

Nuclear pulmonology

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Imaging techniques

Morphology

Physiology

Metabolism

Molecules

X-ray / CT

NM - SPECT/ PET

MRI

MR spectroscopy

fMRI

Ultrasound

Hybrid imaging: SPECT/CT, PET/CT, (PET/MRI)

Radioactivity

It is the spontaneous disintegration (decay) of the nucleus of a radioactive atom - in which the number of protons and neutrons are not stable - and different type of radiation (α , $-\beta$, $+\beta$, γ) comes out from the nucleus.

Number of protons

= elemental identity number

Number of protons and neutrons

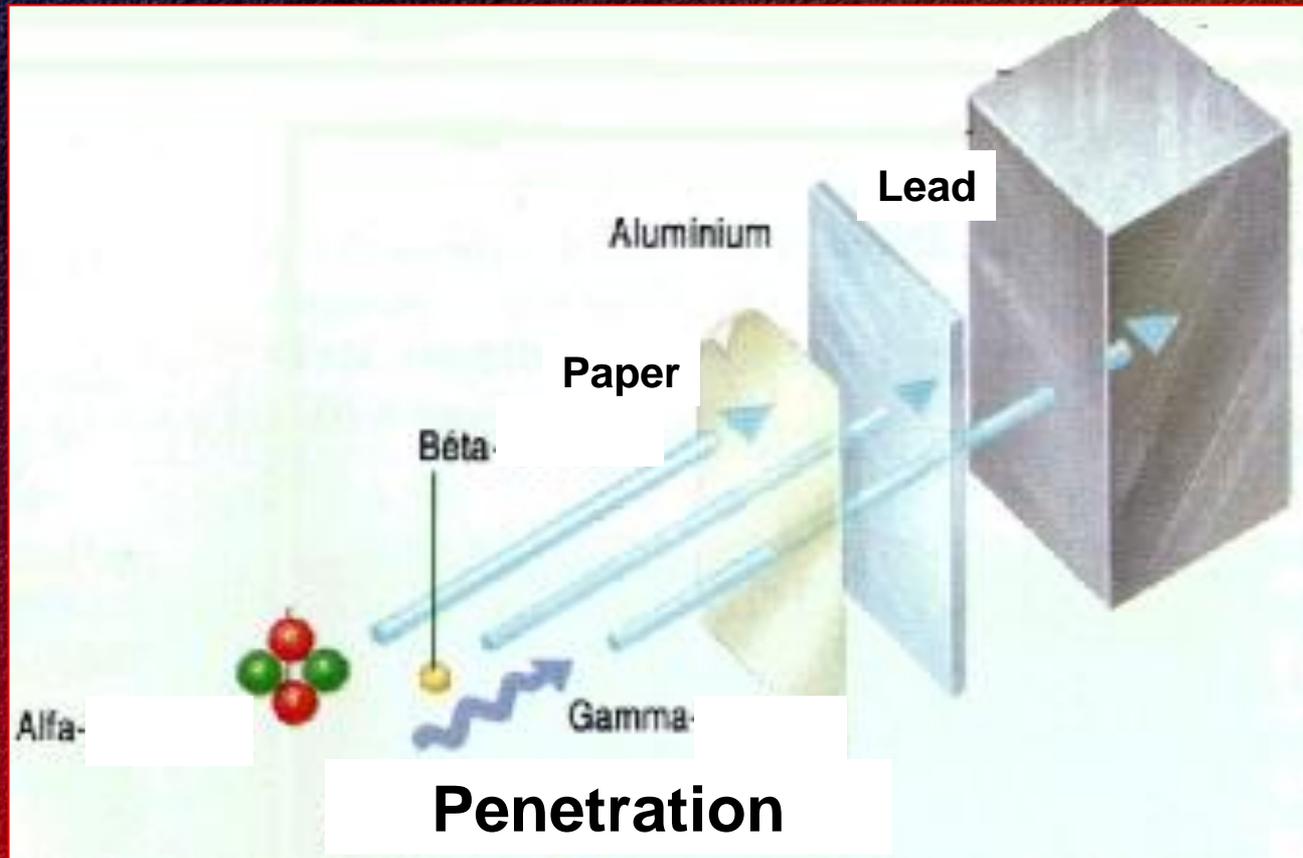
= mass number

- Atoms with the same number of protons but differing number of neutrons are called isotopes of that element.

- The behaviour of the different radioactive isotopes of an element is the same as the stable form in every conditions.

Rays of radioactive decay

- **Corpuscular rays (α , $-\beta$, $+\beta$)**
- **Electromagnetic ray (γ)**



Gamma radiation

- really electromagnetic radiation
- physically similar to X-rays, but it comes out from the nucleus of the atom
- very penetrated and easily pass through tissue
- SO: it can be detected externally well, it can be used for diagnostics
- 99meta-technetium (arteficial)
- *using the radioactive material as a tracer (Hevesy György 1923)*

The equipments I.

Gamma-camera

- it „sees” the whole entire area below the detector



Structure of the gamma-camera

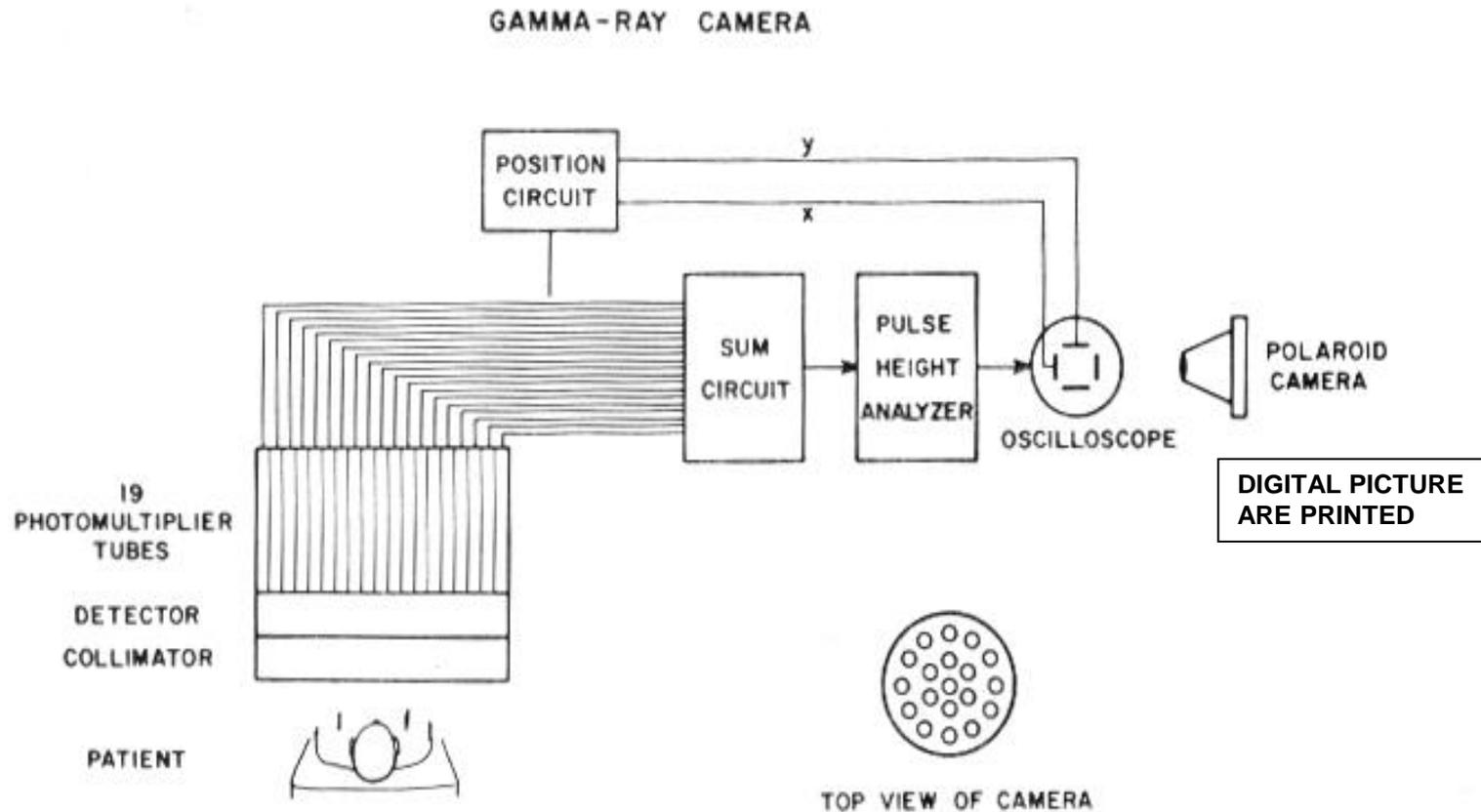


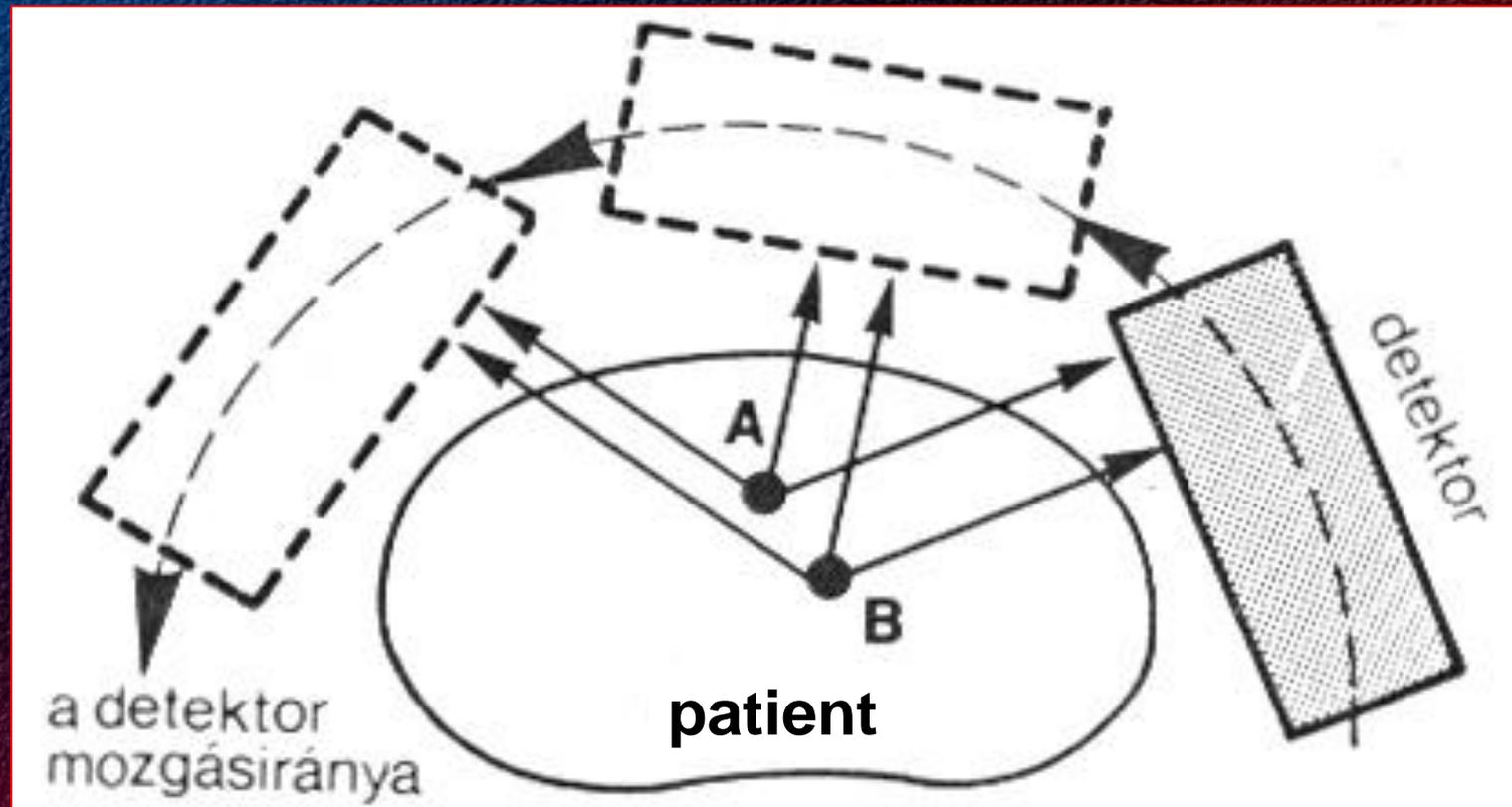
Fig. 1.11. The basic components of an Anger γ -ray camera. There is a one-to-one correspondence between the location of γ -ray interactions in the scintillation crystal and the location of the dot flashed on the oscilloscope screen.

The equipments II.

- SPECT (Single Photon Emission Computer Tomograph)
- SPECT/CT: multimodality!



The principle of the SPECT



The detector whirls around the patient and makes pictures from different steps. The computer program reconstructs the transversal, sagittal and coronal slices of the organ.

Radionuclide studies

- are based on the function of an organ or an organ system
- are easily performed
- need no any premedication
- are not associated with any morbidity and complication, have only minimal risk
- are very sensitive, but aspecific methods

Method

- **gamma emitting isotopes, which are detected outside**
- **carrier molecules, which participate the function of the examined organs**
- **together: radiopharmakon**
- **they are usually administered intravenously in steril physiological NaCl solution**
- **various delayed times before the examinations**
- **imaging by scintillation detector**

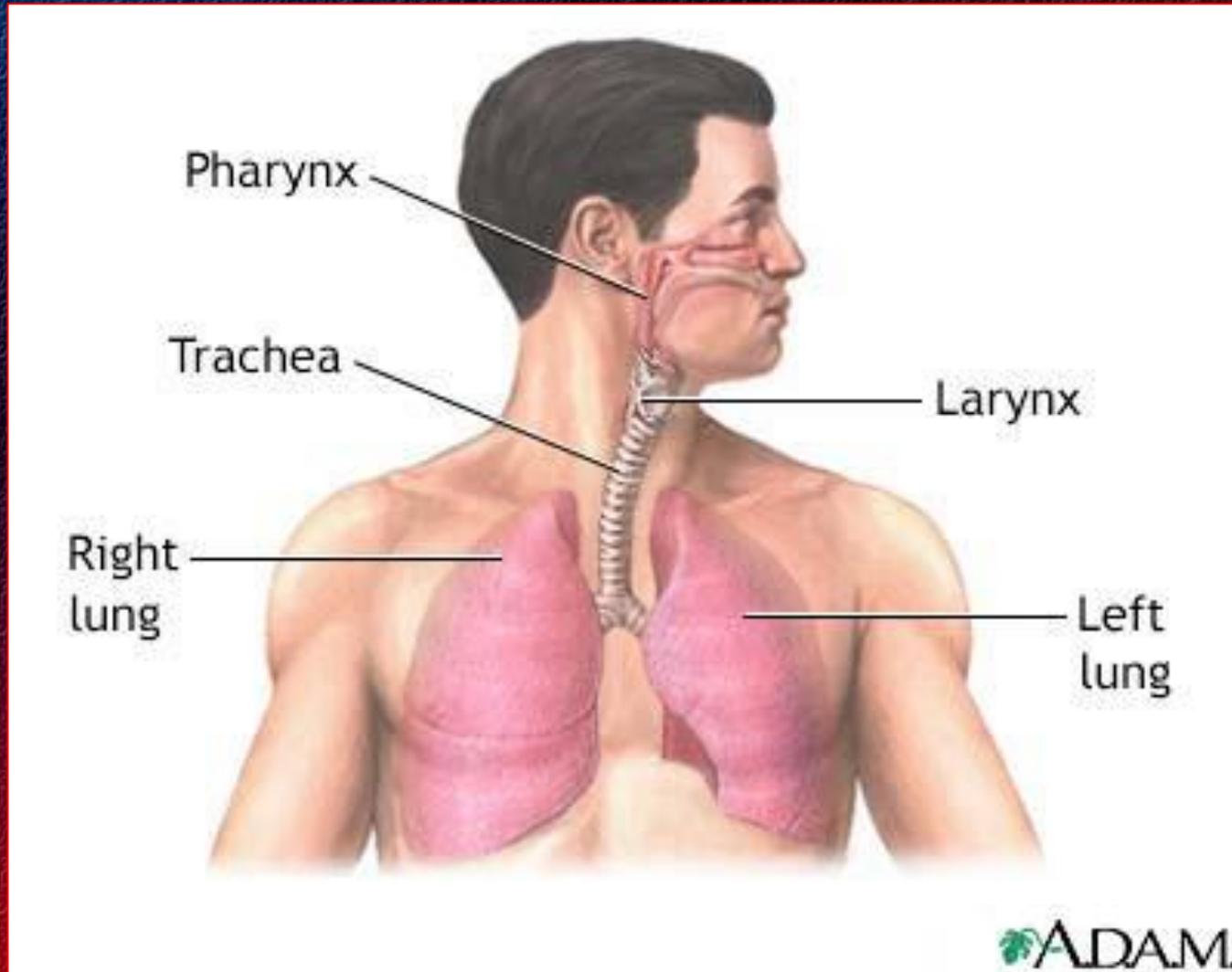
Nuclear medicine methods

- **Static examinations (scintigraphy):**
 - **an optimal time-period after the subject administration is delayed and several photos are made of the organ from different directions**
- **Dynamic studies:**
 - **a frame-serie is stored in the computer from the time of the isotope injection during an optimal time-period of the examined organ function**

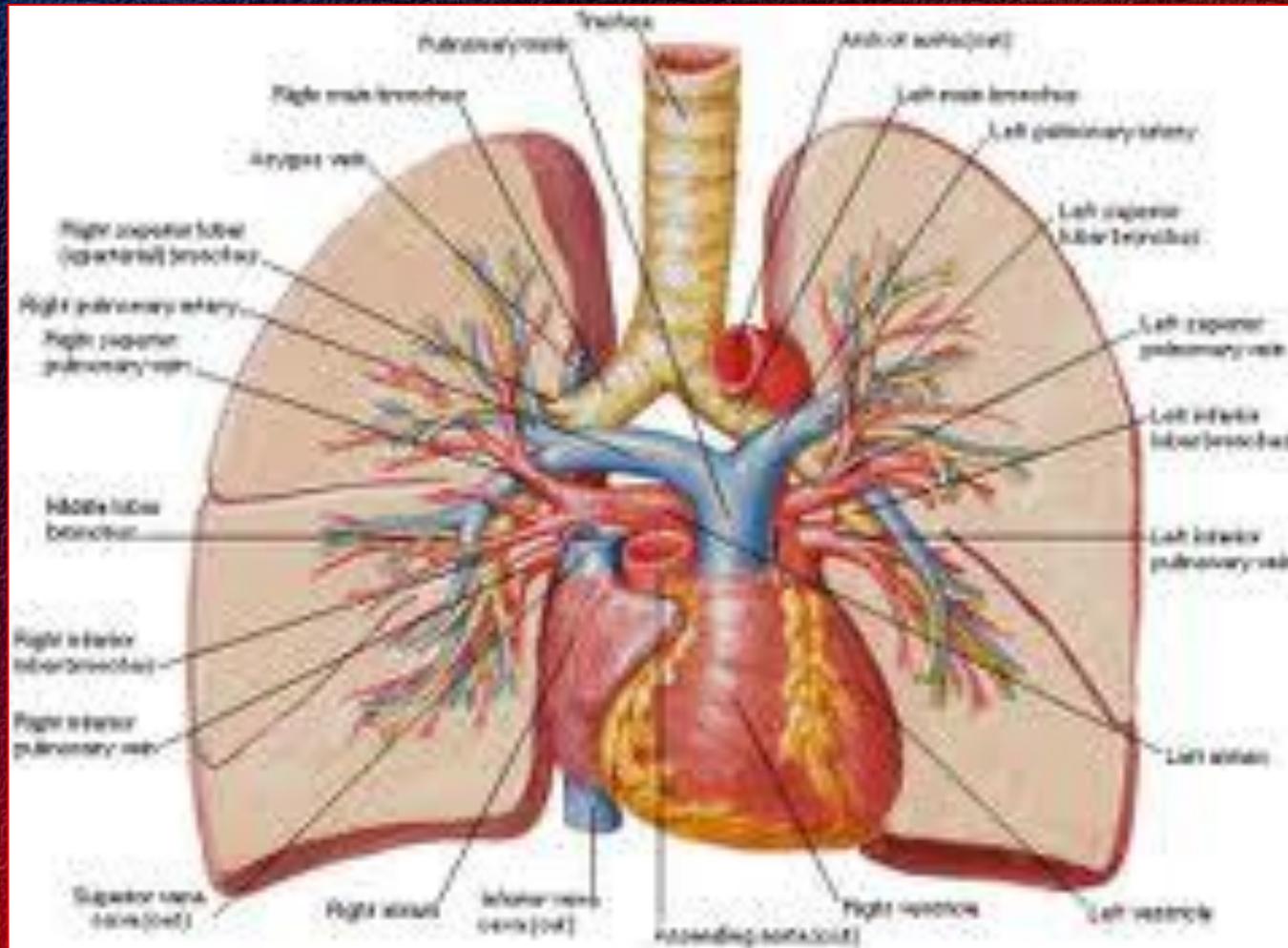
Static studies

- **Negative scintigraphy:**
pathological decreased activity
or lack of the activity
(focal defect)
- **Positive scintigraphy:**
pathological increased activity
(hot spot)

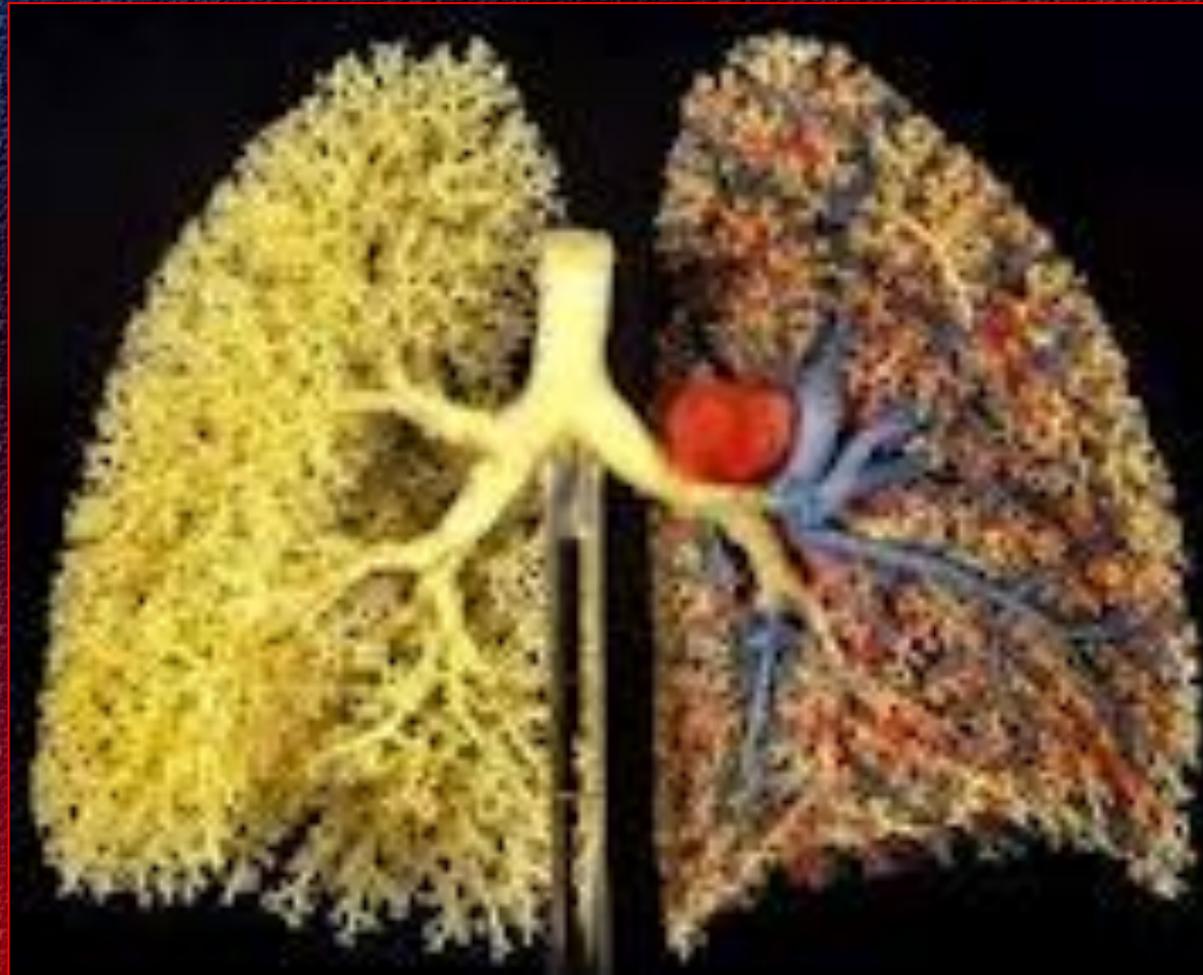
The lungs in the chest



The lung and the heart



The pulmonary vasculature and the bronchial tree



The pulmonary vasculature

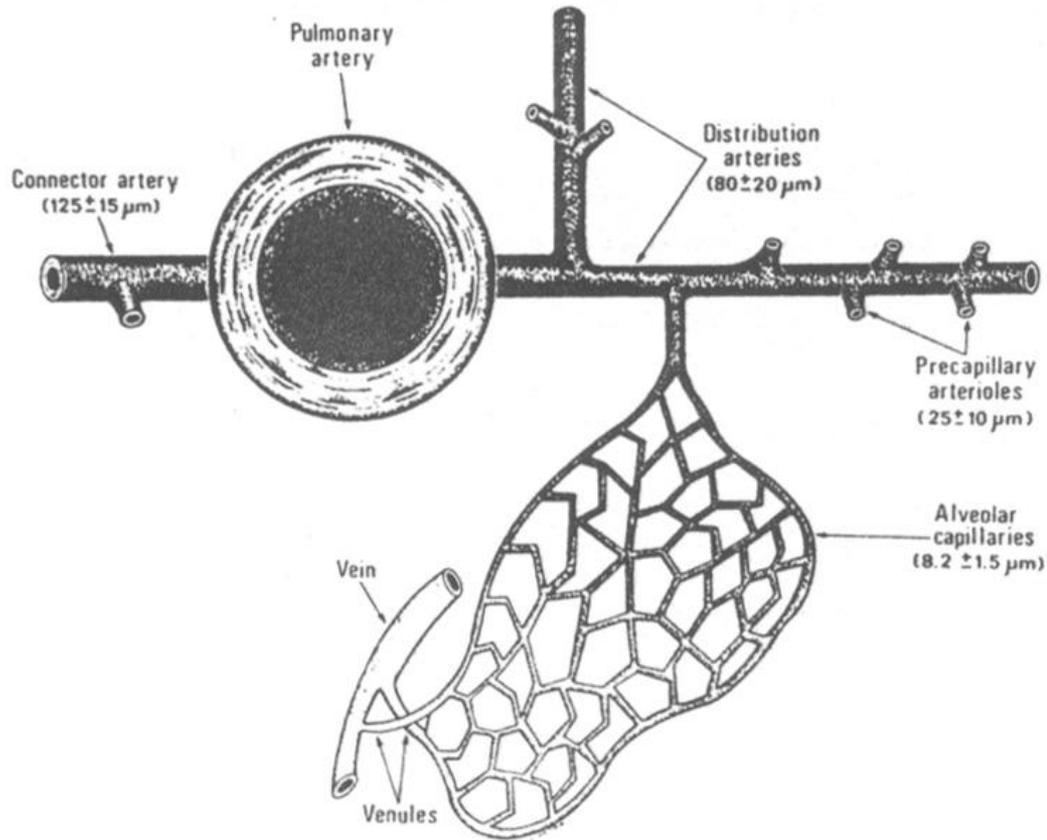


Fig. 3.1. Anatomy of the pulmonary vasculature. Distribution arteries arise from the connector arteries and precapillary arterioles branch off the distribution arteries. The intricate capillary network connects to the pulmonary vein via venules. (Reproduced by permission of the Society of Nuclear Medicine).

Zones of the lung

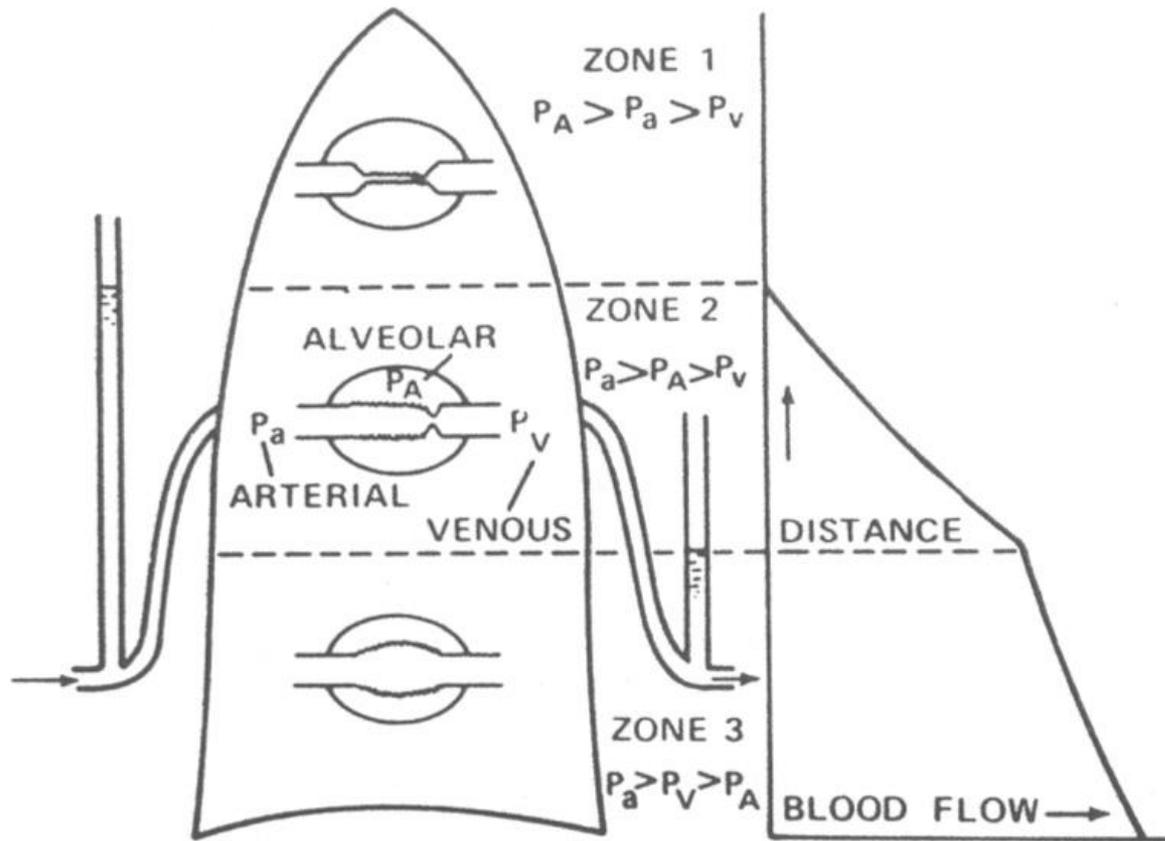
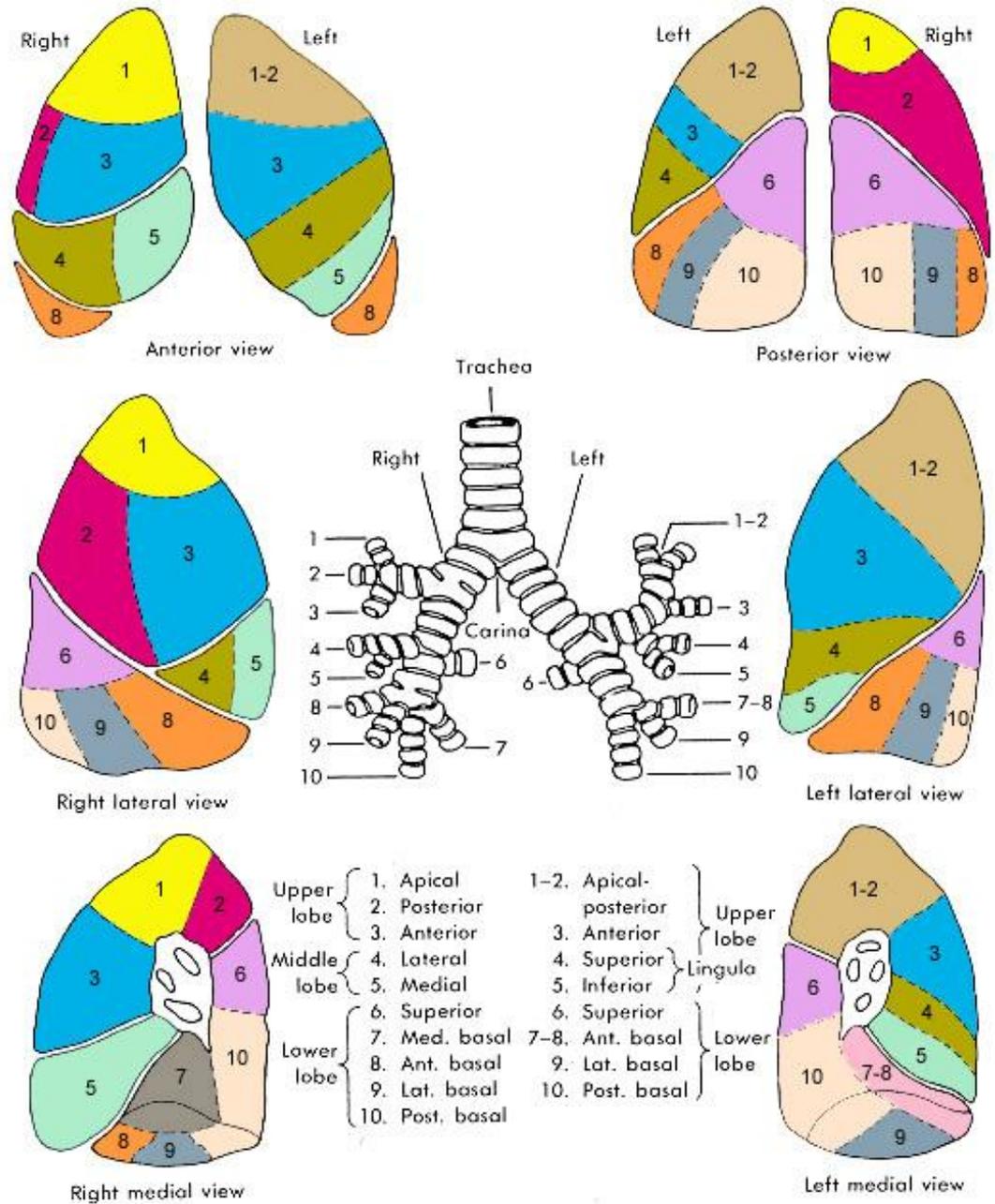


Fig. 3.4. Zones of the lung. Because of the relationships among alveolar, arterial and venous pressure, blood flow is greatest in zone 3 of the lung and least in zone 1. (Reproduced by permission of the American Physiological Society)

Lung segmental anatomy



Pulmonary studies

- **Perfusion lung scintigraphy:**
shows the accurate assesment of the regional perfusion of the lung
- **Inhalation or ventillation examination:**
shows the distribution of the inhaled radioactive gases or aerosol

Perfusion lung scintigraphy

- Injected subject: **99mTc-macro-albumon**
 - with mean particles size of about 30 μm
 - blocks the precapillary arterioles, but only less than 0.1 % of and this is not permanent
- Administration: intravenously in lying position (because of the perfusion zones of the lung)
- Study can be started immediately

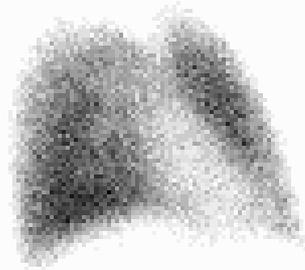
Indications of the perfusion scintigraphy

- Verify the pulmonary embolism
(couple of the chest X-ray!)
- Evaluation of regional lung function in patients with lung tumor before the operation
- Evaluation of regional lung function in asthmatic and obstructive lung diseases
- Assessment of regional lung function after the therapy

Normal perfusion lung scan



ANT



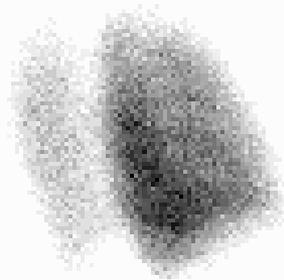
RAO



LAO



POST

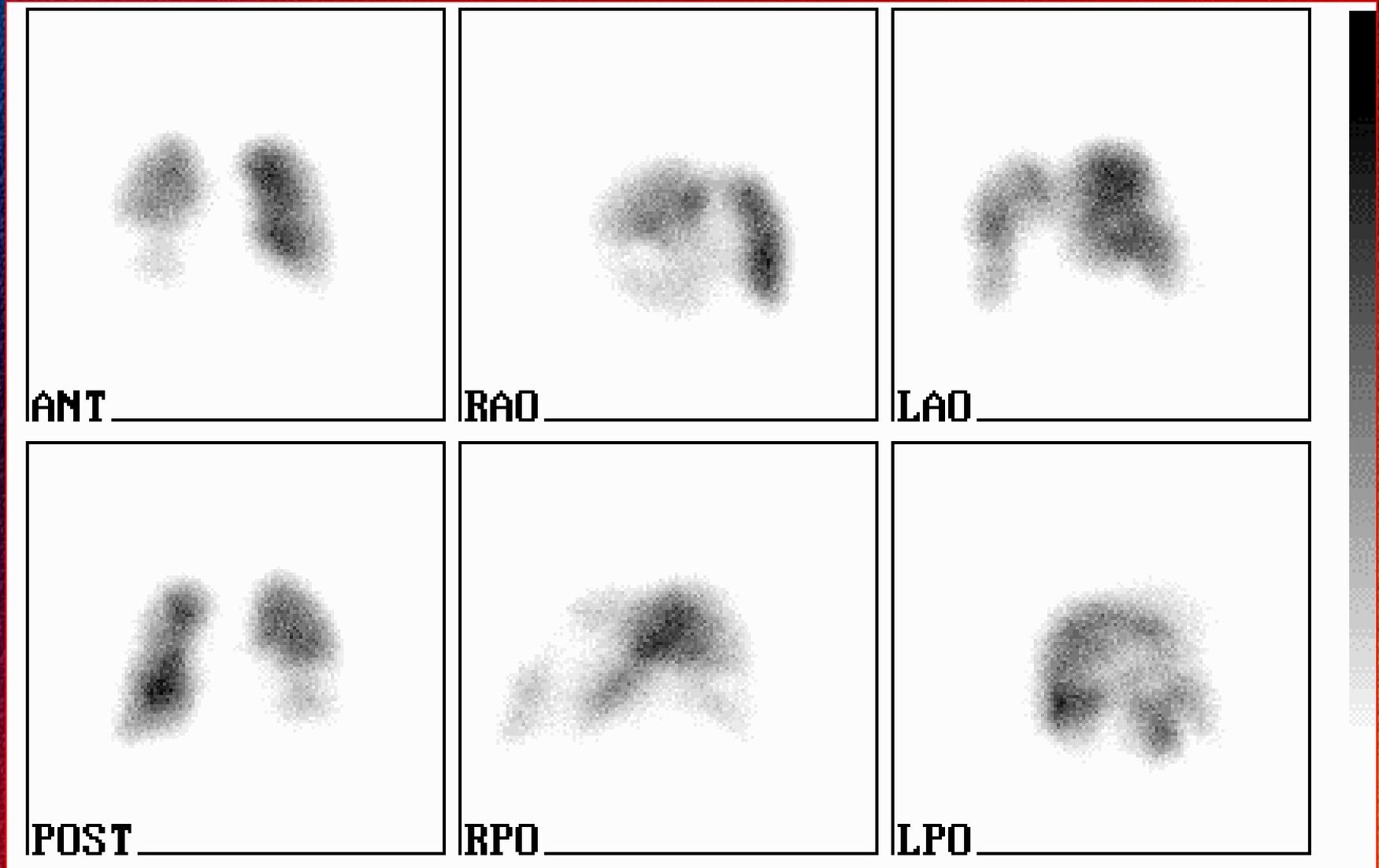


RPO



LPO

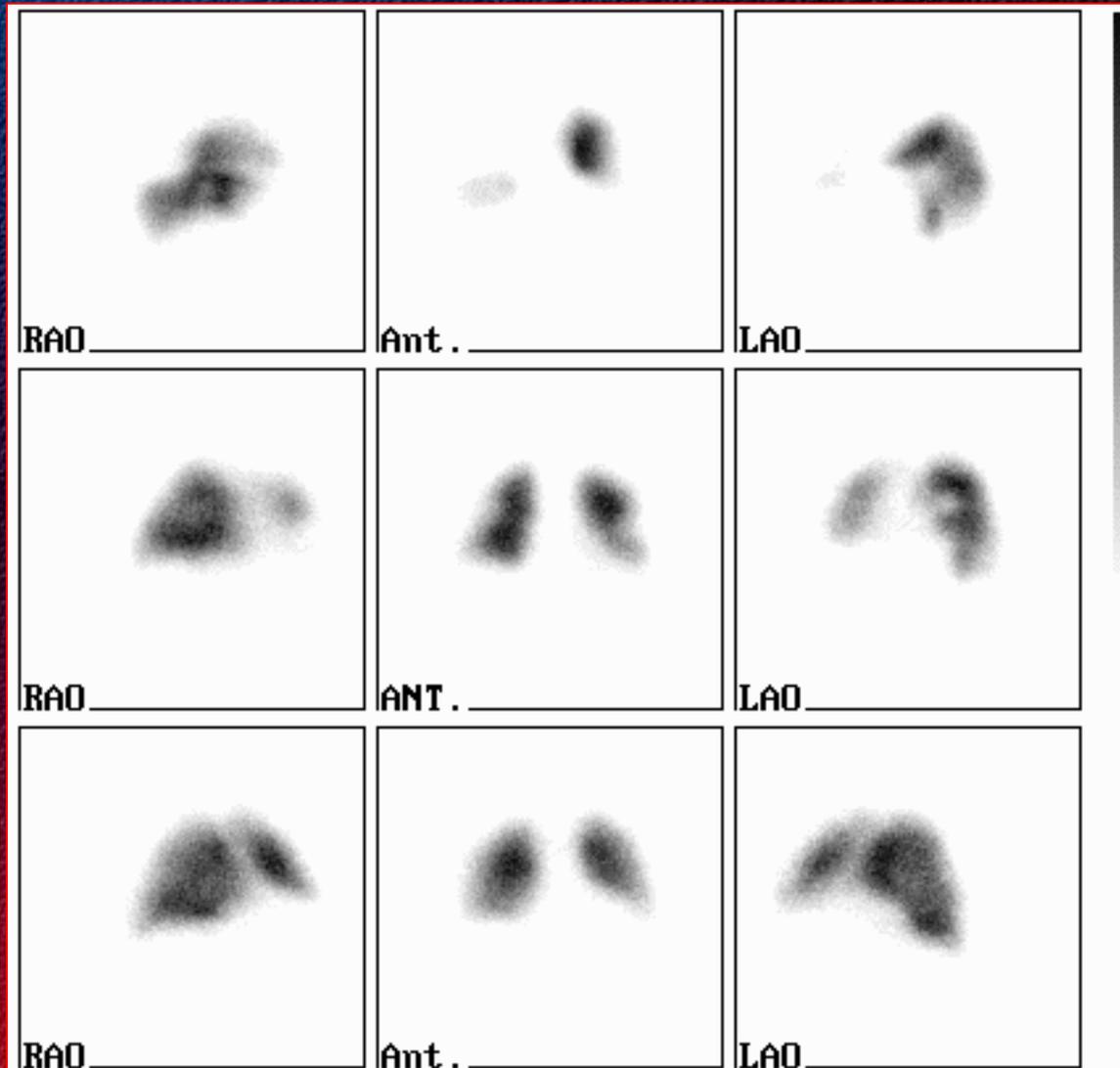
Perfusion defects on the lung scan



Therapy: thrombolysis

- Indication: **great perfusion defect on the scintigram, at least the half of the lungs + negative chest x-ray**
- **Contraindication: tumor, metastasis or infiltration on the chest x-ray**
- **previous operation or punctio**
- **hemorrhagical diseases**
- **Streptokinase, Urokinase, Actylise infusion**
- **it can be repeated in every day**

Therapy of pulmonary embolism



Before
streptolysis

One day after
streptolysis

Two days after
streptolysis

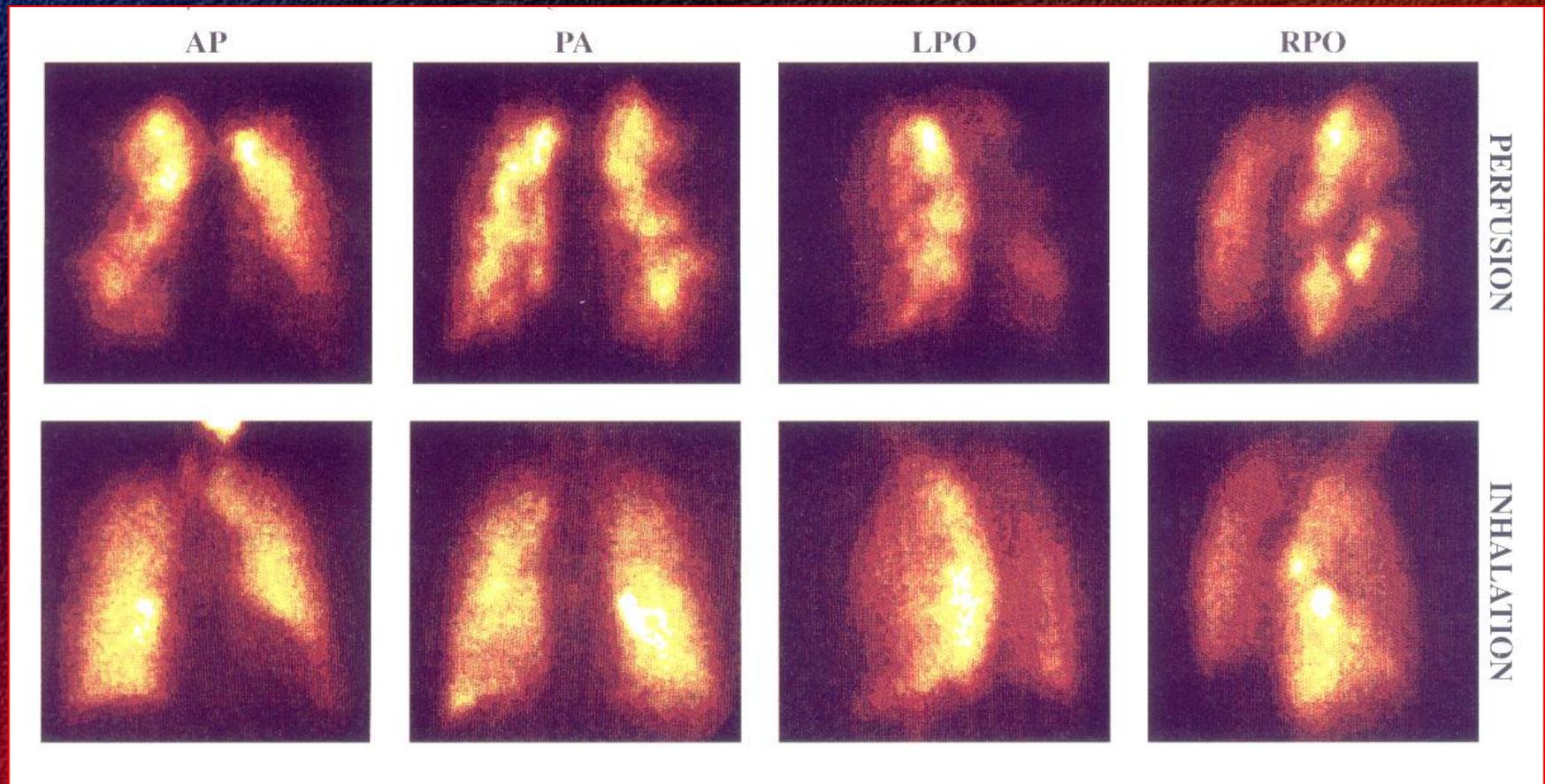
Inhalation study

- Inhaled subject: **99mTc-DTPA aerosol**
- The examination can be started immediately
- Indications:
 - *pulmonary embolism*
(with perfusion study: „mismatch”)
 - **lung tumor**
(with perfusion study: „match”)
 - **obstructive lung diseases**
accumulation hot spots in the central bronchii

Ventilation study

- **81m-Krypton: from 81-Rubidium generator, T 1/2: 13 s, energy: 193 keV**
- **133-Xenon: T1/2: 5.2 days, energy: 80 keV, during 3-5 minutes \Rightarrow equilibrium**
- **127-Xenon: T 1/2: 36 days, energy: 172, 203, 375 keV**
- **Technegas: 99mTc-DTPA is vapourised in argon atmosphere on grad 2000-2500 Celsius \Rightarrow behaves as a gas with 0.015-0.5 μm particle size**

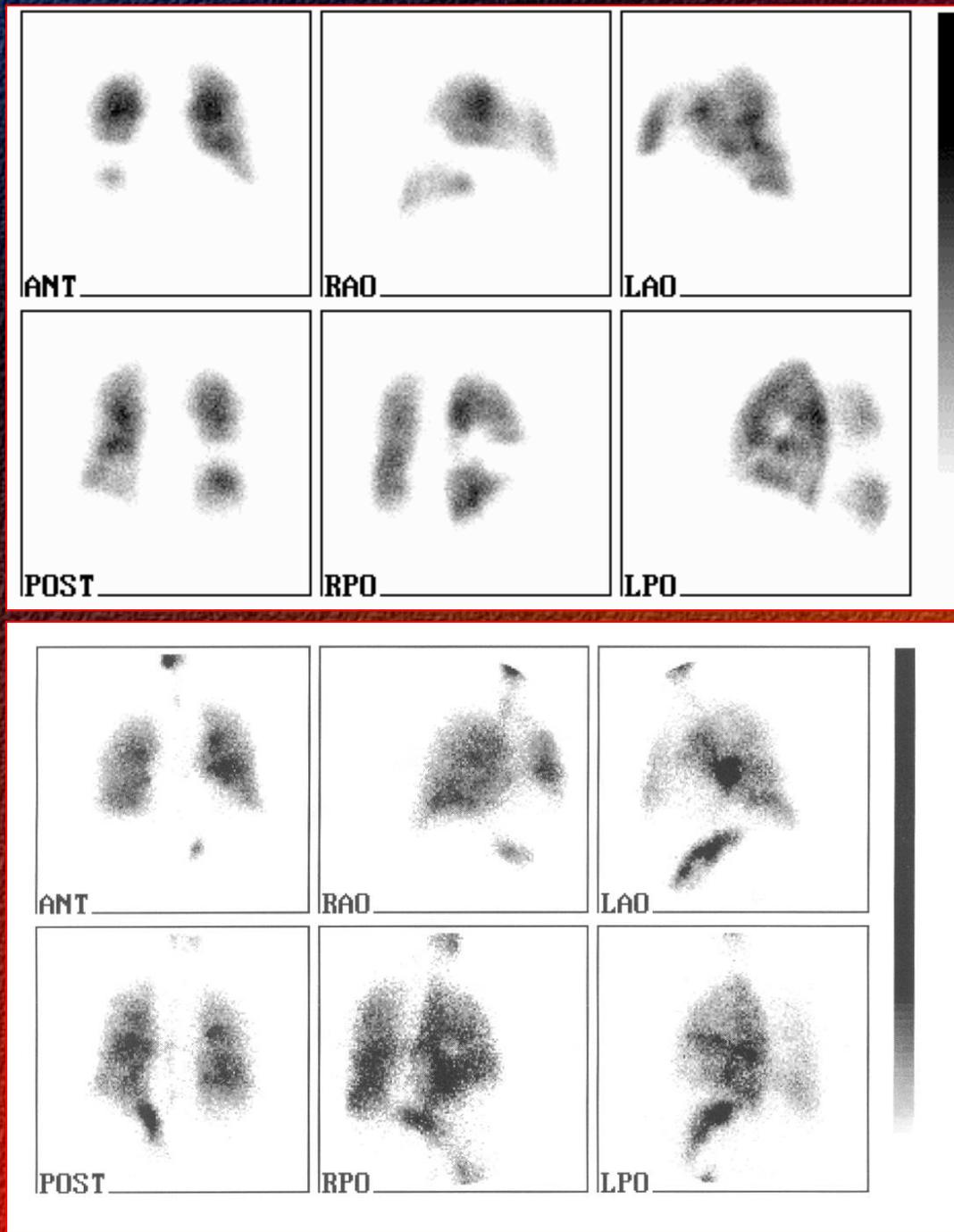
Pulmonary embolism (mismatch)



Pulmonary embolism

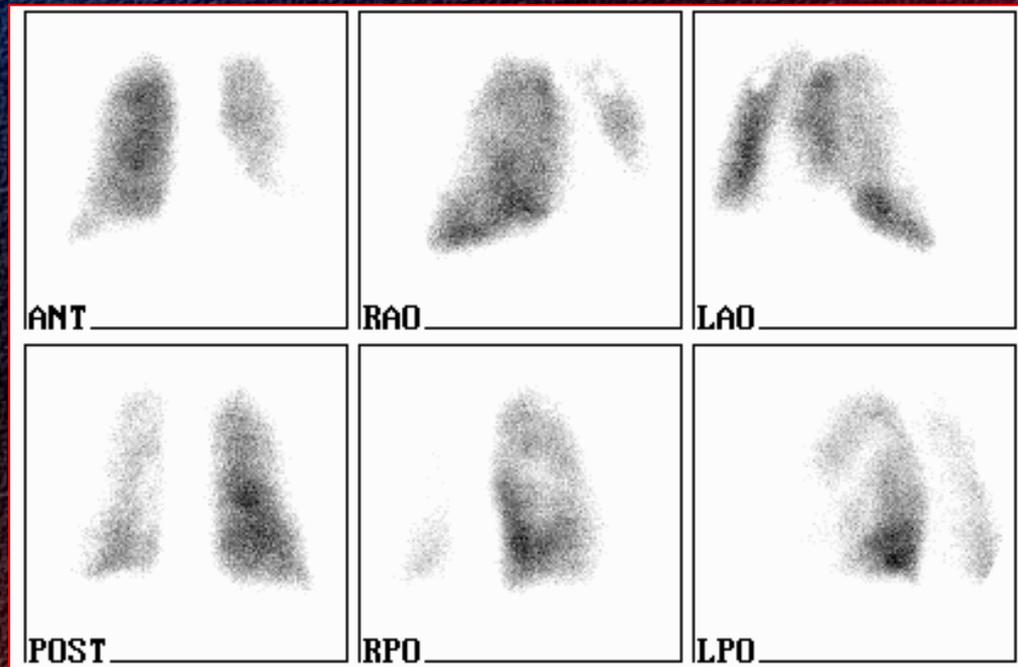
Perfusion scintigraphy

Inhalation scintigraphy

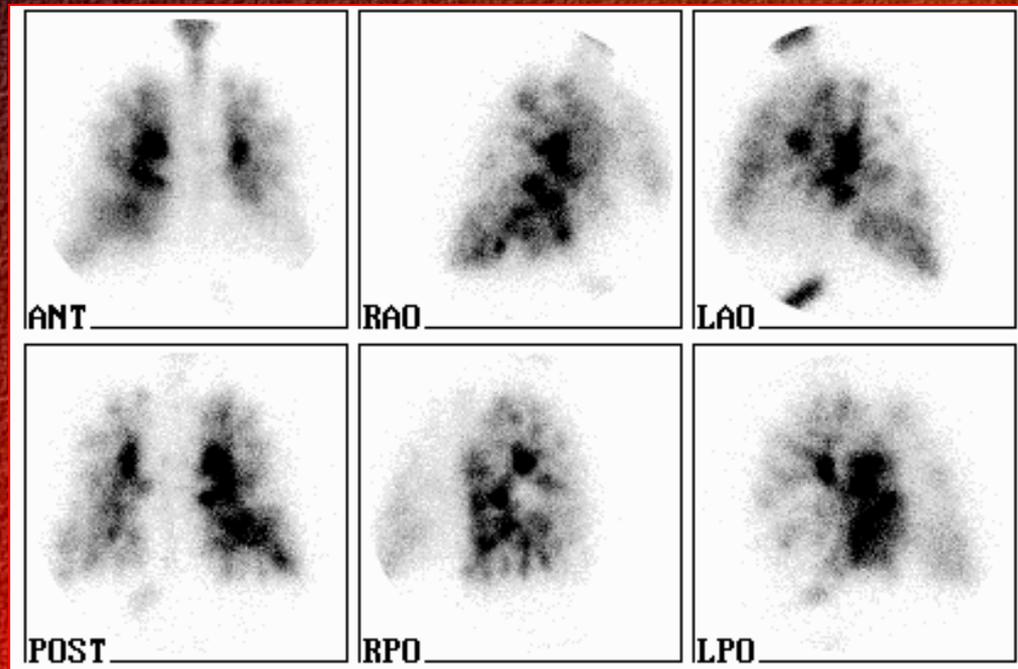


Obstructive bronchitis

Perfusion scintigraphy

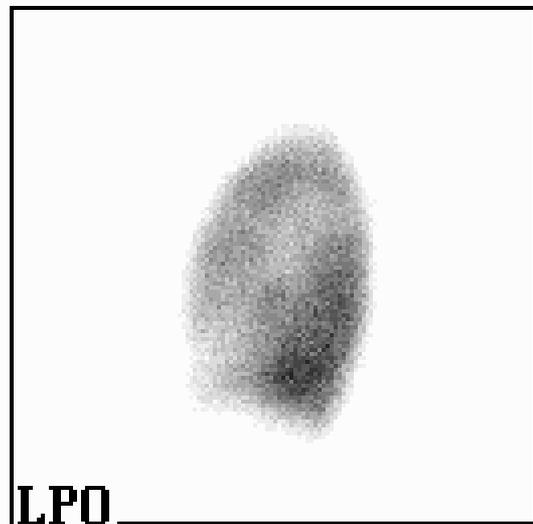
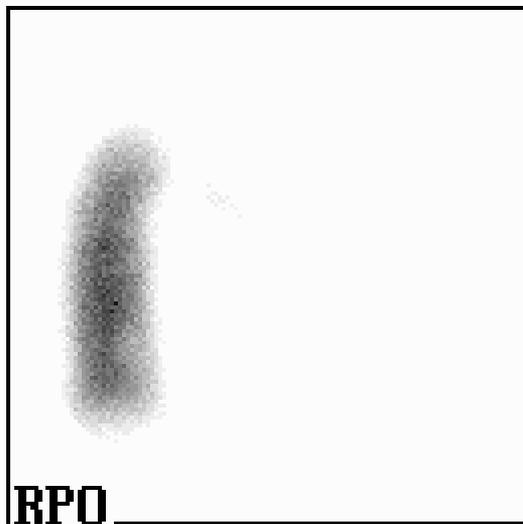
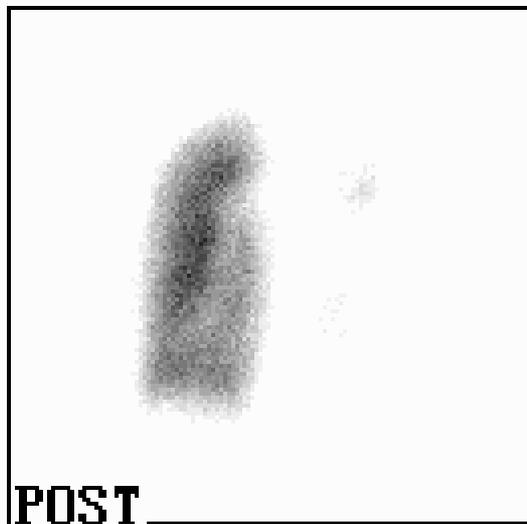
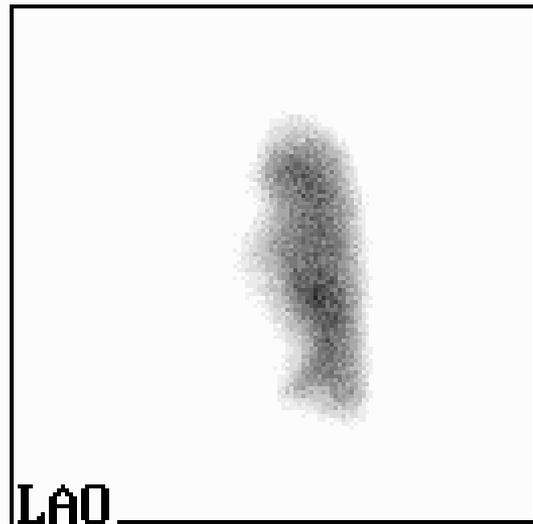
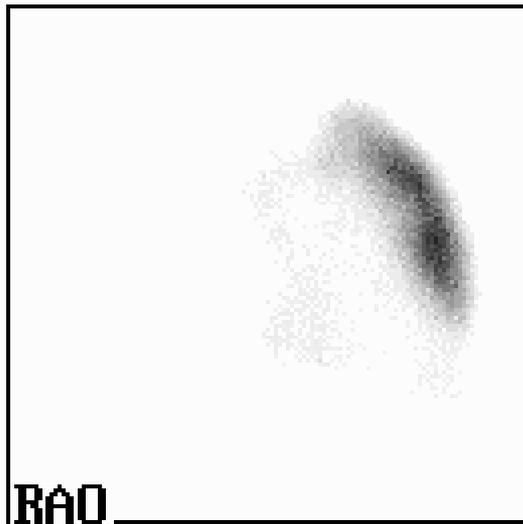
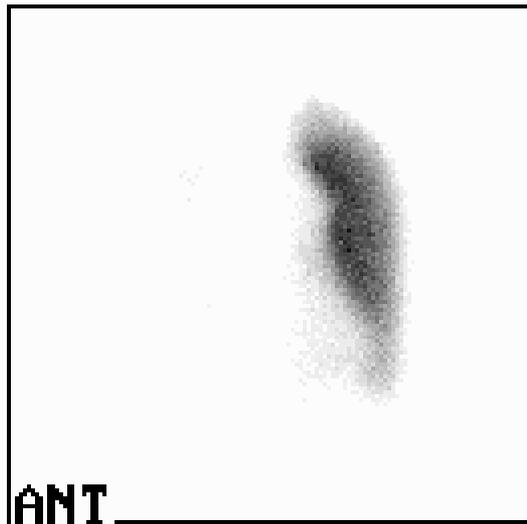


Inhalation scintigraphy

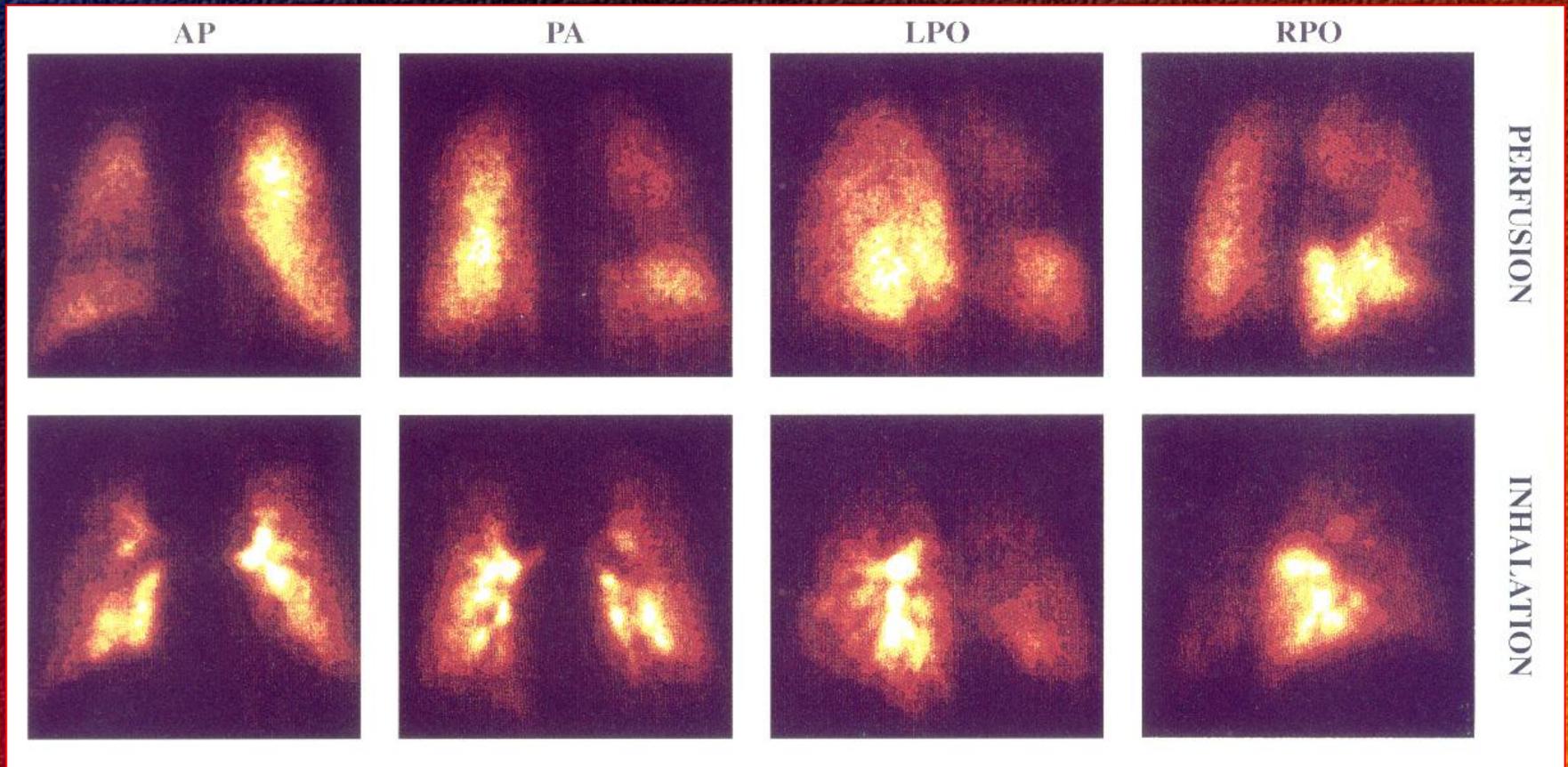


Central tumor in the right side

(the lung is in the chest, but no any perfusion in the lung)



Bronchial carcinoma

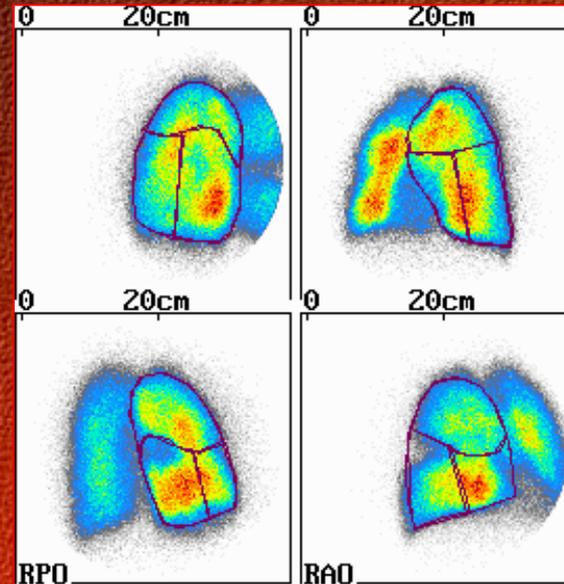
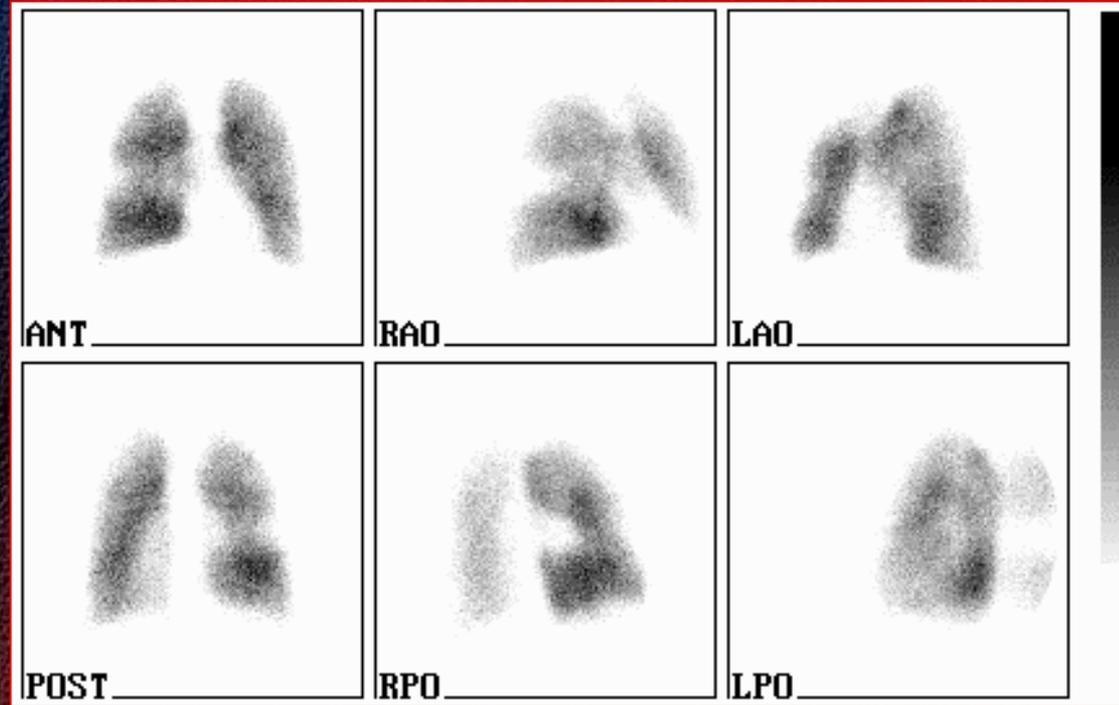


Periferial tumor in the right lung

The activity of the lungs:
Both lung: 17216 cps

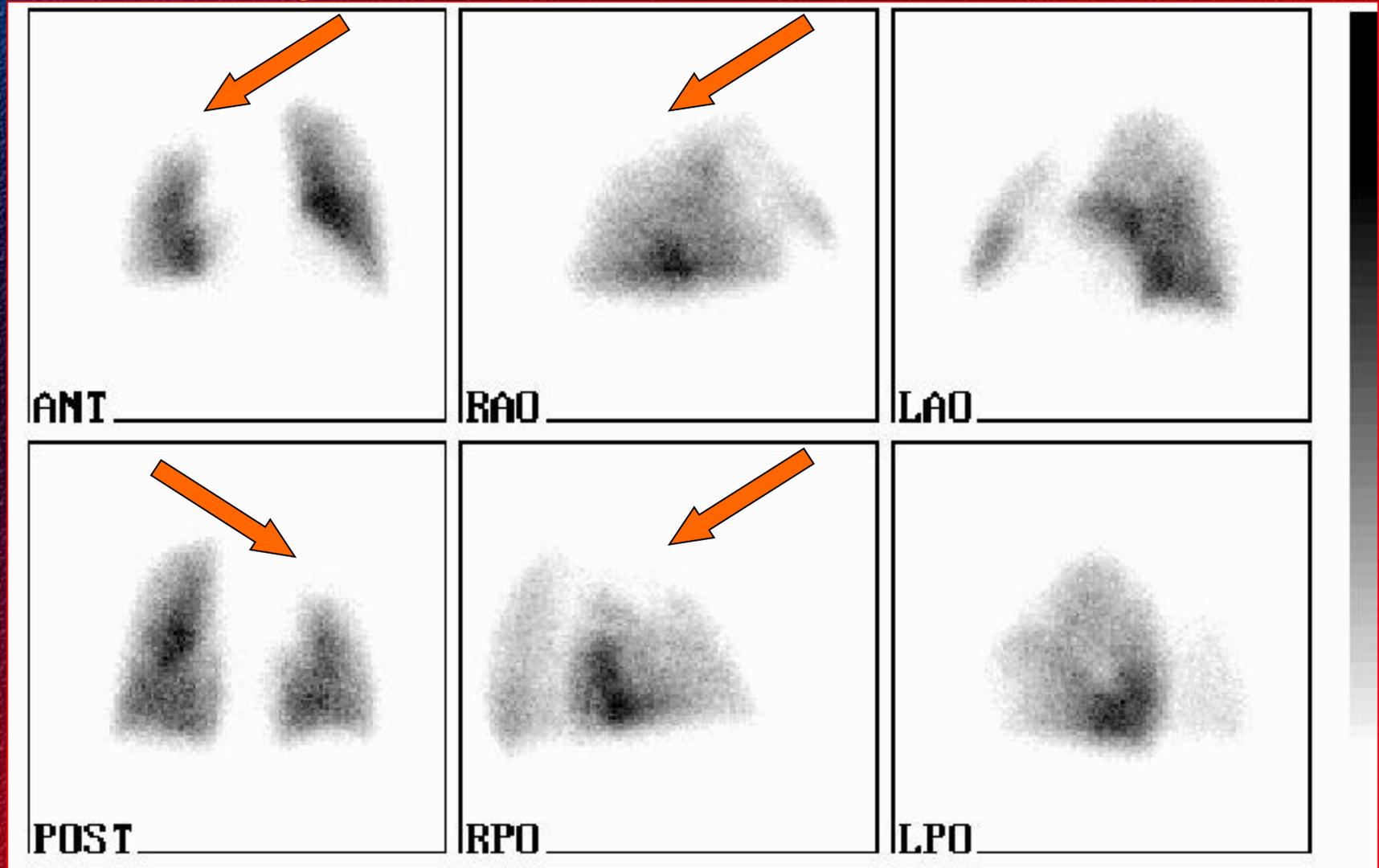
Left lung: 48.3 %
Right lung: 51.7 %

Left upper lobe: 2597 cps
Lingula: 2307 cps
Left lower lobe: 3766 cps
Right upper lobe: 3594 cps
Right middle lobe: 2423 cps
Right lower lobe: 3211 cps



Adenocarcinoma in the upper lobe of the right lung

Pulmonary embolism in other localization?

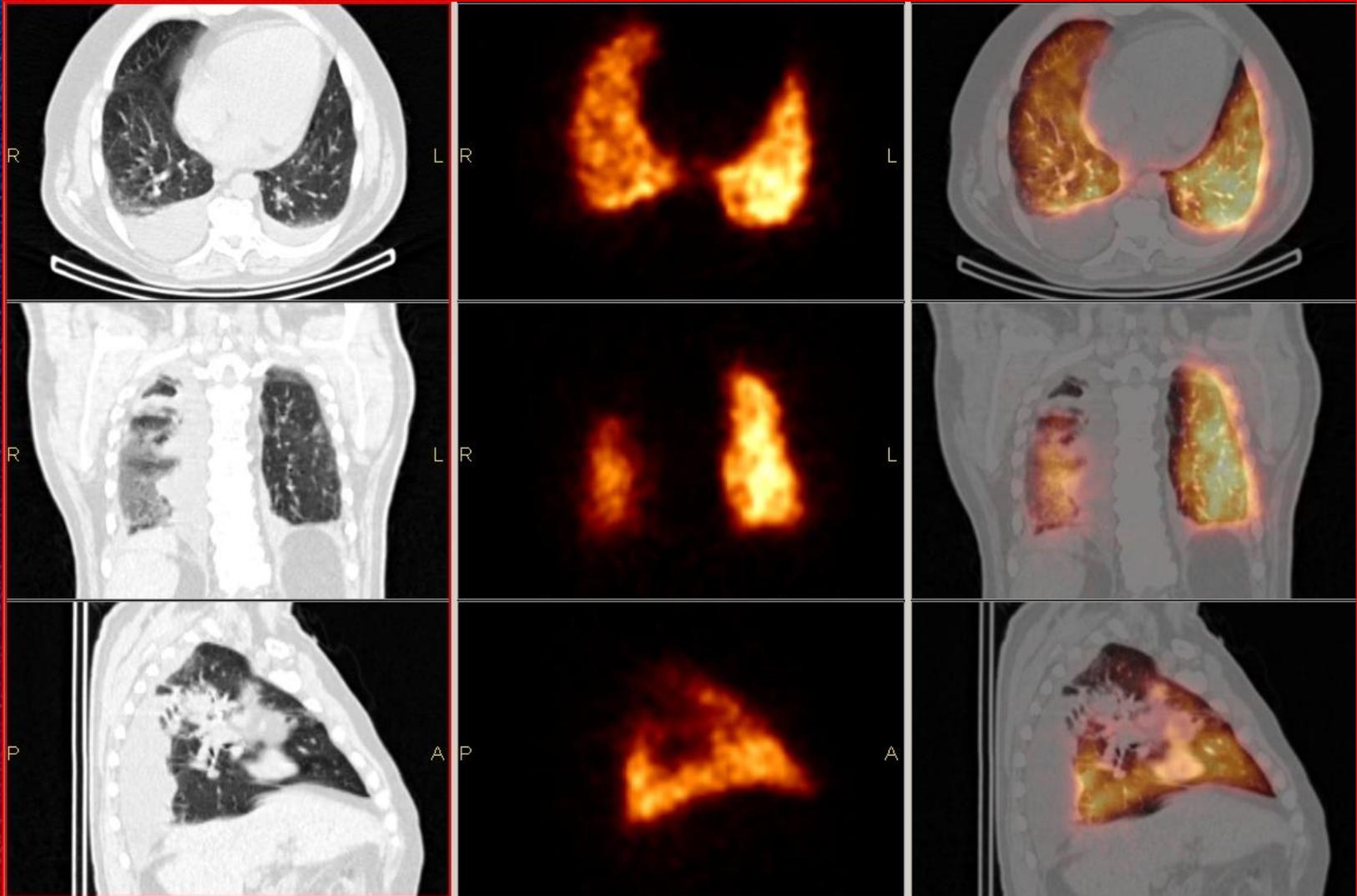


No embolism in the right side!

CT

SPECT

SPECT/CT

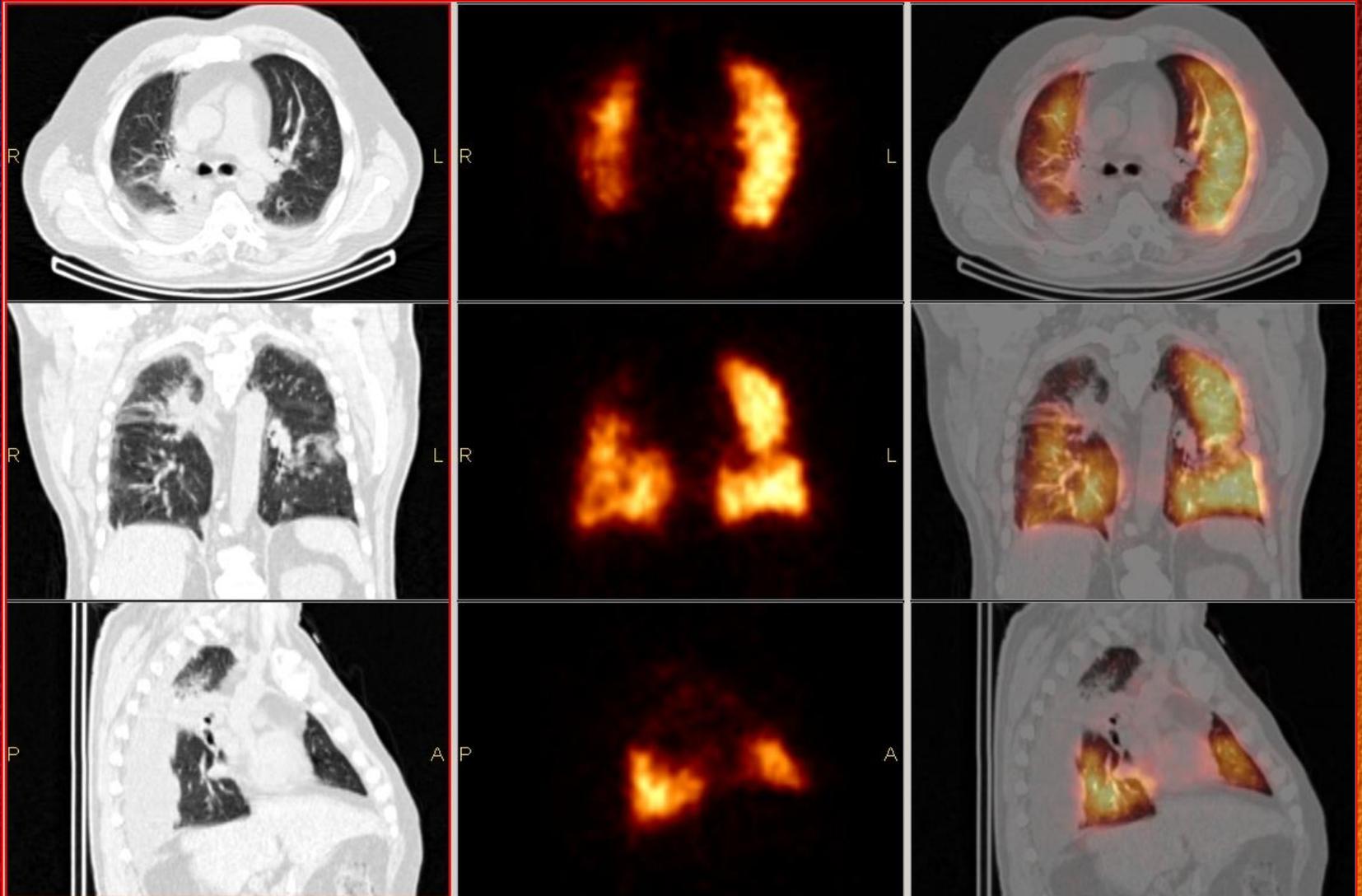


No embolism, BUT: metastasis on the left side!

CT

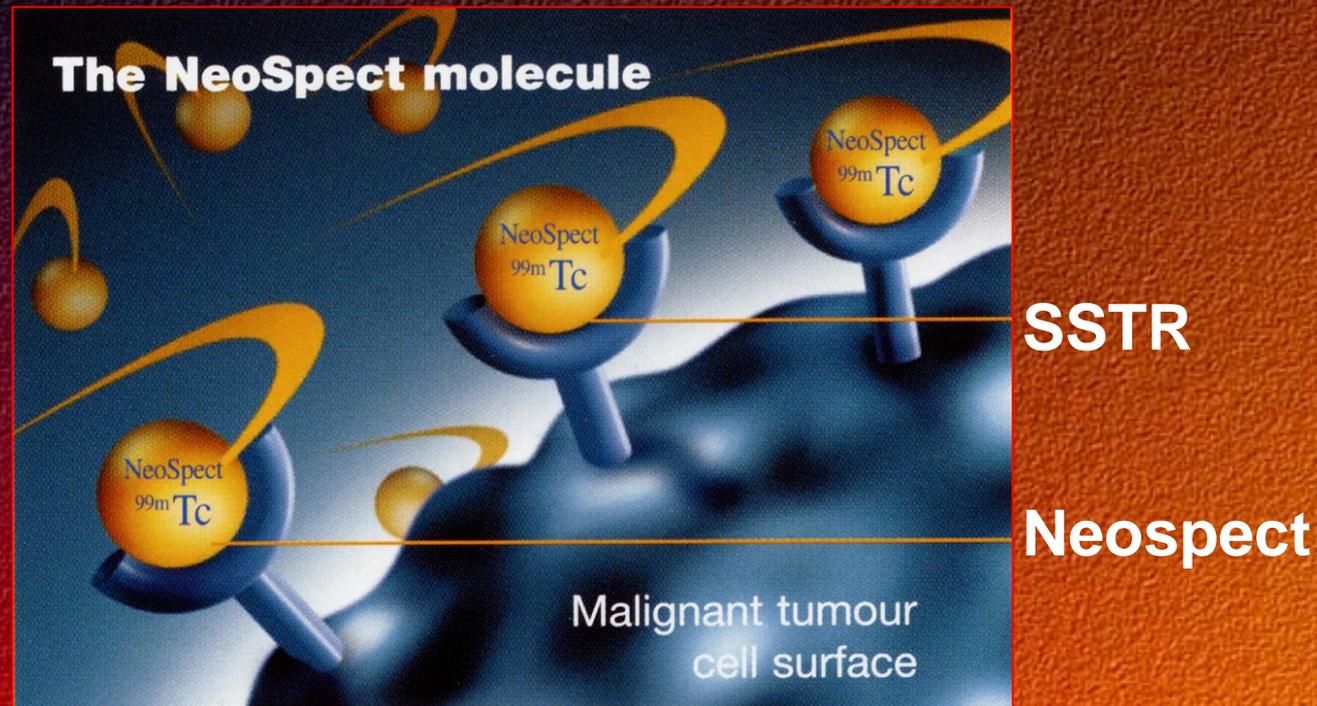
SPECT

SPECT/CT



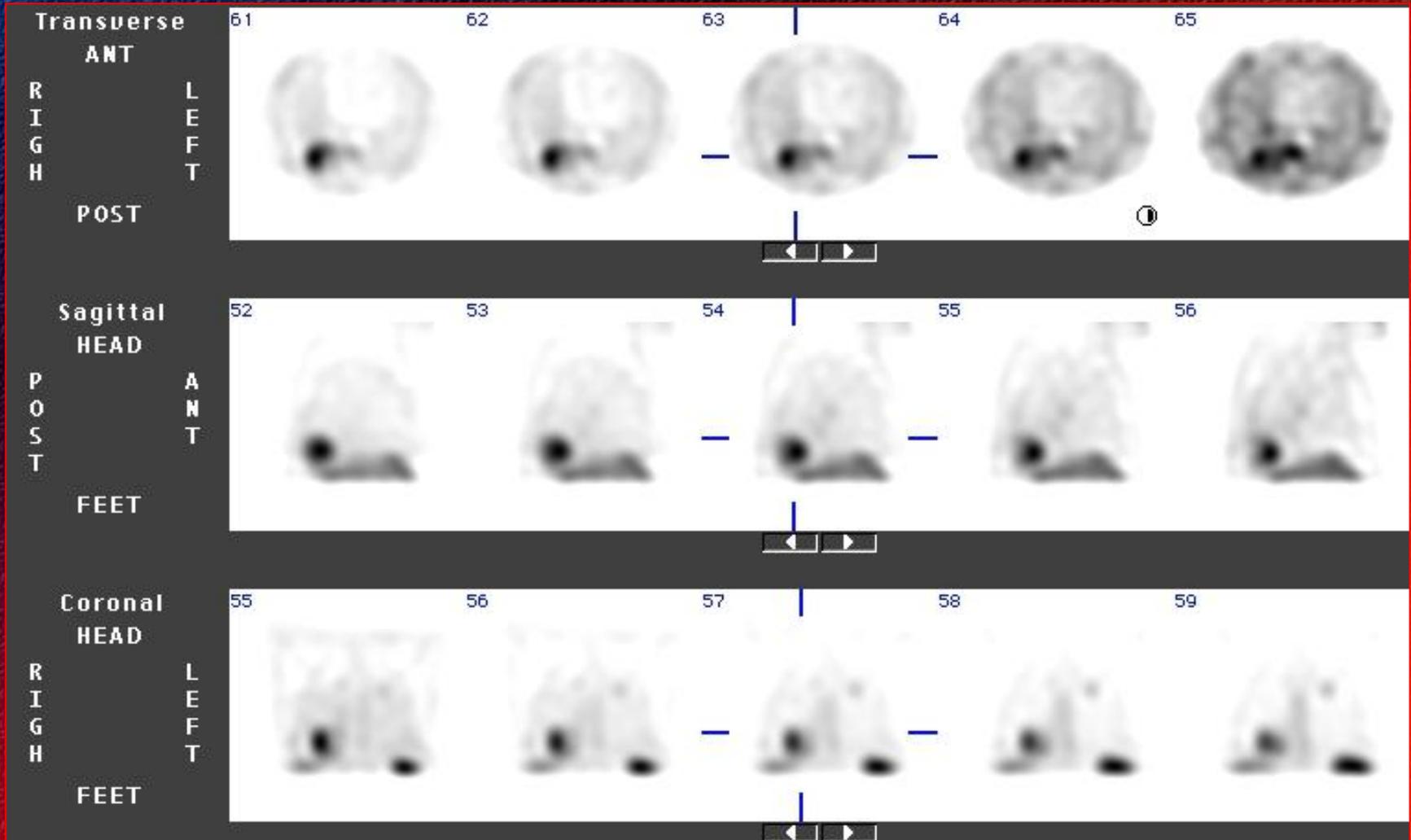
Specific examination of pulmonary cancers

^{111}In -octreotide (SSTR 2,3,5) and $^{99\text{m}}\text{Tc}$ -depreotide (SSTR 2) binding to the somatostatin receptors which are overexpressed on the surface of the tumor cells are suitable for the diagnosis



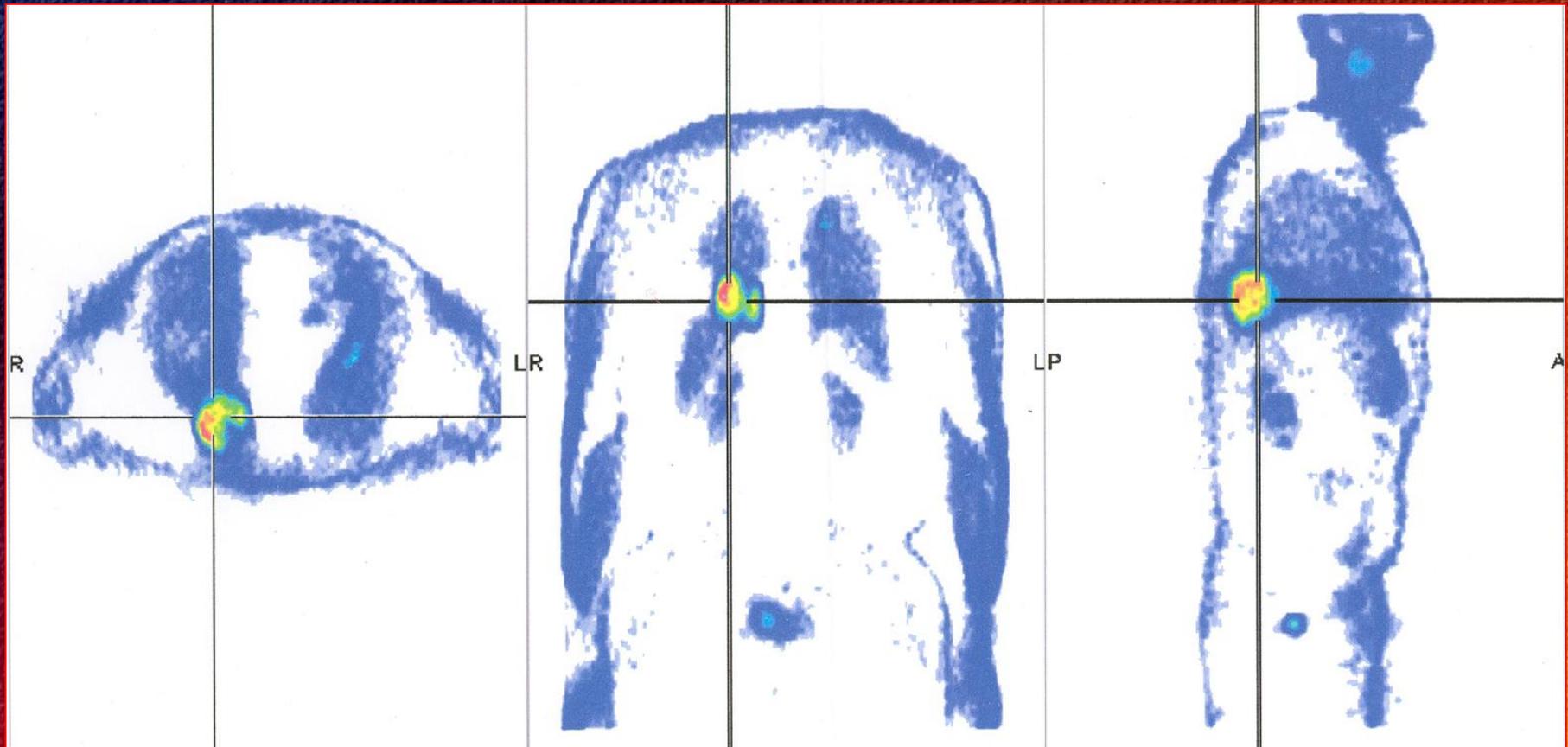
Adenocarcinoma in the right lung by 99mTc-Neospect

SPECT imaging



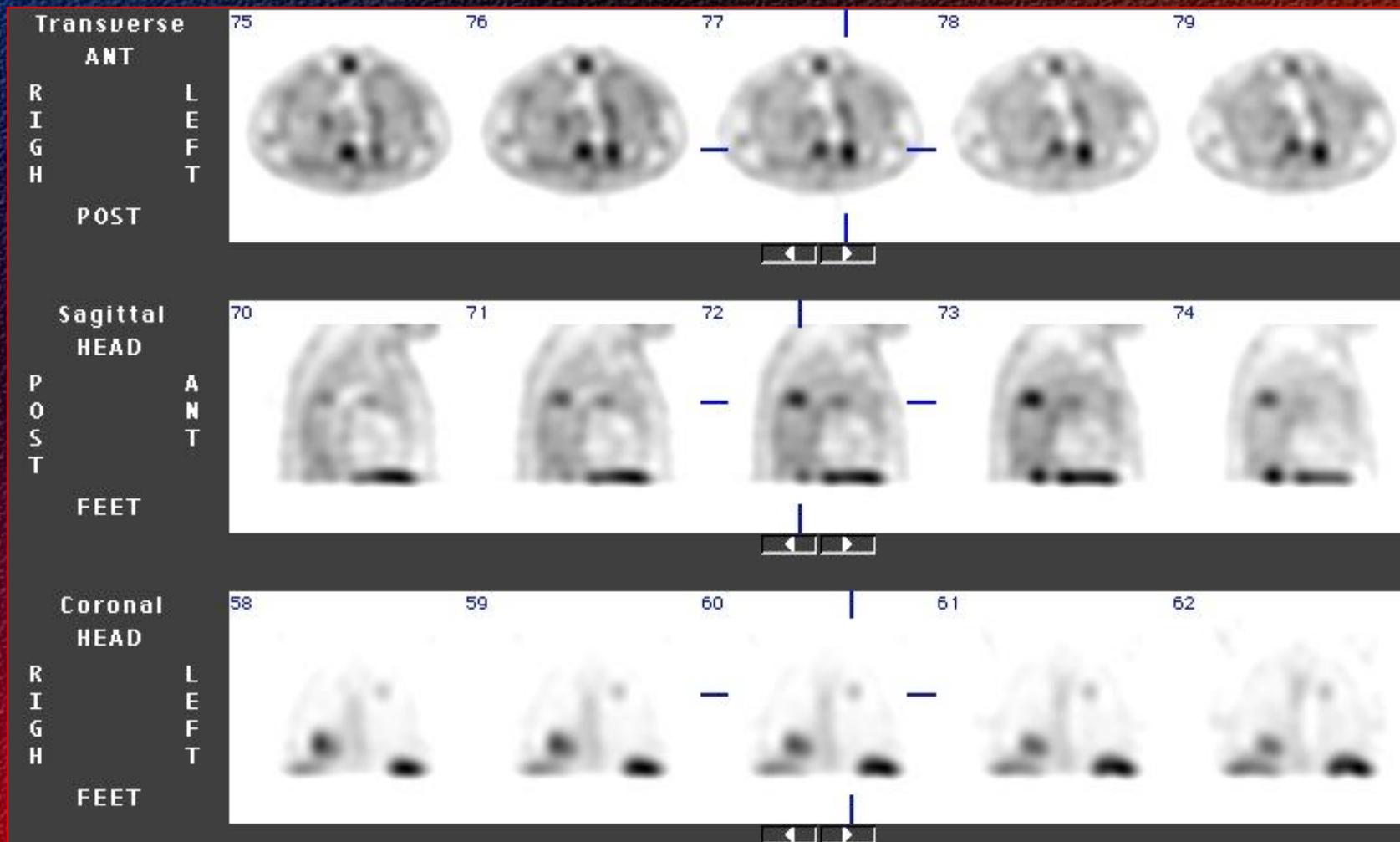
Adenocarcinoma in the right lung by ^{18}F -FDG

PET imaging



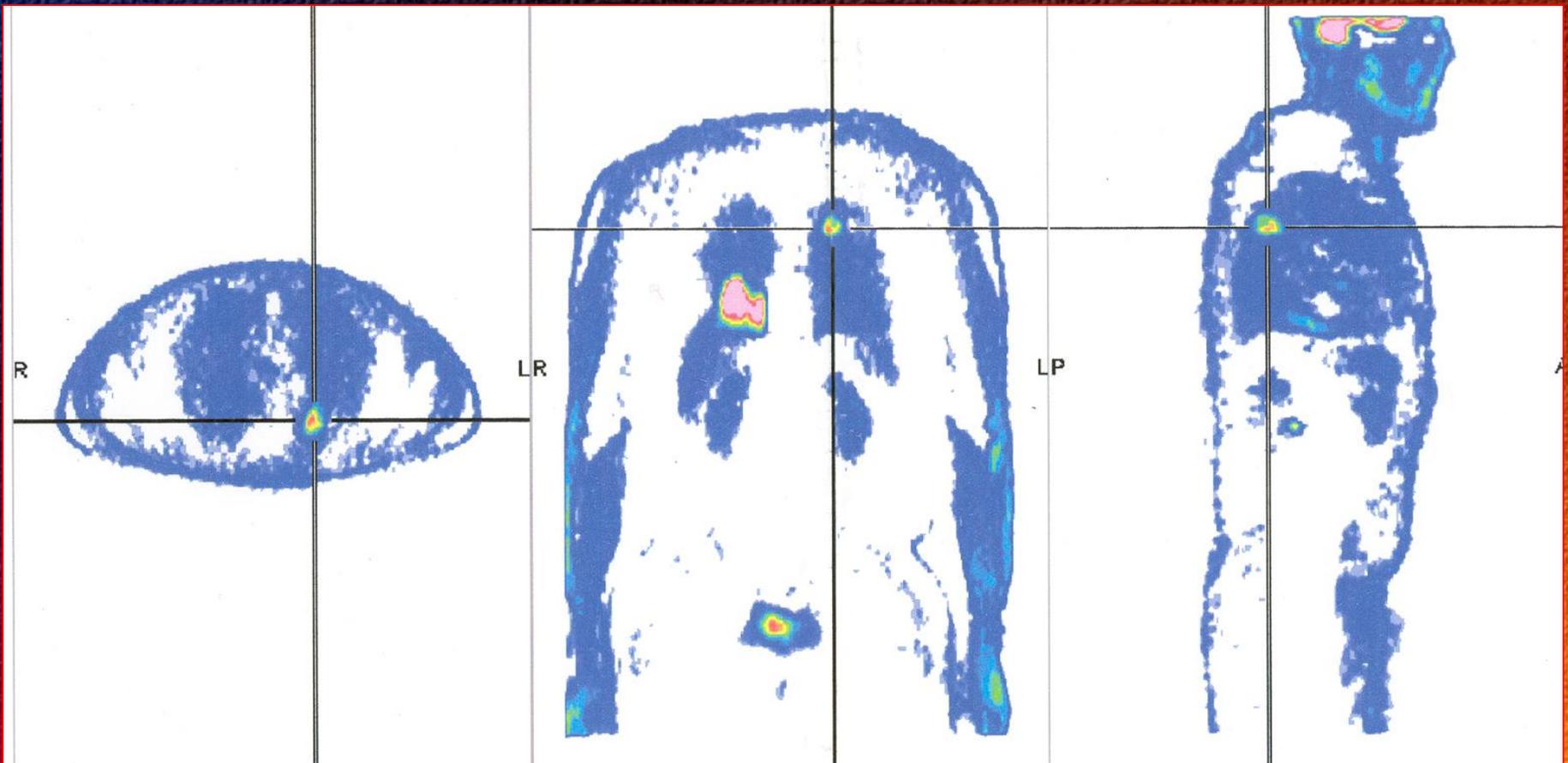
Adenocarcinoma in the left upper lobe by 99mTc-Neospect

SPECT imaging



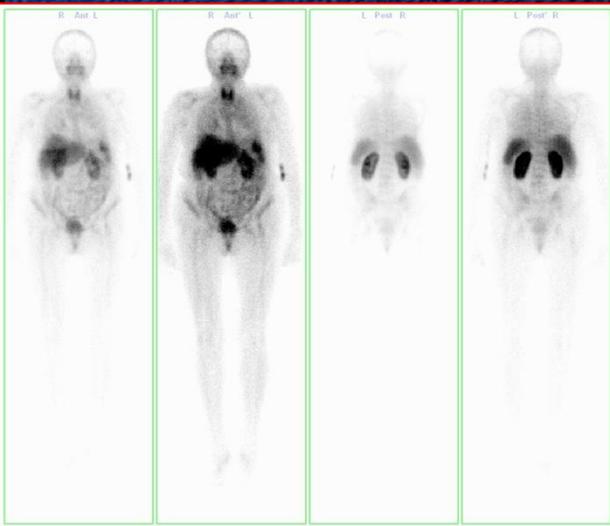
Adenocarcinoma in the left upper lobe by 18F-FDG

PET imaging



Operation of lung carcinoid on the right side, metastasis on the left side

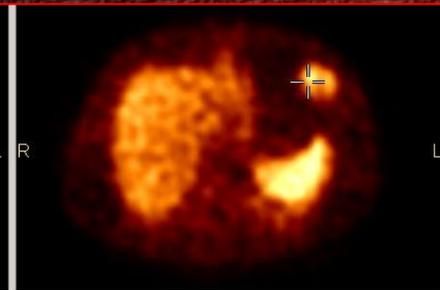
Whole body scan



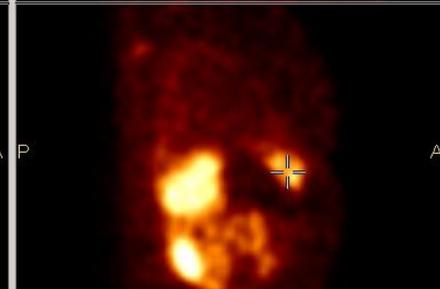
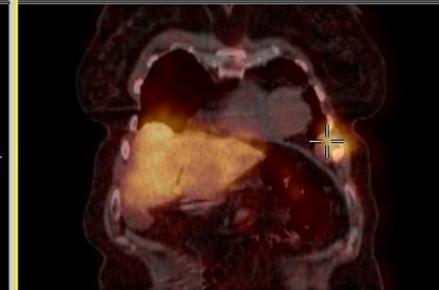
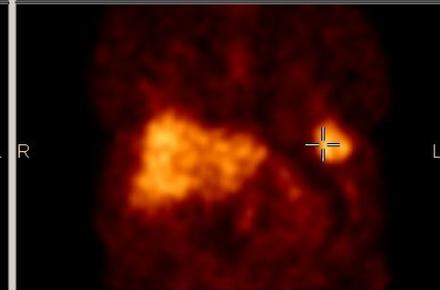
CT



SPECT

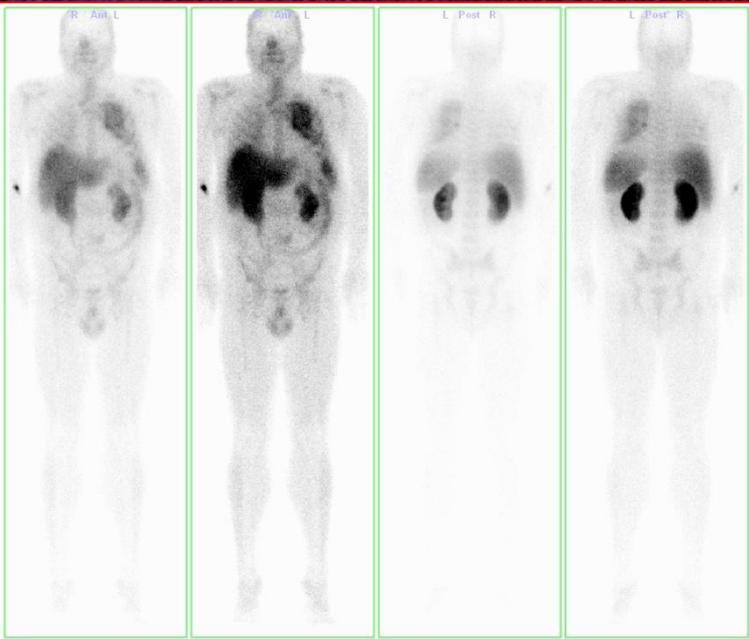


SPECT/CT



Carcinoid in the left lung

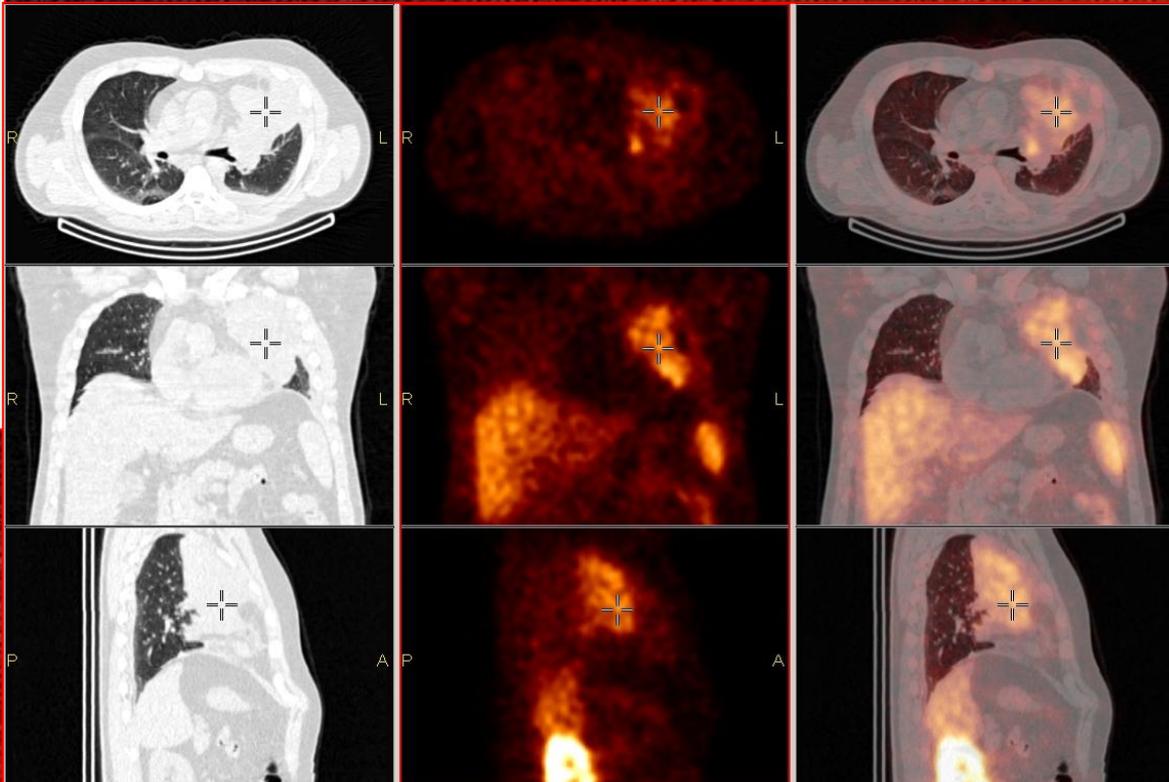
Whole body scan



CT

SPECT

SPECT/CT



The gallium67 scintigraphy I.

There is an isotope, which are binding aspecifically to the transferrine receptors of the tumor cells are found on their surface.

Half-life: 78 hours

Energy: 93 keV - 393 keV

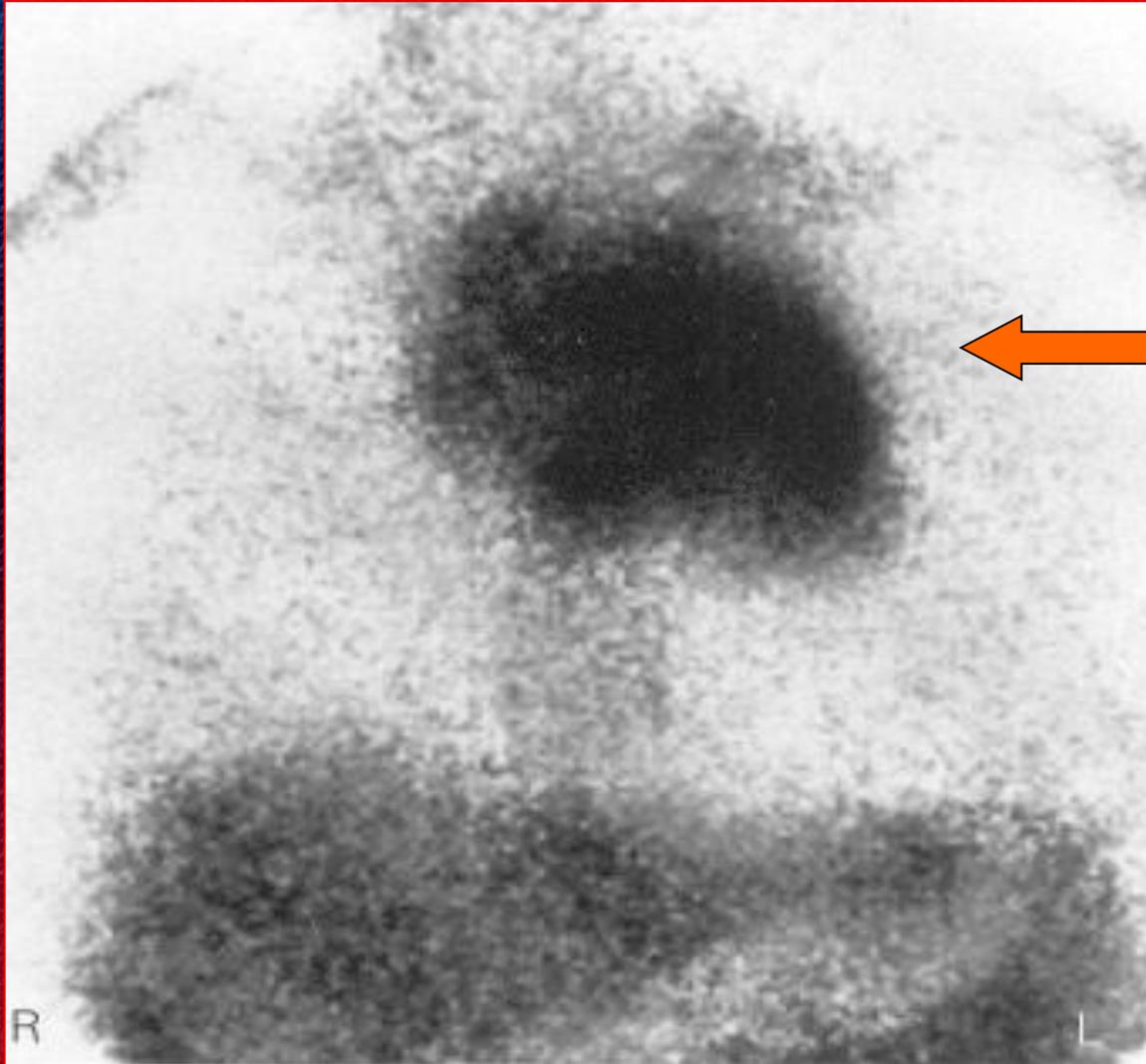
The gallium67 scintigraphy II.

Indications:

- the localization, evaluation and follow up of patients with *neoplastic disorders* such as Hodgkin's and non- Hodgkin's disease, soft tissue sarcoma, bronchogenic carcinoma, melanoma and hepatoma
- sarcoidosis of the lungs
- the detection of focal *inflammatory processes*, abdominal abscesses, osteomyelitis

Anterior view of the chest

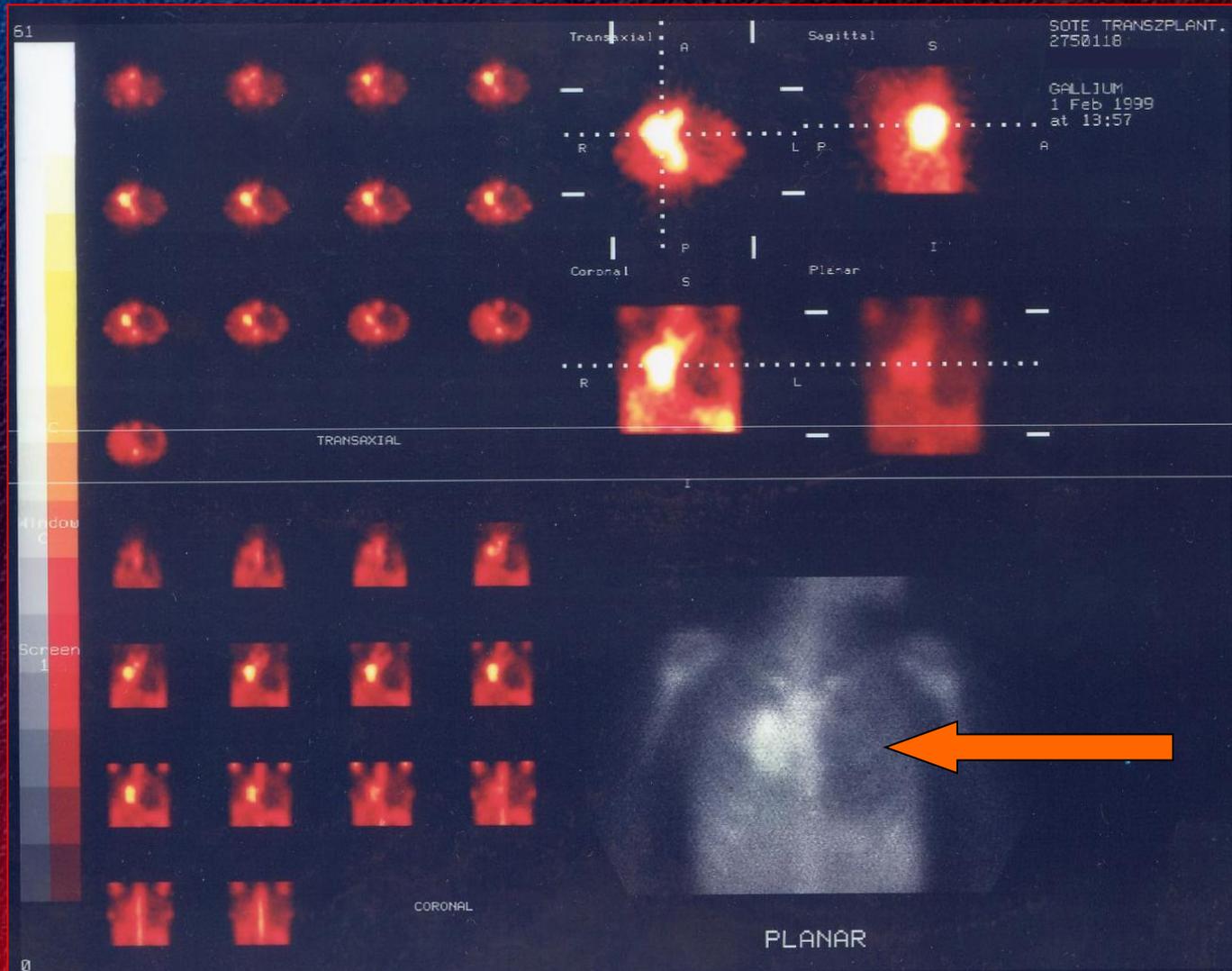
Dg: Hodgkin disease



**Mediastinal
mass**

Anterior view and SPECT imaging of the chest

Dg: Non-Hodgkin disease before radiation

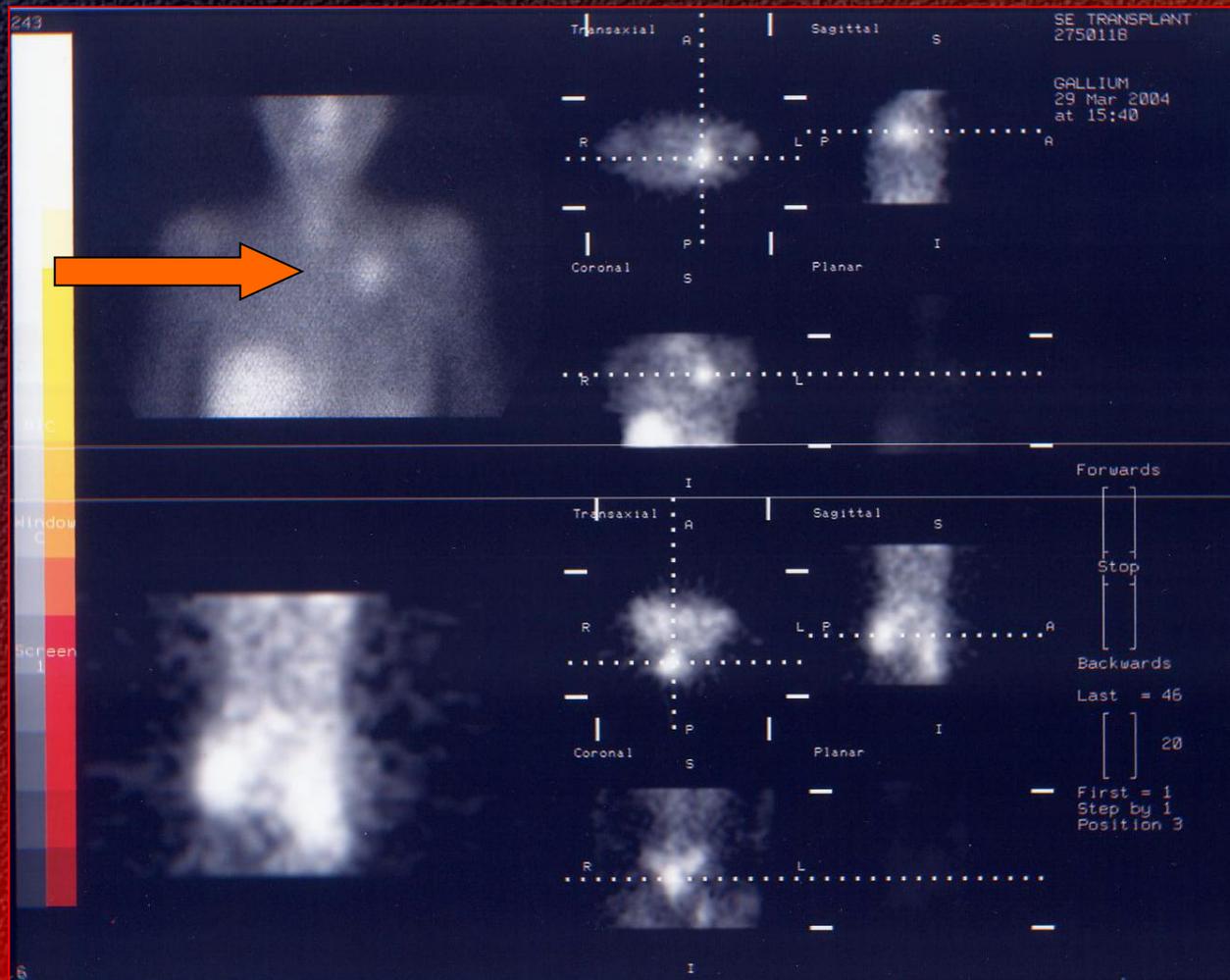


**Mediastinal
mass
in the
right side**

Anterior view and SPECT imaging of the chest

Dg: Non-Hodgkin disease after radiation
+ recidiva in the opposite side

New lung manifestation in the left side



+Beta (positron) radiation

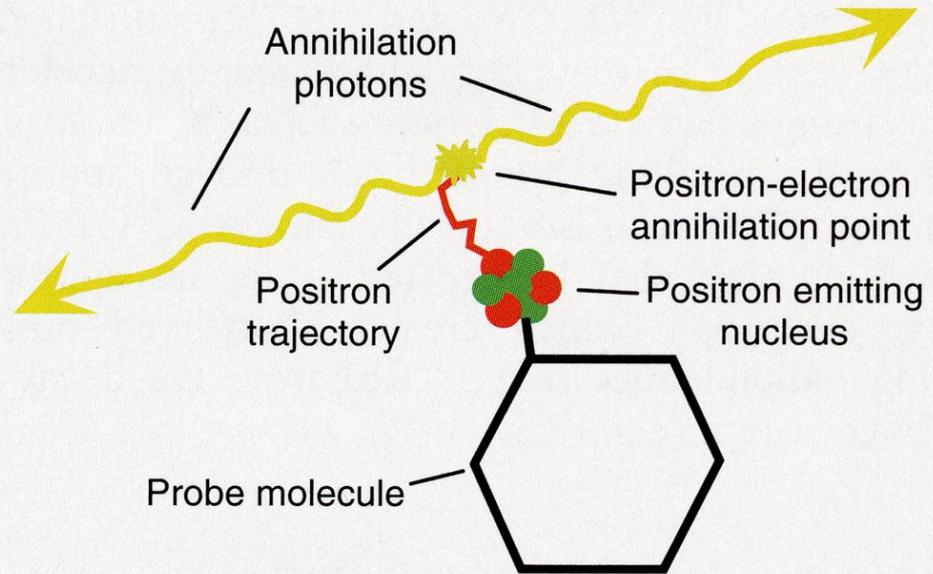
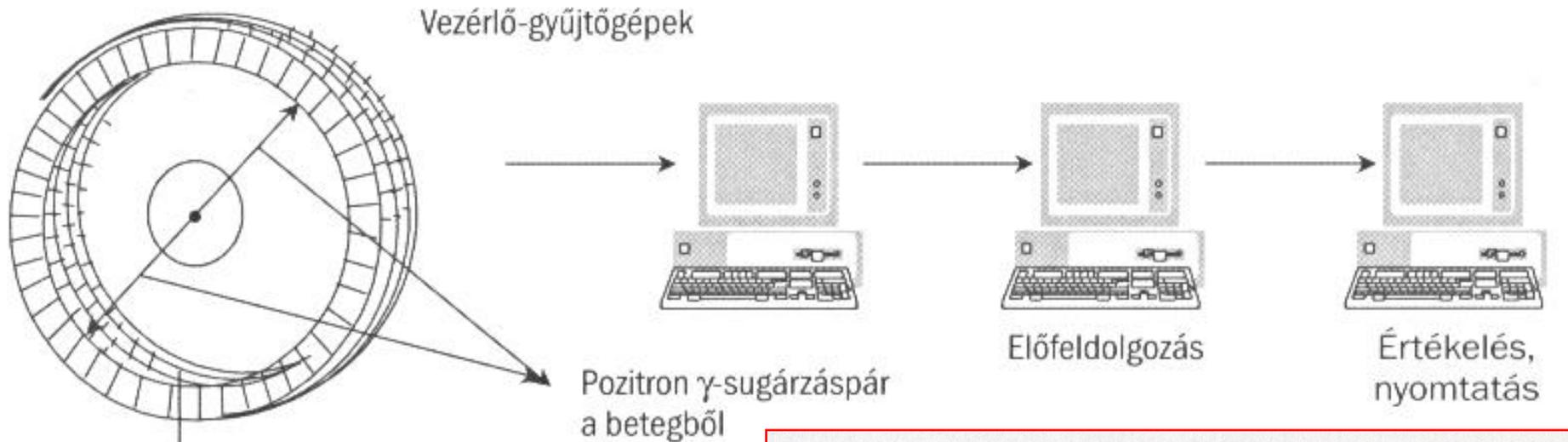
- too many protons are in the nucleus**
- its life is very short, when it slows down, it combines with a normal electron in a process known annihilation, which destroys both the electron and positron and produces two energetic photons each with 511 keV**
- they are used for PET examinations**

The equipments III.

- PET (Positron Emission Tomograph)
- PET/CT: multimodality!



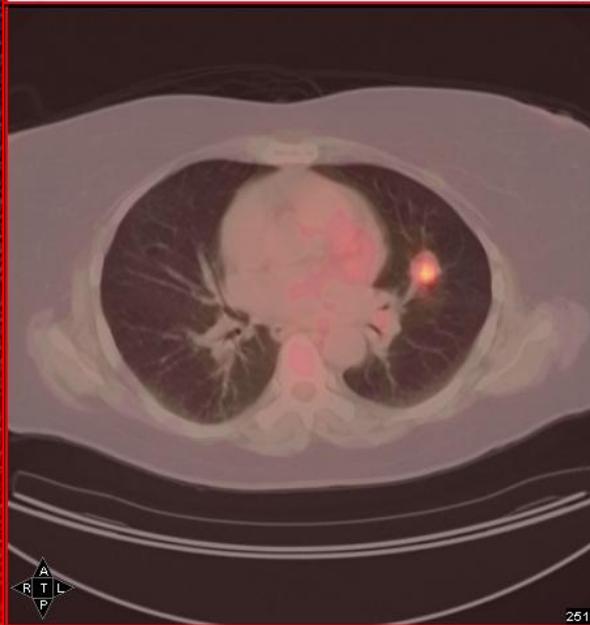
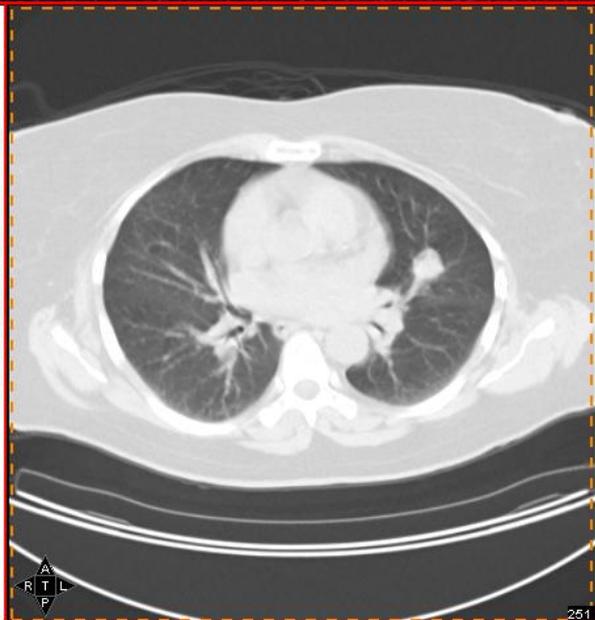
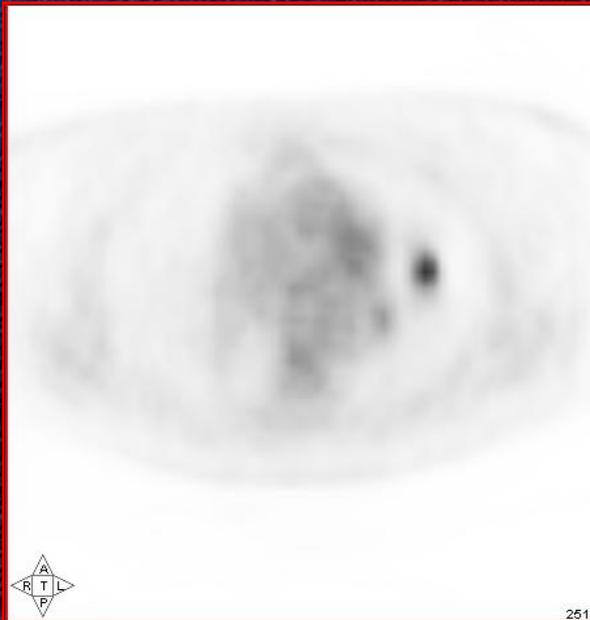
The principle of the PET imaging



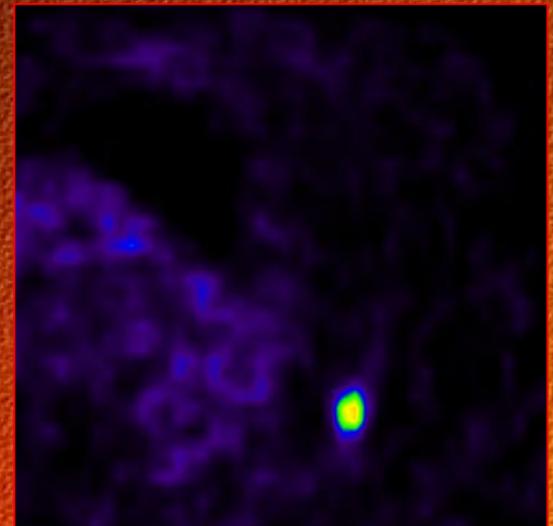
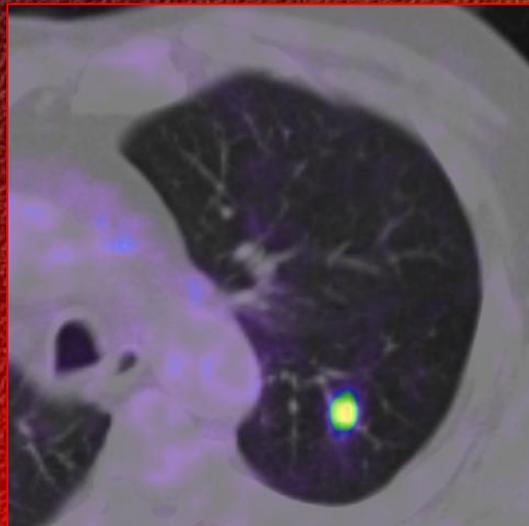
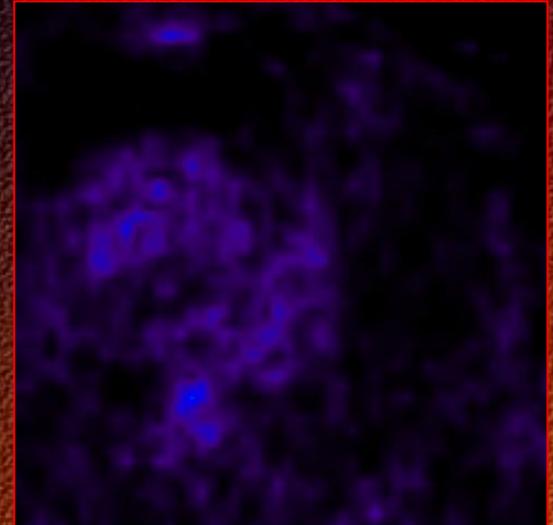
**Peripheral
lung
tumor and
mediastinal
lymph node
metastasis
by ^{18}F -FDG
(fluoro-
desoxy-
glucose)
PET/CT**



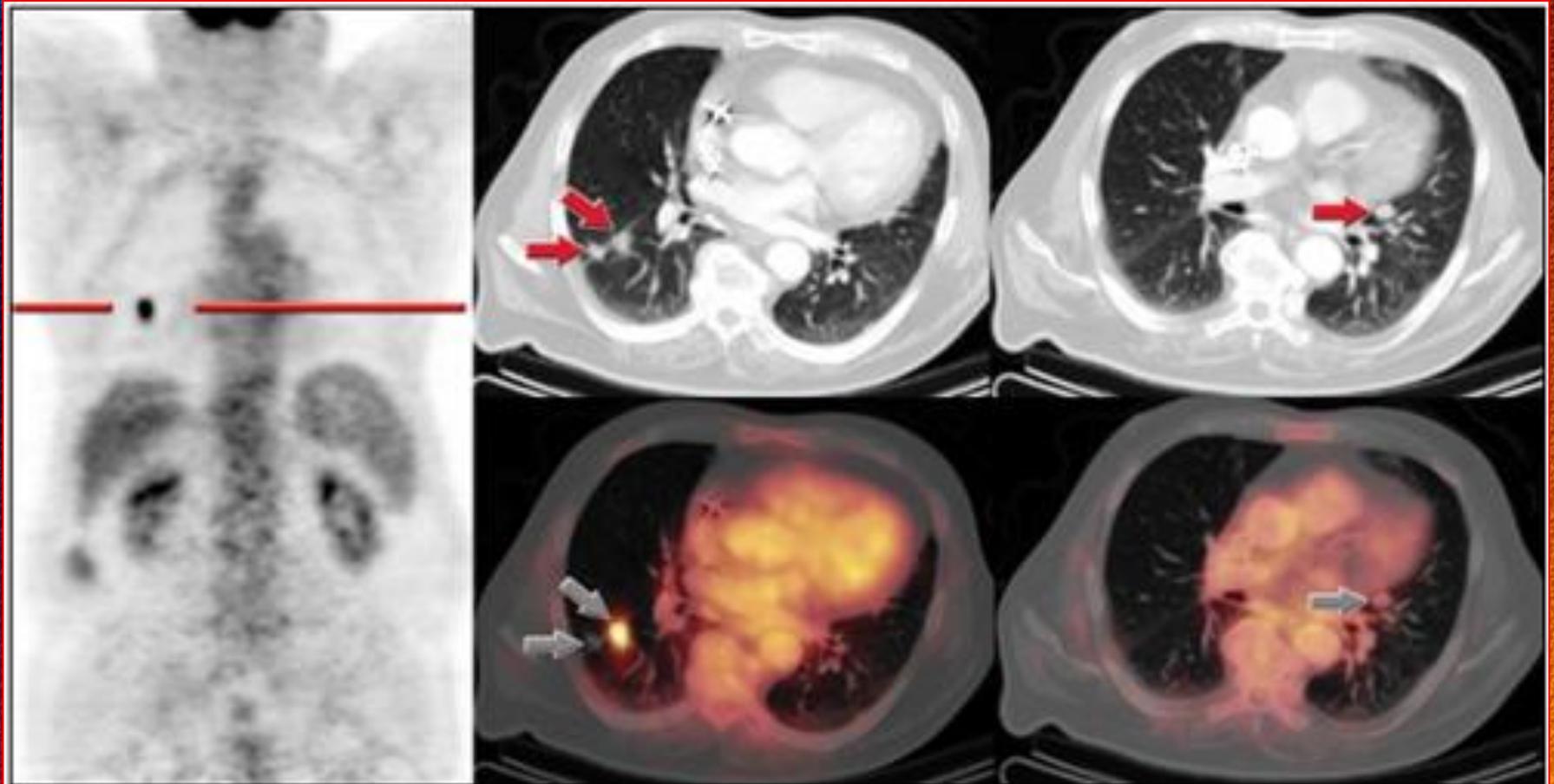
Bronchogenic carcinoma by 18F-FDG PET/CT



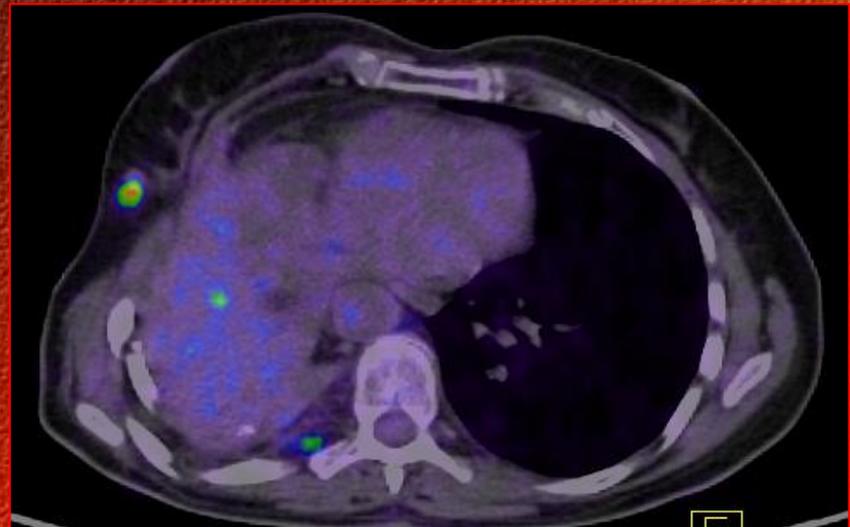
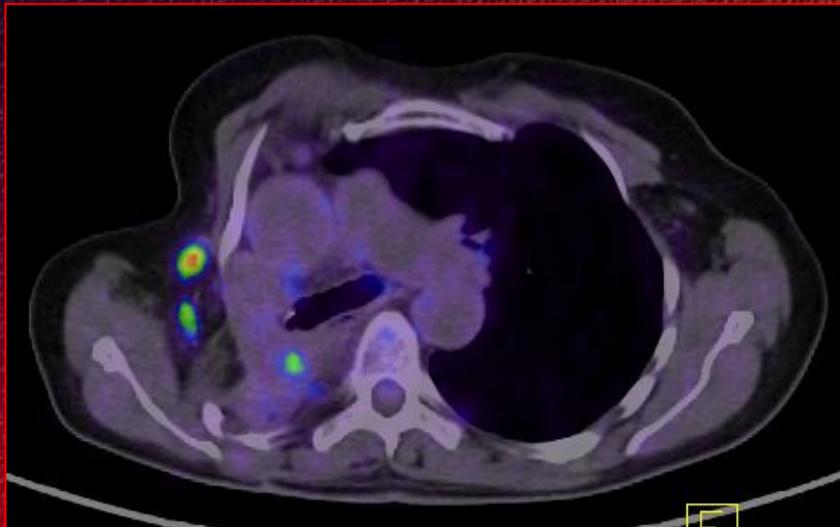
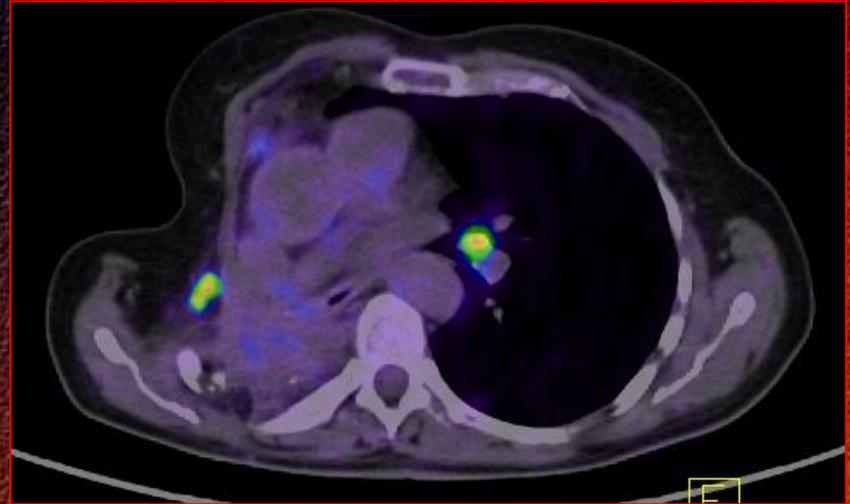
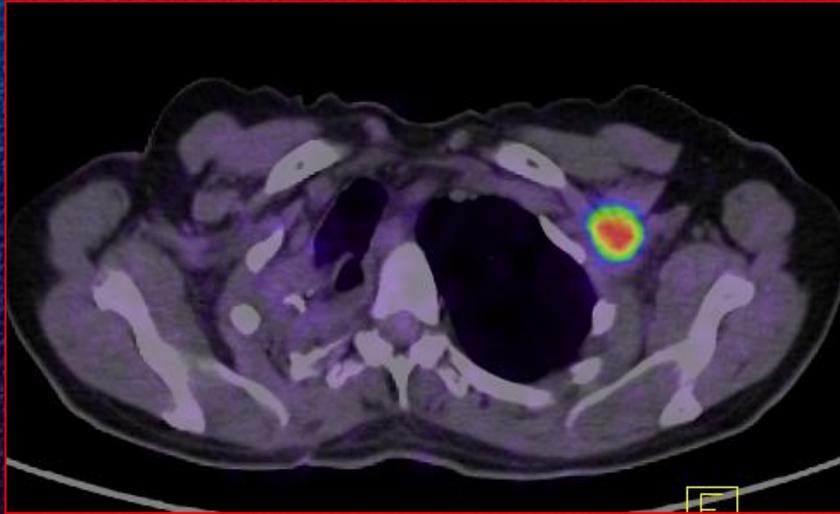
FDG avid lung metastasis and FDG negative benign tumor



**FDG avid adenocarcinoma in the right lung
and 2 benign hamartomas in both side
by 18F-FDG PET/CT**

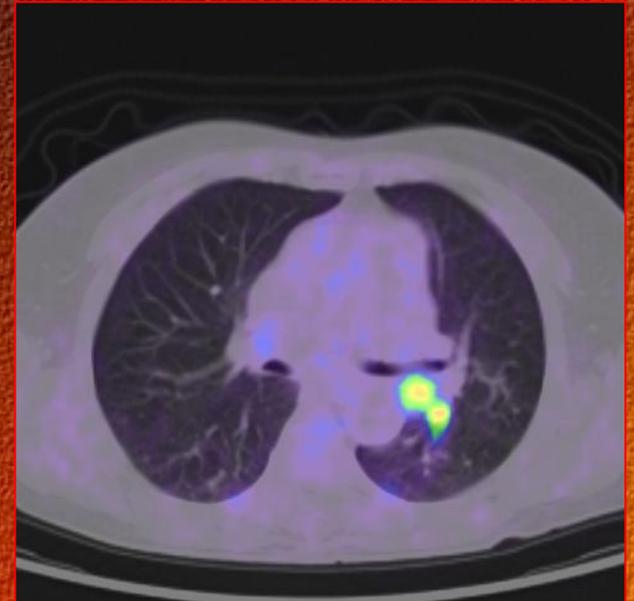
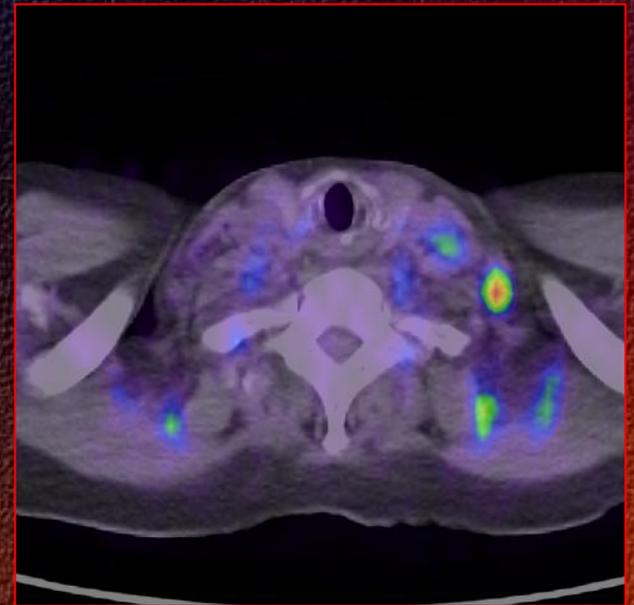
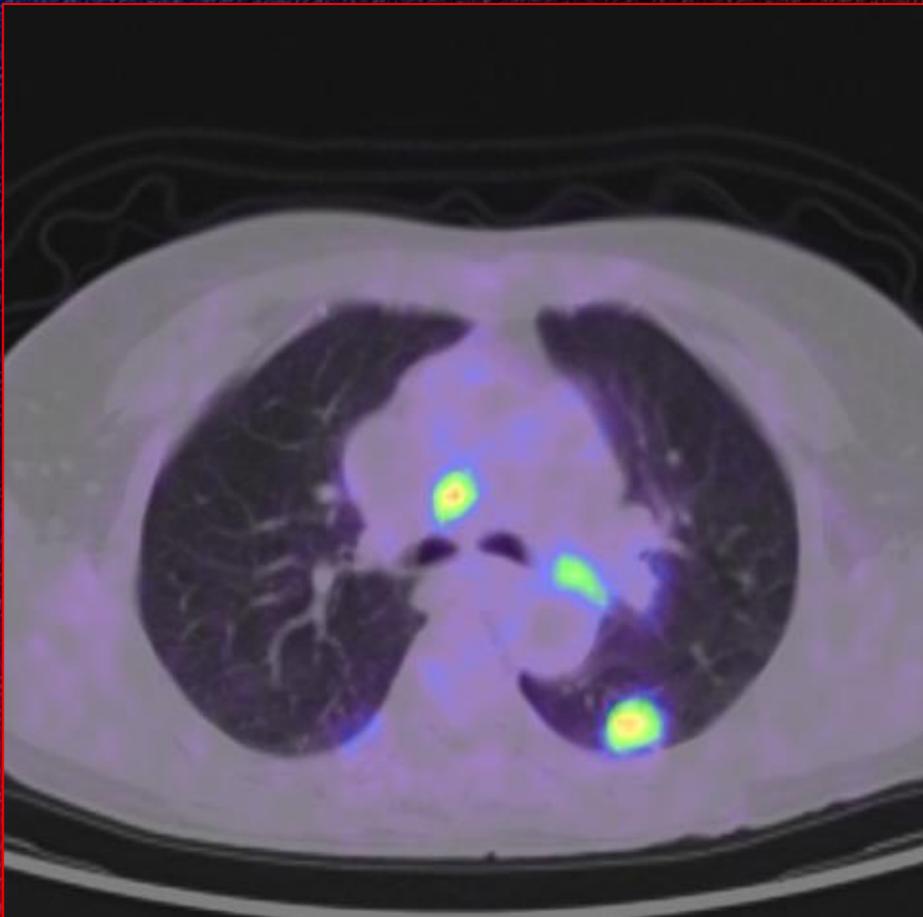


Recidiva of small cell lung cancer after pulmonectomy

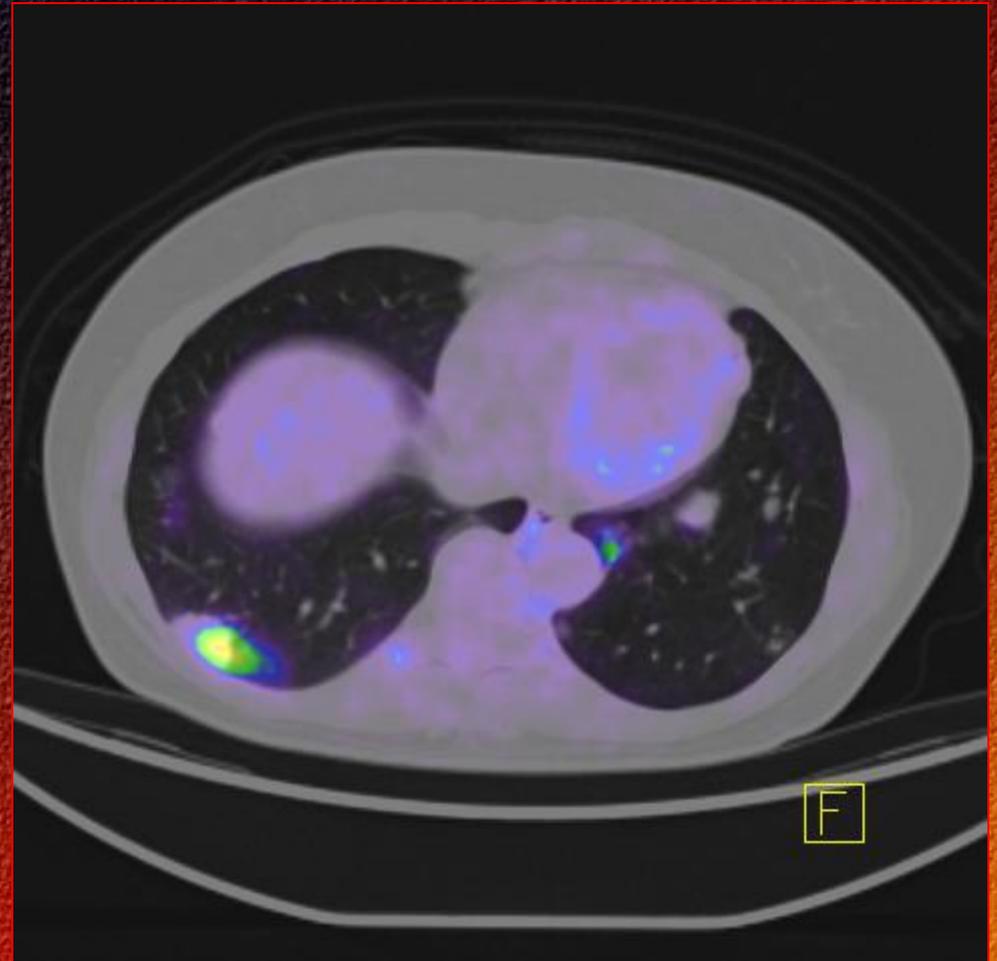
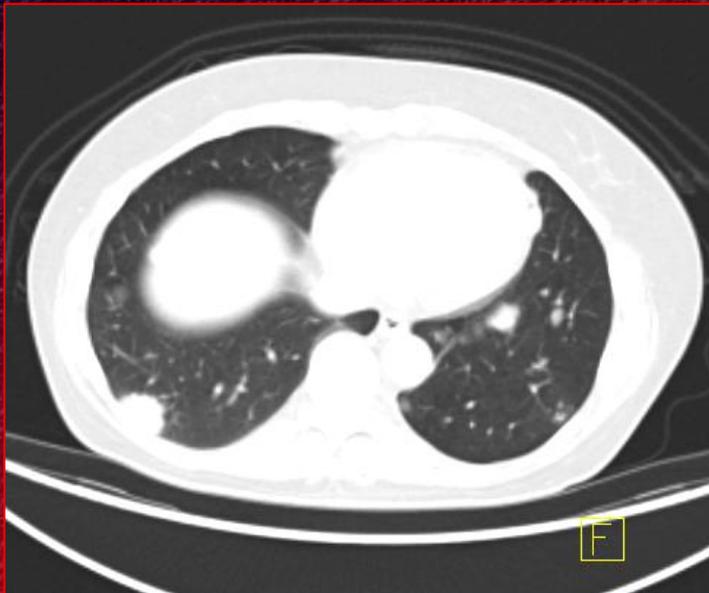
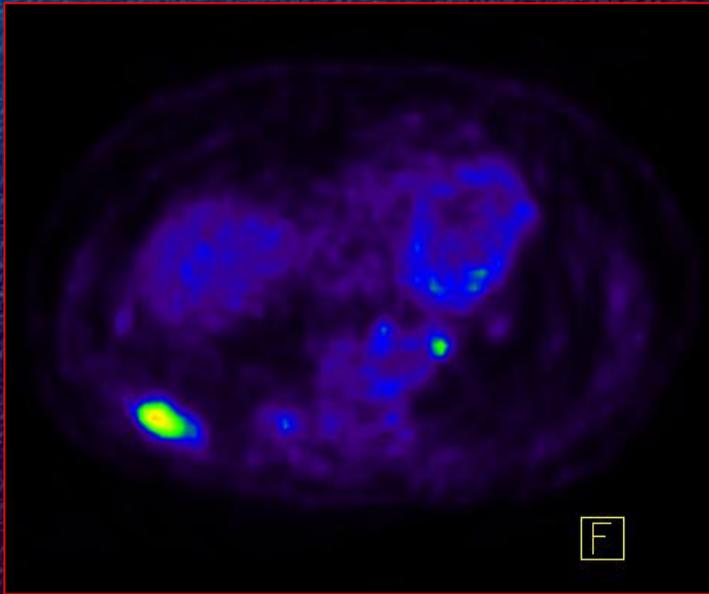


Staging, restaging

Metastases of adenocarcinoma



Localization of the biopsy



„First passage” study

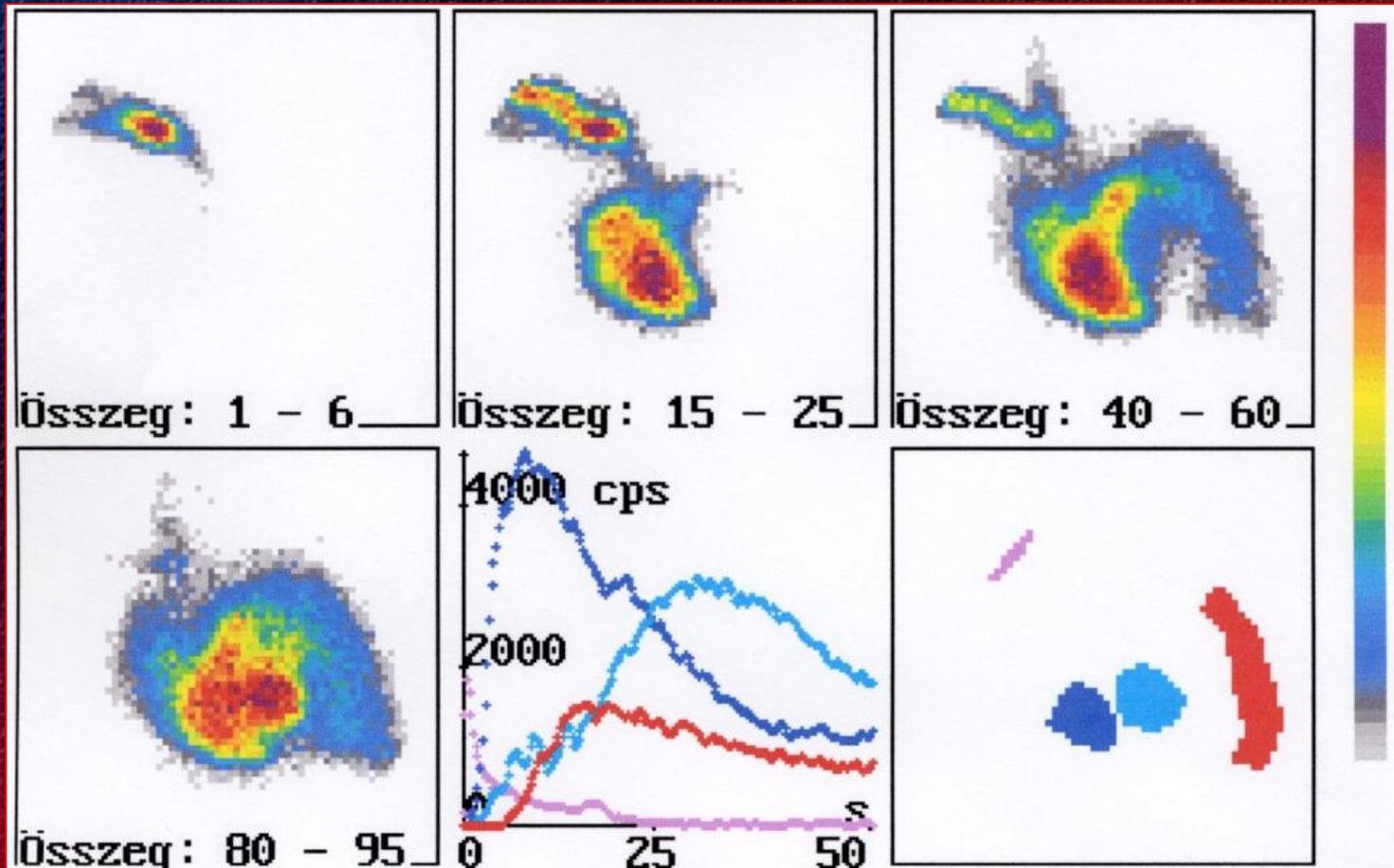
- The radioactive subject: **^{99m}Tc -DTPA** (rapid movement from the body through the kidneys)
- Fast dynamic through the heart and the lung
- „Bolus” of the injection is important
- Cardio-pulmonary circulation times
- Cardiac output, stroke volume

The way of the bolus

sup. v. cava

right ventricle

pulm. artery+lungs

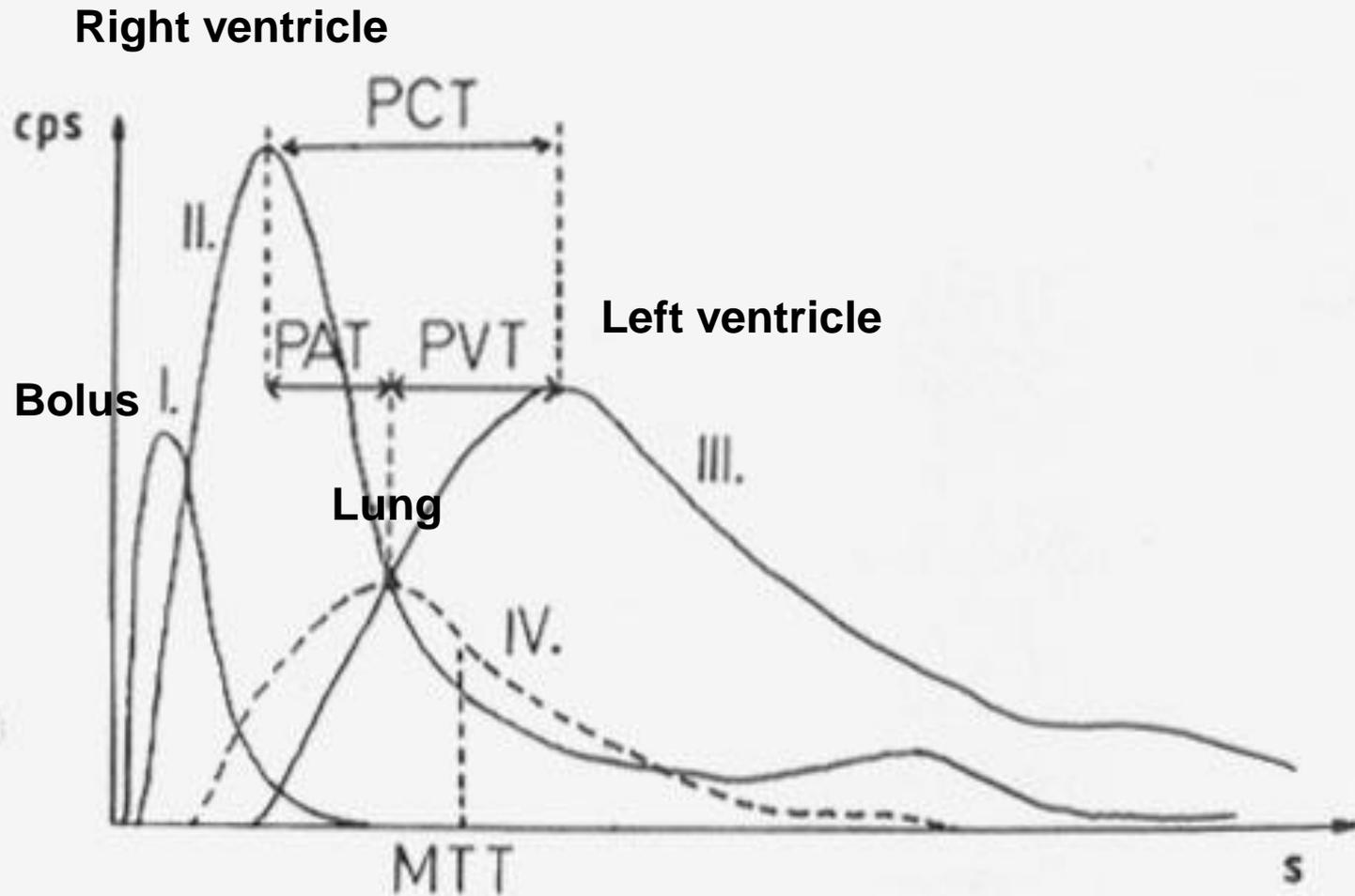


left ventricle

curves

ROIs

Time-activity curves and circulation times

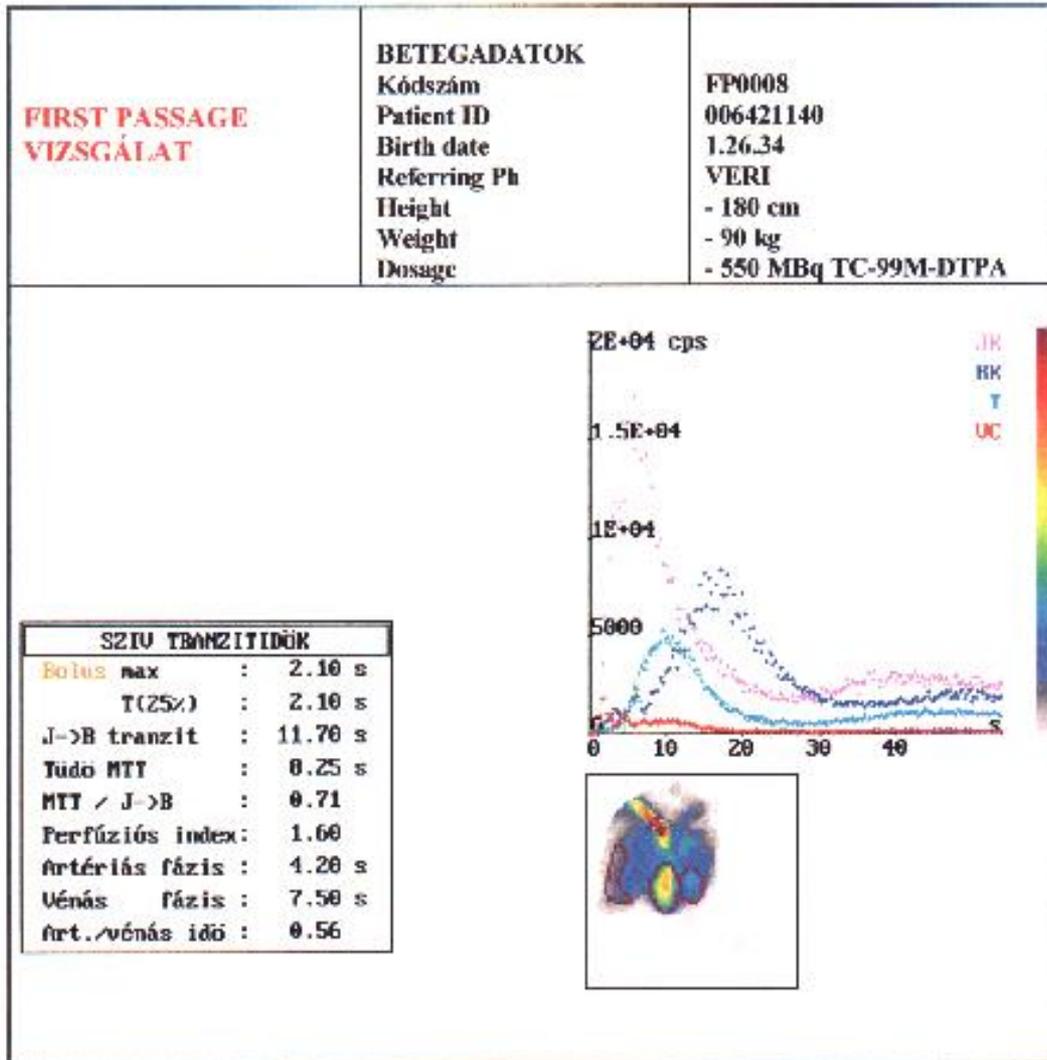




Átlagos tüdőátfolyási idő vizsgálat lelete

PÉCSI TUDOMÁNYEGYETEM ÁLTALÁNOS ORVOSTUDOMÁNYI KAR
Központi Klinikai Radioizotóp Laboratórium
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The report of the FP examination



Bone scintigraphy I.

- **Bone tissue has high activity for the intravenously injected phosphate agents (99mTc-MDP). The effectivity of the incorporation depends on the blood supply and on the calcium and phosphorus metabolism of the bone.**
- **The method is very sensitive, which becomes positive in the earliest stage of the bone disorders. The increased bone metabolism already can be shown 6 months earlier than the changing of bone structure in the X-ray.**

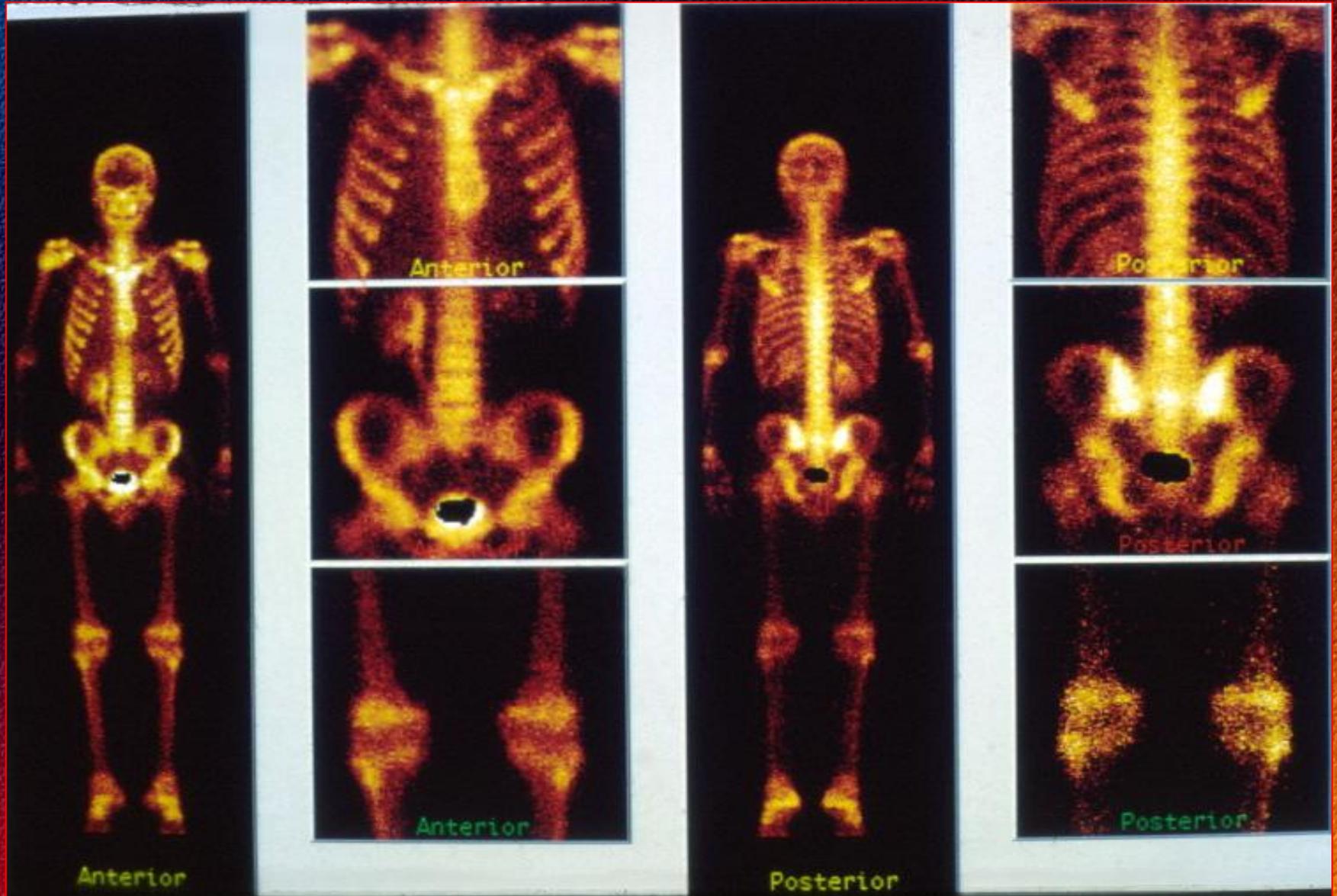
Bone scintigraphy II.

- Injected subject: **99mTc-phosphate (MDP, EDP, Pyrophosphate) intravenously**
- The study can be started after 2-3 hours **(slow metabolism)**
- Important: **rich fluid input!**

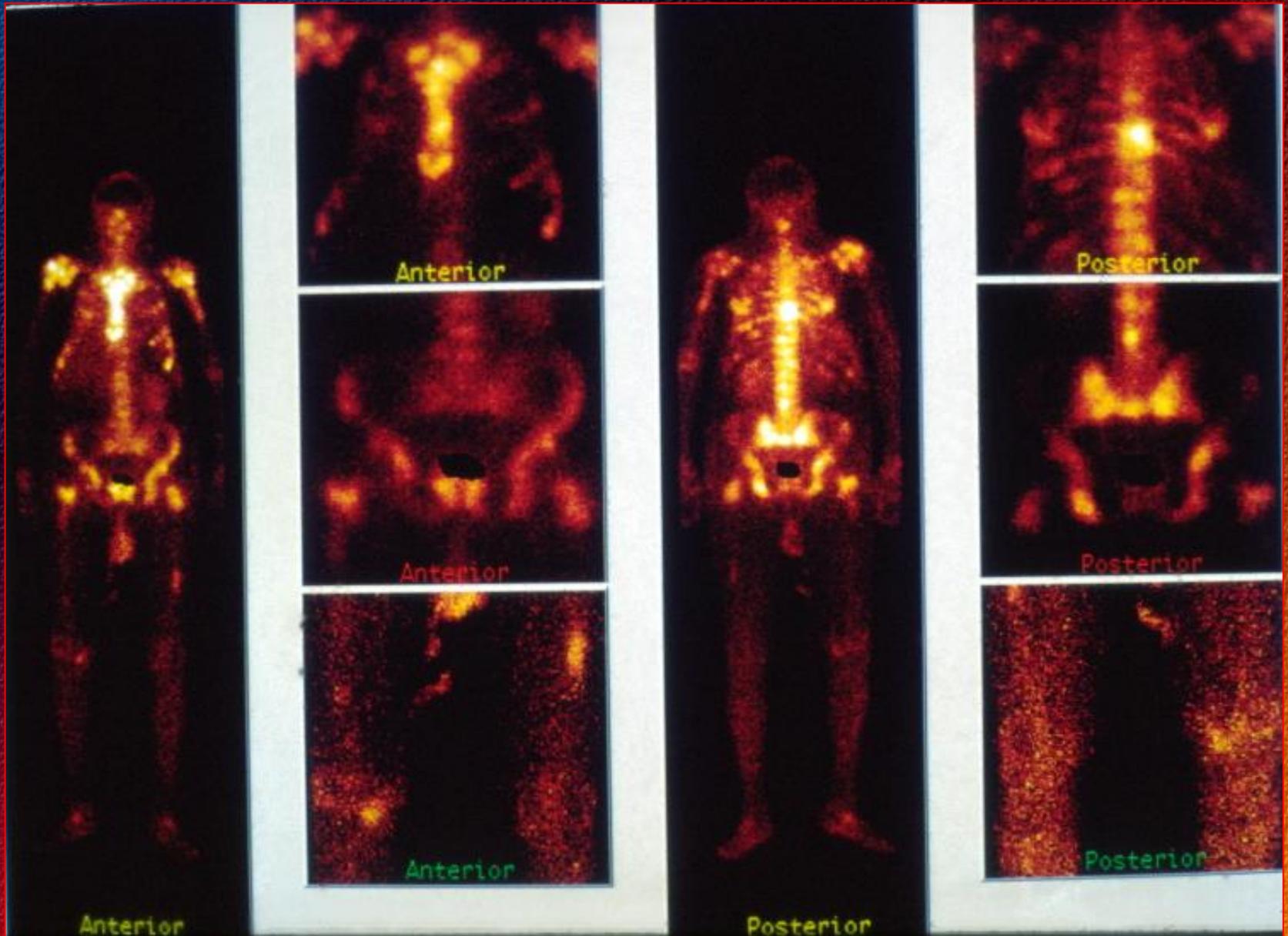
Indications of the bone scintigraphy

- **Metastases of the bone (mamma cc., prostatic cc, lung cc., malignant melonoma, and so on)**
- **Primary bone tumors**
- **Osteomyelitis, other inflammatory diseases**
- **Fractures (pathologic and stress fracture)**
- **Metabolic diseases (e.g. Paget disease)**
- **Osteonecrosis (e.g. M. Perthes)**

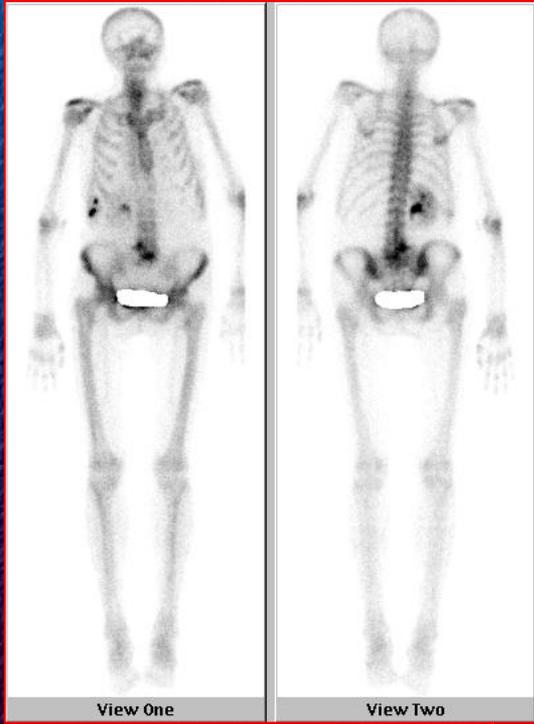
Normal whole body bone scintigraphy



Multifocal hot-spots in bronchial carcinoma



WBB

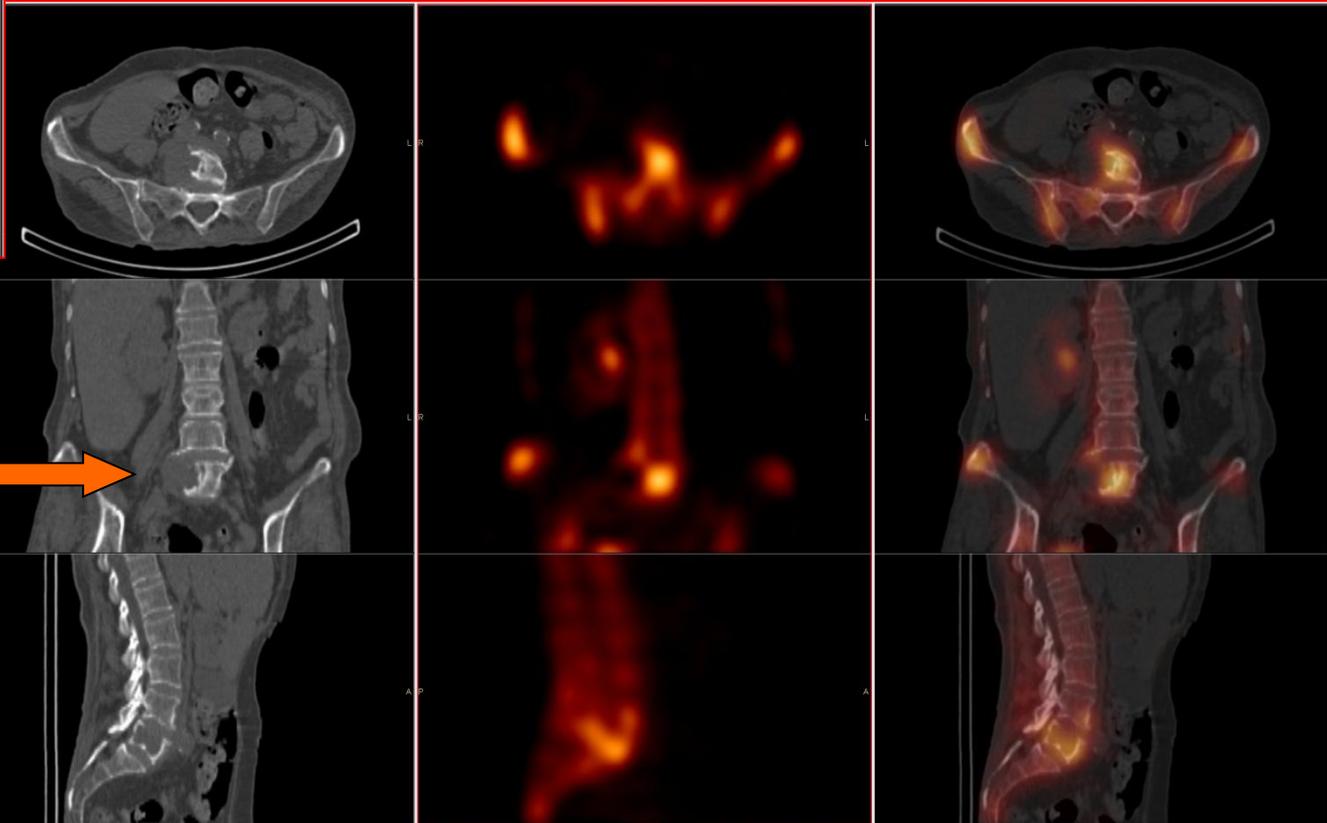


Hot spots in the lumbal spine: degenerative or metastatic lesions?

CT

SPECT

SPECT/CT



Thank you for your attention!

