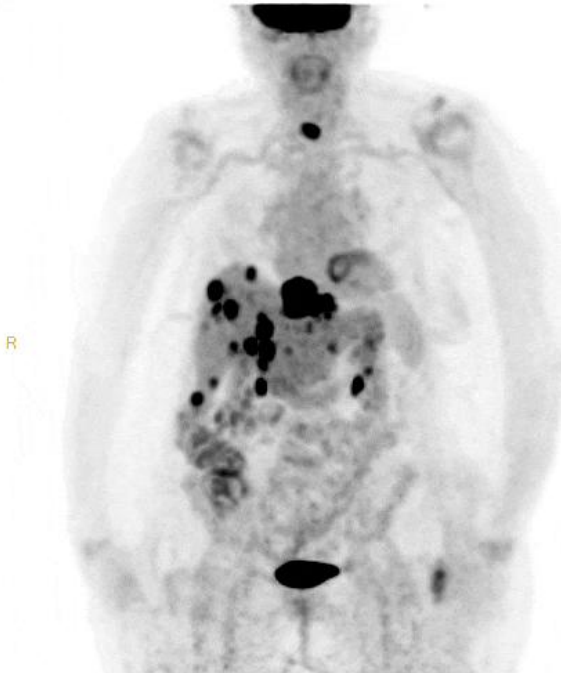
Imaging in oncology



HOMEWORK

To get credit for the course, please provide written answers to the following questions into your Radiology notebook:

1. Role of imaging in the oncologic decision process
2. Imaging methods of investigation in Oncology.
3. Characteristics of benign tumors
4. Characteristics of malignant tumors
5. Ultrasound imaging in Oncology. Advantages and disadvantages.
6. Computed Tomography (CT) imaging in Oncology. Advantages and disadvantages.
7. Magnetic Resonance Imaging (MRI) in Oncology. Advantages and disadvantages.
8. Nuclear Medicine imaging in Oncology. Imaging modalities and indications.

Role of imaging
in the Oncologic Decision Process

early detection, precise tumor mapping, to give information of tumor volume, structure, vascular nature

- **To detect** tumor (to finde the primary and metastasis)
- **To stage** prior to treatment, T / N / M
  - To give comparable information of tumor volume and structure
  - To finde nodal metastases
  - To finde distant metastases
- **To evaluate therapy response**
- **To fix a baseline** status following initial therapy,
- **To follow the patient** - to finde the early recurrent TU
- **To restage the patient.**
- **To give information about the „nature" of the disease (biopsy)**

- **Imaging plays an important role also in planning radiotherapy**

Imaging Methods

1. **Radiologycal methods** (based on using X-rays)
   - Radiography
   - Radioscopy
   - Linear Tomography
   - Tomosynthesis
   - Computed Tomography (CT)
2. **Ultrasonography** (based on using ultrasound waves)
3. **Magnetic Resonance Imaging** (based on using magnetic fields and radiofrequency pulses)
4. **Nuclear Medicine modalities** (based on using radiopharmaceuticals that emit gamma-rays)
   - Scintigraphy
   - SPECT-CT
   - PET-CT

Characteristics of benign tumors

Relatively common features

- Regular borders
- Solitary (single tumor)
- Homogeneous (uniform) structure
- Not invading adjacent tissues and organs
- Do not spread metastases
- Slow growth

Characteristics of malignant tumors

Relatively common features

- Irregular borders
- Heterogeneous (non-uniform) structure
- Invading adjacent tissues and organs
- Regional and distant metastases
- Rapid growth

Radiographic imaging in Oncology

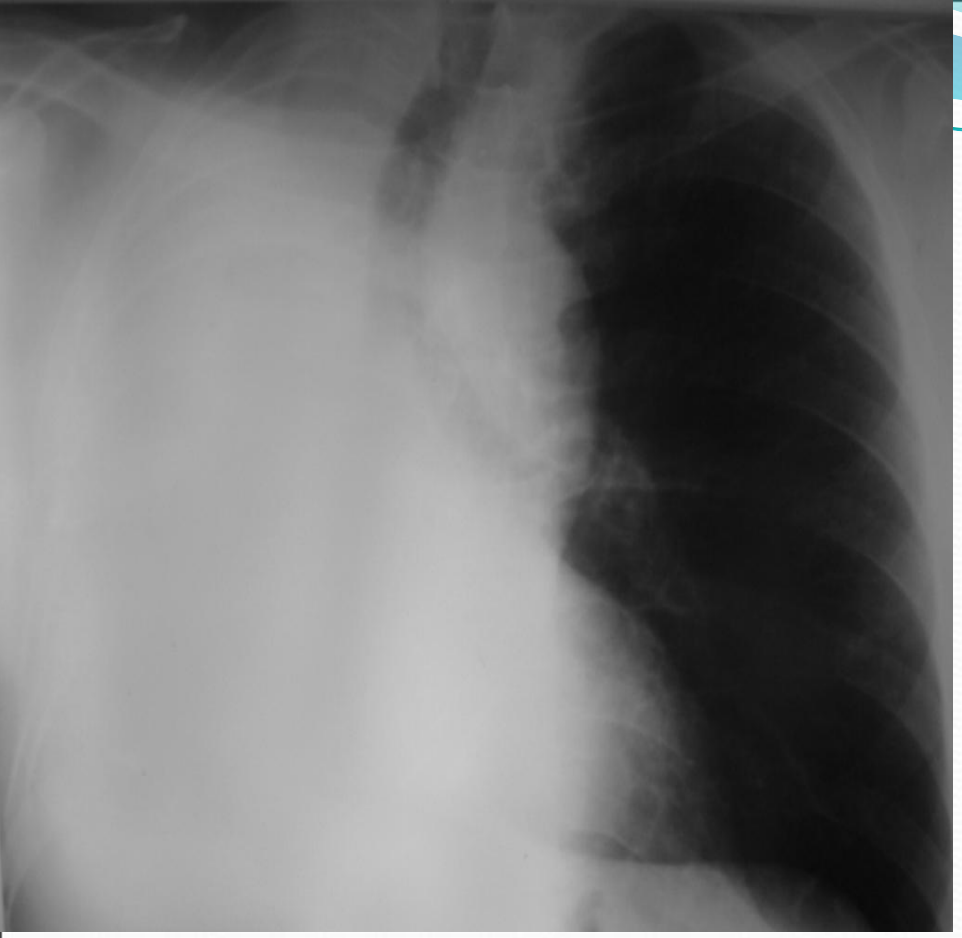
- Radiographic imaging of the chest is frequently performed on patients with suspected diseases of the chest or lungs, or on patients with one or more of the following symptoms:
  - Chronic cough
  - Chest injury
  - Chest pain
  - Coughing up blood
  - Difficulty breathing

Pulmonary opacity

Medical imaging in tables and algorithms: Guidelines
Malîga O, Obadă A, Rotaru N.

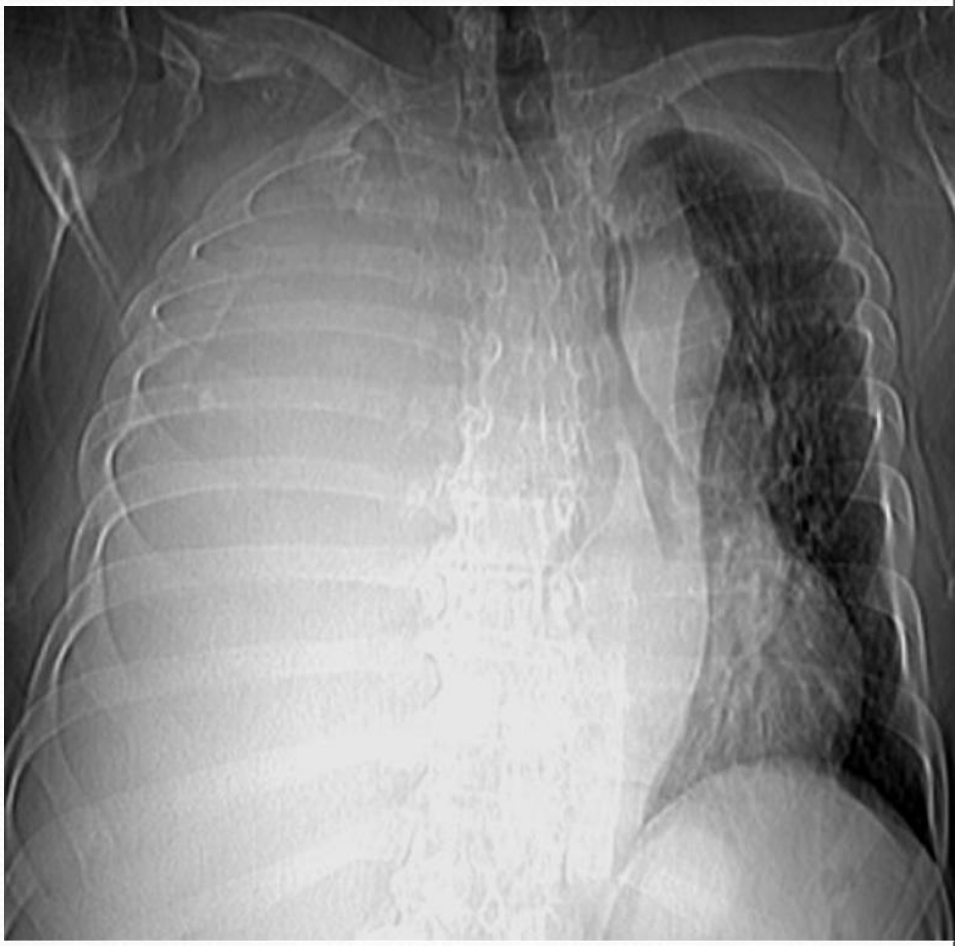
1. Localization	segment, lobe, lung
2. Number	single, multiple disseminated
3. Form	Corresponding to anatomical structures (lob, segment); Rounded Ring-shaped Linear Triangle Irregular
4. Dimensions	Extensive: total (al the hemithorax) subtotal: 2/3 of hemithorax Limited: up to 1/3 of hemithorax Nodular: less then 2.5 cm
5. Borders	ill-defined well-defined regular, irregular
6. Structure	homogeneous, heterogeneous
7. Mediastinum	Without displacement Displaced towards the opacity Displaced from the opacity

https://radiologie.usmf.md/wp-content/blogs.dir/131/files/sites/131/2018/04/Guidelines.pdf



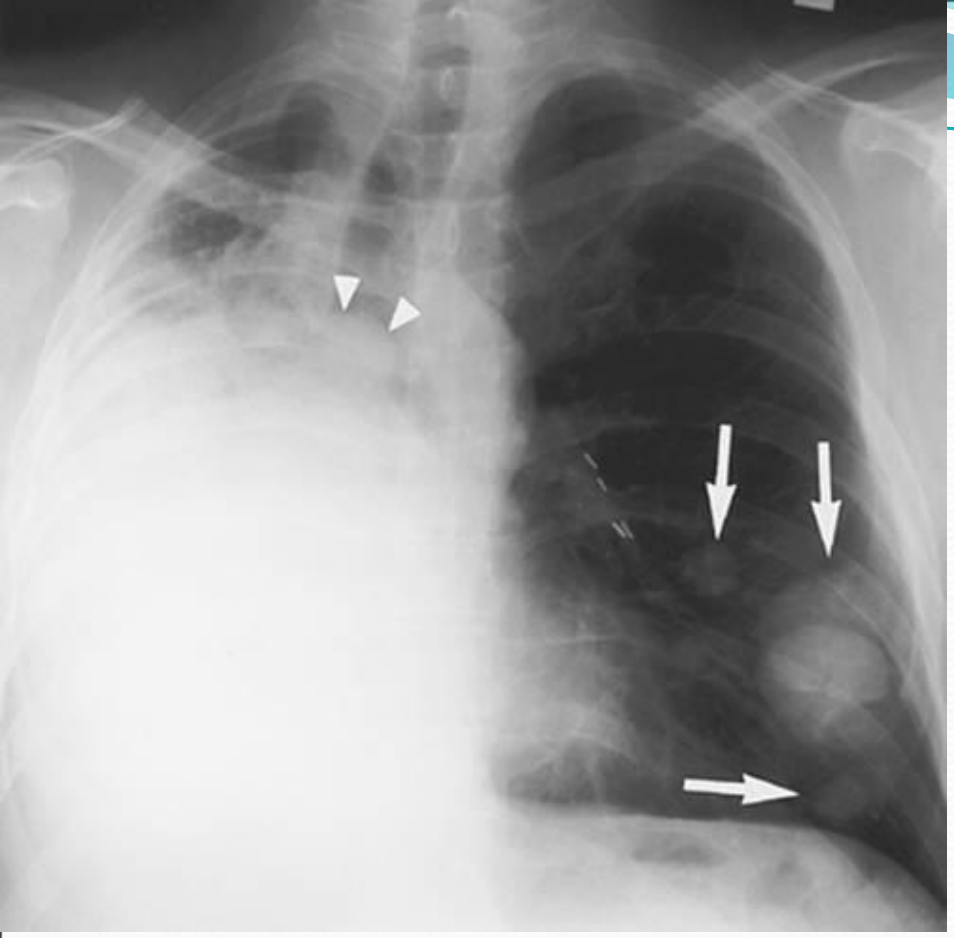
Shift of the mediastinum TOWARDS the opacity - indicates volume reduction or shrinkage of the affected side (for example, lung atelectasis in central lung cancer due to obstruction of the affected bronchus)

Total opacification of a hemithorax



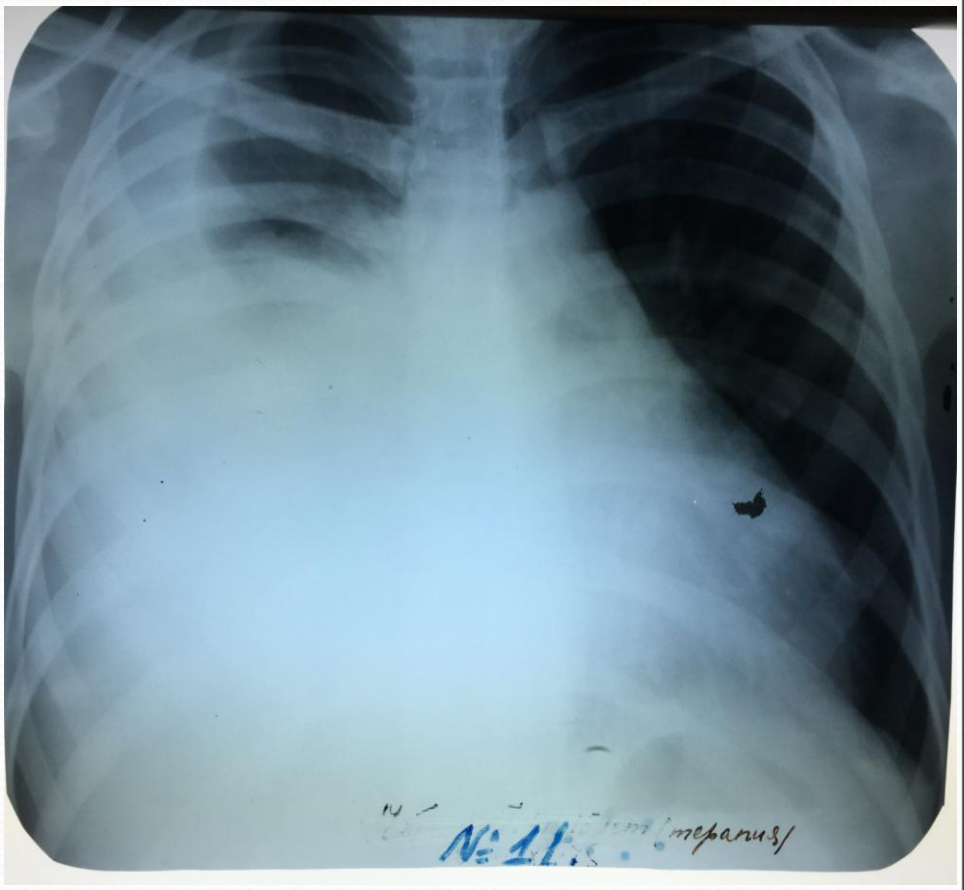
Shift of the mediastinum AWAY from the opacity - indicates extra-volume or volume expansion on the affected side (for example, in pleural effusion)

Subtotal opacification of a hemithorax

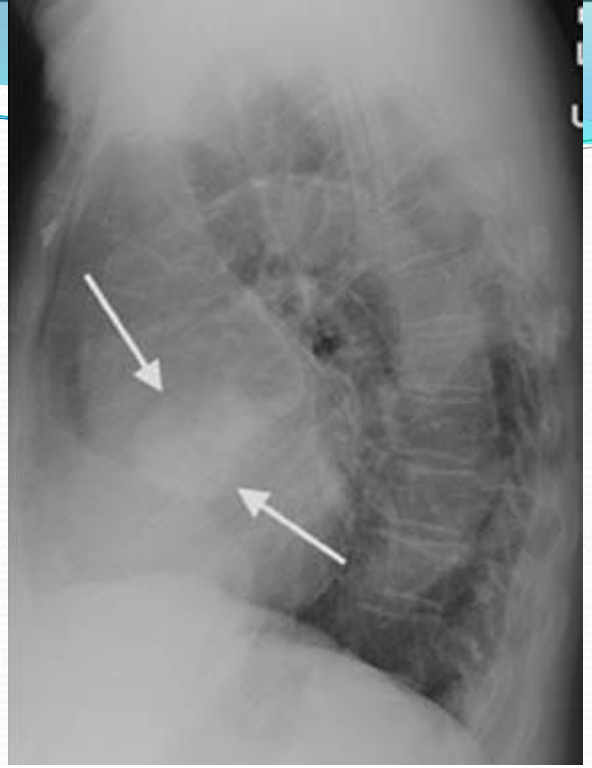


Shift of the mediastinum TOWARDS the opacity in a patient with nearly complete collapse (atelectasis) of the right lung due to a large, rounded endobronchial metastasis that is obstructing the right main bronchus (arrowheads). Numerous parenchymal metastases are also seen within the left lung (arrows).

Image source: https://doctorlib.info/medical/chest/11.html



Shift of the mediastinum AWAY from the opacity in a patient with right pleural effusion. Note the oblique upper border of the opacity (“meniscus sign”).

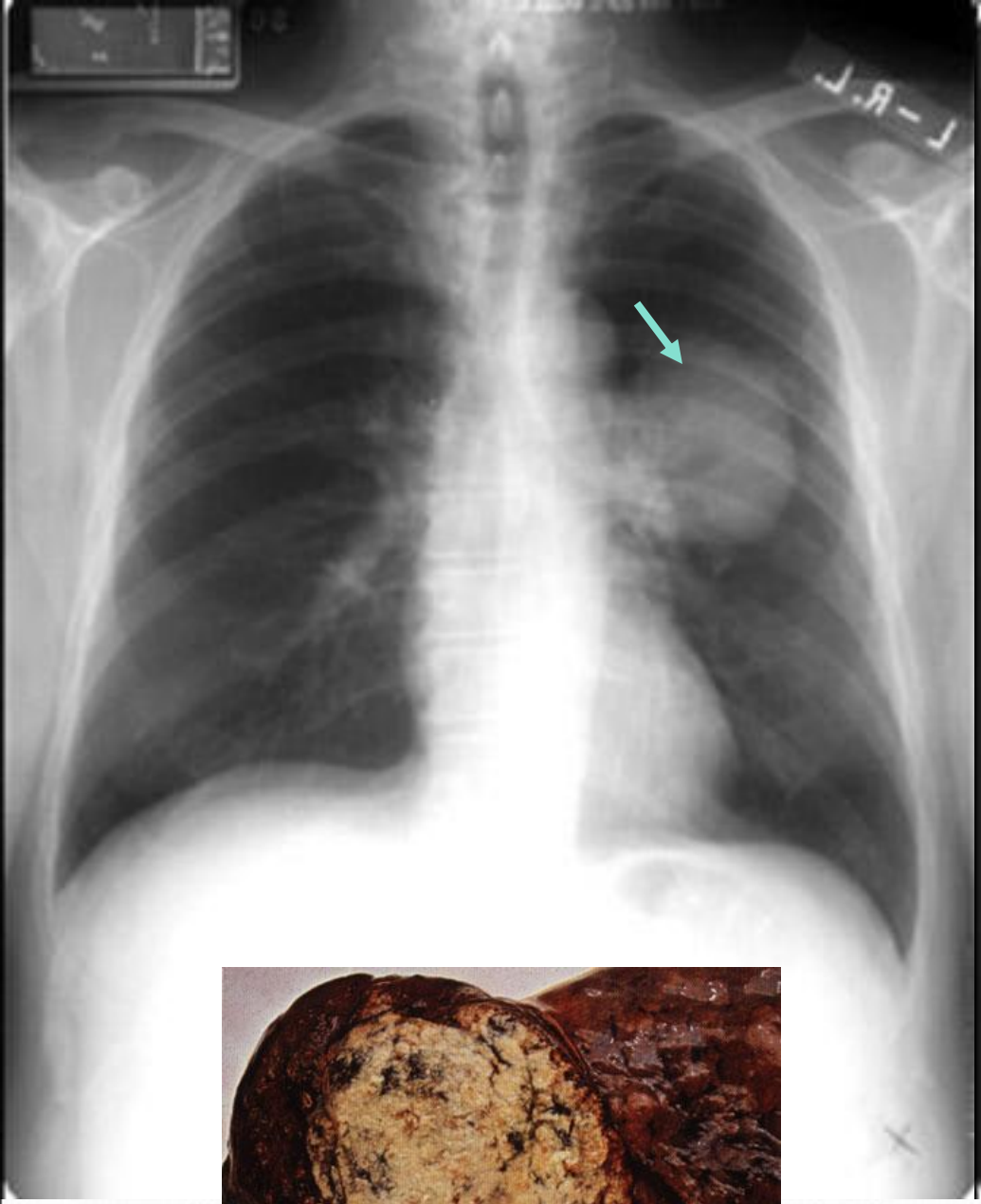


Rounded opacity

Rounded opacity in a patient with peripheral squamous cell carcinoma

Squamous cell carcinomas are most commonly central in location (within the main, lobar, or segmental bronchi), although approximately 25% are peripheral. Squamous cell carcinoma is the most common type of lung cancer to cavitate.

Image source: https://doctorlib.info/medical/chest/15.html



Lung Mass

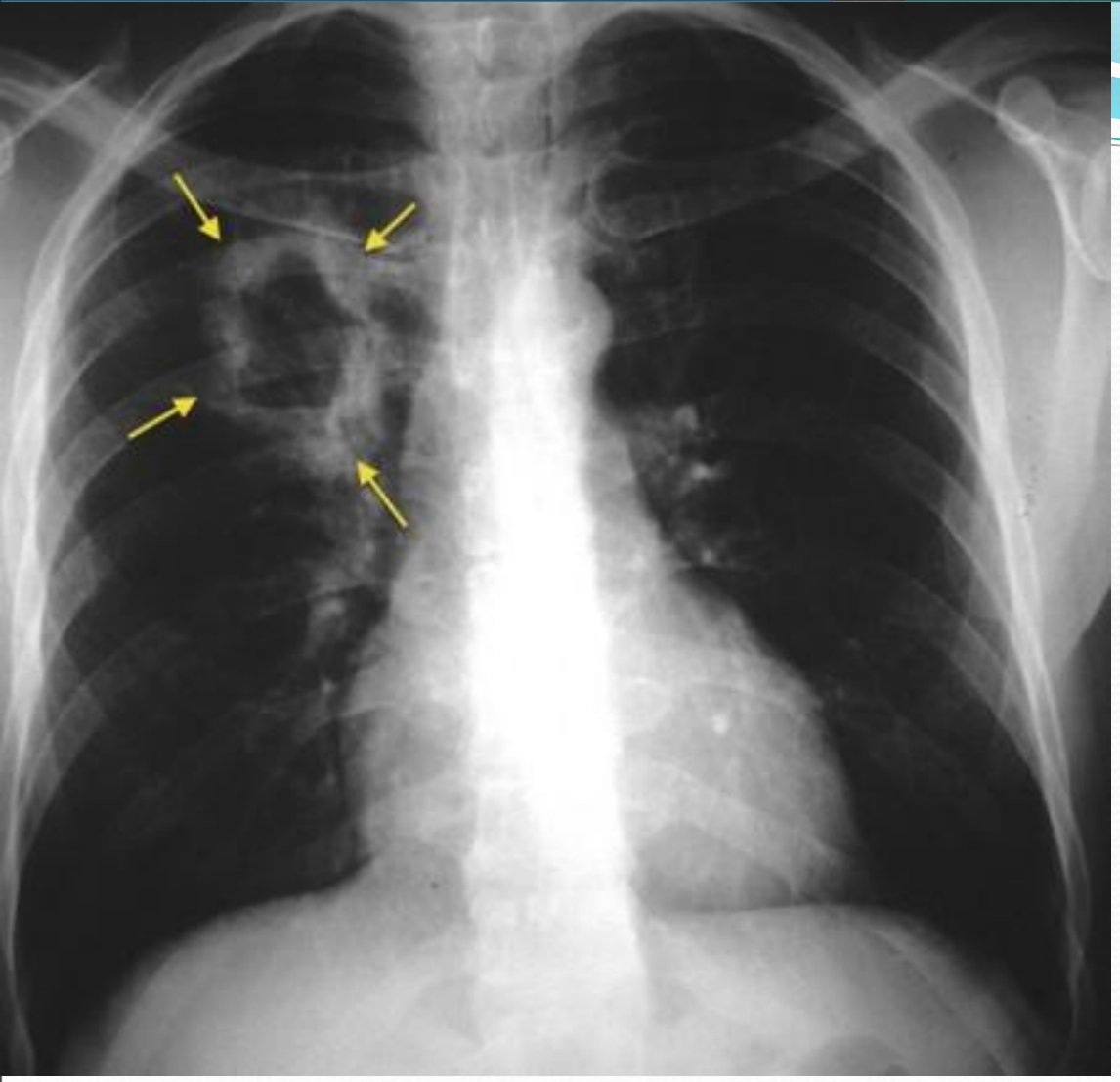
Rounded opacity

Nodular opacity

Solitary pulmonary nodule

Nodular opacity (<2.5 cm) completely surrounded by pulmonary parenchyma

Image source: NBME Internal Medicine Shelf. https://www.memorangapp.com/flashcards/67879/Lung+cancer/



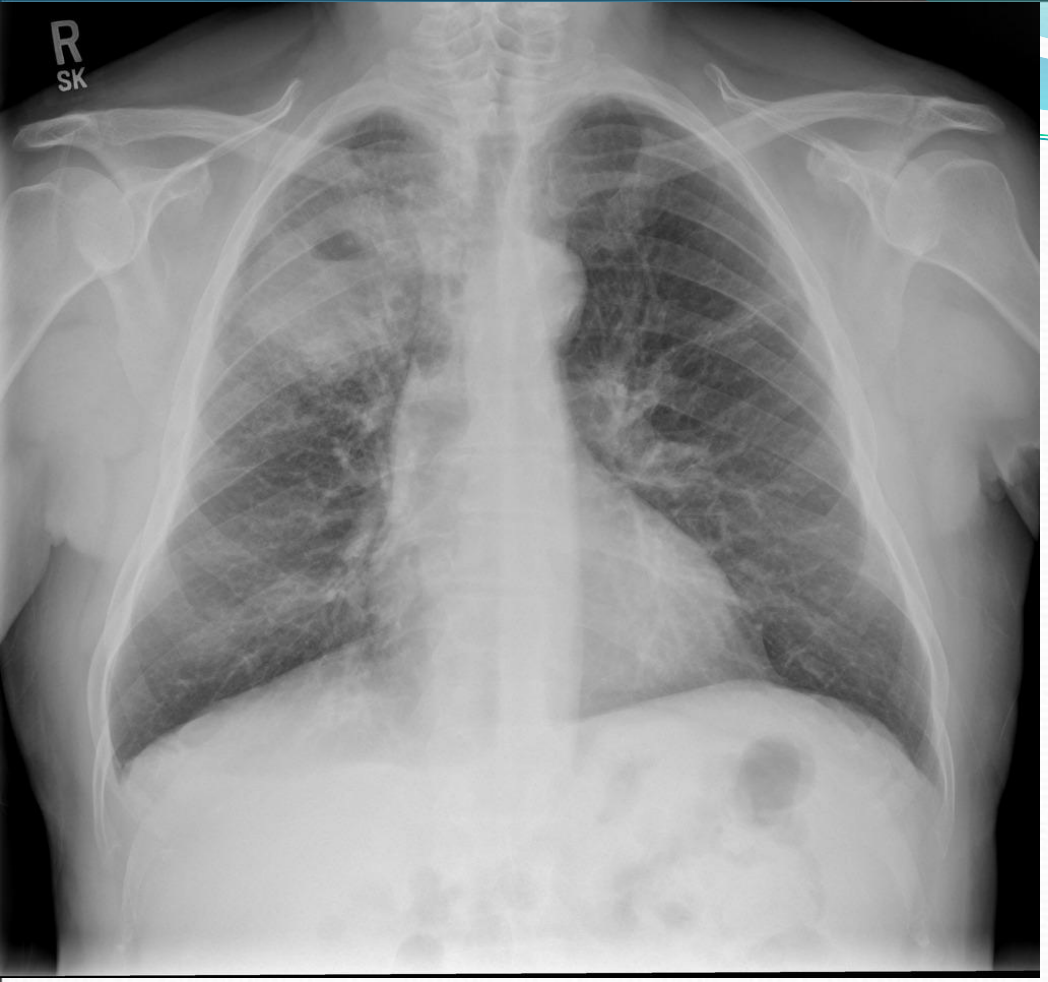
Ring-shaped opacity

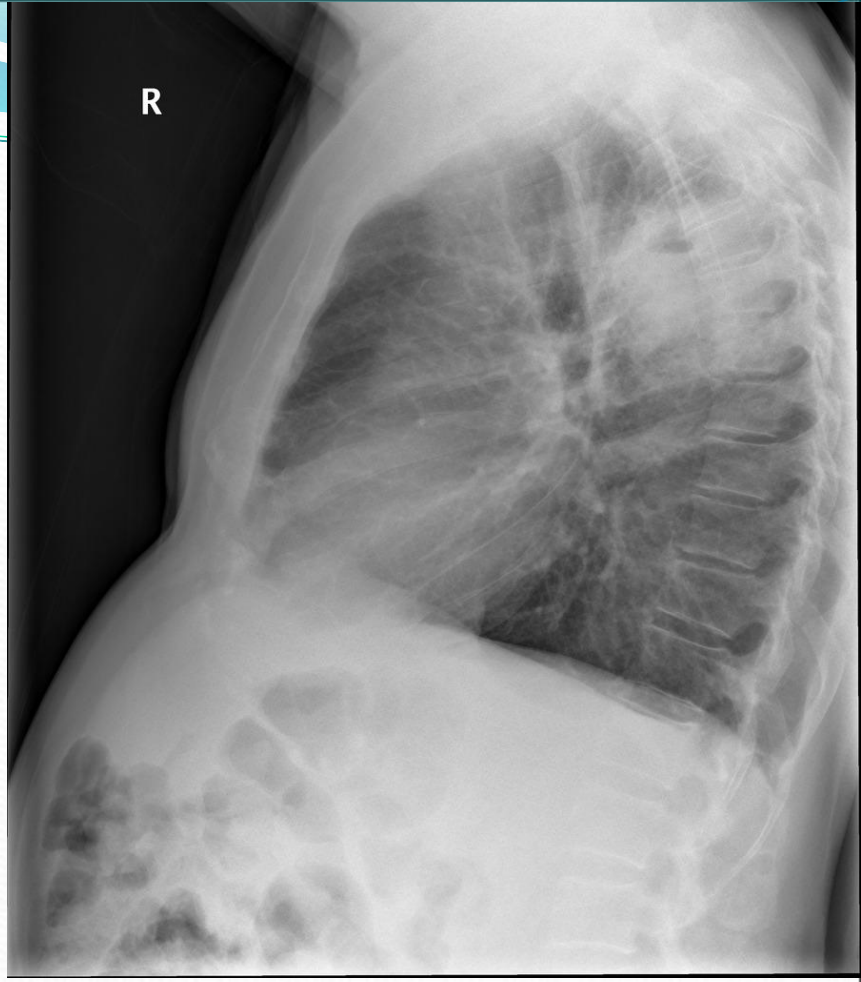
Cavitating lung cancer. This patient has a large thick-walled cavitating mass in the right lung. CT-guided biopsy of the wall of this cavity showed squamous cell carcinoma.

Squamous cell carcinoma is the second most common type of bronchogenic carcinoma, and it is strongly associated with cigarette smoking.
It is the most common type to cavitate.

The differential diagnosis for this appearance includes cavitating pneumonia, lung abscess, pulmonary tumours (particularly squamous cell carcinoma), tuberculosis as well as some systemic conditions such as Wegener's granulomatosis, rheumatoid nodules etc.

Image source: http://www.svuhradiology.ie/case-study/cavitating-lung-cancer/





Ring-shaped opacity

A large right upper lobe cavitary lesion, with air-fluid level. Left midzone atelectasis. Simple case of consolidation with cavitation, in this case secondary to primary lung cancer in a smoker.

Image source: https://radiopaedia.org/cases/cavitating-lung-cancer-2

Representative radiographic images in common lung malignancies

Adenocarcinoma of the lung

Commonly presents with large irregular peripheral lesions seen on chest radiography (image obtained in a 60-year old non-smoker)

Adenocarcinoma accounts for **50% of all bronchogenic** carcinomas, and it is the most common cell type seen in **women and nonsmokers**.

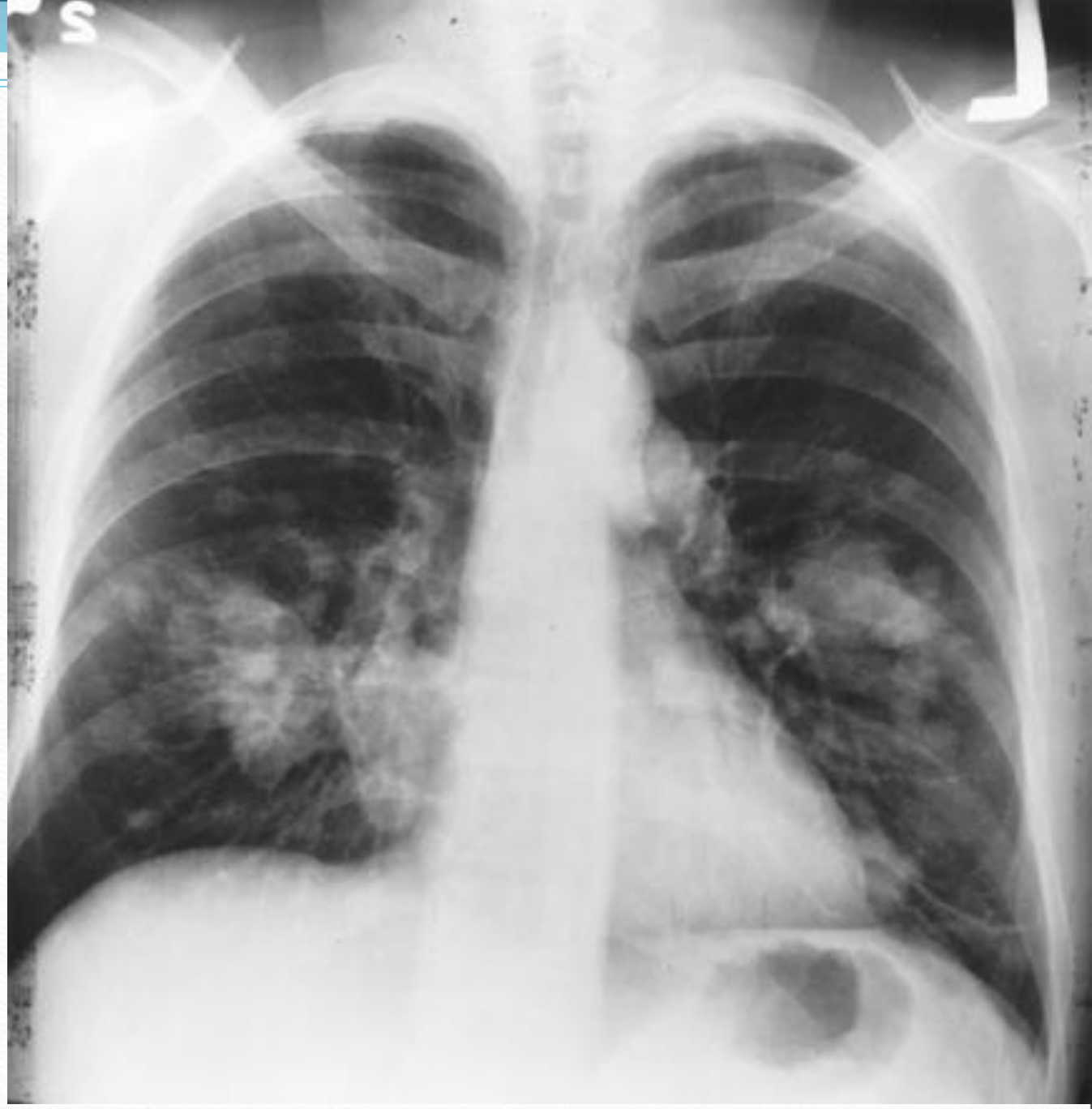
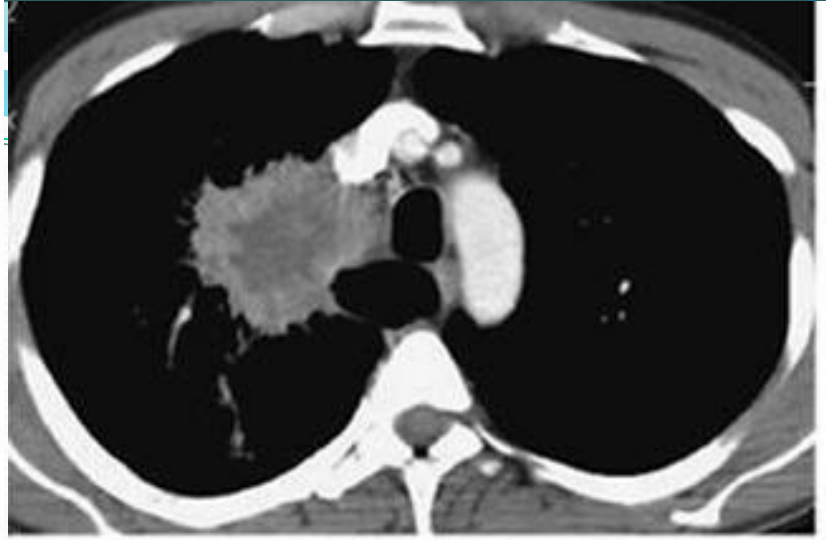
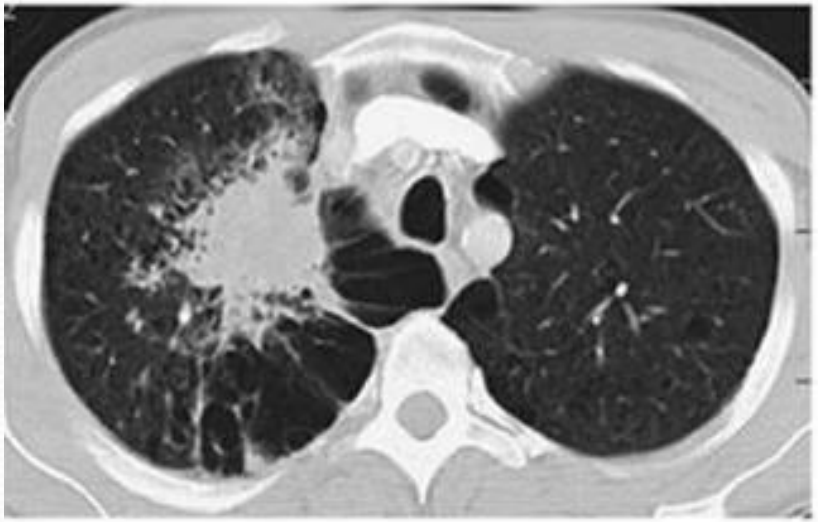


Image source: NBME Internal Medicine Shelf. https://www.memorangapp.com/flashcards/67879/Lung+cancer/





Adenocarcinoma of the lung

PA chest radiograph shows an irregular mass in the right upper lobe abutting the mediastinum.
CT shows the mass extending into the mediastinum. The center of the mass is of low attenuation, secondary to tumor necrosis.
CT with lung windowing shows the spiculated mass and a background of paraseptal and centrilobular emphysema.

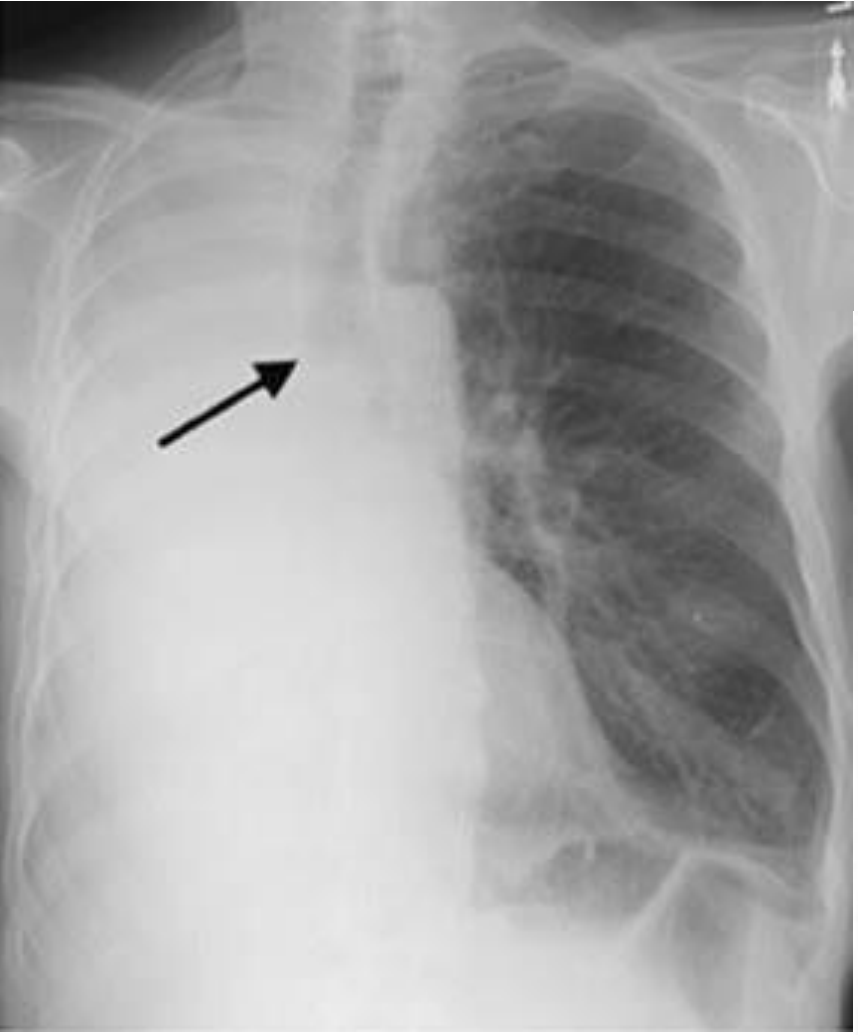
Image source: https://doctorlib.info/medical/chest/15.html

Bronchioloalveolar carcinoma

Bronchioloalveolar carcinoma is considered a sub-category of adenocarcinoma. It has the reputation of being slow growing and often multicentric (breaking out in multiple areas of the lung).
The bronchoalveolar subtype of adenocarcinoma accounts for up to 6% of primary lung cancers.
This subtype demonstrates a broad spectrum of radiographic findings, presenting as
a **solitary nodule** in 43% of cases, **multicentric or diffuse disease** in 27%, or **diffuse consolidation** in 30%.

Image source: https://doctorlib.info/medical/chest/15.html

Squamous cell carcinoma is the second most common type of bronchogenic carcinoma, and it is strongly associated with cigarette smoking. It is the most common type to cavitate and to be associated with hypercalcemia.



A 63-year-old man with squamous cell carcinoma. The right main bronchus appears to be cut off (arrow). The appearance of a central tumor with postobstructive pneumonia and atelectasis secondary to total or partial bronchial obstruction is typical of squamous cell carcinoma.

Image source: https://doctorlib.info/medical/chest/15.html

A 62-year-old woman with squamous cell carcinoma. Approximately 25% of squamous cell lung cancers are peripheral in location.

Squamous cell carcinoma of the lung

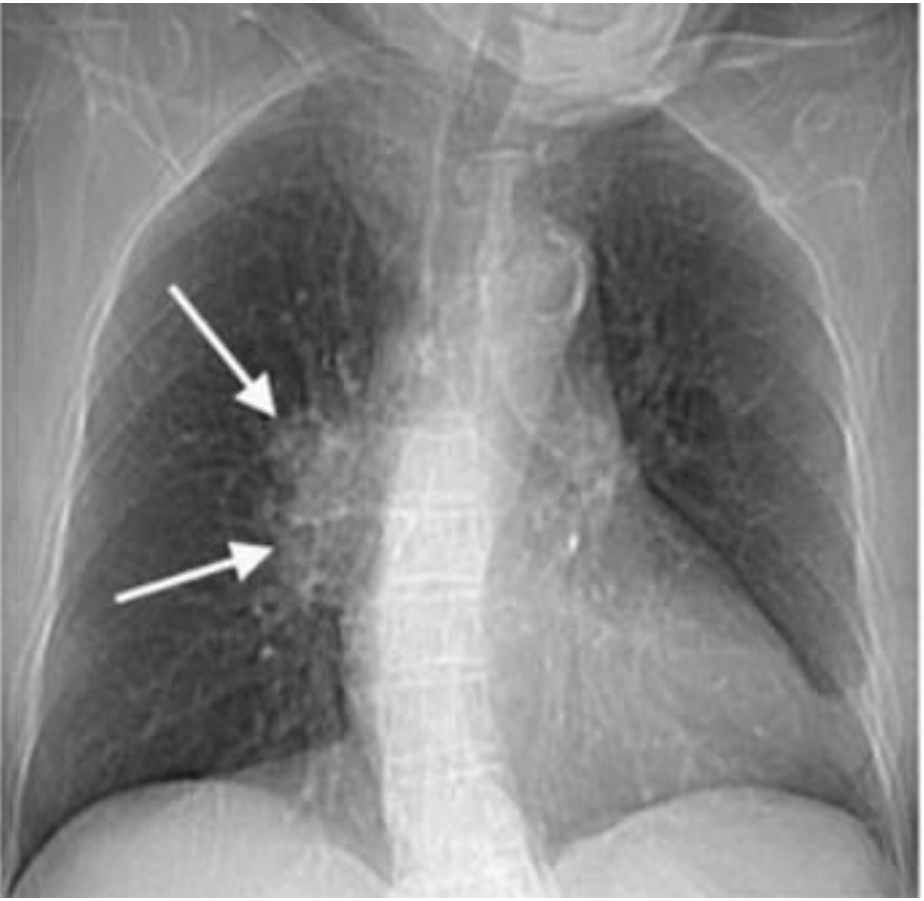
A 75-year old smoker with a Pancoast tumor (P)

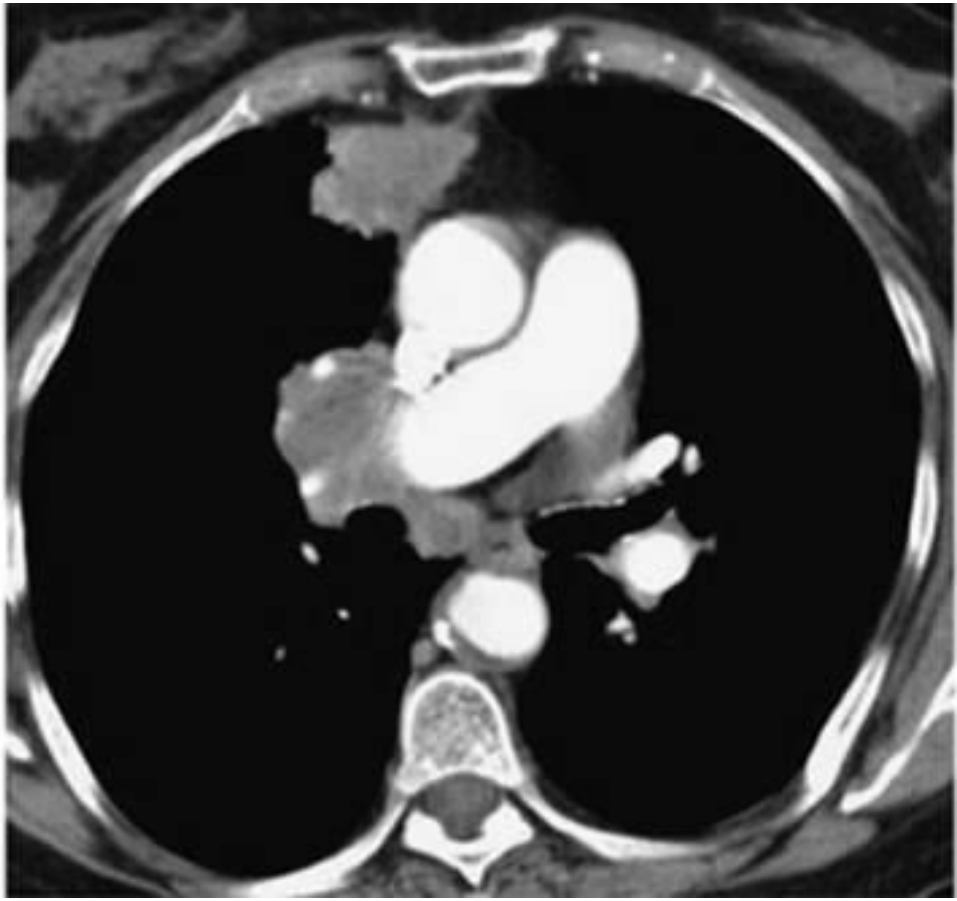
Peripheral squamous cell carcinoma is the most common type of bronchogenic cancer to cause the Pancoast syndrome.

Image source: NBME Internal Medicine Shelf. https://www.memorangapp.com/flashcards/67879/Lung+cancer/

Small cell lung cancer

- Small cell carcinoma is a rapidly growing neoplasm characterized by early and widespread metastases and by a strong association with cigarette smoking.
- The chest radiograph usually shows a **hilar** or **perihilar** mass associated with mediastinal widening; this can be caused by the primary tumor, metastases to hilar/mediastinal lymph nodes.
- The primary tumor might not be evident, and nodal enlargement may be the dominant abnormality





A: CT scout image of a 73-year-old woman with a 75–pack-year history of cigarette smoking shows a right hilar mass (arrows). B: CT shows tumor infiltrating the mediastinum. Image source: https://doctorlib.info/medical/chest/15.html

Small cell lung cancer

A 75-year old smoker with a central lesion (left parahilar opacity) seen on chest radiography

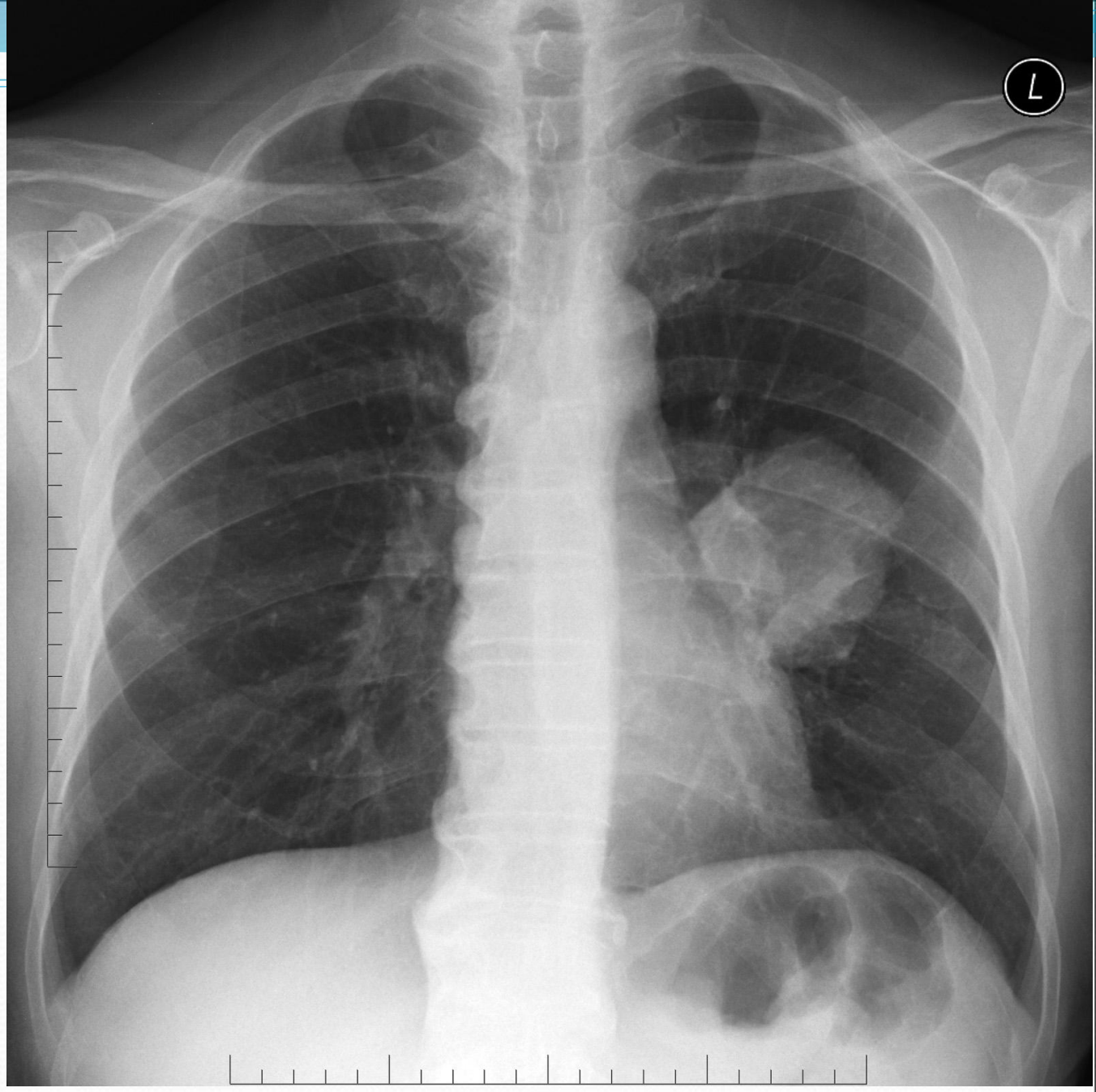
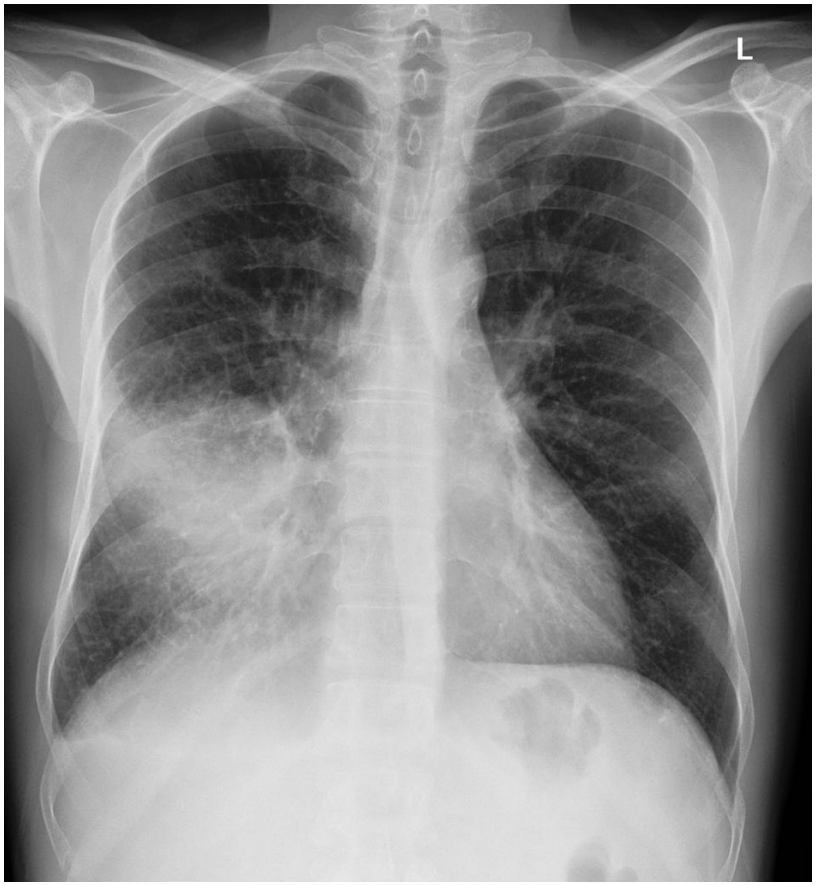
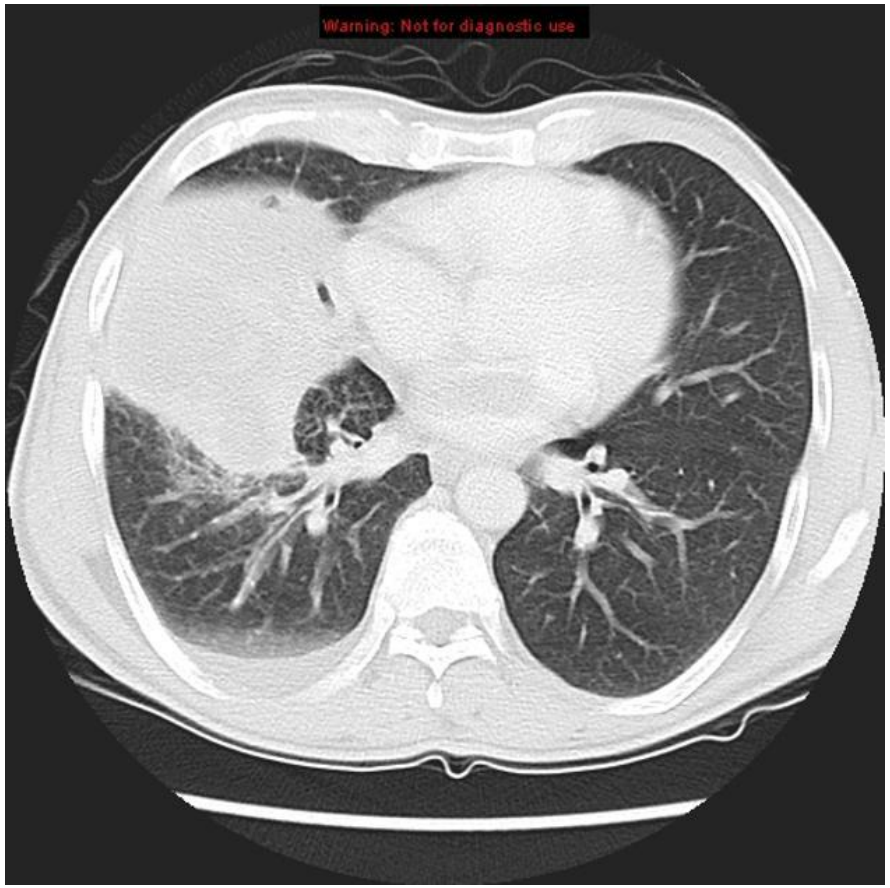


Image source: NBME Internal Medicine Shelf. https://www.memorangapp.com/flashcards/67879/Lung+cancer/

Large cell carcinoma

- Large cell carcinomas are the least common type of bronchogenic carcinoma.
- They grow rapidly, metastasize early, and are strongly associated with cigarette smoking.
- Large cell carcinomas are appropriately named: they are usually bulky tumors > 3 cm in diameter.
- They are typically located in the lung periphery, but central lesions are not uncommon.
- The typical radiologic appearance of these tumors is a large peripheral lung mass.

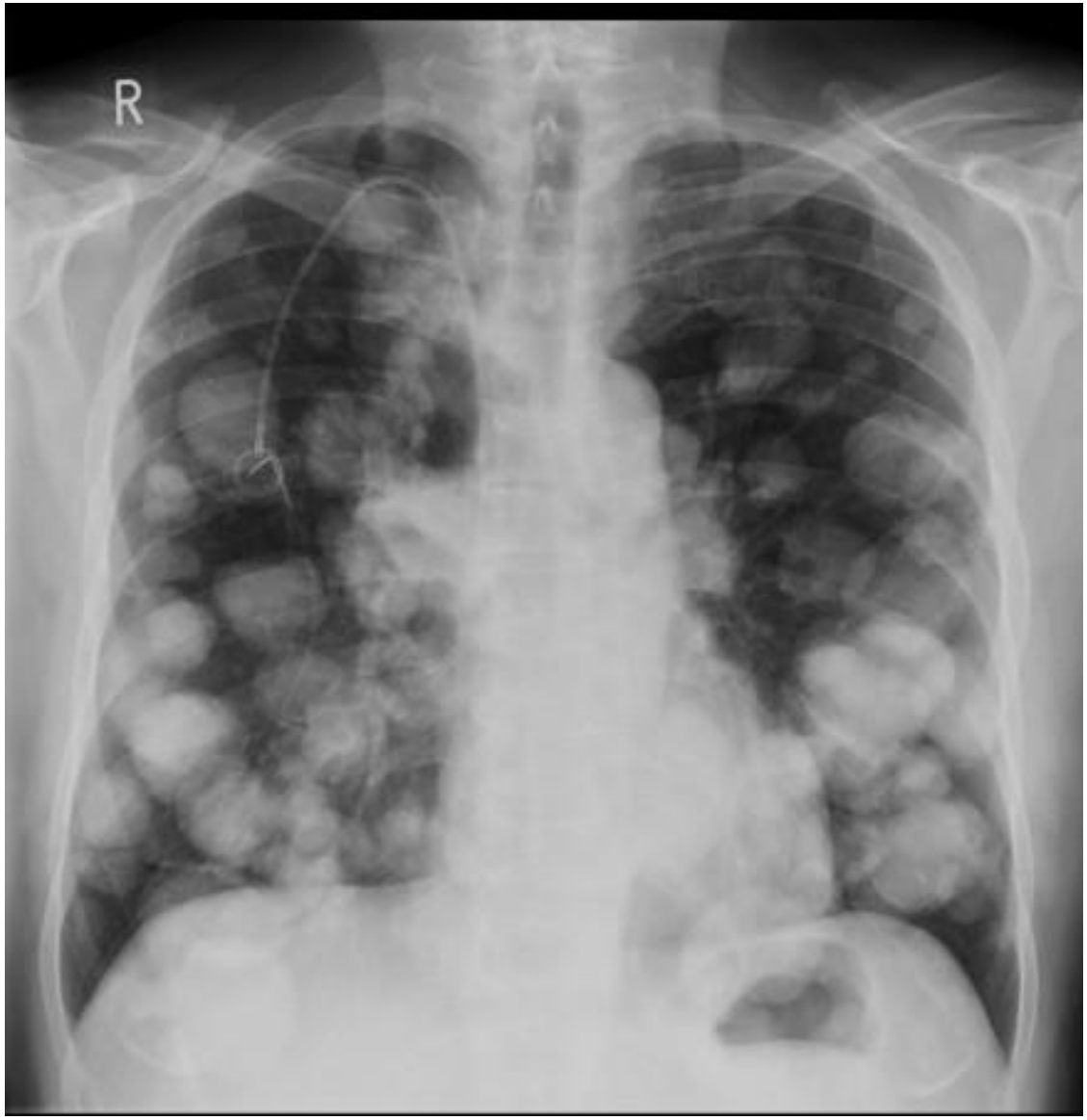




Pathologically proven undifferentiated large cell carcinoma of the lung in a 50-year old male.
Image source: https://radiopaedia.org/cases/undifferentiated-large-cell-carcinoma

Lung metastases

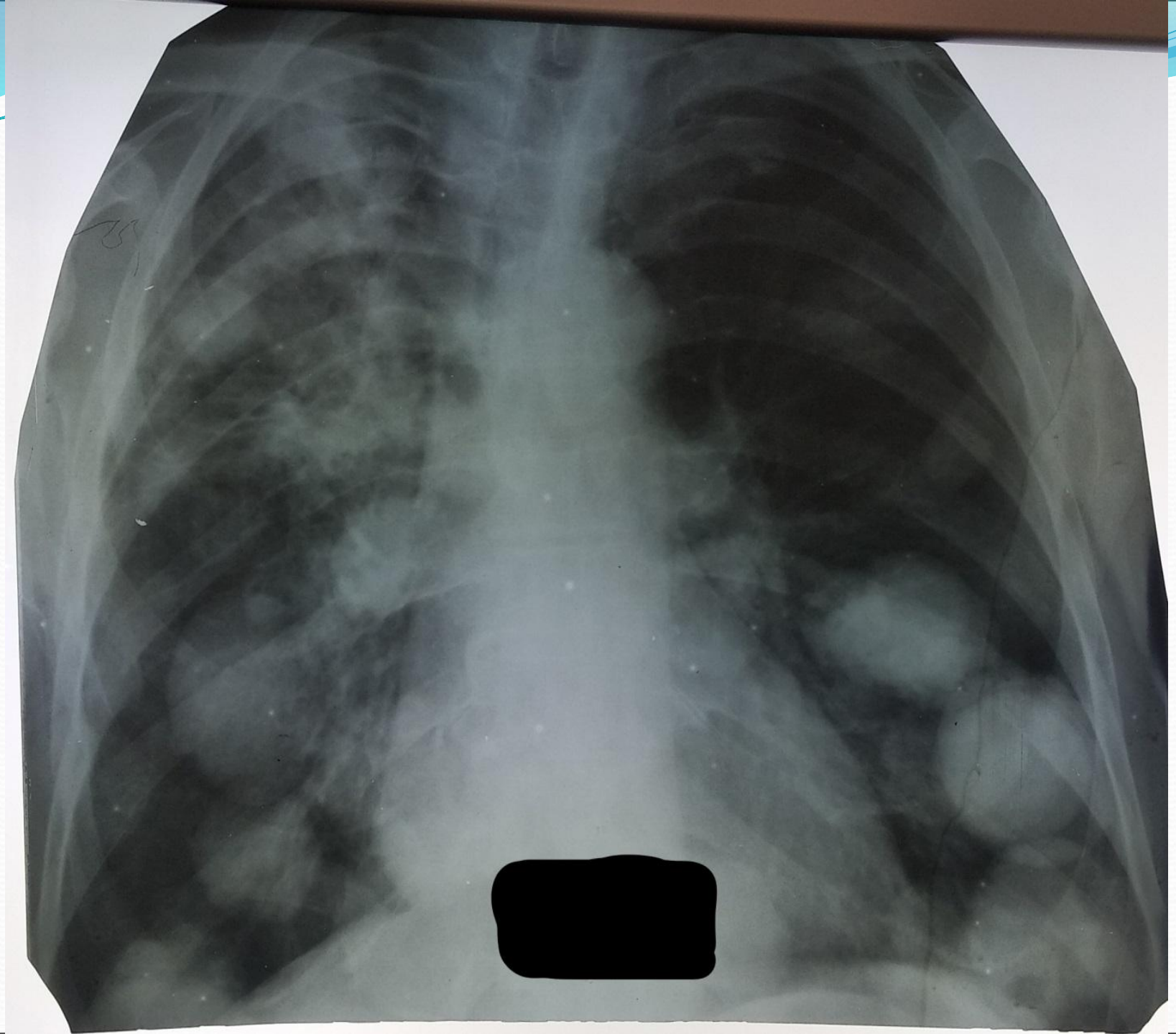
Cannonball metastases – colorectal cancer



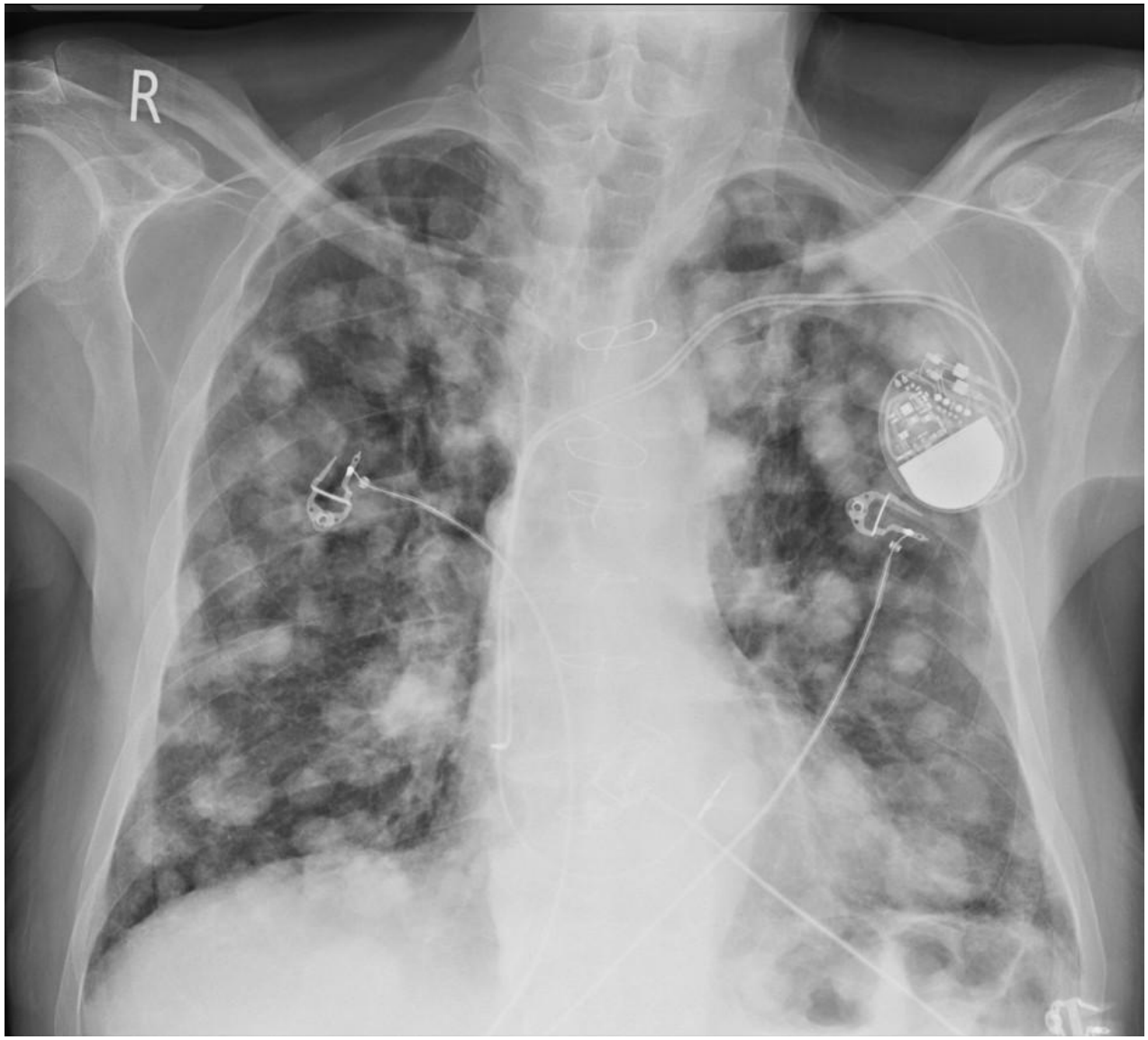
An example of multiple huge ‘cannonball’ lung metastases in a patient with colon cancer.

Note the portacath in the right chest wall, used for administering the patient’s chemotherapy.

Image source: http://www.svuhradiology.ie/case-study/cannonball-metastases-colorectal-cancer/



Cannonball metastases – prostate cancer

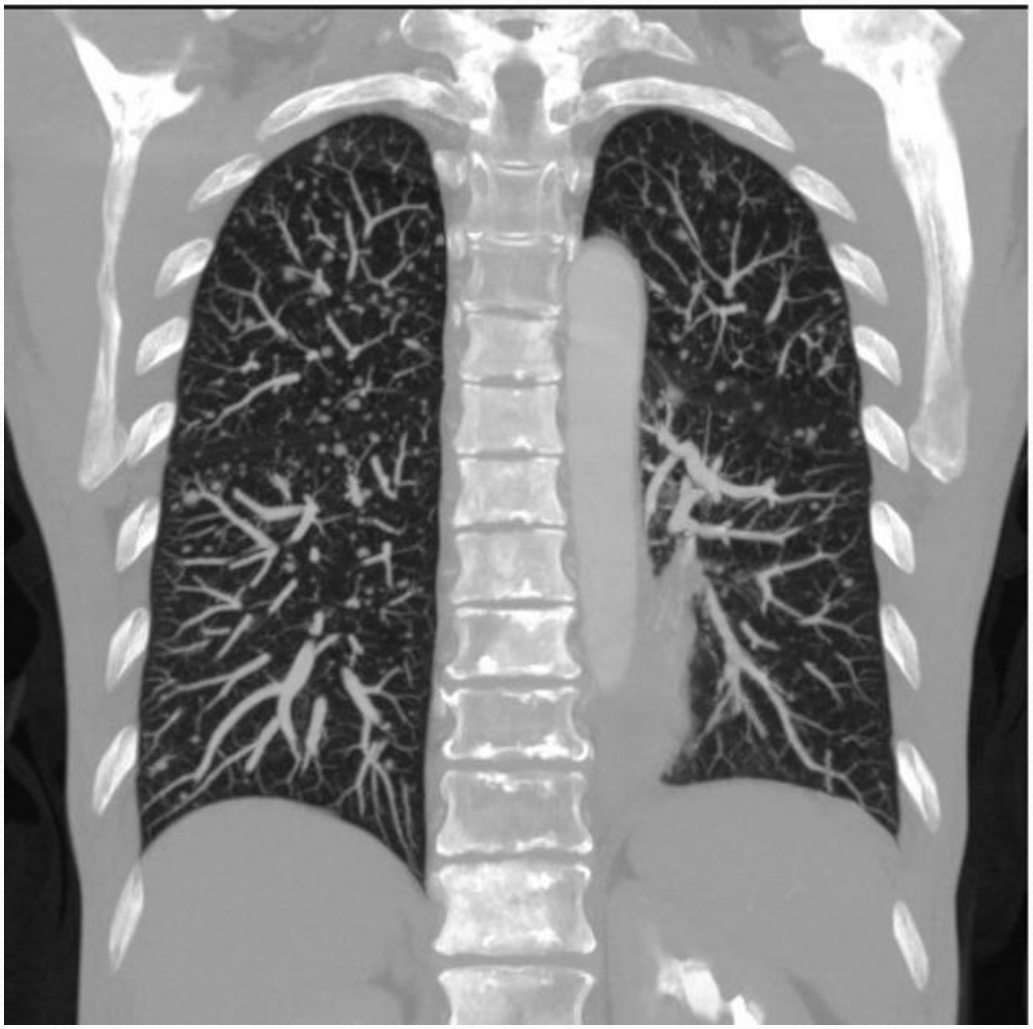


Diffuse large "cannonball" metastases throughout both lungs in an 80-year-old patient with prostate cancer. These are new from the radiograph of 5 years previously, but have been seen on cross sectional imaging.

Two chamber pacemaker and sternal wires noted.

Image source: https://radiopaedia.org/cases/prostate-metastases-to-lung

Lung metastases in breast cancer

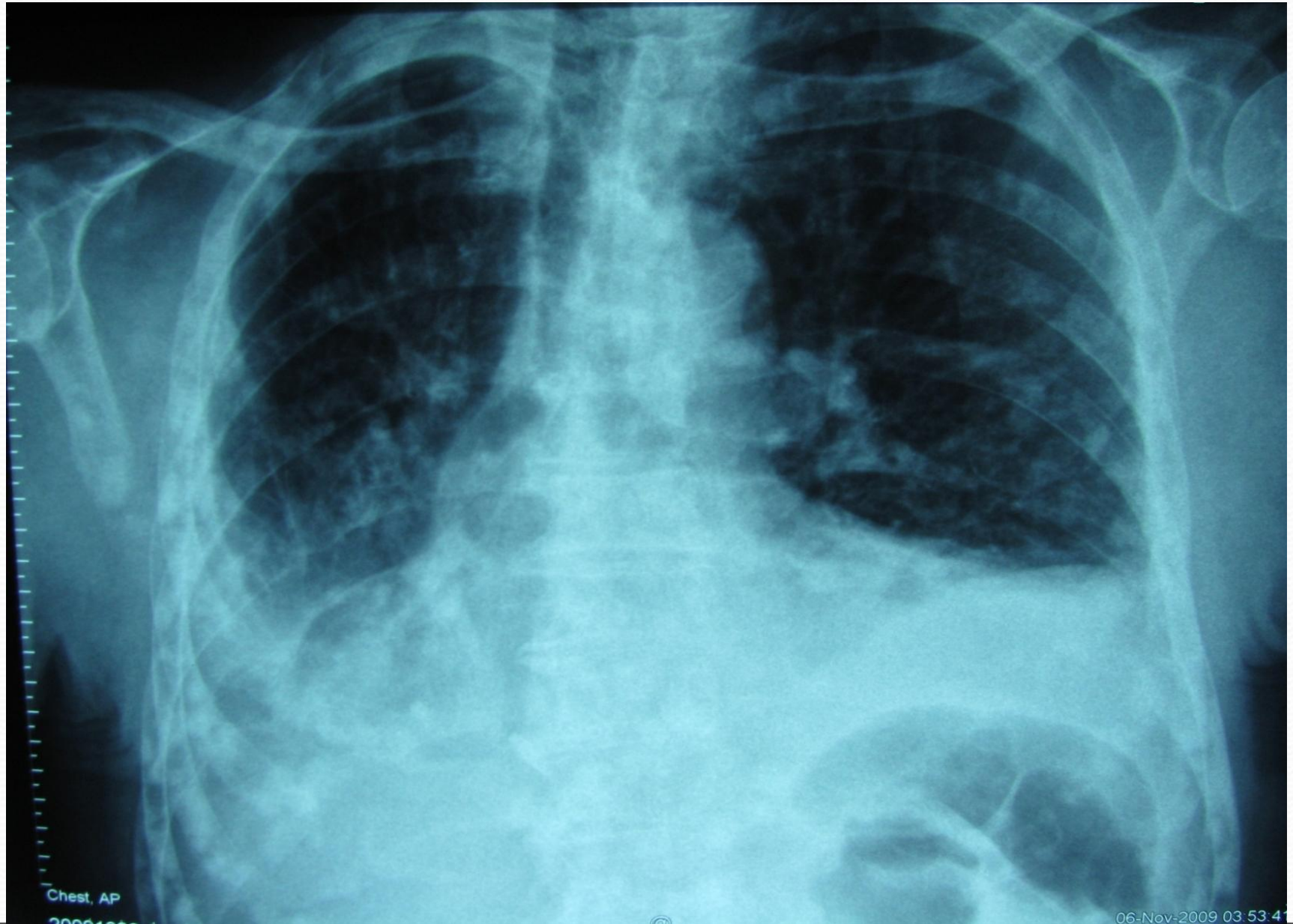


Multiple metastatic pulmonary nodules in a patient with breast cancer.

Image source: https://radiopaedia.org/cases/lung-metastases-from-breast-cancer

Lung metastases in breast cancer

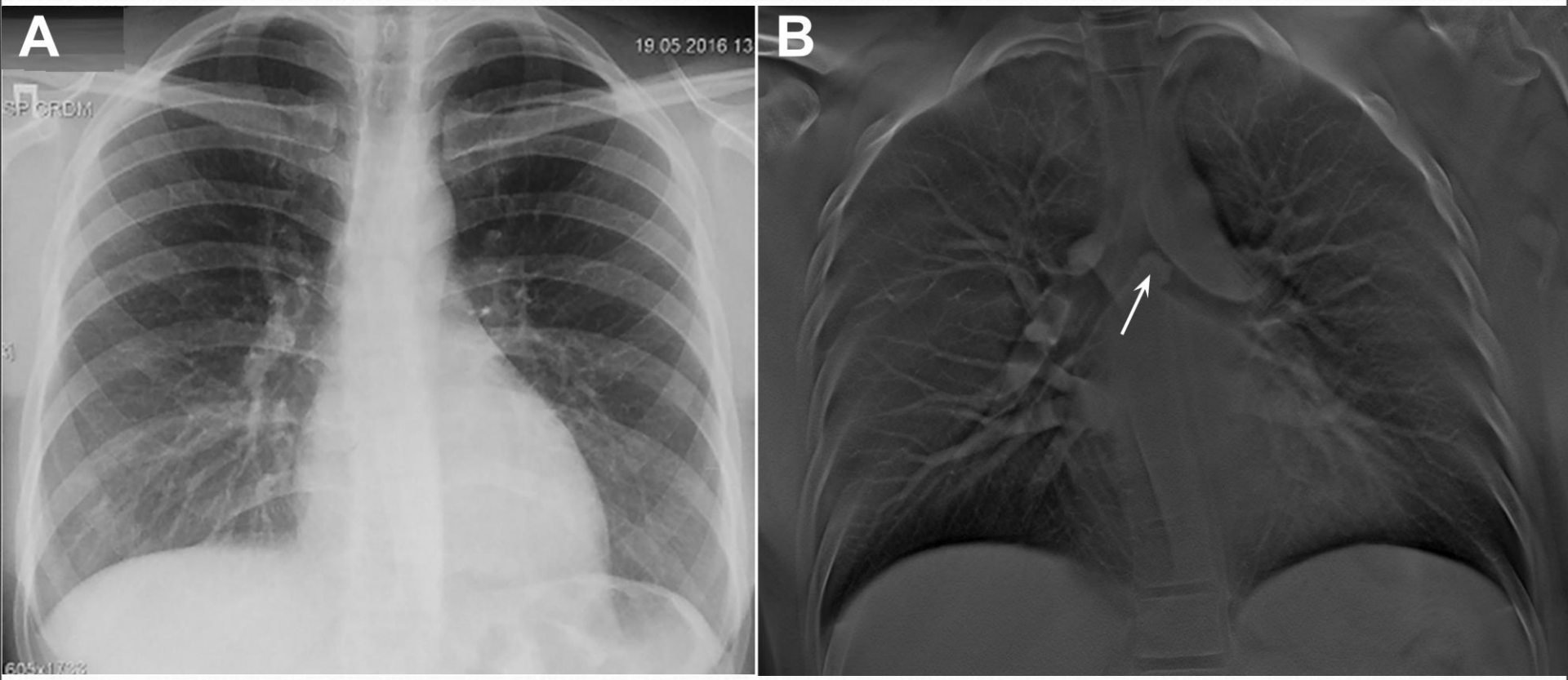
Bone metastases



Lytic bone metastases

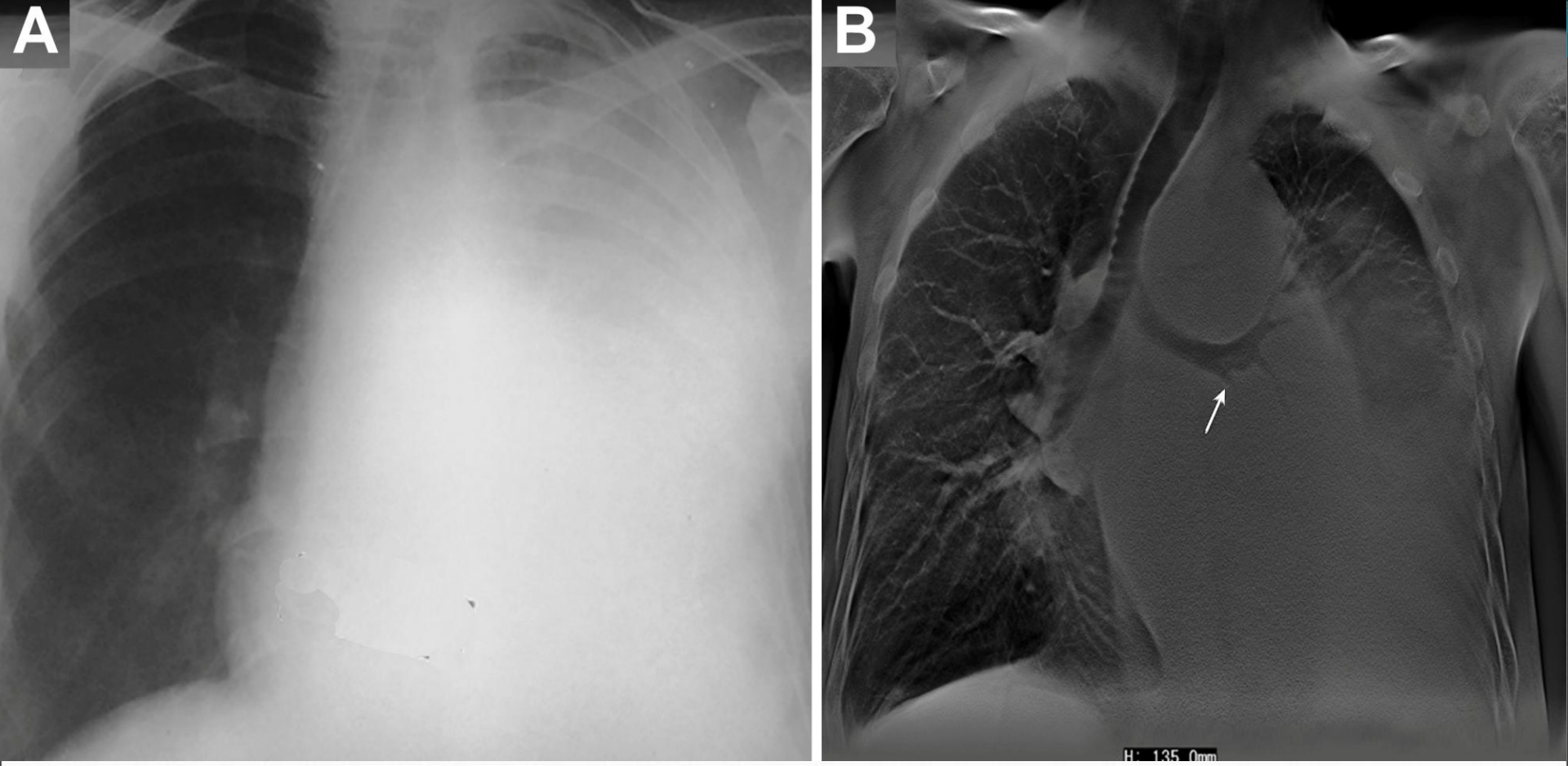
Sclerotic bone metastases

Digital chest tomosynthesis



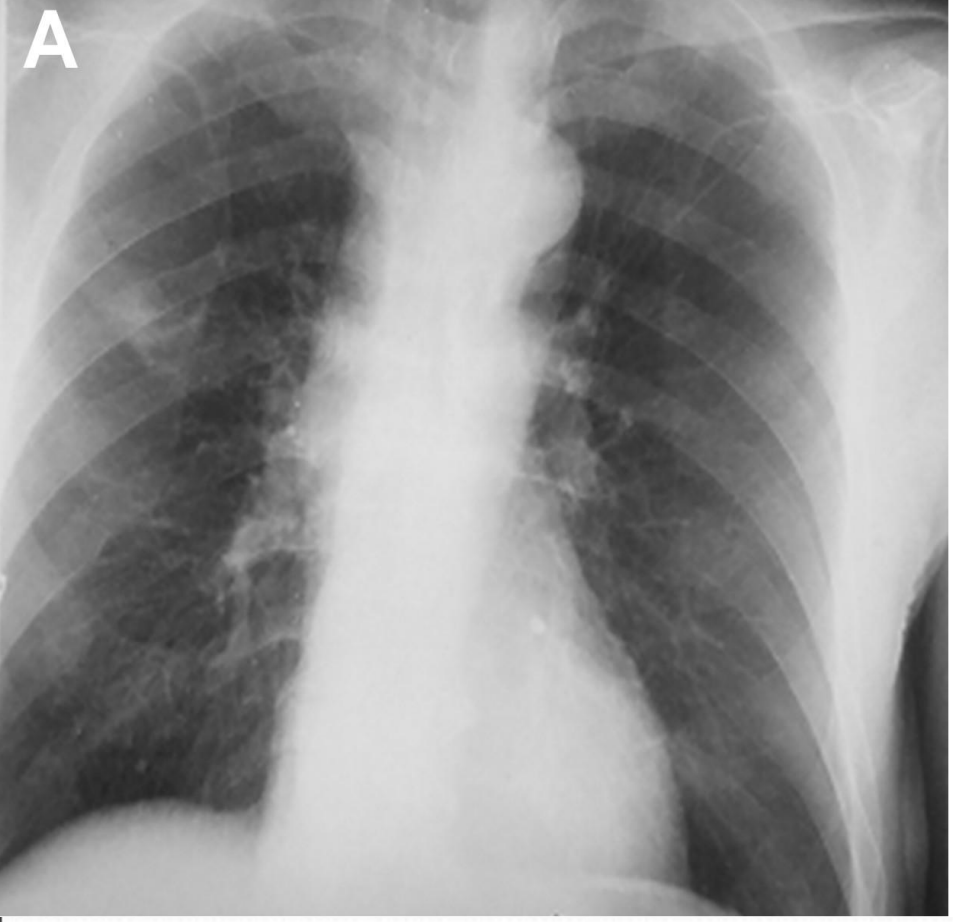
A 29-year-old female presenting with dyspnea. Chest radiography (A) appears relatively normal, while digital chest tomosynthesis (B) reveals a 1.7cm lesion obstructing the left main bronchus (arrow).

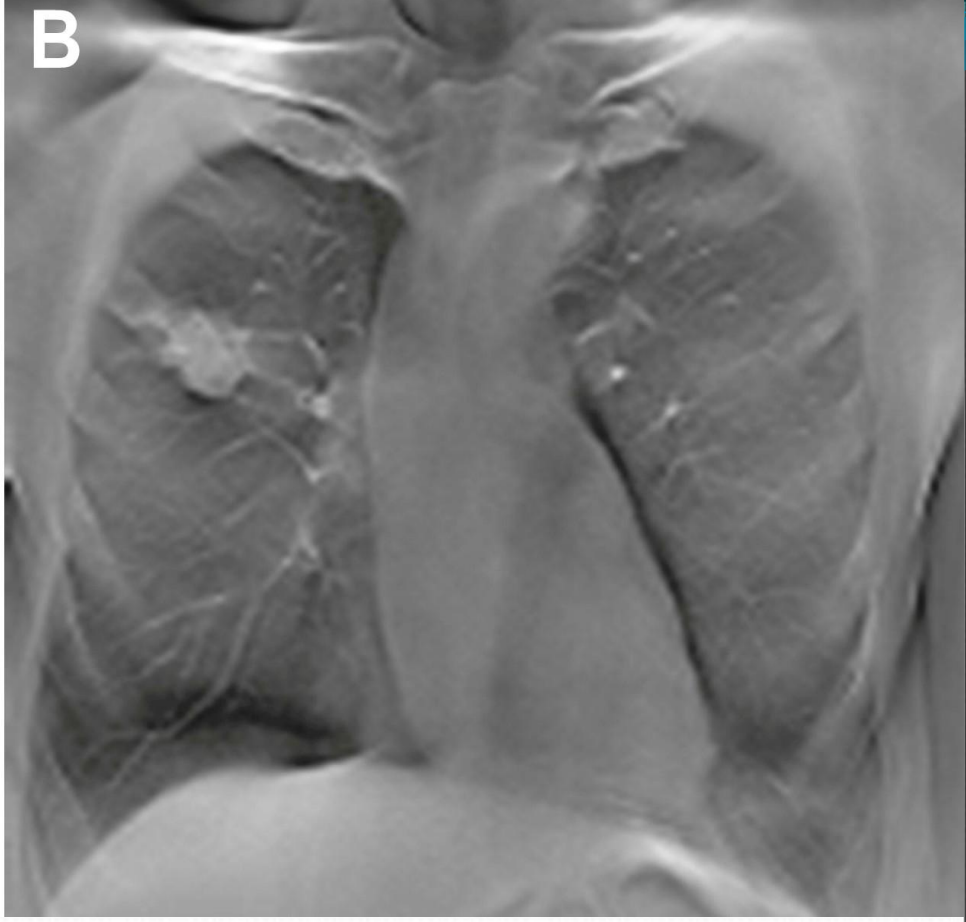
N. Rotaru, M. Harea, I. Codreanu. The role of Digital Chest Tomosynthesis in the diagnosis and follow-up evaluation of patients with lung cancer. European Congress of Radiology (ECR) 2019.
Web: https://dx.doi.org/10.26044/ecr2019/C-0981



Chest radiography (A) of a 48-year old patient showing a subtotal opacity over the inferior left lung field. Digital chest tomosynthesis (B) reveals amputation of the left inferior lobar bronchus at the site of bifurcation of the left main bronchus (pointed by arrow) with resulting atelectasis of the left lower lobe. Narrowing of the left superior segmental bronchi and hipoventilation of the parahilar lung segments are also noted. Subsequent investigations confirmed central lung cancer.

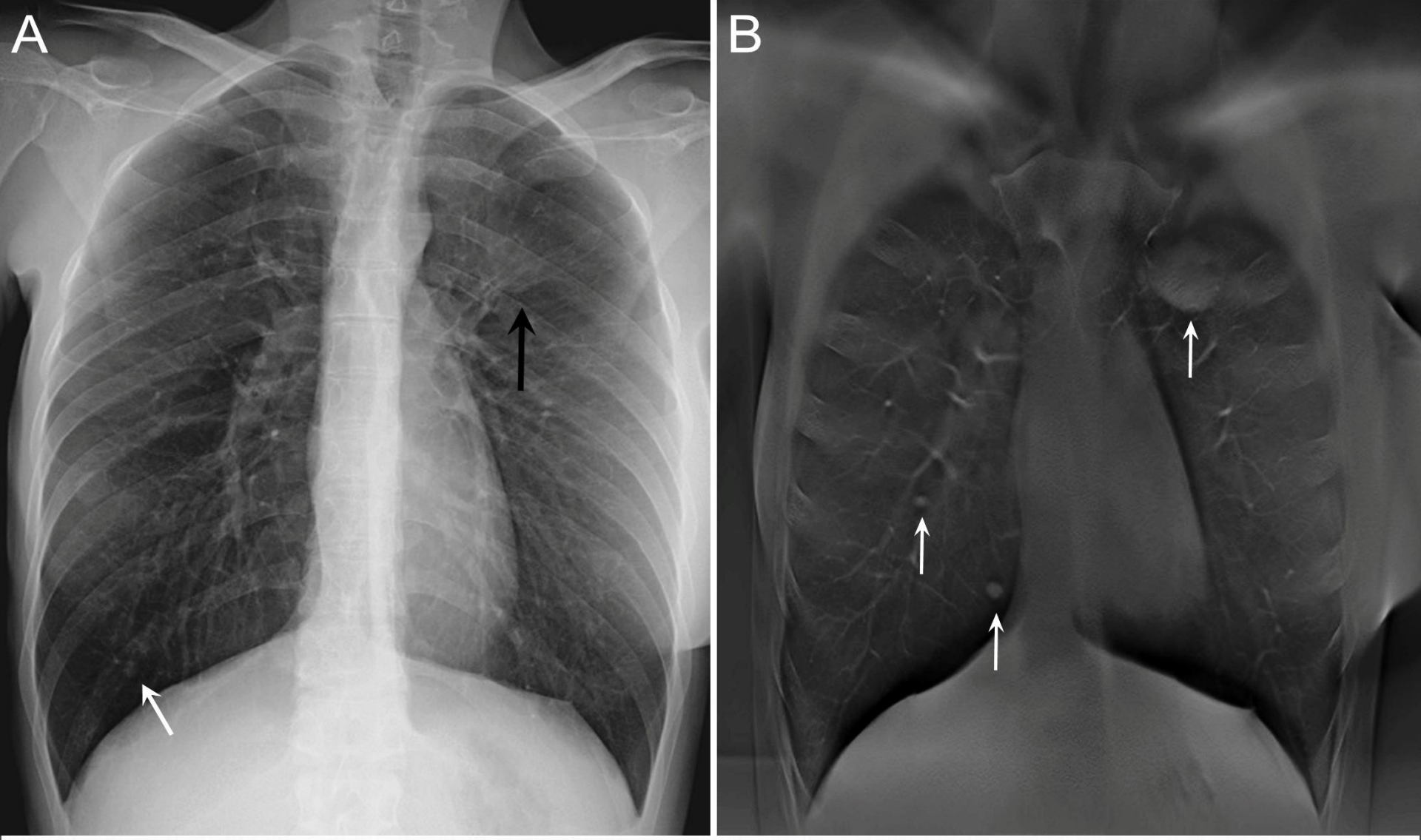
N. Rotaru, M. Harea, I. Codreanu. The role of Digital Chest Tomosynthesis in the diagnosis and follow-up evaluation of patients with lung cancer. European Congress of Radiology (ECR) 2019.
Web: https://dx.doi.org/10.26044/ecr2019/C-0981





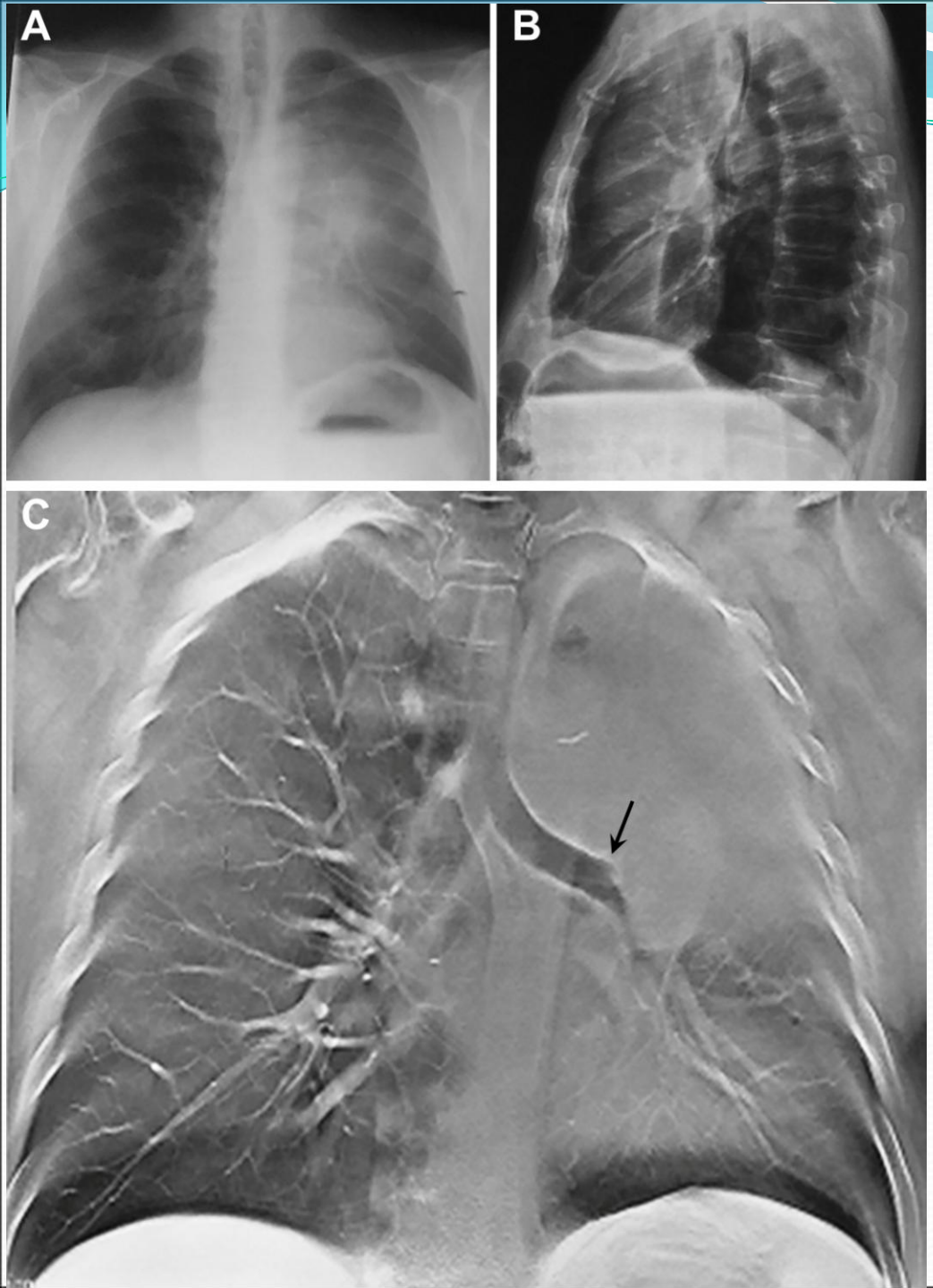
Chest radiography (A) of a 68-year old patient showing a poorly defined opacity overlaying the anterior portion of the right 3rd rib. Digital chest tomosynthesis (B) reveals a spiculated opacity in the anterior segment (S3) of the right upper lobe. Subsequent investigations confirmed peripheral lung cancer in S3.

N. Rotaru, M. Harea, I. Codreanu. The role of Digital Chest Tomosynthesis in the diagnosis and follow-up evaluation of patients with lung cancer. European Congress of Radiology (ECR) 2019.
Web: https://dx.doi.org/10.26044/ecr2019/C-0981



A 28-year female with history of right breast cancer. Chest radiography (A) revealed a suspicious ground glass opacity over the left lung field (black arrow) and an apparent lung nodule at the right lung base (white arrow). Digital chest tomosynthesis (B) showed multiple bilateral pulmonary nodules consistent with metastatic lesions (white arrows).

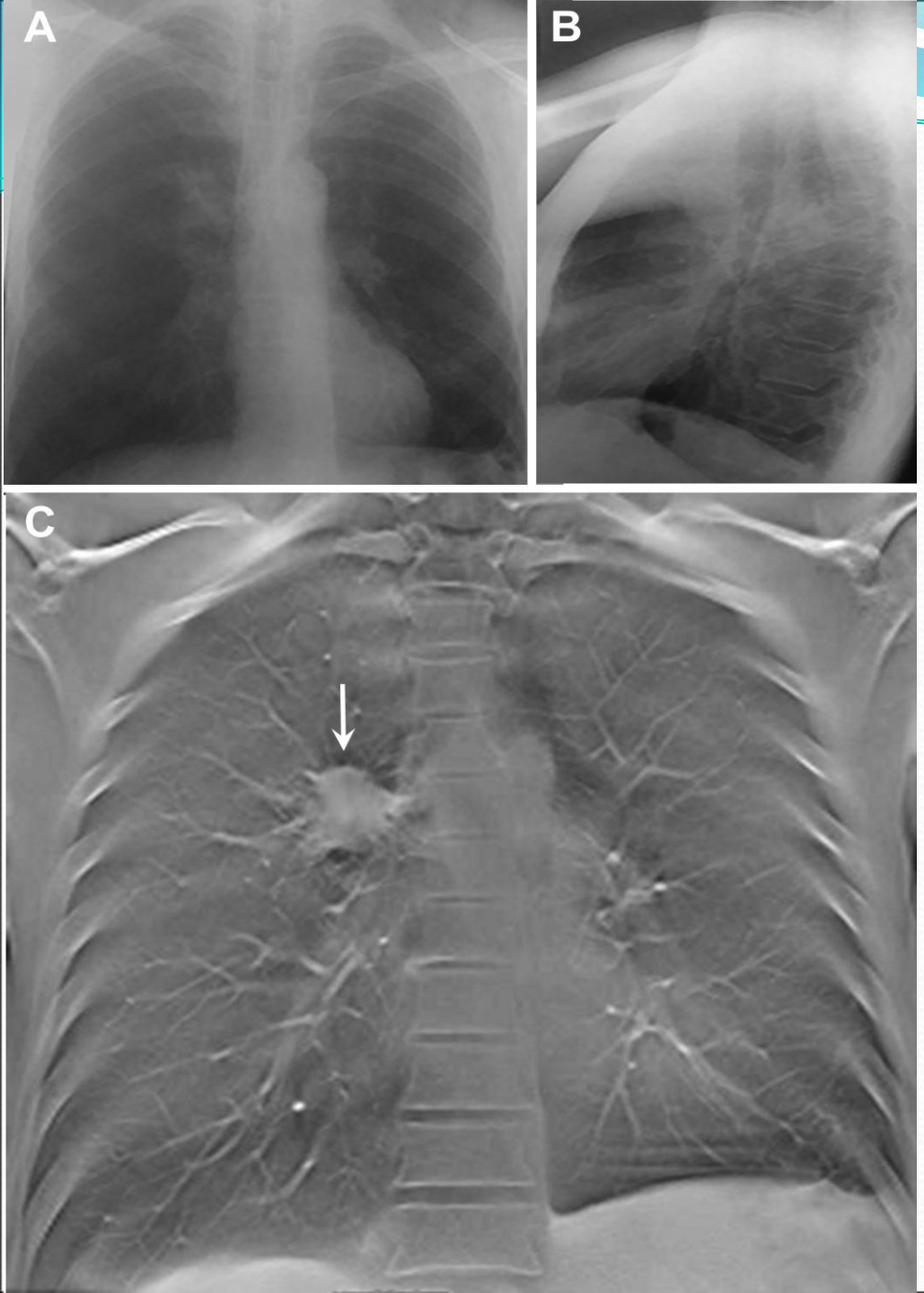
N. Rotaru, M. Harea, I. Codreanu. The role of Digital Chest Tomosynthesis in the diagnosis and follow-up evaluation of patients with lung cancer. European Congress of Radiology (ECR) 2019. Web: https://dx.doi.org/10.26044/ecr2019/C-0981



Chest radiography (A, B) of a 67-year old patient showing an enlarged craggy left hilum with reduced left upper lung field and elevated left hemidiaphragm.

Digital chest tomosynthesis (C) reveals amputation of the left superior lobar bronchus at the site of bifurcation of the left main bronchus (pointed by arrow) with resulting atelectasis of the left upper lobe. Narrowing of the left inferior lobar bronchus by locally enlarged lymph nodes is also noted.

N. Rotaru, M. Harea, I. Codreanu. The role of Digital Chest Tomosynthesis in the diagnosis and follow-up evaluation of patients with lung cancer. European Congress of Radiology (ECR) 2019. Web: https://dx.doi.org/10.26044/ecr2019/C-0981

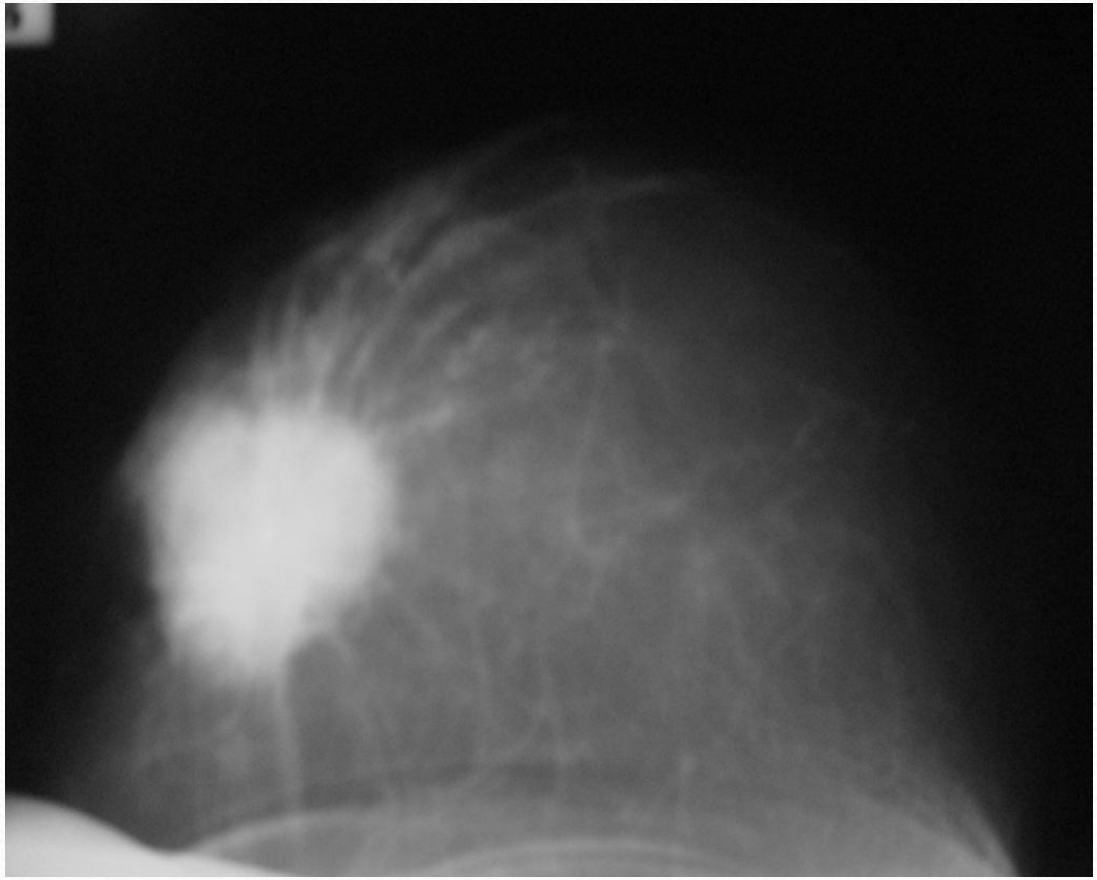


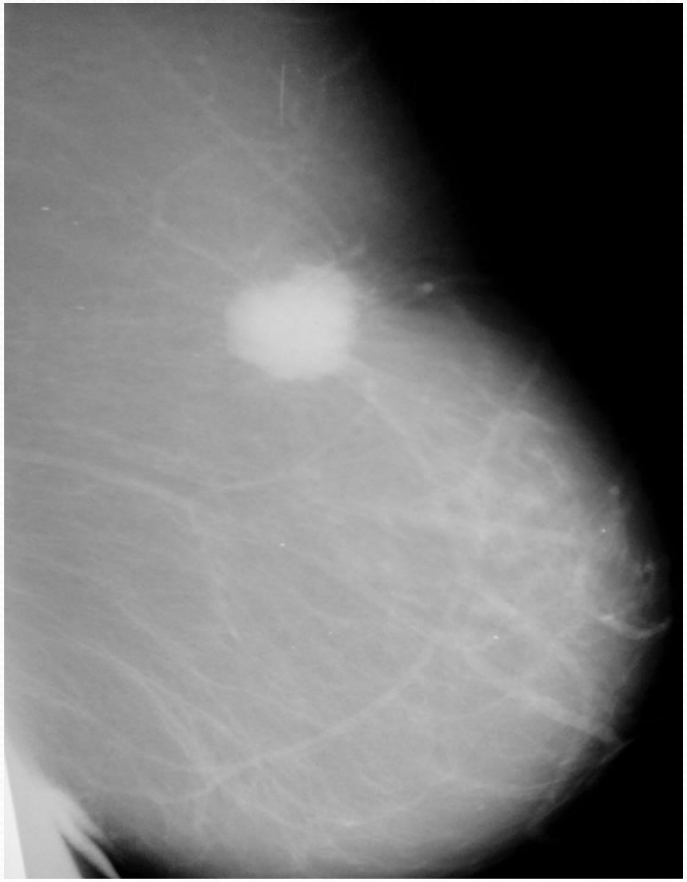
Chest radiography (A, B) of a 57-year old male showing a mildly enlarged right hilum.

Digital chest tomosynthesis (B) reveals a spiculated opacity in right lung (pointed by arrow) extending to the right hilar region. Subsequent investigations confirmed peripheral lung cancer in the apical segment of the right lower lobe (S6).

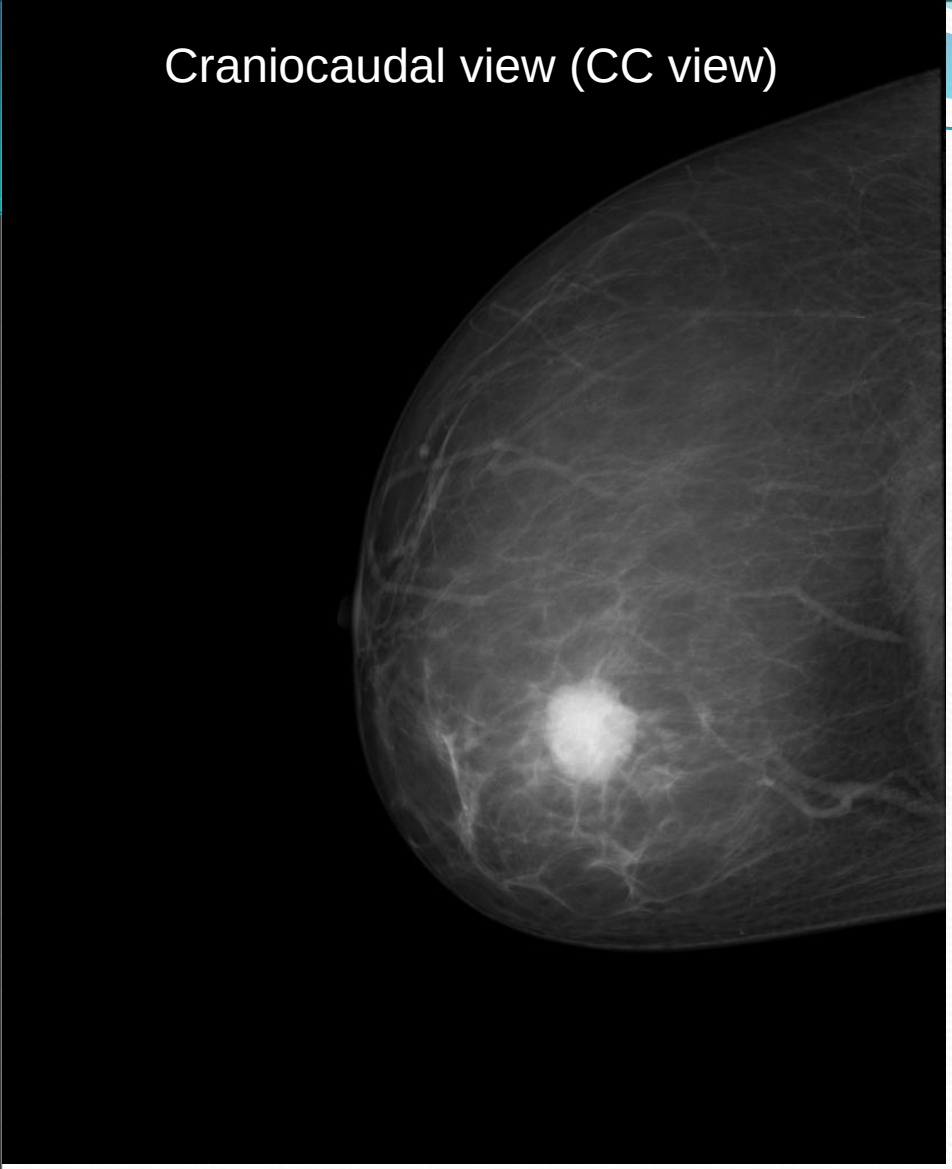
N. Rotaru, M. Harea, I. Codreanu. The role of Digital Chest Tomosynthesis in the diagnosis and follow-up evaluation of patients with lung cancer. European Congress of Radiology (ECR) 2019. Web: https://dx.doi.org/10.26044/ecr2019/C-0981

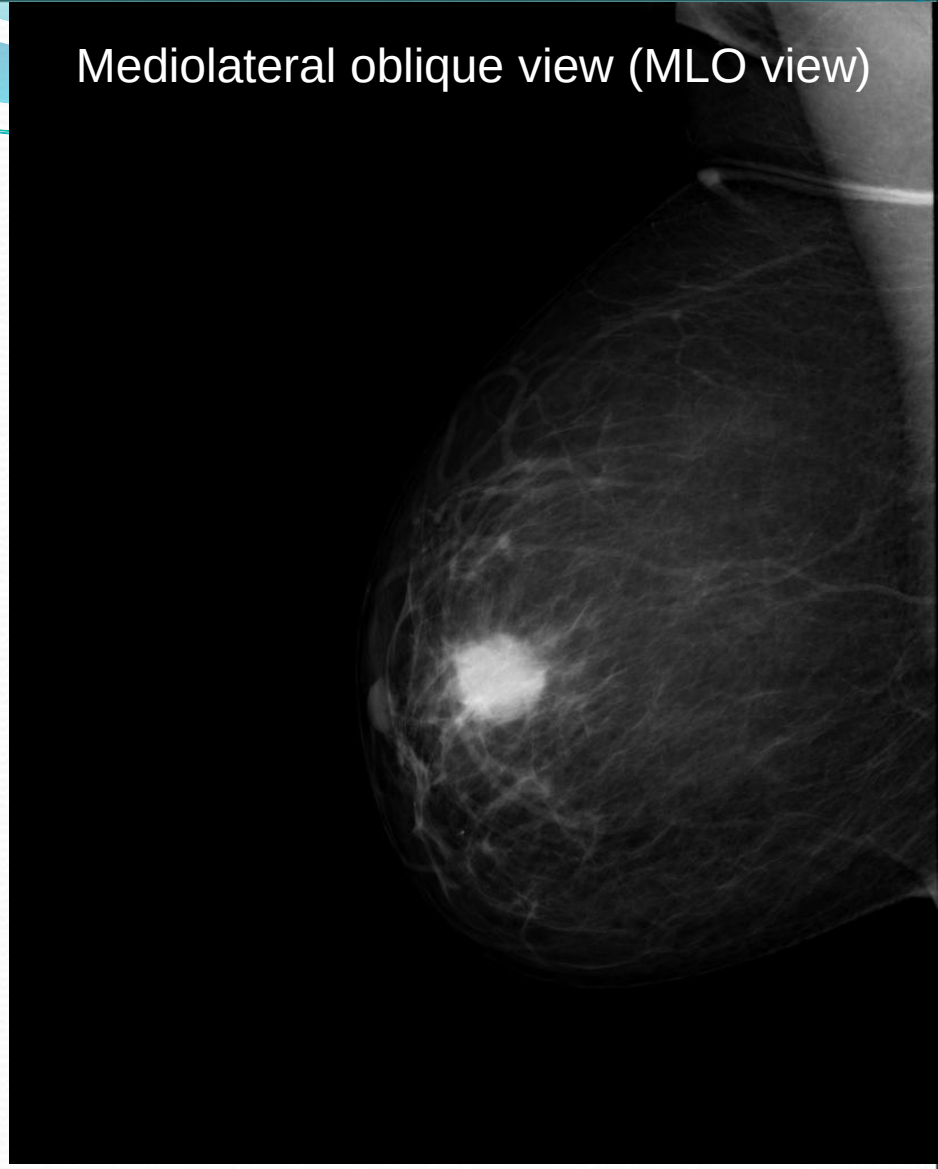
Mammography





- Mammograms are used as a screening tool to detect early breast cancer in women experiencing no symptoms.
- They can also be used to detect and diagnose breast disease in women experiencing symptoms such as a lump, pain, skin dimpling or nipple discharge.





Mammography demonstrates a fairly well defined dense lesion with microlobulated borders in a patient with metaplastic carcinoma of the breast (proven histologically).

Image source: https://radiopaedia.org/cases/metaplastic-carcinoma-of-the-breast?lang=us

Ultrasound imaging in Oncology

Scanned regions and organs

- Thorax: Confirms pleural effusions and pleural masses.
- Abdomen: Visualizes liver, gallbladder, pancreas, kidneys, etc.
- Pelvis: Useful for monitoring pregnancy, uterus and ovaries.
- Peripheral: Assesses thyroid, testes and soft-tissue lesions.
- Brain: Imaging the neonatal brain.

Ultrasound imaging in Oncology

Advantages

- Not associated with ionizing radiation.
- Relatively low cost of equipment.
- Portable equipment can be taken to the bedside for ill patients.
- Can be repeated frequently, for example in pregnancy.
- When associated with Doppler, can be used for evaluation of blood flow.
- Can be used for imaging guidance in various interventional procedures (biopsy and drainage).

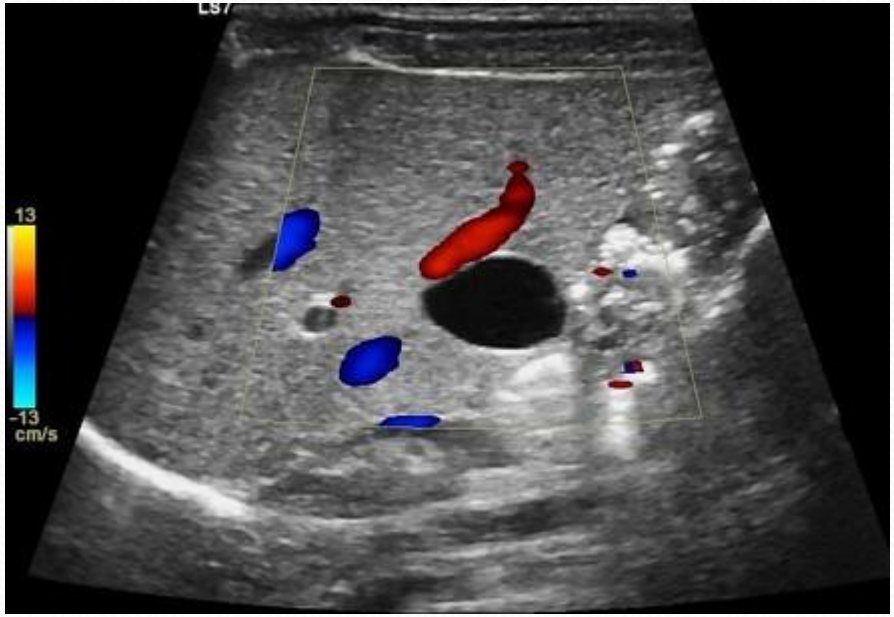
Ultrasound imaging in Oncology

Disadvantages

- Operator dependent.
- Scattering of sound through fat produces poor images in obesity.
- Inability of sound to cross an interface with either gas or bone causes unsatisfactory visualization of underlying structures.

Reflected echos

- **Strong Reflections = White dots**
  - Diaphragm, tendons, bones are ‘hyperechoic’
- **Weaker Reflections = Grey dots**
  - Most solid organs and thick fluids are ‘isoechoic’
- **No Reflections = Black dots**
  - Fluid within a cyst, urine, blood represent ‘hypoechoic’ or echo-free structures



Doppler imaging

- **Red color = flow towards the transducer**
- **Blue color = flow away from the transducer**

Image source: https://radiopaedia.org/articles/simple-hepatic-cyst

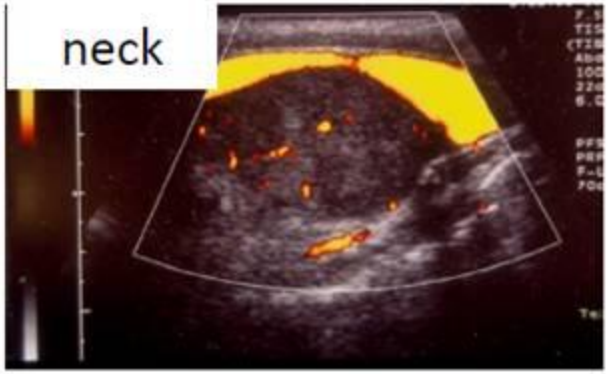
US
excellent soft tissue resolution
BUT
lack of complex information

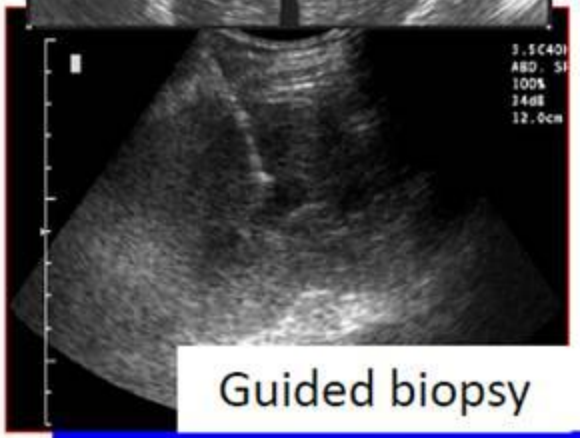
liver

Endorectal US-in rectal ca

Bile duct

neck



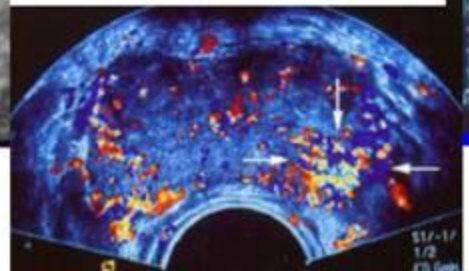


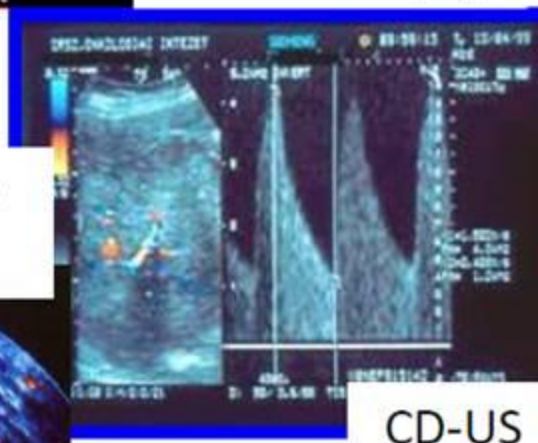
Guided biopsy

Renal tu

Ovarian ca

Endorectal US-in prostate ca





CD-US

Computed Tomography (CT) imaging in Oncology

- Any region of the body can be scanned: brain, neck, abdomen, pelvis and limbs.
- Staging primary tumors such as colon and lung for secondary spread, to determine operability or the baseline status for chemotherapy.
- Exact anatomical detail when ultrasound is not successful.
- Radiotherapy planning.

Computed Tomography (CT) imaging in Oncology

Advantages

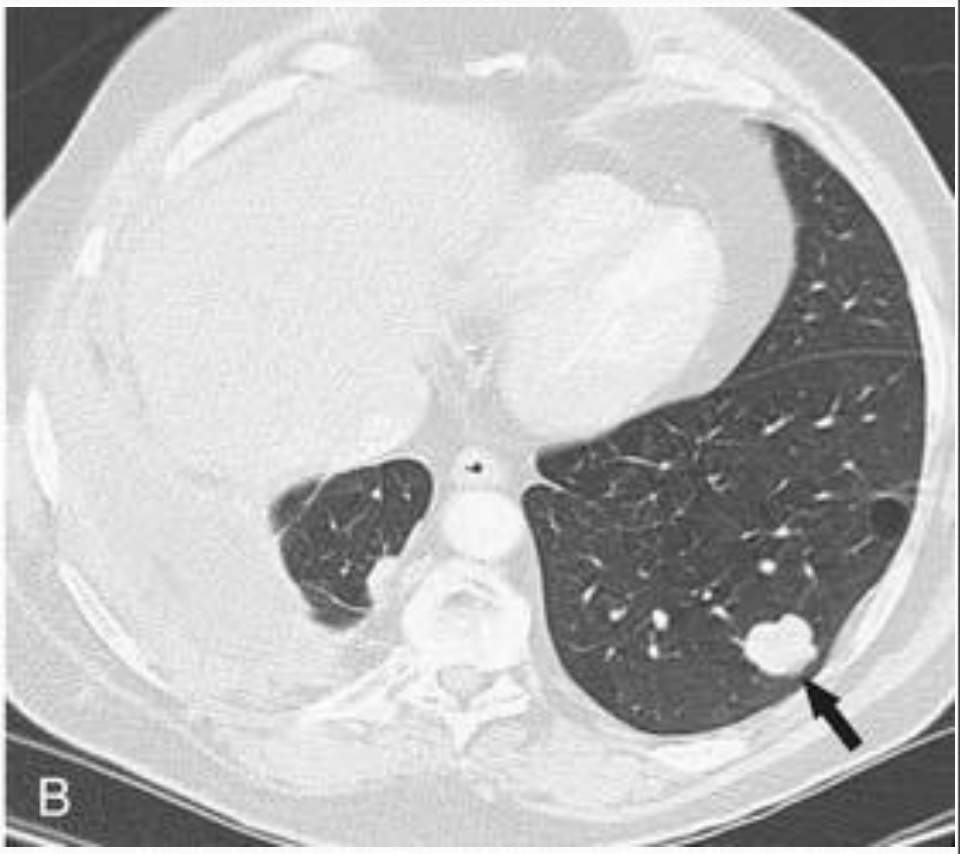
- Good contrast resolution.
- Precise anatomical detail.
- Rapid examination technique, being valuable for ill patients.
- In contrast to ultrasound, good quality diagnostic images are obtained in obese patients as fat separates the abdominal organs.

Computed Tomography (CT) imaging in Oncology

Disadvantages

- High dose of ionizing radiation for each examination
- High cost of equipment and scan.
- Bone artefacts in brain scanning, especially the posterior fossa, degrading the images.
- Scanning mostly restricted to the transverse plane, although reconstructed images can be obtained in other planes.

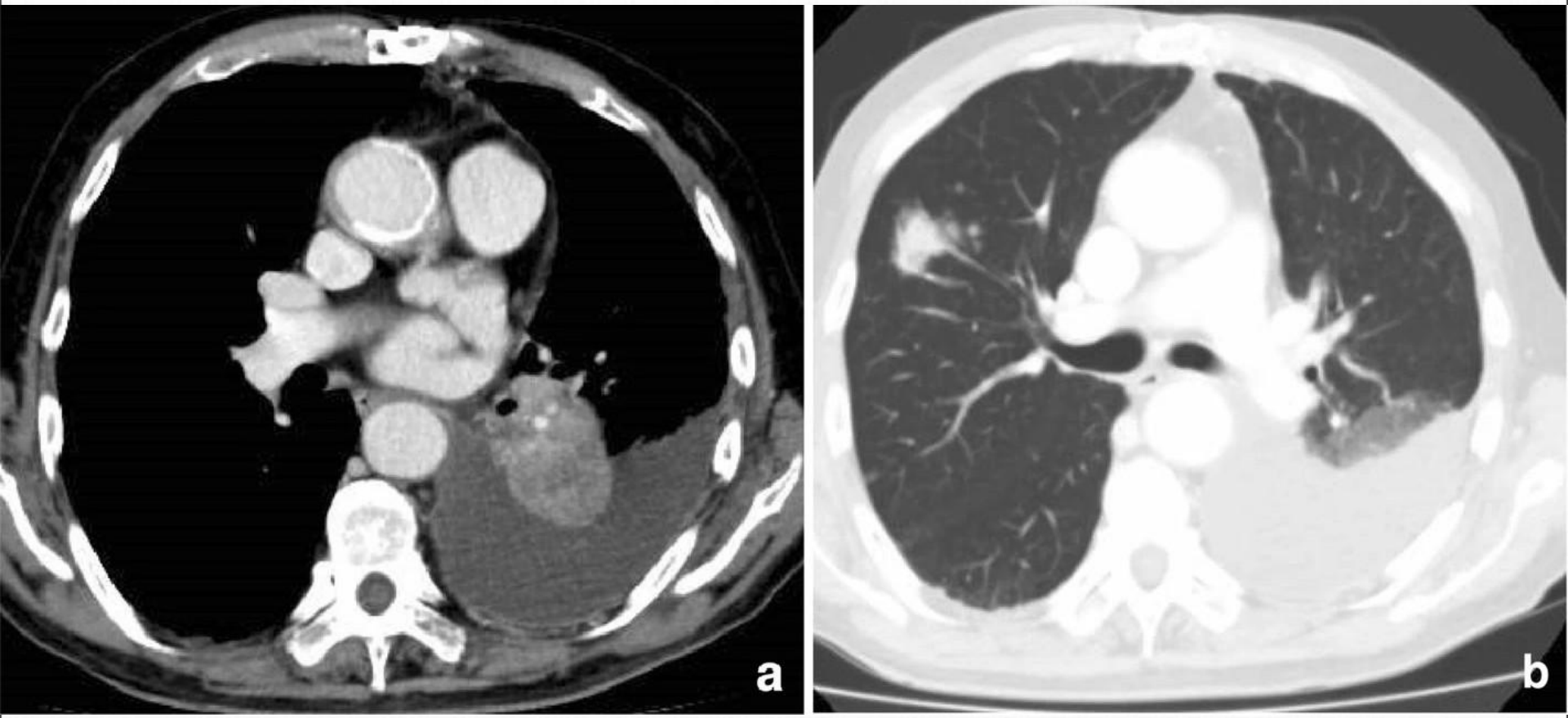
Computed Tomography (CT) imaging in Oncology



A 61-year-old man with right epithelioid malignant pleural mesothelioma (MPM). Contrast-enhanced CT with mediastinal window (**A**) and lung window (**B**) show nodular right pleural thickening, small right pleural effusion, and rounded atelectasis in the middle and right lower lobes. Note the well-circumscribed left lower lobe 1.5-cm nodule *(arrows)* consistent with metastasis.

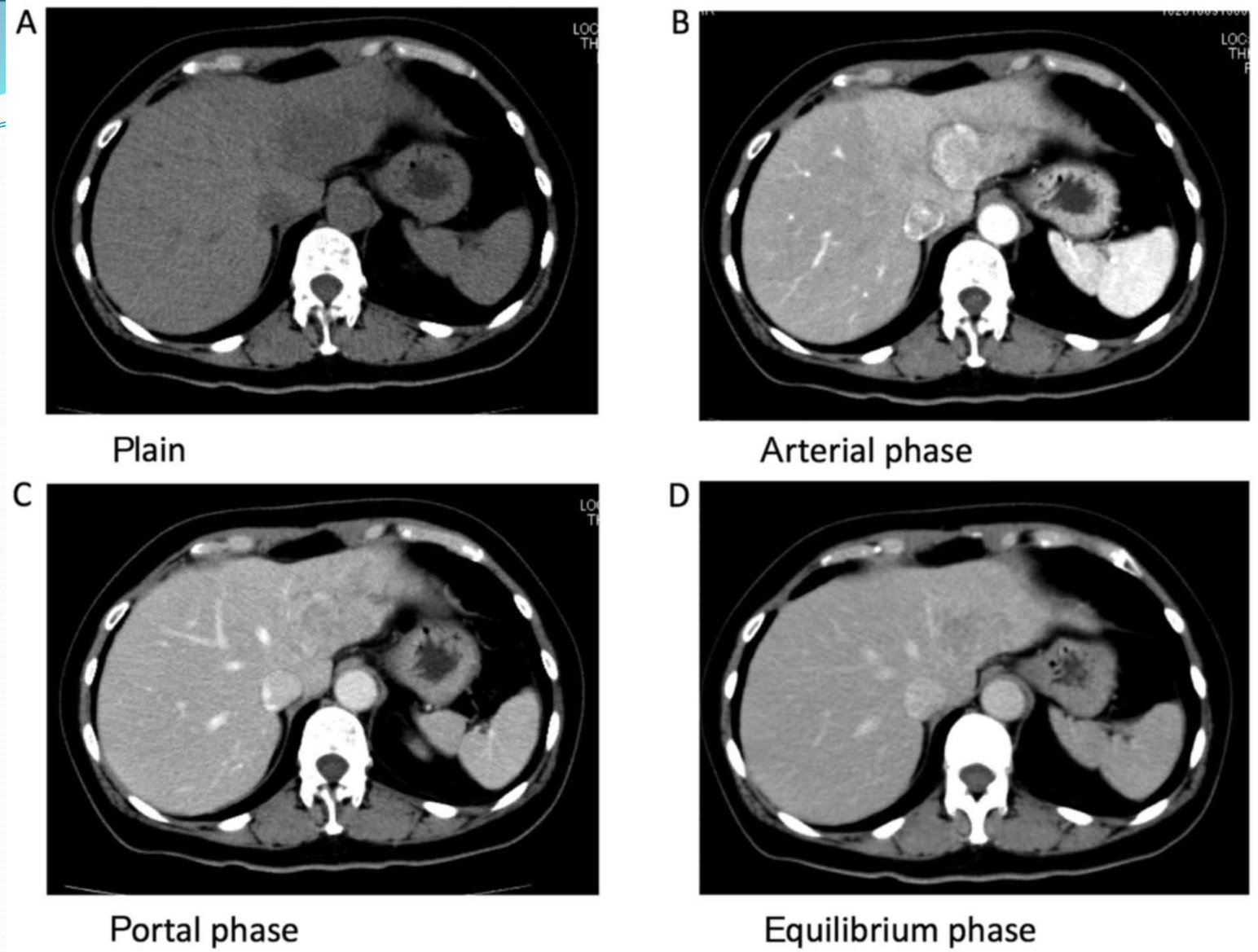
Image source: https://radiologykey.com/pleural-tumors/

Computed Tomography (CT) imaging in Oncology



CT scan of the chest. CT scan of the chest, showing left hilar lung mass and left pleural effusion (**a**) and multiple lung nodules in the right lung (**b**)

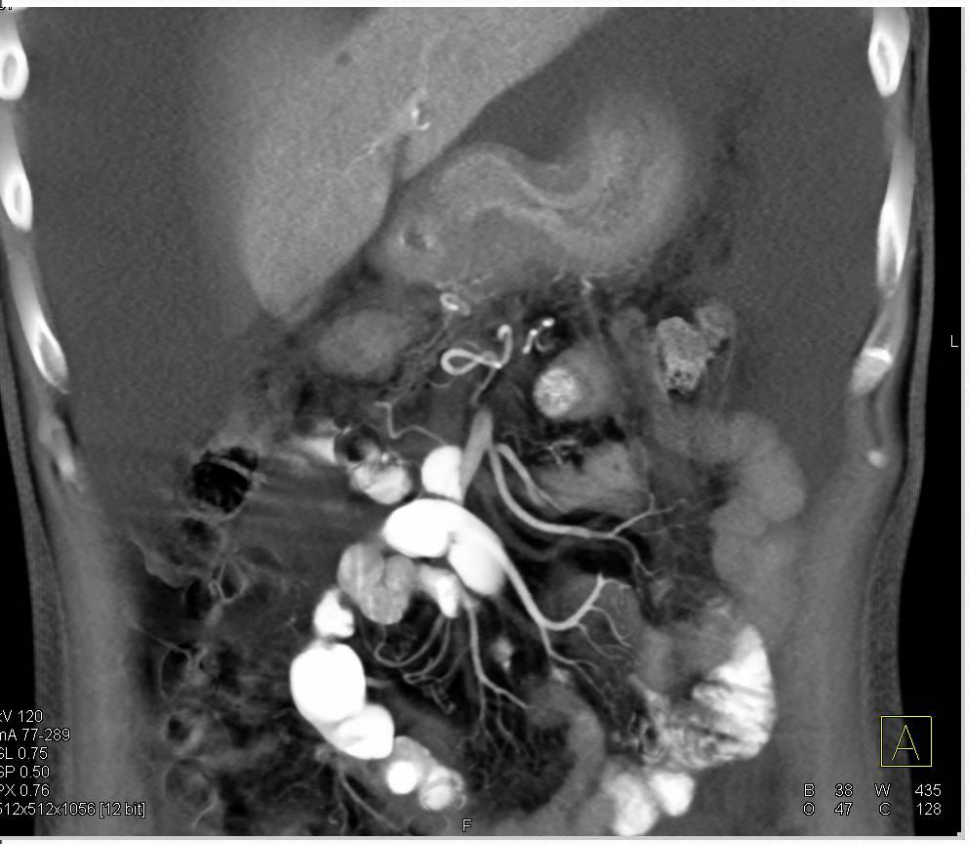
Image source: Abe M, Watanabe K, Shinozaki-Ushiku A, et al. Identification of a metastatic lung adenocarcinoma of the palate mucosa through genetic and histopathological analysis: a rare case report and literature review. BMC Cancer. 2019;19(1):52.
Web: https://pubmed.ncbi.nlm.nih.gov/30634950/

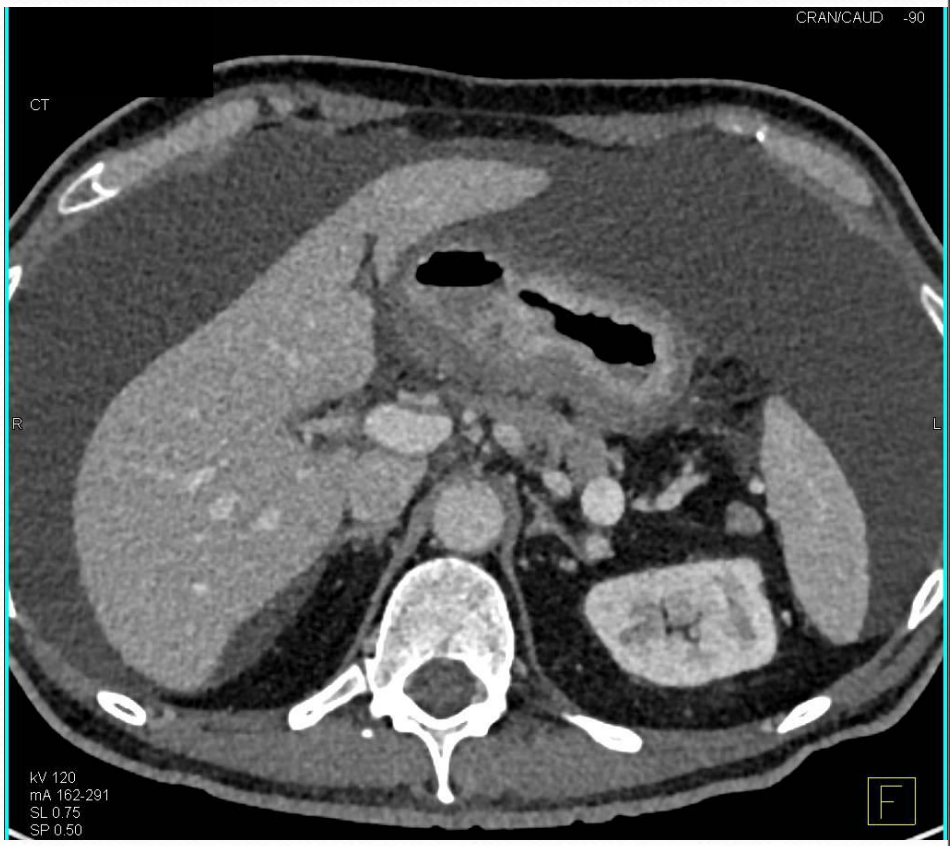


Abdominal CT in a patient with a liver tumor. (A) CT demonstrated a low-density mass, measuring 50 mm in the largest diameter, in segment 2 of the liver. (B) The tumor exhibited slight enhancement during the arterial phase and persistent enhancement during the (C) portal and (D) equilibrium phases. CT, computed tomography.

Image source: Nagata, Ken et al. “A case of intrahepatic cholangiocarcinoma that was difficult to diagnose prior to surgery: A case report.” *Oncology letters* vol. 17,1 (2019): 823-830. Web: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6313065/

Computed Tomography (CT) imaging in Oncology

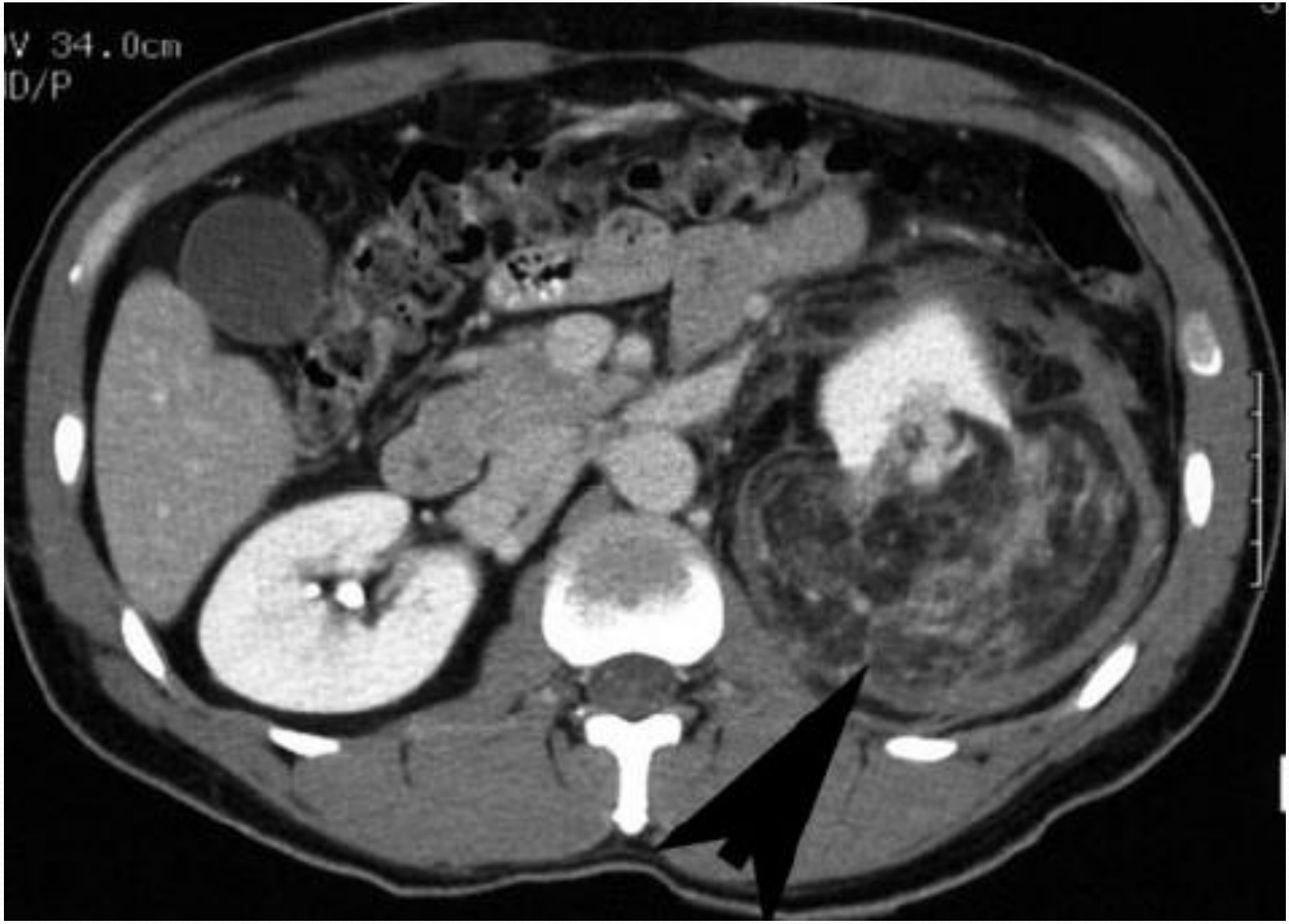




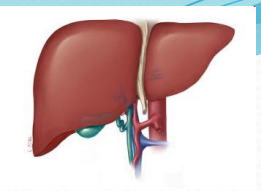
Linitis Plastica Stomach with ascites secondary to breast cancer metastases

Image source: Abe M, Watanabe K, Shinozaki-Ushiku A, et al. Identification of a metastatic lung adenocarcinoma of the palate mucosa through genetic and histopathological analysis: a rare case report and literature review. BMC Cancer. 2019;19(1):52.
Web: https://pubmed.ncbi.nlm.nih.gov/30634950/

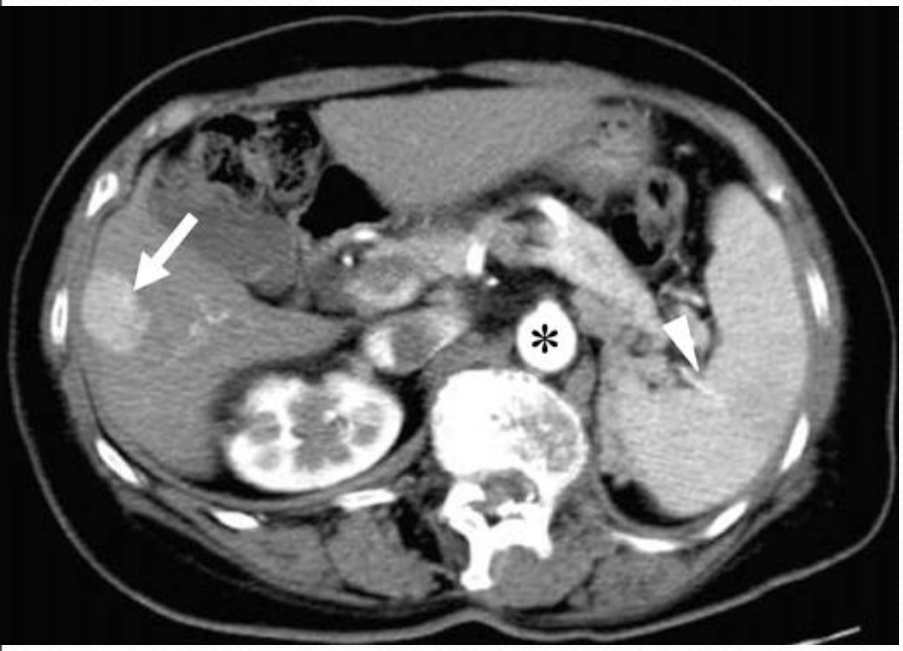
Computed Tomography (CT) imaging in Oncology



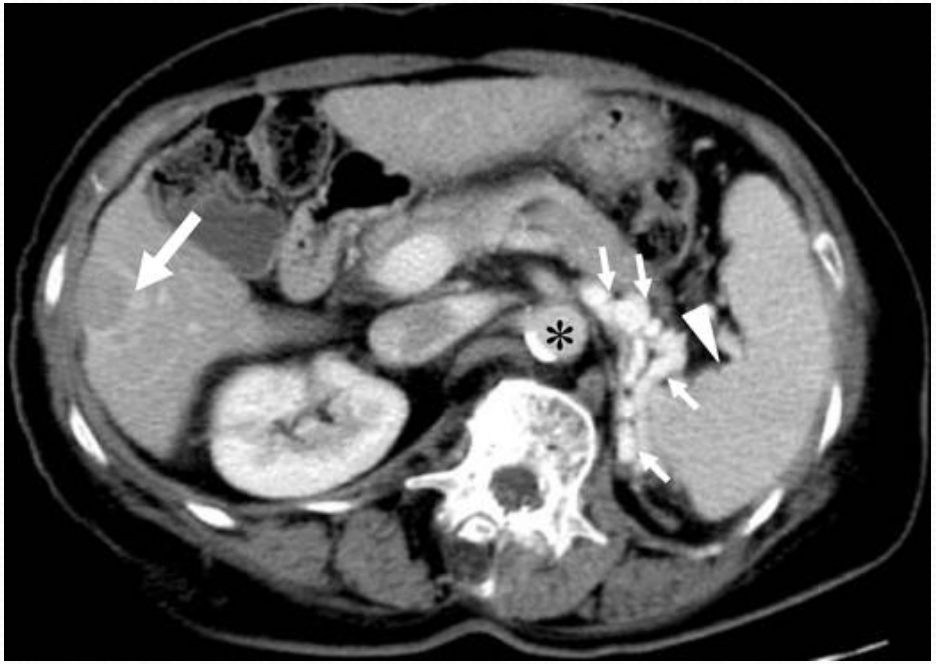
Computed Tomography (CT) imaging in Oncology



Hepatocellular cancer in the right lobe of the liver at CT

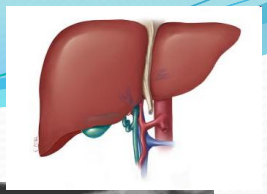


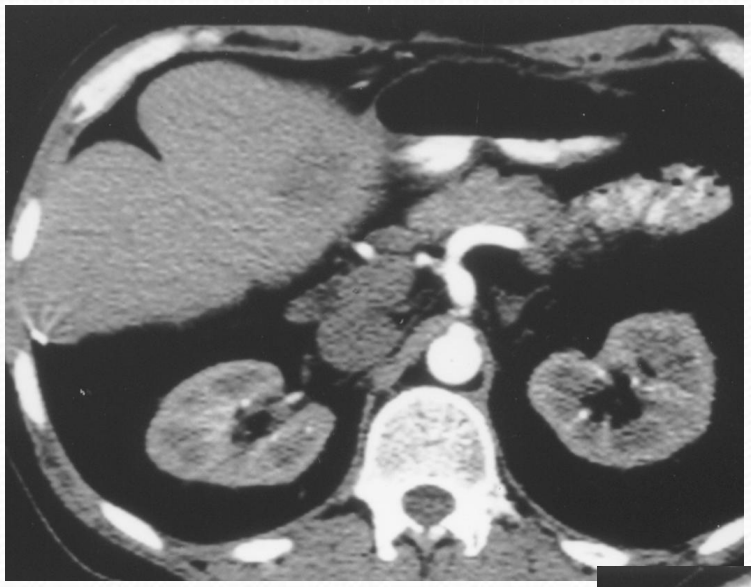
Arterial phase



Venous phase

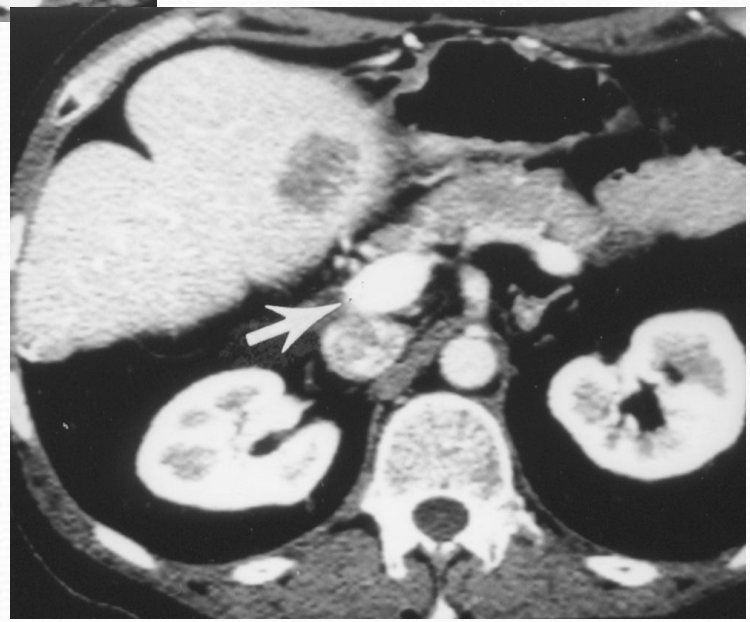
Colon cancer: liver metastases





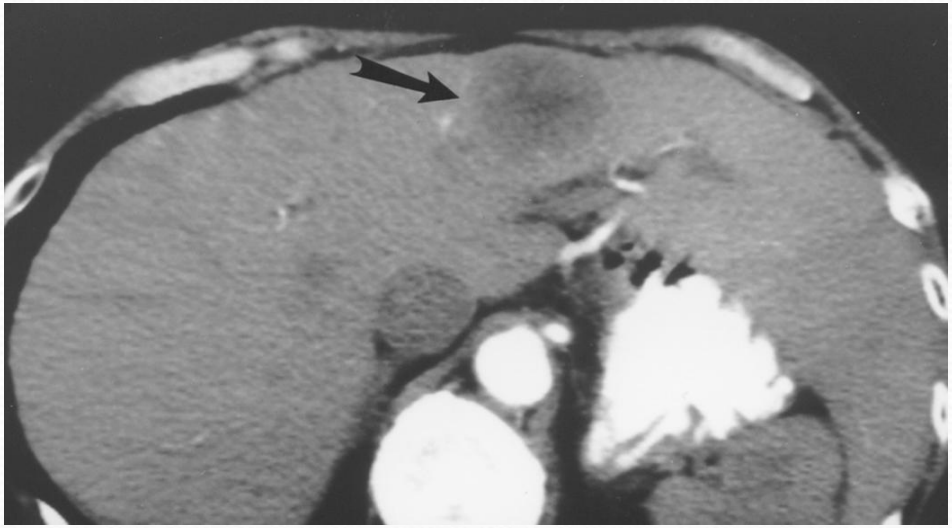
Early arterial phase

Tardive arterial phase



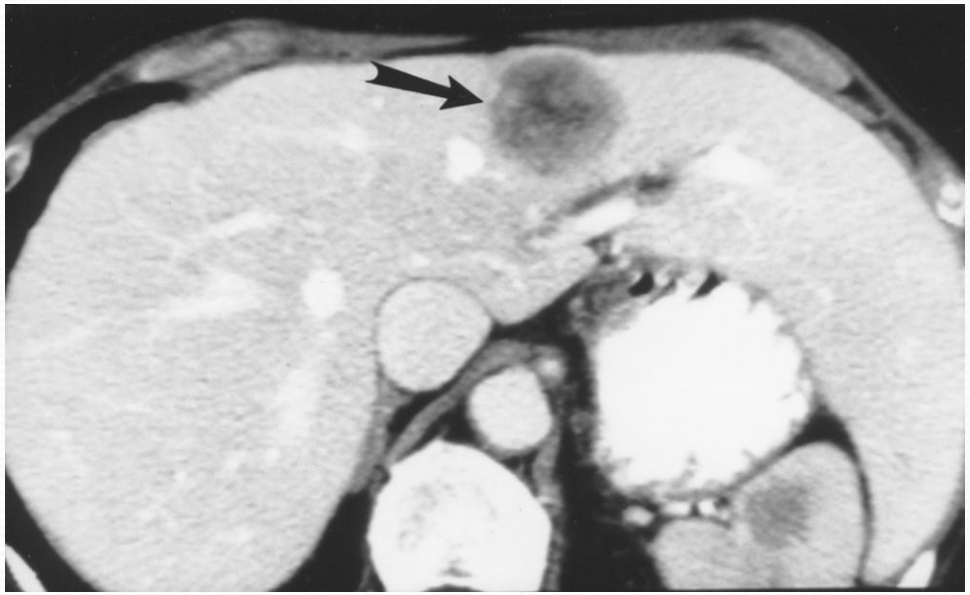
Portal phase

Colon cancer: liver MT



Arterial phase

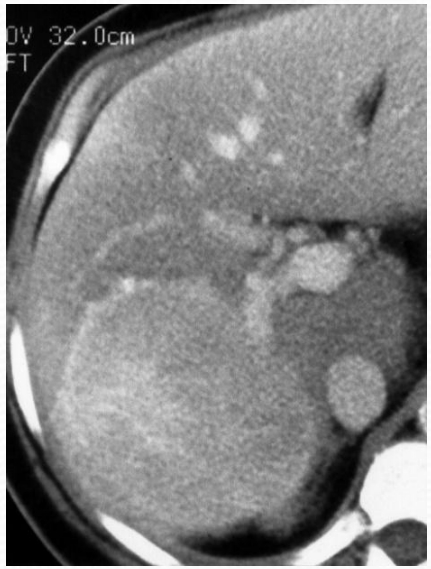
Venous phase



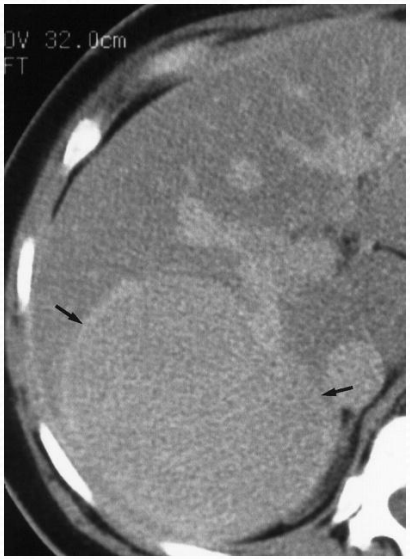
Liver adenoma

Native phase

Arterial phase



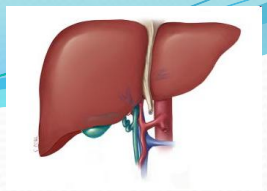
Venous phase



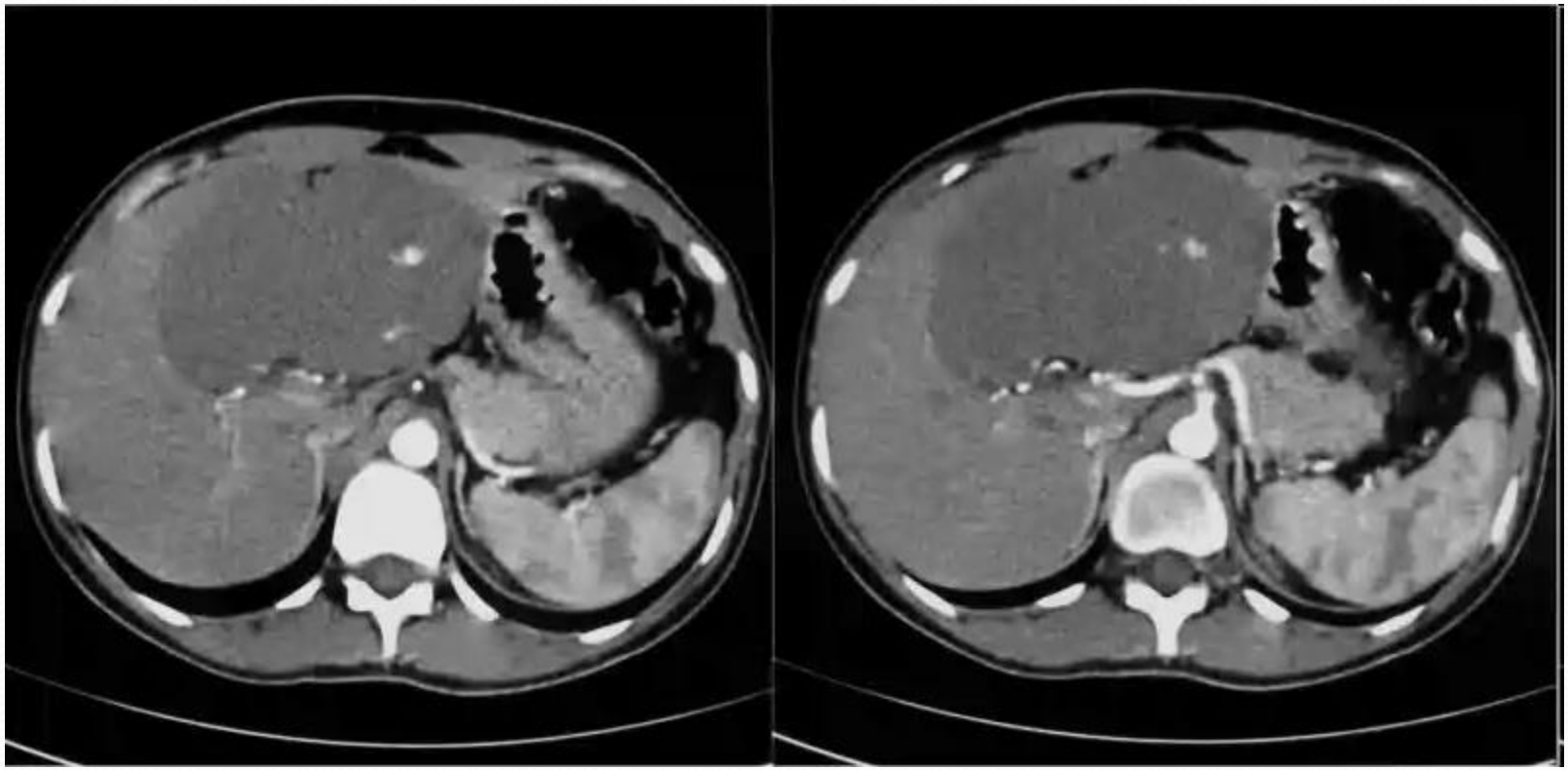
Tardive phase after 10 min

- In general, hepatic adenomas are well marginated and isodense to the liver.
- On contrast administration, they demonstrate transient relatively homogenous enhancement returning to near isodensity on portal venous and delayed phase images.

Hepatic hemangioma



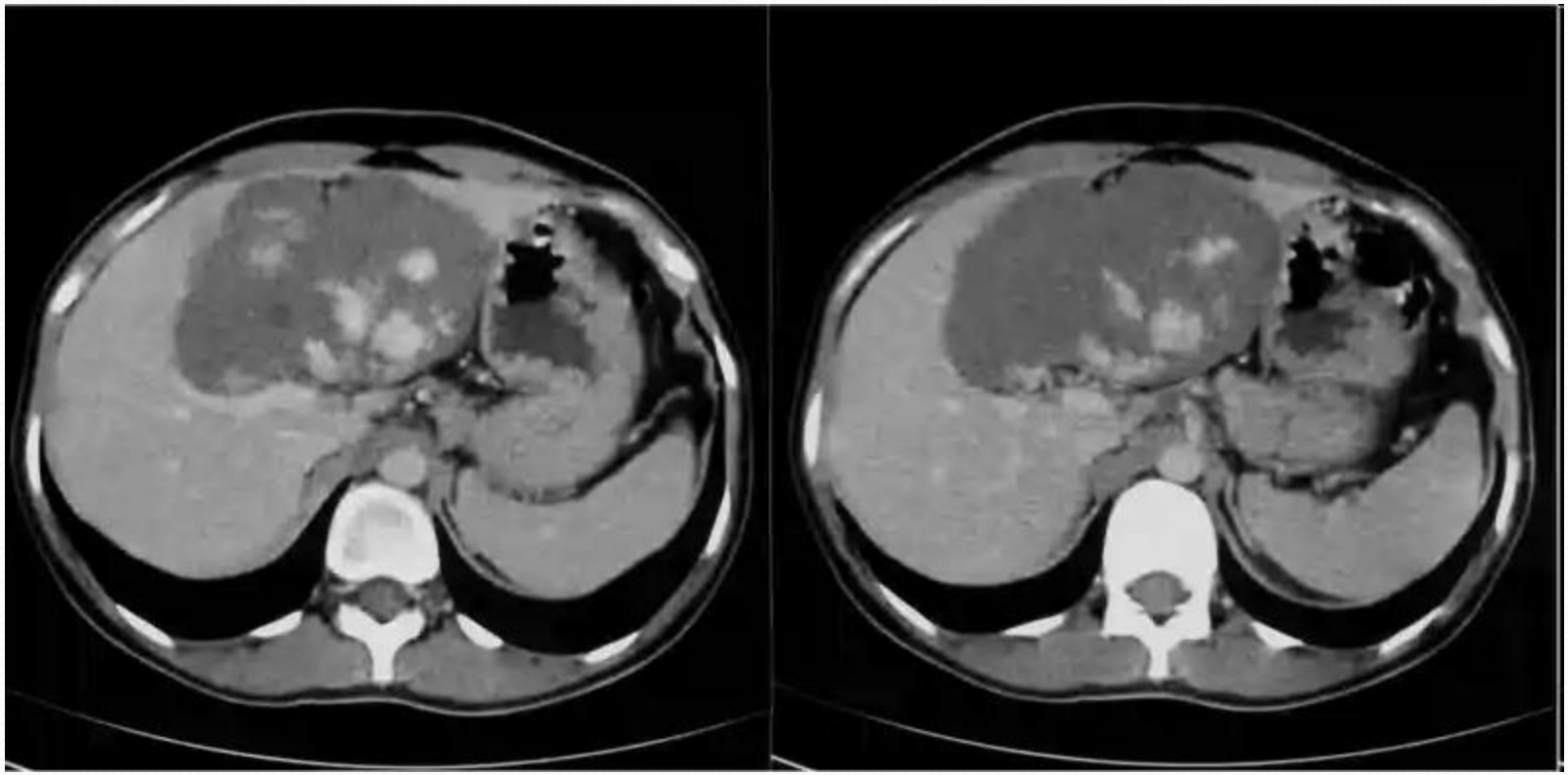
The dynamic enhancement pattern is related to the size of its vascular space



Arterial phase

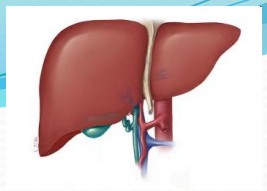
- on arterial phase typically show discontinuous, nodular, peripheral enhancement (small lesions may show uniform enhancement)
- bright dot sign (on arterial and portal venous phase)

Hepatic hemangioma

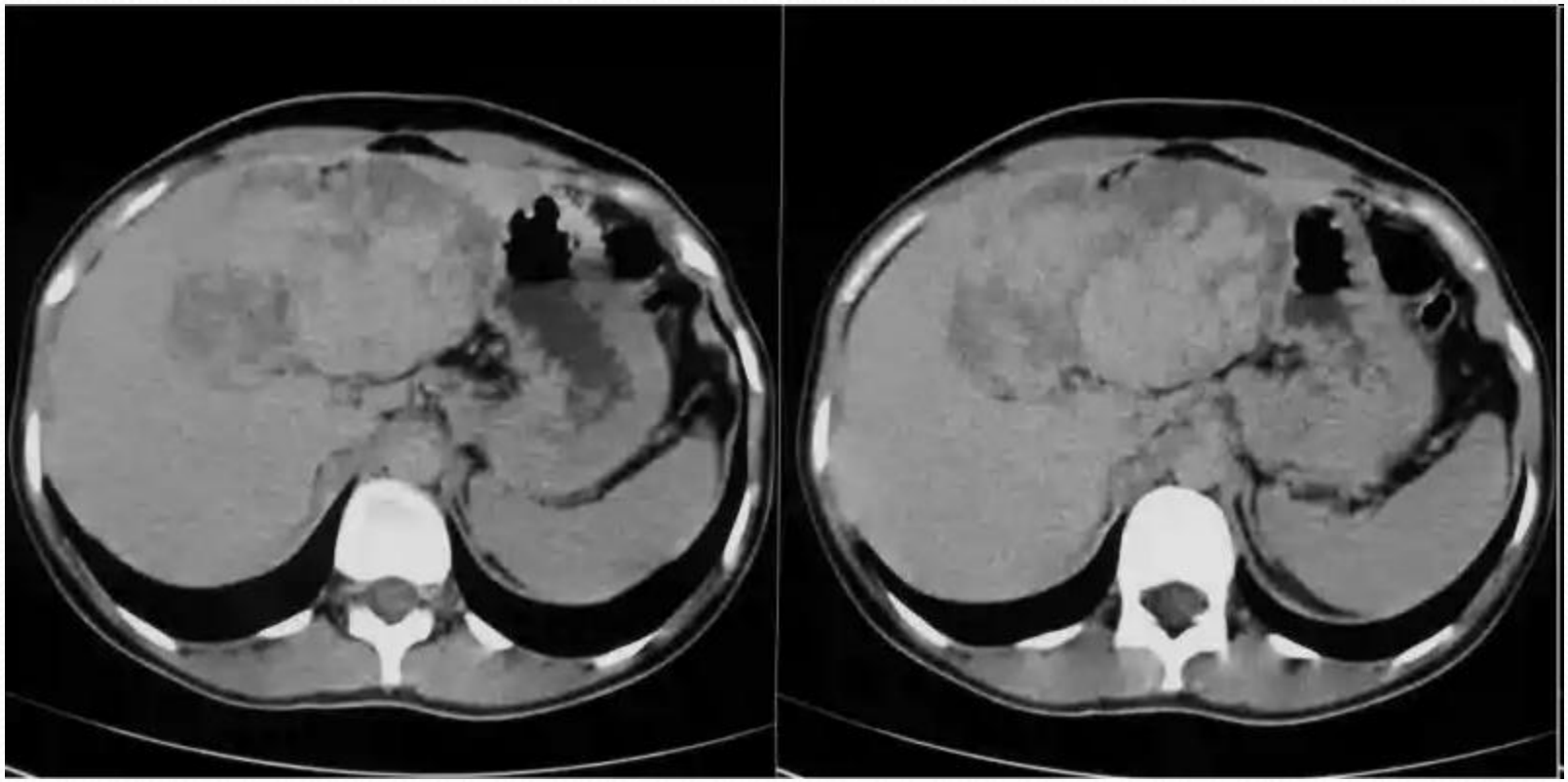


Portal phase

- on portal venous phase typically show progressive discontinuous peripheral enhancement with more centripetal fill-in



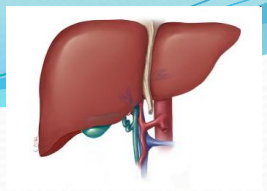
Hepatic hemangioma



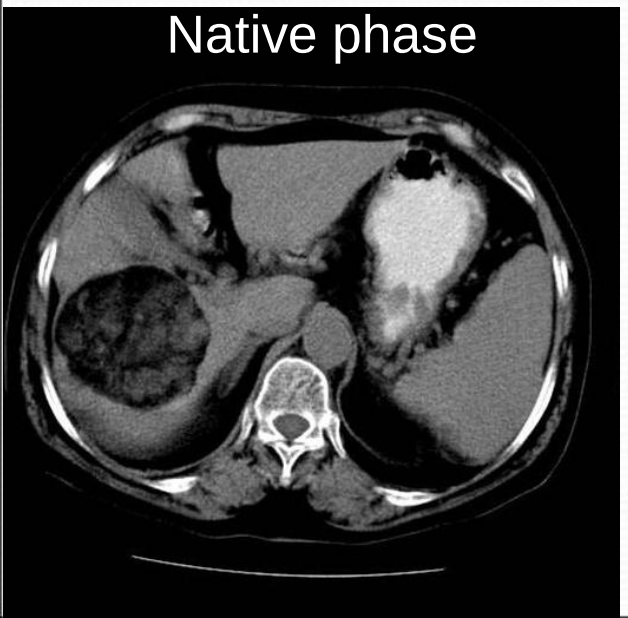
Tardive phase

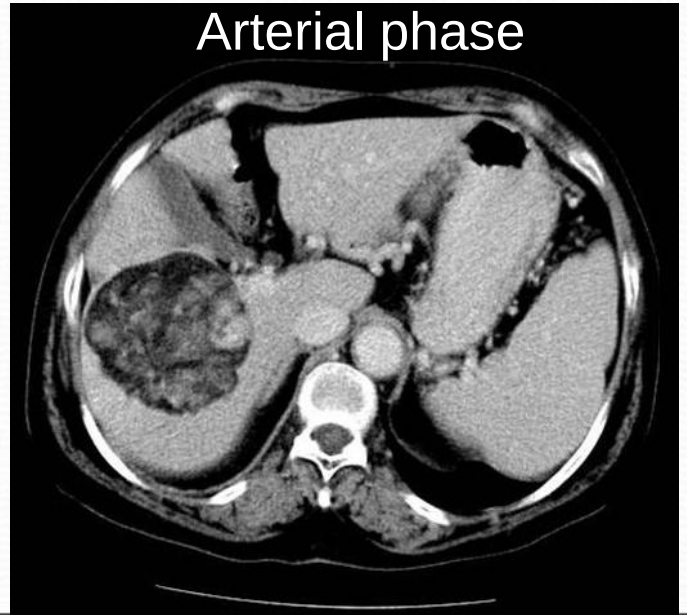
- on tardive phase typically show further irregular filling and a slow wash-out (in contrast to liver metastases), even though the dynamic enhancement pattern is commonly related to the size of hemangioma's vascular space

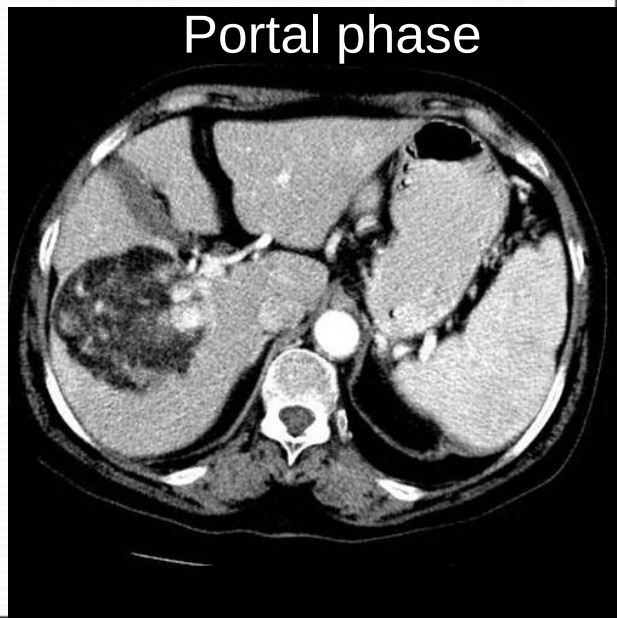
Hepatic angiomyolipoma



- Hepatic angiomyolipoma (HAML) is an uncommon benign hamartomatous hepatic mass lesion, containing blood vessel (angioid), smooth muscle (myoid) and mature fat (lipoid) components.
- On non-enhanced CT, angiomyolipoma presents as well defined solid heterogeneous mass containing markedly hypodense area.
- Due to the presence of the vascular component, marked enhancement in the arterial phase is evident.
- Drainage is via the hepatic veins, and this is the main differentiating point from fat-containing HCC that drains mainly in the portal vein.







Magnetic Resonance Imaging (MRI) in Oncology

Scanned regions and organs

- Central nervous system (CNS): technique of choice for brain and spinal imaging.
- Musculoskeletal: accurate imaging of joints, tendons, ligaments and muscular abnormalities.
- Cardiac: imaging with gating techniques related to the cardiac cycle enables the diagnosis of many cardiac conditions.
- Thorax: assessment of vascular structures in the mediastinum.
- Abdomen: abdominal organs are well visualized, surrounded by high signal from surrounding fat.
- Pelvis: staging of prostate, bladder and pelvic neoplasms.

Magnetic Resonance Imaging (MRI) in Oncology

Advantages

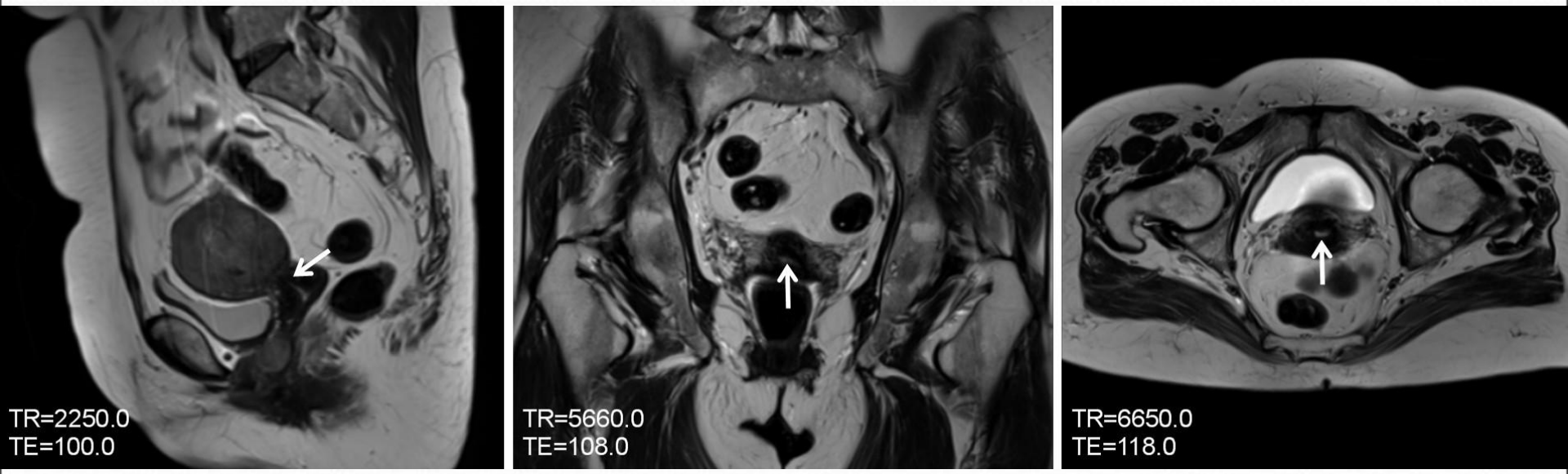
- Not associated with ionizing radiation.
- Excellent anatomical detail especially of soft tissues.
- Intravenous contrast with much less side effects
- Can image in any plane: axial, sagittal or coronal.
- No bony artefacts due to lack of signal from bone.
- Magnetic Resonance Angiography (MRA) can also visualize blood vessels without contrast

Magnetic Resonance Imaging (MRI) in Oncology

Disadvantages

- High operating costs
- Long time of scanning
- Inability to image patients with metallic foreign bodies (shrapnel, postsurgical clips, cardiac pacemakers etc)
- Claustrophobic patients may require anesthesia
- Poor images of lung fields

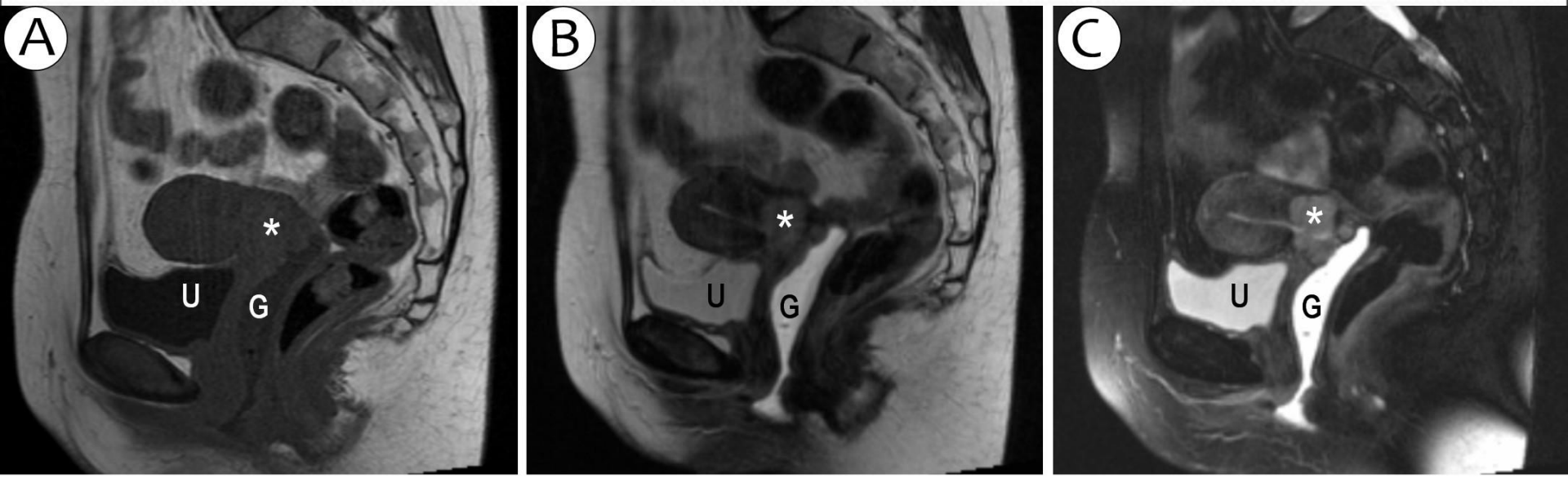
Magnetic Resonance Imaging (MRI) in Oncology



T2 weighted images in sagittal, coronal, and transaxial planes obtained using a 3.0T MRI scanner. A uterine carcinoma is extending to the cervical region (arrow).

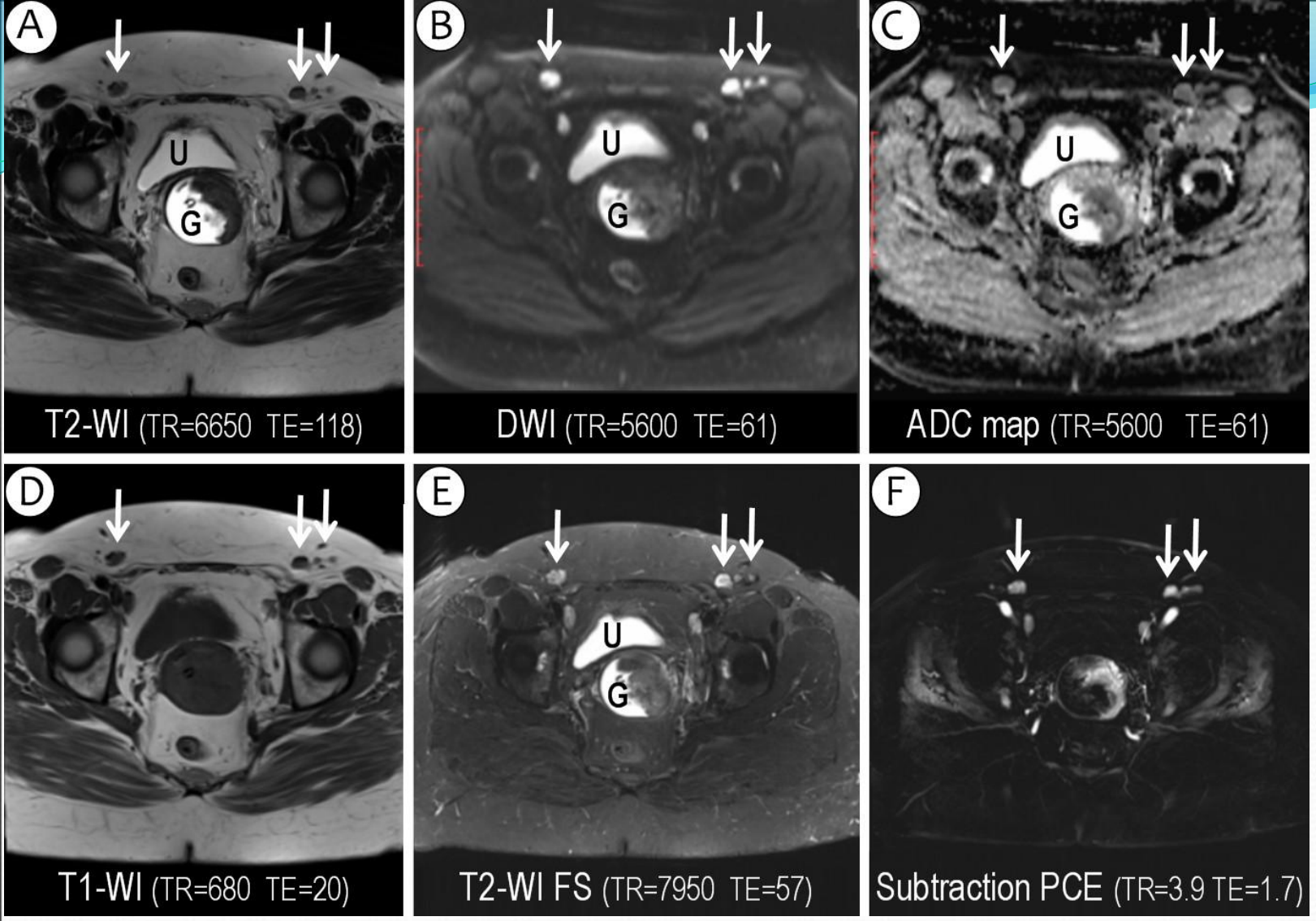
M. Crivceanschi, A. Cealan. The impact of MRI on cervical cancer at vaginal fornix. European Congress of Radiology (ECR) 2018.
Web: https://dx.doi.org/10.1594/ecr2018/C-1436

Magnetic Resonance Imaging (MRI) in Oncology



Sagittal MR images of a patient with cervical carcinoma. The infiltrative primary tumor mass (asterisk) in cervical region is less conspicuous on T1-WI, appearing isointense to the cervical stroma (panel A). The lesion, however, can be clearly delineated on T2-WI (panel B) and T2-WI with fat suppression (panel C). G – intravaginal ultrasound gel, U – urinary bladder.

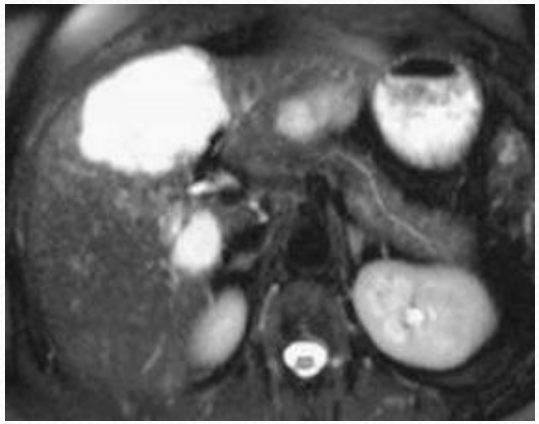
M. Crivceanschi, A. Cealan. The impact of MRI on cervical cancer at vaginal fornix. European Congress of Radiology (ECR) 2018.
Web: https://dx.doi.org/10.1594/ecr2018/C-1436



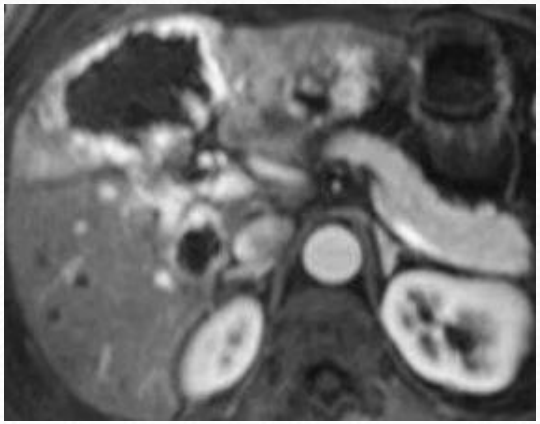
M. Crivceanschi, A. Cealan. The impact of MRI on cervical cancer at vaginal fornix. European Congress of Radiology (ECR) 2018. Web: https://dx.doi.org/10.1594/ecr2018/C-1436

Vizualization of lymph nodes on different MRI sequences. The inguinal lymph nodes pointed by arrows can be noted on all panels, even though some MRI sequences can significantly facilitate their detection. The signal intensity on T2-WI without fat supression (panel A) and on T1-WI (panel D) is relatively similar to that of the muscles and other pelvic organs, making the appearance of the lymph nodes less obvious. These nodes, however, are less likely to be missed on DWI sequence (panel B), T2-WI with fat supression (panel E - a T2-tirm sequence used in this image) and subtraction post contrast enhancement images (panel F).

Hepatic hemangioma at MRI

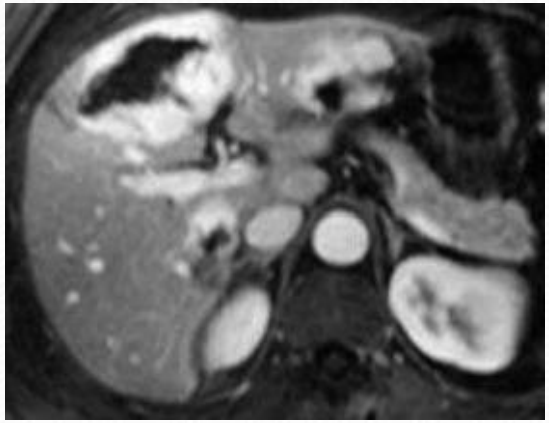


T2



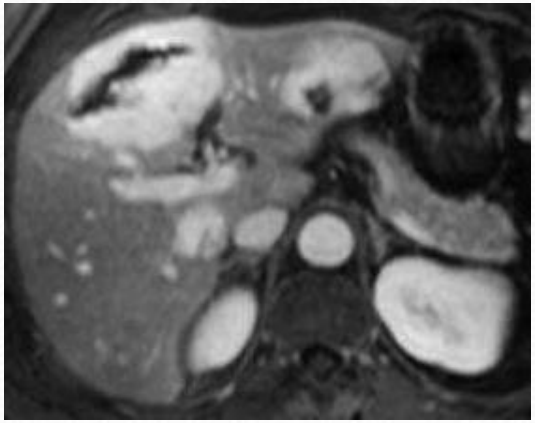
T1

Arterial phase



T1

Portal phase



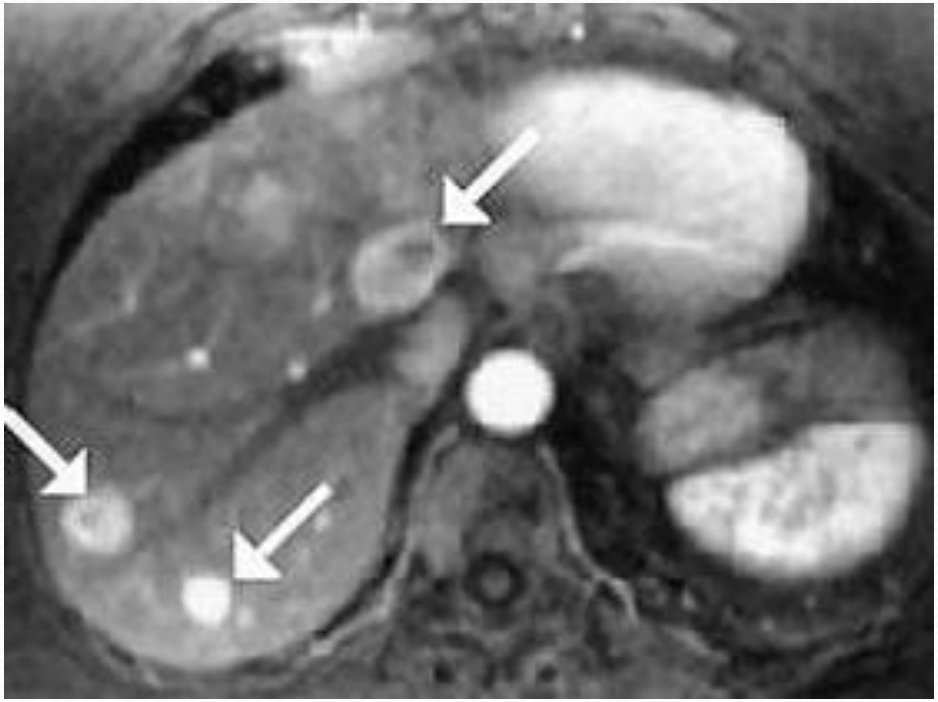
T1

Tardive phase

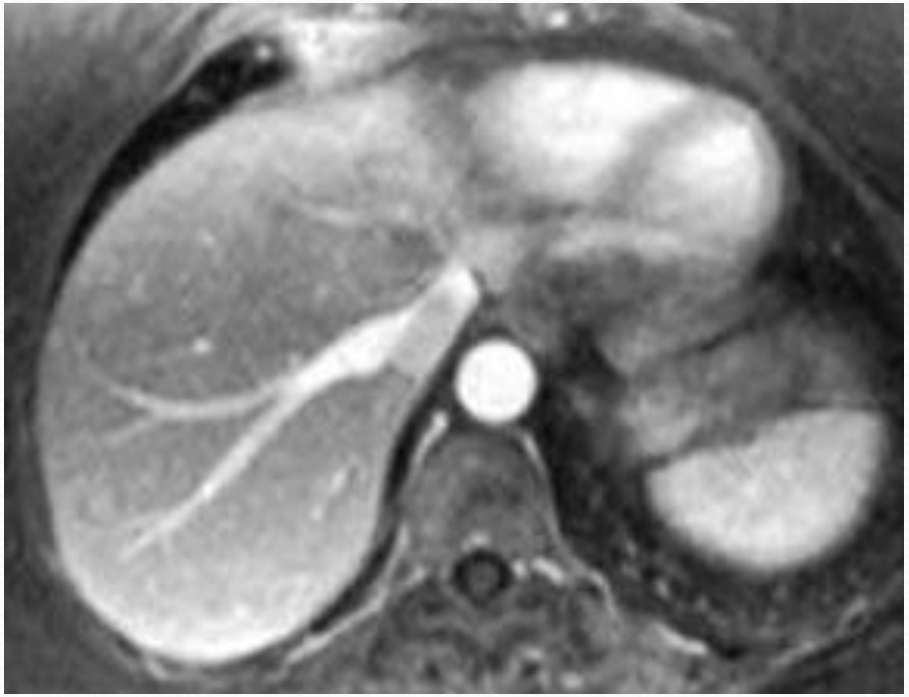
- **T1:** hypointense relative to liver parenchyma
- **T2:** hyperintense relative to liver parenchyma, but less than the intensity of CSF or of a hepatic cyst
- **T1 contrast enhancement (Gd):** often shows peripheral nodular discontinuous enhancement which progresses centripetally (inward) on delayed images. Tend to retain contrast on delayed (>5 min) images.
- DWI: hyperintense on diffusion-weighted imaging even with high b-values due to slow blood flow and can be hyperintense or mixed (hyper and hypointense regions) on ADC map

Hypervascularized liver metastases

Gd T1w arterial phase

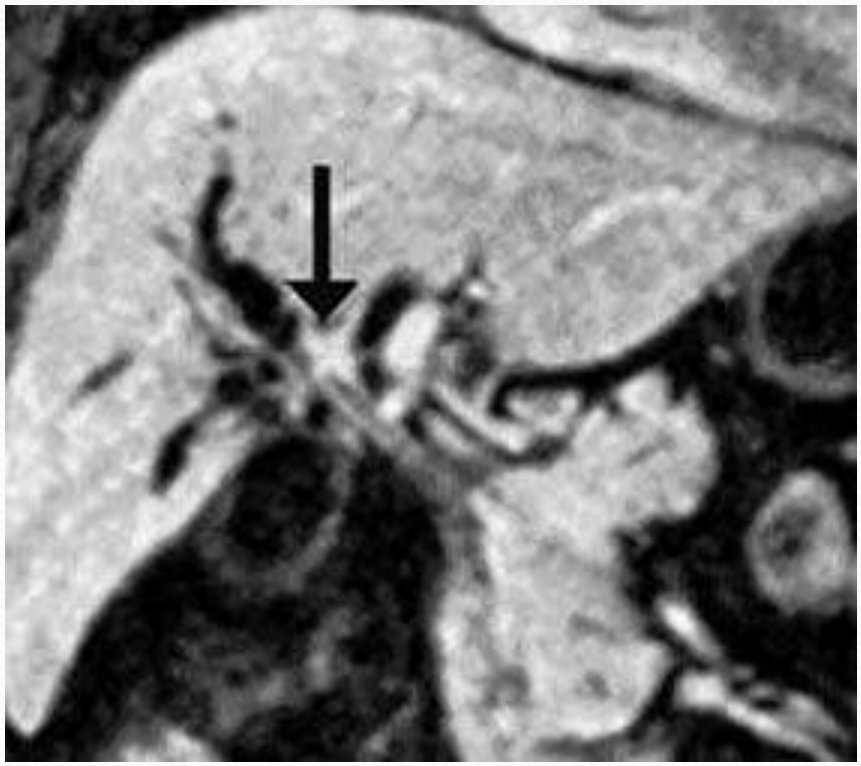


Gd T1w portal phase

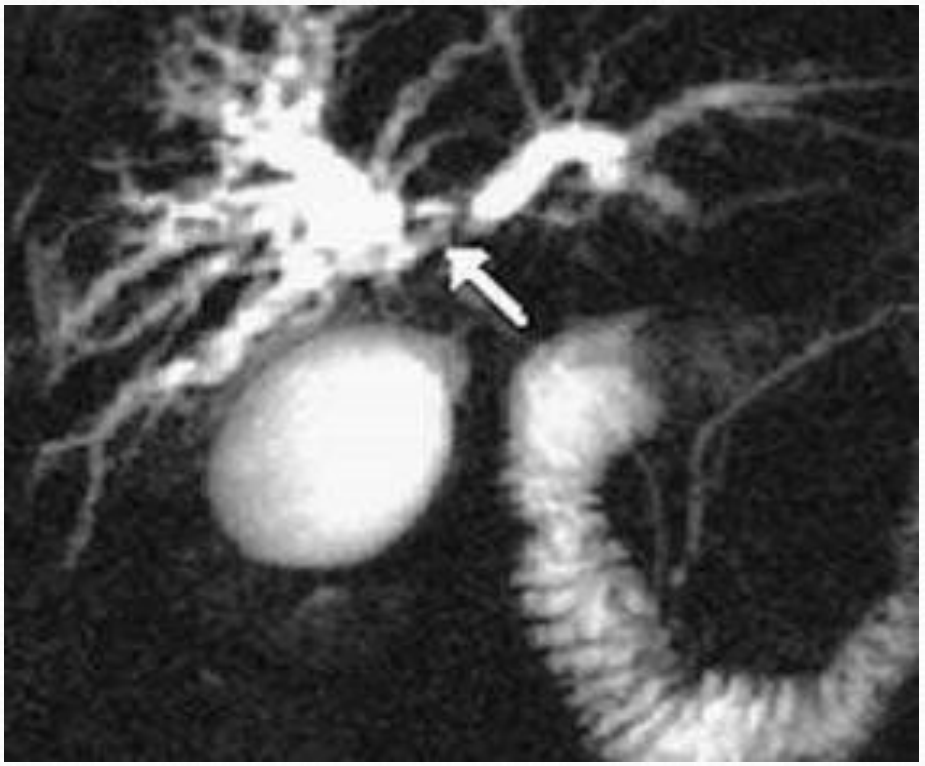


Cholangiocarcinoma

Post Gd T1w

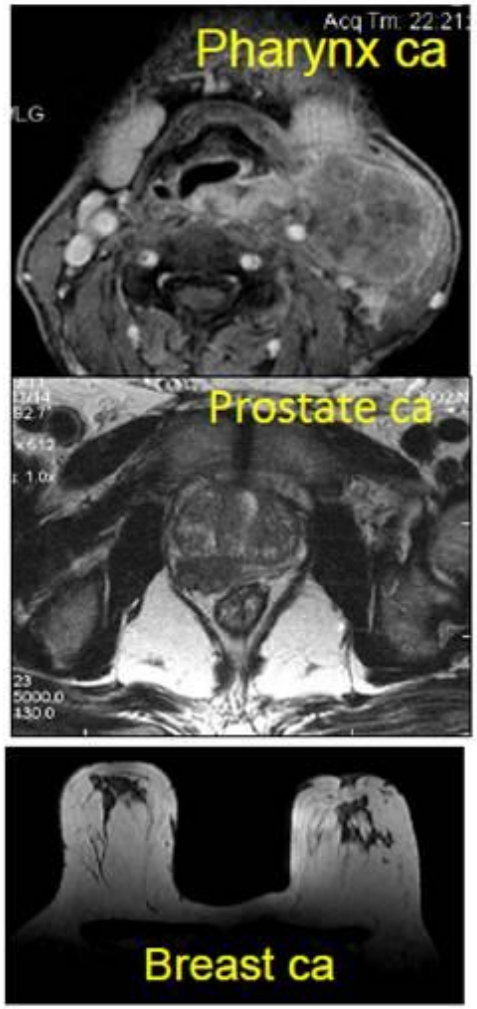


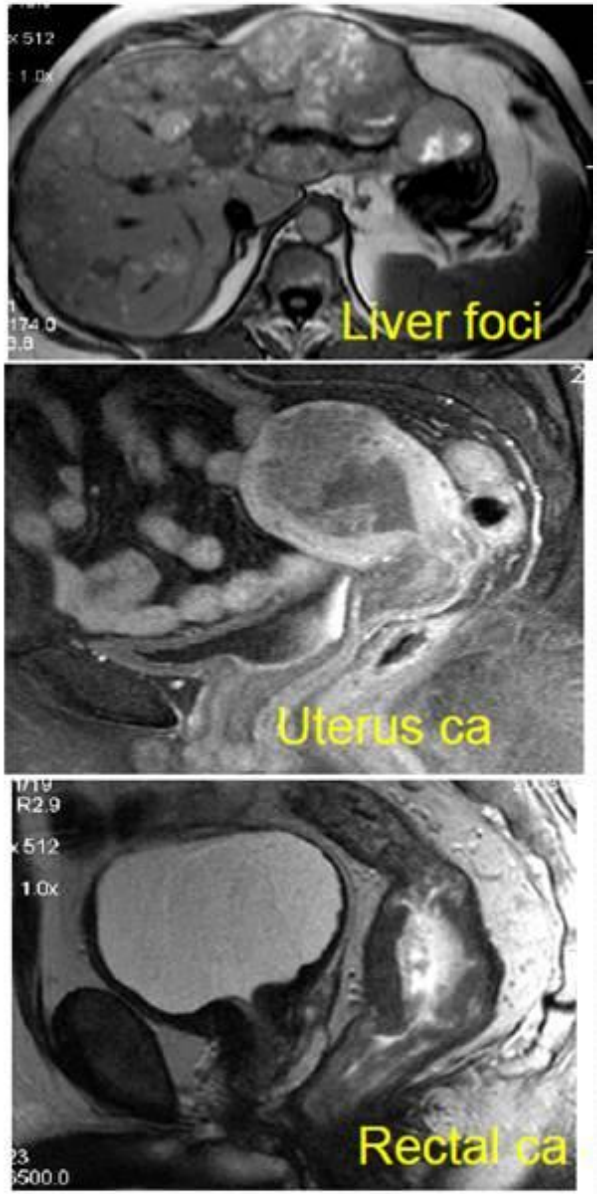
T2 HASTE MRCP



- Cholangiocarcinomas are malignant tumors arising from cholangiocytes in the biliary tree and are the second most common primary hepatic malignancy after hepatocellular carcinoma (HCC).
- MRI is the imaging modality of choice, as it can best visualize all three the tumor itself, the biliary ducts and the blood vessels, all of which are essential for determining resectability.

To day: MRI- Basic method



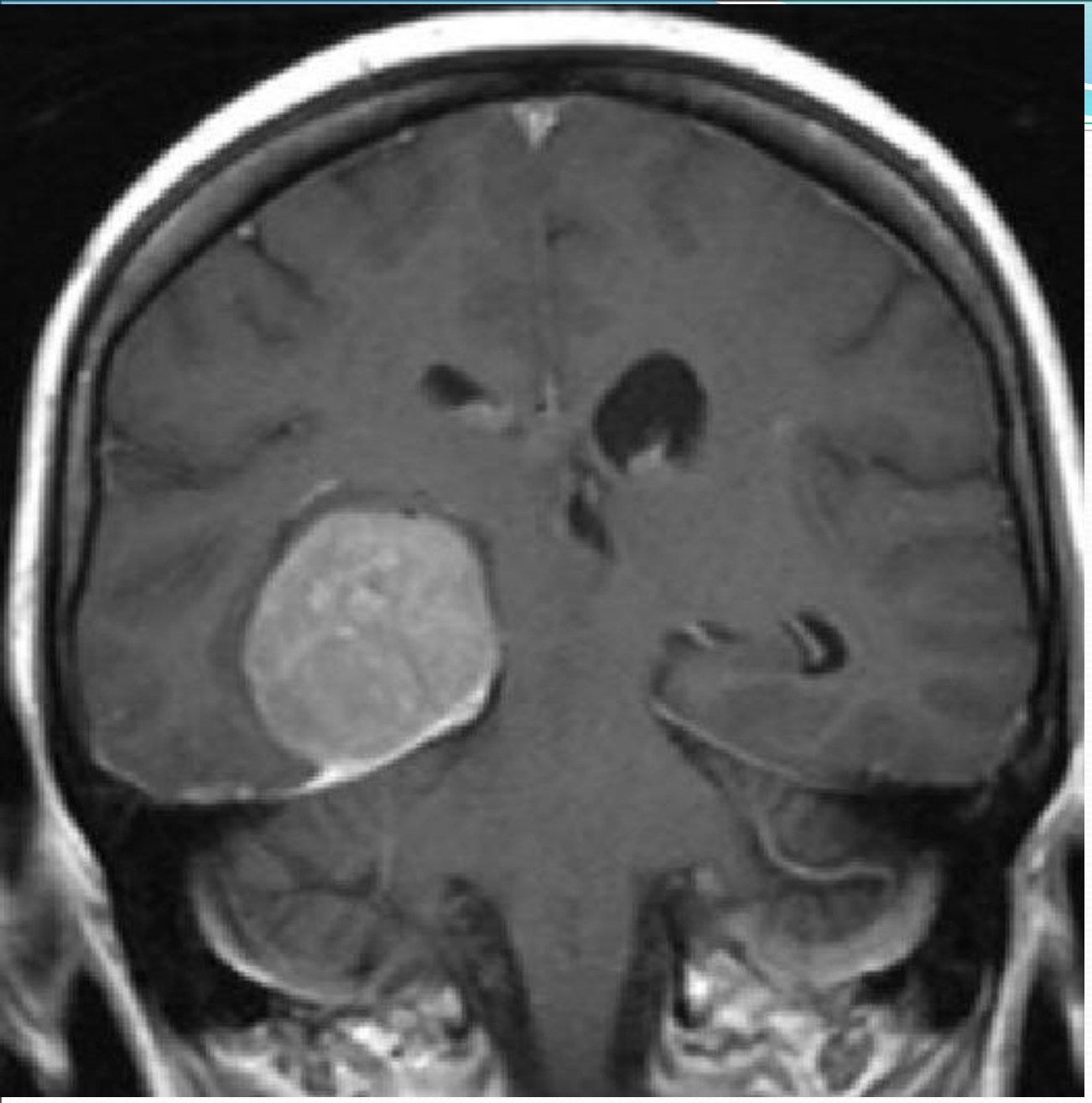


MEDULLOBLASTOMA in the IV. ventricle
MRI- CE-T1-w images

Best evaluation in intracranial tumors

- Medulloblastomas are the most common malignant brain tumor of childhood. They most commonly present as midline masses in the roof of the 4th ventricle with associated mass effect and hydrocephalus.

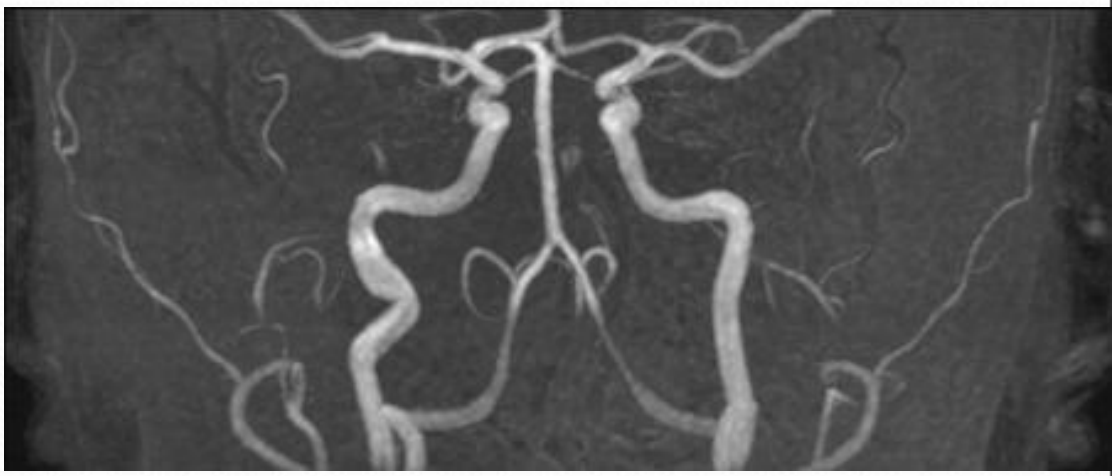
- MRI is able to delineate the fourth ventricle and subarachnoid space to a much greater degree than CT.
- Although medulloblastomas project into the fourth ventricle, unlike ependymomas they do not usually extend into the basal cisterns

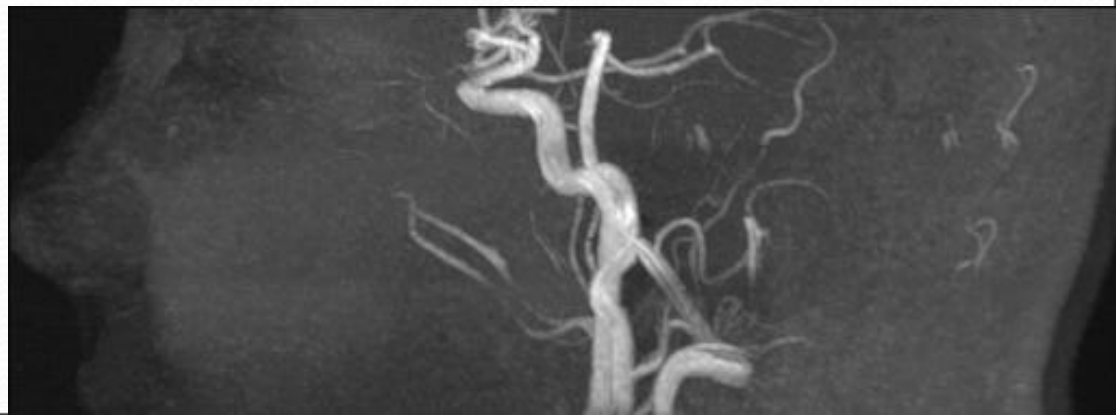


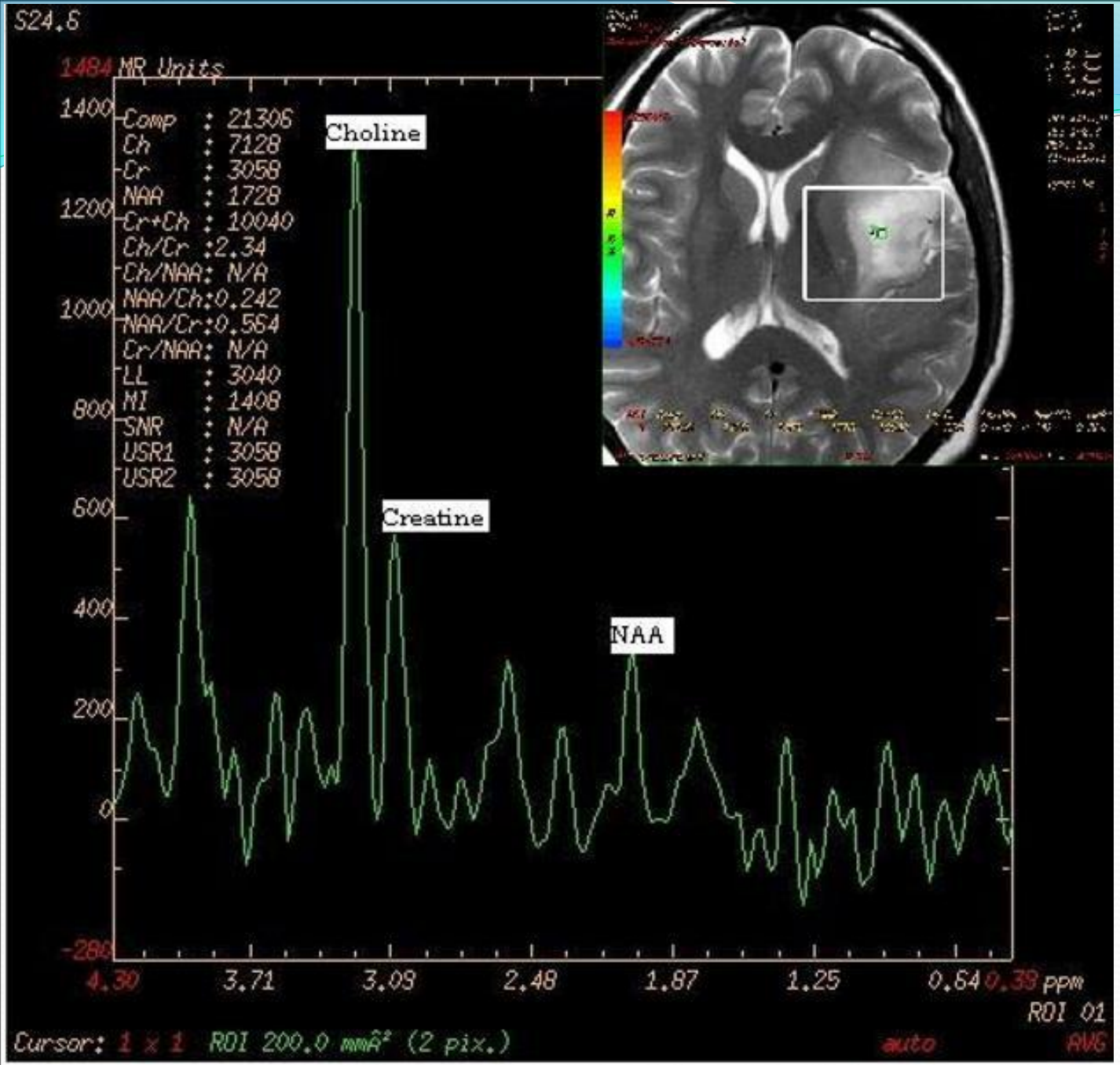
The coronal contrast-enhanced T1-weighted image shows a right temporal meningioma with the "dural tail sign“ below and lateral to the lesion, along the right tentorium.

Image source: Mujagić S. et al. (2011). Dural tail sign adjacent to different intracranial lesions on contrast-enhanced MR images. Journal of Health Sciences. 1. 96-102. 10.17532/jhsci.2011.121.

Magnetic Resonance Angiography (MRA)







MR spectroscopy

MR spectroscopy (MRS) allows tissue to be evaluated noninvasively for the presence and concentration of various metabolites.

MR spectroscopy in a patient with brain glioma.

Image source: https://radiopaedia.org/articles/mr-spectroscopy-1

Nuclear Medicine imaging

Nuclear medicine contributes in a variety of different ways to the management of the oncological patient including:

- **Diagnosis of disease;**
- **Staging of disease and determination of extent;**
- **Providing information on tumor characteristics and assessment of prognostic factors;**
- **Evaluation of response to treatment;**
- **Search for relapses at follow up of treated patients;**
- **Functional evaluations of organs and systems before and after treatment.**

Nuclear Medicine imaging

There are two main types of radionuclides:

I. Single photon emitters

- Static (planar) scintigraphy
- Single photon emission computed tomography (SPECT)

II. Positron emitters

- Positron emission tomography (PET)

Nuclear Medicine imaging

Box 9-1 Overview of Tumor-Imaging Radiopharmaceuticals

ORGAN-SPECIFIC

Cold Spot Imaging

Thyroid imaging: Iodine-123, Technetium-99m pertechnetate

Liver imaging: Technetium-99m sulfur colloid

Hot Spot Imaging

Brain scans: Technetium-99m DTPA, Technetium-99m glucoheptonate

Bone imaging: Technetium-99m MDP, Technetium-99m HDP

NONSPECIFIC

Gallium-67 citrate

Thallium-201 chloride

Technetium-99m sestamibi

Technetium-99m tetrofosmin

Fluorine-18 fluorodeoxyglucose (FDG)

TUMOR-TYPE SPECIFIC

Iodine-131: papillary-follicular thyroid cancer

Iodine-131 MIBG: neural crest tumors (adrenal medulla tumor imaging)

Iodine-131 NP-59: adrenal cortical tumor imaging

Technetium-99m HIDA: hepatocyte origin tumors

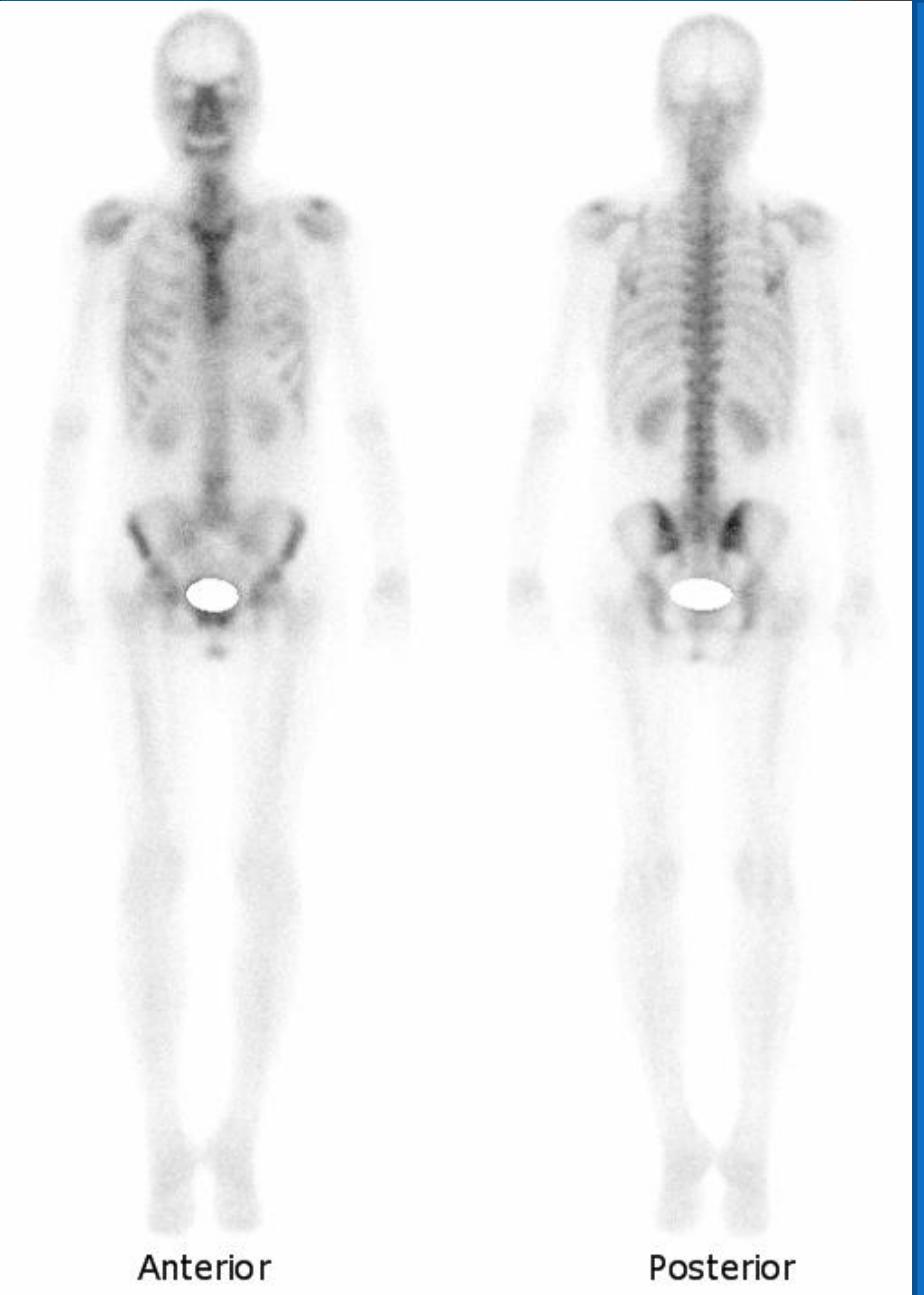
Radiolabeled monoclonal antibodies against tumor surface antigens

- Indium-111 OncoScint: colorectal and ovarian cancer
- Technetium-99m CEA-SCAN: colorectal cancer
- Indium-111 ProstaScint: prostate cancer
- Technetium-99m Verluma: small cell carcinoma of the lung

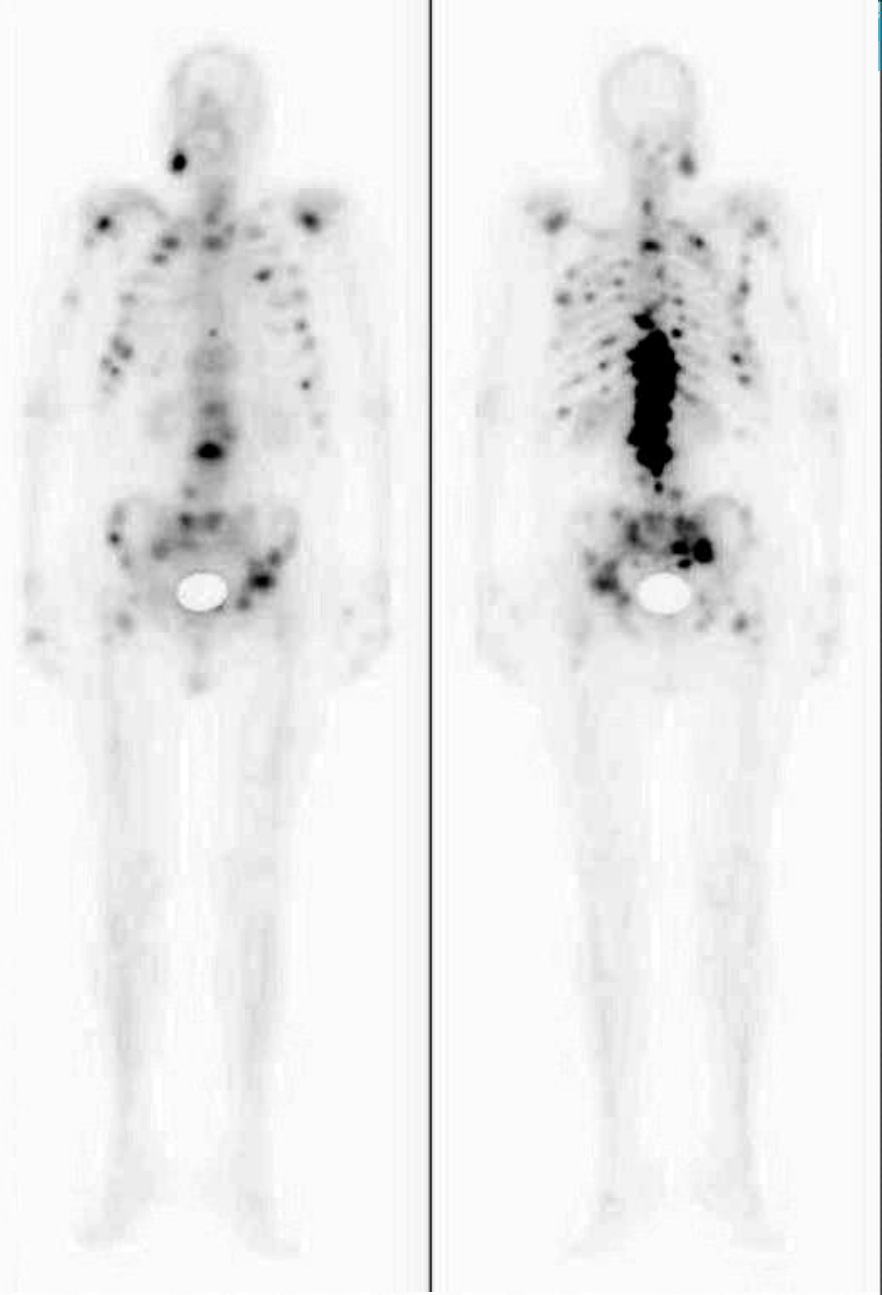
Radiolabeled peptides

- Indium-111 OctreoScan: somatostatin receptor imaging of neuroendocrine tumors
- Tc-99m NeoTect: somatostatin receptor imaging of lung carcinoma

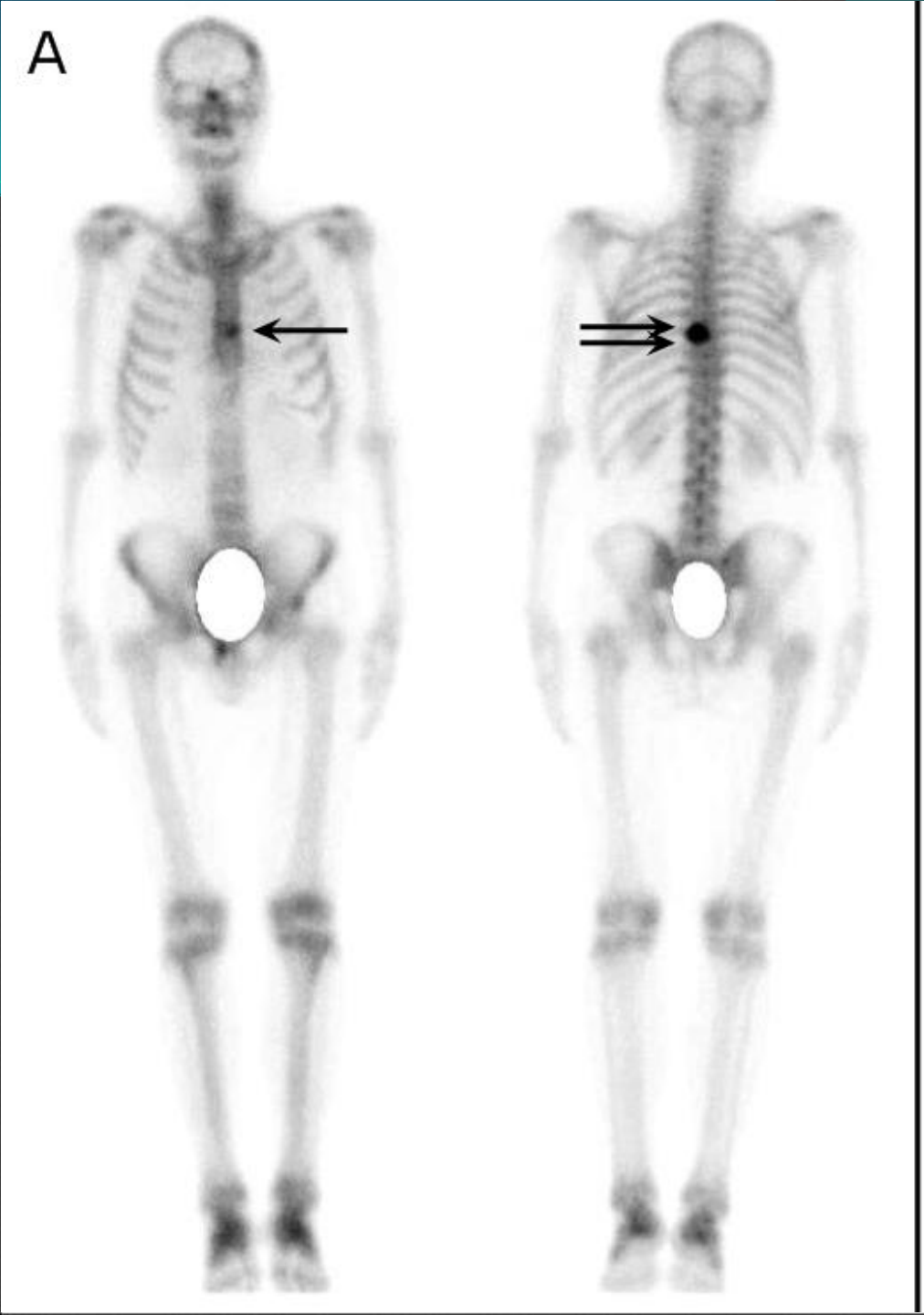
Source: Ziessman H.A. et al. Nuclear medicine: the requisites. 3rd ed. p. 264 ISBN 0-323-02946-9



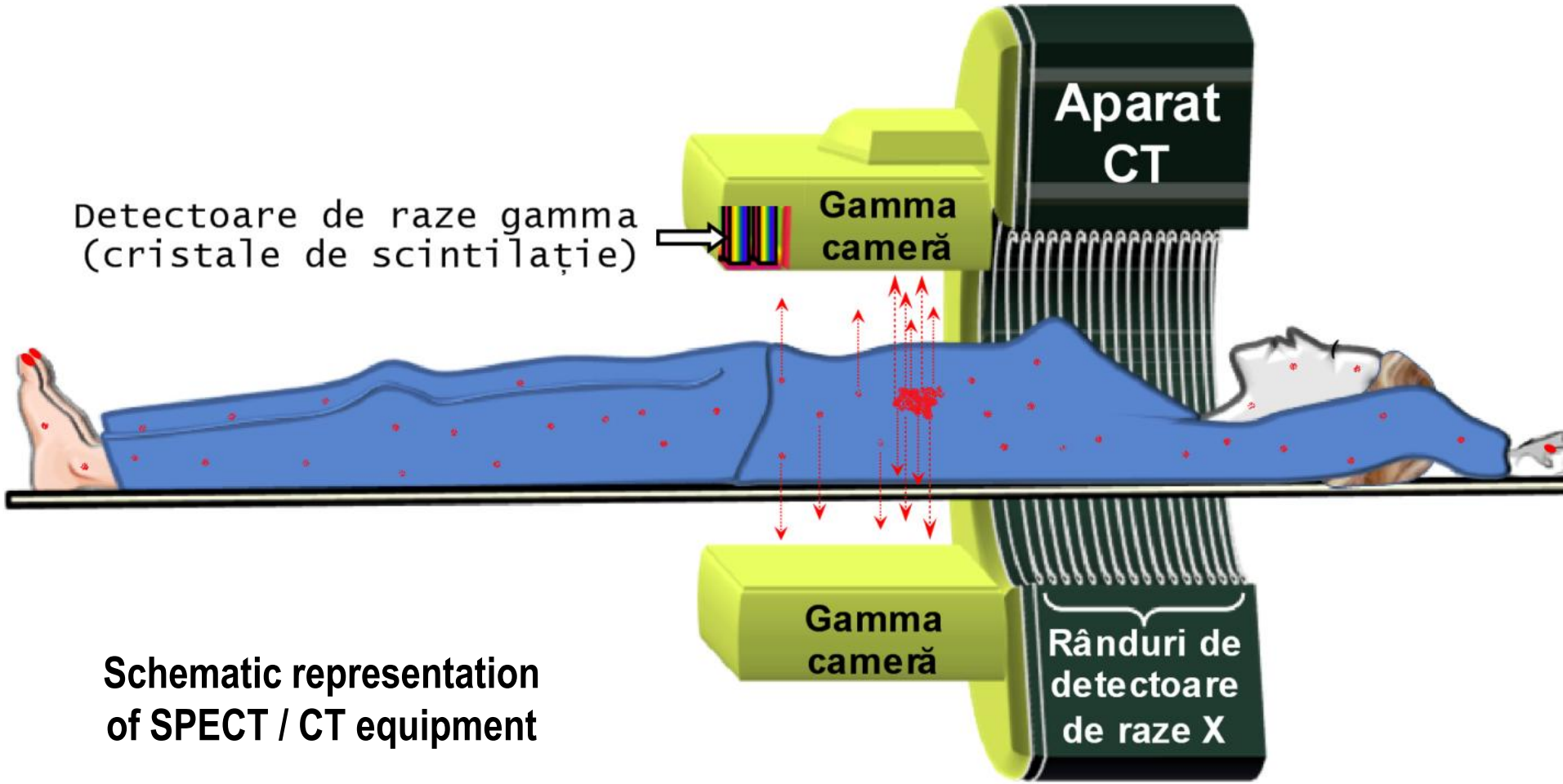
Whole body bone scintigraphy with ^{99m}Tc-MDP.
Physiological radiotracer distribution.



Whole body bone scintigraphy with ^{99m}Tc-MDP in a patient with multiple osseous metastases.

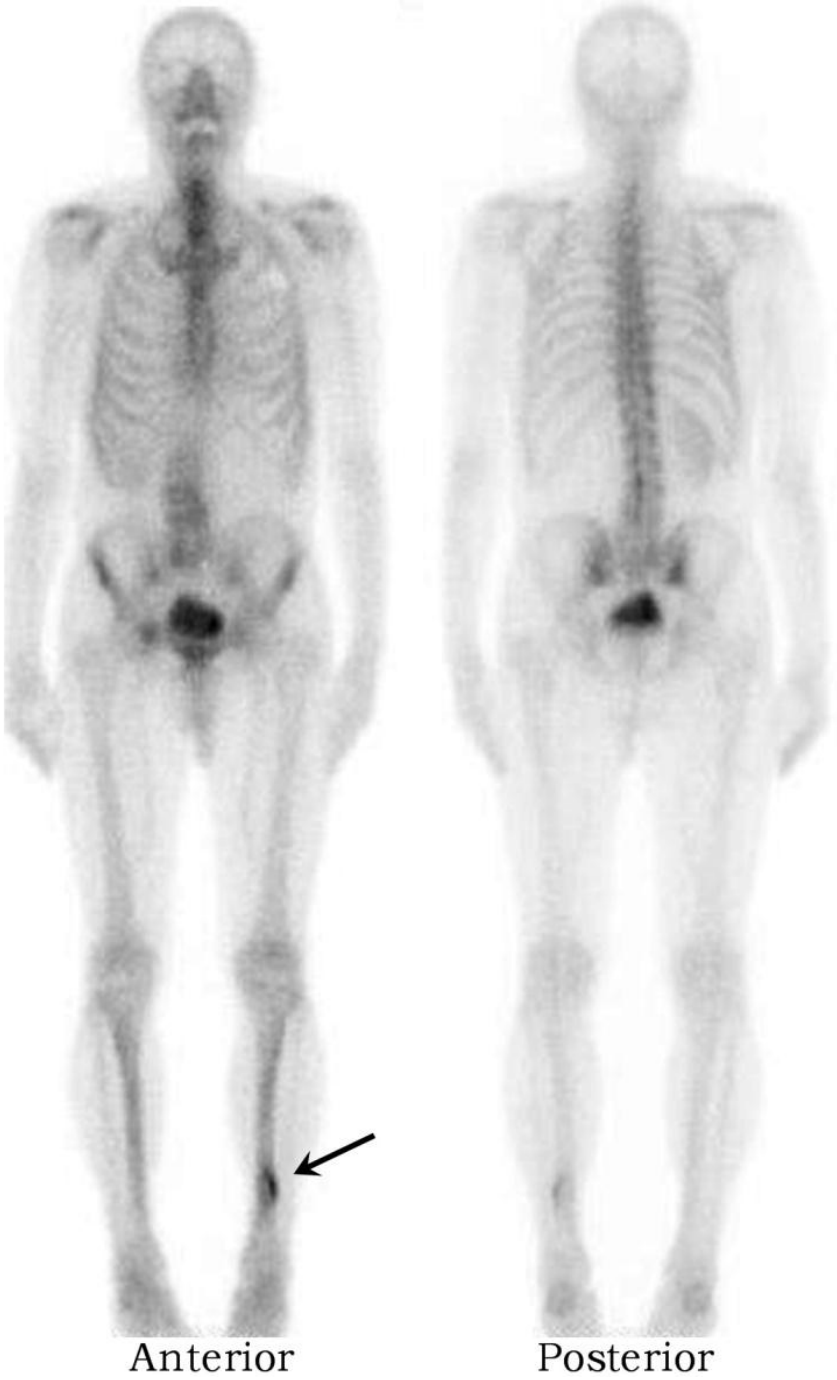


Whole body bone scintigraphy with ^{99m}Tc-MDP (panel A) and lateral spot images of the chest

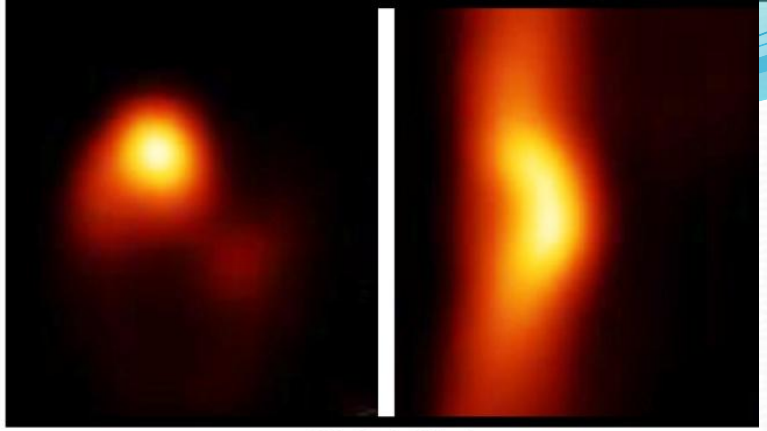


Schematic representation of SPECT / CT equipment

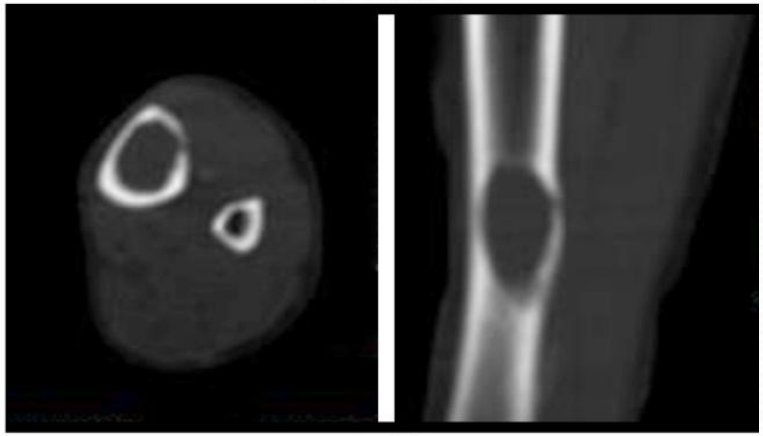
- Acquisition of planar (2-D) images using gamma cameras allows obtaining **planar scintigraphy** images;
- Rotation of the gamma cameras around the region of interest allows visualization of the distribution of the radiopharmaceutical in the scanned region in different planes as well as 3-dimentional reconstruction - obtaining **SPECT (functional) images**;
- Performing computed tomography allows visualization of anatomical tissues and structures in the same region - **obtaining CT (anatomical) images**;
- The overlap of CT and SPECT images results in **hybrid SPECT / CT images**, which allow the visualization of the accumulated radiopharmaceutical in various tissues and anatomical structures.



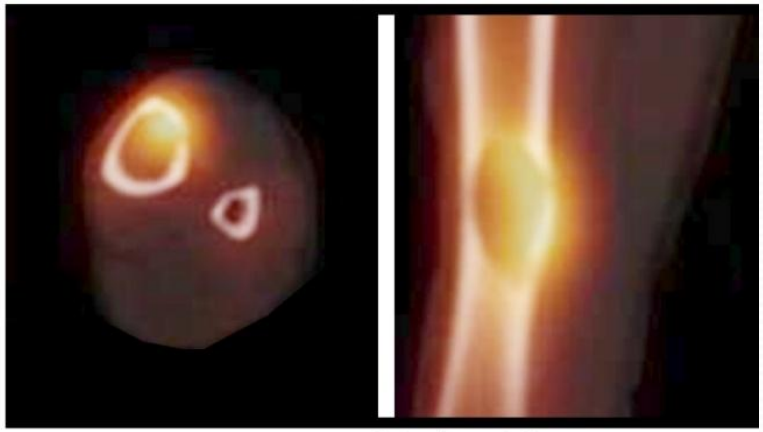
Planar scintigraphy



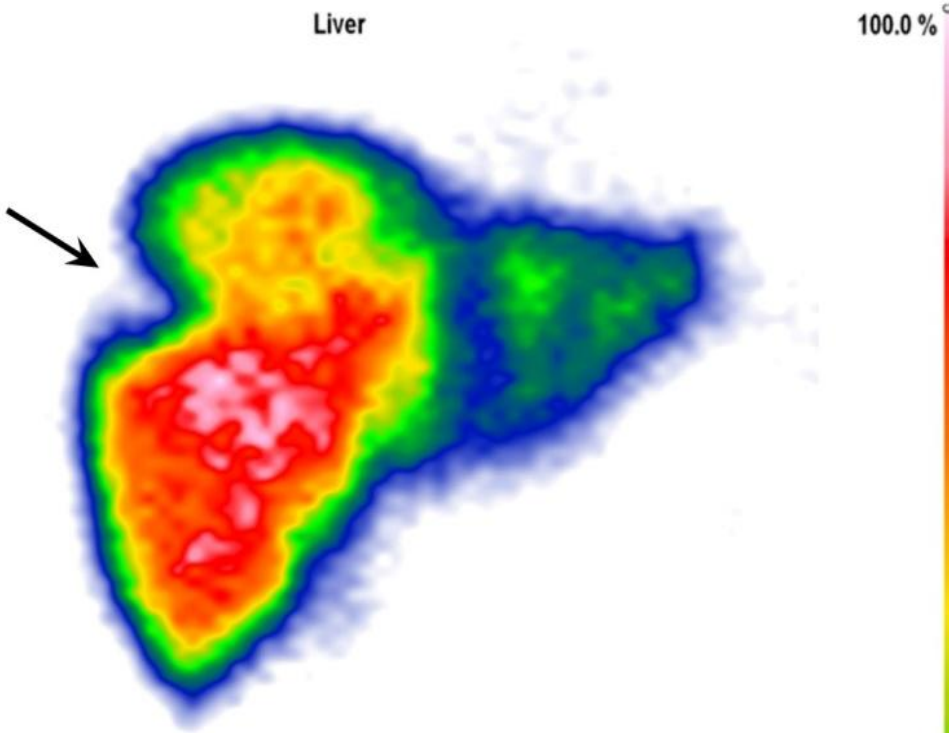
SPECT



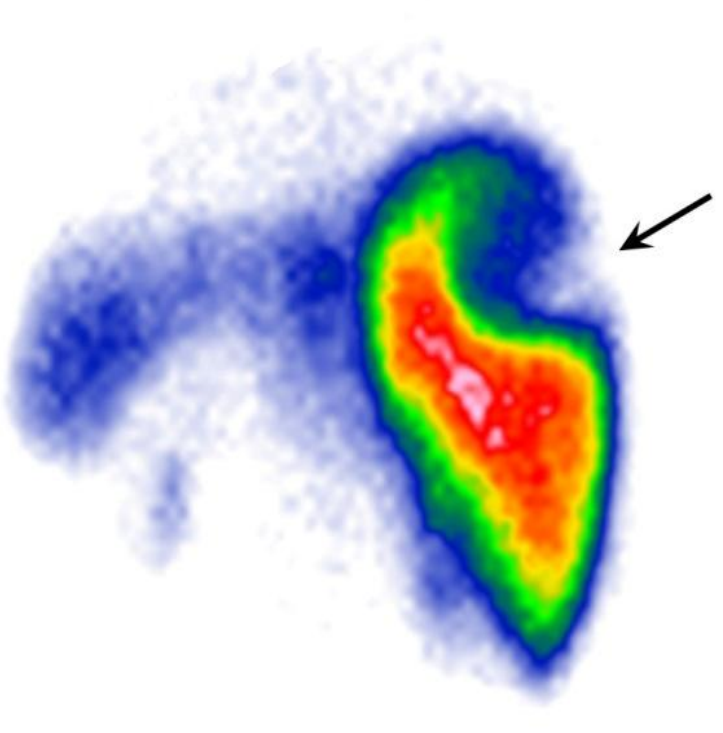
CT



SPECT / CT



Anterior



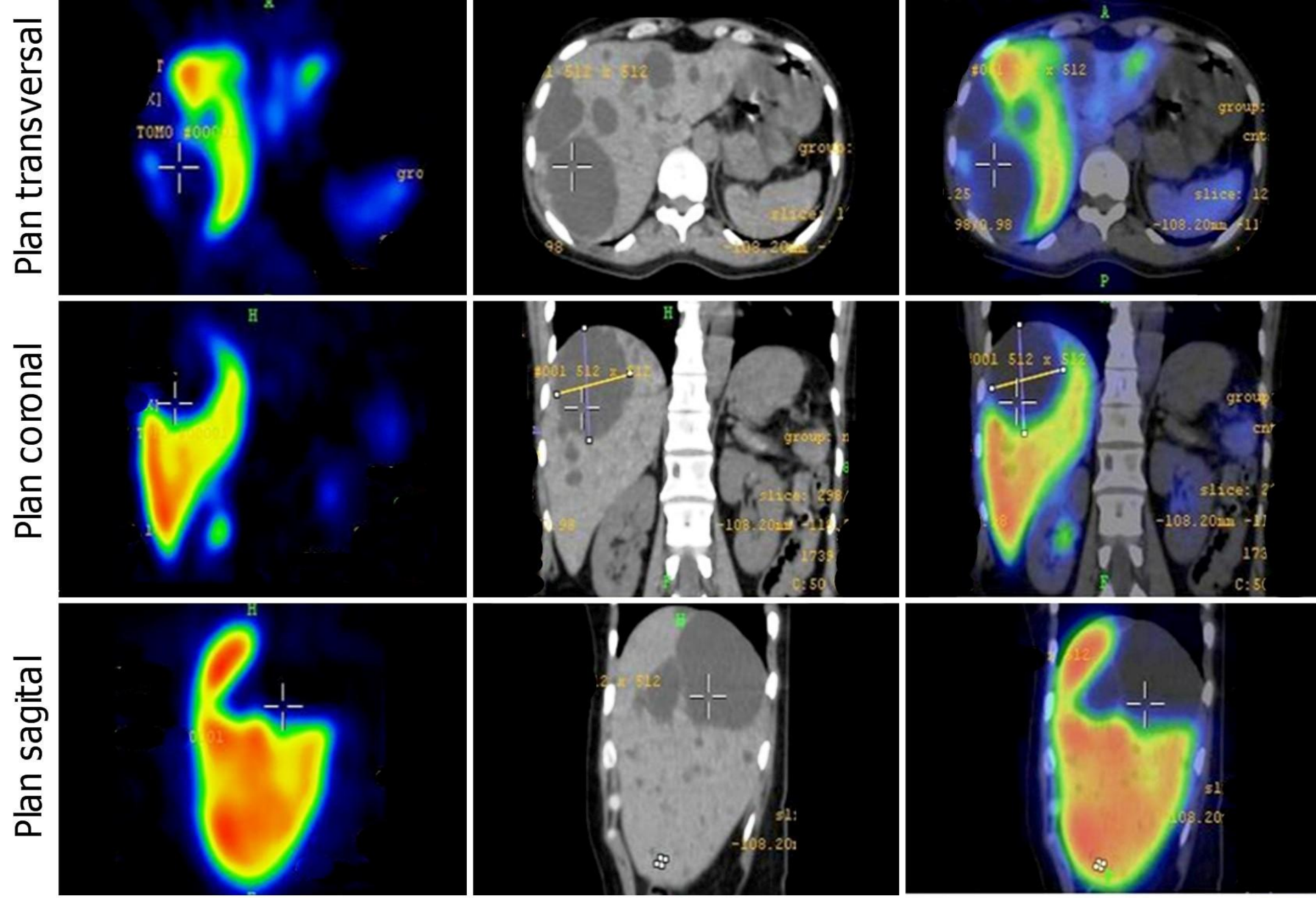
Posterior

Ratio of mean counts

Liver / Spleen	6.79

ROI Statistics

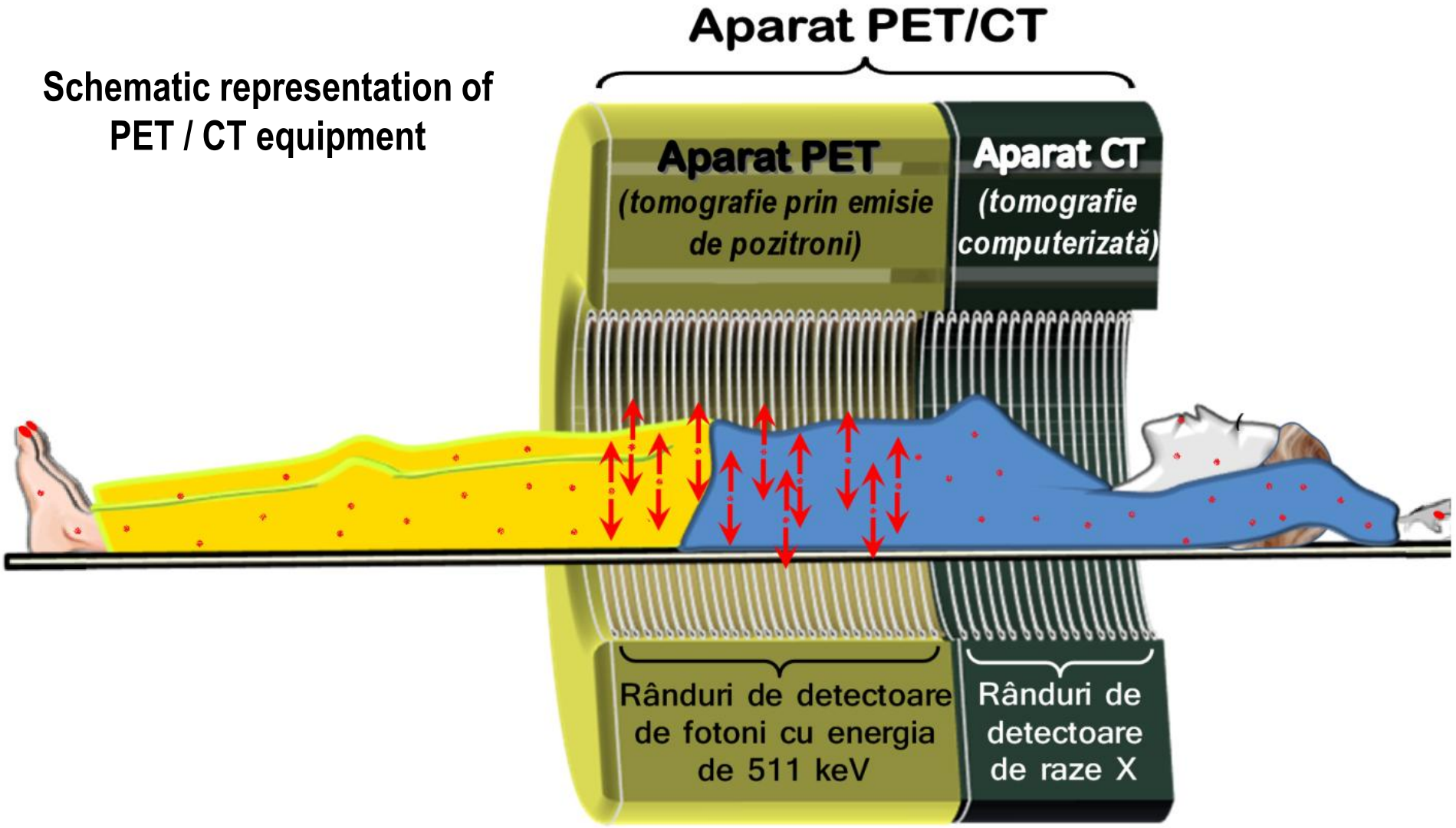
ROI	Area	Counts	Avg
Full Liver	1420.0	386377.0	272.1
Left Lobe	355.5	60272.4	169.6
Right Lobe	937.9	311049.2	331.7
Spleen	314.8	15303.7	48.6
Background	18.4	184.7	10.0


Plan transversal
Plan coronal
Plan sagital
Tomoscintigrafie (SPECT)
Tomografie computerizată (CT)
SPECT / CT

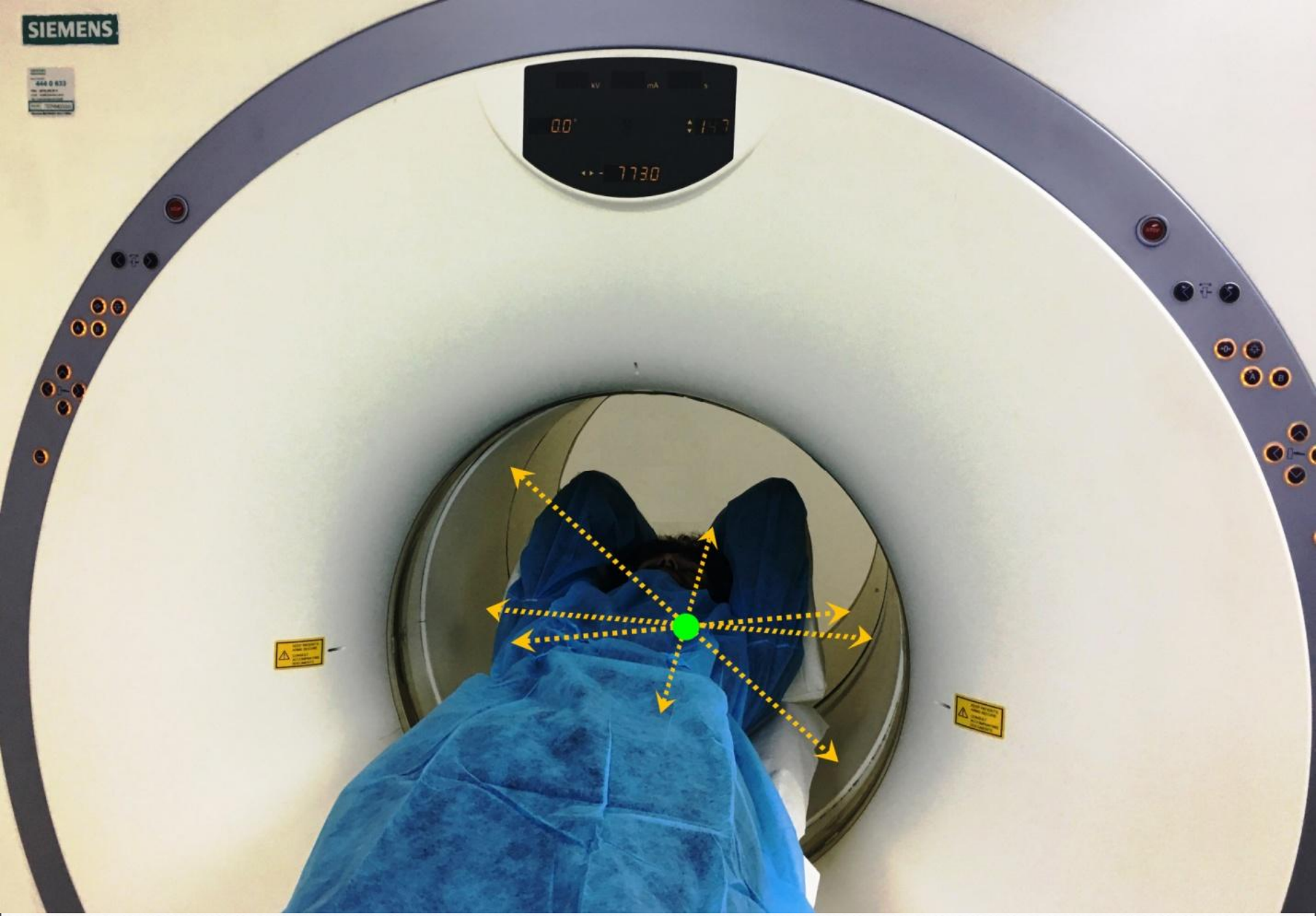
Positron Emission Tomography (PET)

- **In most cases, cancer cells are more metabolically active and divide more rapidly than normal tissues;**
- **By using radiopharmaceuticals such as F-18 Fluorodeoxyglucose (F-18 FDG) that target glucose metabolism, PET enables imaging and quantification of cellular function and tumor detection;**
- **The majority of PET scans are performed to evaluate cancer. Uses include cancer diagnosis, staging, restaging and monitoring response to therapy;**
- **Positron Emission Tomography requires special radio-pharmaceuticals (positron emitters) and special imaging equipment (PET scanner).**

Schematic representation of PET / CT equipment

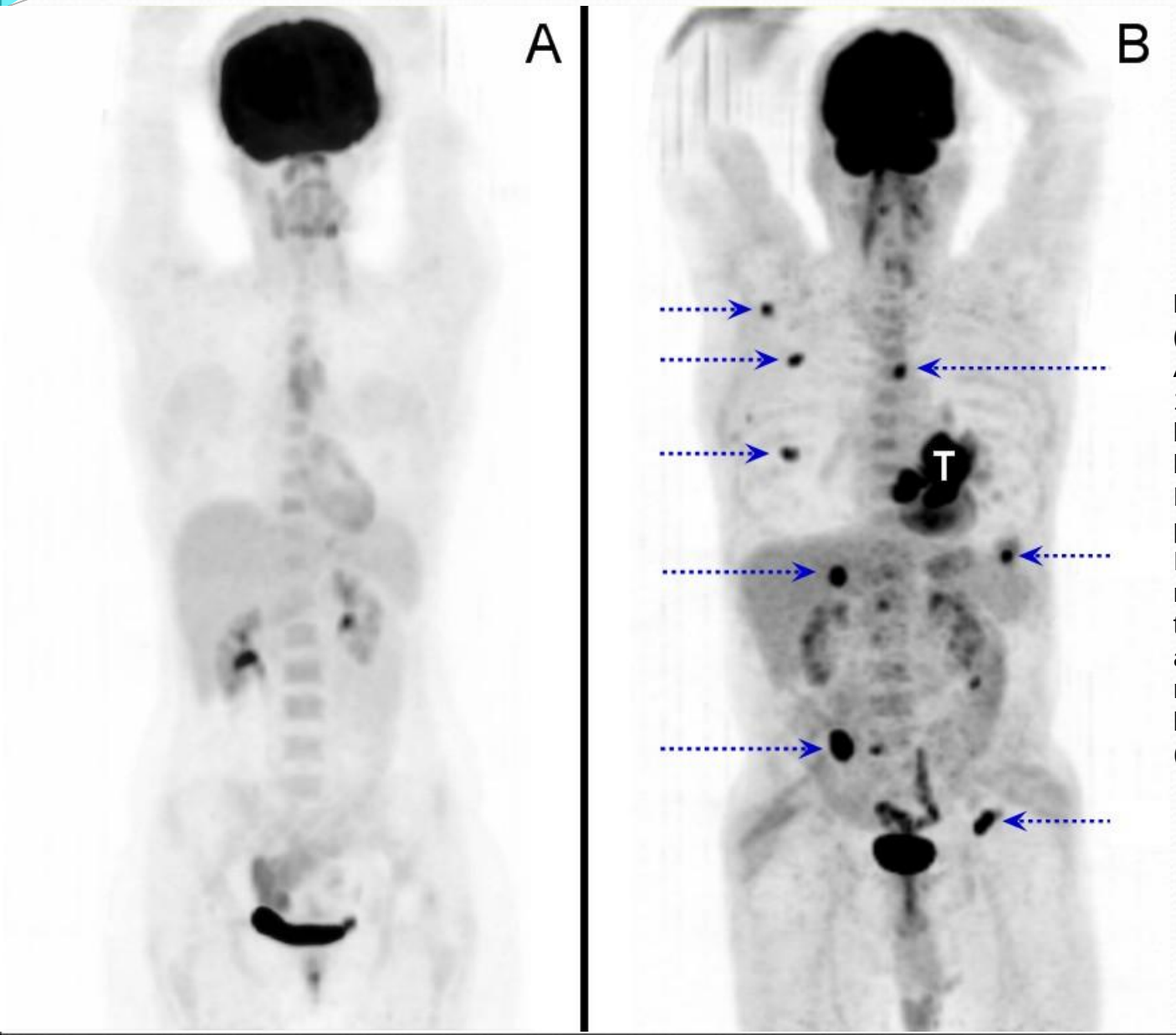


- A PET scanner is commonly combined with a CT scanner, which allows overlapping PET (functional) and CT (structural) images and obtaining fused PET / CT images, and visualization of the administered radiopharmaceutical in various tissues and anatomical structures.



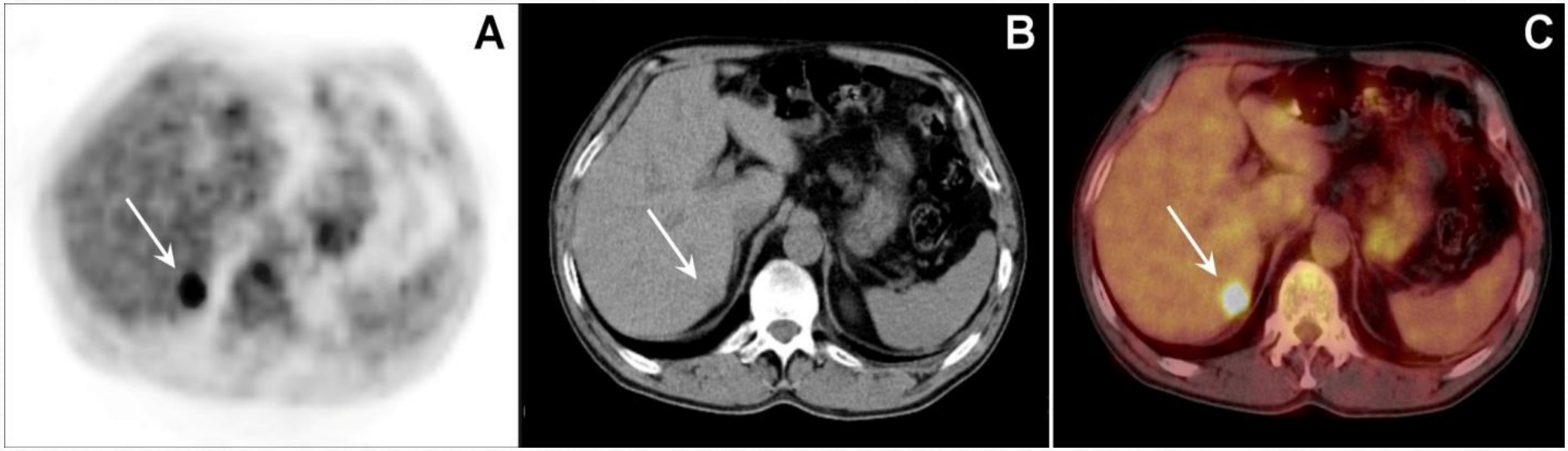
PET / CT scanner in Moldova

Positron Emission Tomography (PET)



Maximum intensity projection (MIP) 18F-FDG PET images.
A - physiological distribution of 18F-FDG is observed in the brain, kidneys and urinary bladder.
B - 18F-FDG distribution in a patient with lung cancer. Increased FDG accumulation is noted at the site of primary tumor (T) in the left lung, as well as at the sites of tumor metastases in the right lung, liver, spleen, and skeleton (arrows).

Positron Emission Tomography (PET)



Axial cross-section of a hybrid PET / CT investigation.

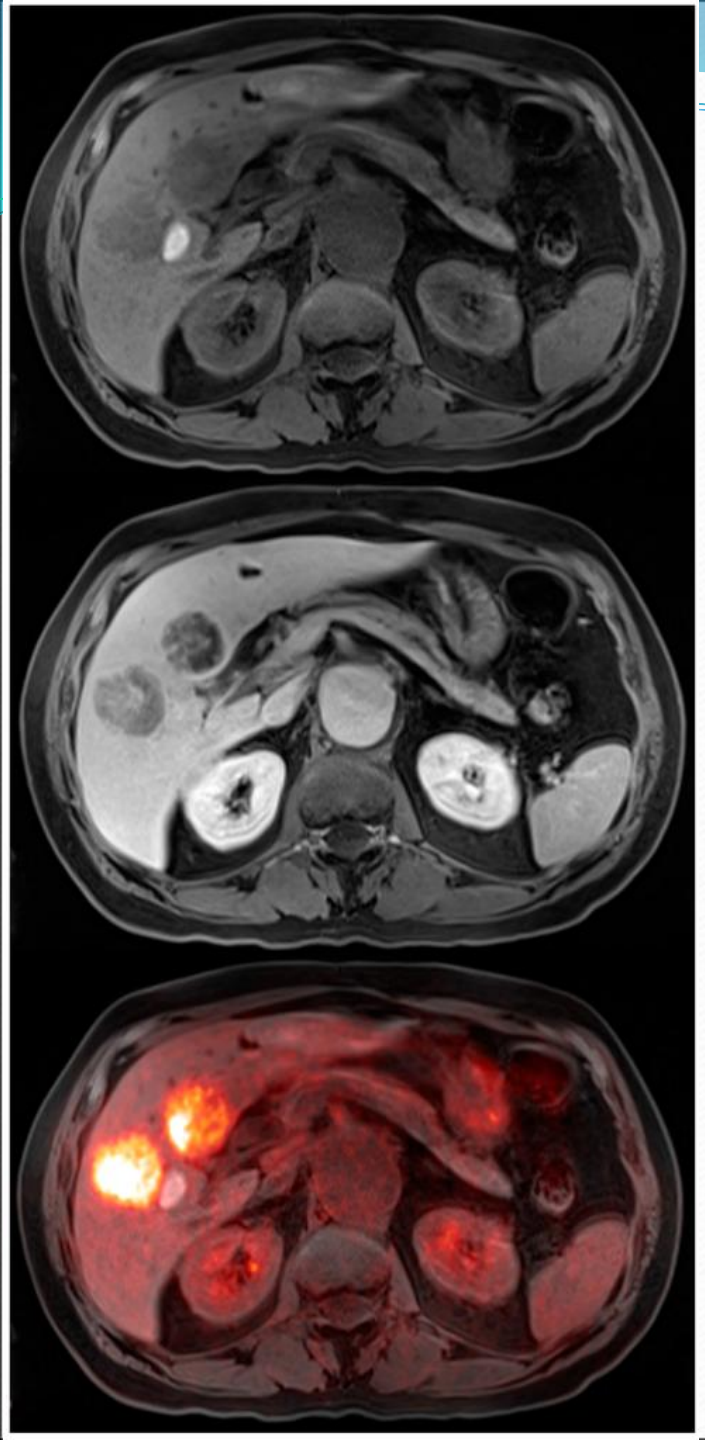
A. **PET image** reflecting 18F-FDG distribution;

B. **CT image** with visualization of the anatomical structures obtained with the patient in the same position;

C. **PET / CT hybrid image** that reflects the 18F-FDG distribution superimposed on the anatomical structures. The arrow is pointing towards a liver metastasis.

Positron Emission Tomography (PET)

Visualization of bone metastases on a PET / CT investigation with 18F-FDG (cross sections of PET, CT and PET / CT images). Bone lesions are pointed by arrows.



PET-MRI fusion imaging

72-year-old male with colon cancer:

- T1 precontrast transaxial image shows two low signal masses in segment 4B and 5 of the liver (*top*).
- T1 post contrast transaxial imaging with gadoxetate disodium reveals heterogenous enhancement of these two masses consistent with metastatic colon cancer (*middle*).
- PET-MRI transaxial fusion image confirms malignancy by demonstrating intense FDG activity (*bottom*).

Also note the adjacent benign hemorrhagic cyst with high T1 signal that does not exhibit increased metabolic activity on the fusion images.

Image source:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5039569/

HOMEWORK

To get credit for the course, please provide written answers to the following questions into your Radiology notebook:

1. Role of imaging in the oncologic decision process
2. Imaging methods of investigation in Oncology.
3. Characteristics of benign tumors
4. Characteristics of malignant tumors
5. Ultrasound imaging in Oncology. Advantages and disadvantages.
6. Computed Tomography (CT) imaging in Oncology. Advantages and disadvantages.
7. Magnetic Resonance Imaging (MRI) in Oncology. Advantages and disadvantages.
8. Nuclear Medicine imaging in Oncology. Imaging modalities and indications.

THANK YOU!