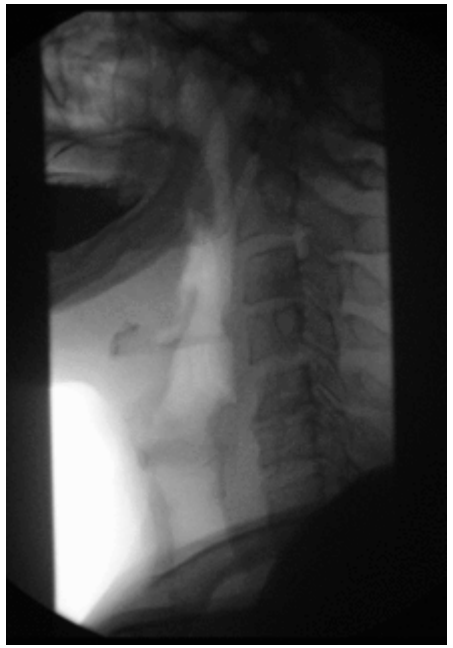
Gastrointestinal and abdominal imaging

Imaging methods

Fluoroscopy

Fluoroscopy involves the use of a continuous X-ray beam that allows a dynamic visualization of the structures included in the acquisition plan.



Imaging methods

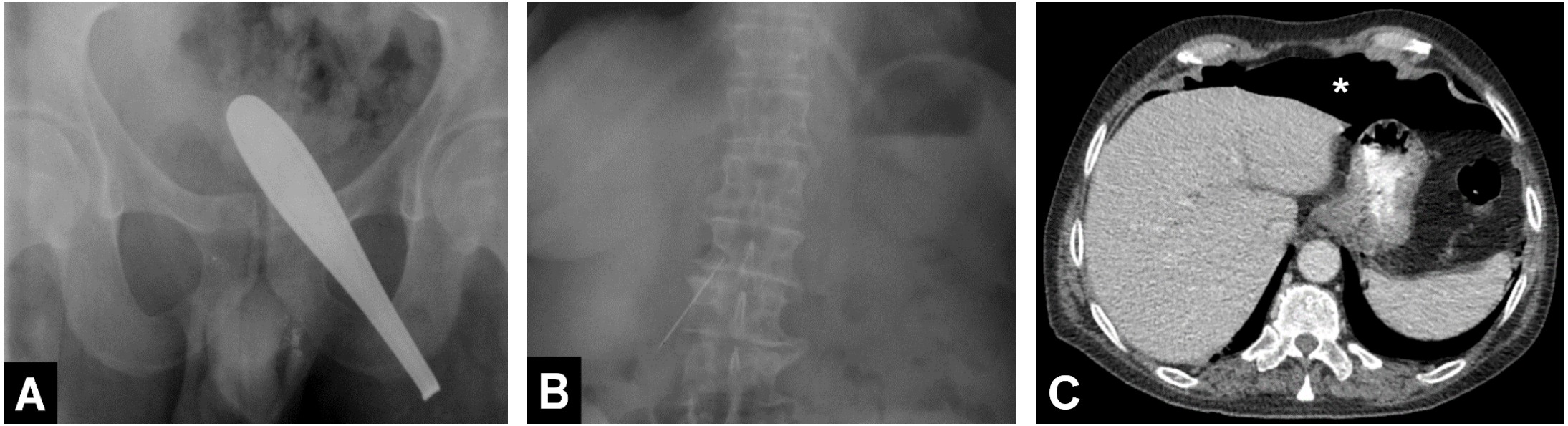
Abdominal X-ray

Abdominal radiography is a fast and non-invasive method for evaluating the abdomen. Compared with the modern imaging methods, the amount of information provided by this method is low.

An abdominal x-ray may show changes regarding ***the position of the hemidiaphragms*** (ascension / descent), ***calcifications*** (for example, on the projection area of the liver, spleen, pancreas), ***foreign radio-opaque bodies*** (needles, projectiles etc.), ***hydro-aeric levels*** (in case of bowel occlusion) or ***pneumoperitoneum*** (free air inside the peritoneum in a postoperative context or after perforation of a cavitary organ).

Imaging methods

Abdominal X-ray



Imaging methods

Barium swallow

This method involves oral administration of a radio-opaque contrast agent. For the evaluation of the digestive tract, barium sulphate is used most often.

The initial position of the patient during barium swallow is in orthostatism, antero-posterior incidence (A-P) and slightly oblique left, facing the examining doctor and back to the plate, with the upper limbs relaxed next to the body. The patient is positioned correctly using fluoroscopy. Then, the correct parameters are established according to the patient's weight and height. Thus, an initial control X-ray is performed. The next step involves the oral administration of barium sulphate which the patient will swallow when the doctor indicates so. As the patient swallows the oral contrast agent, the doctor will examine its passage through fluoroscopy. If pathological changes are noted, serial radiographs are performed. Prolonged and unnecessary patient exposures are avoided due to the intensely irradiating nature of this technique.

Imaging methods

Barium swallow

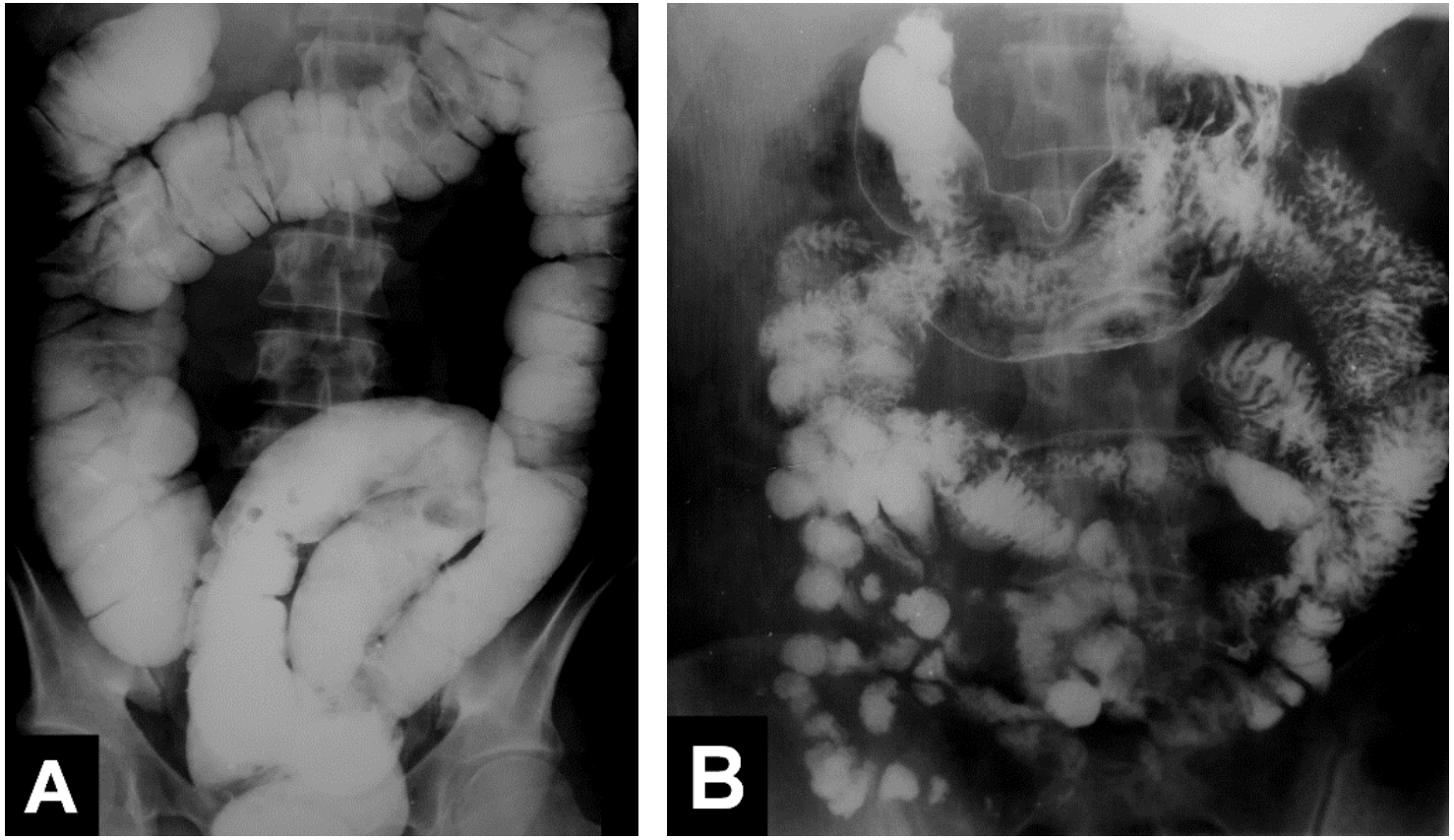
Imaging methods

Barium enema

For the examination of the colon and rectum, radiologists can use the barium enema (irigography). This examination method requires to position the patient in lateral decubitus and administer the barium sulphate intrarectally. The passage of barium sulphate at this level is evaluated in real time using fluoroscopy. If pathological changes are detected (tumors, polyps etc.), serial radiographs are performed in order to highlight the lesion. The small bowel can be analyzed radiologically by performing an X-ray at 24 hours after the barium swallow.

Imaging methods

Barium enema



Imaging methods

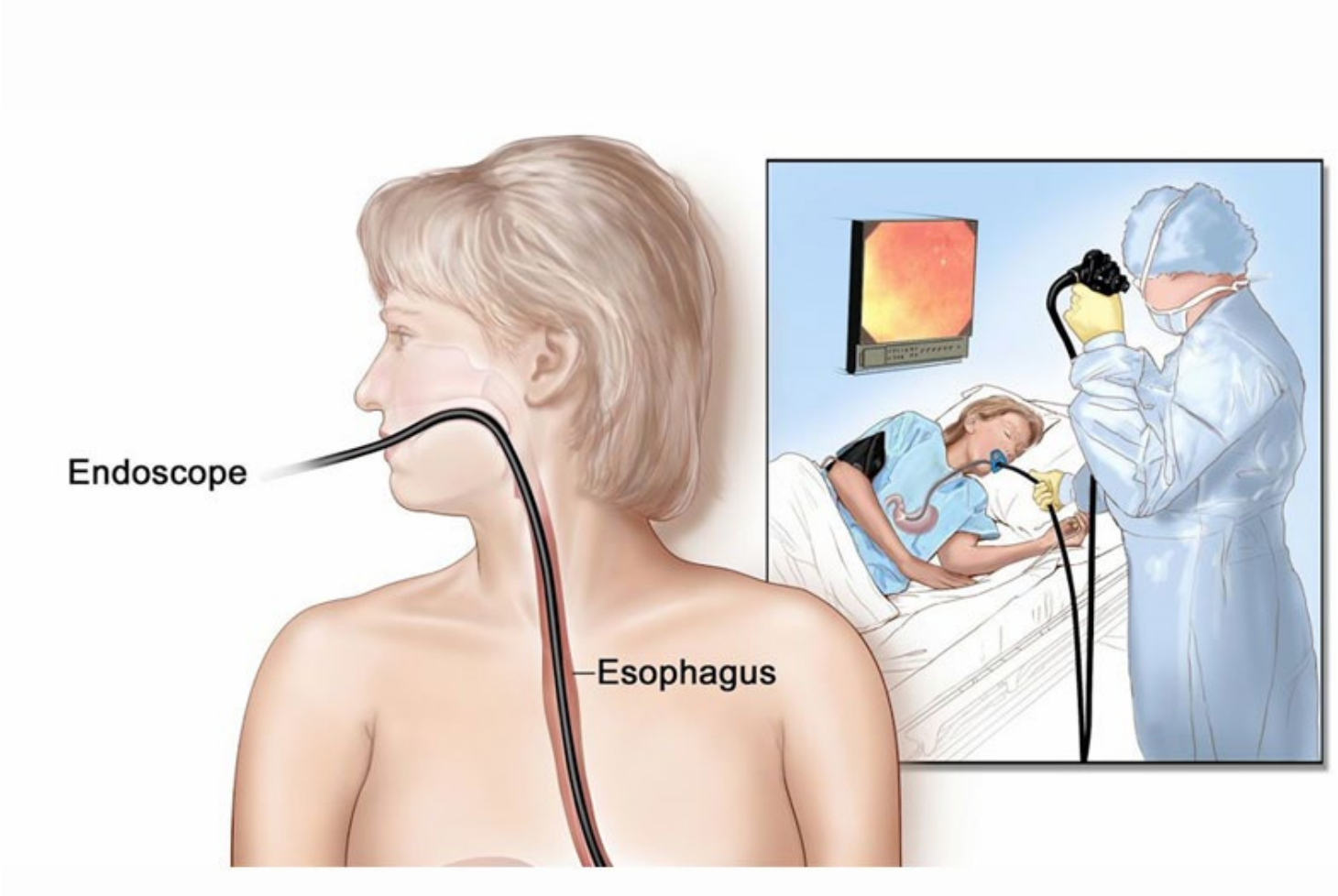
Esogastroduodenoscopy

Esogastroduodenoscopy is a modern method of evaluation of the esophagus, stomach, and duodenum. This technique requires a flexible tube to be inserted through the oral cavity. At the end of this tube a light source and a camera transmit real-time images to a monitor. This flexible tube is handled by the examining physician.

This method has both a diagnostic role (can take biopsies) and a therapeutic role (resection of polyps or stop an upper digestive haemorrhage). Currently, this has become the method of choice for the evaluation of the esophagus, stomach and duodenum.

Imaging methods

Esogastroduodenoscopy



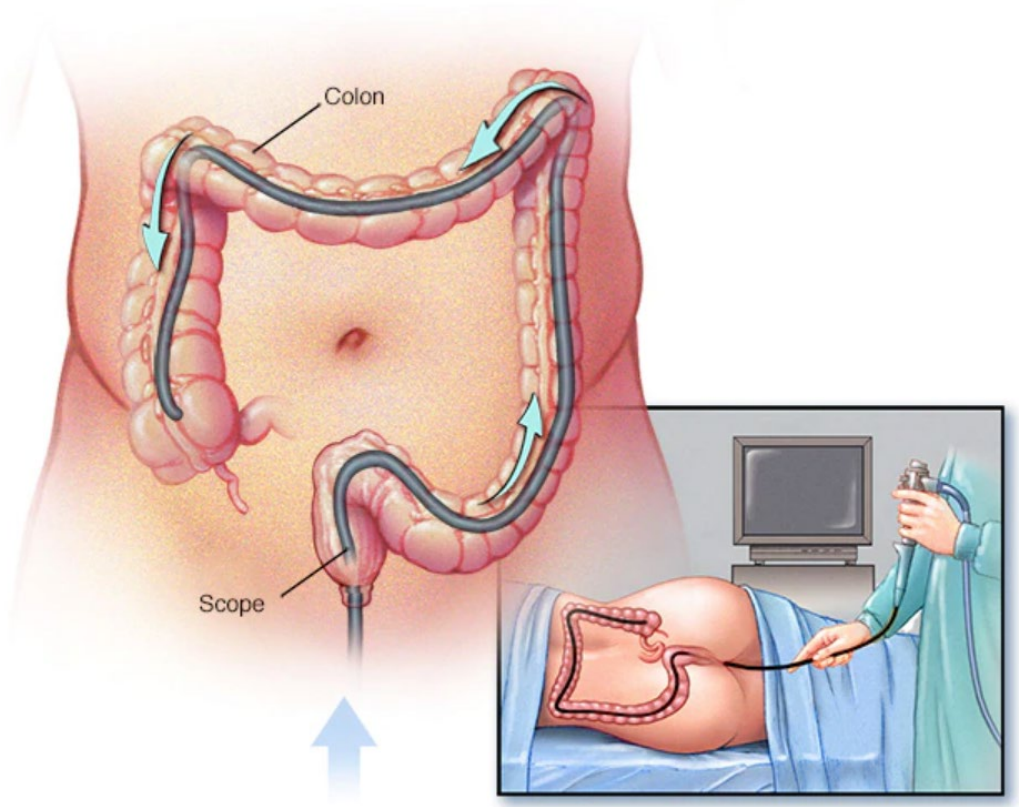
Imaging methods

Colonoscopy

Lower digestive endoscopy/Colonoscopy is used for rectal and colon evaluation. This method offers similar advantages as the esogastroduodenoscopy regarding the ability to prelevate biopsies and resect one or more polyps. Colonoscopy has become the method of choice regarding rectal and colon evaluation.

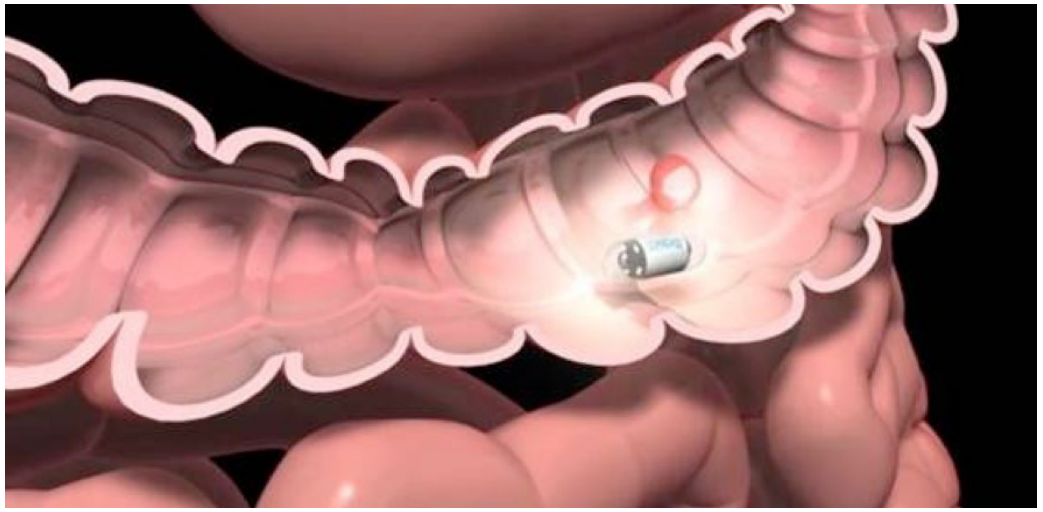
Imaging methods

Colonoscopy



Imaging methods

Endoscopic videocapsule



Imaging methods

Ultrasonography

US is preferred as the initial imaging method for evaluating parenchymal organs due to its non-invasive nature, rapidity, increased availability and reduced costs. An ultrasonographic examination can be performed natively (without contrast agent) or using a contrast agent based on gas bubbles. In addition to the pathological changes in the liver, pancreas and bile ducts, the US can detect pneumoperitoneum and ascites.

Imaging methods

Ultrasonography

Imaging methods

Computed Tomography

Most of the time, the CT evaluation of the abdomen is preceded by an initial US examination of the abdomen that detected pathological changes, but could not specify the nature of the lesions. A CT scan can be performed natively (without contrast agent) or using a iodinated contrast agent.

The protocol of a CT examination with iodinated contrast agent begins by obtaining native images, acquired before administering the contrast. Subsequently, the iodinated contrast agent is administered intravenously and successive scans are performed at predefined time intervals. Reported at the time the injection began, the images obtained at approximately 25-30 seconds correspond to the arterial phase, those obtained at 60-70 seconds correspond to the venous phase and those obtained at approximately 5-10 minutes correspond to the late phase, when the contrast agent is eliminated through the renal pathway.

Imaging methods

Computed Tomography

The advantages of CT examination include fast image acquisition (which is why it is preferred as a diagnostic imaging method in emergency), the possibility to store the acquired images in an online database that can be accessed anywhere and anytime an Internet connection is available, as well as the possibility to carry out multi-planar reconstructions in all 3 planes (axial, coronal, sagittal). However, the method is limited by the relatively high costs of examinations, but also by the harmful effects of X-rays in case of repeated scans.

Due to the irradiating nature of this imaging diagnostic method, pregnancy is a contraindication to both native and postcontrast CT. Other contraindications are renal failure, iodine allergy or other medications.

Imaging methods

Magnetic Resonance Imaging

Most often, an MRI examination is preceded by a CT examination and plays an important role in the additional and complex characterization of the lesions. MRI examination can be done natively (without contrast agent) or using a gadolinium—based contrast agent.

In the case of the native MRI scan, the basic sequences are T1 IP (in-phase), T1 OP (out-of-phase), T2, T2 SPAIR (with fat suppression), DWI (diffusion weighted imaging).

In case of MRI, there are several types of contrast agents (extracellular, with hepatocyte specificity, etc.). The extracellular ones behave similar to those used in CT and offer the possibility of acquiring images in the three phases (arterial, venous and late). Initially, hepatocyte-specific contrast agents behave similar to the extracellular ones, acquiring images in the three phases (arterial, portal and parenchymal). Subsequently, some of the contrast agent enters the functional hepatocytes and is eliminated in the bile ducts. Thus, the hepatic lesions can be characterized more accurately by a new hepato-biliary phase, which occurs approximately 20-30 minutes from the moment of injection.

Imaging methods

Magnetic Resonance Imaging

The advantages of using MRI include the non-radiating character and the possibility of storing the images in an online database. Regarding disadvantages, the MRI technique involves an increased image acquisition time (which is why it is not used in emergency like the CT) and significantly higher costs.

Pregnancy in the first trimester, allergy to the contrast agent, the presence of metal rods or prostheses, cardiac valve prostheses and claustrophobia are contraindications to perform an MRI examination.

Imaging methods

Hybrid imaging – PET/CT, PET/MR

PET-CT and PET-MRI are modern imaging techniques that involve the use of a radioactive tracer. Most commonly, 18F-fluorodeoxyglucose (18F-FDG) is used as a radiotracer. The imaging methods described above can detect lesions that exhibit intense radiotracer concentration due to the intense metabolic activity at this level.

Radiological functional changes of the digestive tract

1. CHANGES OF TONUS

A. Hypertonia implies an elevation of the tonus.

RX:

- early peristaltic waves;
- the mucosal folds get closer to each other and become thicker;
- the affected digestive segment becomes reduced in size;
- rapid evacuation of the content with distension of the underlying segment.

B. Hypotonia implies a decreased tonus.

RX:

- late-onset peristaltic waves;
- distancing and flattening of the mucosal folds;
- the affected digestive segment becomes increased in size;
- delayed evacuation of the content.

Radiological functional changes of the digestive tract

C. Atonia represents the disappearance of the tonus and is associated with the following radiological (RX) changes:

- disappearance of the peristaltic waves;
- disappearance of the mucosal folds;
- marked expansion of the affected digestive segment;
- the evacuation of the content is absent.

D. Spasm is radiologically (RX) translated by:

- narrowing of the affected segment on a short distance;
- the outline is clean, regular;
- superjacent dilation may occur.

Radiological functional changes of the digestive tract

2. PERISTALTIC CHANGES

A. Hyperkinesia represents the accentuation of the peristalsis and is responsible for the following radiological (RX) changes:

- increasing the frequency and amplitude of the peristaltic waves as well as their propagation speed;
- is associated with an accelerated evacuation of the content.

B. Hypokinesia involves the reduction of peristalsis and generates the following radiological (RX) changes:

- decrease of the frequency and amplitude of the peristaltic waves as well as their propagation speed;
- is associated with a delayed evacuation of the content.

C. Akinesia involves the depletion of the contractile capacity of the affected segment and is associated with the following radiological (RX) changes:

- absence of the peristaltic waves;
- marked expansion of the affected digestive segment;
- lack of content evacuation.

Radiological functional changes of the digestive tract

Hyperkinesia

Radiological functional changes of the digestive tract

3. TRANSIT CHANGES

A. Accelerated evacuation

B. Delayed evacuation

Radiological morphological changes of the digestive tract

1. CHANGES IN POSITION

A. Ptosis - caudal displacement of a digestive tract segment due to elongation of the supporting ligaments (for example, gastric ptosis);

B. Ascension - cranial displacement of a segment of a digestive tract segment (for example, type I hiatal hernia);

C. Traction - most commonly, it occurs due to a retractable fibrotic process manifested over a digestive tract segment (for example, a fibrotic process located in the lung apex can achieve traction on the same side of the esophagus and other mediastinal structures);

D. Push - refers to the mass effect generated by an expansion process on a digestive tract segment located in the immediate vicinity.

Radiological morphological changes of the digestive tract

2. MOBILITY CHANGES

A. Decreased mobility of the digestive tract segments that normally presents mobility - may represent an inflammatory process at this level, an extrinsic tumor formation invading the segment or a tumor formation specific to the affected segment;

B. Mobility in a normally fixed digestive tract segment - may be caused by a surgery that affected the supporting means of the digestive tract segment.

Radiological morphological changes of the digestive tract

3. CHANGES IN LENGTH AND SIZE

A. Increased length of a digestive tract segment - **dolicosegment**;

B. Reduction in length of a digestive tract segment - **brahisegment**;

C. Increased caliber of a digestive tract segment - **megasegment**;

D. Reduced caliber of a digestive tract segment - **stenosis**.

Radiological morphological changes of the digestive tract

4. OUTLINE CHANGES

A. Filling pluses – niche, diverticula

The niche represents the radiological expression of an ulcer. The niches are divided into *benign* and *malignant*.

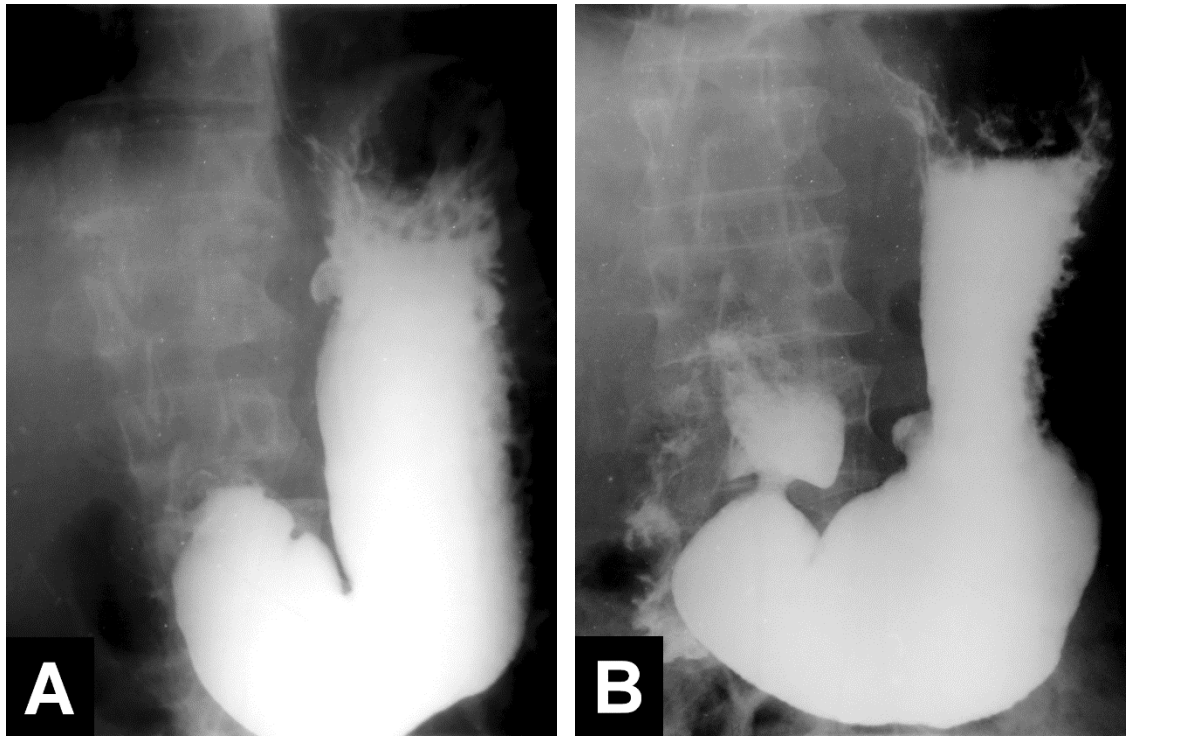
The benign niche has the following radiological characteristics:

- small size (<3 cm);
- taller than wider;
- reduced implantation base;
- protrudes from the contour of the organ;
- painful during screen compression;
- reduces its size or disappears completely under correct anti-ulcer treatment.

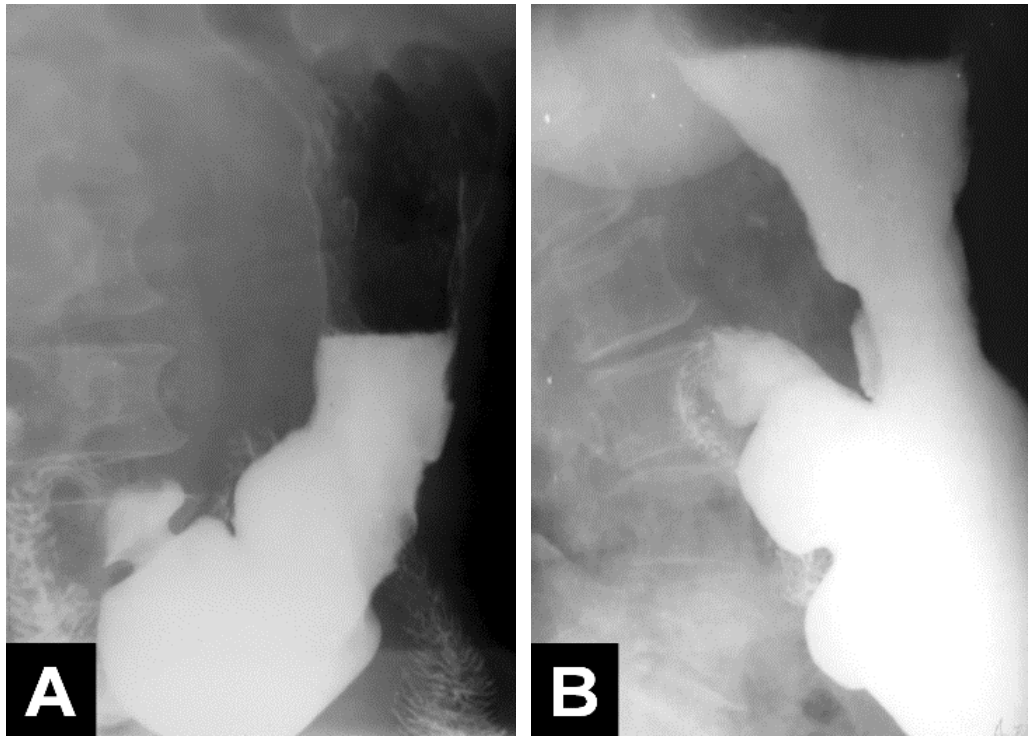
The malignant niche is radiologically translated by:

- large dimensions (> 3 cm);
- wider than taller;
- wide implantation base;
- it does not protrude from the contour of the organ;
- is not painful when compressed under the screen;
- the dimensions may remain the same or grow under correct anti-ulcer treatment.

Radiological morphological changes of the digestive tract



BENIGN



MALIGNANT

Radiological morphological changes of the digestive tract

Diverticula can be classified into traction diverticulum and pulsion diverticulum.

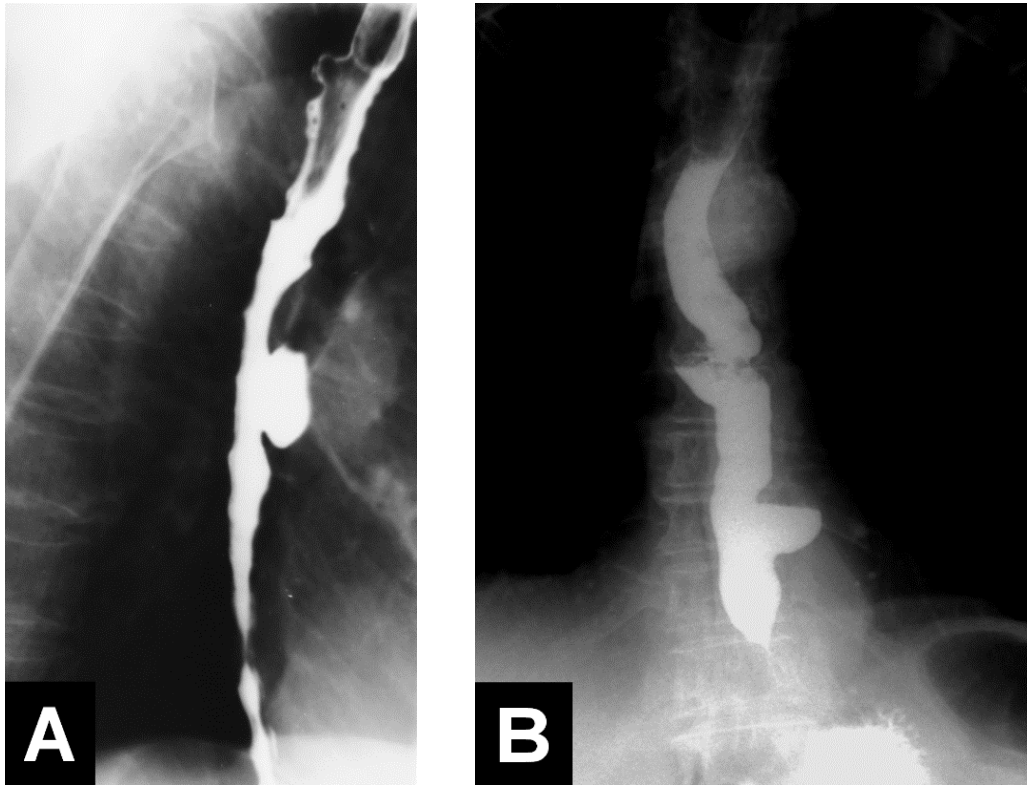
Pulsion diverticula involves the herniation of the mucosa and / or submucosa through a breach created at the muscle tunic and have the following radiological (RX) characteristics:

- they are solitary or multiple;
- round-oval shape, net contour;
- a narrow pedicle connects the affected digestive tract segment with the diverticulum;
- it is homogeneously opacified after barium swallow.

Traction diverticula are associated with the existence of an inflammatory or fibrotic process that develops in the vicinity of the affected digestive tract segment. They are frequently encountered on the anterior and lateral wall of the esophagus following a mediastinal inflammatory process. It presents the following radiological (RX) features:

- triangular shape, with the base oriented towards the lumen and the tip towards the outside;
- net contour;
- wide implantation base that favors the complete evacuation of the diverticulum after barium swallow.

Radiological morphological changes of the digestive tract



Radiological morphological changes of the digestive tract

B. FILLING DEFECTS - lacuna

The filling defect represents the radiological expression of an intraluminal tumor. The filling defects are divided into *benign* and *malignant*.

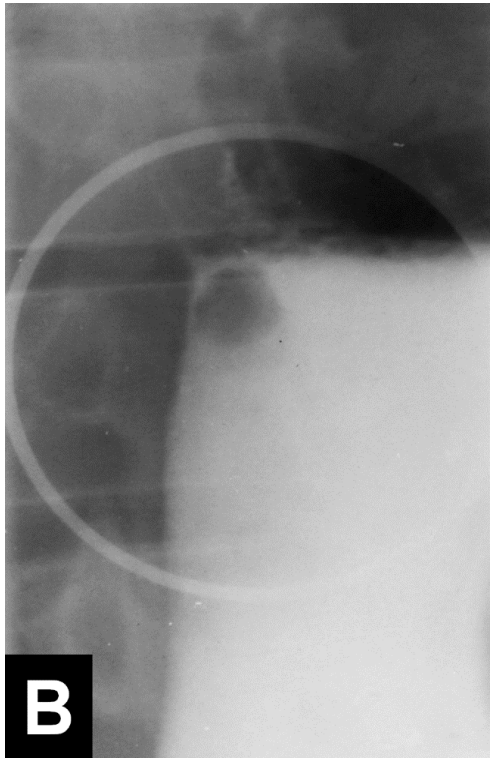
The benign lacuna is radiologically (RX) translated by:

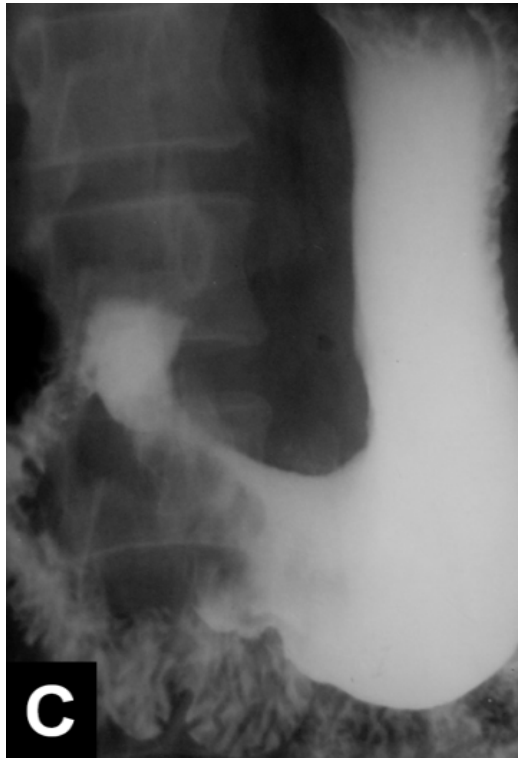
- single or multiple filling defects;
- round-oval shape;
- variable dimensions;
- net contour, regular;
- the mucosal folds around the benign lacuna are not modified.

The malignant lacuna is radiologically (RX) characterized by:

- they frequently appear as unique filling defects;
- irregular shape and outline;
- mucosal folds are interrupted in the vicinity of the malignant lacuna;
- presents semitone (the transition from white to black is not sudden, but gradually due to the tumor infiltration at this level);
- sometimes, malignant spurs can be visualized and is considered pathognomonic;
- the niche image may be present inside the lacuna (ulceration of a vegetant tumor).

Radiological morphological changes of the digestive tract





BENIGN

MALIGNANT

Radiological morphological changes of the digestive tract

C. The segmental rigidity suggests either a malignant tumor or an inflammatory process that infiltrates the wall and generates the following radiological (RX) changes:

- variable dimensions;
- mucosal folds disappear in the affected area;
- peristaltic waves are not transmitted to the infiltrated area;
- the appearance of "plank on waves“ aspect due to the immobility of the infiltrated area compared to the rest of the digestive tract segment.

D. Contour disruption - signals the development of an endoluminal malignant tumor process.

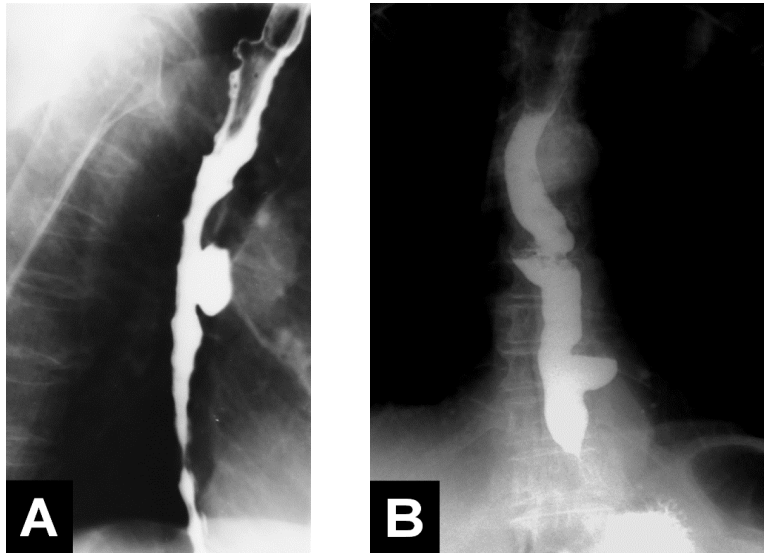
TO REMEMBER !!!

Regardless of the location of the digestive tract, these rules are generally valid:

- **A benign ulcer (gastric, duodenal) is radiologically visualized as a benign niche.**
- **Malignant tumors include 3 main types (vegetant, ulcerative and infiltrative).**
- **Ulcerative malignancies are radiologically visualized as a malignant niche.**
- **Benign tumors (polyp, fibroma, lipoma etc.) are radiologically seen as a benign lacuna.**
- **Malignant vegetant tumors are observed radiologically in the form of a malignant lacuna. In addition, if there is intratumoral ulceration, the niche aspect appears inside the lacuna.**
- **Infiltrative malignancies are radiologically seen as segmental rigidity of the affected digestive tract segment.**

Pathology of the esophagus

1. **Esophageal atresia** – limited food bowl passage due to the discontinuation of the esophagus.
2. **Esophageal duplication** - the existence of two esophageal lumens.
3. **Brachyesophagus** - type I hiatal hernia with short esophagus.
4. **Esophageal diverticula** – pulsion diverticula or traction diverticula. The Zenker diverticulum is located on the posterior wall of the esophagus, at the pharyngoesophageal junction.
5. **Cardiospasm** - represents an intermittent spasm of the cardia sphincter that completely blocks the transit at this level and remits after anti-spastic medication. Thus, cardiospasm is intermittent and total.



Pathology of the esophagus

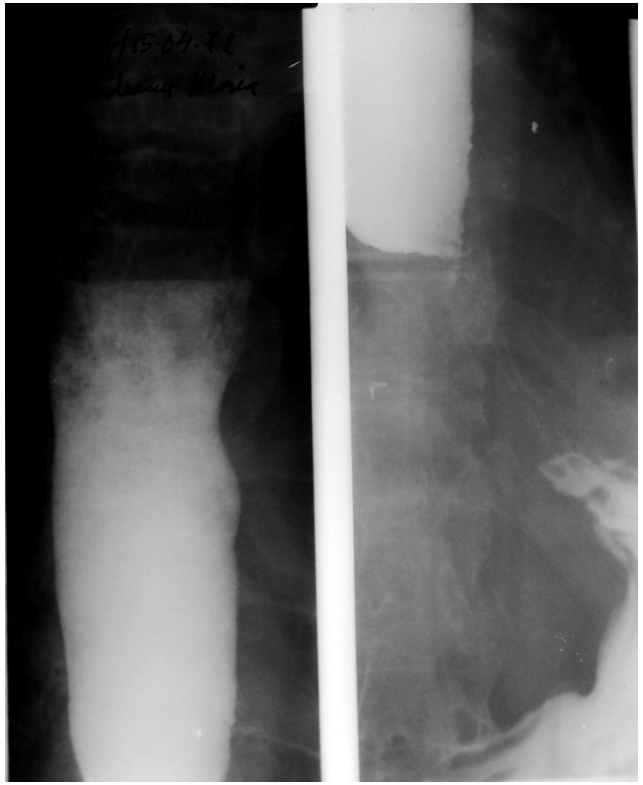
6. **Achalasia** - due to the inability to relax the lower esophageal sphincter. Unlike cardiospasm, achalasia is definitive, but not total.

- RX: barium swallow shows an increased caliber and an inhomogeneous content of the esophagus due to the presence of stasis fluid and residual food (***stage I***). Thus, the barium sulphate ingested by the patient flows into the stasis fluid like snowflakes.
- ***In stage II***, the esophagus has an increased caliber (<10 cm) and the obstacle imposed by the increased tonus of the esophageal sphincter is overcome by increasing the amount of barium ingested and with the help of tertiary contractions in the esophagus.
- In the last stage (***stage III***), the esophagus appears dilated and has an enlarged caliber (>10 cm). Also, three levels can be seen: lower - barium; middle - barium and stasis fluid; upper - air. The esophagus becomes atonic, with no peristalsis and looks like a "sock".

Pathology of the esophagus

I

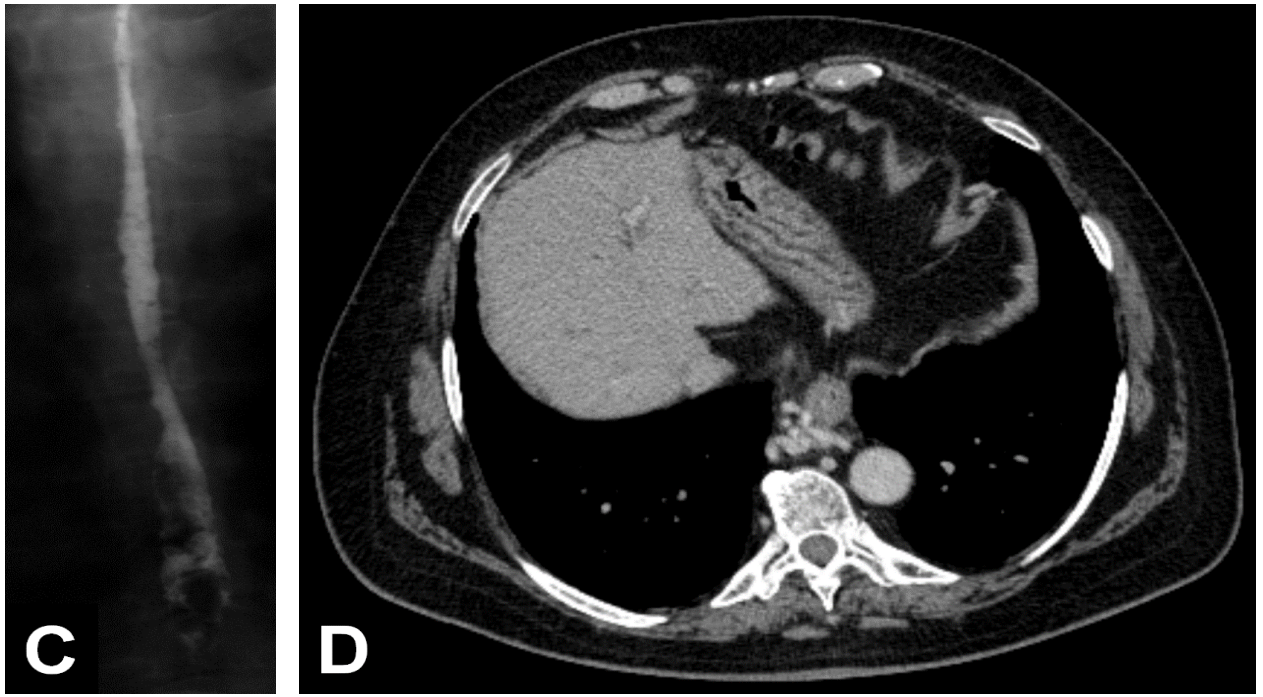
II



III

Pathology of the esophagus

7. Esophageal varices - can be located in the upper 2/3 if they are congenital or in the lower 1/3, when they suggest the presence of portal hypertension. At barium swallow, the esophageal varices are visualized in the form of multiple round-oval, well delineated filling defects. Also in the case of portal hypertension, the CT examination can detect the periesophageal varices (located in the immediate vicinity of the esophagus) in the form of vessels with a sinuous pathway that are filled with intravenous contrast agent.



Pathology of the esophagus

8. Esophageal stenosis

They may be benign (postcaustic or due to benign tumors) or malignant (produced by malignant tumors).

Benign esophageal stenosis is characterized by:

- is located in the organ axis;
- does not interrupt the contour of the organ;
- shows superjacent dilatation.

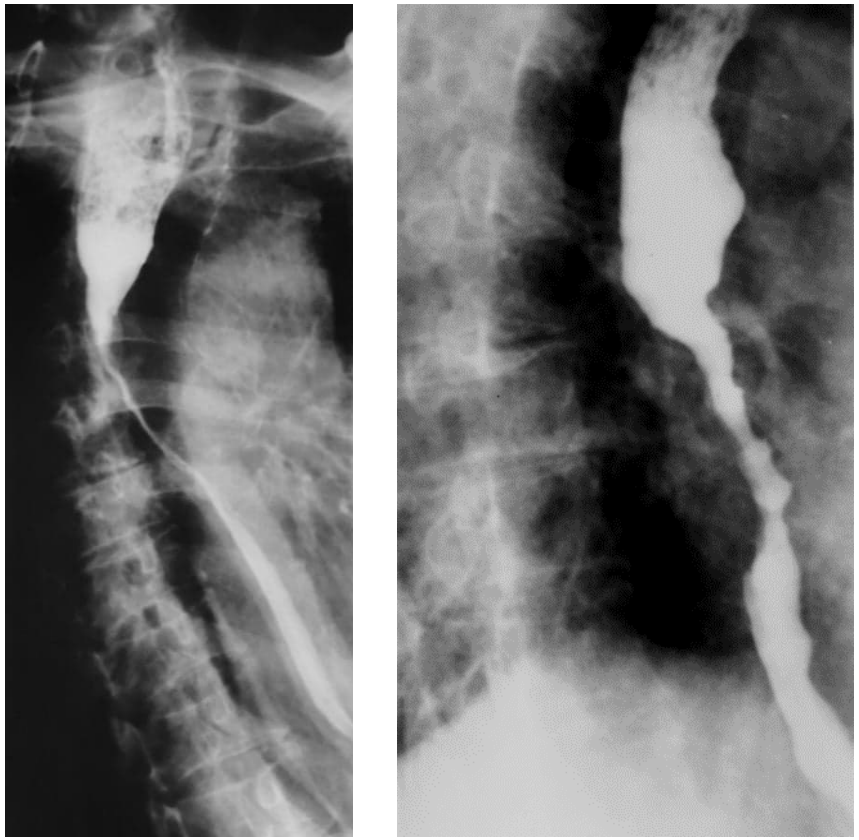
Malignant esophageal stenosis is characterized by:

- is located eccentrically;
- interrupts the contour of the organ;
- does not show superjacent dilatation.

Pathology of the esophagus

9. **Esophageal cancer**
   - Depending on the macrosopic type of the esophageal neoplasm, the radiological aspect is different. Thus, the ulcerated form is seen as a malignant niche, the vegetant form is seen as a malignant lacuna and the infiltrative form is seen as a segmental rigidity.
   - Regardless of the macroscopic form, malignant esophageal stenosis is installed.
   - Esophageal cancer requires a thorough investigation through a CT examination that evaluates the relationships with adjacent structures and the extension of the primary tumor (lymph nodes + metastatic lesions).

Pathology of the esophagus



BENIGN

MALIGNANT

Pathology of the esophagus

10. Hiatal hernia

According to Akerlund's classification, hiatal hernias are of 3 types:

A. Type I (with brachysophagus)

- the esophagus is short, rectilinear;
- the cardia and gastric fornix herniates through the esophageal hiatus;
- cardia is located inside the thorax.

B. Type II (paraesophageal)

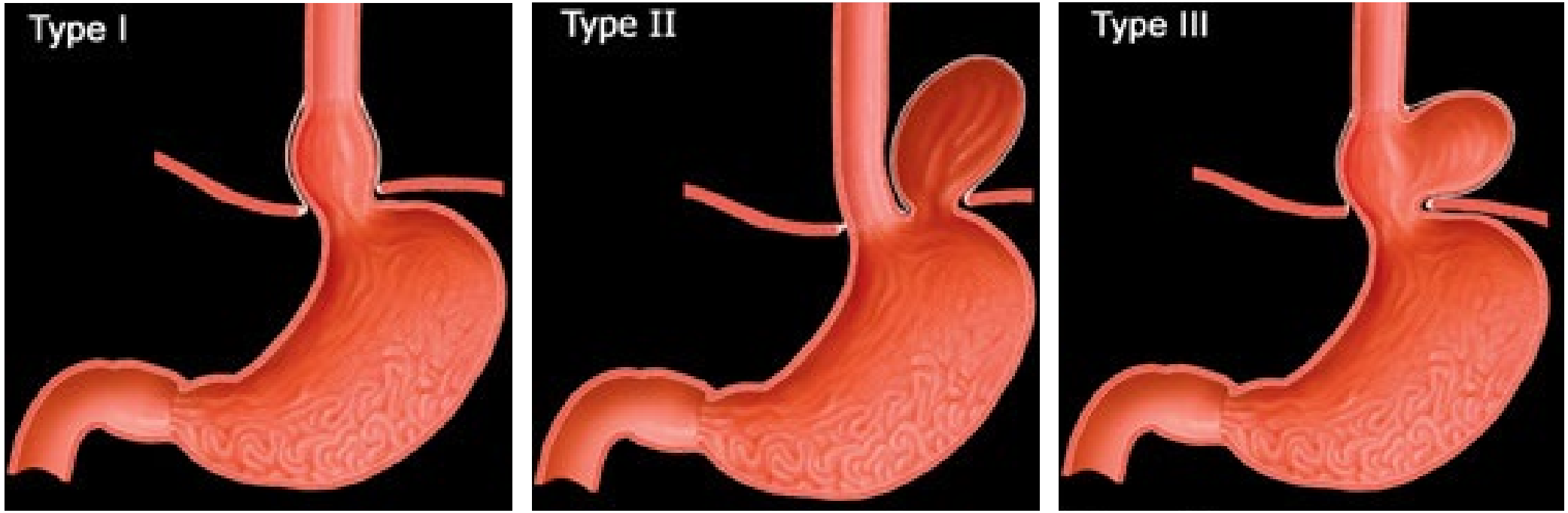
- the esophagus is rectilinear and has a normal size;
- only the gastric fornix herniates through the esophageal hiatus;
- cardia is located inside the abdomen.

C. Type III

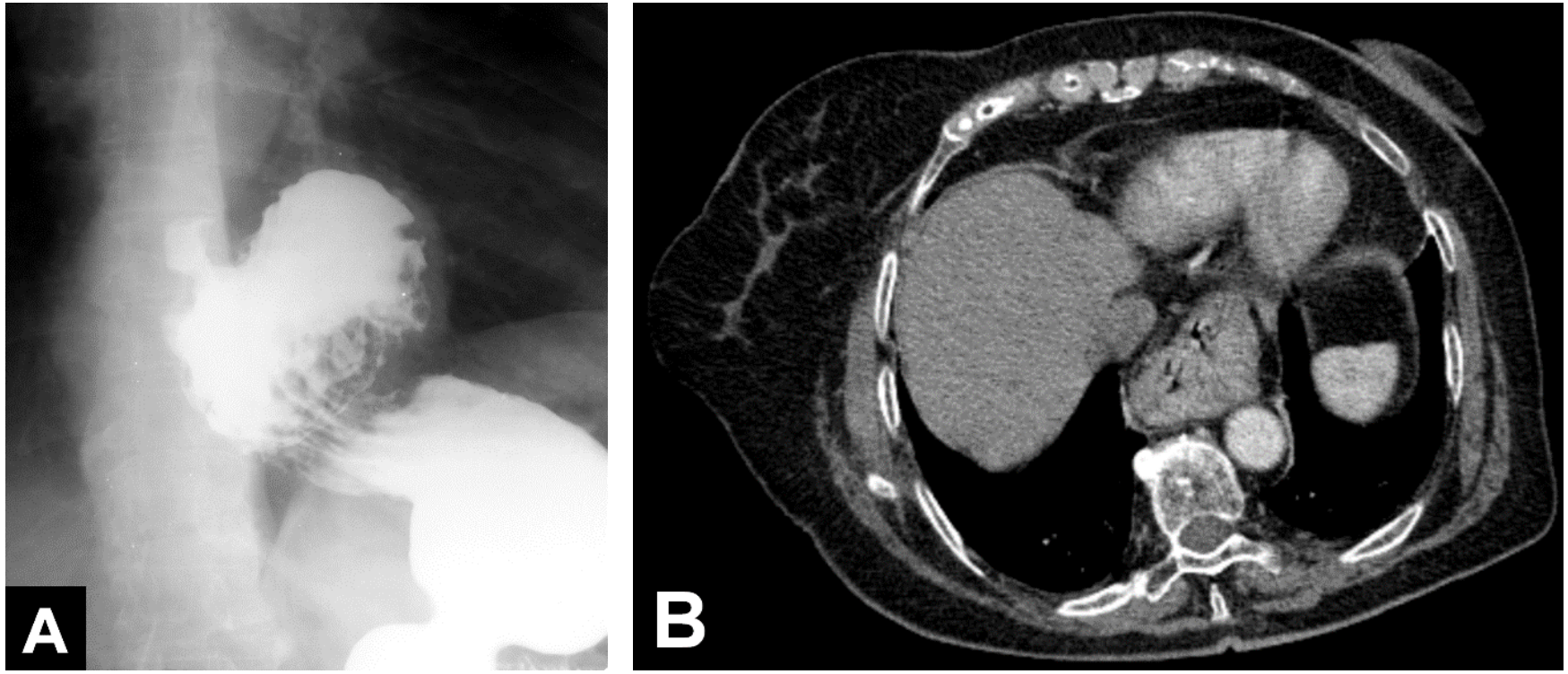
- the esophagus is not rectilinear and has a sinuous path;
- the cardia and gastric fornix herniates through the esophageal hiatus;
- cardia is located inside the thorax.

Hiatal hernias can be assessed using barium swallow or CT scan with oral contrast agent.

Pathology of the esophagus



Pathology of the esophagus



Pathology of the stomach

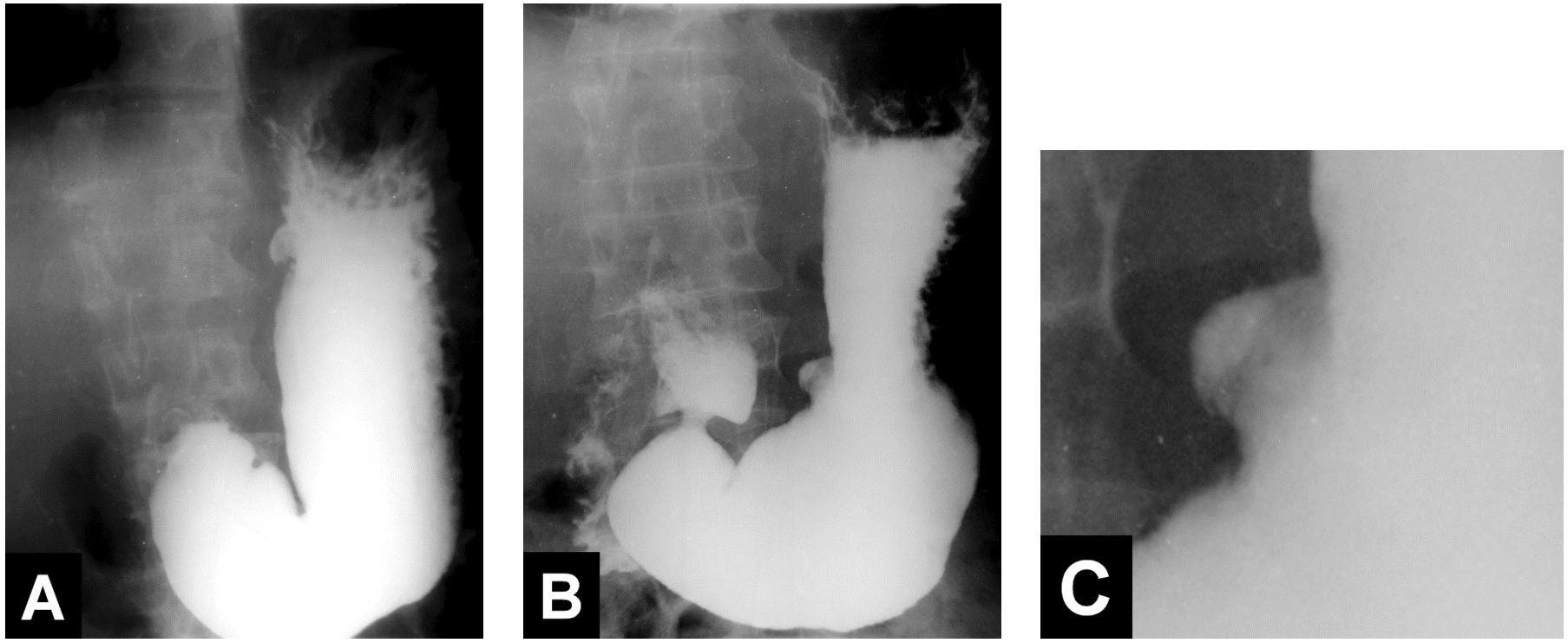
1. Gastritis – inflammatory disorder affecting the gastric mucosa. **RX:** ***Hypertrophic gastritis*** is characterized by gastric hypersecretion, hyperkinesia and hypertrophic gastric folds. ***Atrophic gastritis*** is characterized by the tubular appearance of the stomach and the lack of gastric folds.

2. Benign gastric ulcer – **RX:** benign niche. Benign gastric ulcer is most often located on the lesser curvature of the stomach. Sometimes, on the greater gastric curvature, exactly opposite to the benign niche located on the lesser curvature, a spasm can be highlighted. This indicates the benign ulcerative lesion on the lesser curvature. Also, on the implantation base of the benign niche, the Hampton line can be visualized in the form of a radiolucent linear lesion that represents edema. Gastric ulcer can be complicated by: perforation, penetration and upper digestive bleeding.

Following gastric perforation, a simple abdominal X-ray can reveal pneumoperitoneum as a semilunar radiolucent area located under the diaphragm. A CT scan performed with oral contrast agent can reveal the pneumoperitoneum and extravasation of the contrast agent in case of gastric perforation.

Following gastric penetration, barium swallow can reveal the Haudek niche with three levels (air, liquid, barium).

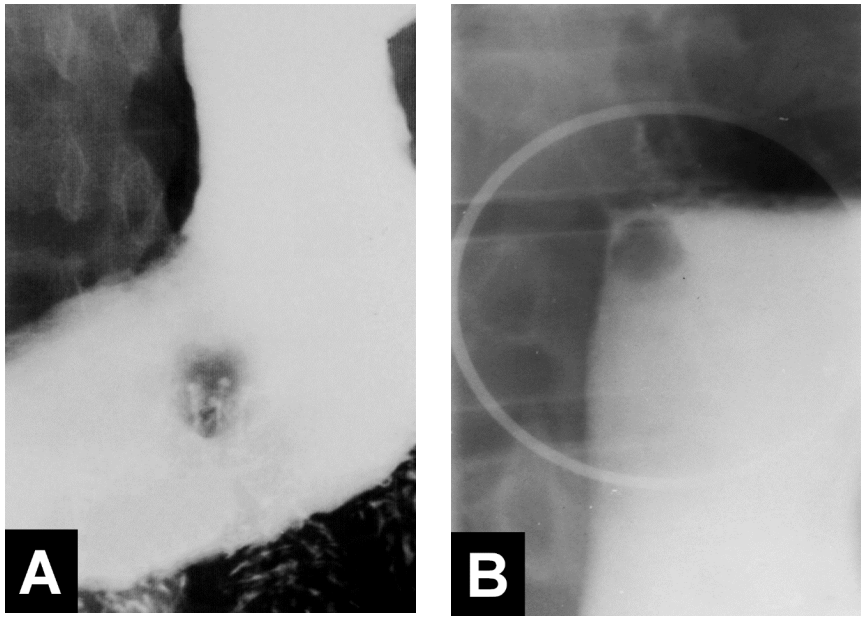
Pathology of the stomach



Pathology of the stomach

3. Gastric diverticula – filling pluses that communicate with the gastric lumen. The barium swallow and CT examination performed with an oral contrast agent highlight the presence of the contrast inside the diverticulum.

4. Gastric benign tumors – RX: benign lacuna of variable dimensions.



Pathology of the stomach

5. Gastric cancer – Depending on the macrosopic type of gastric cancer, the radiological aspect is different. Thus, an ulcerated gastric tumor appears as a malignant niche, a vegetant gastric tumor appears as a malignant lacuna and an infiltrative gastric tumor appears as segmental rigidity. Furthermore, a vegetant gastric tumor with intratumoral ulceration appears as a lacuna with a niche inside the tumoral area.

Gastric cancer requires a thorough investigation through a CT examination that evaluates the relationships of the primary tumor with adjacent structures and detects affected lymph nodes and distant metastases. If necessary, the CT scan can be completed with an MRI exam.

The features of suspicious malignant niches include:

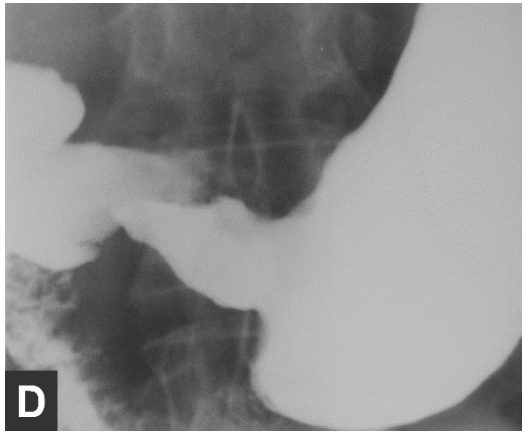
- large implantation base;

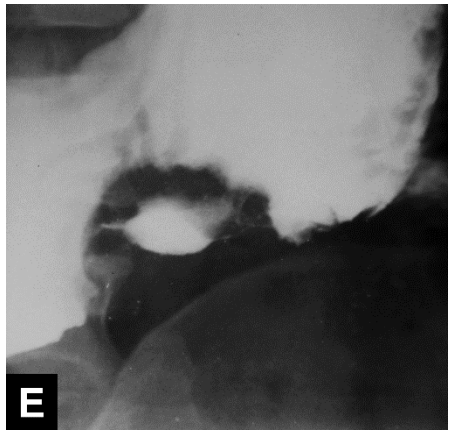
- located on the greater gastric curvature (almost always malignant);

- located further from the cardia and closer to the pylorus;

- over 3 cm in size.

Pathology of the stomach





Pathology of the small bowel

1. Megaduodenum – increased caliber of the duodenum.

2. Duodenum diverticula – filling pluses that communicate with the lumen of the duodenum. The barium swallow and CT examination performed with an oral contrast agent highlight the presence of the contrast inside the diverticulum.

3. Duodenal ulcer – most frequently benign and appears as a benign niche.

4. Small bowel occlusion – can have mechanical or functional causes. The radiological sign considered pathognomonic and which can be detected on a simple abdominal X-ray is the presence of hydro-aeric levels. If the occlusion occurs in the ileum, the hydro-aeric levels will be located centrally in the abdomen.

5. Small bowel benign tumors – RX: benign lacuna of variable dimensions.

6. Small bowel malignant tumors – RX: 3 main types (ulcerative, vegetant, infiltrative). Same radio-imaging aspect as in other digestive tract segments.

7. Enteromesenteric infarction – represents an acute necrosis of the small bowel due to a thrombus obstruction of the superior mesenteric artery (arterial infarction) or superior mesenteric vein (venous infarction). The presence or absence of blood flow to the superior mesenteric artery and vein can be accurately assessed through a CT scan with intravenous administration of a contrast agent.

Colo-rectal pathology

1. Megacolon – increased caliber of the colon.

2. Hirschprung disease – the congenital form of megacolon.

3. Inflamatory bowel diseases (IBD) – ulcerative colitis, Crohn disease

a. Ulcerative colitis is a chronic inflammatory condition that strictly affects the mucosal lining of the colon and rectum in a continuous manner, without leaving unaffected parts in-between. The main radio-imaging diagnostic methods are barium enema, entero-CT and entero-MR. A certain diagnosis can be established through colonoscopy given the possibility to prelevate bioptic tissue.

On barium enema, the mucosa of the colon appears thickened, with irregular mucosal folds and ulcerations. The haustral folds appear asymmetrical. In advanced phases, the mucosal and haustral folds disappear and the lumen appears narrow.

On entero-CT and entero-MR, the mucosa of the colon/rectum appears thickened (>4mm), has ulcerations and enhances vividly.

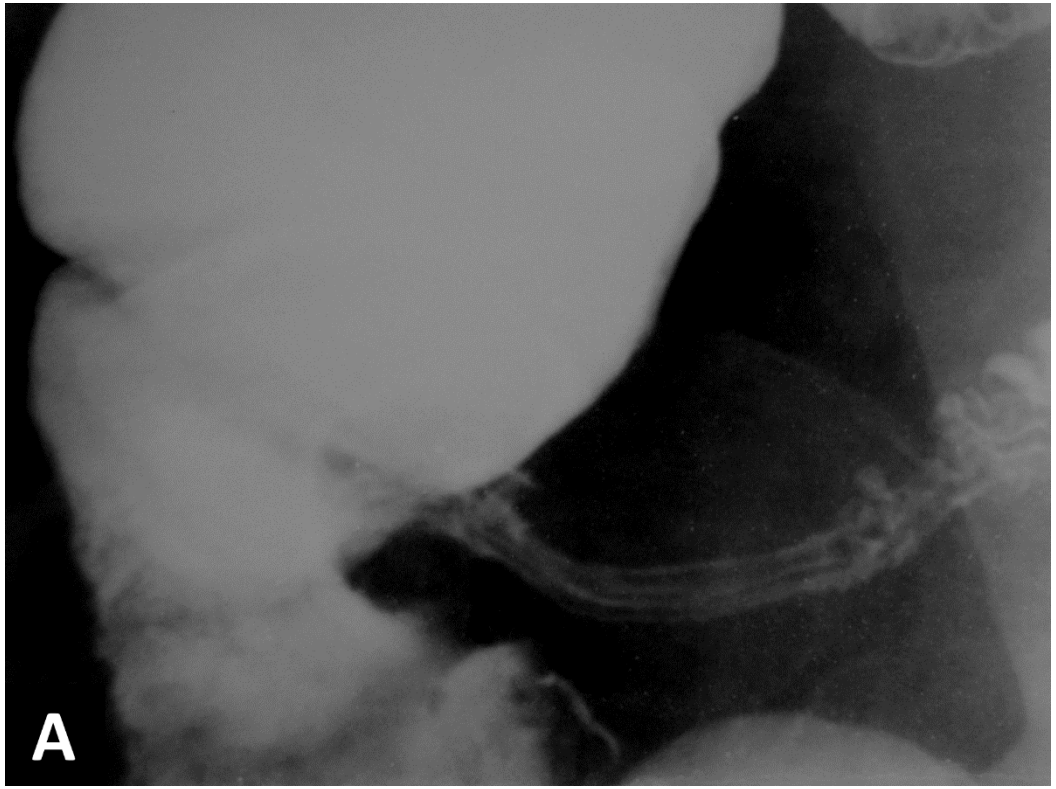
Colo-rectal pathology

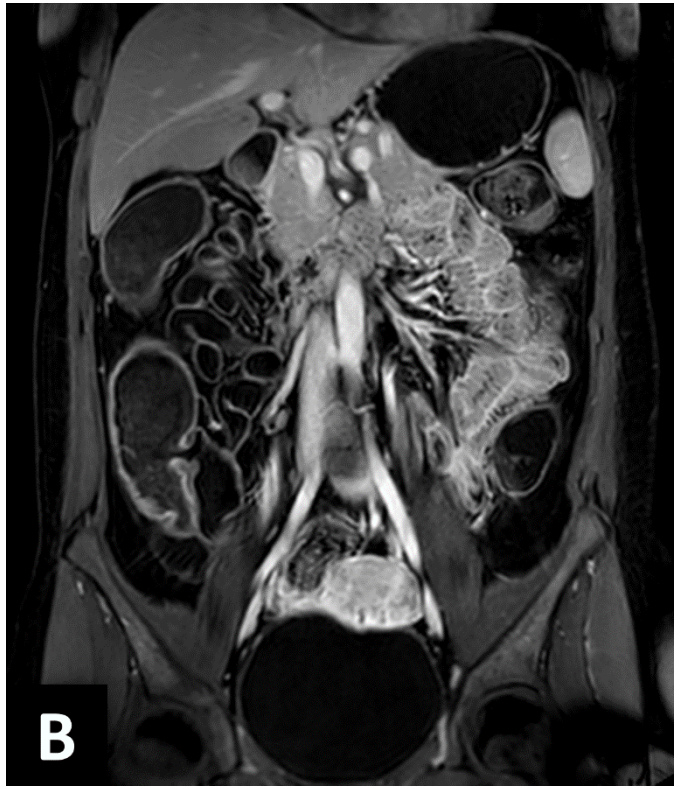
b. Crohn disease – a chronic inflammatory disorder that causes inflammation of the gastrointestinal tract in a discontinuous manner. The inflammatory process begins in the mucosa and extends transmurally in evolution. Most commonly, Crohn's disease is located in the terminal ileum and proximal colon, but can affect any segment of the digestive tract. The main radio-imaging diagnostic methods are barium enema, entero-CT and entero-MR. A certain diagnosis can be established through colonoscopy given the possibility to prelevate bioptic tissue.

On barium enema, the mucosa of the colon appears thickened, with irregular mucosal folds and ulcerations. The haustral folds appear asymmetrical. In advanced phases, the mucosal and haustral folds disappear and the lumen appears narrow.

On entero-CT and entero-MR: the walls of the affected digestive tract segment appear thickened over 10 mm, have ulcerations and enhance vividly postcontrast. Also, we can notice the densification of the adjacent mesenteric fat, the presence of strictures with overlying dilatation, fistulas and / or abscesses.

Colo-rectal pathology





Colo-rectal pathology

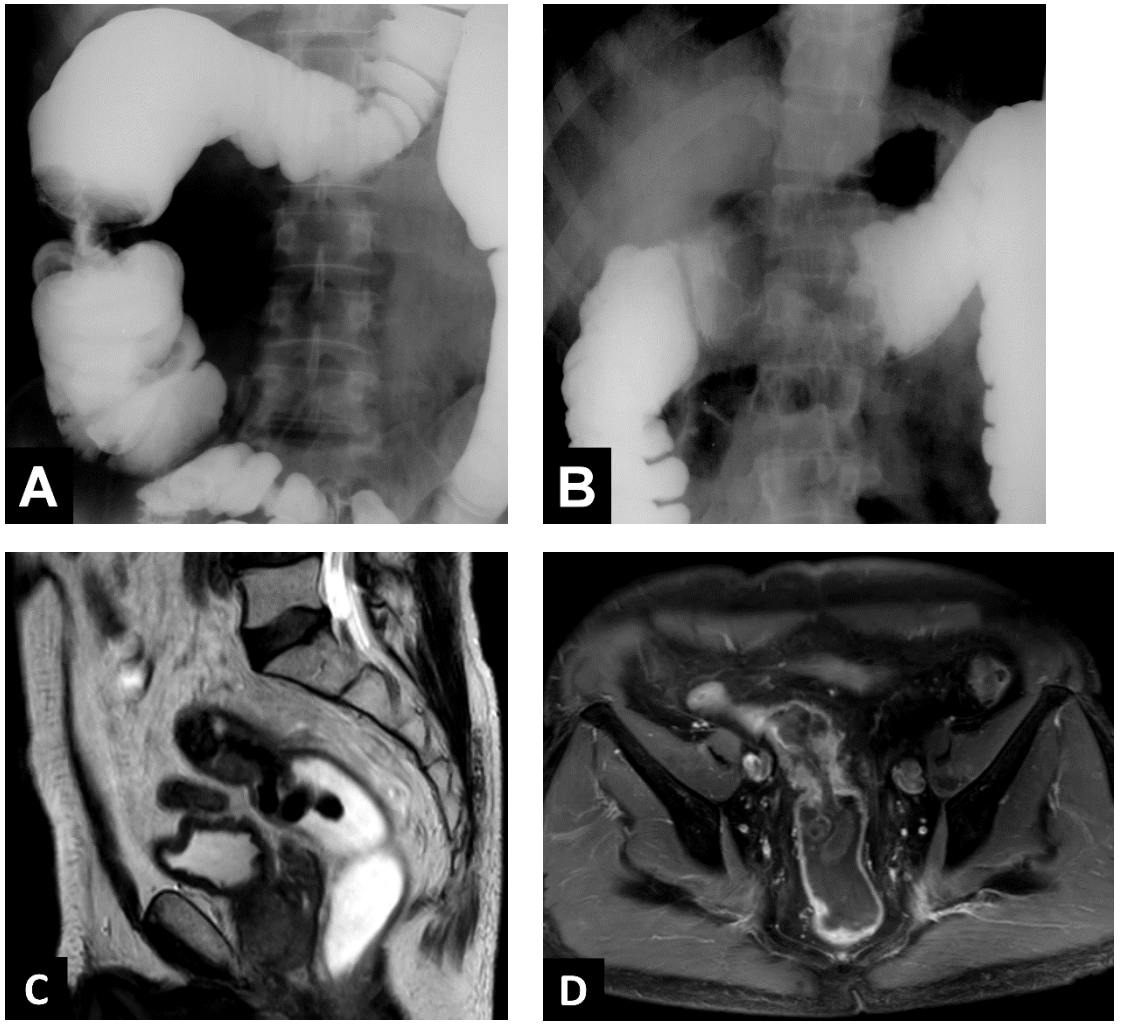
4. Large bowel occlusion – hydro-aeric levels located anywhere along the colon framework.

5. Colon diverticula – filling pluses that communicate with the colon. The barium swallow and CT examination performed with an oral contrast agent highlight the presence of the contrast inside the diverticulum.

6. Large bowel benign tumors – RX: benign lacuna of variable dimensions.

7. Large bowel malignant tumors – RX: 3 main types (ulcerative, vegetant, infiltrative). Same radio-imaging aspects as in other digestive tract segments.

Colo-rectal pathology



Liver pathology
Diffuse liver lesions

The liver plays an important metabolic role and can be the focal point for numerous pathological processes. These can be classified into diffuse and focal liver lesions. At CT scan, the average liver density is between 55-65 UH (Hounsfield units).

1. Diffuse hepatic steatosis

Diffuse hepatic steatosis involves abnormal growth of the hepatocyte fat content. At US, the fat appears hyperechoic. On a CT scan, the adipose tissue has negative densities between -50 and -100 UH. On an MRI scan, adipose tissue appears in hyperintense in T1 and T2 and is canceled in fat-supression sequences (hypointense).

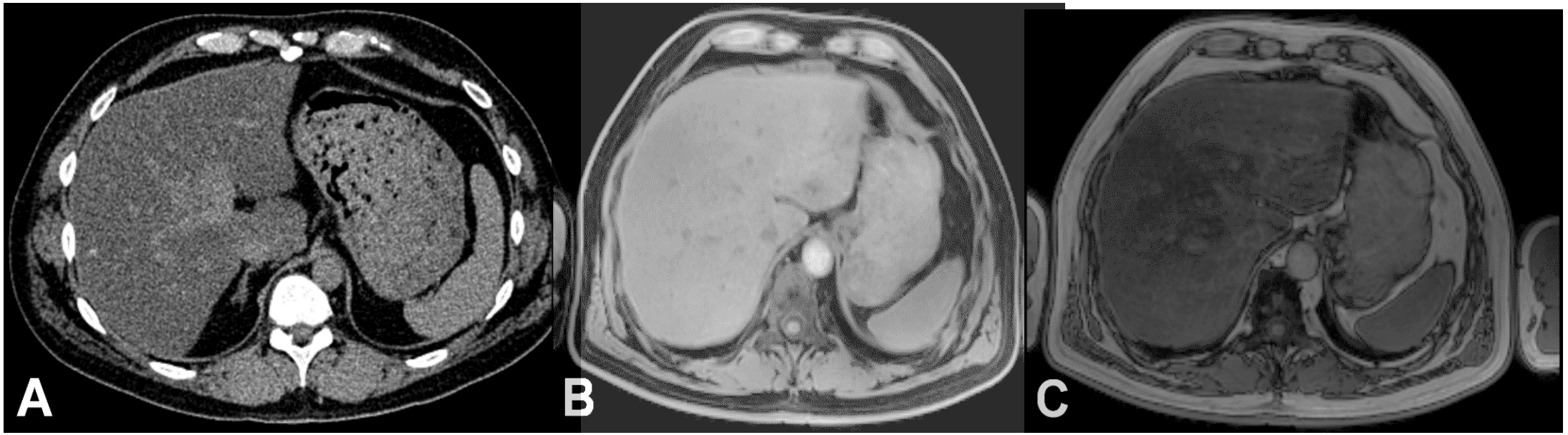
US: The echogenicity of the liver is increased.

CT: The mean liver densities decrease below 45-55 UH proportional to the amount of adipose tissue present at this level.

MRI: The T1 and T2 signals in the liver are increased. In addition, in the T1 out-of-phase sequence (T1 OP), we notice a signal drop compared to the T1 in-phase sequence (T1 IP) due to the presence of the fat tissue. MRI spectroscopy is useful in the quantitative, non-invasive evaluation of hepatic steatosis.

Liver pathology
Diffuse liver lesions

1. Diffuse hepatic steatosis



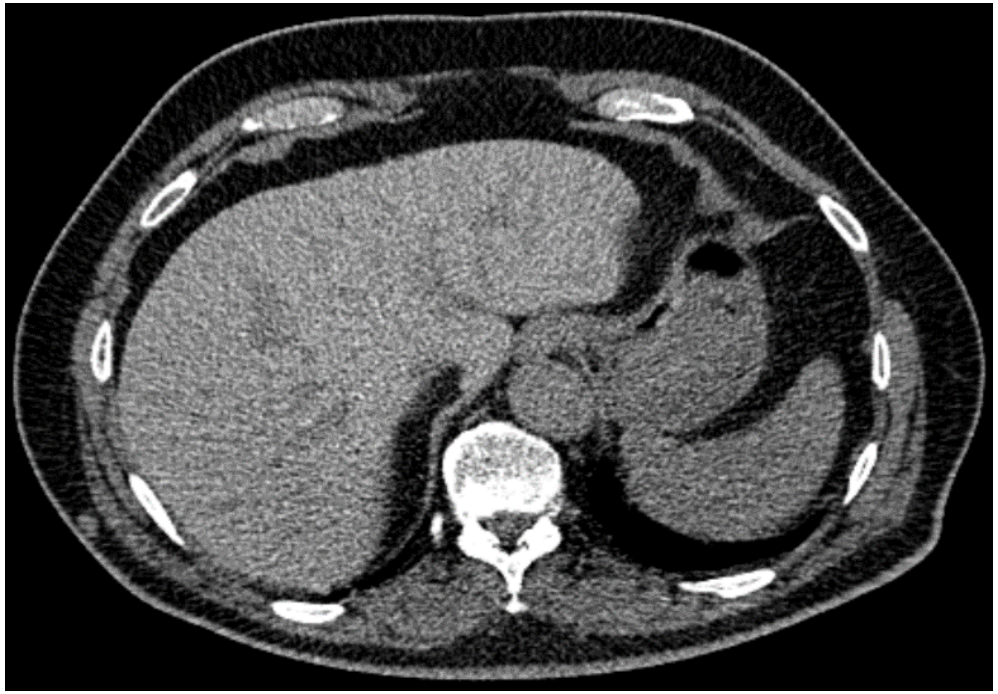
Liver pathology
Diffuse liver lesions

2. Hemochromatosis

Hemochromatosis represents an increased iron absorption in the intestine, followed by an excessive storage in the form of ferritin or hemosiderin mainly in the liver and to a lesser extent in the pancreas and heart.

CT: The average densities of the liver increase above 65-75 UH in proportion to the amount of iron stored at this level.

MRI: T1 and T2 signal drop in the affected liver area.



Liver pathology
Diffuse liver lesions

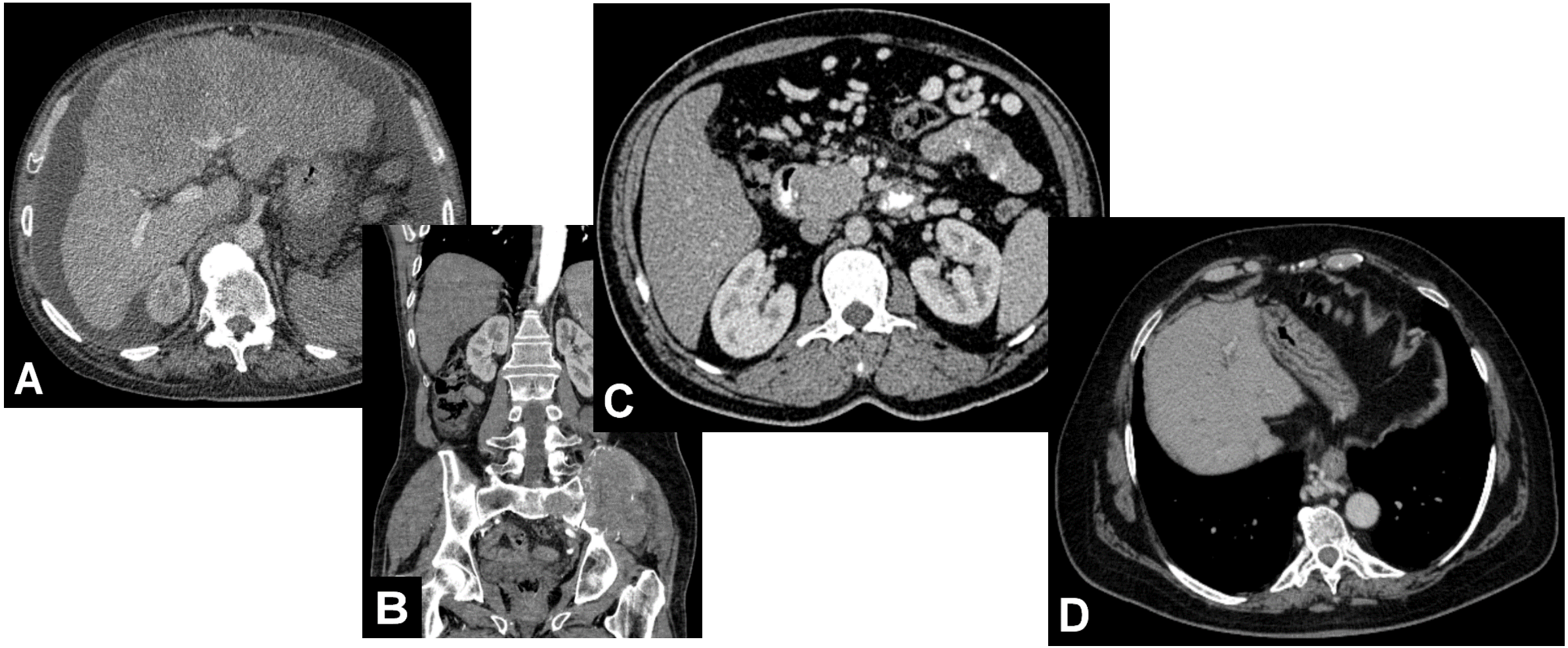
3. Liver cirrhosis

Liver cirrhosis is a plurietiological disorder that involves an evolution towards an irreversible fibrotic process developed inside the liver parenchyma. Simultaneously, the normal architecture of the liver is destroyed. Liver cirrhosis can be of several types: micronodular (nodules <3 mm), macronodular (nodules> 3 mm) or mixed.

In the early stages of liver cirrhosis, the liver may have a normal appearance. Subsequently, atrophy of the right lobe and hypertrophy of the caudate lobe may appear. Some of the changes encountered on CT and MRI examinations in liver cirrhosis include: the presence of regeneration/dysplastic nodules, an irregular contour of the liver, hepatomegaly, splenomegaly, increased size of the portal vein and / or splenic vein, development of collateral circulation and periesophageal varices, as well as the presence of ascites.

Liver pathology
Diffuse liver lesions

3. Liver cirrhosis



Liver pathology
Focal liver lesions

1. Simple hepatic cyst

The simple hepatic cyst is a round-oval lesion, with liquid content, homogeneous, well delimited by a fine wall. It can be single or multiple.

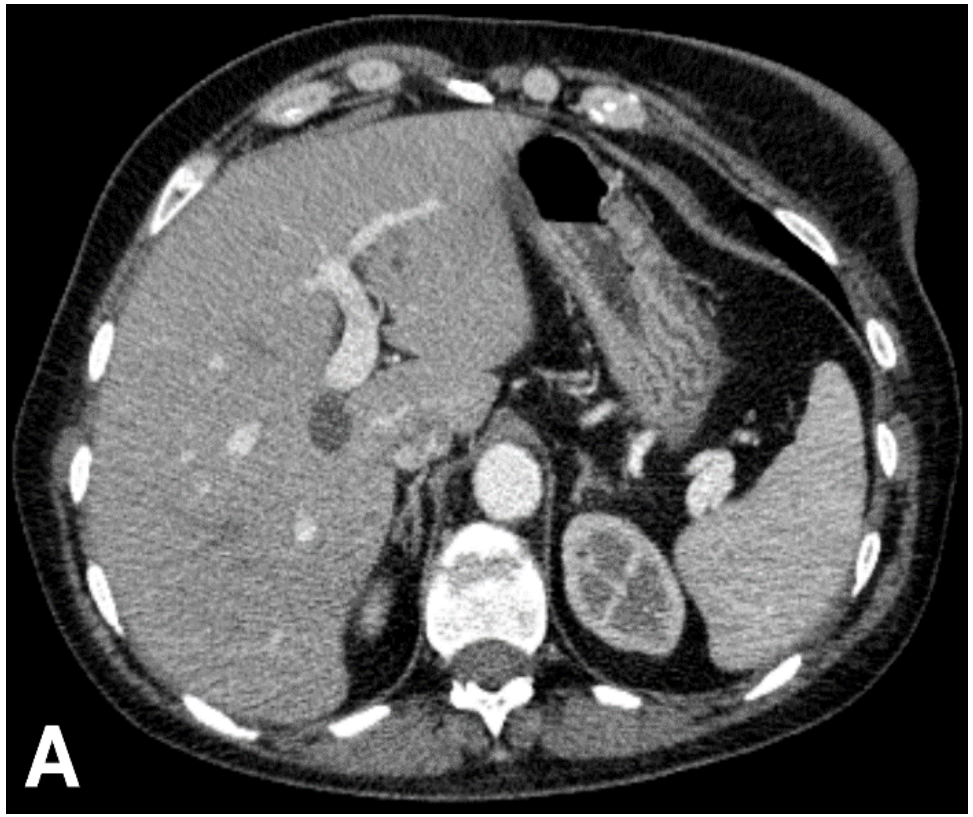
US: The lesion has a transsonic content.

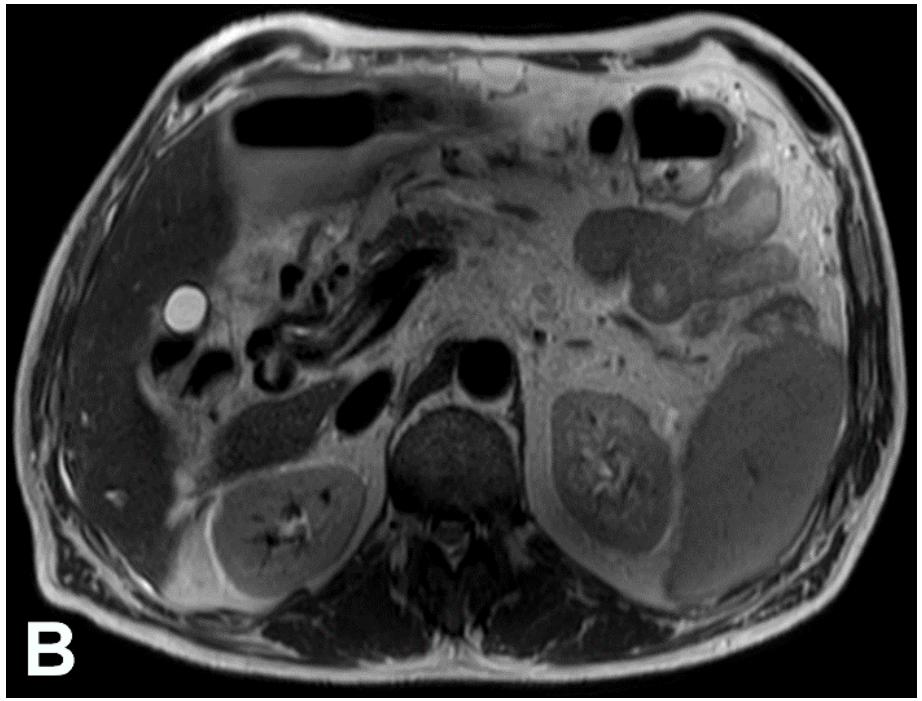
CT: At native examination, the simple liver cyst has a homogeneous appearance and usually is hypodense (densities between 0 and 10 UH). In case of an intra-cystic haemorrhage, an increase in densities is observed. After intravenous contrast administration, the simple hepatic cyst does not enhance.

MRI: The simple hepatic cyst is hypointense in T1 and hyperintense in T2. In case of an intracystic hemorrhage or a high protein content, we observe high signal intensity on T1 sequence. After intravenous contrast administration, the simple hepatic cyst does not enhance.

Liver pathology
Focal liver lesions

1. Simple hepatic cyst





Liver pathology
Focal liver lesions

2. Hepatic abscess

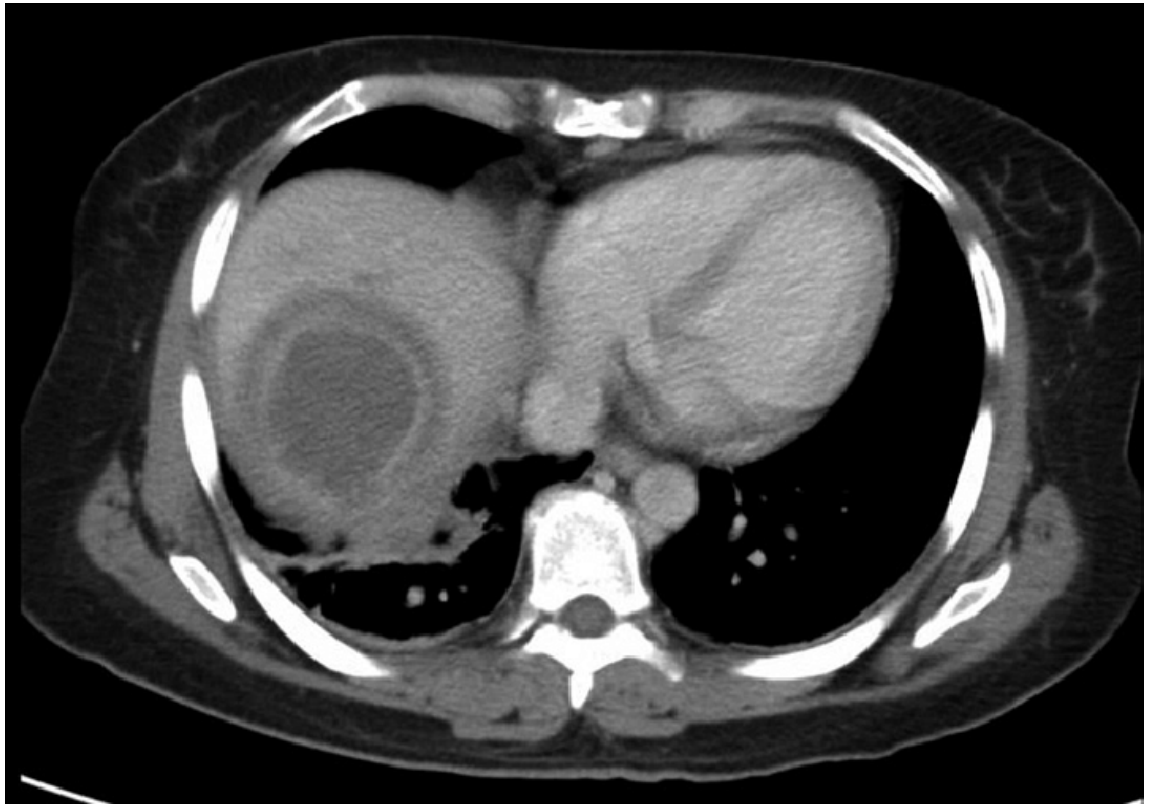
The liver abscess appears as a result of a bacterial infection and constitutes a localized collection that has inflammatory necrotic contents inside.

CT: It is highlighted in the form of single or multiple hypodense lesions, well delimited by a capsule of increased thickness. Post-contrast, we notice the "double target" aspect visualized from the inside of the lesion towards the outside by: hypoenhancement in the central area, surrounded by a hyperenhancing capsule, on the periphery of which there is a hypodense area of perilesional edema. In case of abcedation, the presence of air or hydro-aeric levels inside the abscess is considered pathognomonic.

MRI: The central area of the liver abscess in T1 - hyposignal and in T2 - hypersignal. The perilesional edema is seen in T2 hypersignal. Post-contrast, the capsule of the abscess enhances.

Liver pathology
Focal liver lesions

2. Hepatic abscess



Liver pathology
Focal liver lesions

2. Hepatic abscess

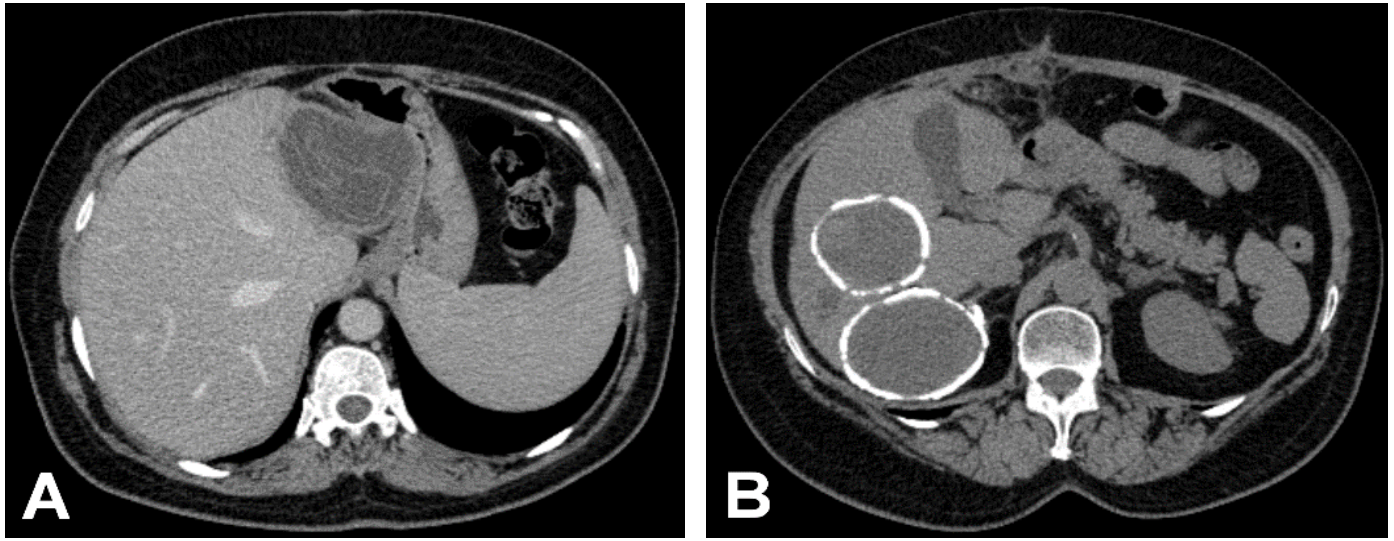
Liver pathology
Focal liver lesions

3. Hepatic hydatid cyst

The hydatic cyst involves an infection with T. Echinococcus.

CT: The hepatic hydatic cyst has fluid densities and is round-oval, well delimited. It can be multi-loculated, septated and can have a proligerous membrane inside. It may also have parietal calcifications. Post-contrast, the lesion enhances in the periphery and in the intralesional septs.

MRI: T1 - hyposignal and T2 - hypersignal. The postcontrast enhancement pattern is similar to the CT exam.



Liver pathology
Focal liver lesions

4. Hepatic hemangioma

Hepatic hemangioma is a benign vascular hepatic tumor.

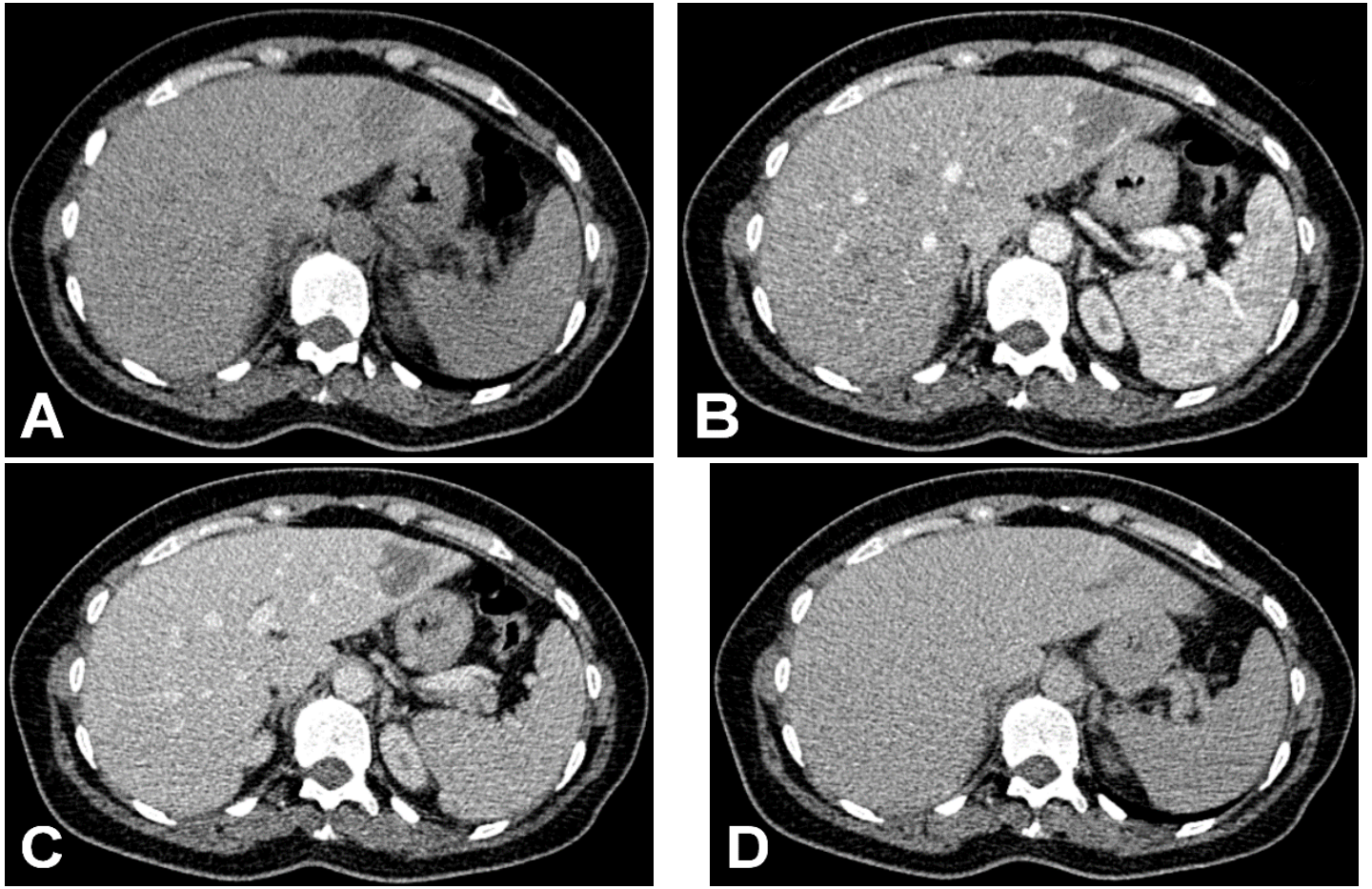
US: Well-defined hyperechoic lesion.

CT: Natively, liver hemangiomas appear hypodense. Post-contrast, enlarged hepatic hemangiomas show progressive, slow centripetal enhancement compared to the adjacent hepatic parenchyma, so that in the late phase, they may be filled completely or almost completely, sometimes with hyperdense appearance. In case of small hemangiomas, it is possible for them to fill rapidly and completely in the arterial phase.

MRI: T1 – hyposignal and T2 – moderate hypersignal. The postcontrast enhancement pattern is similar to the CT exam.

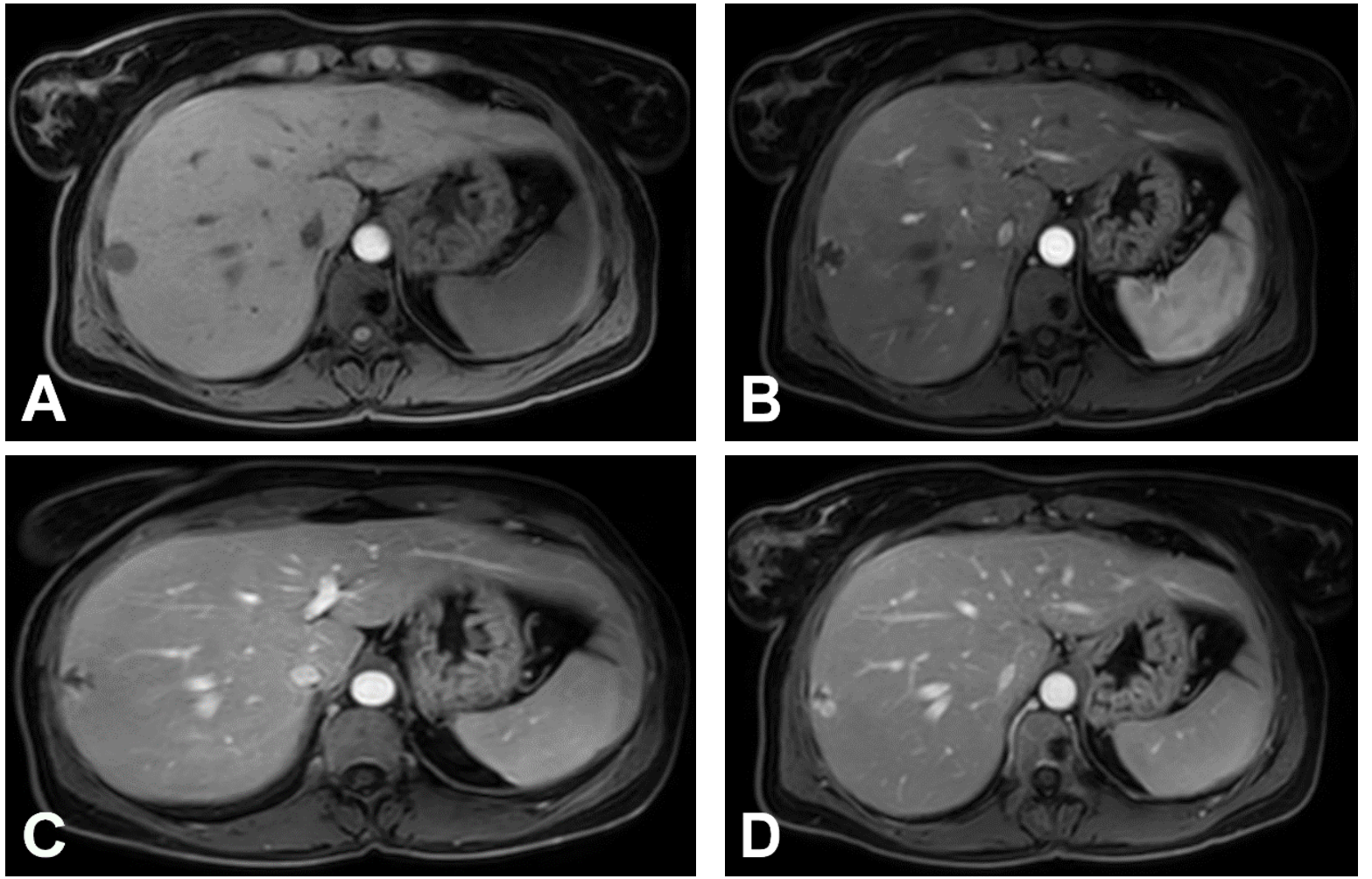
Liver pathology
Focal liver lesions

4. Hepatic hemangioma



Liver pathology
Focal liver lesions

4. Hepatic hemangioma



Liver pathology
Focal liver lesions

5. Focal nodular hyperplasia (FNH)

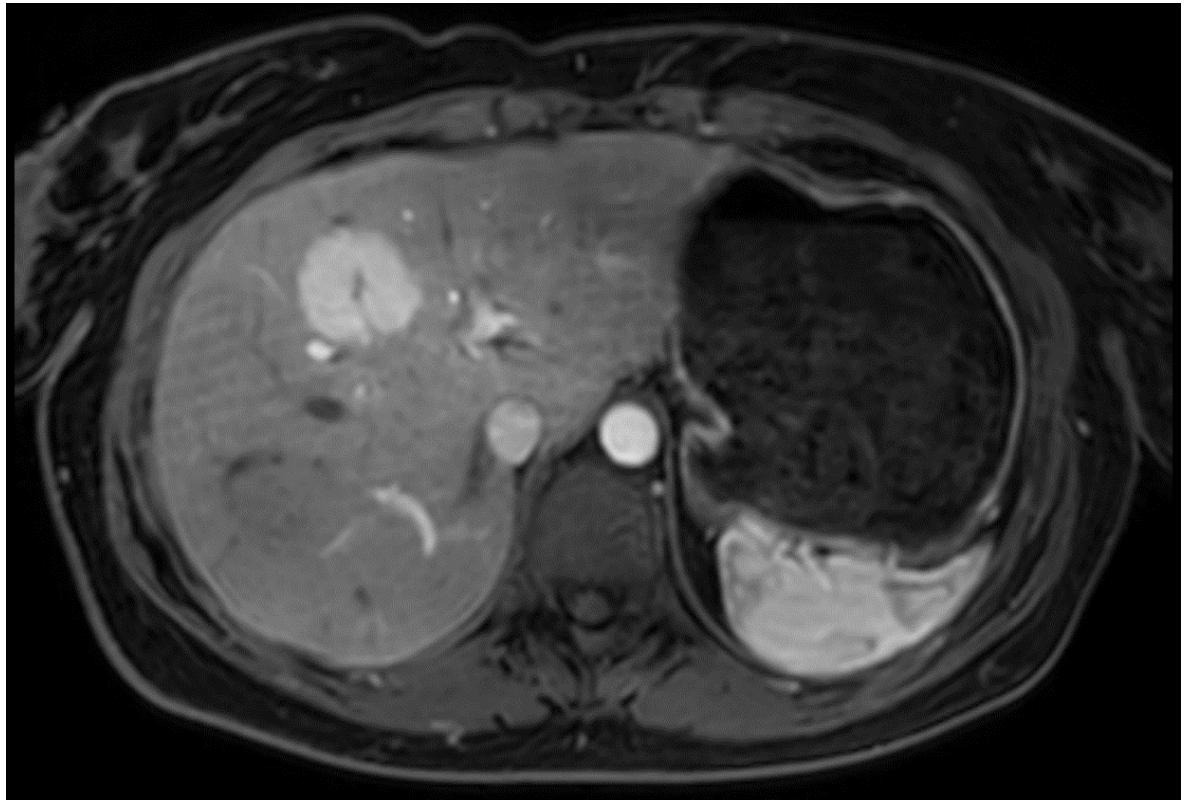
FNH ranks second in frequency among benign liver tumors and mainly affects young women of childbearing age. Most of the time, it appears as a unique lesion. However, it may be associated with other liver lesions (most commonly with liver hemangiomas). The presence of the central scar is considered pathognomonic. The presence of fat and intra-lesional bleeding is possible in FNH, but it is not a characteristic.

CT: Natively, the lesion and central scar appear hypodense. Post-contrast, FNH enhances intensely in the arterial phase. Then, in the venous and late stages, the lesion appears iso / hyperdense relative to the rest of the hepatic parenchyma. The central scar remains hypodense even in the venous phase and becomes hyperdense in the late phase.

MRI: FNH appears in iso- / hyposignal T1 and iso- / hypersignal T2. The central scar shows T1 hyposignal and T2 hypersignal. Post-contrast, the lesion enhances intensely in the arterial phase and then it is seen as iso- / hypersignal relative to the rest of the hepatic parenchyma in the venous and late phases. Similar to CT examination, the central scar does not enhance in the venous phase and becomes hyperintense in the late phase.

Liver pathology
Focal liver lesions

5. Focal nodular hyperplasia (FNH)



Liver pathology
Focal liver lesions

6. Hepatic adenoma

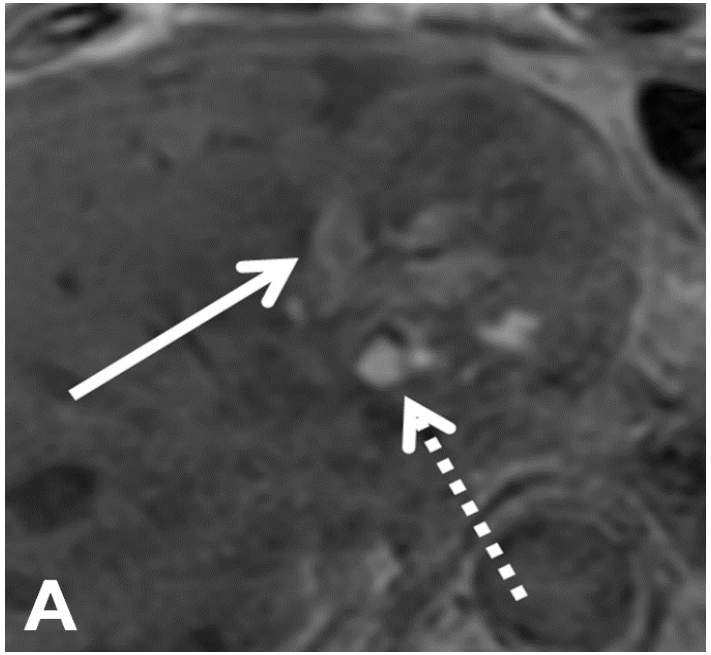
Hepatic adenoma is a benign liver tumor found with a lower frequency compared to FNH, but it affects young women of childbearing age more frequently. Quite often, the hepatic adenoma is manifested in the form of multiple lesions (over 10 - hepatic adenomatosis). In the liver adenoma, fat and intra-lesional hemorrhage are found relatively frequently.

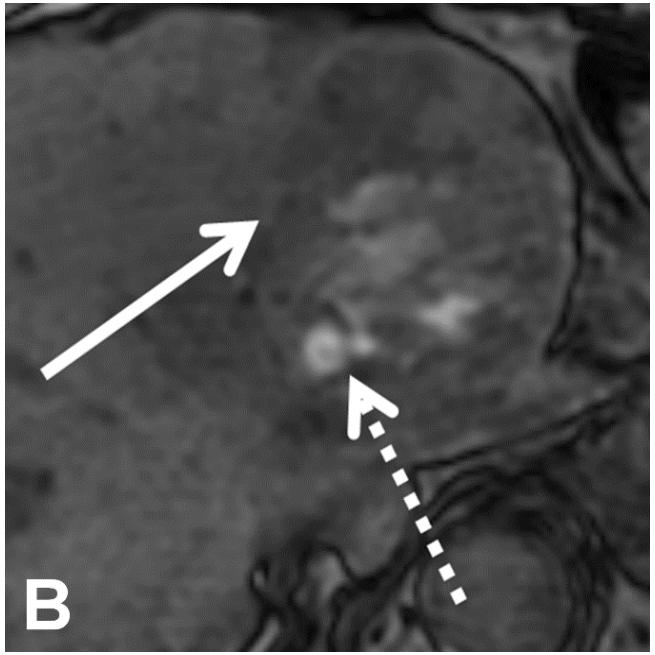
CT: Natively, the appearance and density of the lesion are variable depending on the fat content and the presence of intra-lesional hemorrhage. Post-contrast, the hepatic adenoma enhances in the arterial phase and then becomes isodense relative to the rest of the hepatic parenchyma in the venous and late phases.

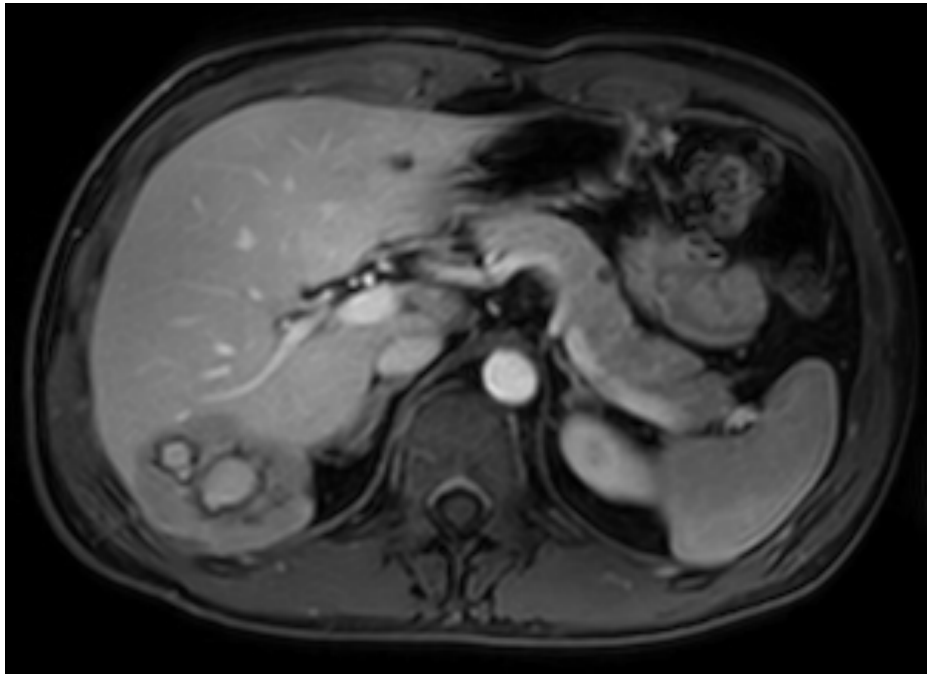
MRI: The fat and intra-lesional haemorrhagic contents appear as hyperintense T1 IP. If the increased signal from T1 IP is maintained in the T1 OP sequence then the lesion has hemorrhagic content. If the increased signal from the T1 IP sequence and is not maintained in the T1 OP sequence then it is intra-lesional fat. Post-contrast, the lesion enhances moderately in the arterial phase, after which it is visualized as isosignal relative to the rest of the hepatic parenchyma in the venous and late phases.

Liver pathology
Focal liver lesions

6. Hepatic adenoma







Liver pathology
Focal liver lesions

7. Hepatocellular carcinoma

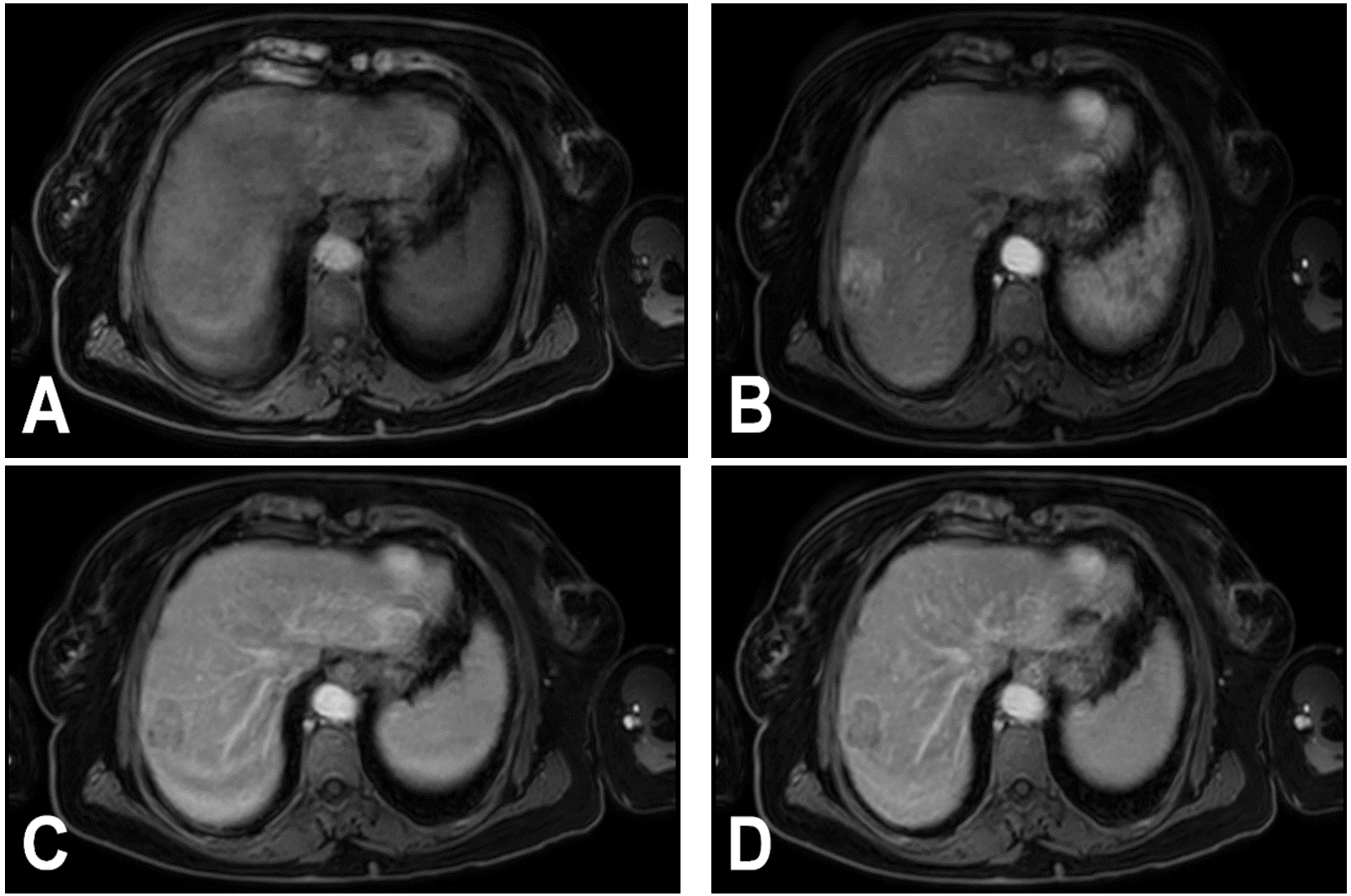
HCC is the most commonly encountered liver malignancy and develops frequently on a cirrhotic liver.

From an imaging point of view, the HCC presents an extremely variable aspect. It can vary in size from several millimeters to several tens of centimeters (tumors that occupy an entire hepatic lobe). Intralesional areas of necrosis, fat and hemorrhagic content can be identified. A hyperenhancing tumor in the arterial phase that presents wash-out (rapid elimination) in the venous and late phases is a characteristic finding in HCC. This imaging aspect can be found in any of the following contrast imaging diagnostic means: US, CT and MRI.

In addition, the MRI examination is of increased utility due to the diffusion sequences and the use of specific hepatocyte contrast agents that can evaluate small lesions. An intense hypersignal of the hepatic tumor formation on these sequences indicates a restricted diffusion. This is due to the increased cellularity inside the HCC, thus preventing the diffusion of water molecules under optimal conditions.

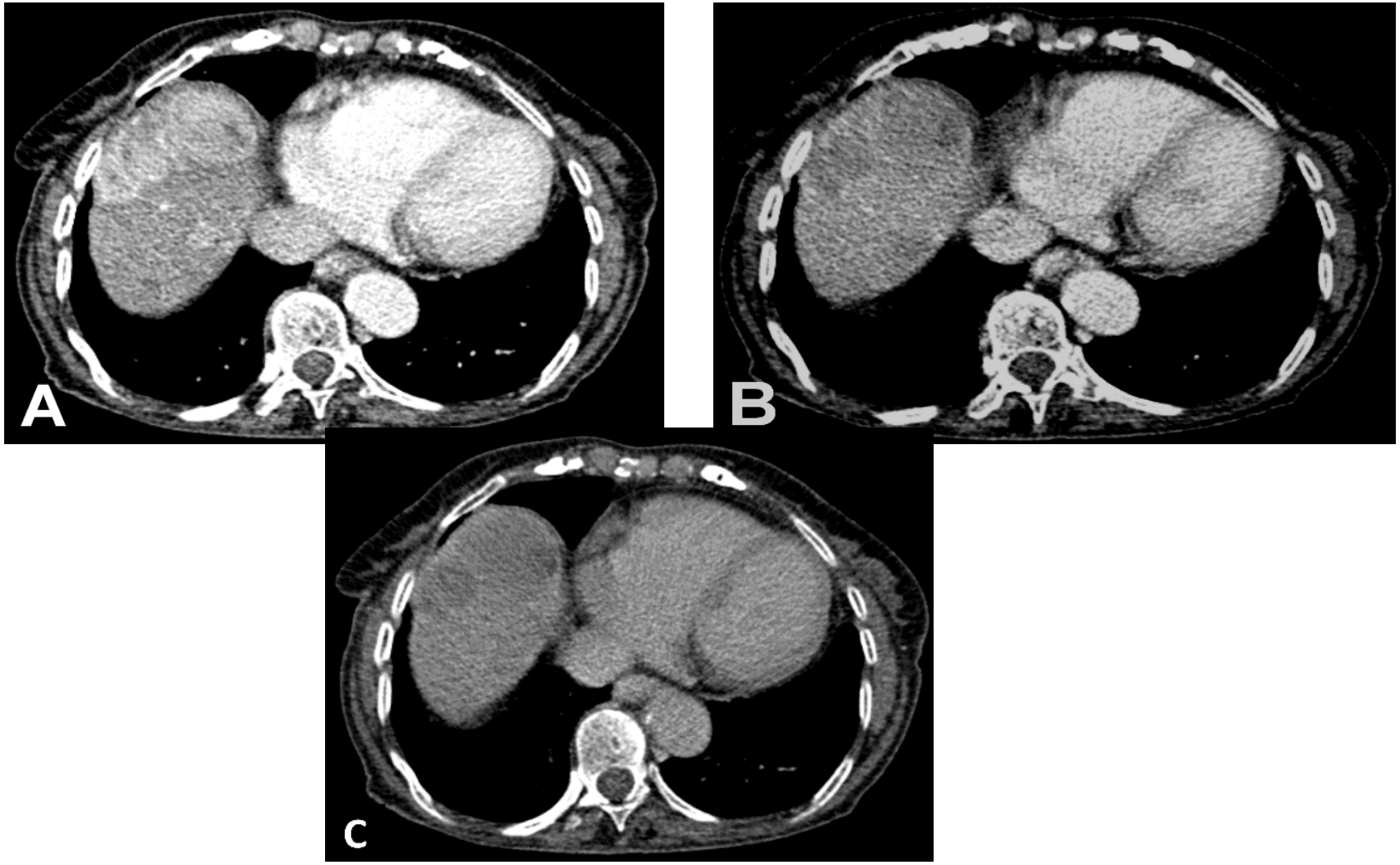
Liver pathology
Focal liver lesions

7. Hepatocellular carcinoma



Liver pathology
Focal liver lesions

7. Hepatocellular carcinoma



Liver pathology
Focal liver lesions

8. Liver metastases

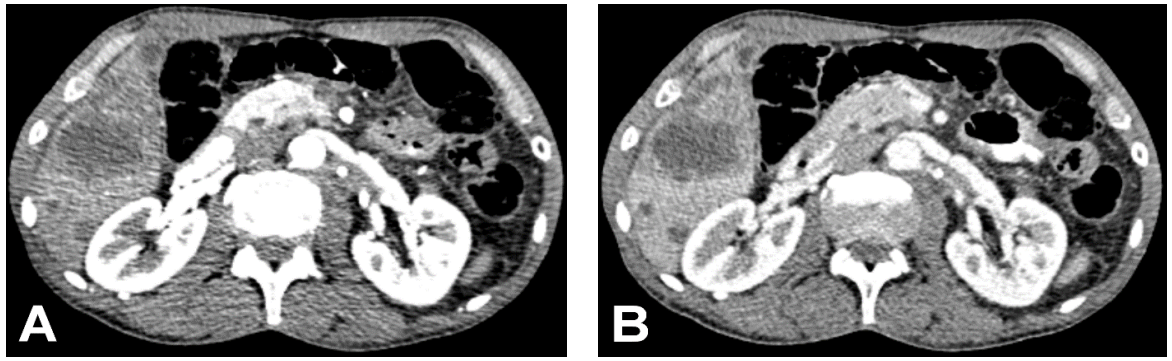
The development of secondary hepatic lesions implies the presence of a primary malignant tumor, thus extending to the hepatic and / or lymphatic level. Primary malignancies that frequently generate liver metastases include colorectal cancer, pancreatic cancer, esophageal cancer, gastric cancer, breast, lung and ovarian cancer. From an imaging point of view, nodular lesions with variable dimensions are most often detected. Secondary liver lesions are divided into hypovascular and hypervascular.

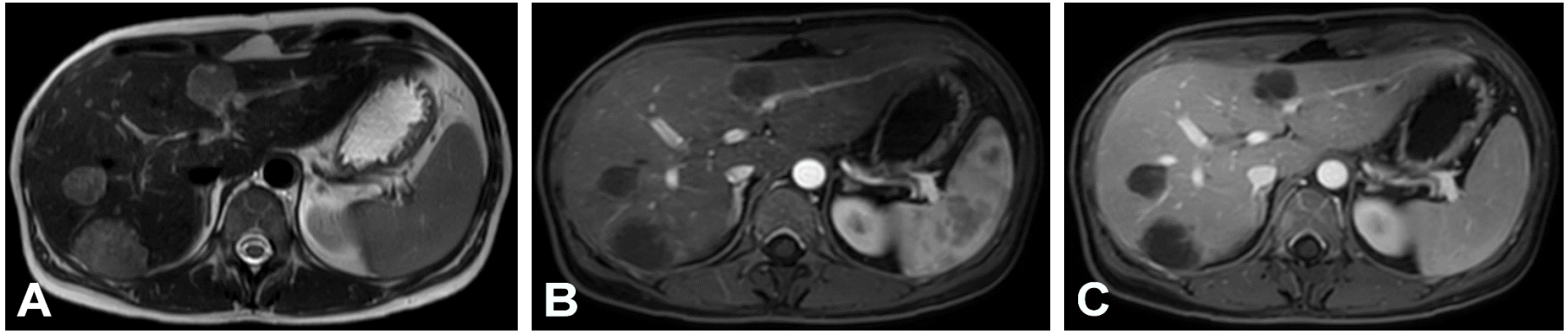
CT: Post-contrast, hypovascular metastases show peripheral enhancement in the arterial phase, and in the venous and late phases there is wash-out in the periphery, while the contrast agent advances towards the center of the lesion. Hypervascular metastases have intense enhancement in the arterial phase, and in the venous and late phases, there is also wash-out in the periphery. The “target sign” aspect is characteristic for metastases regardless of the examination type (CT/MRI).

The diffusion sequences within the MRI examination show a restricted diffusion in the liver metastases due to the increased cellularity in these lesions.

Liver pathology
Focal liver lesions

8. Liver metastases





Liver pathology
Focal liver lesions

9. Liver trauma

A. Subcapsular hepatic hematoma

The hepatic subcapsular hematoma occurs as a result of a trauma affecting the liver. The election examination is CT.

CT: Highlights a perihepatic semi-lunar hematic accumulation. The appearance varies depending on the time elapsed from the moment of the trauma:

- acute phase: the hematoma appears hyperdense in contrast with the hepatic parenchyma;

- subacute phase: the hematoma appears isodense;

- chronic phase: the hematoma appears hypodense.

B. Liver laceration

Liver laceration occurs as a result of severe trauma at this level.

CT: Disruption of the contour of the organ is visualized, with the presence of perihepatic blood accumulation.

Liver pathology
Focal liver lesions

9. Liver trauma

Biliary tract pathology

1. Biliary lithiasis

Biliary lithiasis involves the presence of gallstones inside the gallbladder or the biliary tract. Gallstones are classified into the following three types: cholesterol gallstones (10%), pigmentary gallstones (10%), mixed gallstones (80%). The following imaging methods are used for diagnosis: US, CT and MRI with MRCP sequences.

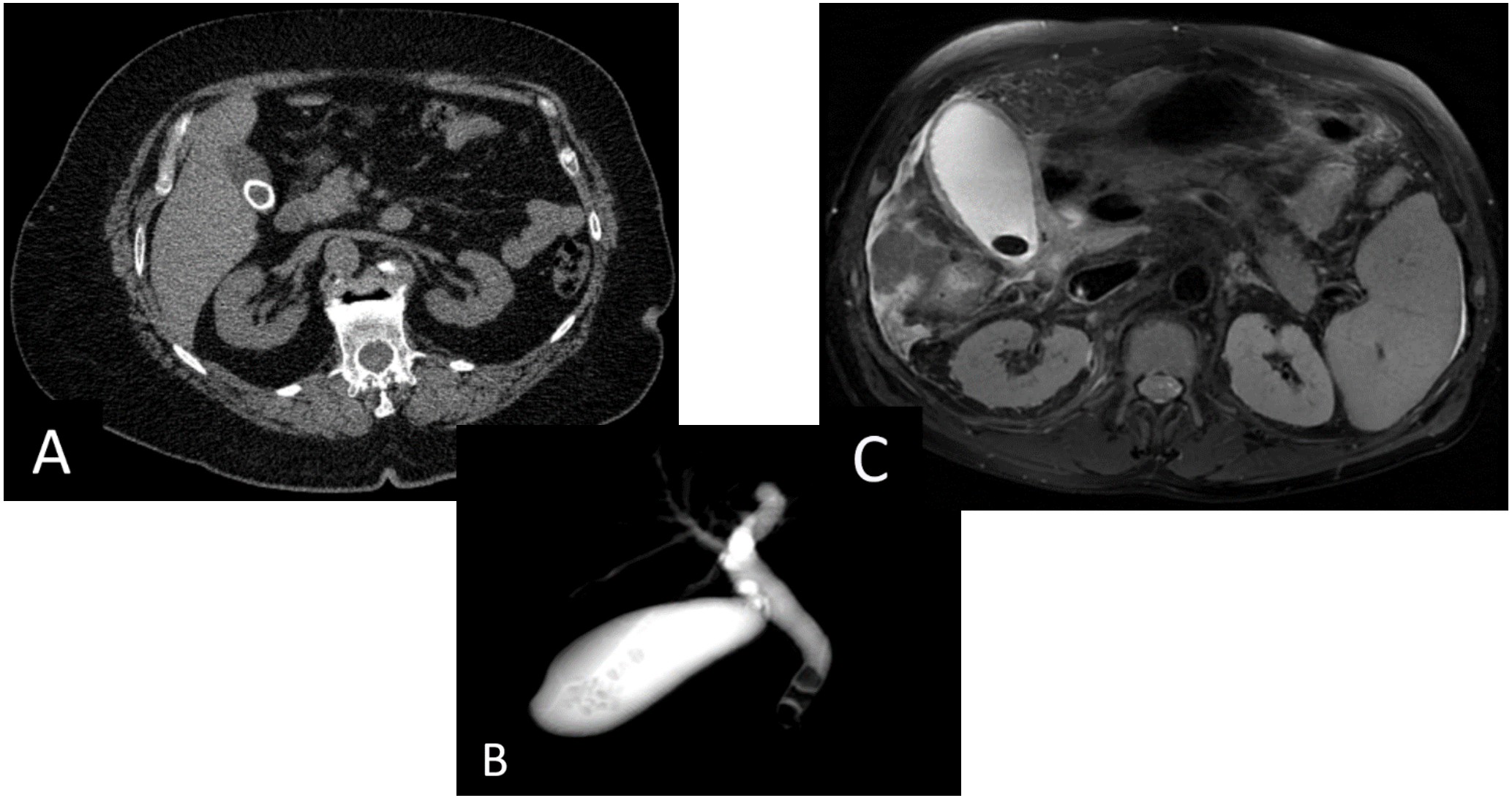
US: Gallstones are visualized as hyperechoic images of variable size, with posterior acoustic shadow and possible dilatations of the superjacent bile ducts. Also, gallstones can be mobilized as the patient's position changes.

CT: Gallstones made of pure cholesterol appear hypodense to the bile, while gallstones containing calcium appear hyperdense to the bile. There are certain situations in which the gallstones cannot be detected by CT, being isodense with the biliary content.

MRI + MRCP: Gallstones are visualized in the form of round-oval images, well delimited, hyposignal to the biliary content, located inside the bile ducts.

Biliary tract pathology

1. Biliary lithiasis



Biliary tract pathology

2. Acute cholecistitis

Acute cholecystitis involves an acute inflammation of the gallbladder. The following are used as imaging diagnostic means: US, CT and MRI with MRCP sequences.

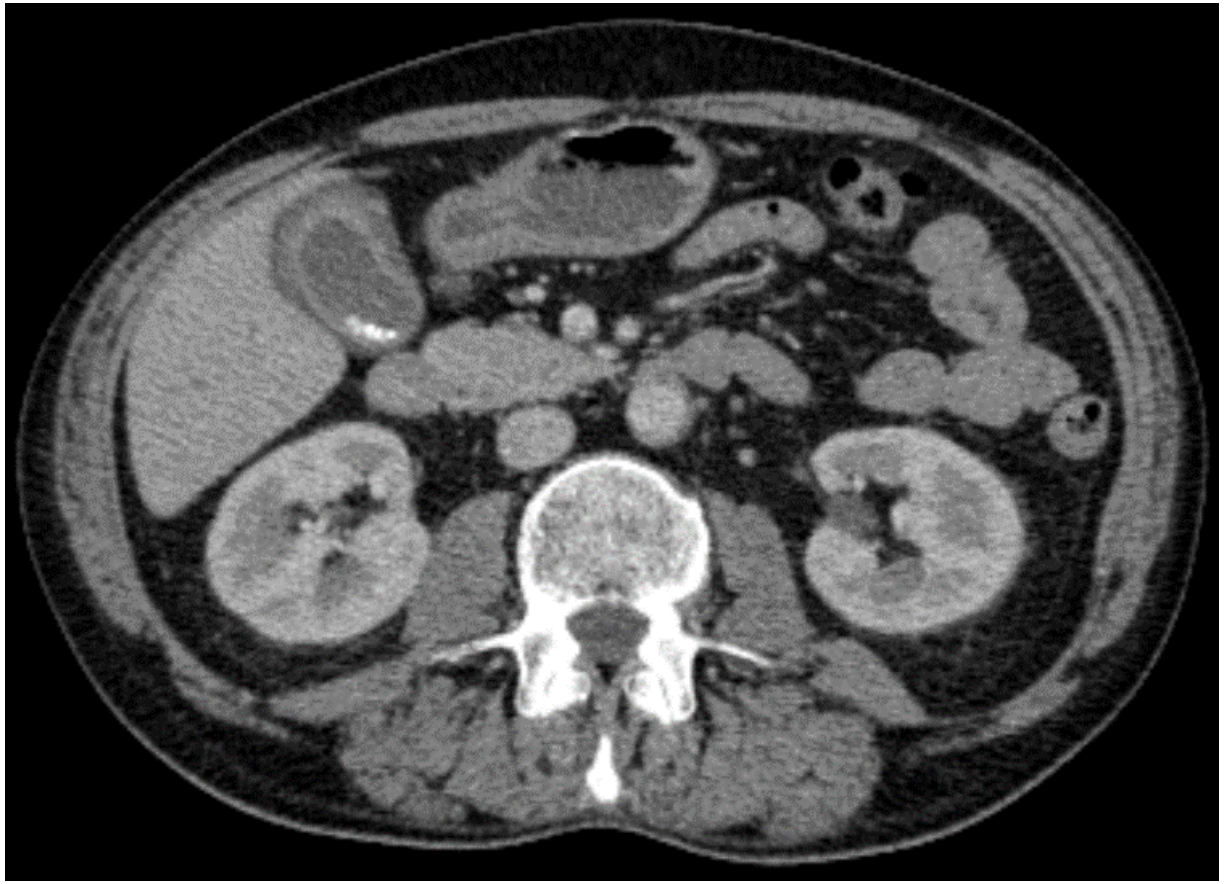
US: The gallbladder appears enlarged, with thickened walls over 3 mm, pericholecistic fluid and gallstones inside the gallbladder and / or cystic duct.

CT: The cholecyst appears increased in volume, with iodophilic walls, thickened walls over 3 mm, pericholecistic fluid and gallstones inside the gallbladder and / or cystic duct.

MRI + MRCP: The gallbladder appears enlarged, with gadophilic walls, thickened walls over 3 mm, pericholecistic fluid and gallstones inside the gallbladder and / or cystic duct.

Biliary tract pathology

2. Acute cholecistitis



Biliary tract pathology

3. Chronic cholecistitis

Chronic cholecystitis involves a chronic, prolonged inflammation of the gallbladder. The following are used as imaging diagnostic means: US, CT and MRI with MRCP sequences.

US: The gallbladder appears with irregularly thickened walls. In the xanthogranulomatous cholecystitis, hypoehoic nodules are seen in the gallbladder wall. In the porcelain gallbladder, hyperechoic images are visualized, with posterior acoustic shadow, located in the wall of the gallbladder.

CT: The gallbladder appears with irregularly thickened walls. In the xanthogranulomatous cholecystitis, hypodense nodules of variable size, located in the thickness of the gallbladder wall can be seen. In the porcelain gallbladder, calcifications located in the thickness of the gallbladder wall +/- hyperdense gallstones can be visualized.

MRI + MRCP: The gallbladder appears with irregularly thickened walls.

Biliary tract pathology

4. Cholangiocarcinoma

Cholangiocarcinoma is the most common malignant tumor of the biliary tract. This pathology may affect the intrahepatic biliary tract (intrahepatic cholangiocarcinoma), the perihilar region (perihilar cholangiocarcinoma - Klatskin tumor) or the main biliary tract (extrahepatic cholangiocarcinoma). The following imaging methods can be used for diagnosis: US, CT, MRI with MRCP, ERCP.

From an imaging point of view, the following pathological changes will be detected depending on the location of the tumor process:

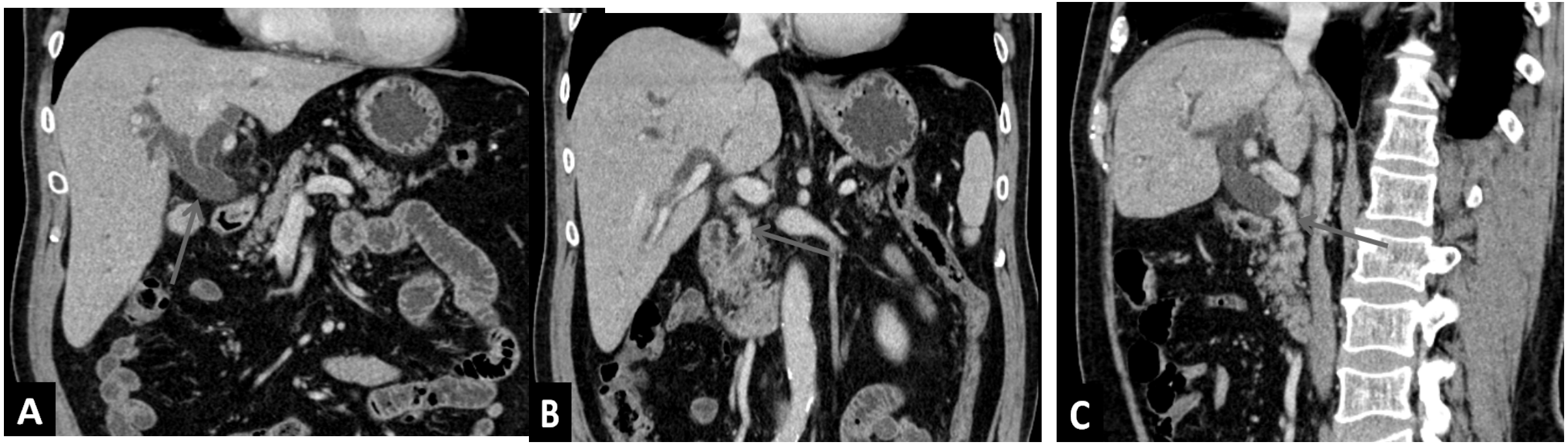
- intrahepatic cholangiocarcinoma: vegetative tumor formation that causes stenosis in the intrahepatic bile ducts and superjacent bile duct dilatation;

- perihilar cholangiocarcinoma: perihilar tumor, the bifurcation of the common hepatic canal can’t be visualized, superjacent dilatations of the intrahepatic bile ducts, no dilatation of the CBD;

- extrahepatic cholangiocarcinoma: infiltrative or vegetative lesion located in the CBD, with superjacent dilatation of the bile ducts.

Biliary tract pathology

4. Cholangiocarcinoma



Pancreatic pathology

1. Acute pancreatitis

Acute pancreatitis is the acute inflammation of the pancreatic and peripancreatic tissue. Most of the time, the patient is brought to the emergency room. The examination of choice for the diagnosis of acute pancreatitis is CT.

The CT examination allows the calculation of the Balthazar score as follows:

- depending on the inflammatory process:

A: normal appearance of the pancreas (0p);

B: enlargement of the pancreas (1p);

C: inflammatory changes in the pancreas and peripancreatic fat (2p);

D: unique, imprecisely delimited peripancreatic fluid collection (3p);

E: two or more peripancreatic fluid collections, imprecisely delimited (4p).

Pancreatic pathology

1. Acute pancreatitis

- depending on the area of pancreatic necrosis:

a. absent (0p);

b. ≤30% (2p);

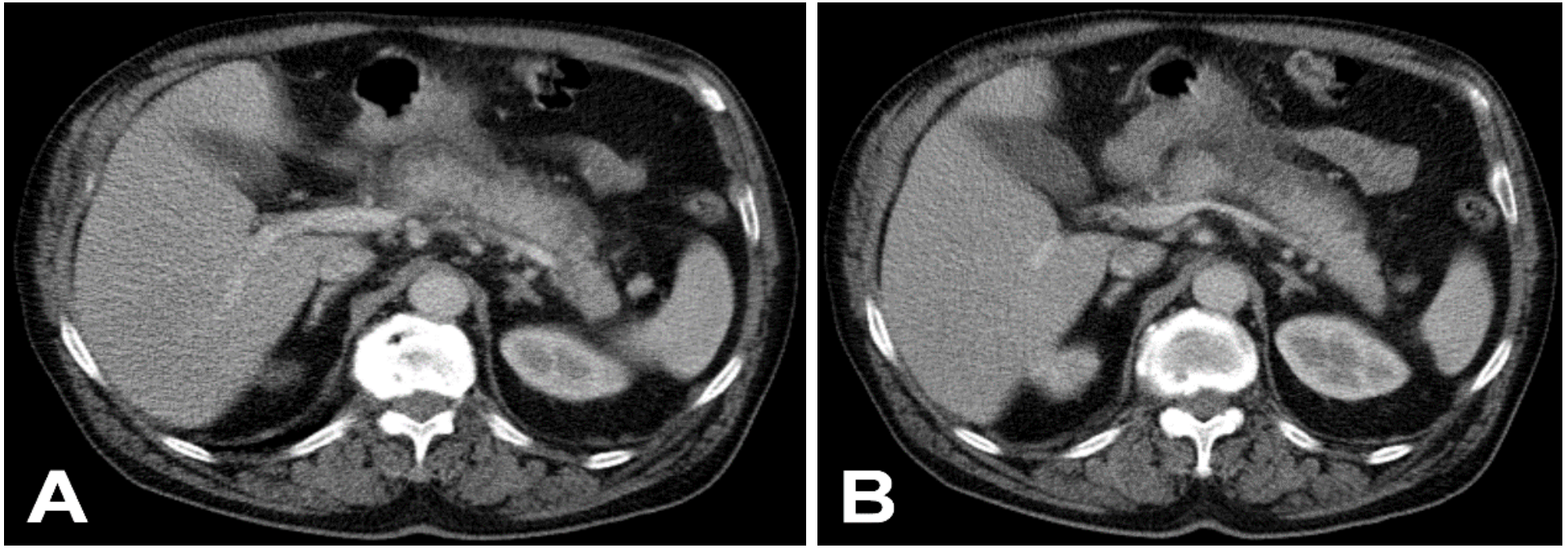
c. > 30-50% (4p);

d. > 50% (6p).

The score obtained is between 0 and 10. The higher the score, the higher the severity of the pancreatitis.

Pancreatic pathology

1. Acute pancreatitis



Pancreatic pathology

2. Chronic pancreatitis

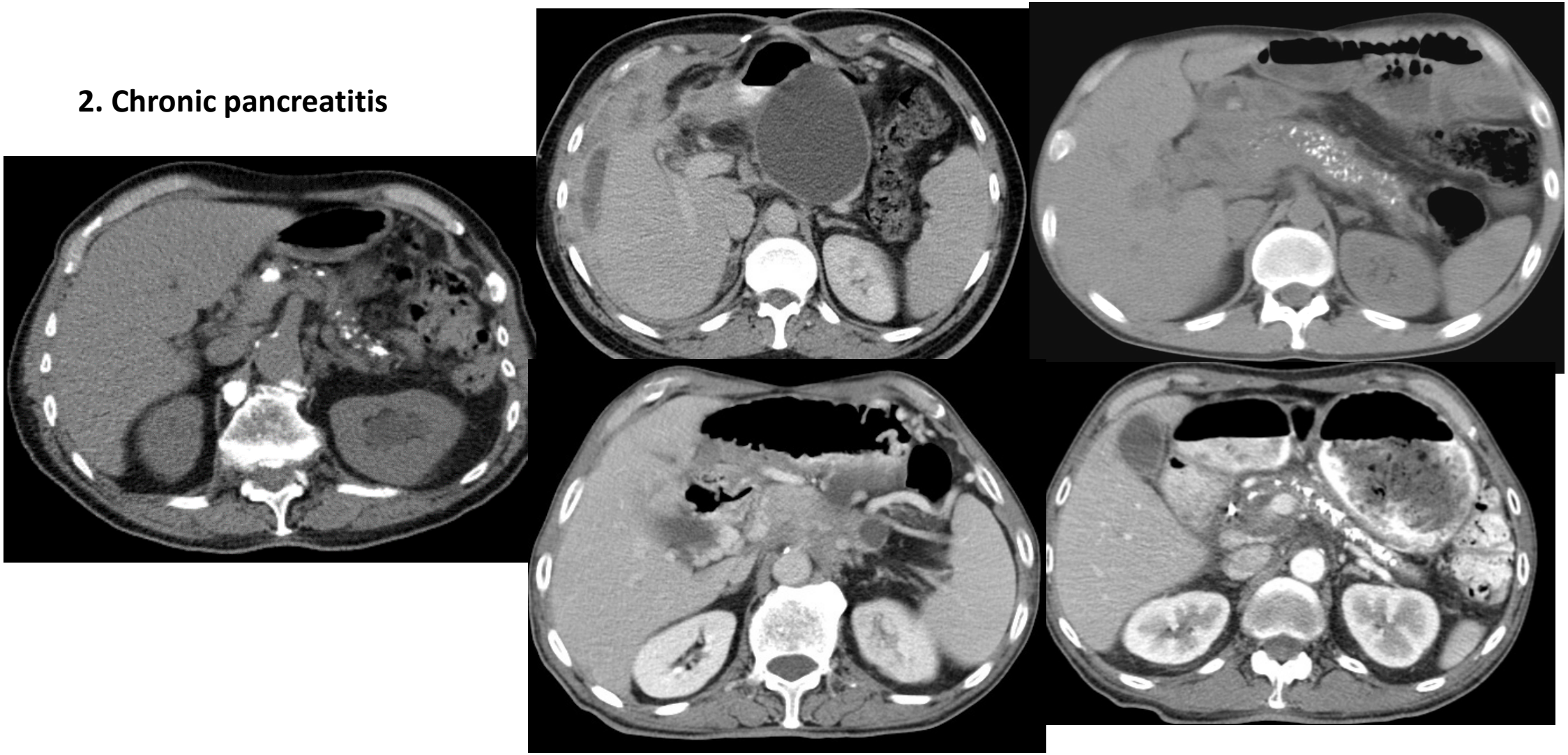
Chronic pancreatitis implies a prolonged inflammatory process in the pancreatic tissue, with irreversible alteration of its architecture.

CT: In case of chronic pancreatitis, the following features can be identified: size changes (global or focal atrophy / hypertrophy), calcifications in the pancreatic tissue, dilatation of the Wirsung duct, caliber changes of the choledoch, the presence of pancreatic pseudocysts.

MRI: In addition to the CT examination, MRI may reveal a decrease in the signal given by pancreatic tissue in the T1 sequence, as well as a decrease in contrast enhancement at this level due to fibrotic changes. It can be supplemented with MRCP sequences that highlight the caliber changes of the choledoch and Wirsung duct.

Pancreatic pathology

2. Chronic pancreatitis



Pancreatic pathology

3. Pancreatic tumors

Tumors that can develop in the pancreatic parenchyma are classified into benign and malignant.

Benign pancreatic tumors are relatively rare and include: simple pancreatic cyst, adenoma, serous cystadenoma.

The simple pancreatic cyst represents a round-oval lesion, with liquid content, homogeneous, well delimited by a fine wall. They can be single or multiple.

US: The lesion presents transsonic content.

CT: At native examination, the simple pancreatic cyst has a homogeneous content and usually appears hypodense (densities between 0 and 10 UH). In case of intra-cystic hemorrhage, an increase in densities is observed. Postcontrast, the simple pancreatic cyst does not enhance contrast.

MRI: The simple pancreatic cyst appears in T1 hyposignal and intense T2 hypersignal. In case of intracystic haemorrhage or high protein content, the hypersignal is noted on the T1 sequence. Postcontrast, the simple pancreatic cyst does not enhance the administered contrast agent.

Pancreatic pathology

3. Pancreatic tumors

Serum cystadenoma is a cystic benign pancreatic tumor characterized by the presence of multiple cystic areas (usually over 6) with individual cyst dimensions not exceeding 2 cm.

The imaging diagnosis can be established through US, CT and MRI.

US: Hypoechoic polylobate mass, septate, with fine echoes inside.

CT: Multilobate, septated mass, with multiple cystic areas grouped in a similar matter to grapes. The lesion enhances peripherally and in the intralesional septa and may present a central fibrous scar that enhances in the late phase.

MRI: Multilobate, septated mass, with multiple cystic areas in T1 hyposignal, T2 hypersignal, grouped in grape clusters. The lesion enhances peripherally in the intralesional septa and may present a central fibrous scar that enhances in the late phase.

Pancreatic pathology

3. Pancreatic tumors

The imaging aspect of malignant pancreatic tumors is highly variable and corresponds to the histological type. The imaging diagnosis can be established through US, CT and MRI.

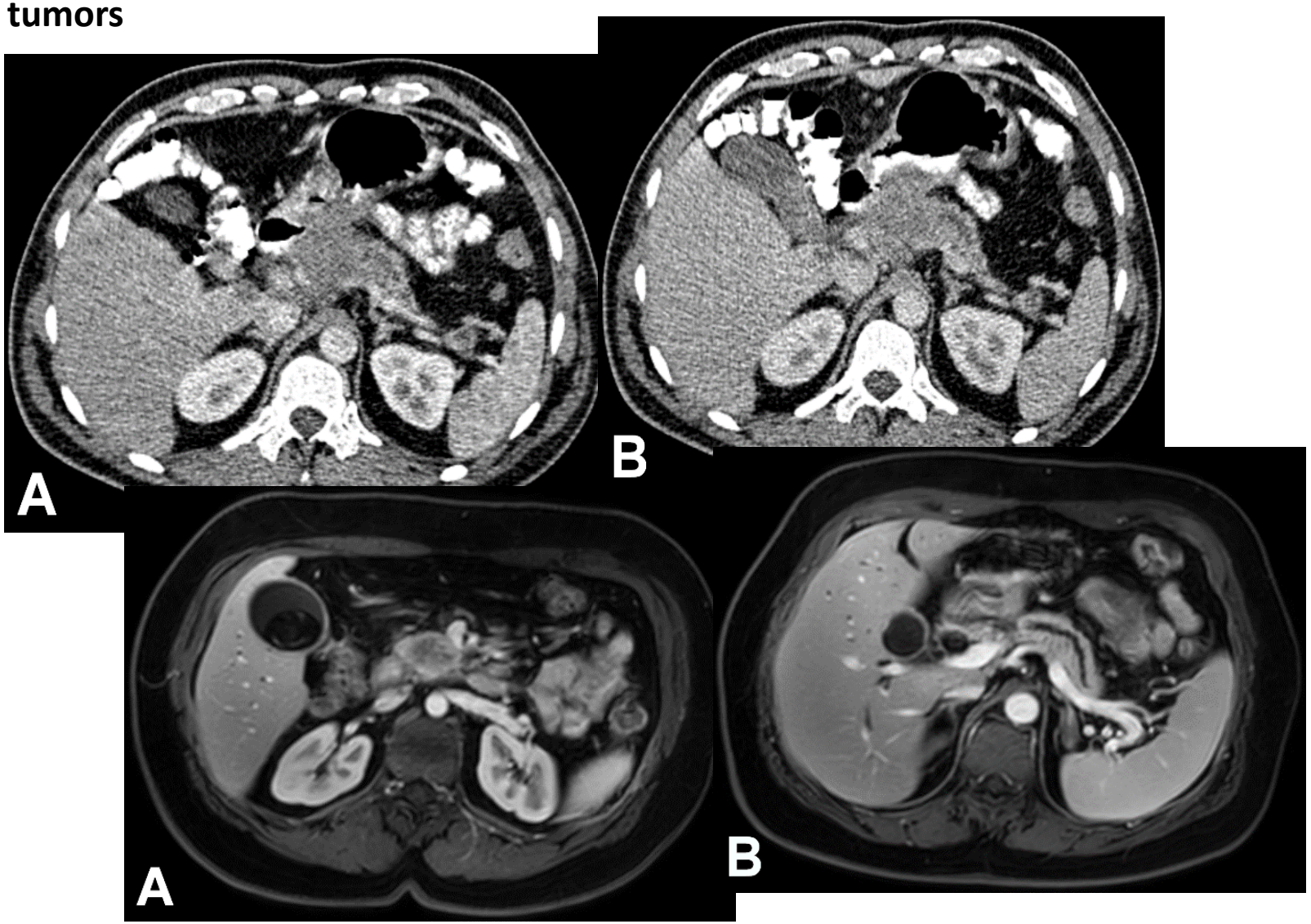
CT: A number of common features of pancreatic neoplastic processes can be highlighted: enlargement of the pancreas (global or focal - head, body or tail), presence of necrosis areas, extension of the malignant tumor process in the peripancreatic fat, vessel invasion and / or regional lymph nodes, presence of metastases (liver), caliber changes of the CBD and / or the main pancreatic duct.

MRI: Provides increased accuracy in assessing pancreatic malignancy, extension of the neoplastic process in the immediate vicinity, as well as in evaluating caliber changes of the CBD and Wirsung duct.

Ecoendoscopy is of great utility in the evaluation of patients with pancreatic tumors, as it allows bioptic material to be obtained, but this examination is performed by the gastroenterologist.

Pancreatic pathology

3. Pancreatic tumors

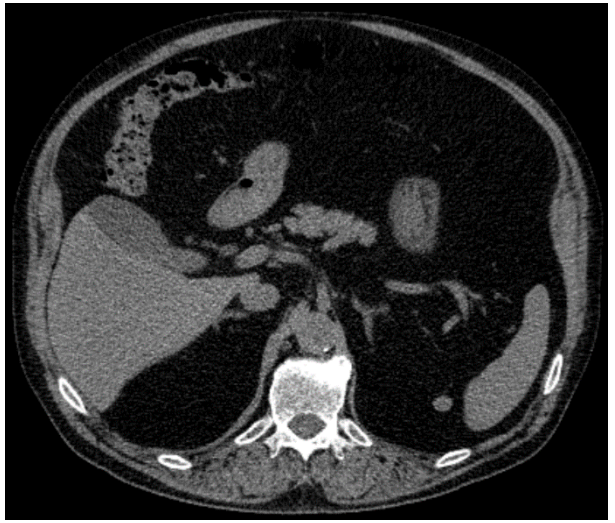


Splenic pathology

1. Congenital disorders and anatomical variants

The accessory spleen is the presence of ectopic splenic tissue and constitutes an anatomical variant. It is frequently located near the splenic hilum and / or pancreatic tail. The number of accessory splines and their dimensions are variable (from a few millimeters to about 2 cm). For diagnosis, the CT or MRI exam are frequently used.

Asplenia is the absence of splenic tissue development and may be associated with a number of other malformations.



Splenic pathology

2. Benign splenic tumors

The simple splenic cyst is a round-oval lesion, with liquid content, homogeneous, well delimited by a fine wall. It can be single or multiple.

US: The lesion has a transsonic content.

CT: At native examination, the simple splenic cyst has a homogeneous appearance and usually is hypodense (densities between 0 and 10 UH). In case of an intra-cystic haemorrhage, an increase in densities is observed. After intravenous contrast administration, the simple splenic cyst does not enhance.

MRI: The simple splenic cyst is hypointense in T1 and hyperintense in T2. In case of an intracystic hemorrhage or a high protein content, we observe high signal intensity on T1 sequence. After intravenous contrast administration, the simple splenic cyst does not enhance.

Splenic pathology

2. Benign splenic tumors

The splenic hemangioma is a benign vascular splenic tumor.

US: Well-defined hyperechoic lesion.

CT: Natively, splenic hemangiomas appear hypodense. Post-contrast, enlarged splenic hemangiomas show progressive, slow centripetal enhancement compared to the adjacent splenic parenchyma, so that in the late phase, they may be filled completely or almost completely, sometimes with hyperdense appearance. In case of small hemangiomas, it is possible for them to fill rapidly and completely in the arterial phase.

MRI: T1 – hyposignal and T2 – moderate hypersignal. The postcontrast enhancement pattern is similar to the CT exam.

Splenic pathology

3. Malignant splenic tumors

The most common malignant splenic tumor is lymphoma. Malignant lymphoma is usually secondary. For imaging diagnosis, the following methods can be used: US, CT and MRI.

US: Most commonly, the presence of enlarged and confluent lymphadenopathies, as well as splenomegaly, is noted. Also, the spleen may be diffusely infiltrated, without differentiating focal lesions or it may have hypoechoic nodular areas in case of focal lesions.

CT: The presence of enlarged and confluent lymphadenopathies, as well as splenomegaly, is noted. Also, the spleen may be diffusely infiltrated, without differentiating focal lesions or it may present hypodense, hypoenhancing areas in case of focal lesions.

MRI: Most commonly, the presence of enlarged and confluent lymphadenopathies, as well as splenomegaly, is noted. Also, the spleen may be diffused infiltrate, without differentiating focal lesions or it may have nodular areas in iso- / hypo-signal T1 and T2, hypoenhancing in case of focal lesions.

Splenic pathology

3. Malignant splenic tumors

Also, the spleen is an important site where secondary lesions develop in oncologic patients. Primary tumors that lead to splenic metastases include: melanoma, ovarian cancer, breast cancer, prostate cancer and lung cancer.

For imaging diagnosis, the following methods can be used: US, CT and MRI.

US: Notable spleen enlargement (splenomegaly) and presence of hypoechoic nodular areas in a patient known to have a primary tumor.

CT: The volume increase of the spleen and the presence of hypodense, hypoenhancing nodular areas are noted in a patient with a primary tumor.

MRI: Splenomegaly and nodular areas are observed in T2 hypersignal, with restricted diffusion in a patient known with a primary tumor. Also, the detection of a T1 hypersignal within the metastatic lesions confirms their hemorrhagic content.

Splenic pathology

4. Splenic trauma

A. Splenic subcapsular hematoma

The splenic subcapsular hematoma occurs as a result of a trauma affecting the spleen. The preferred examination is CT.

CT: Highlights a perisplenic semi-lunar hematic accumulation. The appearance varies depending on the time elapsed from the moment of the trauma:

- acute phase: the hematoma appears hyperdense in contrast with the splenic parenchyma;

- subacute phase: the hematoma appears isodense;

- chronic phase: the hematoma appears hypodense.

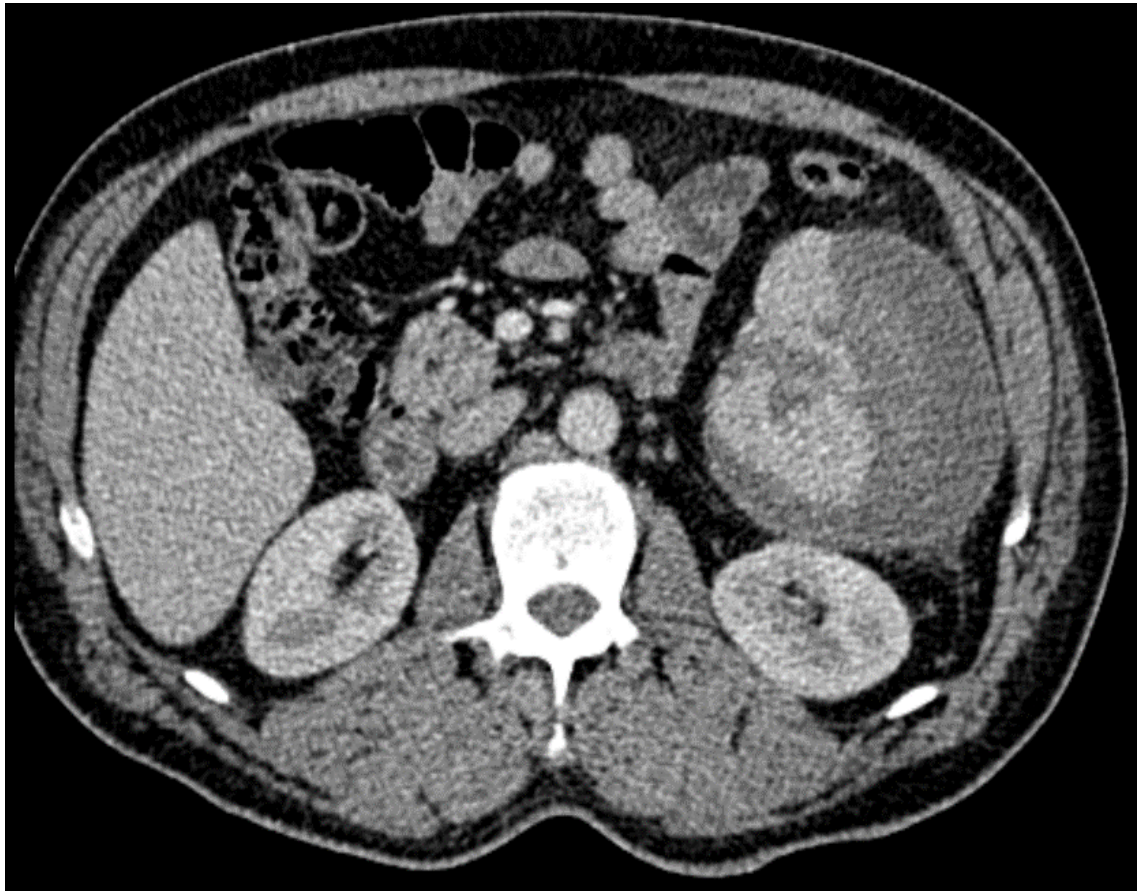
B. Splenic laceration

Splenic laceration occurs as a result of severe trauma at this level.

CT: Disruption of the contour of the organ is visualized, with the presence of perisplenic blood accumulation.

Splenic pathology

4. Splenic trauma



Splenic pathology

4. Other diseases

Splenic infarction

CT: The postcontrast CT reveals a hypodense, non-enhancing triangular area with the base towards the splenic capsule and the tip towards the splenic hilum. Sometimes, the splenic infarction can affect the entire splenic parenchyma (the entire spleen appears hypodense and it does not enhance at all).