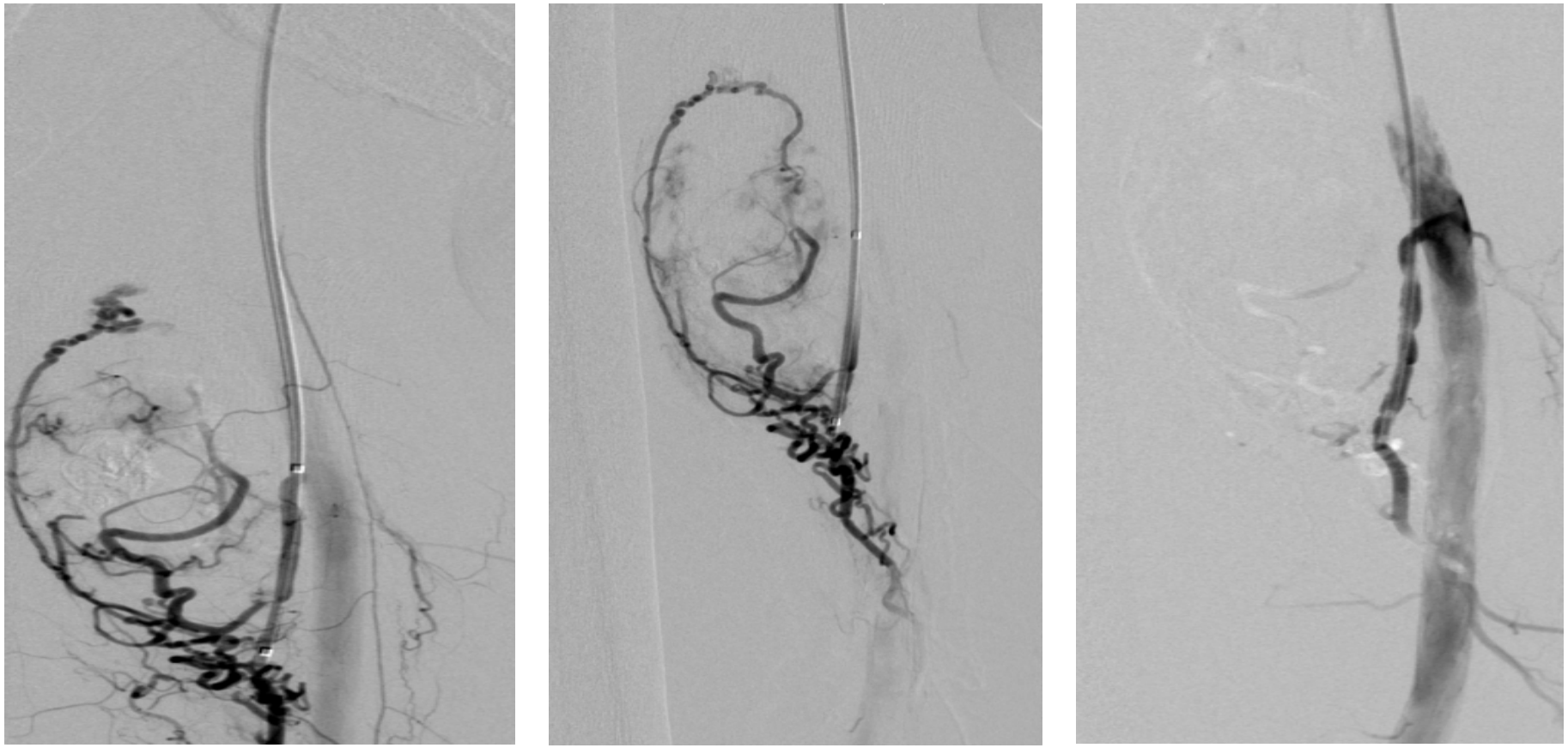
Indications of vena cava filters

- patients with deep vein thrombosis in the presence of contraindications and complications of anticoagulant treatment;
- massive pulmonary embolism, with residual thrombi in the deep venous system.

Conventional chemoembolization with microparticles

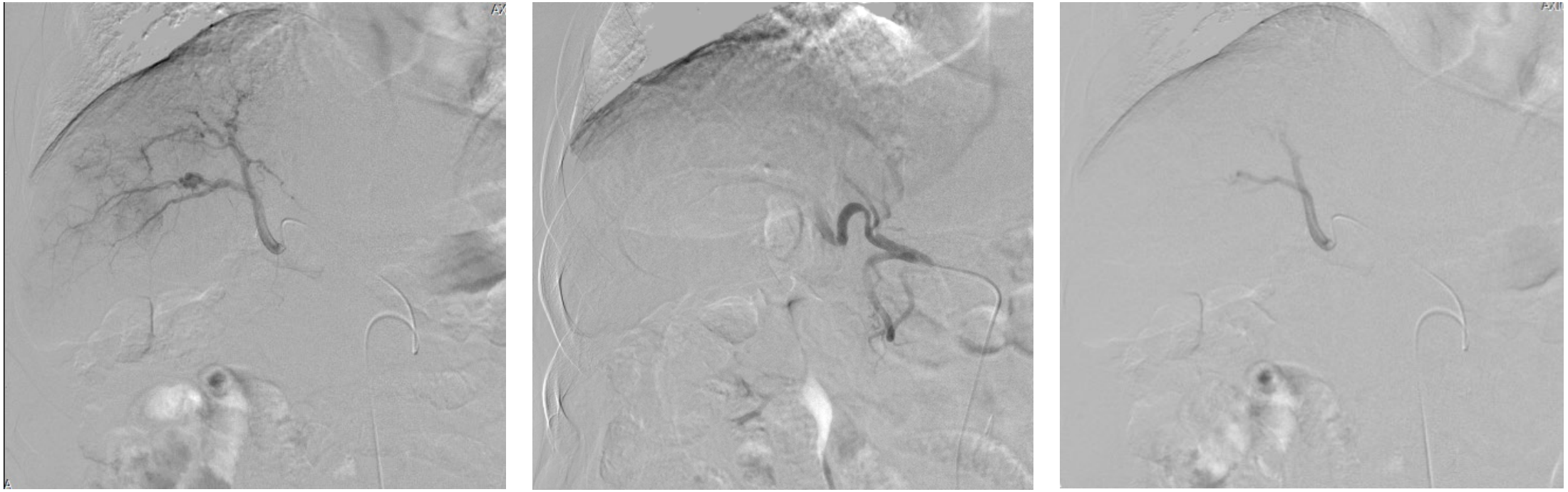
This technique aims to induce intratumoral necrosis both chemically (administration of a cytostatic near the tumor) and mechanically (administration of an embolizing material that presents tropism for the tumor tissue). Thus, the cytostatic is released slowly, inside the tumor.

Conventional chemoembolization with microparticles



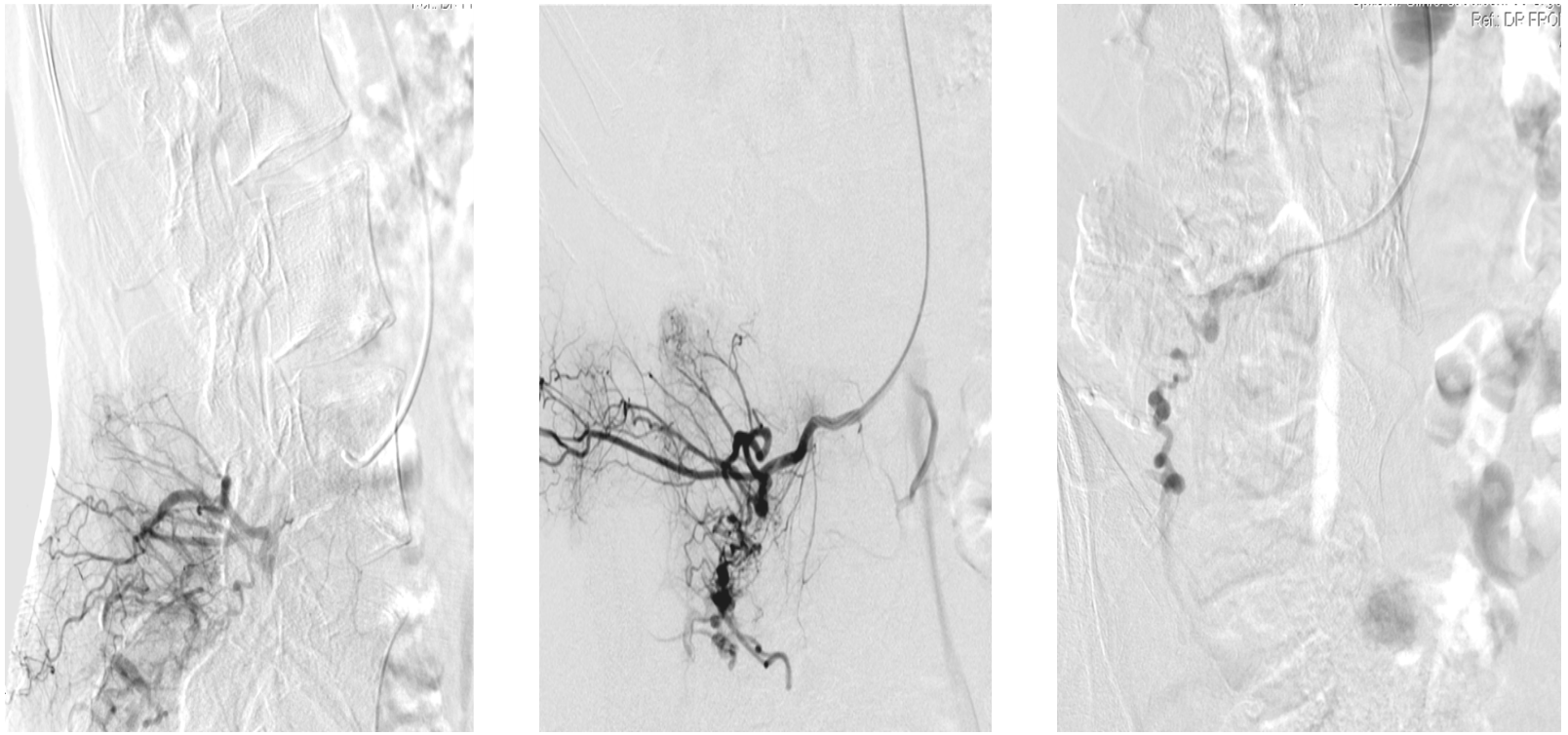
Selective embolization of a thigh tumoral mass

Conventional chemoembolization with microparticles



Chemoembolization of a liver tumoral mass

Conventional chemoembolization with microparticles



Selective embolization of a right lumbar angiofibroma

Local chemoinfusion

This method involves a selective injection of the cytostatic agent, without being accompanied by the embolizing material used in case of chemoembolization. Adverse reactions are lower compared to systemic therapy due to local administration of the cytostatic therapy, but the efficacy of this method is lower compared to chemoembolization.

Subcutaneous cytostatic reservoir

This technique requires a reservoir filled with cytostatic to be places subcutaneously. This reservoir is connected to the tumor and it allows a slow and local release of cytostatic agents.

Preparing the patient for biopsy

Before performing the biopsy, the doctor performing the procedure should obtain the following data:

- patient history;
- previous imaging investigations;
- laboratory tests - especially those aimed at coagulation;
- previous treatments followed by the patient - some patients may take chronic anticoagulant treatment.

Biopsy contraindications

- the area of interest does not allow a clear and secure access path;
- coagulation abnormalities;
- non-cooperating patient who may increase the risk of bleeding by not respecting the doctor's instructions during the examination.

Biopsy using fluoroscopy

- increased utility in biopsy of lung and pleural masses;
- technique that involves exposing both the doctor and the patient to a large amount of ionizing radiation;
- unlike CT and MRI, with the help of fluoroscopy, the adjacent structures can not be visualized as the needle advances.

Biopsy using ultrasonography

- at the thoracic level, ultrasonography can be used to guide the biopsy of the pleural masses or the superficial lung masses, as well as for aspiration of the pleural fluid collections;

- at the abdominal level, ultrasound may be useful for the biopsy of liver, kidney and pancreatic masses, as well as of retroperitoneal lymphadenopathies or large masses located in the adrenal glands;

- ultrasonography allows a real-time control of the needle position without using ionizing radiation, but the difficult visualization of deep lesions and the presence of artifacts given by air or bone structures are important disadvantages of this technique.

Biopsy using CT

- the CT examination may be useful for biopsy of small lesions located intrathoracically and intra-abdominally;
- this imaging method offers a high spatial resolution and allows the visualization of the structures interposed between the biopsy needle and lesion;
- the main disadvantages of this technique are that it uses harmful ionizing radiation for both the doctor and the patient and does not allow real-time control of the biopsy needle.

Radiofrequency ablation

- minimally invasive technique that uses electromagnetic energy and aims to induce tissue thermal injury;
- shows an increased utility in the imaging guided ablation of the primary or secondary (metastatic) tumors;
- to determine coagulation necrosis in the area of interest, it is necessary to reach a temperature of 60-100 ° C;
- the use of radiofrequency ablation as a curative therapeutic means involves the following:

a. the tumor lesion must be less than 5 cm;

b. it is necessary to achieve an area of necrosis of about 0.5-1 cm around the tumor lesion, so in the apparently healthy adjacent liver tissue, in order to prevent early local recurrence and to destroy the micrometastases at this level.

- the use of radiofrequency ablation in case of tumor lesions over 5 cm has a palliative role.

Percutaneous transhepatic cholangiography

PTC involves introduction of a needle through the skin and subcutaneous tissues until it reaches the hepatic parenchyma. Subsequently, it is directed to the biliary tract. If bile is aspirated on the needle, then a catheter is inserted at this level which is subsequently used to administer a radio-opaque contrast agent. In case of focal biliary obstruction, intervention procedures such as balloon dilatation or stent placement in the affected biliary tract can be performed. In benign stenosis, balloon dilation is used, while in malignant stenosis, the use of metal stents is preferred.

Indications for percutaneous biliary drainage

- the impossibility to undergo ERCP;
- no indication for radical surgery;
- increased surgical risk;
- bilio-digestive anastomoses, which are not accessible through endoscopic techniques.

Contraindications for percutaneous biliary drainage

- coagulopathies that cannot be corrected;
- ascites liquid in large quantity;
- allergy to the contrast substance;
- chronic renal failure.