# The chiefs of the groups

after the lecture send the presence of the students of your group to the address

**anatolie.obada@usmf.md**

# All students

write in the chat

**Last name, First name, group number**

to confirm your presence

# MEDICAL IMAGING

# MEDICAL IMAGING

- **RADIOLOGY**
- **NUCLEAR MEDICINE**
- **ULTRASONOGRAPHY (ECHOGRAPHY)**
- **MRI (MAGNETIC RESONANCE IMAGING)**
- **THERMOGRAPHY**

# MEDICAL IMAGING

| Modality | Radiography Fluoroscopy | Computed Tomography | Ultrasono-graphy | Magnetic Resonance Imaging | Nuclear Medicine |
|---|---|---|---|---|---|
| **Energy type** | X-rays | | Ultrasuond | Magnetic field and radiofrequency | Gamma rays |
| **Source of energy** | X-ray tube | | Piezoelectric crystal | Magnet, RF coils | Raionuclides |
| **Terminology used for black and white** | Opacity Lucency | Hyperdensity Hypodensity | Hyperecogenity Hypoecogenity | Hyperintensity Hypointensity | Hyperfixation, (hot spot) Hypofixation (cold spot) |
| **Ionizing radiation** | + | | - | - | + |
| **Contraindica-tions** | Pregnancy, prophylactic investigations in children | | - | Implanted metal devices | Pregnancy, children up to one yeary |
| **Contrast substances** | High and low density substances | | Substances with microbubbles | Paramegetic substances | - |

# MAGNETIC RESONANCE IMAGING
# (MRI)

# Imagistica prin rezonanță magnetică (IRM)

Magnetic resonance imaging (MRI) is currently one of the most modern and sophisticated technologies, using magnetic fields, radio waves and a powerful computer to produce high-resolution images of body structures;

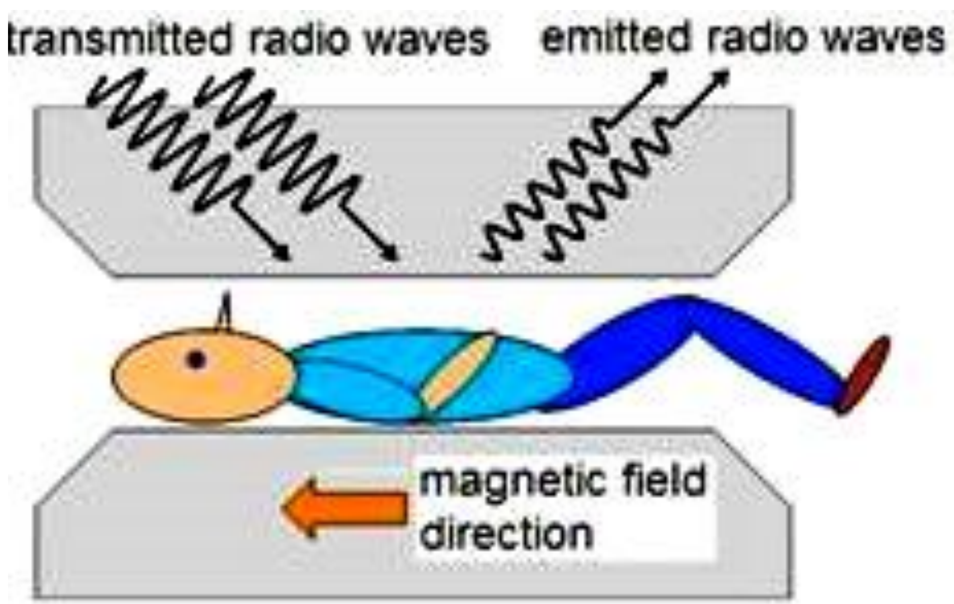
Each tissue has its own composition and the percentage of water and protons varies, and the areas affected by various pathological processes change their structure compared to the adjacent tissue.

# MRI
## (MAGNETIC RESONANCE IMAGING)

- BASED ON RADIO-FREQUENCY RADIATION PRODUCED BY THE EXCITATION OF ODD ATOMIC NUCLEI IN A STRONG MAGNETIC FIELD

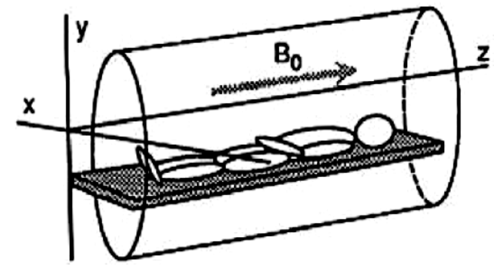
# MRI

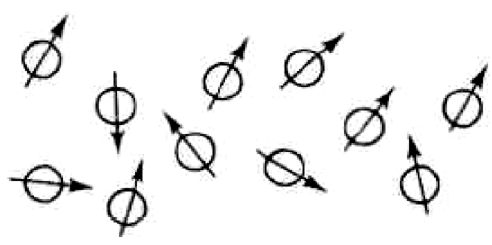
Uses magnetic fields and radio waves to produce images of thin slices of tissues (tomographic images).



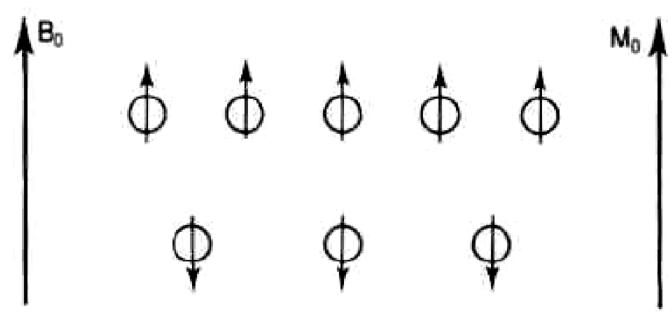
# MRI

- Normally, protons within tissues spin to produce tiny magnetic fields that are randomly aligned.
- When surrounded by the strong magnetic field of an MRI device, the magnetic axes align along that field.



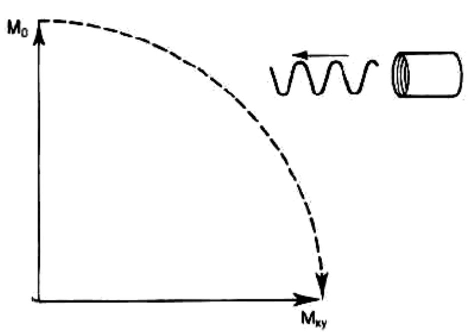
(a)

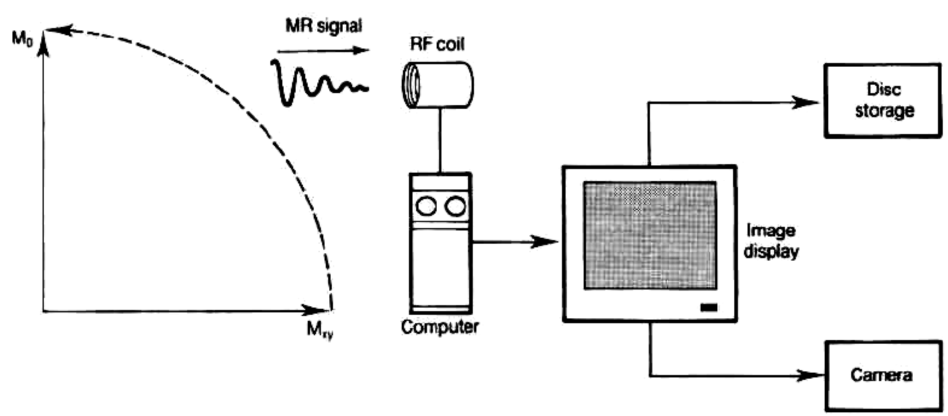



(b)

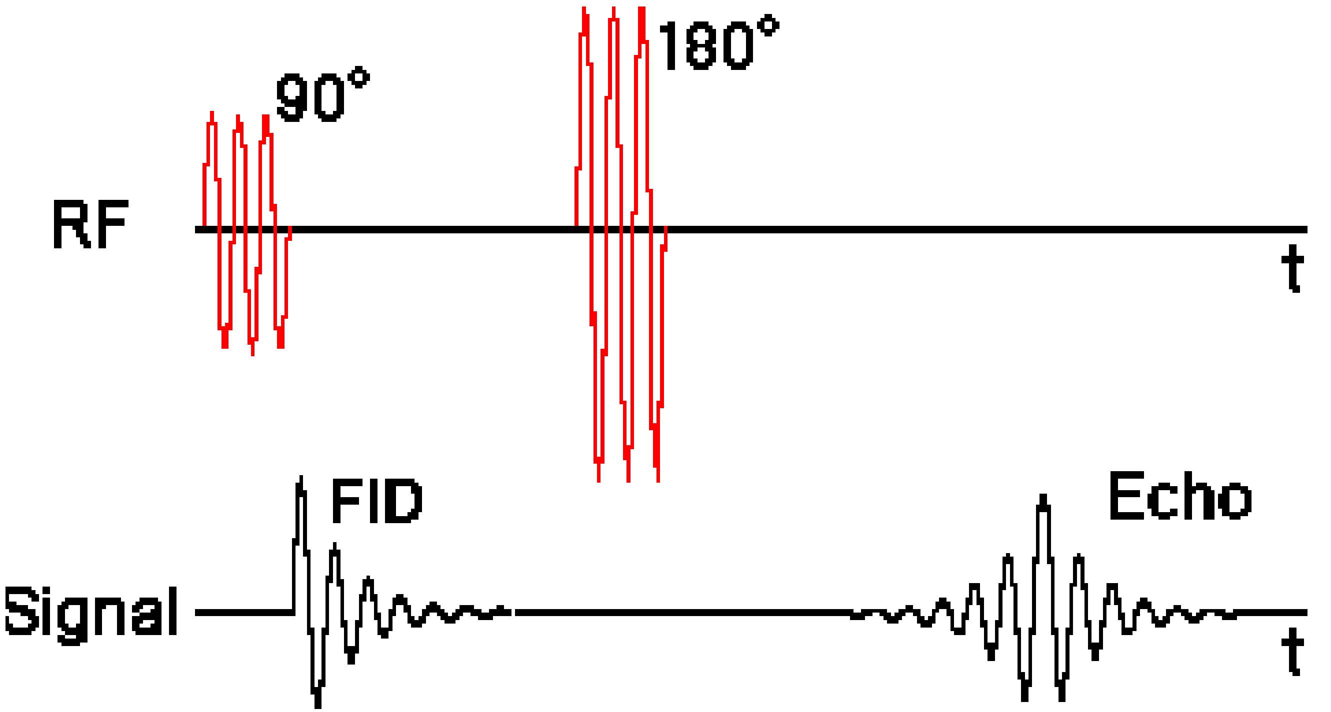
# MRI

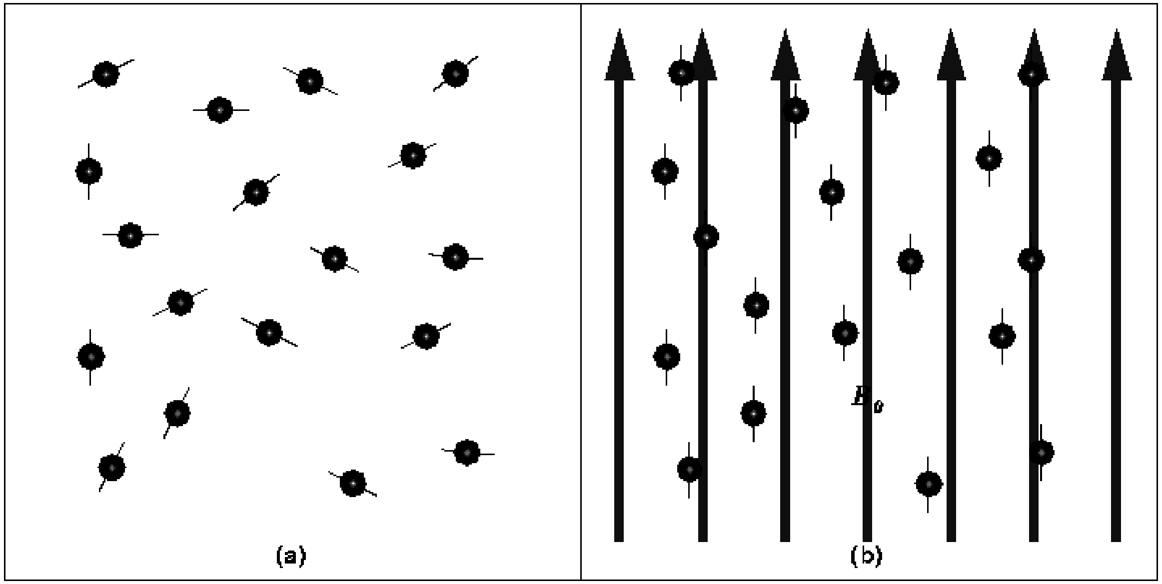
- A radiofrequency pulse is then applied, causing the axes of all protons to momentarily align against the field in a high-energy state.
- After the pulse, some protons relax and resume their baseline alignment within the magnetic field of the MRI device.
- The magnitude and rate of energy release are recorded by a coil (antenna) as spatially localized signal intensities:
  - as the protons resume this alignment - T1 relaxation
  - as they wobble (presses) during the process - T2 relaxation
- Computer algorithms analyze these signals and produce anatomic images.



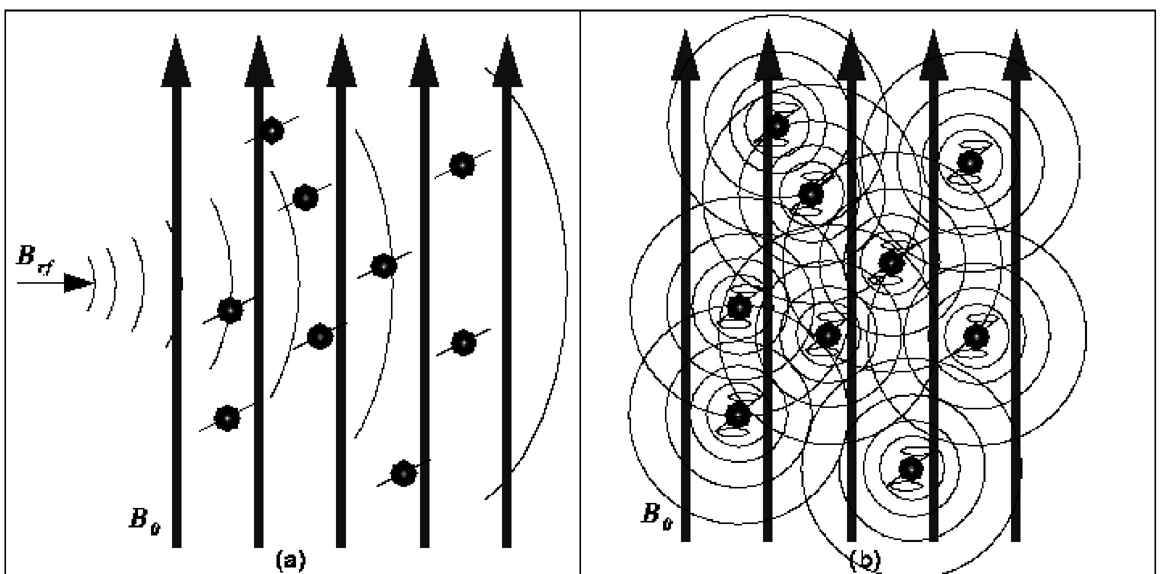



# MRI





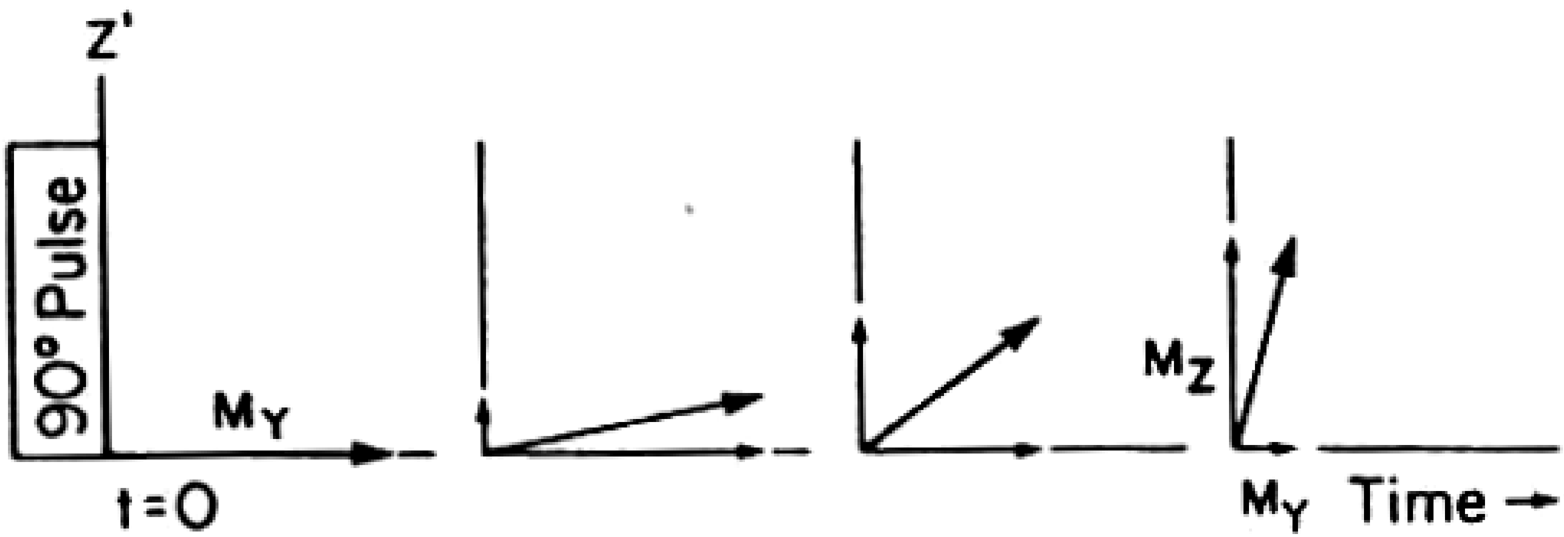
(a)
$B_0$
(b)

$B_{rf}$
$B_0$
(a)
$B_0$
(b)

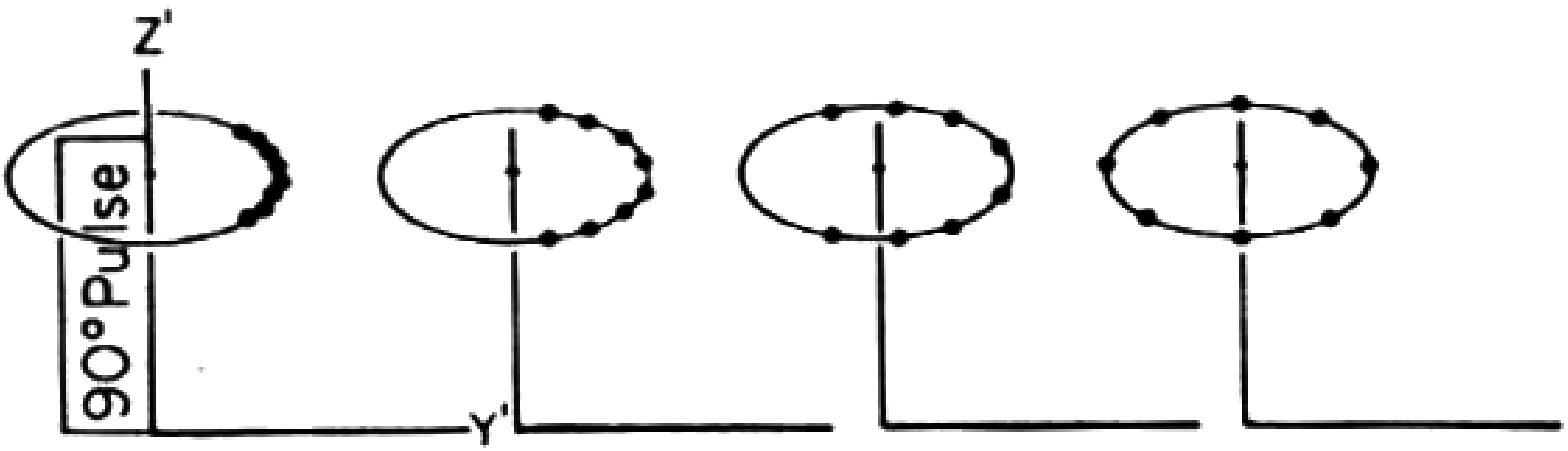
# MRI

the protons during the process of relaxation resume their baseline alignment within the magnetic field of the MRI device - **T1 relaxation**

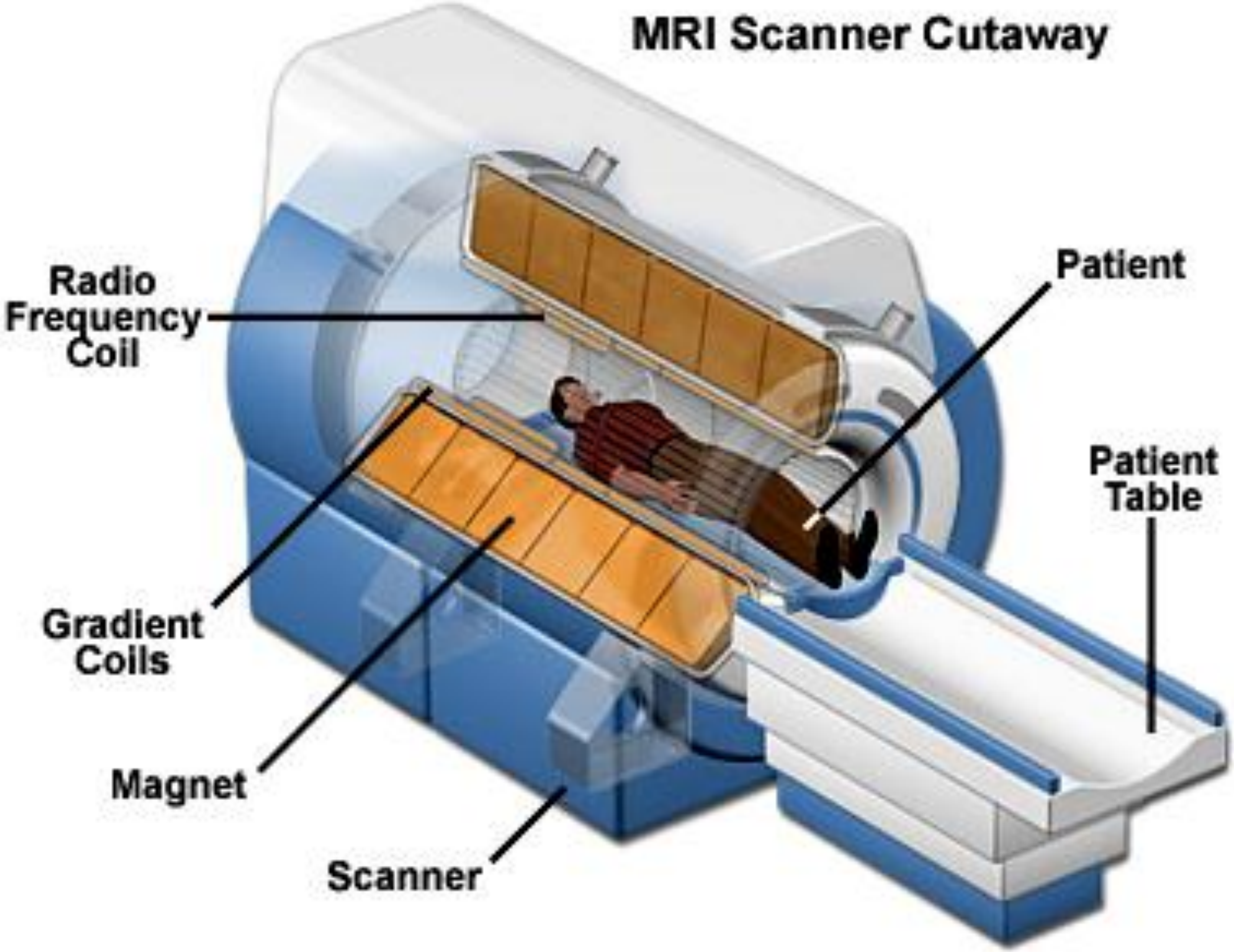


# MRI

the protons wobble (presses) during the process of relaxation within the magnetic field of the MRI device - **T2 relaxation**

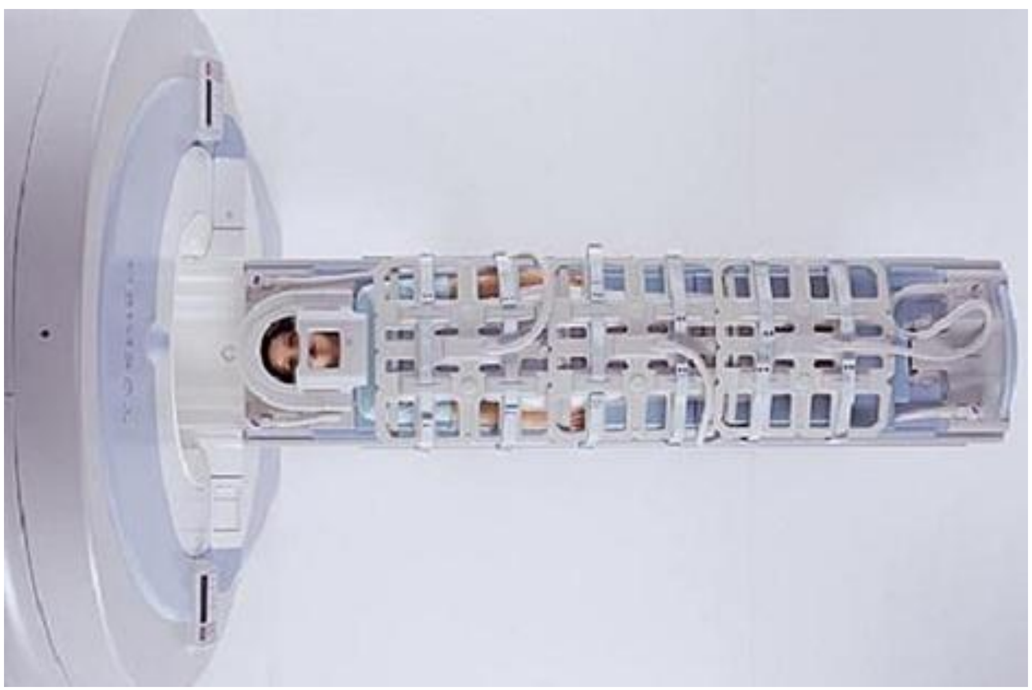



3T


MRI Scanner Cutaway
Radio Frequency Coil
Patient
Patient Table
Gradient Coils
Magnet
Scanner

# MRI

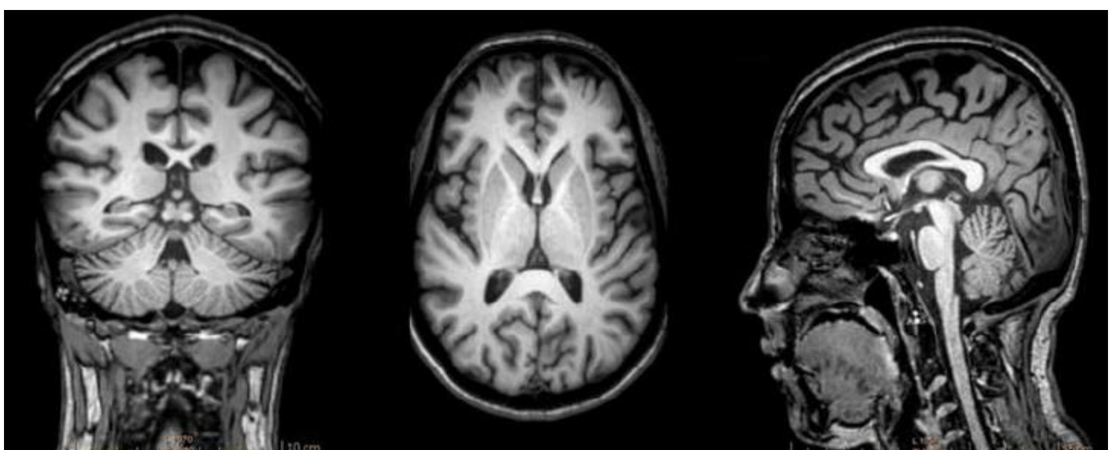
Coils (antenna)



# T1 weighted images

- T1 varies with molecular structure as well as with solid or liquid state (being longer for liquids compared to solids)

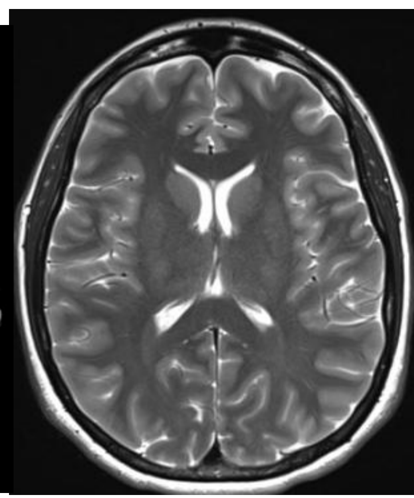
- Short T1 – **white color – hyperintensity** (fat, brain)
- Long T1 – **black color – hypointensity** (liquids)

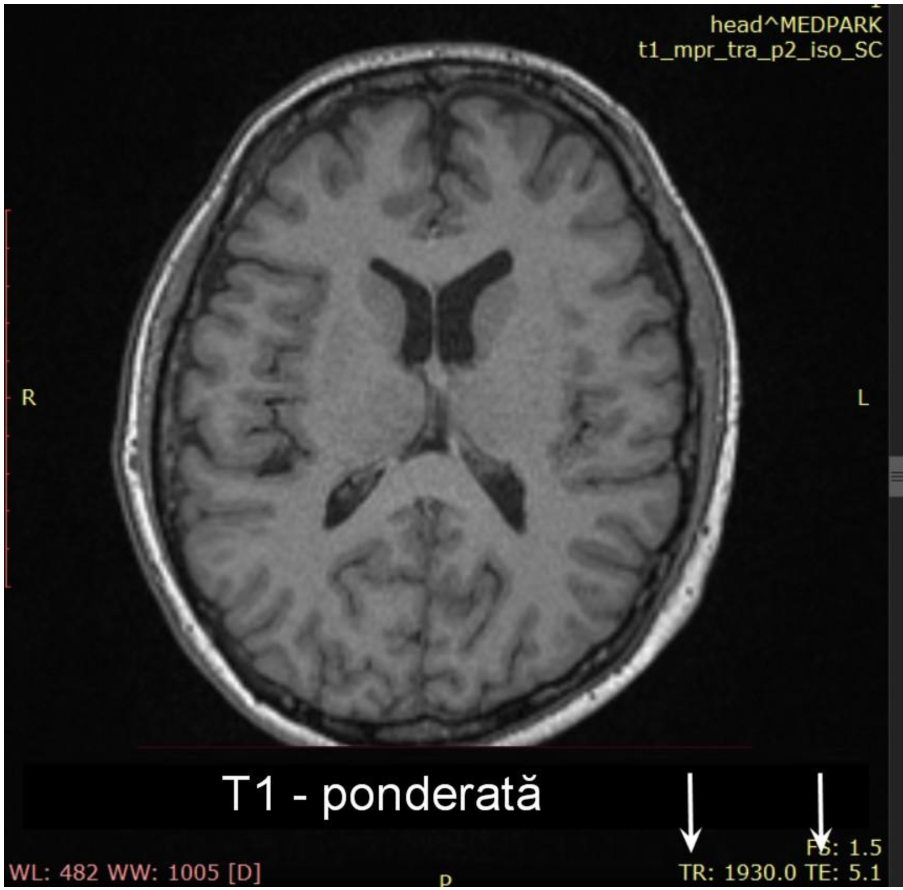


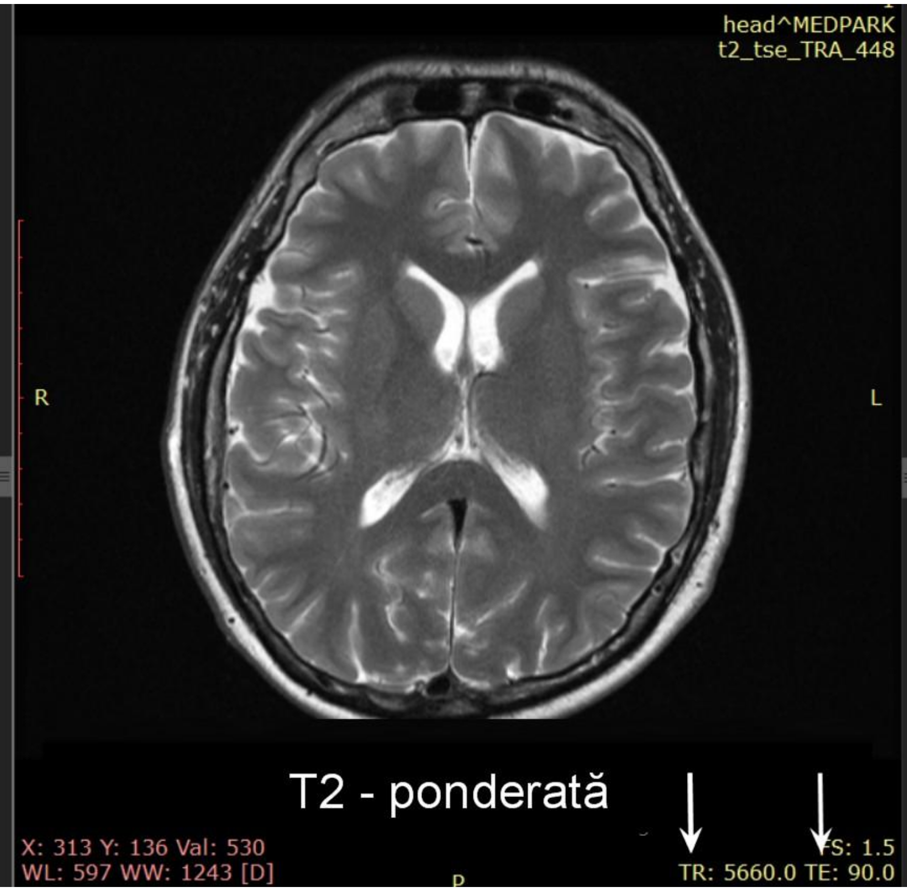
# T2 weighted images

- T2 varies with molecular structure as well as with solid or liquid state (being longer for liquids compared to solids)

- Long T2 – **white color – hyperintensity** (fat,liquids)
- Short T2 **– black color – hypointensity** (brain)

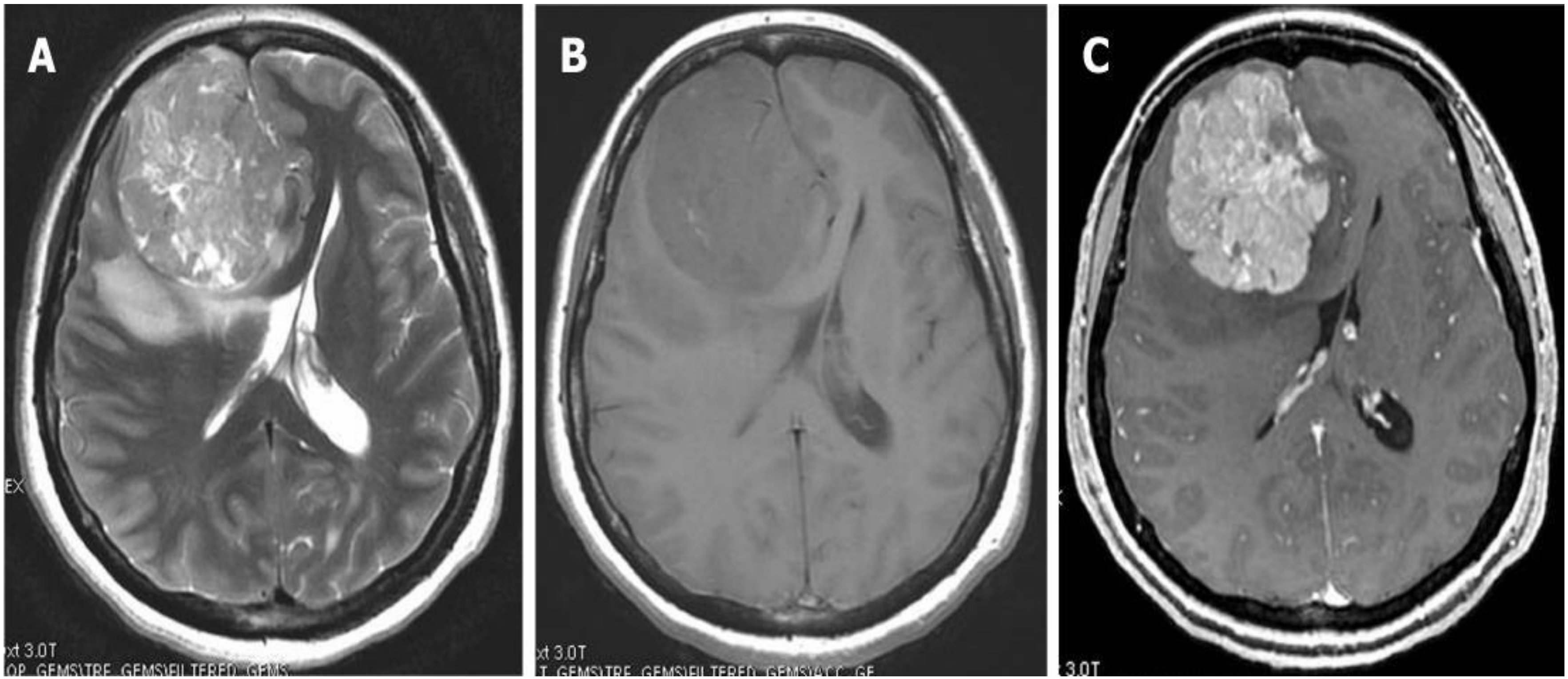

head^MEDPARK
t1_mpr_tra_p2_iso_SC
R
L
T1 - ponderată
FS: 1.5
WL: 482 WW: 1005 [D]
P
TR: 1930.0 TE: 5.1


head^MEDPARK
t2_tse_TRA_448
R
L
T2 - ponderată
FS: 1.5
X: 313 Y: 136 Val: 530
WL: 597 WW: 1243 [D]
P
TR: 5660.0 TE: 90.0


T2 weighted image


T1 weighted images

# Substanțe de contrast în IRM

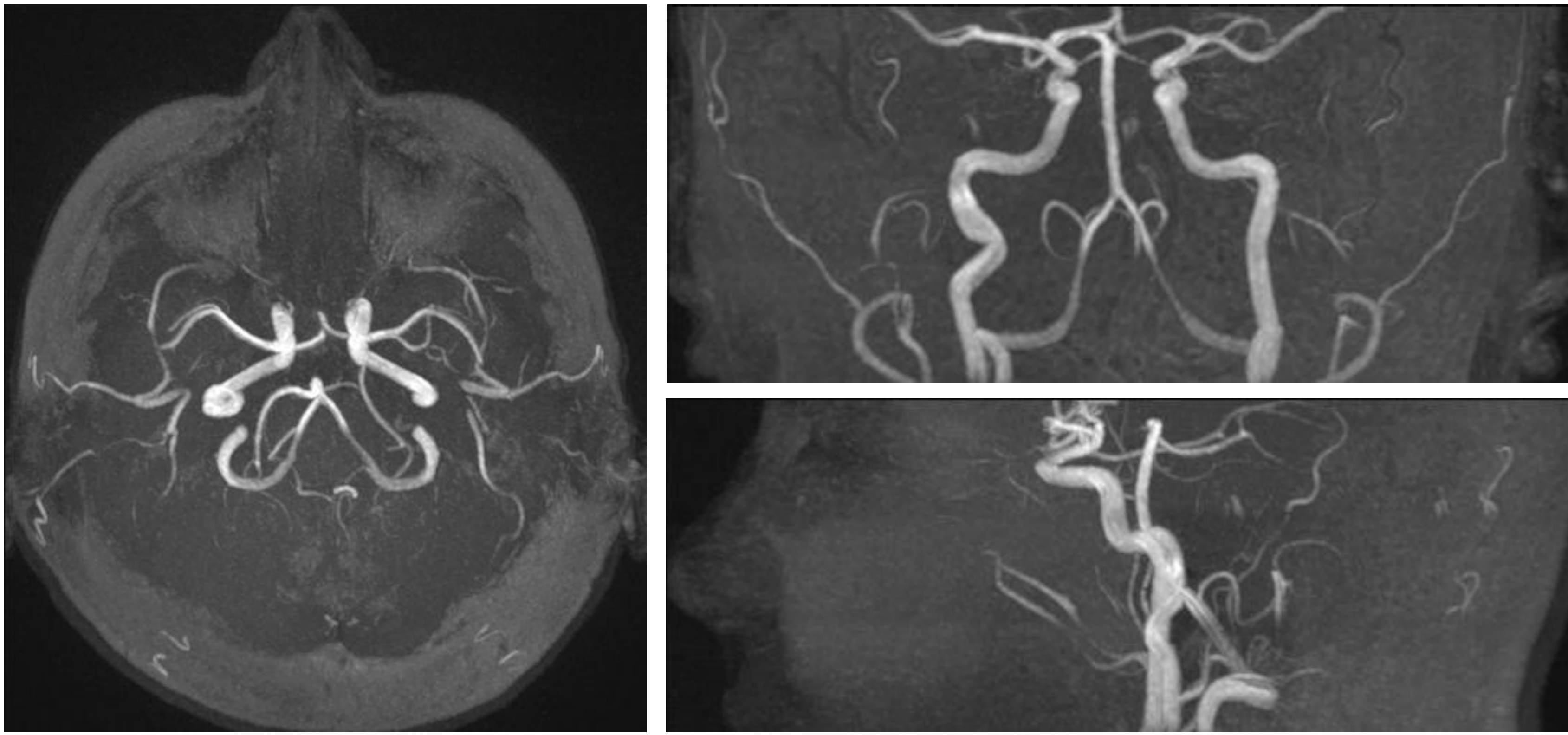



T2w

T1w without contrast media

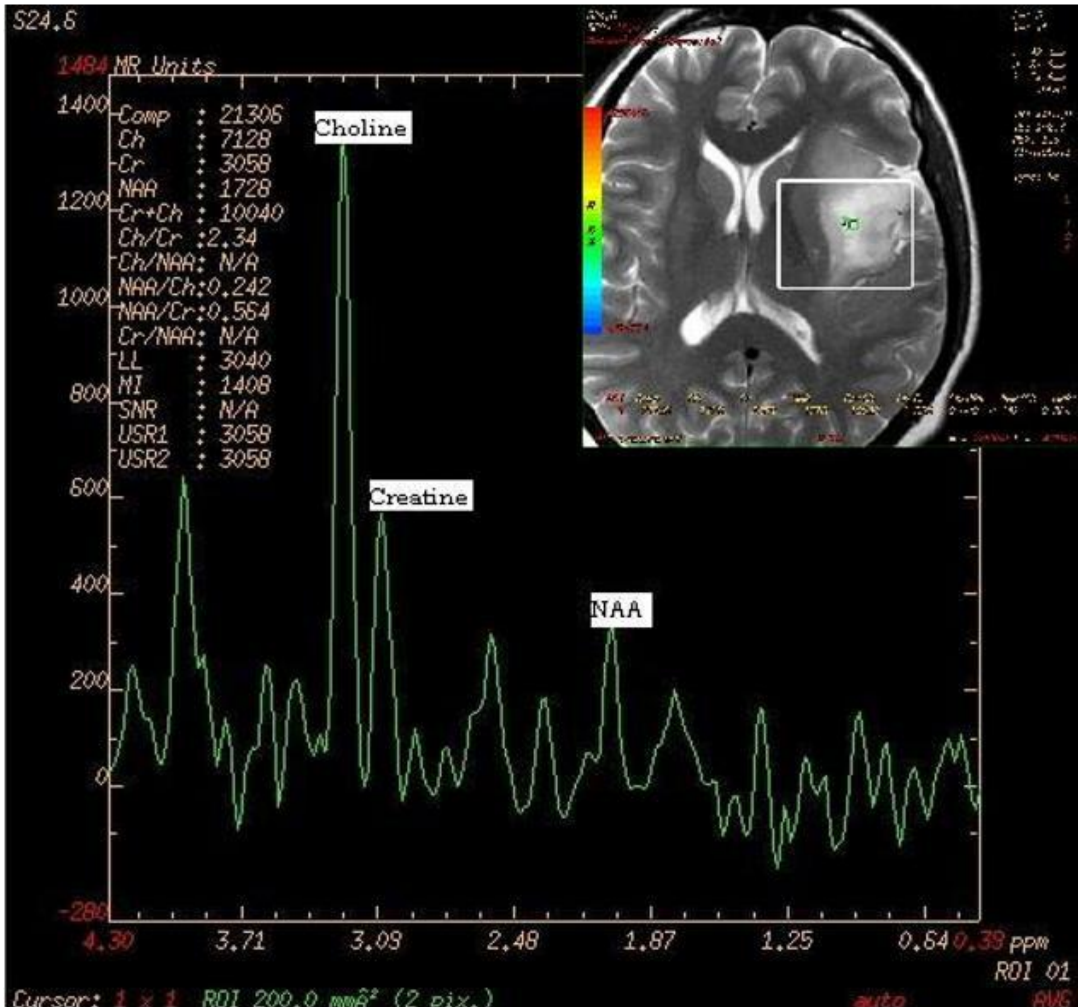
T1w with contrast media

# MR-Angiography



# Magnetic Resonance Spectroscopy (MRS)

- Magnetic resonance spectroscopy (MRS) is used to measure the levels of various metabolites in pathological tissues (inflammation, tumors).




MRS of cerebral tumor

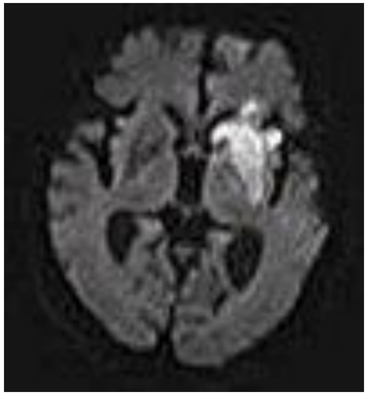
# Other types of MRI sequences

MRA (Magnetic Resonance Angiography)

ADC (Apparent diffusion coefficient)

BOLD Blood-oxygen-level dependent imaging

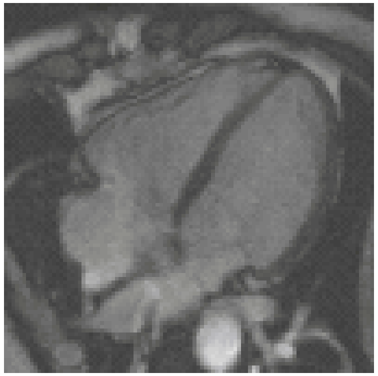
FLAIR (Fluid-attenuated inversion recovery)



DWI (Diffusion weighted imaging)

TOF (Time-of-flight)

DTI (Diffusion tensor imaging)



SSFP (Steady-state free precession)

# MRI

**Advantages:**

- **Does not use ionizing radiation.**
- **Produces sectional images in any projection without moving the patient.**
- **Requires little patient preparation and is noninvasive.**
- **Excellent soft tissue contrast**
- **Lack of artifacts from adjacent bones**



# Disadvantage

- High operating costs;
- Long scanning time, and throughout the investigation the patient must stand still;
- Patients with claustrophobia may need anesthesia.

**Contraindications**

- patients with metallic foreign bodies (metallic splinters, post-surgical clamps, pacemakers, etc.);

# ULTRASONOGRAPHY
## (ECHOGRAPHY)

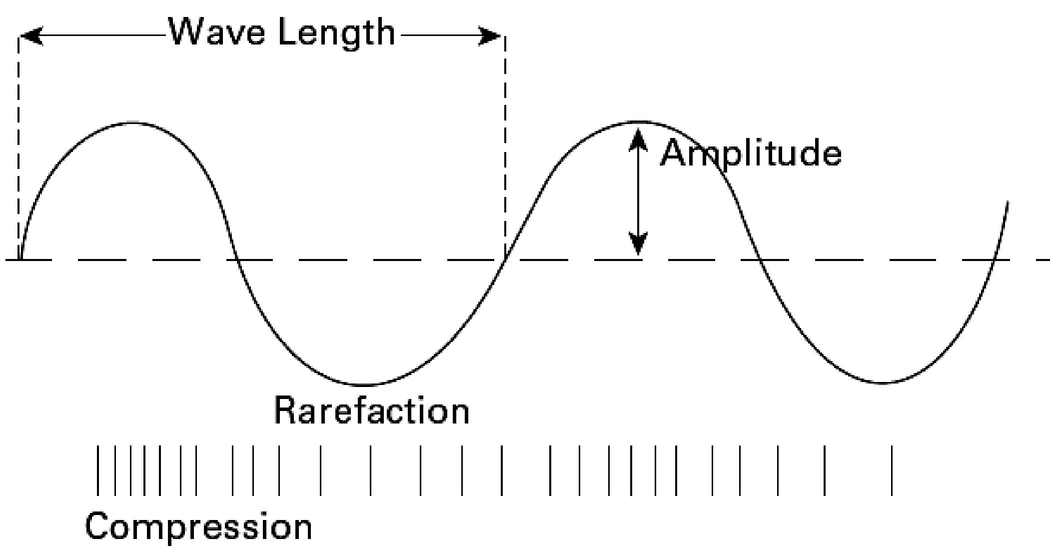
# ULTRASONOGRAPHY

- BASED ON HIGH-FREQUENCY MECHANICAL OSCILLATIONS, EMITTED AND RECEIVED SIMULTANEOUSLY BY A TRANSMITTER-SENSOR (TRANSDUCER)

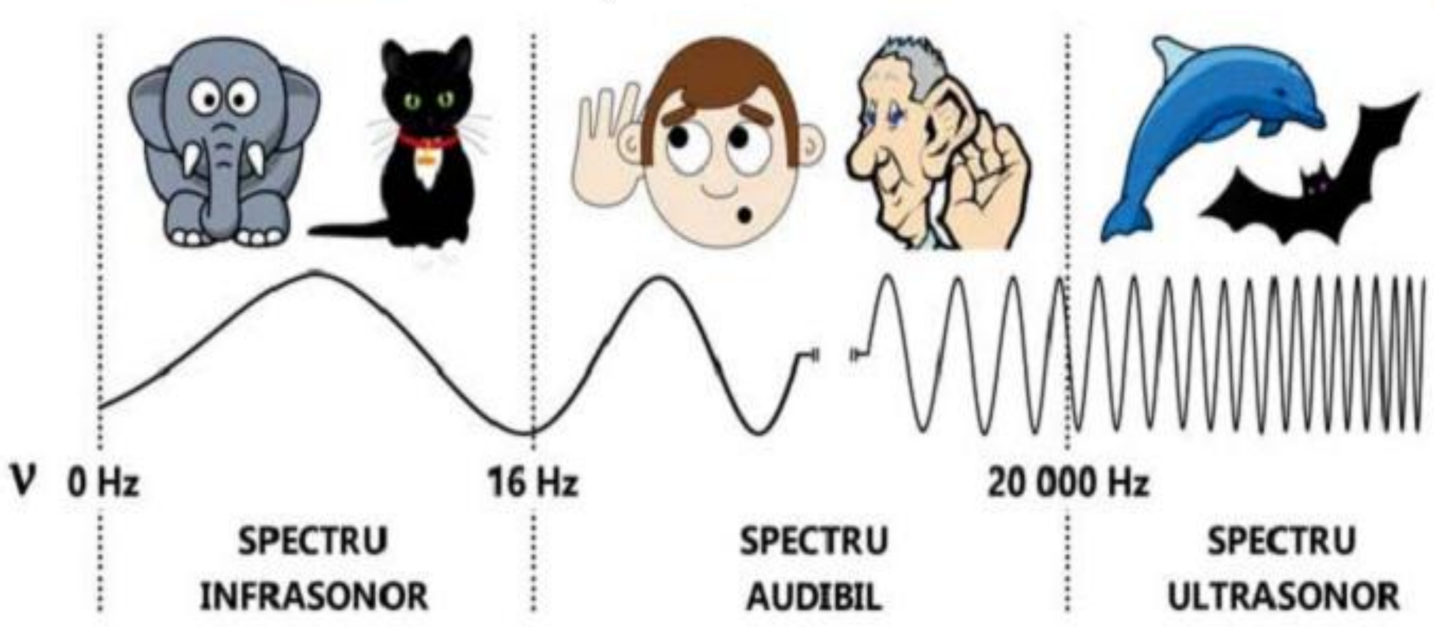
# ULTRASONOGRAPHY

## Ultrasound

- Is an oscillation of pressure transmitted through a solid, liquid, or gas.
- The sound waves used in ultrasound are between 2 and 10 MHz




TITAN


ν
0 Hz
16 Hz
20 000 Hz
SPECTRU INFRASONOR
SPECTRU AUDIBIL
SPECTRU ULTRASONOR

# ULTRASONOGRAPHY

## Advantages :

- can be performed quickly
- no exposure to ionizing radiation, making it also useful in pregnant patients
- inexpensive compared to other imaging modalities such as CT or MRI-based techniques
- inexpensive (much cheaper than computed tomography and MRI)
- accessible to any patient, painless and non-invasive
- it can be repeated as many times as needed,
- it can be performed under any conditions (at the patient's bed, in the operating room), the interpretation of the results is done immediately, even during the investigation.

- **All these make the ultrasonographic investigation to be of first intention in most of the pathologies;in many cases it is sufficient to formulate the definitive diagnosis and to monitor and assess the results of the indicated treatment.**

# ULTRASONOGRAPHY

## Disadvantages :

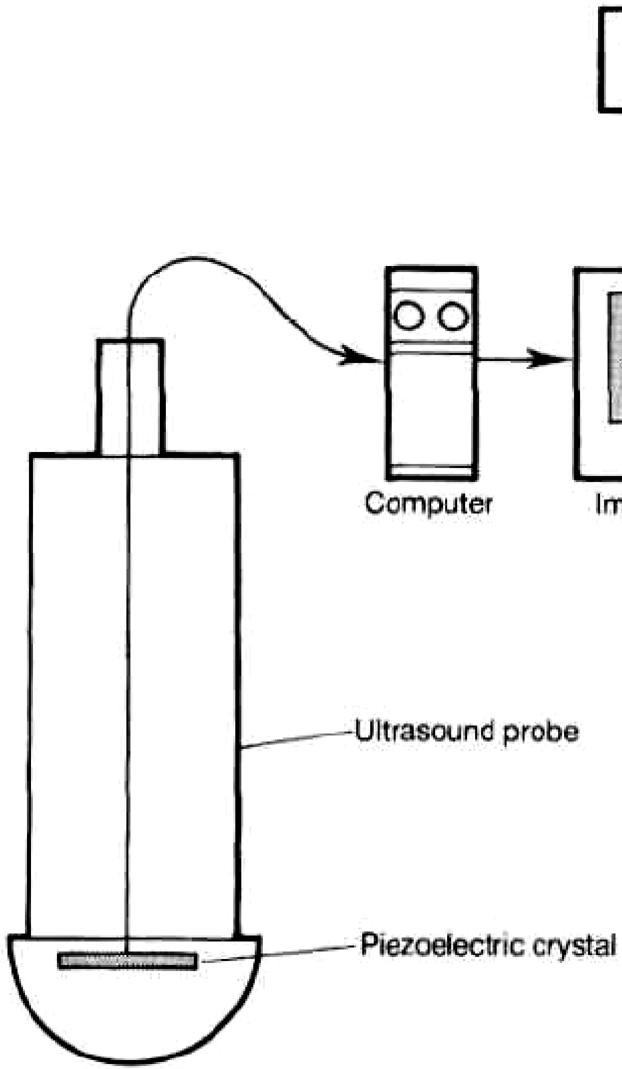
- is highly operator-dependent (i.e. the quality of the imaging depends on the experience of the person performing it).
- the ultrasound beam is also arrested by gas in the abdomen and is unable to penetrate bone.
- in the obese patients ultrasound penetration may be limited so that deep structures may not be well seen

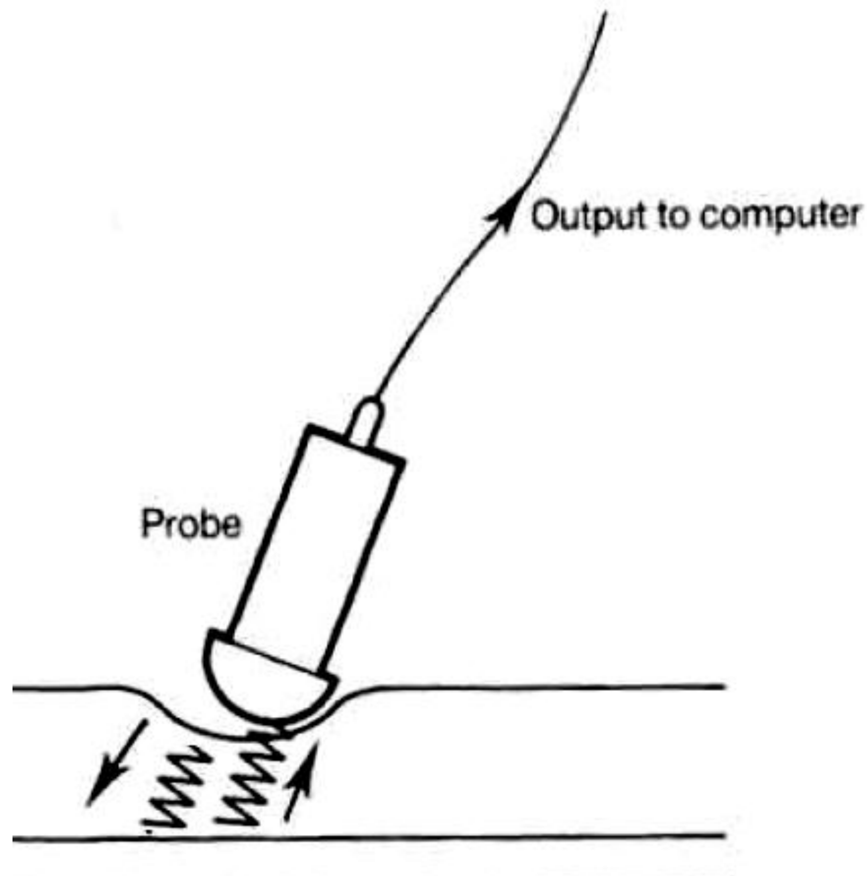
# ULTRASONOGRAPHY

## Principle

- Piezoelectric crystals in the transducer convert electricity into high-frequency sound waves, which are sent into tissues and vice versa.
- The tissues scatter, reflect, and absorb the sound waves to various degrees.
- The sound waves that are reflected back (echoes) are converted into electric signals by the piezoelectric cristals.
- The computer analyzes the signals and displays the information on a screen.

# ULTRASONOGRAPHY




Ultrasonography equipment:

a) ultrasonography device;

b) probes (transducers) for ultrasonic investigation:

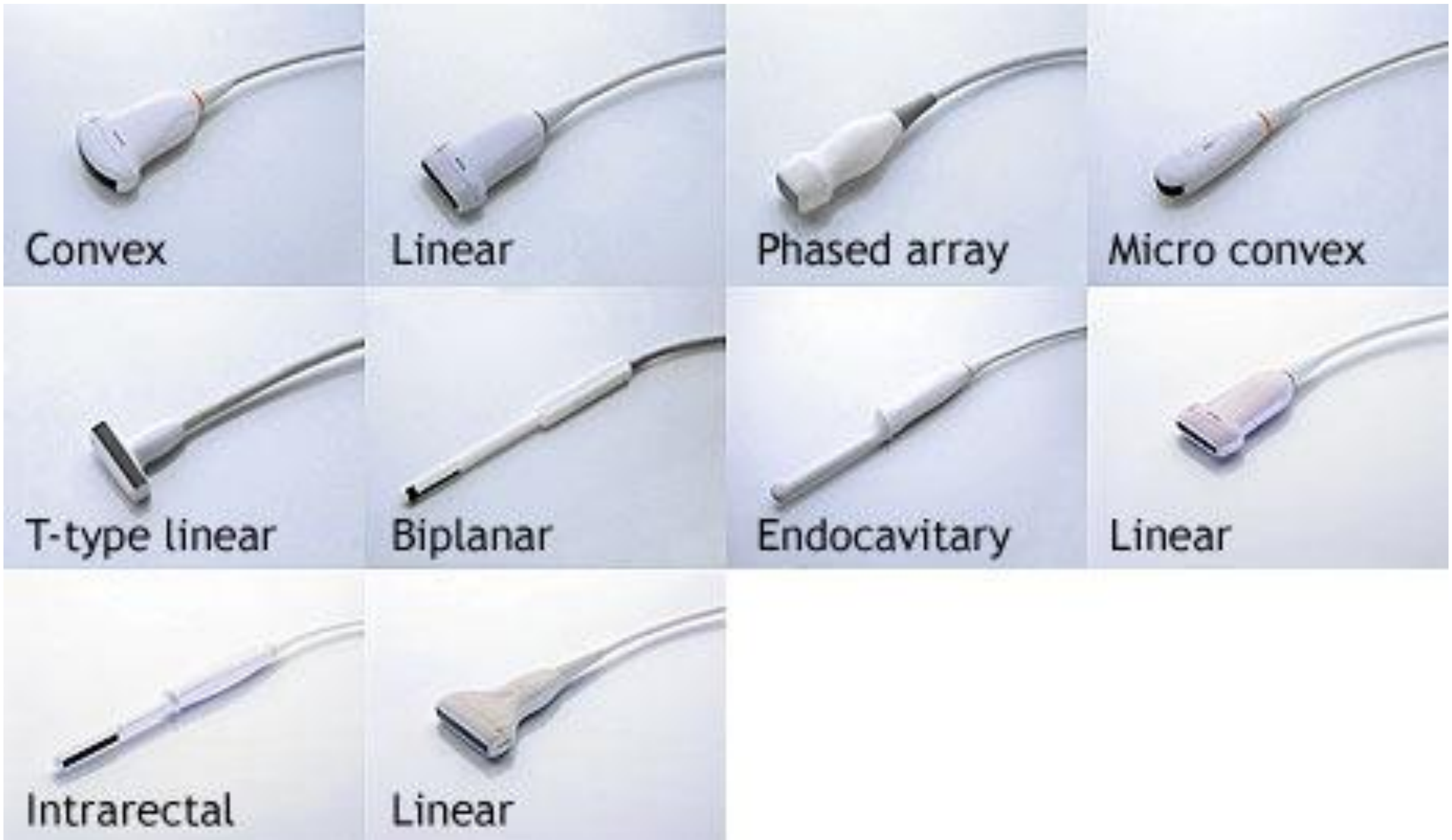
A - linear transducer, used for examining superficially located structures, small joints, blood vessels;

B - convex transducer, allows the examination of structures located deeper, is used to evaluate the organs of the abdominal cavity, urinary tract, etc .;

C - sectoral transducer, basic field of use - echocardiography.

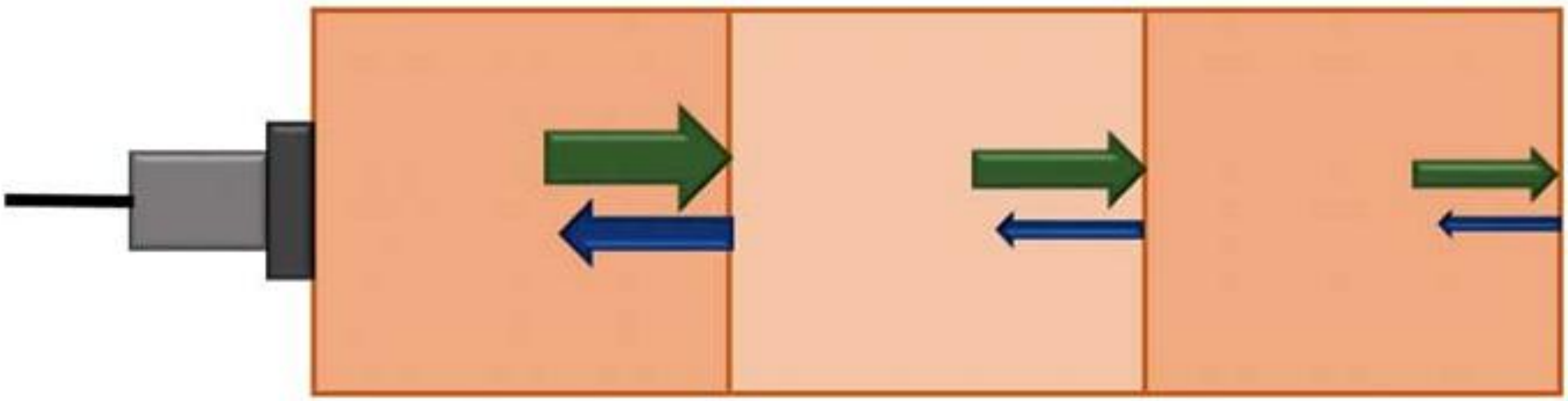
# ULTRASONOGRAPHY

- The shape of the transducer may vary, depending on the object and purpose of the investigation.



# ULTRASONOGRAPHY

- The basis for obtaining the image is the property of the ultrasound to cross an environment and to be partially reflected from the interface between two environments with different density (different acoustic impedance).



Ultrasound emitted from the transducer (green arrows) propagates through the environment; with increasing depth (distance from the transducer), their attenuation takes place. At each interface between two environments with different acoustic impedance takes place the reflection of ultrasound (blue arrows): an echo is produced, which is then received by the transducer which serves both as a transmitter and as a receiver of the echoes (ultrasound).

# ULTRASONOGRAPHY

## Modes

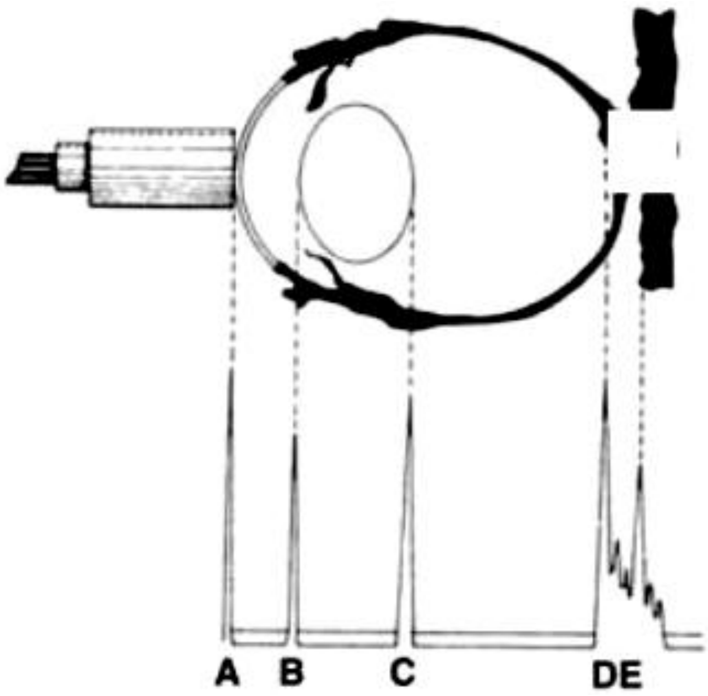
There are currently several modes (types) of ultrasonographic investigation, which include:

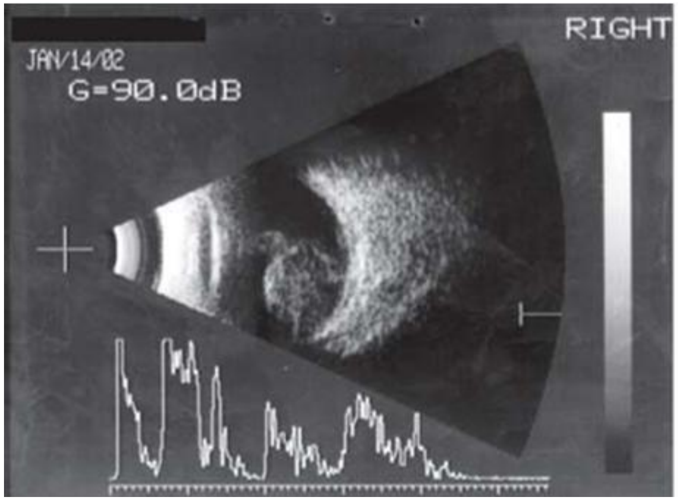
- mode A (amplitude),
- mode B (brigthness),
- mode M (motion),
- 3D, 4D,
- Doppler, etc.

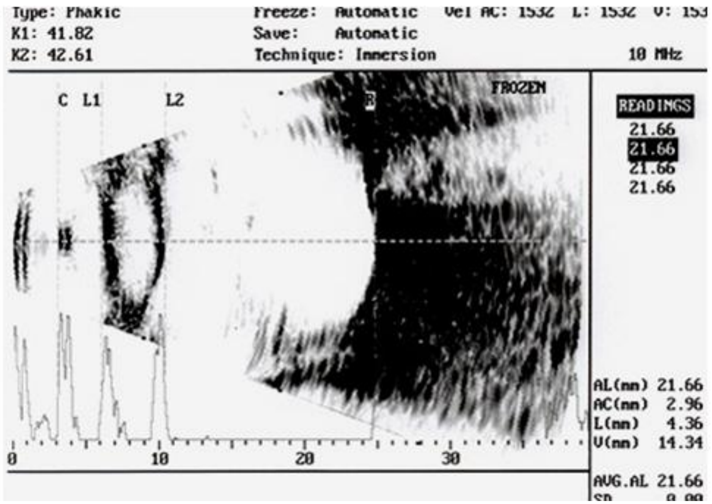
# ULTRASONOGRAPHY

## Modes

- **A-mode:**
  - the simplest;
  - signals are recorded as spikes on a graph;
  - the peaks show the echo amplitude (the density of the tissue), and the distance between them - the depth at which these structures are located t;
  - is used for ophthalmologic scanning.



# ULTRASONOGRAPHY

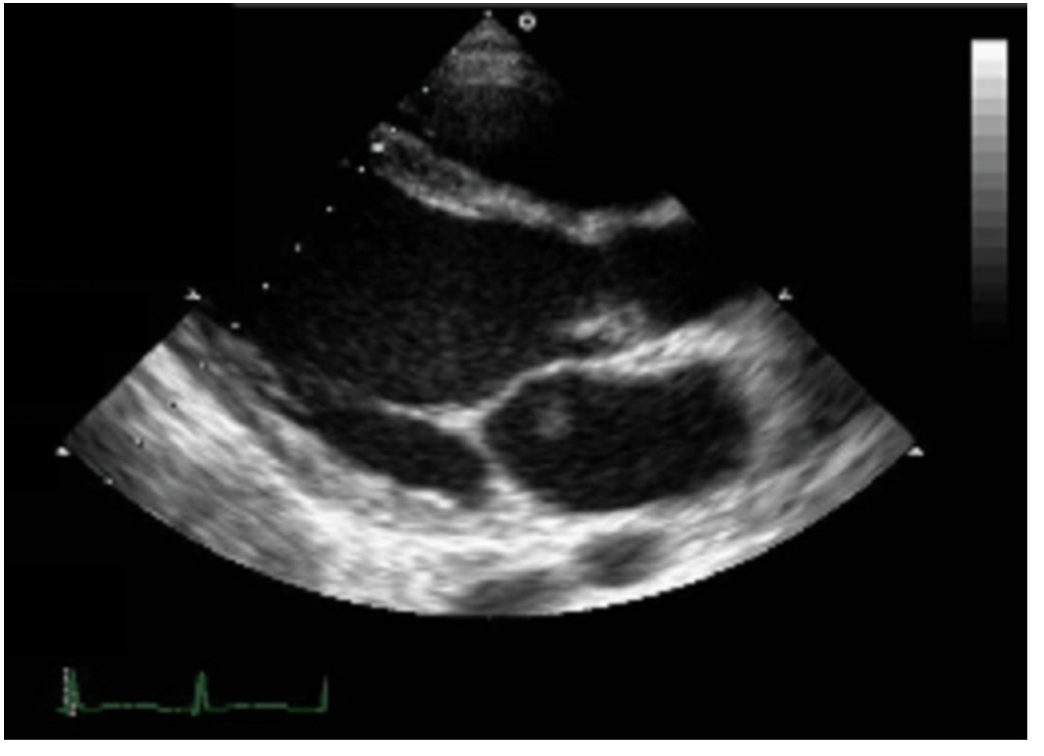
## Modes

- **B-mode (gray-scale):**
  - most often used in diagnostic imaging;
  - signals are displayed as a 2-dimensional anatomic image;
  - commonly used to evaluate the developing fetus and to evaluate organs, including the liver, spleen, kidneys, thyroid gland, testes, breasts, and prostate gland;
  - fast enough to show real-time motion, such as the motion of the beating heart or pulsating blood vessels;
  - real-time imaging provides anatomic and functional information.

# ULTRASONOGRAPHY

## Modes

- **B-mode or 2D mode**: In B-mode (brightness modulation) ultra-sound, a linear array of transducers simultaneously scan a plane through the body that can be viewed as a 2-D image on screen.
- More commonly known as 2D mode now.



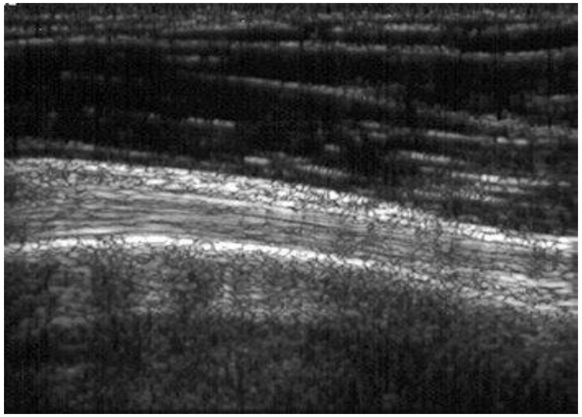
# ULTRASONOGRAPHY

## Modes

- **B-mode or 2D mode**: Due to rapid data collection and processing by a computer the device is capable of demonstrating reflections as tiny "bright" or "less bright" dots on the monitor.
- The resulting images are changing on the monitor very fast (25-40 frames/sec), so it will result in a real-time examination.

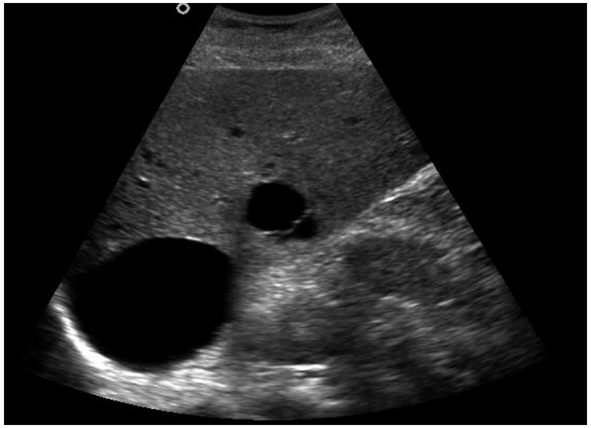
# Reflected echos

- Strong Reflections = White dots
  - Diaphragm, tendons, bones are ‘**hyperechoic**’



- Weaker Reflections = Grey dots
  - Most solid organs and thick fluids are ‘**isoechoic**’

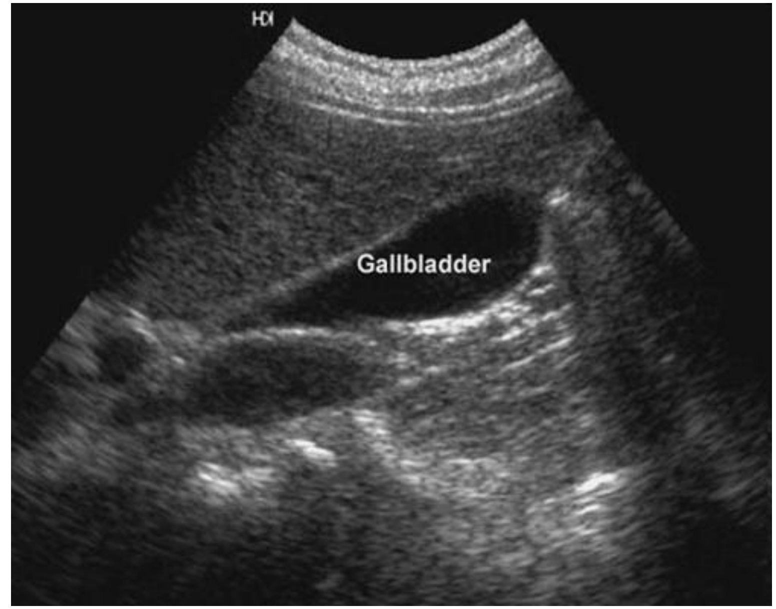
- No Reflections = Black dots
  - Fluid within a cyst, urine, blood represent ‘**hypoechoic**’ or echo-free structures



# ULTRASONOGRAPHY

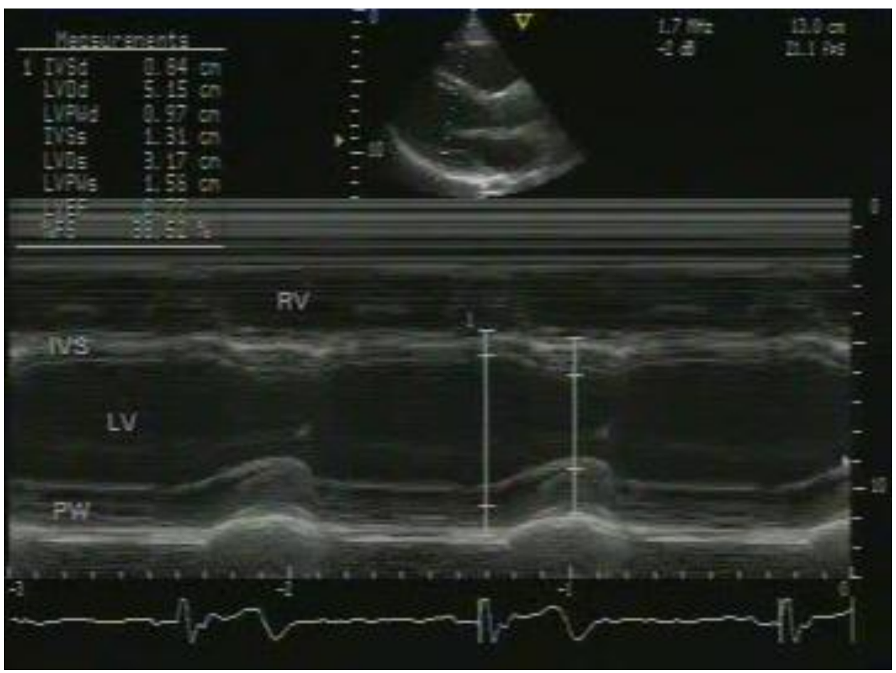
## Modes

- **B-mode**

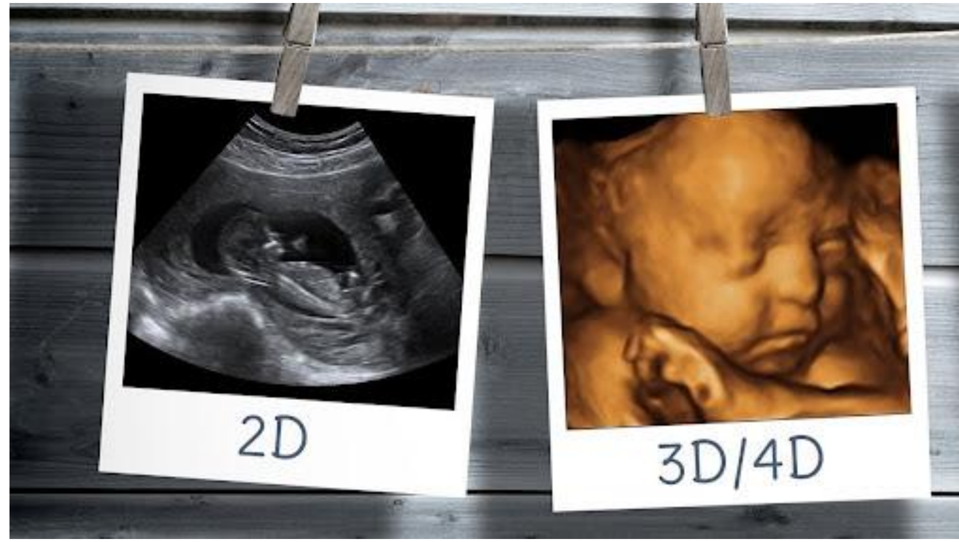

# ULTRASONOGRAPHY
## Modes

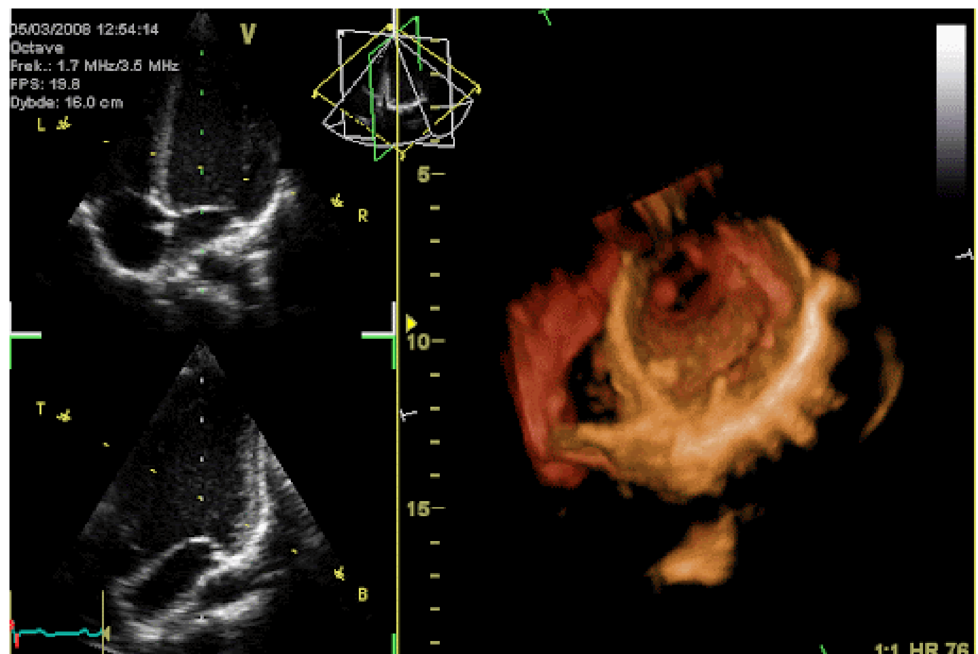
- **M-mode:**
  - used to image moving structures;
  - signals reflected by the moving structures are converted into waves that are displayed continuously across a vertical axis;
  - is used primarily for assessment of fetal heartbeat and in cardiac imaging.




# Modes
# 3D / 4D

The 3D and 4D mode represents the three-dimensional virtual reconstruction (in the case of 4D = 3D + time) of the investigated structures, based on the results of the real two-dimensional scan, and requires special probes and software. The images obtained are impressive, but the real need and indications are relatively limited.



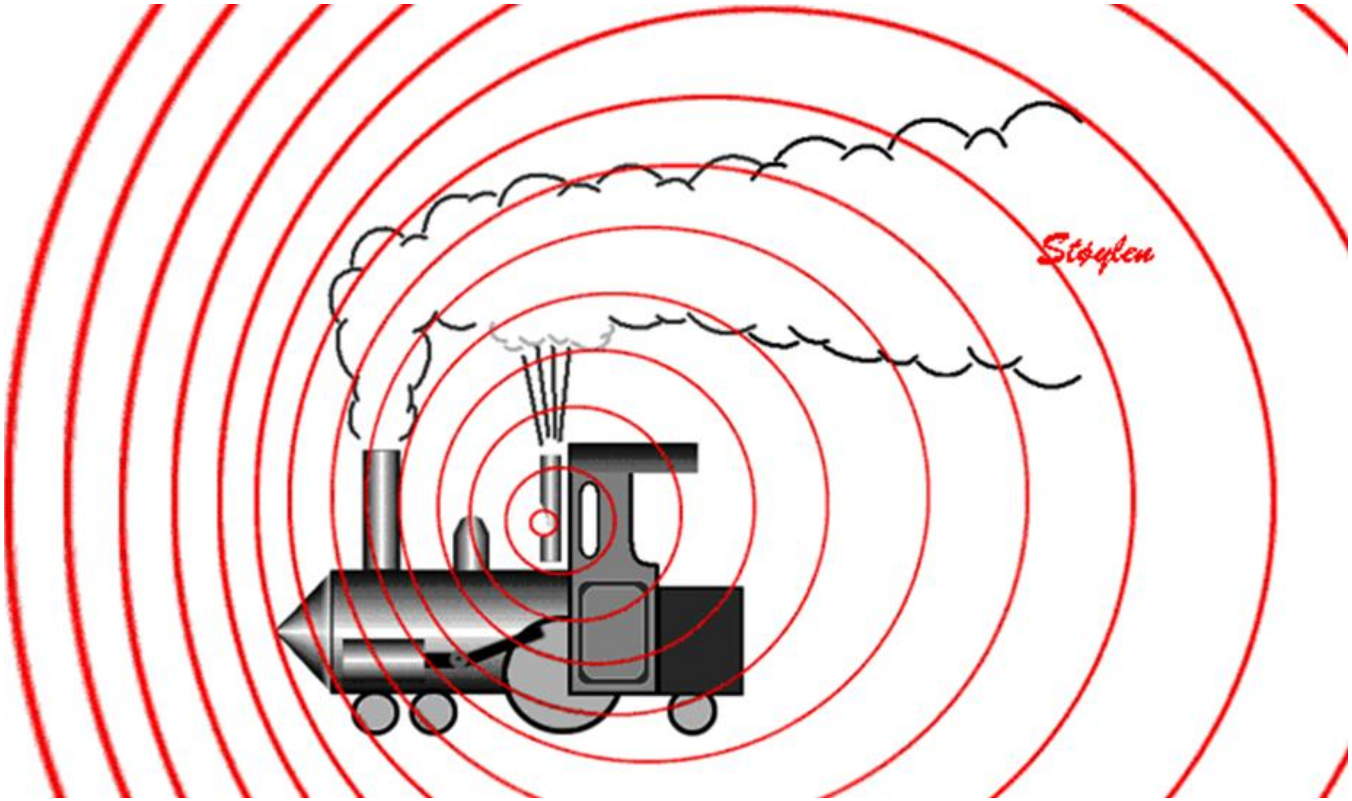



# ULTRASONOGRAPHY

## Modes

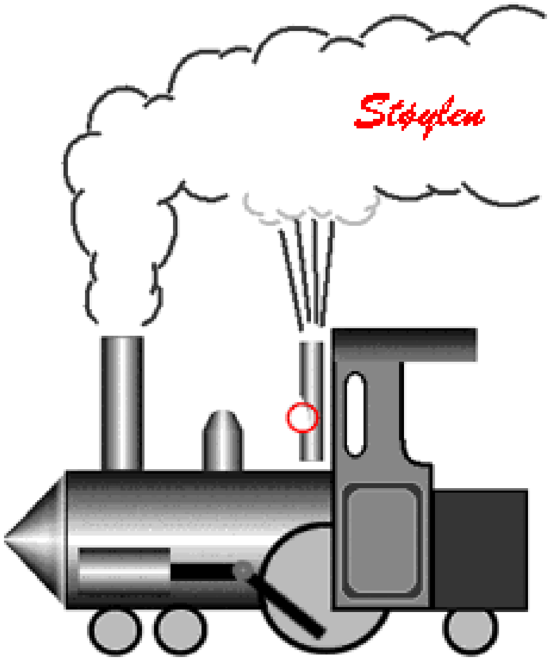
- **Doppler ultrasonography :**
  - allows determination of the speed and direction of blood flow;
  - uses the Doppler effect (alteration of sound frequency by reflection off a moving object);
  - the moving objects are RBCs in blood.

# The Doppler effect



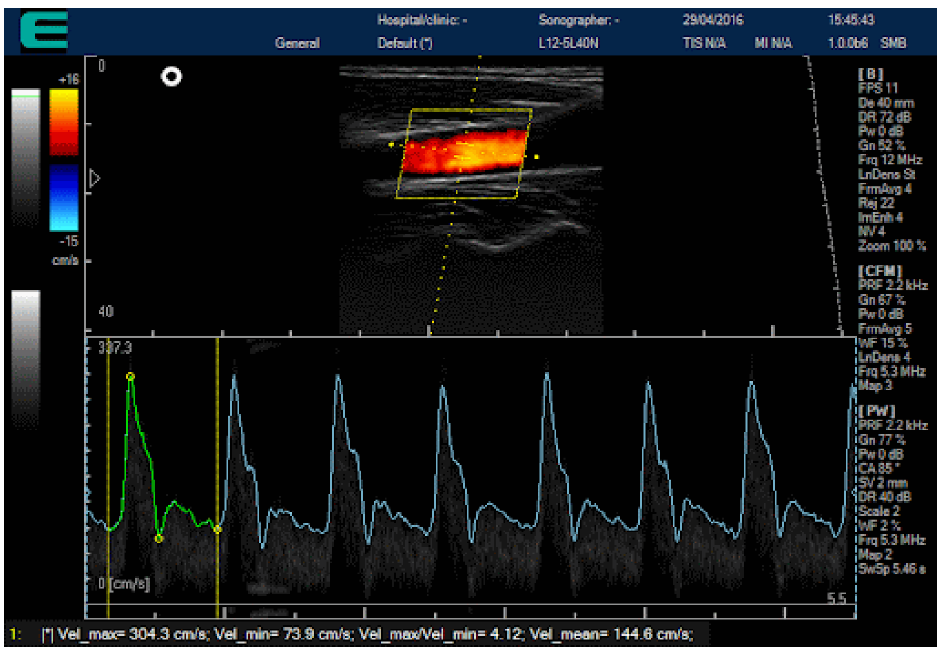

- As the velocity of sound in a medium is constant, the sound wave will propagate outwards in all directions with the same velocity, with the center at the point where it was emitted.
- As the engine moves, the next sound wave is emitted from a point further forward. Thus the distance between the wave crests is decreased in the direction of the motion, and increased in the opposite direction.
- As the distance between the wave crests is equal to the wavelength, wavelength decreases (i.e. sound frequency increases) in front of the engine, and increases (sound frequency decreases) behind it.

# The Doppler effect



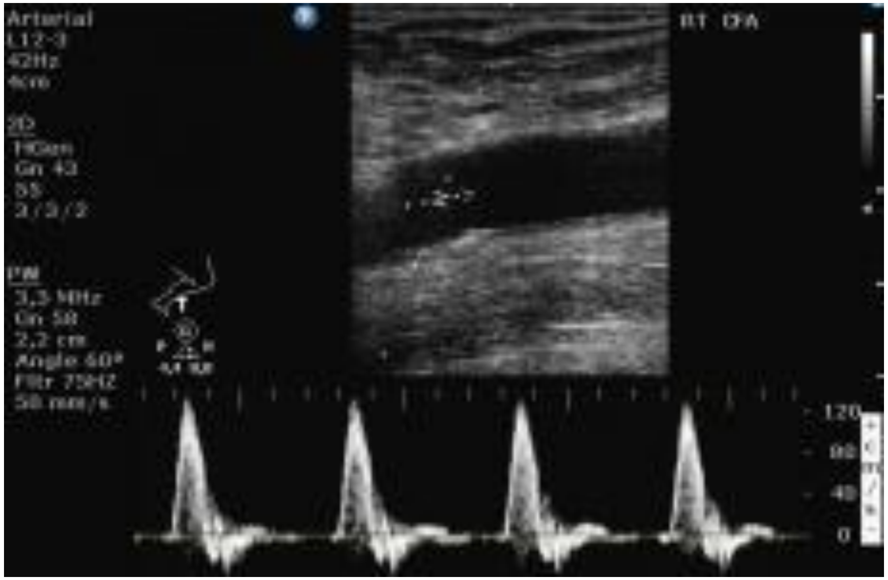
# Doppler ultrasonography

- Doppler ultrasound includes a number of types: spectral Doppler (pulsed and continuous), color Doppler, tissue Doppler, etc.




# Pulse Doppler

- A pulse is sent out, and the frequency shift in the reflected pulse is measured after a certain time.
- This will correspond to a certain depth (range gating), i.e. **<u>velocity is measured at a specific depth, which can be adjusted</u>**.
- The disadvantage is that the speed we can measure is limited, depending on the frequency of repetition of the pulses. In the case of high velocities (eg, valvular or vascular stenosis), the method will not be informative.



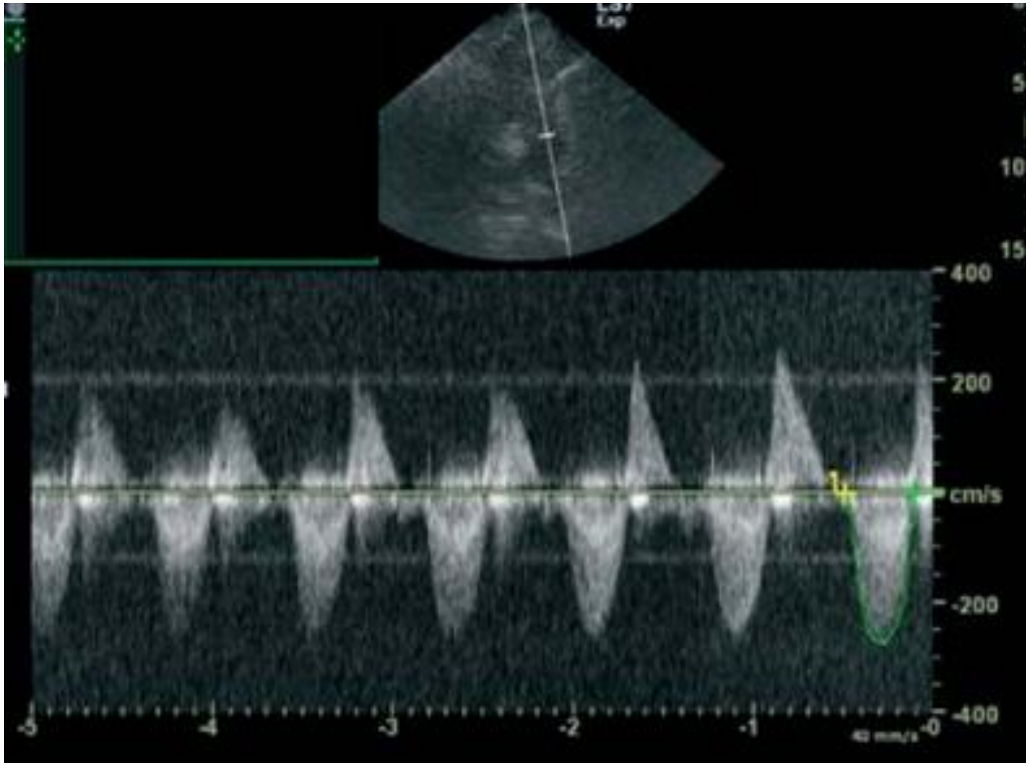

Pulse Doppler - femoral artery


Pulse Doppler – hepatic vein

# Continuous Doppler

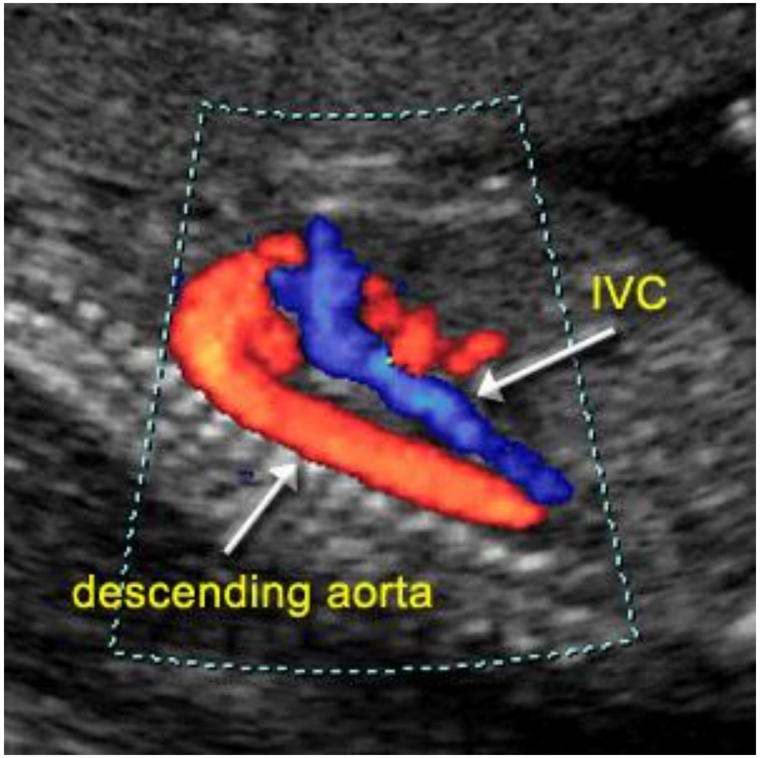
- The ultrasound beam is transmitted continuously, and the received echoes are sampled continuously.
- There is no information about the time interval from the signal to the reflection, and, hence, **no information about the depth of the received signal**.
- It is used for measuring high velocities.

*Continuous Doppler: assessment of the maximum and average speed of blood flow in the right ventricle - pulmonary artery (along the entire emission line).*



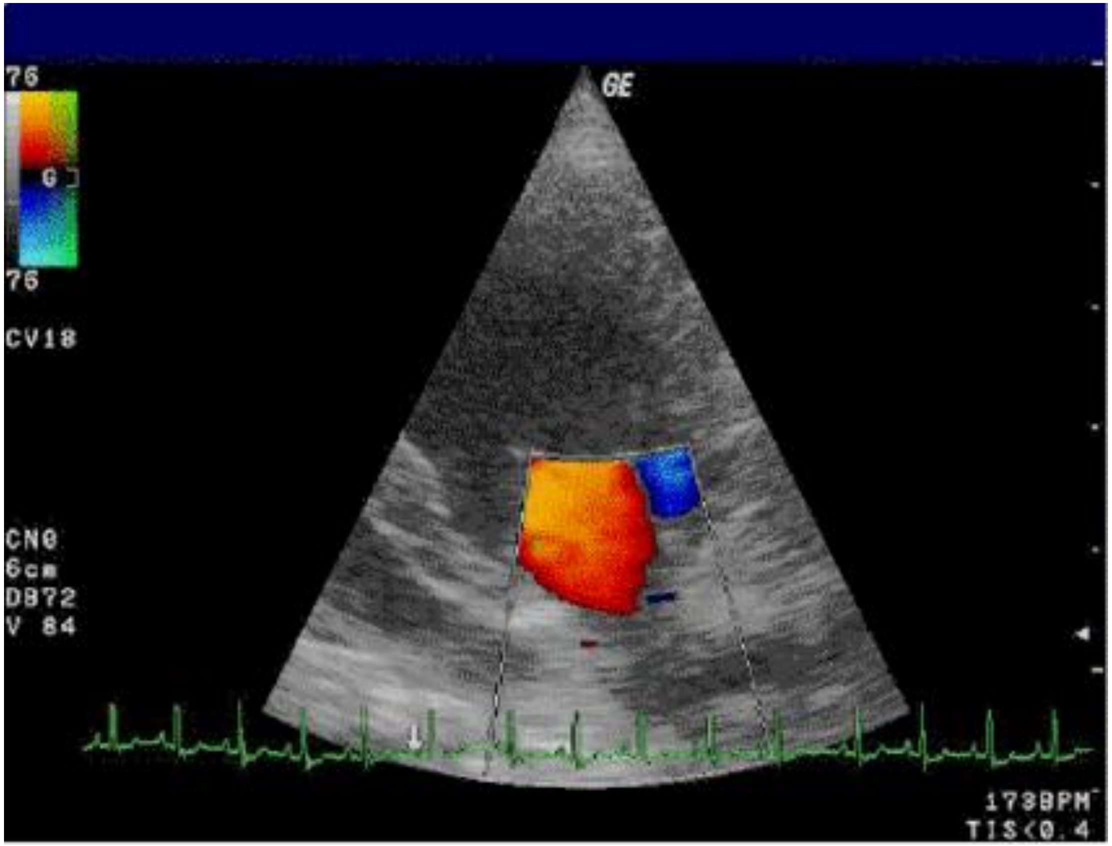
# Color Doppler Ultrasound

- In the sampling area (color box) the flow to the transducer is encoded in red, and from the transducer in blue.
- Other tints are assigned to variable velocity of the flow. Therefore different shapes of colors are commonly displayed at the site of strictures, turbulent flow, etc.




*Parasagittal view of the fetal trunk with superimposed color Doppler showing the descending aorta (red) and the inferior vena cava (blue).*

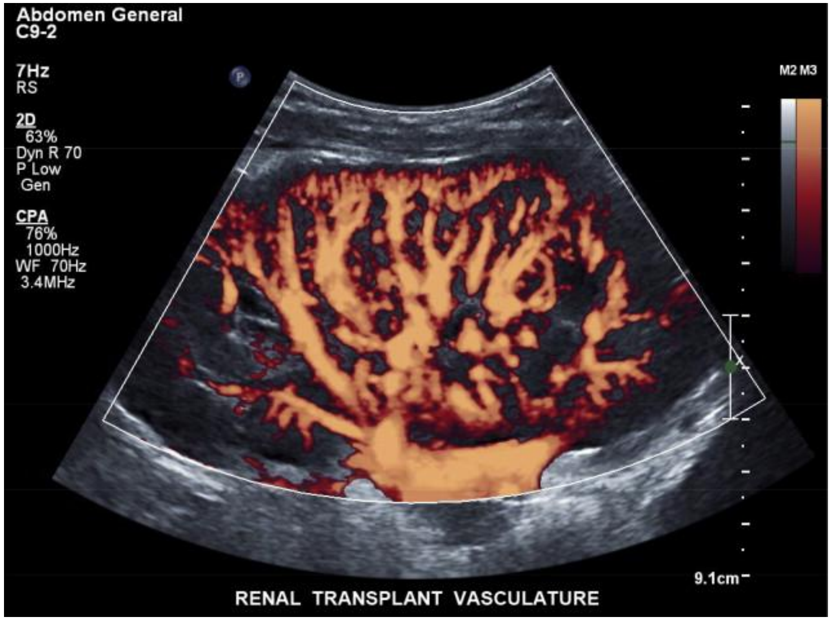
# Doppler Ultrasound




Color-Doppler imaging of the mitral valve, for assessment of regurgitation.

# Power Doppler

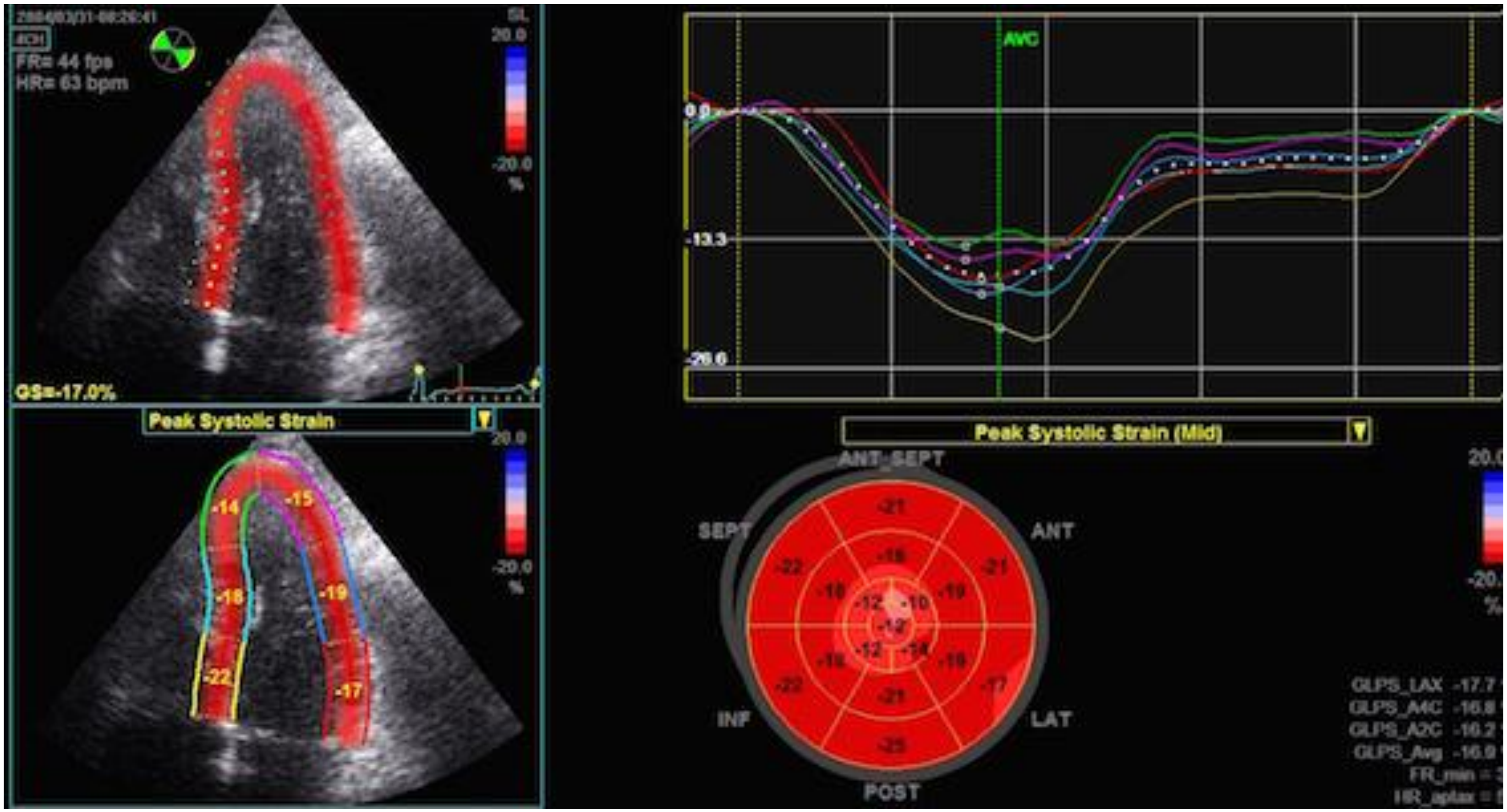
- Power Doppler is much more sensitive in detecting blood flow than color Doppler.
- The method is used for detecting small flows in various body regions.
- However, unable to determine the direction of the flow.




*Renal transplant vascularization obtained by Power Doppler*

# Doppler tissular

- Tissular Doppler allows real-time assessment of moving tissues, which allows for assessment of regional movement of myocardial walls.



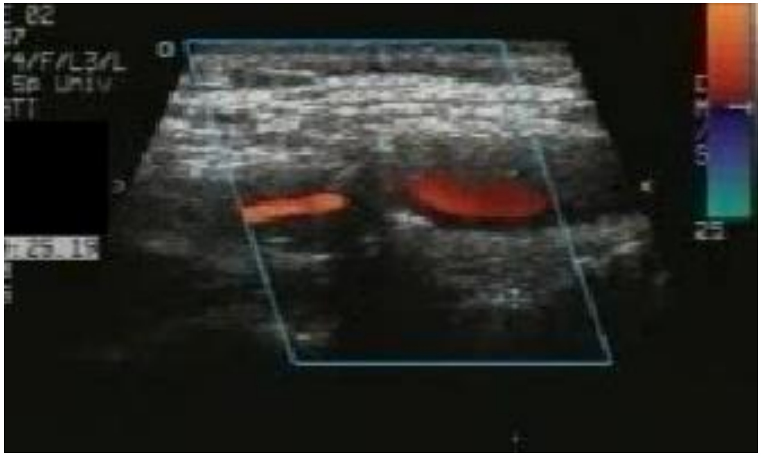
# Duplex ultrasonography

(Putting Color Doppler on top of Grey-scale B-mode)

Duplex ultrasonography incorporates two elements:

1. **Grayscale Ultrasound (B-mode)** to visualize the structure or architecture of the body part).
2. **Color-Doppler Ultrasound** to visualize the flow or movement of a structure, typically used to image blood within an artery.

- Both displays are presented on the same screen ("duplex") to facilitate interpretation.



## The chiefs of the groups

after the lecture send the presence of the students of your group to the address

**anatolie.obada@usmf.md**

## All students

write in the chat

**Last name, First name, group number**

to confirm your presence

# NUCLEAR MEDICINE

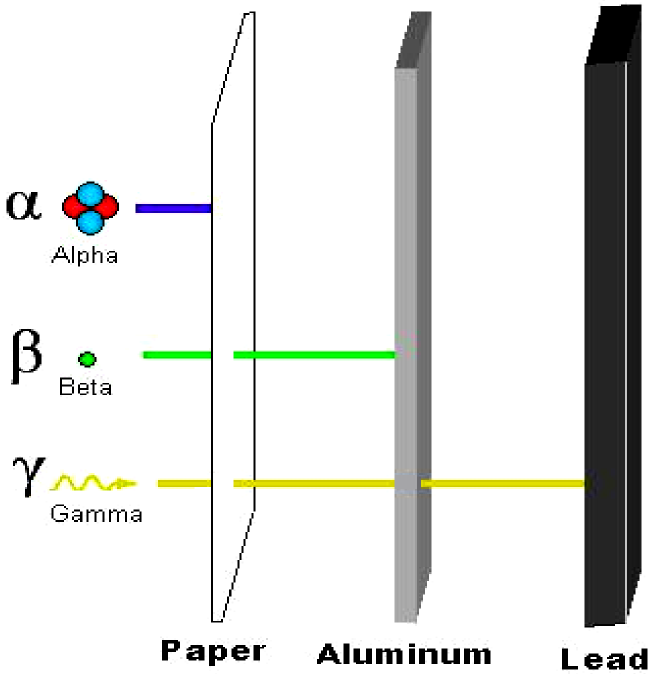
# NUCLEAR MEDICINE

- **Registration of photons (γ-rays) emitted by radioactive isotopes concentrated in tissue.**

# NUCLEAR MEDICINE

Types of nuclear radiation:

- Alpha decay – Alpha particles
- Beta decay – Beta particles
- Gamma decay – Gamma ray



# NUCLEAR MEDICINE

Types of radiation:

- α - consist of two protons and two neutrons bound together into a particle identical to a helium nucleus.

  Electric charge – +2.

  Mass – 4 atomic mass units.

  Low penetration.
- β - high-energy, high-speed electrons or positrons.

  Electric charge – 1.

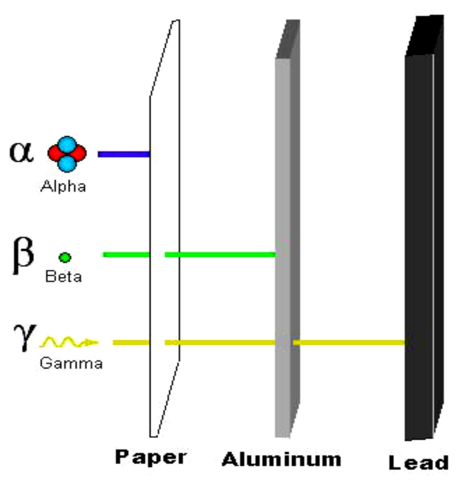
  Mass of electron.

  Penetration higher than α
- γ - electromagnetic radiation of high energy.

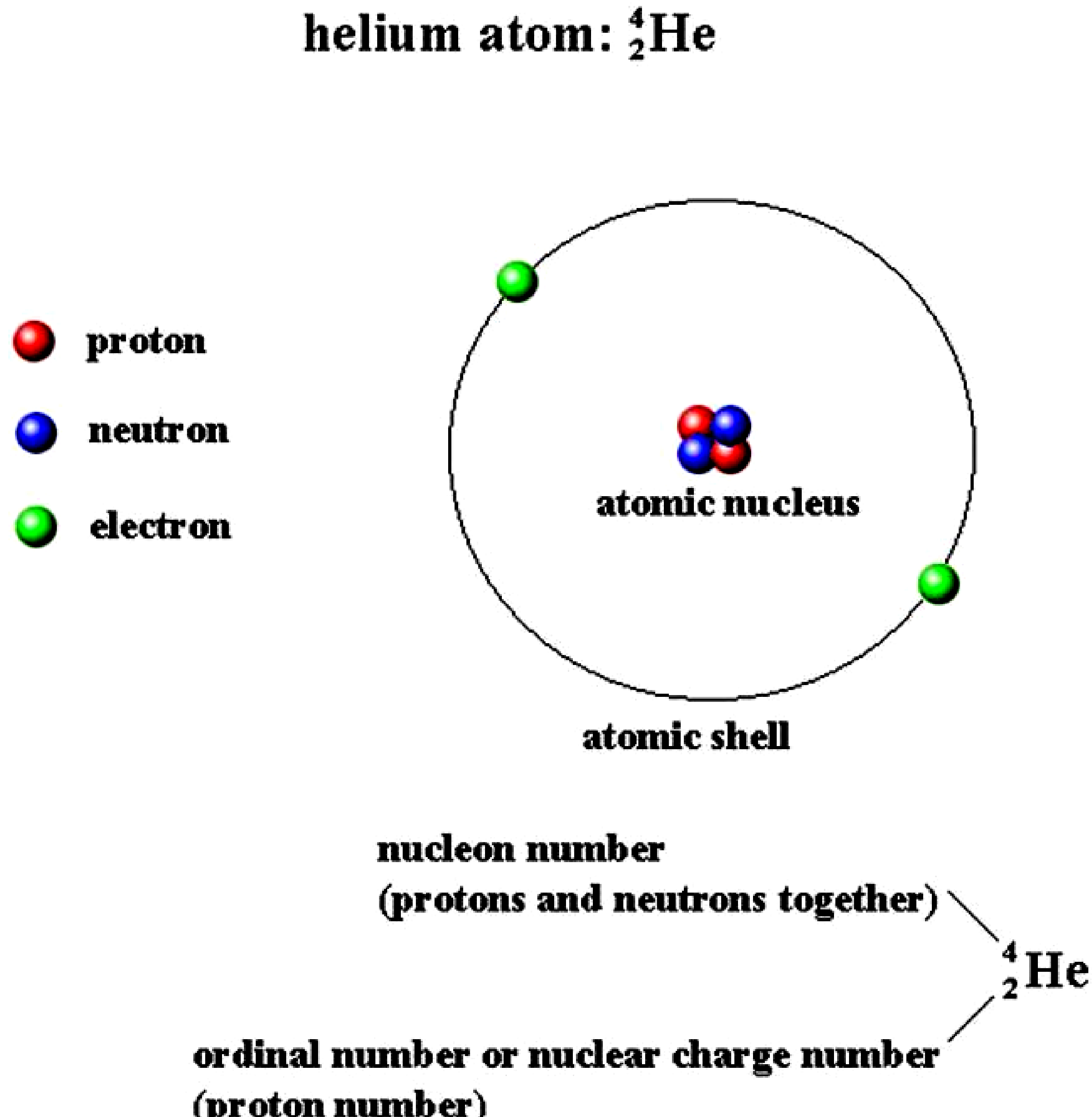
  No electic charge.

  Mass of a photon

  High penetration



# ATOM AND NUCLEUS



# NUCLEAR MEDICINE

## Radionuclide

- an atom with an unstable nucleus that decays spontaneously with the emission of energy (gamma rays) - ***radioactive isotope***.

Tc-99m, Tl-201, I-131, I- 123, Co-57, Xe-133

Positron emitting: O-15, N-13, F-18, C-11

Radioactive isotopes (radionuclides) used in nuclear medicine are produced in:

Nuclear reactor
Cyclotron (particle accelerator)
Nuclear generator

# NUCLEAR MEDICINE

**Radiopharmaceuticals**

- Substances that contain one or more radioactive atoms (radionuclides), used as tracers in the diagnosis and treatment.
- The ideal radiopharmaceutical is distributed only to the organs or structures to be imaged.

# The activity of a radioactive source

- **Physical Half-Life (T1/2)** – the time required to reduce (decay) the number of radioactive nuclei in the source and, respectively, the radioactivity of the source to half. Physical half-life is a constant of any radionuclide (e.g. T-99m physical half-life is 6 hours, I-123 – 13 hours, I-131 – 8 days).

- **Biological Half-Life** – the time required for the human body, to eliminate, by natural processes, half of the amount of a radioactive material that has entered it. Biological half-life is a characteristic of radiopharmaceuticals.

- **Effective Half-life** –the correlation between physical half-life and biological half-life.

# NUCLEAR MEDICINE

- Examinations of nuclear medicine provide details of the function and pathology of that organ long before structural changes occur;
- Depending on the pathological substrate and the mechanism of accumulation of the radiopharmaceutical in various tissues:
  - regions with abnormally increased radioactivity are called ***areas of hyperfixation, hot nodules*** or ***hypermetabolic foci/ regions***,
  - regions with abnormally low or absent radioactivity are called ***areas of hypofixation, cold nodules*** or ***photopenic (hypometabolic) foci / regions.***

# NUCLEAR MEDICINE

- Technetium 99m (Tc-99m) fixed by a diphosphonate which is used in bone metabolic processes as the bone radiotracer 99mTc-MDP (99mTc-methylene diphosphonate). After injection into the body, it is captured by the skeleton, reflecting the intensity of bone metabolism and spotting areas with abnormal high metabolic activity.

- Tc-99m fixed by substances that are eliminated by glomerular filtration such as diethylenetriaminepentaacetic acid (DTPA) provides relevant information about the glomerular filtration rate, while Tc-99m fixed by substances eliminated mainly by tubular secretion such as mercaptoacetyltriglycine (MAG-3) is used for quantification of renal plasma flow.

- Tc-99m fixed by fat-soluble compounds such as iminodiacetic acid (Tc-99m HIDA), which are captured by hepatocytes and eliminated into the bile ducts, are widely used in dynamic hepato-biliary scintigraphy to visualize the liver, bile ducts and gallbladder.

# NUCLEAR MEDICINE

## Radionuclide requirements

In order to use a radionuclide in medical diagnosis, they must meet certain requirements:

•Disintegrate by emitting only gamma rays;

•Be pure, i.e. not containing other radioactive isotopes;

•Be stable, being fixed in the composition of the radiopharmaceutical, in order to be able to follow its accumulation in the respective organ or tissue;

•To be removed from the body completely and as quickly as possible, but enough to allow the diagnostic procedure. It is also preferable that at the end of the examination the dose of radiation emitted from the body decreases considerably: the patient is the source of ionizing radiation and, respectively, may be dangerous to people around. Isotopes with a short half-life are used for this purpose.

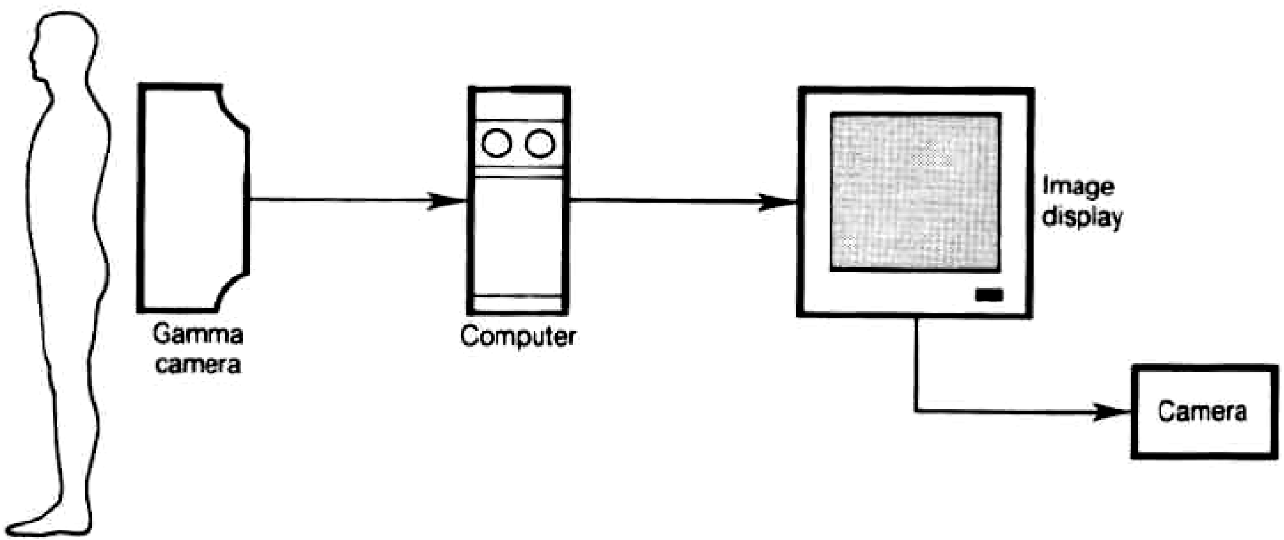
# NUCLEAR MEDICINE

## Modalities:

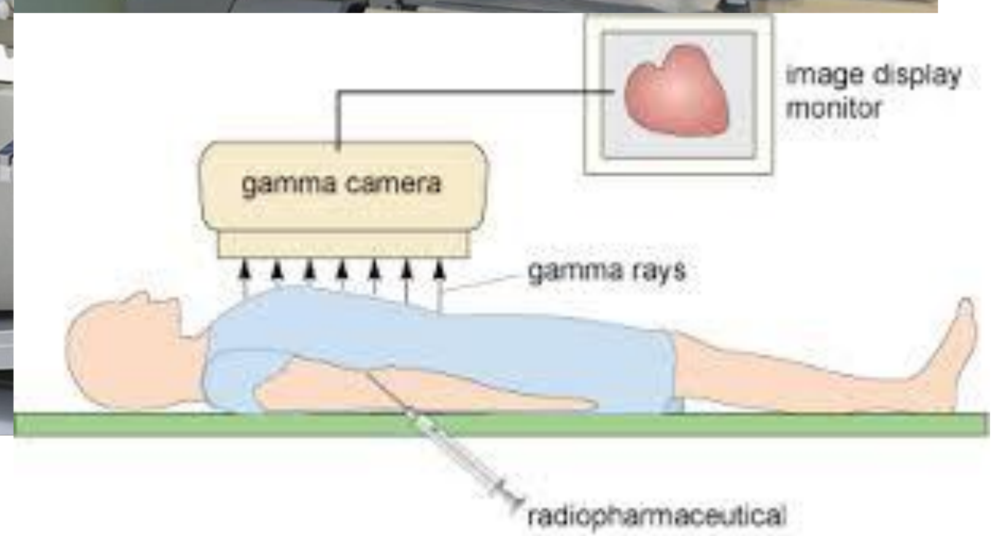
- Scintigraphy
- SPECT
- PET

# NUCLEAR MEDICINE

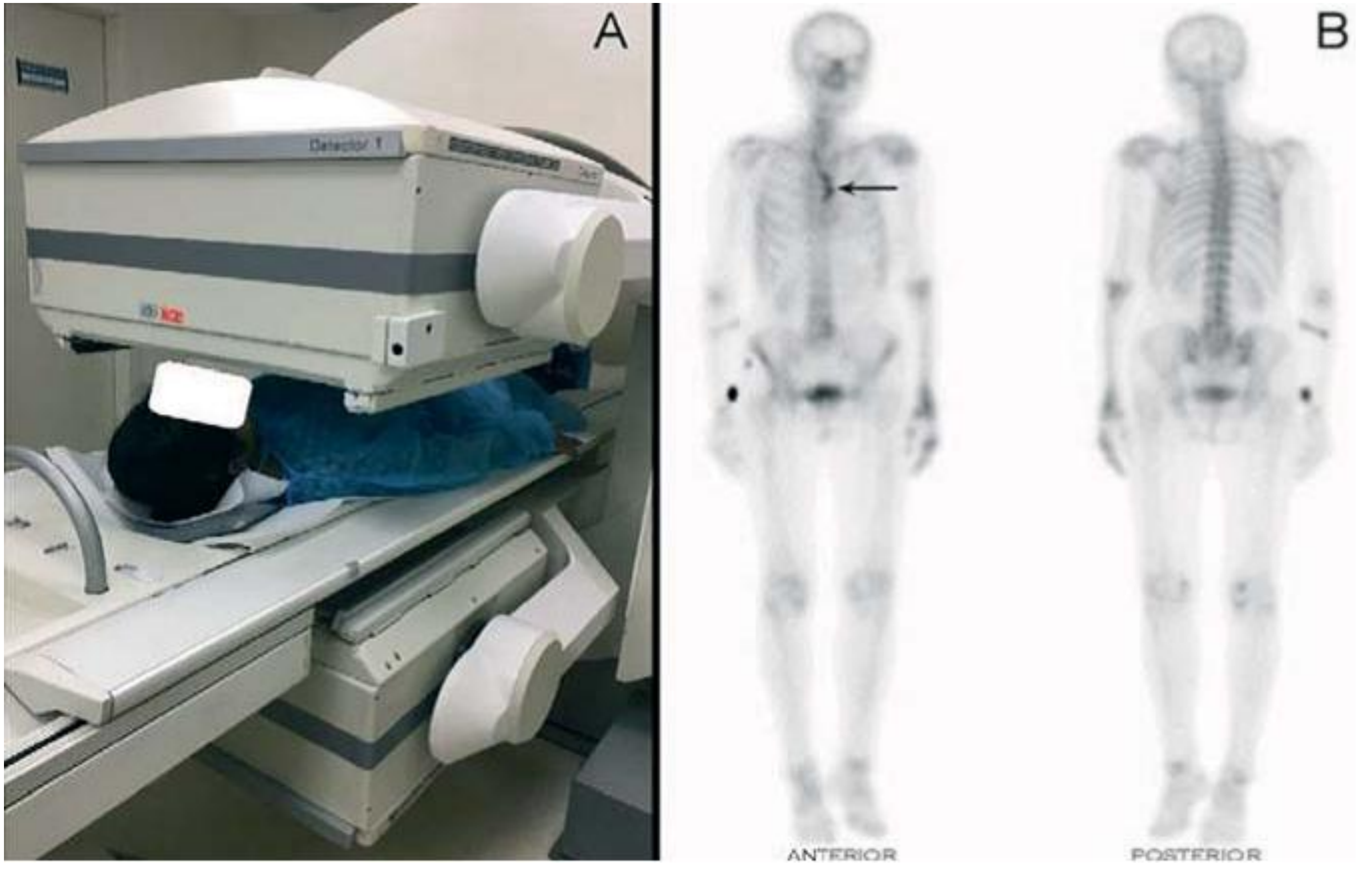
**Scintigraphy** – a diagnostic procedure consisting of the administration of a radionuclide (radiopharmaceutical) with an affinity for the organ or tissue of interest, followed by recording the distribution of the radioactivity by a scintillation camera.



# Scintigraphy

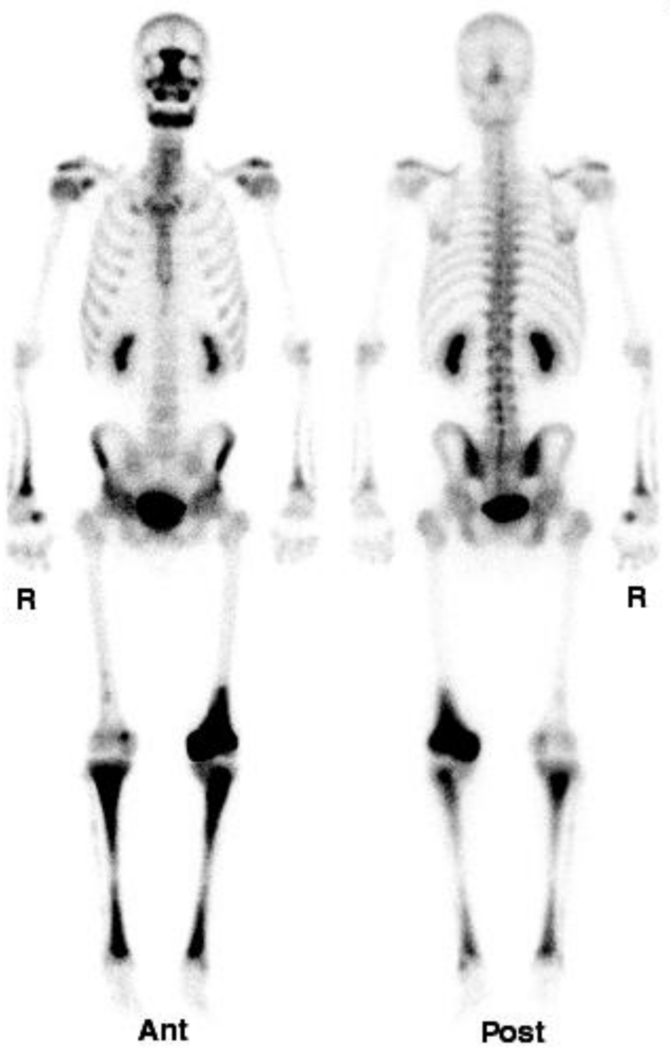


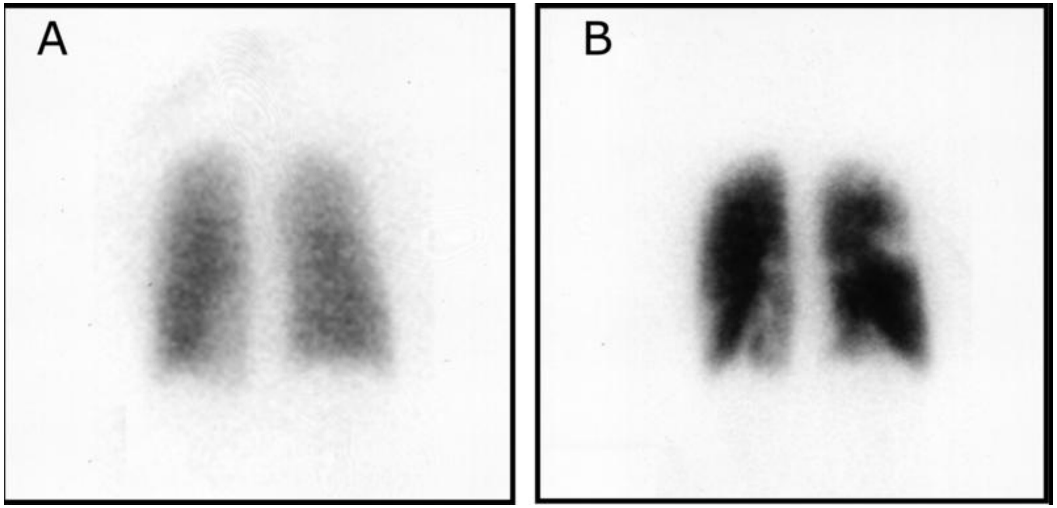
# Scintigraphy

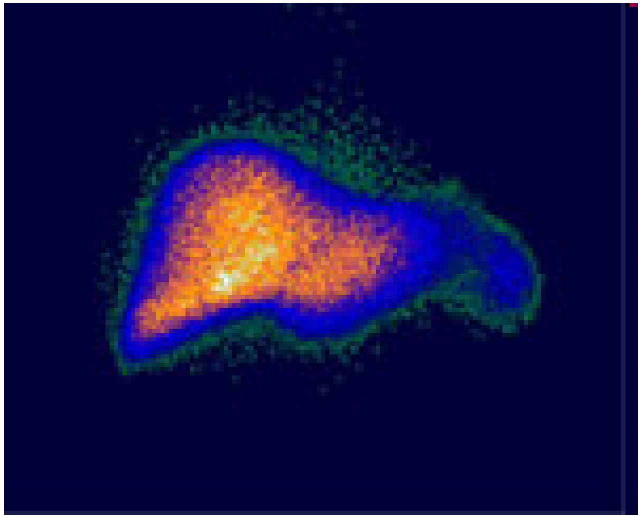



Performing bone scintigraphy. A - the detectors (scintillation cameras) located in static position allow simultaneous obtaining of images in front and posterior projection. B - the scintigraphic images obtained reveal a region of intense accumulation of the radiopharmaceutical in the thorax region (indicated by an arrow).

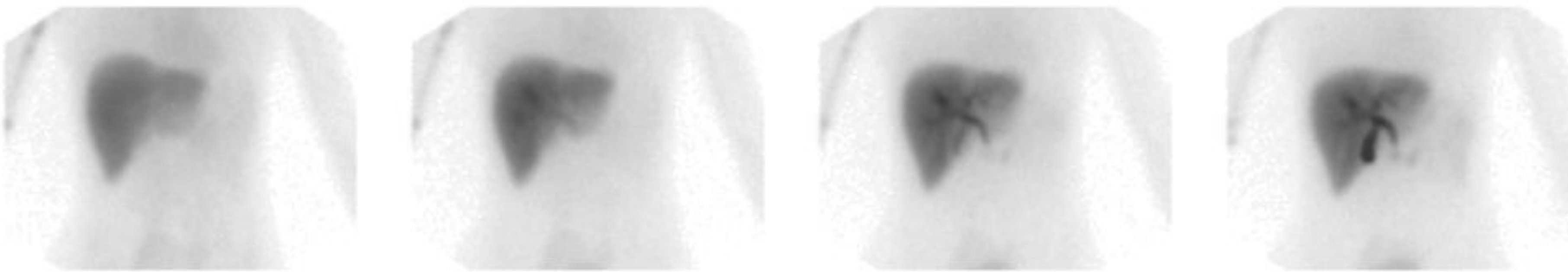
# Scintigraphy



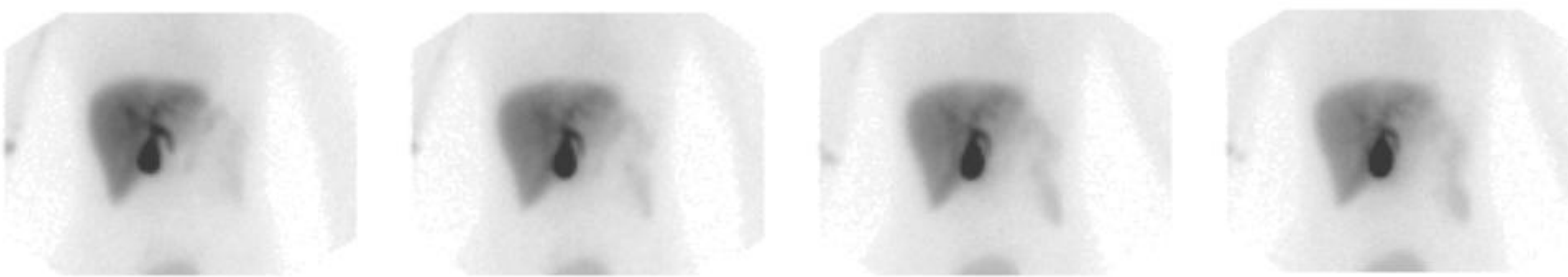



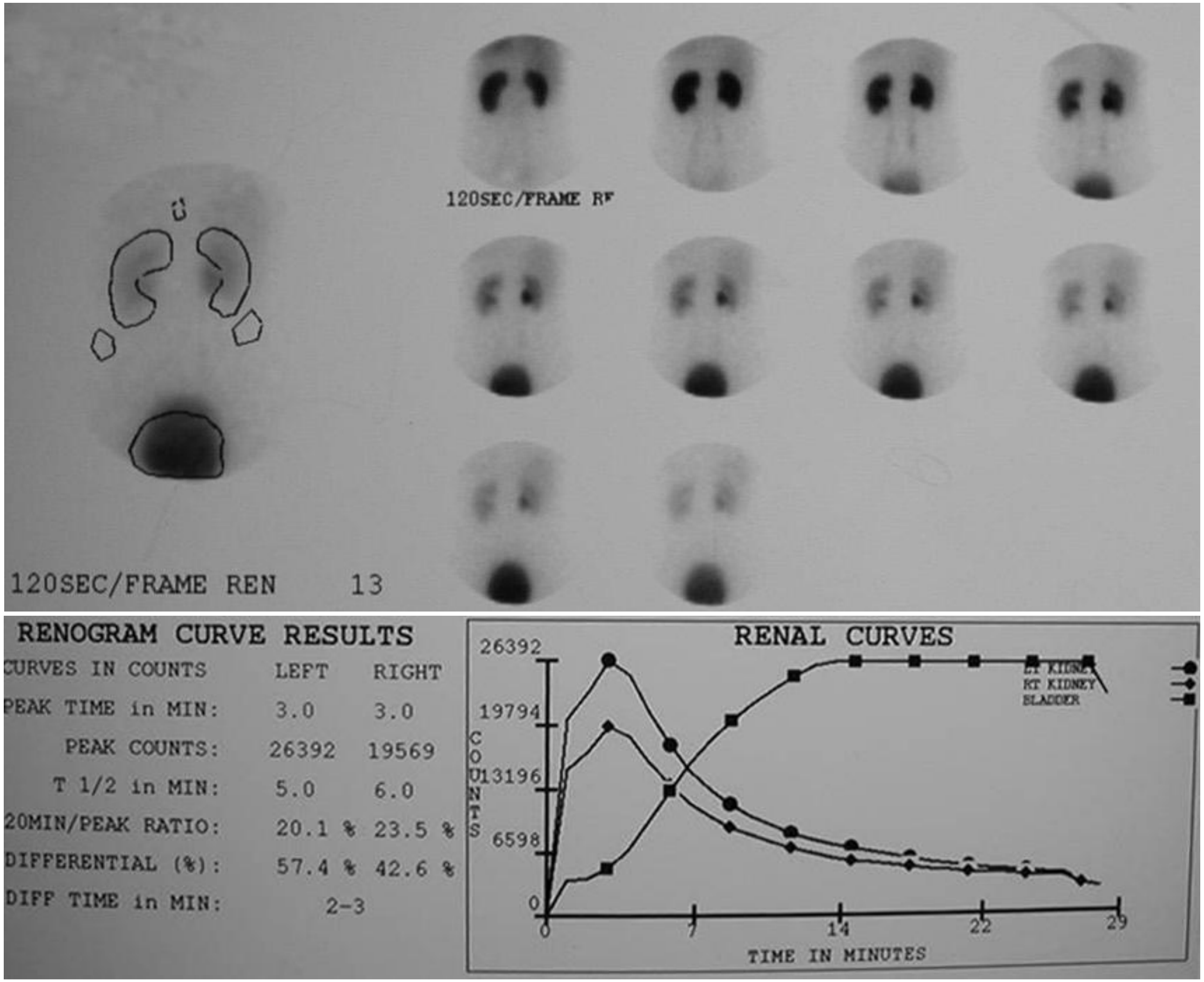
# Hepato-biliary scintigraphy



5 minutes per frame



# Renal scintigraphy and renogram curves



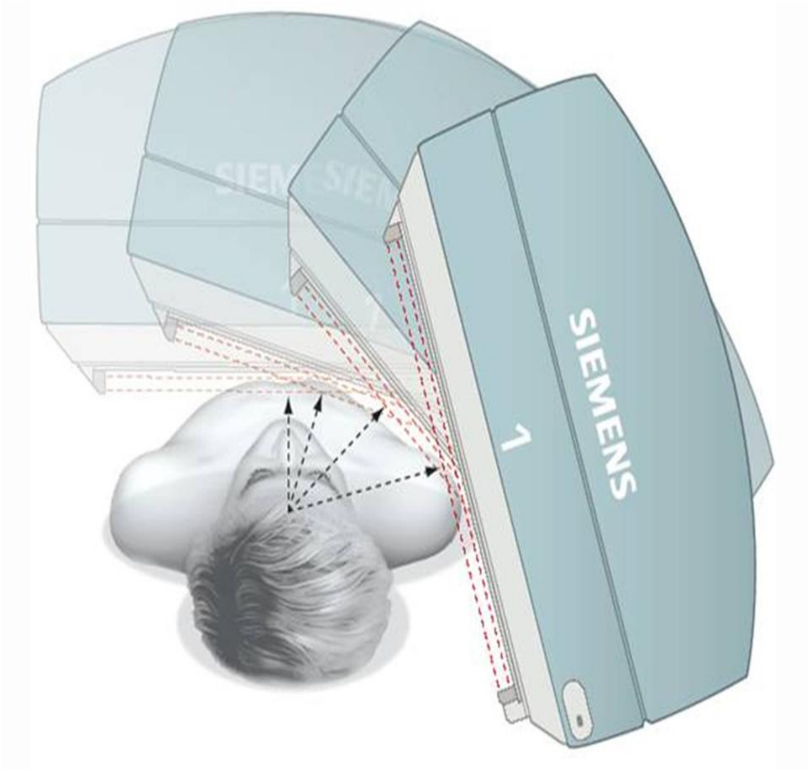

This study measures radioactivity as it moves through the kidneys over time. Regions of interest are drawn on the computer and counts are calculated for 30 minutes. This generates functional imaging with data indicating peak time, rate of excretion and percent function

**A pharmaceutical agent which is secreted by the kidneys is injected IV. Sequential imaging allows assessment of renal function.**

# SPECT

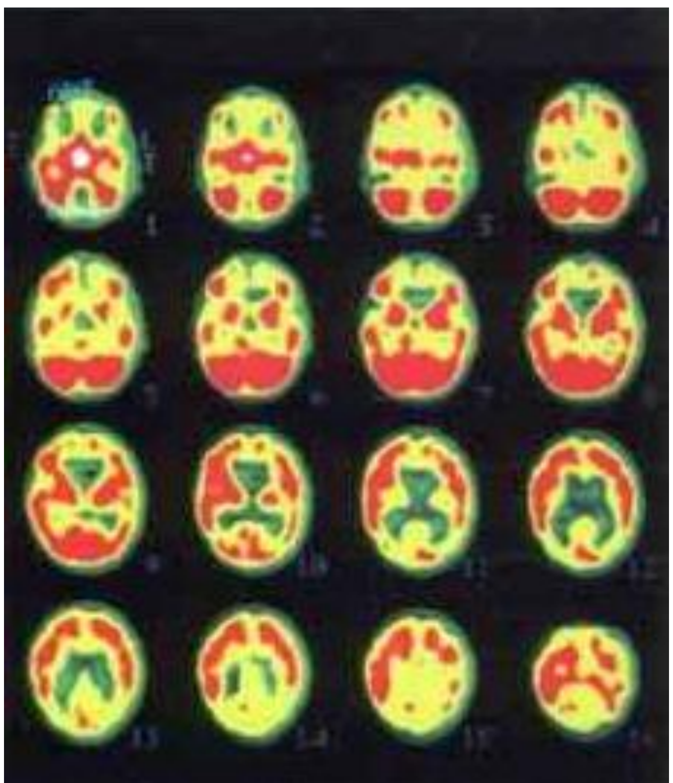
## (Single Photon Emission Computed Tomography)

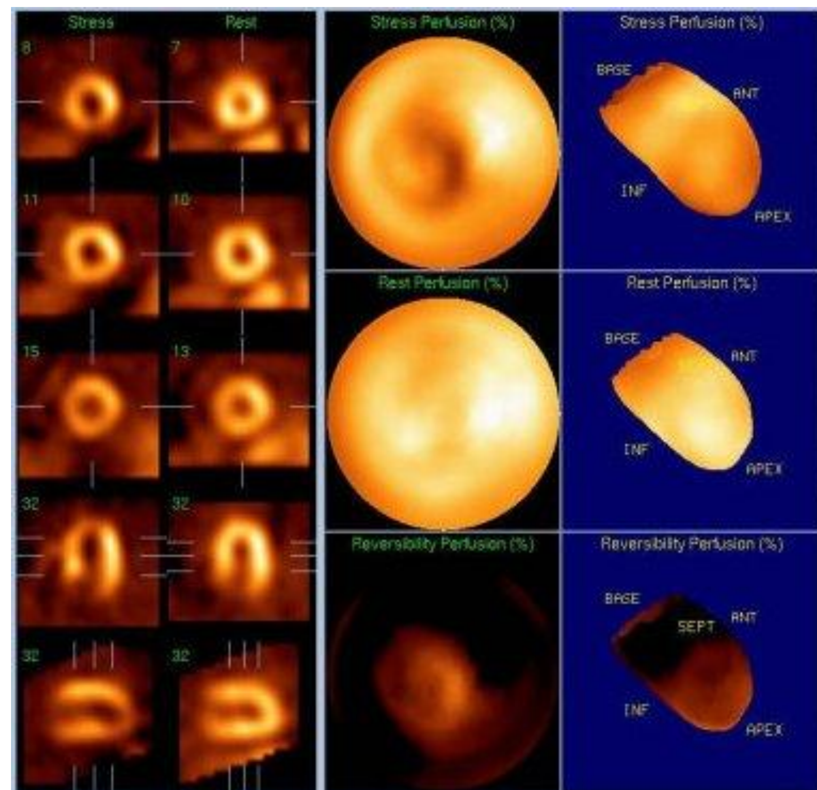
- gamma camera rotates around the patient to provide data from multiple angles around the patient



# SPECT
## (Single Photon Emission Computed Tomography)

- gamma camera rotates around the patient to provide data from multiple angles around the patient
- obtaining images of as cross-sectional slices
- providing true 3D information

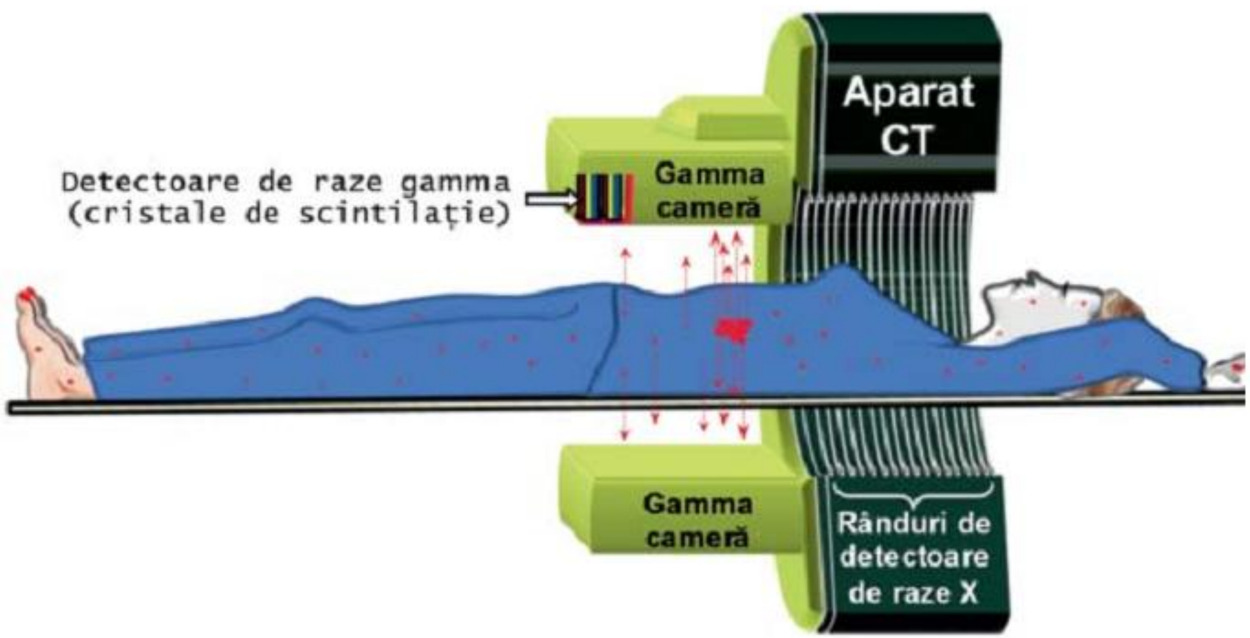




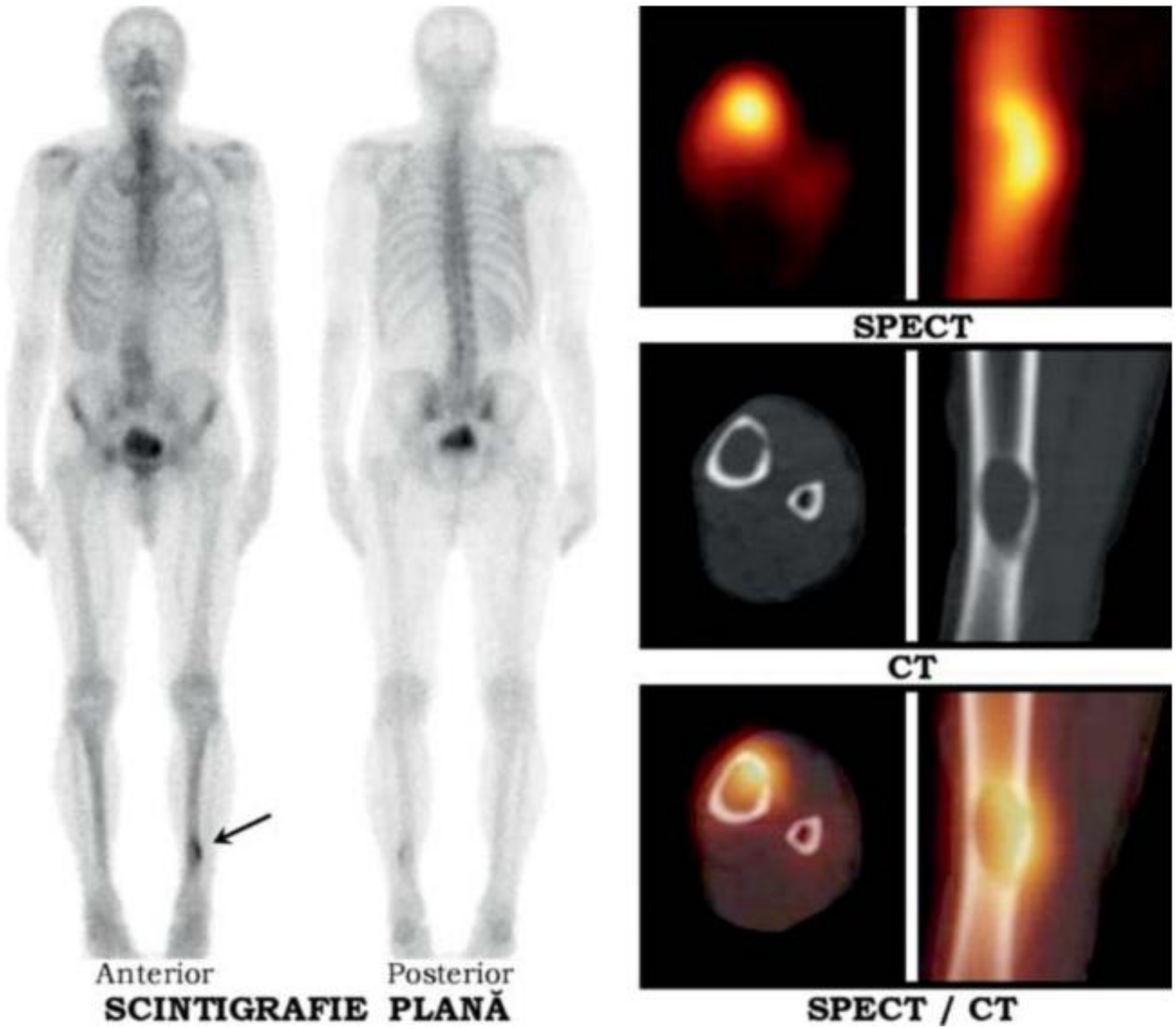
# SPECT / CT

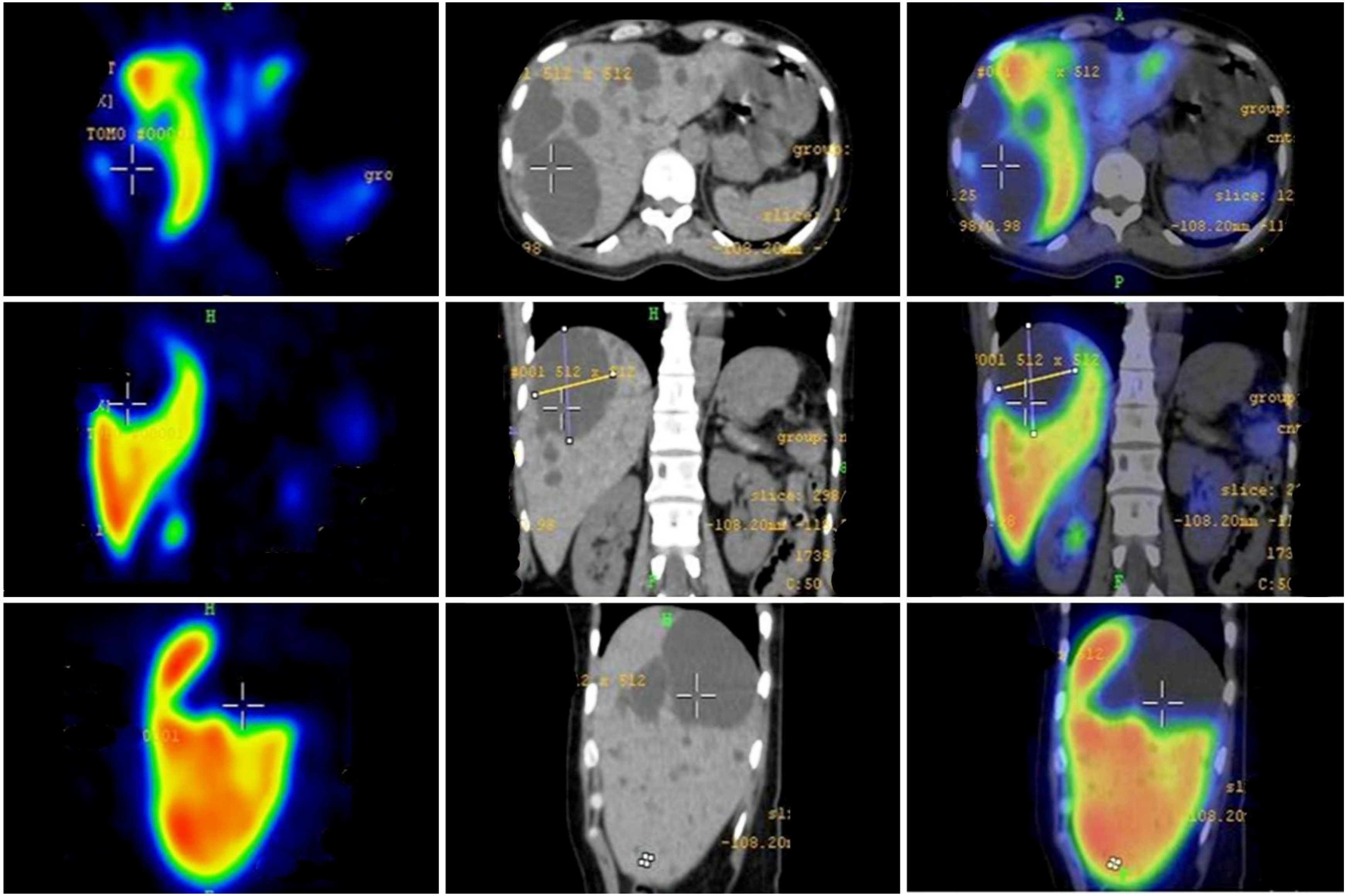
- Hybrid devices include gamma camera coupled with a computed tomography device. Thus, after performing the tomoscintigraphy (SPECT), the patient table is moved inside the computed tomography (CT) device, the hybrid investigation being called SPECT / CT.

- Because the patient remains motionless during the procedure, the results can be processed automatically by overlapping the distribution of the radiopharmaceutical in various anatomical structures, obtaining hybrid SPECT / CT images.



# SPECT / CT

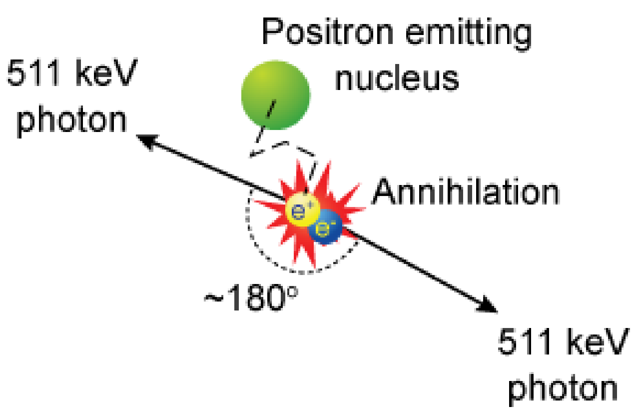




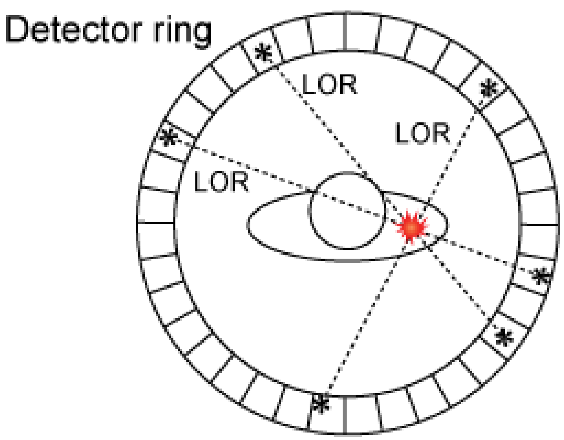
SPECT / CT to clarify the diagnosis

# Positron Emission Tomography

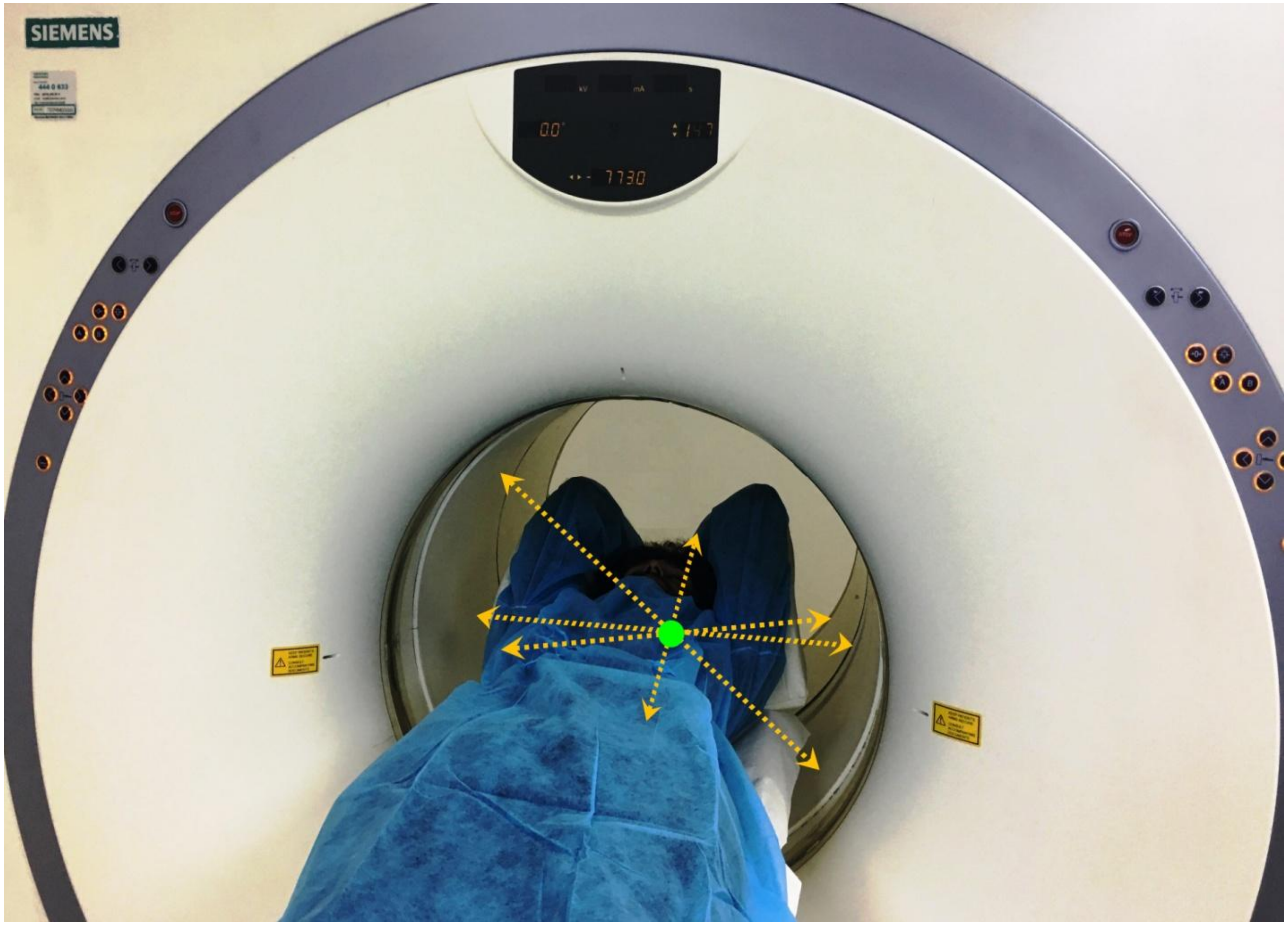
- Positron Emission Tomography is a modern imaging method of nuclear medicine that uses radionuclides that emit positrons as a result of decay.
- A positron emitted from the nucleus will combine with an electron in the adjacent tissue due to opposite charges and attraction, the distance traveled by the positron after emission is relatively short (up to a few millimeters in the tissues of the human body).
- The process is followed by the annihilation of the two particles, with the emission of two gamma annihilation quanta with an energy of 511kev, which move in opposite directions from the place of annihilation at an angle of 180 degrees (line of response). These photons are also called annihilation radiation.




(a)




(b)




Positron emission tomography (PET). Simultaneous detection of photons with 511 keV energy emitted in diametrically opposite directions following the annihilation of the positron-electron pair and subsequent localization of the location of the emitted photons in the patient's body.

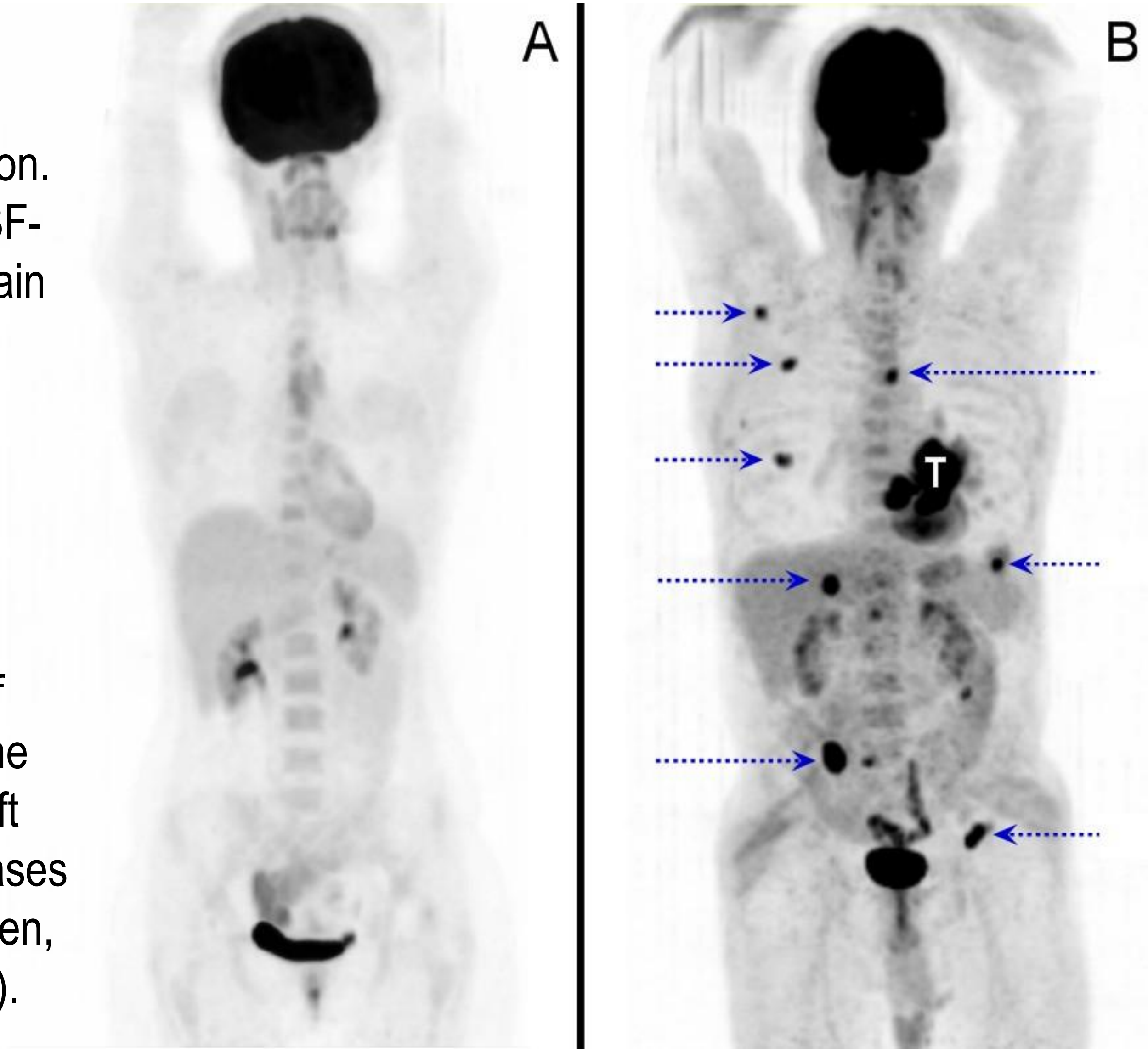
# Positron Emission Tomography

- One of the most commonly used positron emitting isotopes is a fluorine isotope - 18F (physical half-life T1 / 2 = 110 minutes), due to the possibility of its attachment to the glucose molecule.
- Most commonly used PET radiophramaceutical is fluorodeoxyglucose (2-18-F-deoxi-D-glucoze 18-F-FDG) allowing assessment of metabolic processes.
- The use of 18F-FDG has gained great importance in oncology, allowing the diagnosis and evaluation of the extent of neoplastic processes due to increased metabolic activity of tumoral tissues and thus the greater accumulation of radiolabeled glucose (18F-FDG).

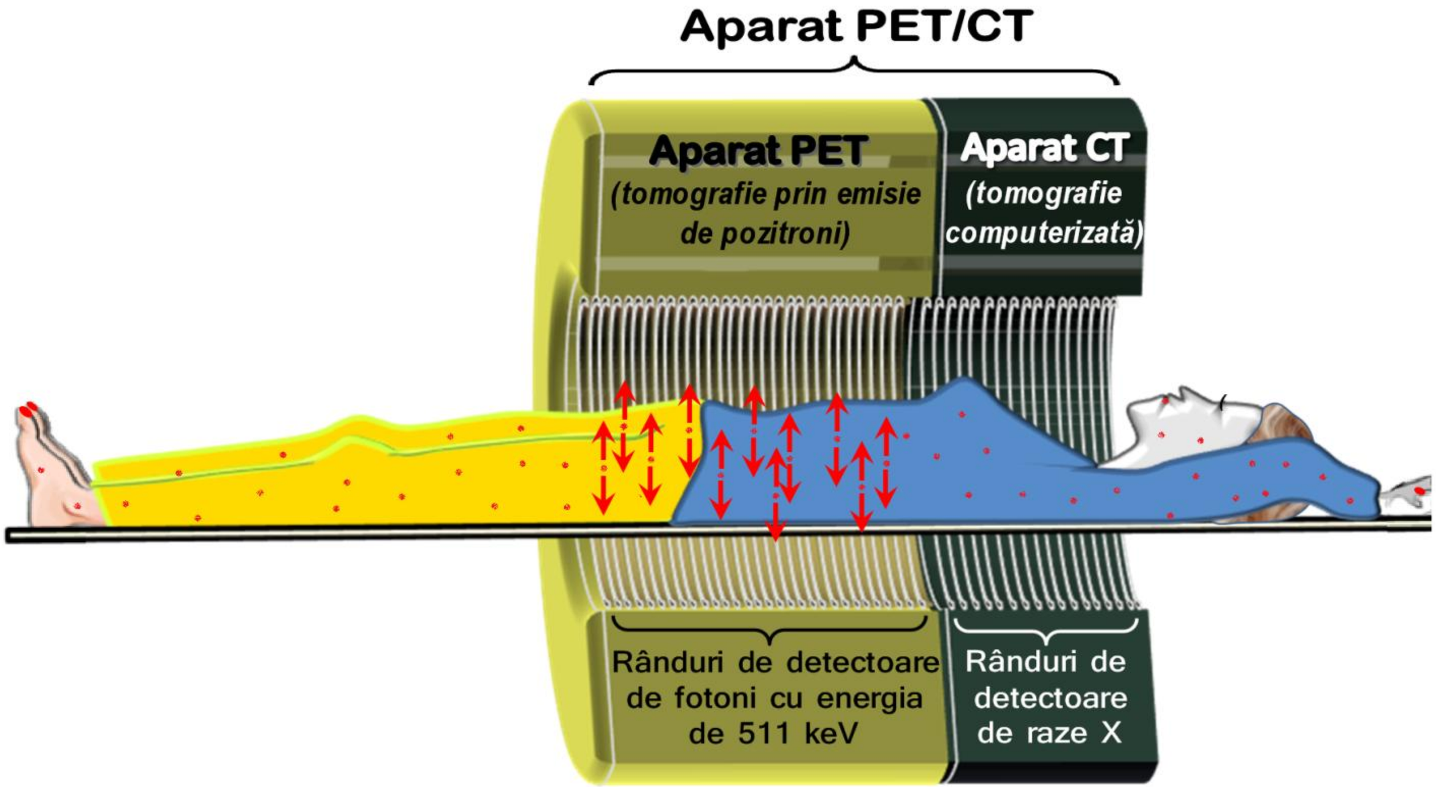
# PET

A – physiological distribution. Physiological activity of 18F-FDG is observed in the brain structures, as well as elimination through the kidneys into the urinary bladder.

B – lung cancer patient. Increased accumulation of 18F-FDG is observed in the primary tumor (T) in the left lung, as well as in metastases in the right lung, liver, spleen, and skeletal bone (arrows).

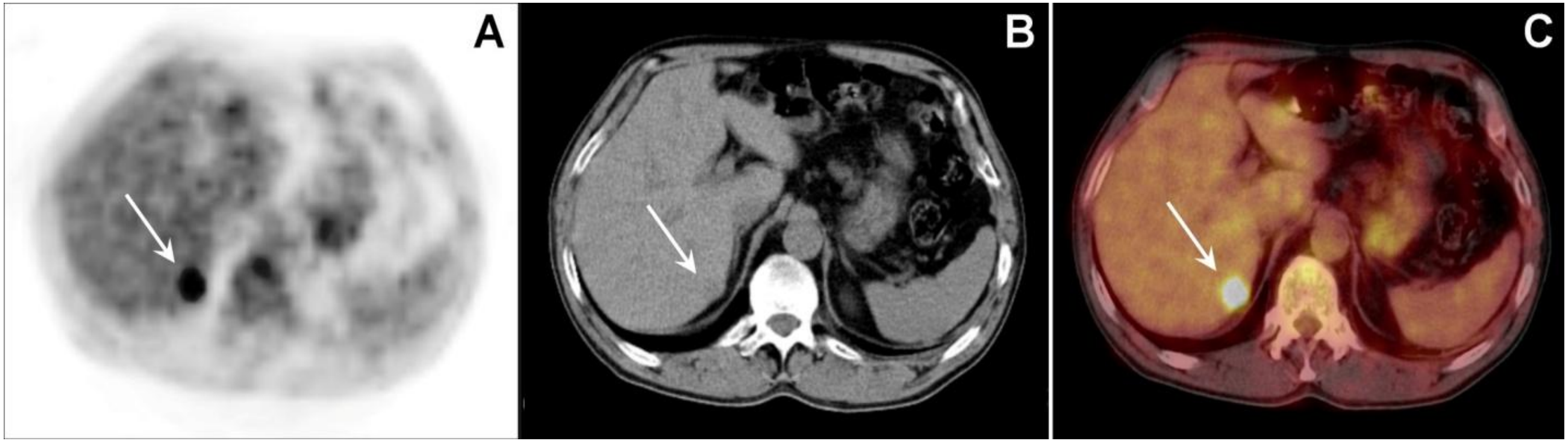


# PET / CT



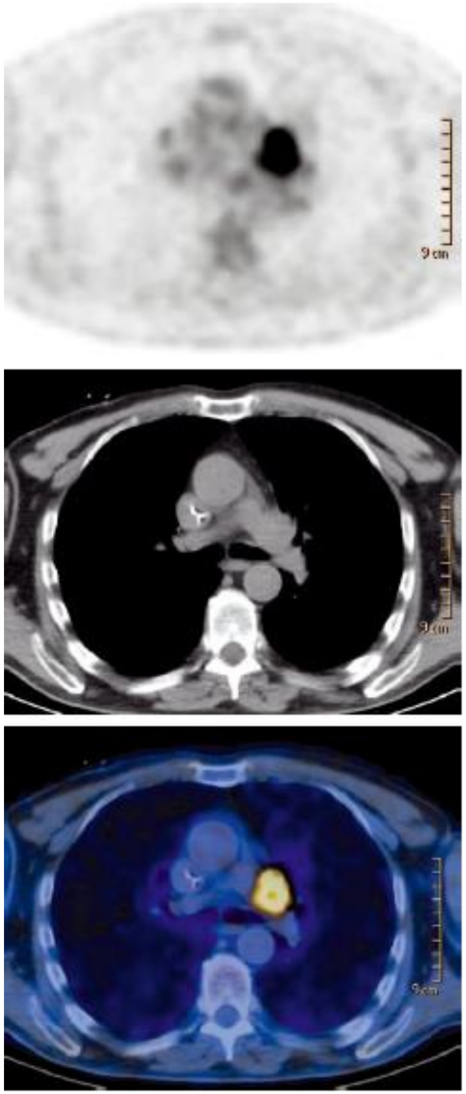

•Most frequently a PET scanner may be built to operate with a conventional CT scanner, with coregistration of images.
•This allows anatomical location on CT of any activity seen on PET.

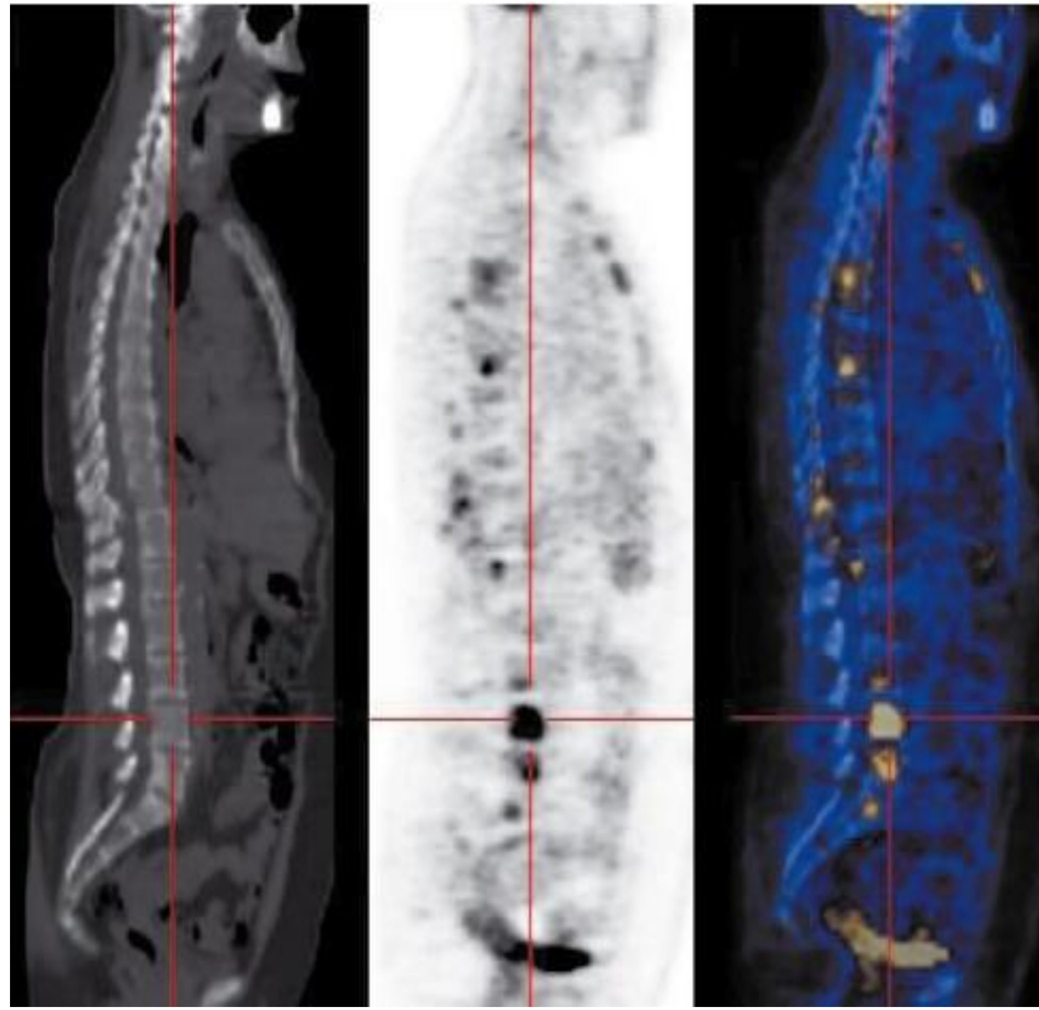
# PET / CT

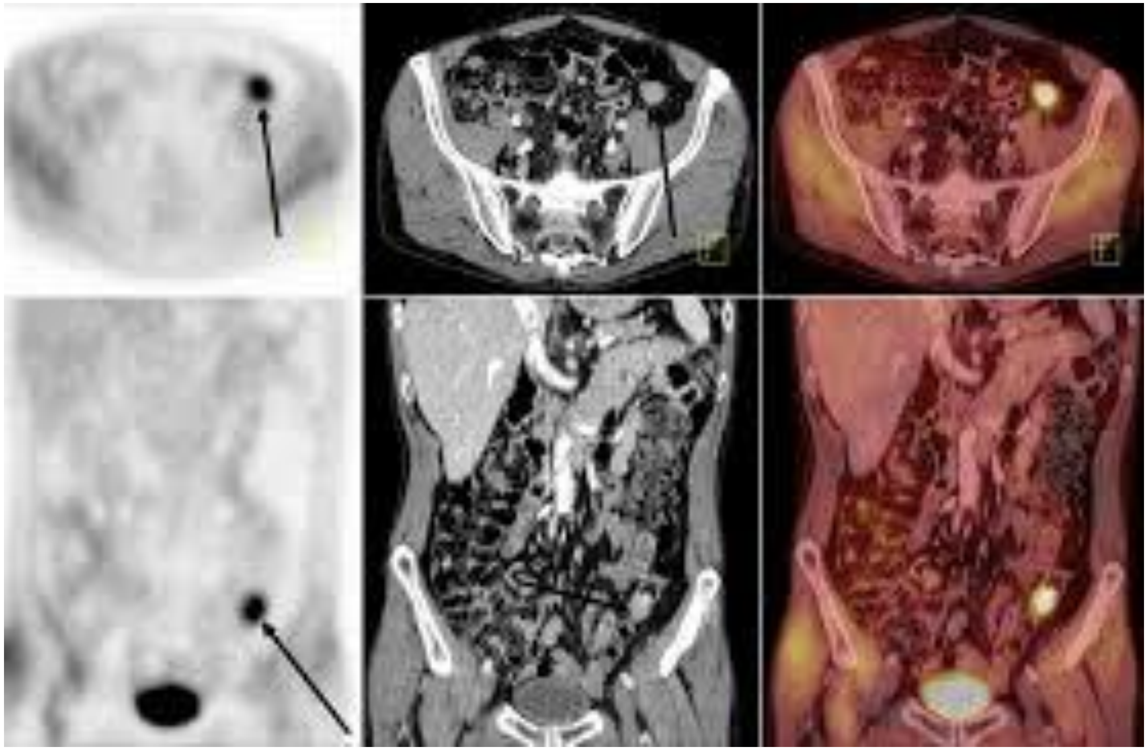


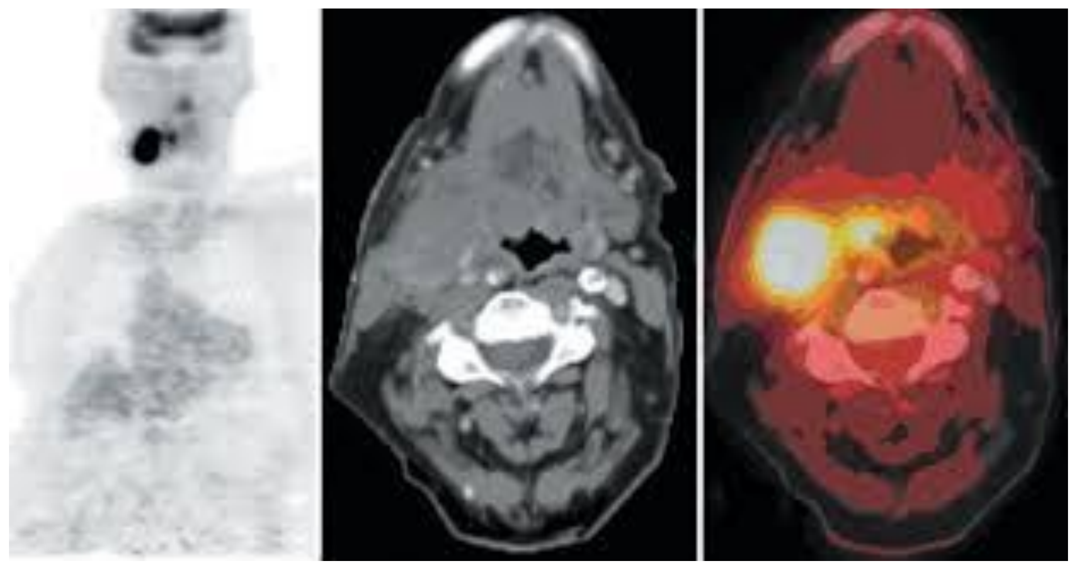

- A – $^{18}$F-FDG distribution in PET image;
- B – anatomical structures in CT image at the same level;
- C – PET / CT hybrid image reflecting the 18F-FDG distribution superimposed on the anatomical structures. The arrow indicates the presence of a liver metastasis.

# PET / CT

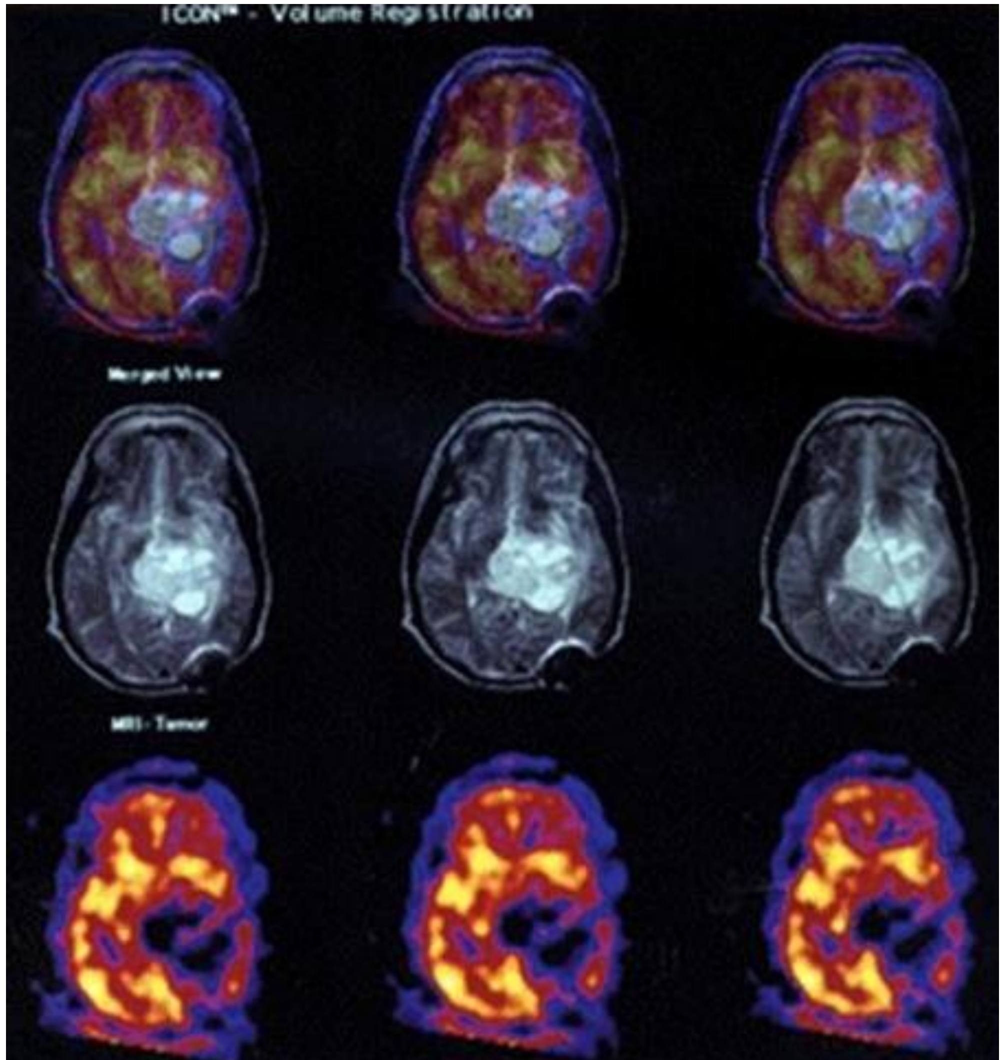






# PET / MRI



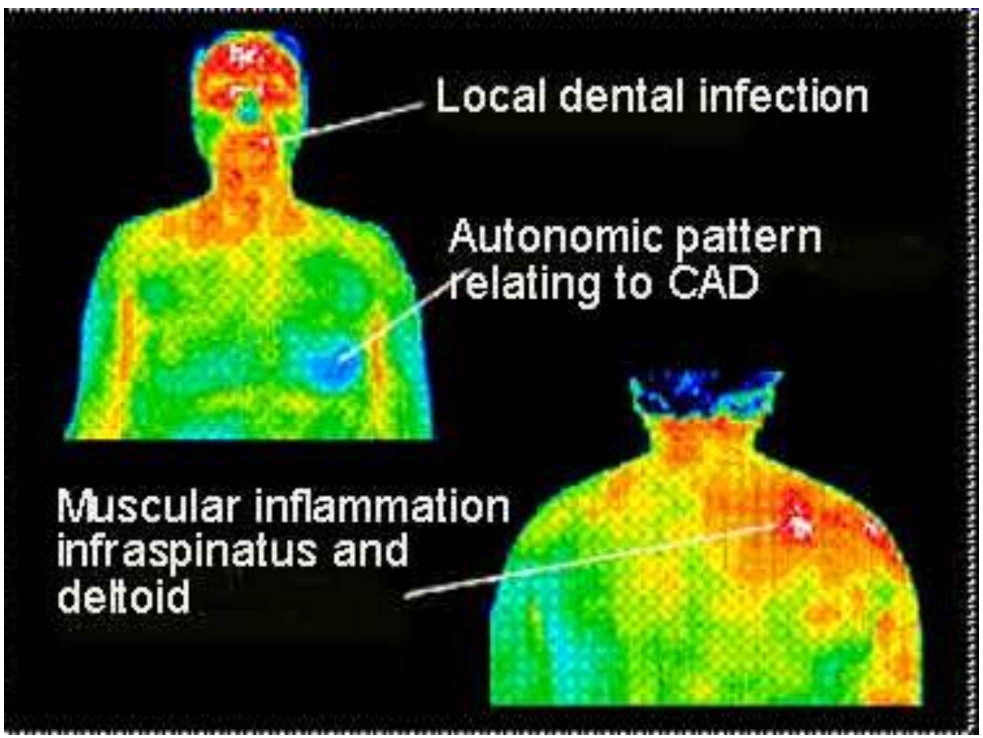
# MEDICAL THERMOGRAPHY

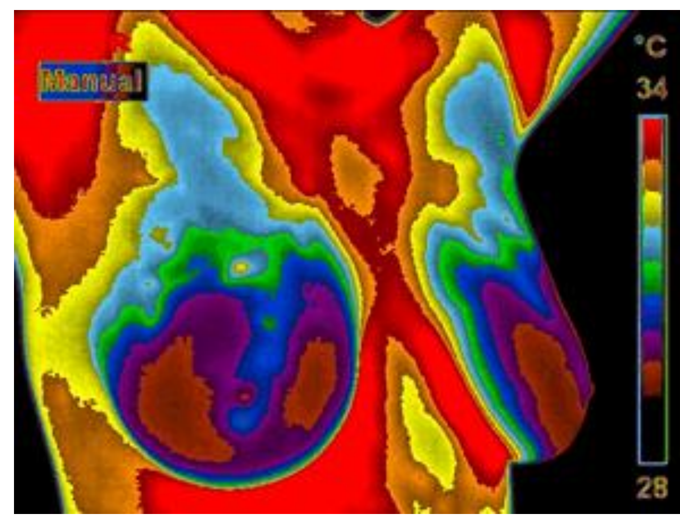
# THERMOGRAPHY

- BASED ON INFRARED RADIATION EMITTED BY LIVING TISSUE

# MEDICAL THERMOGRAPHY

- **Measures body tissue heat energy. Generally "problem areas" show high or low temperatures due to increased or reduced blood flow and metabolic activity, respectively.**
- **infrared radiation is emitted by all objects based on their temperatures above -237° C.**

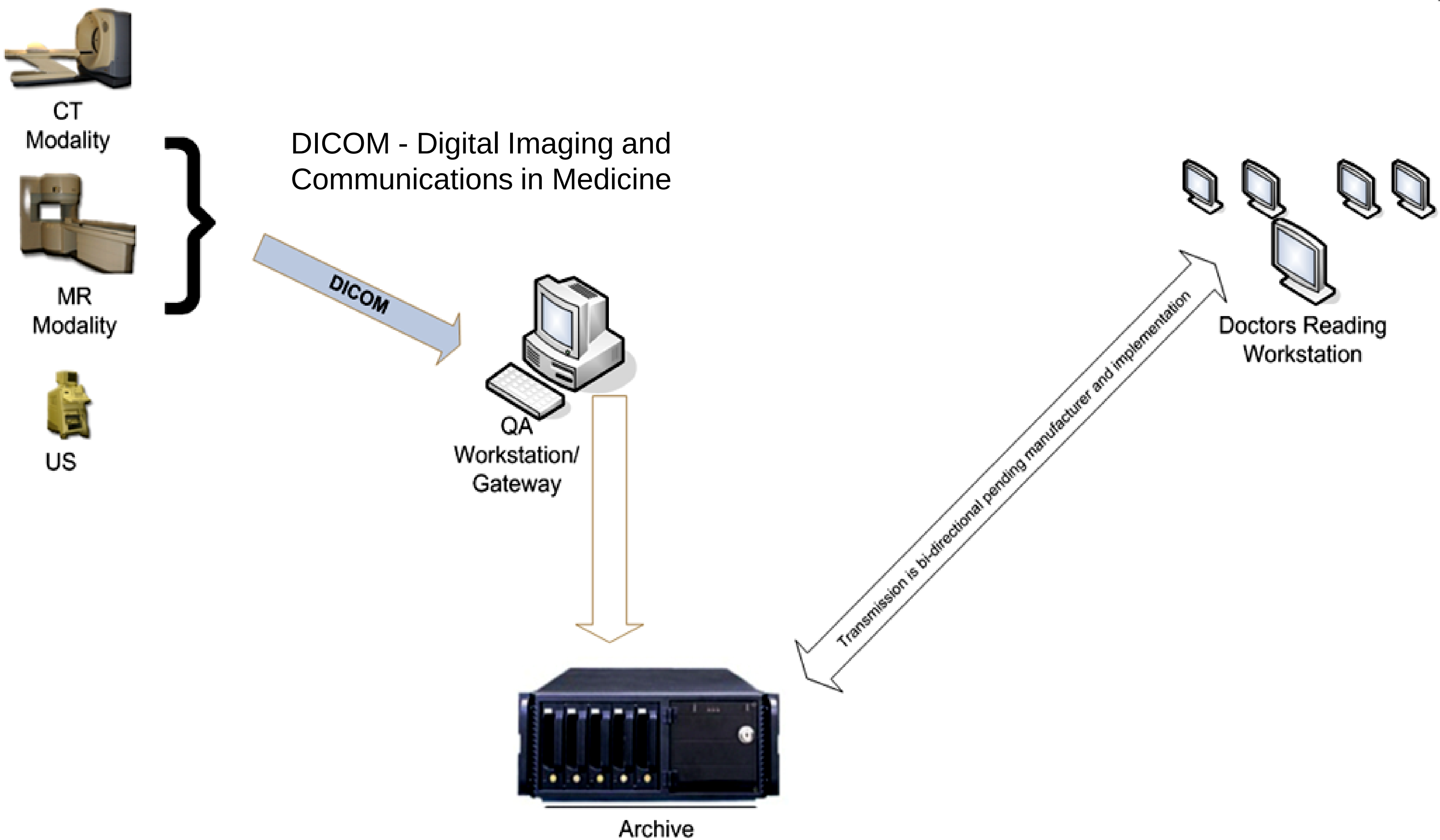


# PACS

# PACS

## (Picture Archiving and Communication System)



## The chiefs of the groups

after the lecture send the presence of the students of your group to the address

**anatolie.obada@usmf.md**

## All students

write in the chat

**Last name, First name, group number**

to confirm your presence