24 Agosto 2020

Interventional Radiology

When we talk about radiology, we need to know that there are 2 main fields: diagnostic radiology, and interventional radiology. When we talk about interventional radiology, we refer to all the **diagnostic and therapeutic procedures performed under imaging guidance with a percutaneous approach**. Wd can have interventional radiology related to cardiac diseases, venous diseases, diseases causing extreme pain to be relieved, oncology, neurology intervention, intervention related to fertility, kidney diseases.
The interventional radiologist is a figure who needs to have knowledge of diagnostic radiology, of technique and materials, of internal medicine and of surgery.
Interventional radiology started with a guy called Seldinger, who developed the Seldinger technique, which is based upon the development of a needle. He developed the needle to have an access through the skin, the percutaneous access to the arteries and the veins and to fluid collections that is nowadays at the bases of interventional radiology. After that, there was the development of the first angiography suit, an operating room in which we have an X-ray system with a screen where the interventional radiologist can follow all of the procedures he does under the radiographic guidance.
Why do we do interventional radiology procedures?

1. Because it's less invasive than other surgical procedures —> less adverse events and less hospitals stay
2. Because there's a cost reduction
3. Because it has comparable results, as compared to standard approaches, in most diseases

There are two procedures types:
- Diagnostic procedures (biopsy), done to obtain a diagnosis
- Therapeutic procedures, done to obtain a therapeutic result

Diagnostic procedures - BIOPSY

INDICATIONS:

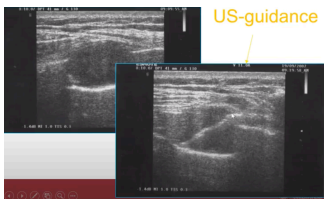
- **Definition of a lesion**: whenever we see a mass within an organ or tissue with imaging examinations and we want to know whether it's a tumor or a benign lesions; if we want to know exactly the type of the disease and the kind of therapy we need to start (in a patient with a tumor, which kind of chemotherapy or immunotherapy or radiotherapy do we need?), we need to know exactly the histotype of the disease (we need to know all the receptors expressed by the tumor).
- **Cyto-molecular stadiation** (especially for tumors)
- **Before surgical intervention**

TECHNIQUE

Imaging (fluoroscopy/X-ray, US or CT) + needle

- US-guidance

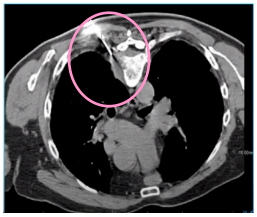
In case we have superficial organs and diseases, US is the best modality, also because it allows a real time guidance.



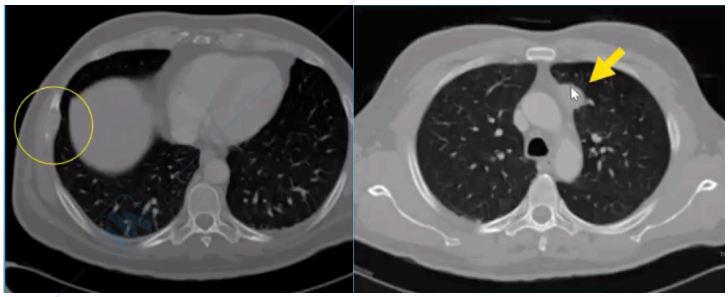
In this case for example, in the first image we can see a cervical lymphnode on US (hypoechoic mass); in the second image we can clearly see the needle inserting into the mass in order to obtain the biopsy (the hyperechoic line crossing the mass in the middle signaled by the mouse arrow).

- CT-guidance

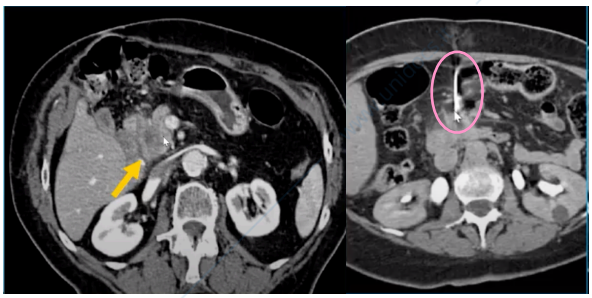
If the tissue we want to sample is deeper, like at the level of the **chest**, we can use CT to guide the needle for biopsy. For example, in this picture, we can see a paravertebral soft tissue mass, and CT allows us to track the needle (at the top of the picture) to know exactly where we are and to avoid complications.



The same is true if we want to biopsy, for example, a bone metastasis (pic on the left, mass in the ribs in the circle), or a lung tumor (pic on the right, arrow).



The same can be done for lesions at the level of the **abdomen**. In abdominal lesions, generally, US guidance is preferred because it's a real time guidance, especially if we have a moving organ, because we can also track the needle while the organ is moving. But if the lesion is very deep, as for example in the case of pancreatic tumors (picture below), CT is preferred, especially to avoid complications (like bowel loops perforations).



PRE-PROCEDURAL PLANNING

Correct imaging + coagulation and Htc + inform consent + material definition

CORE NEEDLE BIOPSY - How does it work?

We use these needles that are most of the times automatic needles. They are placed within the mass that we want to biopsy, there is a sheath that is fired; then, thanks to the very specific shape of the needle, we obtain the sample, and at the end we withdraw the needle.

Therapeutic Procedures

Therapeutic interventional radiology can be divided into 3 main fields:

1. **Vascular interventional radiology** (example: aortic aneurysm with a thrombus —> we can place a bifurcated stent below the renal arteries to recover normal caliber of the aorta and to protect form the aneurysm and thrombus). Before these procedures were introduced, the treatment of aneurysm was bypass graft done by open surgery, it was a major surgery, but, since the early 90s, the stents have been developed and they have become the method of choice for thee treatment of aortic aneurysms. Vascular surgeons are using endovascular procedures to treat these kind of diseases more and more.
2. **Non-vascular interventional radiology**: for example used for the biliary tree, for the urinary system and so on.
3. **Interventional oncology**

Materials:

Needles: unit of measures = Gauge. We can use two types of needles:

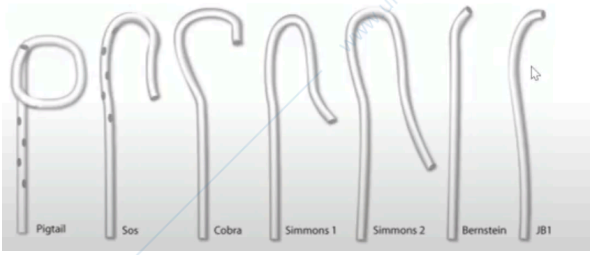
- **Seldinger needle**: for vascular puncture. It is a cannula, we have the *sheath* and the needle itself. We puncture an easily accessible artery (for instance the femoral artery at the level of the inguinal canal) with an oblique approach, and once inside the artery blood will come out (this is how you know you reached the artery). Immediately after puncturing we insert trough the needle a *guide wire* (either metallic or plastic), and once the latter is inside we retract the needle and insert the *catheter* into the guide wire.

- **Chiba needle**: less traumatic, very thin, to have access for example to biliary tree or urinary system (to the kidneys directly).

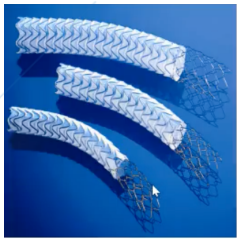
Guide-wire: it allows to navigate inside a duct (vessel or biliary duct). Different types, made of different materials (hydrophilic or non.hydrophilic, stemless), and of different shapes. In most of the cases they are *hydrophilic*, so that they can move within the vessels very easily. If we need to get access to collateral vessels, we need stiffer guide wires.

Catheters: internal diameters measured in inches, external diameters in French. Function of catheters: 1. Diagnostic; 2. Therapeutic; 3. Stability. They also have different shapes, depending on the vessels we want to catheterize; they are made of plastic; some of them only have a distal hole, other, the great majority, also have lateral holes. Examples:

- if we want to catheterize the aorta, we use the *pigtail catheter* that is non-traumatic at all and has lateral holes, so that as we inject contrast agent into the catheter, it immediately fills the whole aorta;
- if we need to catheterize the splanchnic vessels (renal arteries, superior mesenteric arteriy, coeliac trunk), there are some very specific catheters: the *cobra, Simmons 1 and Simmons 2 catheters;*
- *Bernstein and JB1 catheters* are made to catheterize the coronary arteries.

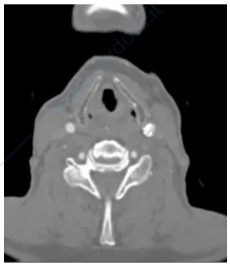


STENT PLACEMENT

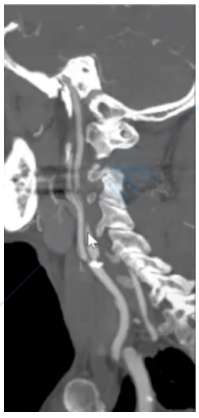


Stent: tubular structure allowing to promote and maintain a patent vessel. They are metallic prothesis that are contained within a very tiny catheter when they are not dilated, and as they are released they get expanded automatically. Stents are made of metal and covered by plastic material of PTFE, which allow to maintain the stent dilated and to avoid blood to go outside the vessel and stent. Stents have different calibers according to the artery that needs them.

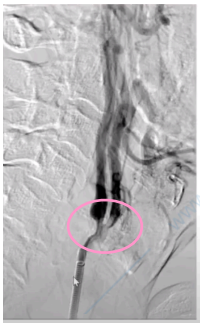
Example: **carotid artery stent**.

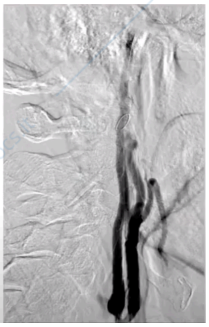


In this image we can see a normal right carotid artery, and the left carotid artery being more hyper-dense because of the presence of some calcifications at the level of the bifurcation of the common carotid artery into internal and external carotid arteries.



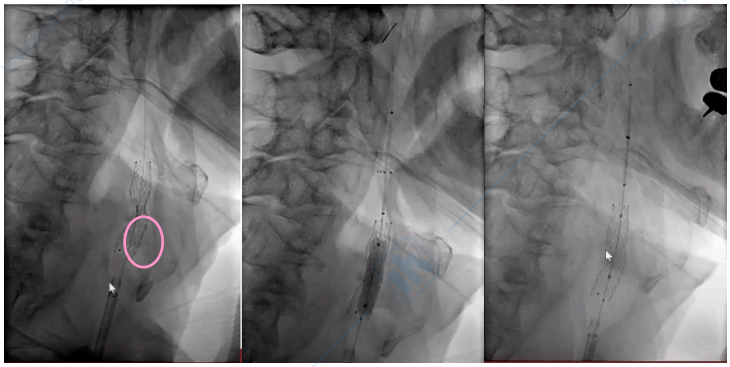
In the lateral view (on the right) we can again see the common carotid artery having a normal caliber, and we can see the hyper-dense calcification at the level of the bifurcation of the common carotid, which represents a plaque that is causing a severe stenosis of the internal carotid artery. We can recognize the internal from external carotid arteries because the external carotid artery has collateral branches in the extra cranial tract, while the internal carotid artery doesn't. This severe stenosis probably caused some neurologic ischemic events, either chronic or acute.





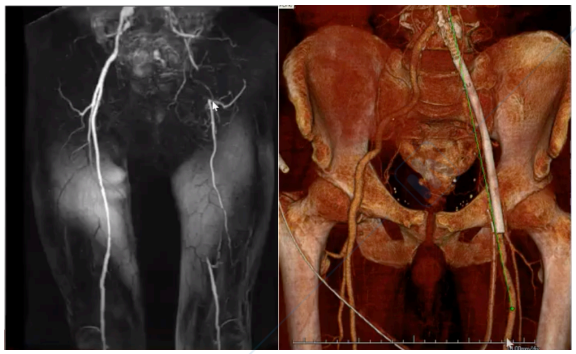
This stenosis is treated by placing a stent in the internal carotid artery.

In the picture on the left we can see the stenosis right after the bifurcation (circle); in the picture on the right we can see the vessels with the normal caliber after the stent has been positioned.



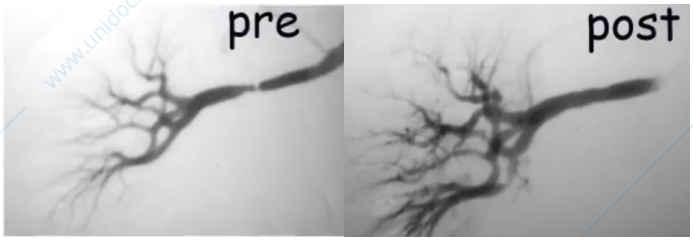
In the first picture we can see the stent being positioned: at the level of the stenosis the stent is decreased in caliber (circle), while above and below the stenosis the caliber is already dilated.
In order to dilate the stent, we go with a ballon catheter at the level of the stenosis (second picture), we inflate the ballon with a very high pressure, and the stent is enlarged, becoming of dilated caliber (third picture), giving as a result what we see in the picture above.
We don't care too much if the patient still has some stenosis of the external carotid arteries, because there are some collaterals that can compensate for the reduced blood flow through he external carotid.
Balloon: stents can be placed anywhere, and balloons are needed to expand the stents and make the vessels patent while placing the stent in position.

These approaches can be used in every single vessel of the body, the coronary arteries, the carotid arteries, the renal arteries, the aorta and so on. In some instances, even when there is a compete occlusion, such as in the case of claudication intermittens when there is complete occlusion of the iliac artery, the disease is treated with stent positioning and we can also inject fibrinolytic therapy to help break the occluding material.



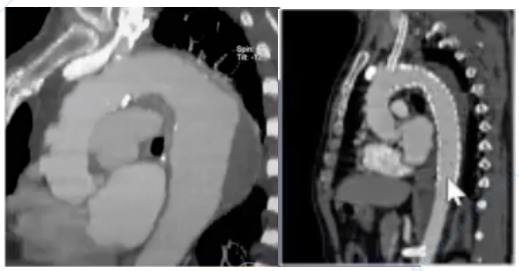
This on the left is the angio-MRI of a patient with multiple arterial occlusions before the placement of stents; on the right, the CT showing the placement of a very long stent to fix the occlusions. After this stent placement, the flow is restored and the legs and feet will be correctly supplied by blood.
In case there is an acute occlusion, we can also inject fibrinolytic agents with very tiny catheters (ex: we can solve ischemia of a foot by using a very thin catheter to restore blood flow in the tibial artery).

Basically there are very different techniques that can be used, but with the same end result: *any occluded vessel can be treated with stent placement to restore blood flow.*



Another example is the case of renal artery occlusion due to stenosis: in this case, the patient will present clinically with arterial hypertension. This situation is again treated with dilatation with ballon and, in case it's needed, also stent positioning.

Very important diseases treated with stent positioning are aneurysms (AAA) and dissections, especially type B, for which stent positioning is now the the gold standard treatment. These are long stents that are placed distal to the brachiocephalic trunk, all the way down to the abdominal aorta.



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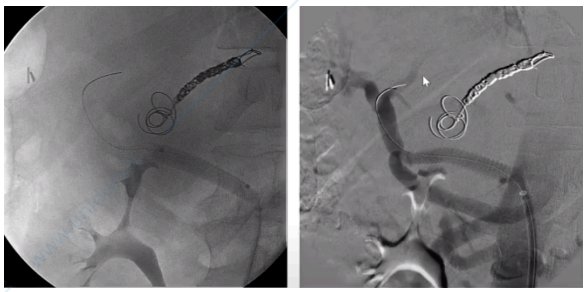
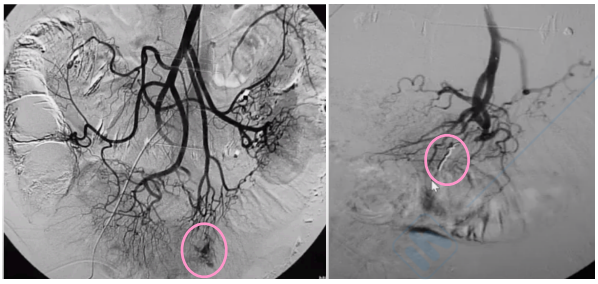
EMBOLIZATION

Sometimes we have patients who are bleeding a lot, from any kind of aneurysm or vessel (for example at the level of the brain we can have subarachnoid hemorrhages due to rupture of aneurysms of small cerebral arteries; or bleeding from bronchial arteries in the chest or any abdominal vessel) even after trauma. In these cases, surgery is extremely difficult to perform, while doing interventional procedures is easier. What we do is use interventional radiology to reach the vessel that is bleeding and then we perform embolization to occlude the bleeding vessel and thus treat the patient. There are two types:

- Glue: absorbable (spongostan) or non-absorbable (onix)
- Mechanic: vascular plug, detachable coil (metallic coils released through the catheter and determine interruption of the bleeding right away), beads

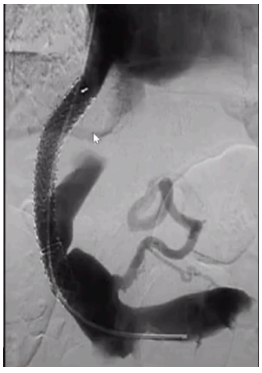


This pictures show detachable coils to treat a bleeding vessel. They are released within the vessel and by doing so we can close and interrupt the bleeding.



In this picture we can see, at the bottom, a minor bleeding of a branch of the superior mesenteric artery (circle), which causes intestinal bleeding. In this case we can catheterize the big patent vessels with guide wires and caterers, we can reach the bleeding vessel and release the coils (seen in circle in the second picture) that interrupt immediately the bleeding.

TIPS (trans-jugualr intrahepatic portosystemic shunt)



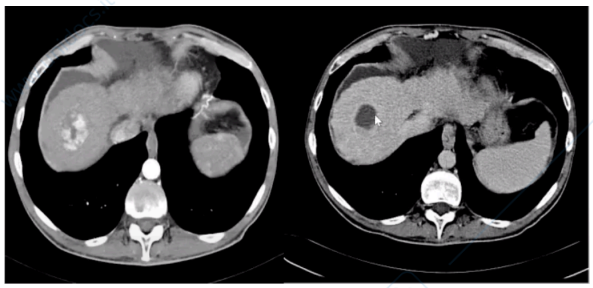
We can also have venous bleedings that can be very severe. For example, one of the most common causes of death in patients with cirrhosis and portal hypertension is the bleeding of esophageal or gastric varies, which are determined by the portal hypertension. A way to avoid this bleeding id to reduce the pressure at the level of the portal vein, and this is the purpose of TIPS.
In the procedure, a stent is placed to connect one of the hepatic veins to one of the major branches of the portal vein, in order to create a communication between the portal venous system and systemic circulation (we can see the stent being correctly placed with contrast-enhanced CT, like in the picture).
Right after the positioning of the stent, there is a decrease in the pressure and the patient is treated.

INTERVENTIONAL ONCOLOGY

Interventional oncology is a huge field now that is growing more and more. There are two types of interventional oncology: either endovascular, so we catheterize the vessels that feed the focal lesion within an organ (**TACE**), or we can percutaneously puncture the lesion we need to treat and then we use different types of sources to determine a necrosis of the tumor itself (**ablation**).

TACE (trans-arterial chemo embolisation)

In this picture we can see an hyper-vascularized tumor at the top (mouse arrow) in the liver (reminder: a hyper-vascularized lesion in the liver is HCC). The procedure consists of reaching the lesion with a catheter by passing inside the vessels supplying it, and then injecting something that blocks the blood vessel so that the tumor cannot brain nutrients nor oxygen anymore, causing tumor cells necrosis.

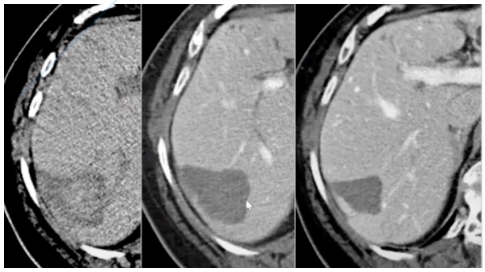


This pictures show the HCC before and after TACE was performed: before we can see an hyper-vascularized lesion (hyper-echoic), while after the treatment we can see a dark mass that is made of necrotic tissue.

Ablation

In case chemo embolization can't work, we can perform ablation. It's made by puncturing directly the lesion and then, using a very specific needle that increases the temperature within the tumor, we cause death of the tumor cells by basically "burning" them with the increased temperature.

This is an example: the mass becomes smaller as it's treated with ablation. This technique is used in primary tumors and also in metastases to the liver.

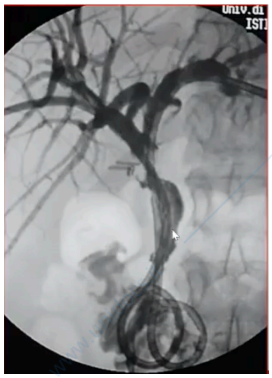


What is extremely important is the way we can guide these treatments, especially ablations: we can use either US with a direct real-time guidance, or we can guide it with MRI or CT.

EXTRA-VASCULAR INTERVENTIONAL RADIOLOGY

Used for biliary system, urinary system, drainage, muscolo-skeletal system (MSK), but also to treat complications after surgery.

Biliary Tree

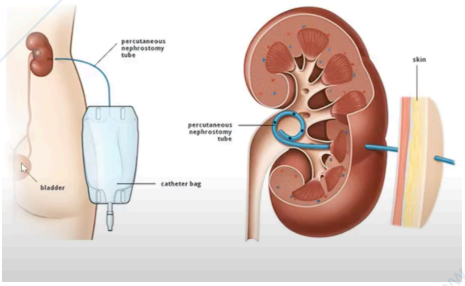


These are biliary drainages in a patient that, for example, had a tumor that determine an obstruction of the biliary tree (e.g: Klatskin tumor): this patient had several catheters placed percutaneously through the biliary tract and down to the duodenum, in order to have bile going form the liver down to the duodenum.

How is it done? We puncture with a very fine needle (Chiba needle) the biliary ducts under US guidance; once we punctured, we enter the biliary tree with a catheter and the guide wire, we pass over the stenosis, and then we go over to the duodenum; if needed we place a stent or a catheter (as shown in the picture on the left).

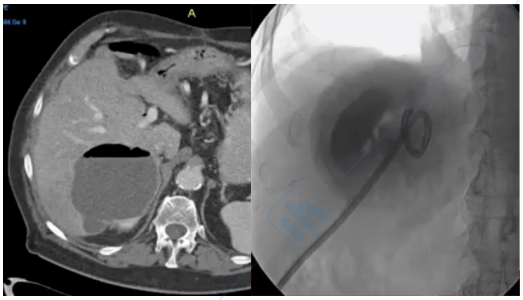
Urinary Tract

In the kidneys we can do exactly the same as we can do for biliary tree, for example for patients who have obstruction of the ureters in which cystoscopy can't be done (for instance in cases we have a very proximal obstruction in the proximal ureter). In these cases we can perform nephrostomy: we place a catheter in the pelvis of the kidney, and urine is eliminated trough there catheter into the catheter bag.

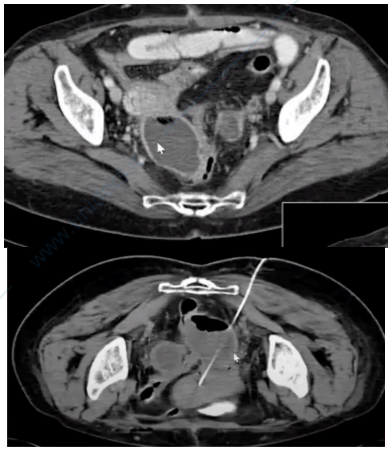


Drainage

There are several complications that can be treated and treatments that can be done by percutaneous approaches.



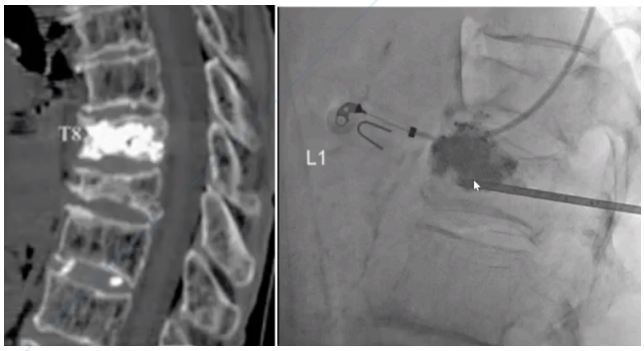
For example, this patient is presenting with a huge abscess in the liver, we can see the fluid collection with some air-fluid level. The abscess can be punctured percutaneously either under US or CT guidance, then we put a catheter and guide wire, and then we insert a large catheter with side holes that allows us to treat the fluid collection.



Also, in patients that have undergone surgery, they may have leaks of fluid at the level of anastomosis, which needs to be removed. In this picture we can see some fluid collection (mouse arrow) after sigmoid resection. The patient can have septic fever due to the presence oof the fluid, where an infection will develop. We can treat this condition by placing a percutaneous catheter in order to drain the fluid, under either US or CT guidance (the latter shown in the lower image).

MSK

It's becoming more and more common, used for example to treat patients with osteoporotic fractures (below).



Vertebroplasty: we can see here that there is a reduction in the size of the vertebras, and in case we want to stabilize the vertebral bodies, we puncture the vertebras under CT guidance and inject cement within them in order to make them thicker and expand the bodies. In the picture on the right we can see the procedure: the needle is injecting the cement into the vertebral body.

This procedure is fluoroscopy guided, and indications for its performance are:

- Symptomatic vertebral angioma
- Painful vertebral body tumors and acetabular tumors
- Severe painful osteoporosis with loss of height and/or with compression fractures of vertebral bodies.

To conclude: interventional radiology (IR) is a huge field now and it's developing more and more, there are very thin needles that allows its application in many systems. Interventional radiologists are on call 24/7 due to the fact that patients arrive at the ER for several reasons: stroke patients are treated with interventional radiology by the injection of thrombolytic substances at the level of the occluded vessels in the brain; patients who have accidents come in the ER all the time with high bleedings that can be treated by IR (embolization), and many other fields of application.

Questions and answers:

Q: *Are tortuous iliac arteries a contraindication for catheterization or can flexible wire be used?*

A: Tortuous vessels are sometimes a contraindication, if they are extremely tortuous we can find an alternative artsy. Basically we can puncture any vessel, the femoral arteries are the easiest to

have access through and easiest to puncture and this is why we generally use them; some other times we use the radial arteries at the level of the wrist or the humeral artery at the level of the elbow. *Basically any vessel can be punctured now.*

Q: W*hen do we perform only dilation and when dilation + stent placement?*
A: In the past we didn't have stents, or their quality wasn't very good, so we used to perform only ballon dilations; now we basically only perform stenting or dilation + stenting. The materials used for stents are extremely sophisticated, so now they are extremely good and rarely get ruptured, so we can use them more and more often.