Introduction to Nuclear Medicine

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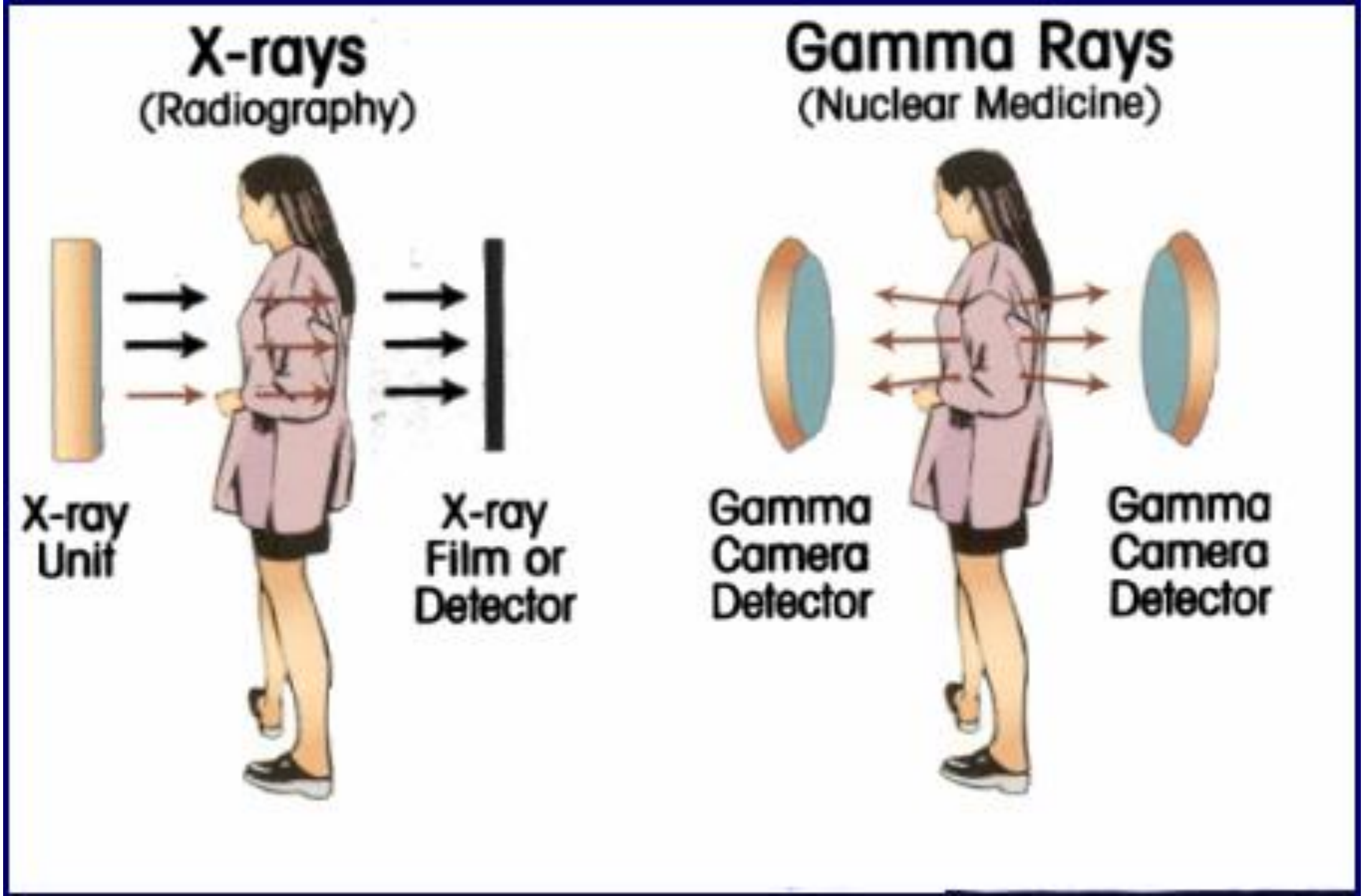

X-rays
(Radiography)
X-ray
Unit
X-ray
Film or
Detector
Gamma Rays
(Nuclear Medicine)
Gamma
Camera
Detector
Gamma
Camera
Detector

X-rays (Radiography):

- Radiation source is outside the patient (X-ray Unit).
- X-rays pass through the body and are captured on film or a digital detector.
- The image is formed based on how much different tissues absorb the X-rays.

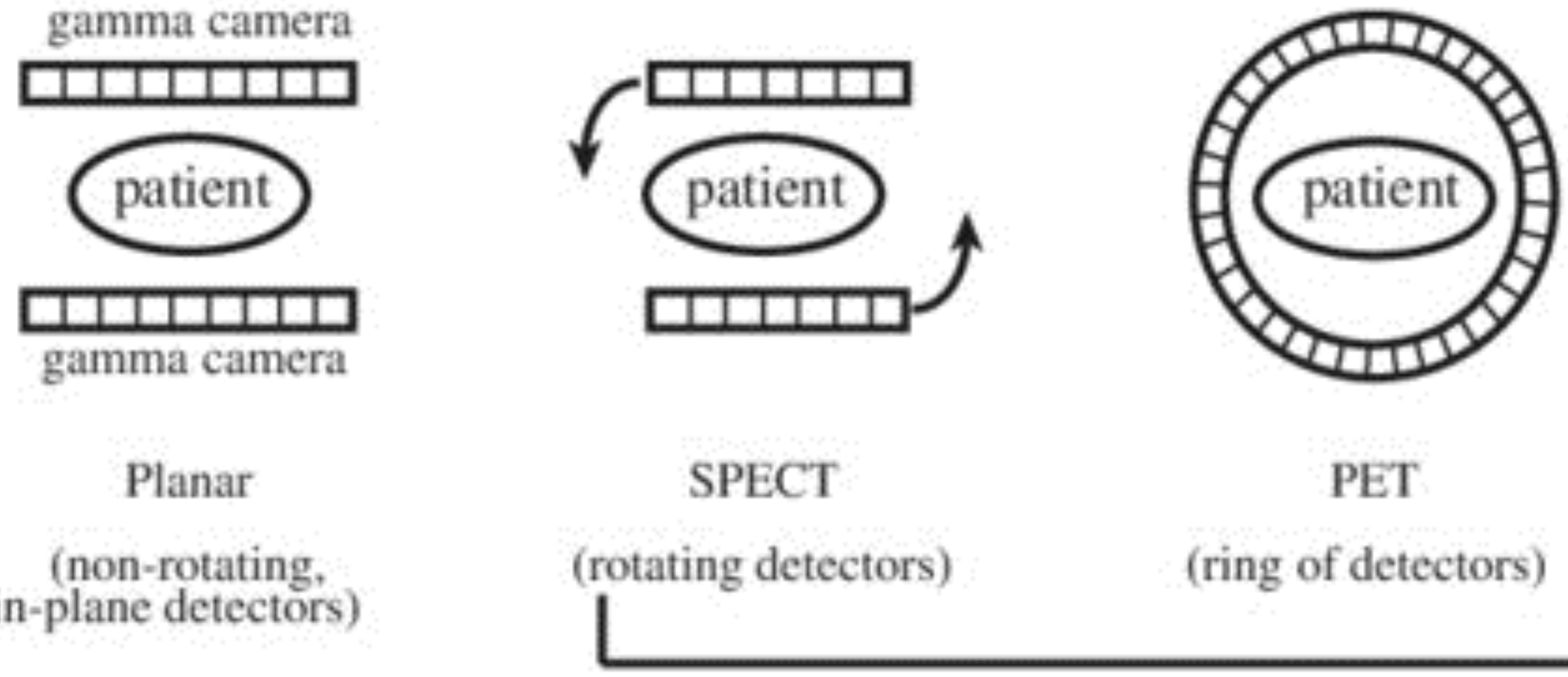
Gamma Rays (Nuclear Medicine):

- Radiation source is inside the patient (radioactive tracer injected, swallowed, or inhaled) radiopharmaceutical
- Gamma rays emitted from the patient are detected by gamma cameras placed outside the body.

Nuclear medicine is not used to study the anatomy of a certain organ (the image is of a low quality). However, nuclear medicine can be thought of as the study of function of a certain organ. A nuclear image takes time, while an X-ray is almost instantaneous.

- Depending on the organ, different materials are used.

The key distinction between nuclear medicine and almost all other imaging modalities – images may indicate dynamic information – ***function***, not just structure


gamma camera
patient
gamma camera
patient
patient
Planar
(non-rotating,
in-plane detectors)
SPECT
(rotating detectors)
PET
(ring of detectors)
Tomographic

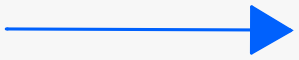
From dossier

Types of nuclear studies:

1. Planar imaging:
    - Here, the images can be dynamic or static.
    - They take an image of the organ in any direction
    - A common example is a renal nuclear scan

2. SPECT:
    - Single Photon Emission Computer Tomography
    - The radioactive material used produces one photon only; ex. Technicium
    - The body emits a radiation, and a camera takes an image. Then, a computer reconstructs a 3D representation of the structure.
    - The radioactive materials here are of a high molecular weight.
    - The resolution of this photo is lower than a PET scan.

3. PET
    - Positron Emission Tomography
    - The PET scan uses positron emitting substances. These substances include radioactive fluorine (most important), radioactive oxygen, radioactive
    - carbon, radioactive nitrogen, and gallium.
    - A positron is an electron with a positive charge; it is produced through a process called positron emission or beta decay.



How is a positron produced?

- A proton inside the radionucleotide is transformed into a neutron.
- When this transformation happens, the neutron decays into a particle called a positron.
- The positron is released from the molecule.
- Upon its release, the positron loses energy. As it loses energy, the positron can interact with electrons in the surroundings.
- The process of interaction between a positron and an electron is called annihilation. The process of annihilation produces gamma rays. (both the positron and electron need to have 520 kEV energy to interact)
- The produced gamma rays are detected by a gamma camera, and the image is recorded

🔶 As you have noticed, a PET scan uses two particles to produce gamma rays. Therefore, its resolution is higher than a SPECT scan.

🔶 These radionucleotides can be inserted into normal compounds in order to obtain the image. For example, we can use radioactive amino acids, radioactive water, or radioactive RBCs, etc….

🔶 The most commonly used radionucleotide is fluorine.

🔶 The mostly commonly used radioactive compound is radioactive glucose

Radioactive glucose (fluorodeoxyglucose)

- We replace the hydroxyl group of glucose with a radioactive fluorine atom.
- Radioactive glucose will be taken up by the cell just like normal glucose.
- It will start the glycolysis pathway; however, it will not proceed until the end (due to the replacement of hydroxyl with fluorine)
- These molecules will accumulate inside the cells, and will emit a radiation that is detected by the detectors placed around the patient.
- Any cell with increased glucose uptake, will emit more radiation.
- So, a PET scan using radioactive glucose can show any smallincrease in metabolism inside a certain cell. This is ideal for detecting small tumor cells

What is a radiopharmaceutical?

A radionuclide (radioactive and emits something we can detect, usually gamma rays)

A pharmaceutical (which gives the physiologic function)

For example, we attach technetium-99m to DTPA, which is filtered by the kidney, to calculate glomerular filtration rate.

Or we can attach it to MDP, which is taken up by the bone, to do a bone scan.

Ideal diagnostic radiopharmaceutical

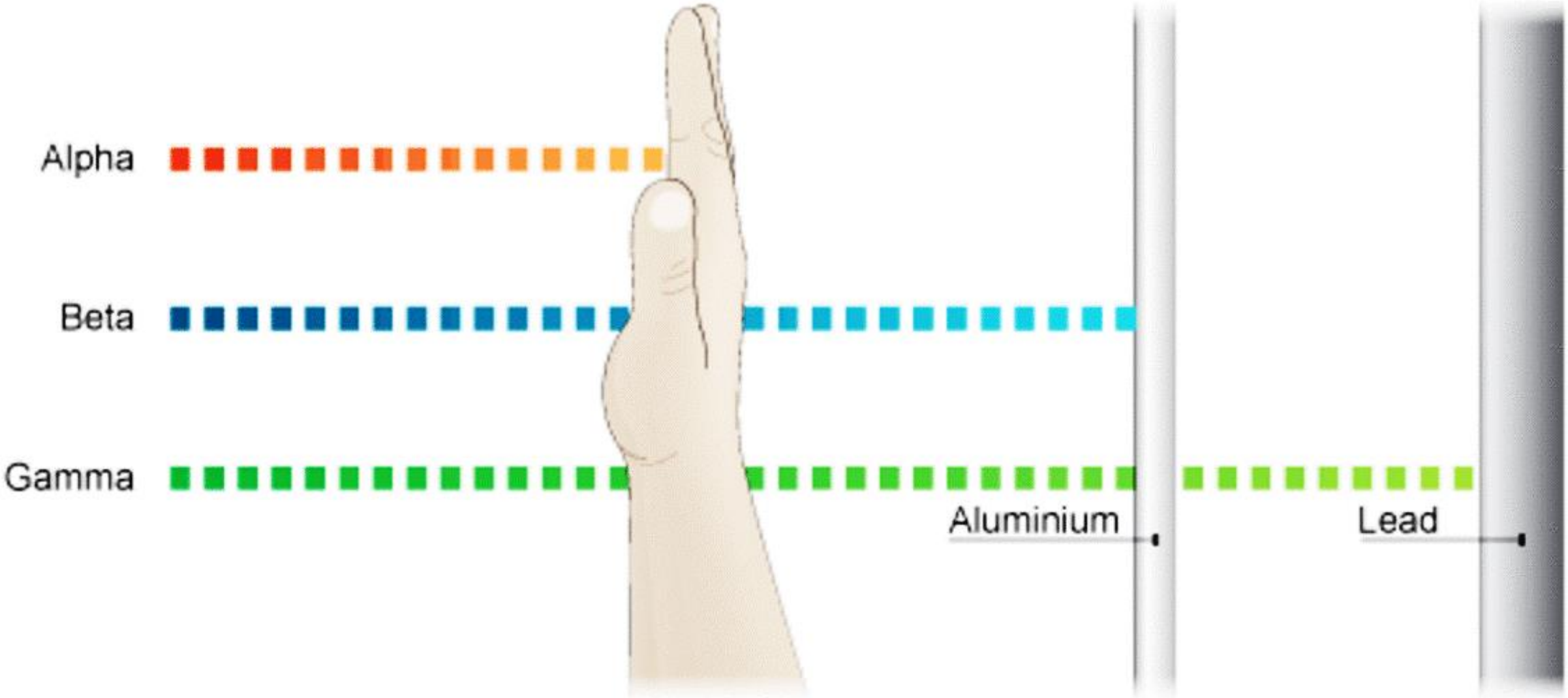
Pure Gamma Emitter
- Alpha and Beta Particles are unimageable and deliver high radiation dose

Energy of Gamma Rays
- Ideal: 100 - 250 keV
  - ^{99m}Tc, ^{123}I, ^{111}In
- Suboptimal: < 100 keV
  - ^{201}Tl
- > 250 keV
  - ^{67}Ga, ^{131}I

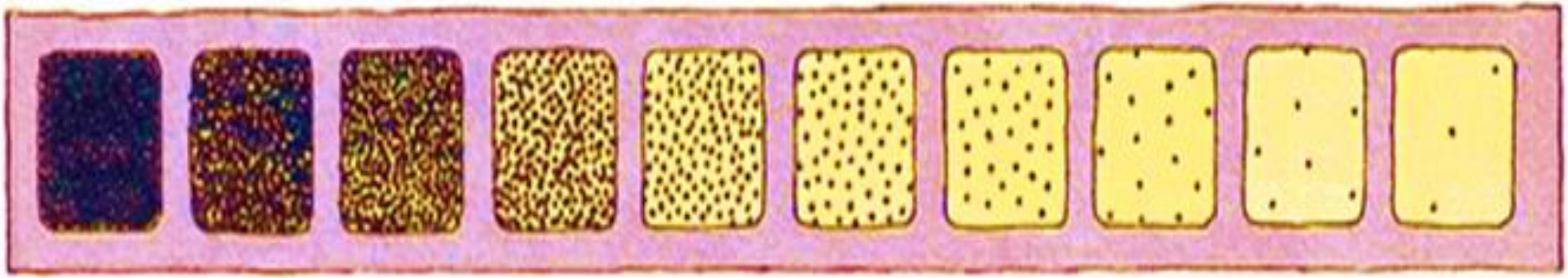
High target to non-target ratio

Easily available

Suitable effective half life


Alpha
Beta
Gamma
Aluminium
Lead

Decay rate of radioactivity: After ten half lives, the level of radiation is reduced to one thousandth



Time: One half life two three four five six seven eight nine

Radionuclide Production

Characteristics	Production Method			
	Cyclotron	Reactor (Fission)	Reactor (Nuclear Activation)	Generator
Examples	^{201}T, ^{123}I, ^{18}F	^{99}Mo, ^{131}I	^{125}I	^{99m}Tc, ^{68}Ga

^{99m}Tc (99-metastable-Technitium)

Most used radionuclide

Pure gamma radiation (the only radiopharmaceutical that produce gamma)

140 keV energy level

Has a suitable energy level, if the energy was lower, the rays would not penetrate the body. If the energy was higher, the rays would cause damage to the body

Half life of 6 hours

Available

Cheap

Produced by a generator from ^{99}Mo

Thyroid Scintigraphy

^{99m}Tc-pertechnetate and ^{131}I

Indications

- Low TSH
  - Diffuse toxic goiter (Graves' disease)
  - Single toxic nodule
  - Toxic multi-nodular goiter
- Evaluate nodule (hot vs. cold)

^{131}I Uptake

Radioactive Iodine (RAI) is used for thyroid uptake.

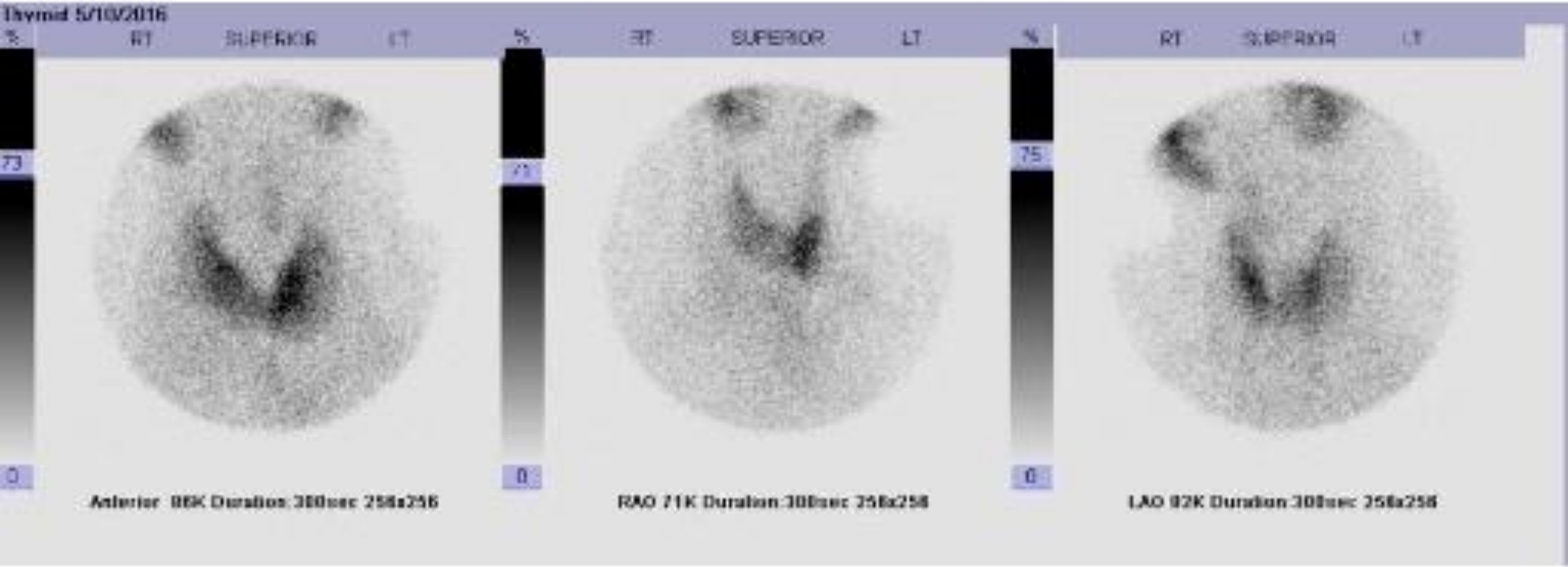
RAI is given orally

Follicular cell traps Iodine and organifys it to be incorporated with thyroid hormone.

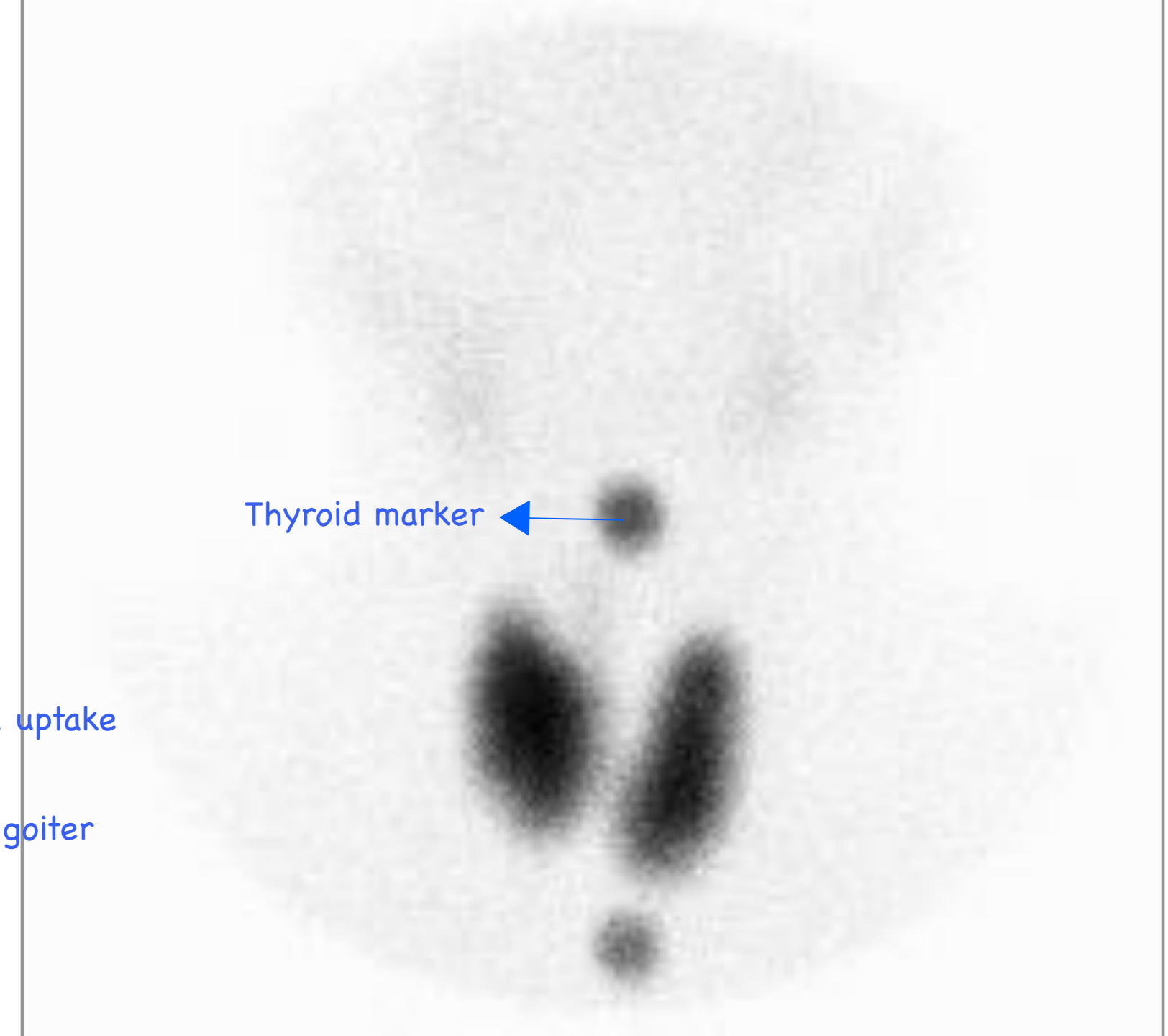
Uptake are obtained after 24 hours

- Measure photons in the given RAI by a special probe (uptake probe) just before taking RAI.
- After 24 hours, measure photons in the neck (thyroid gland).
- Calculate % of photons concentrated in thyroid gland.

Norma range = 10 – 30%



Normal Scan - RAIU 18%

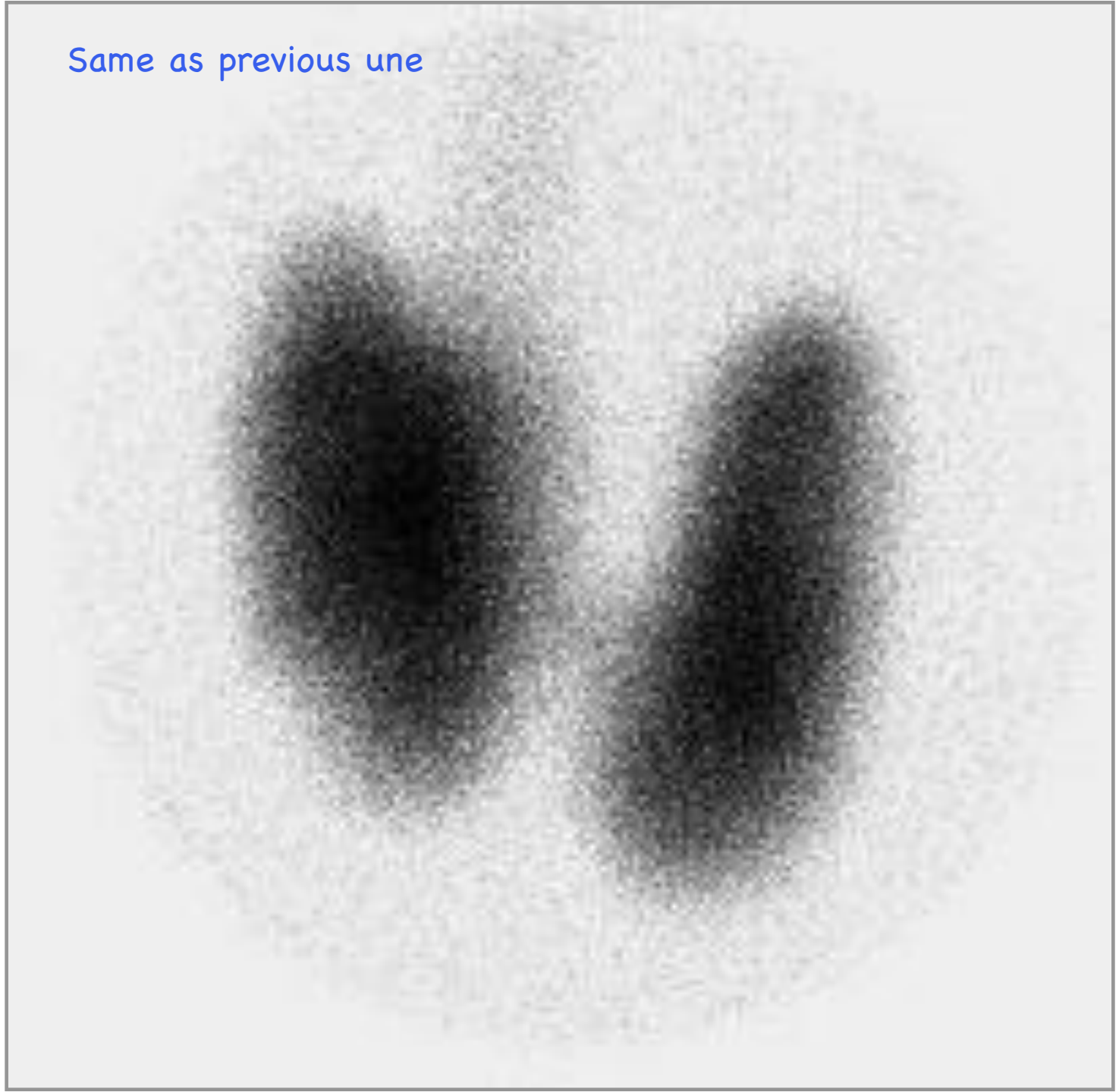


Hot nodule

Diffuse increased uptake

Dx: diffuse toxic goiter

Same as previous une



Graves' Disease

Also known as diffuse toxic goiter

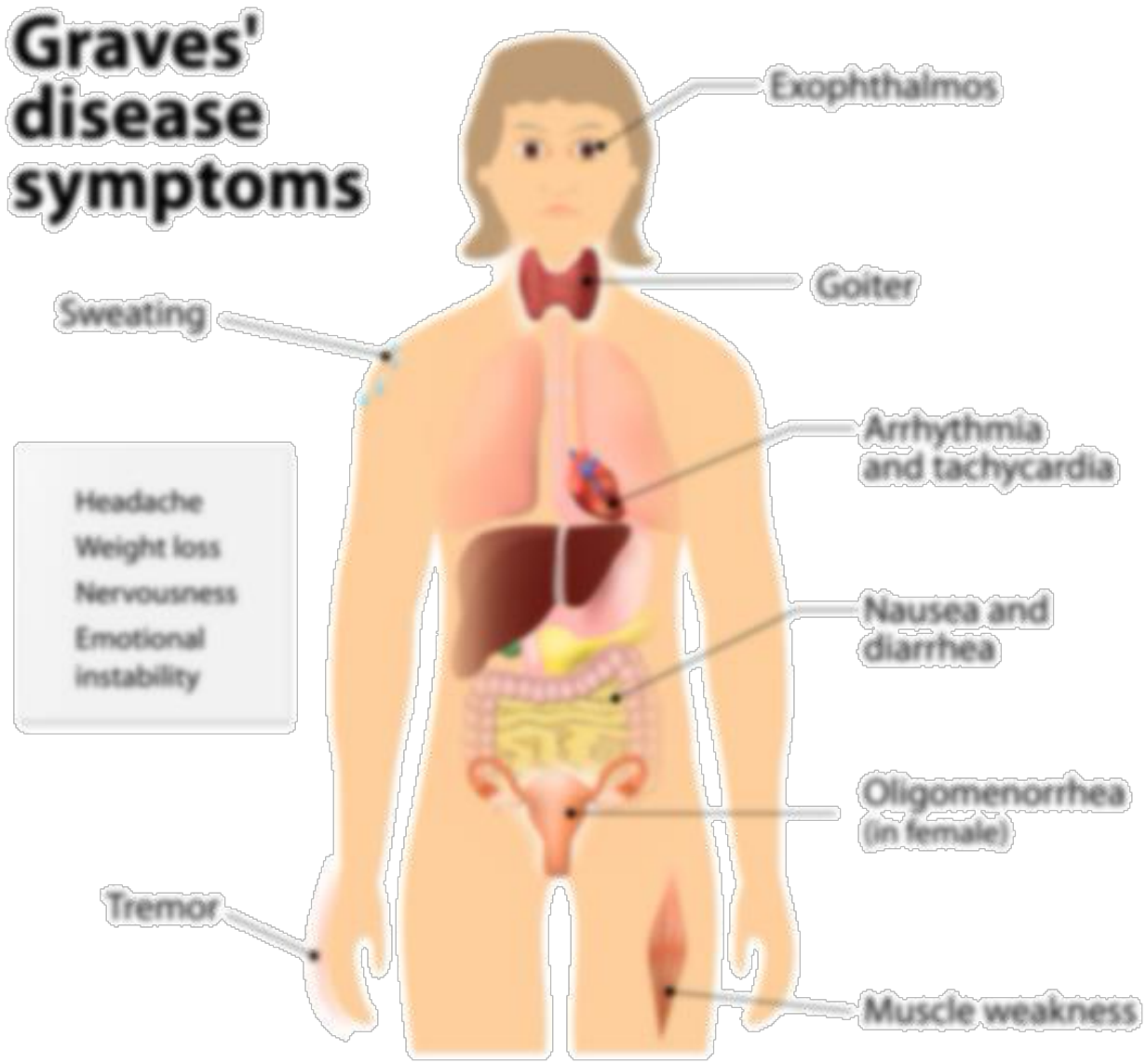
Diffuse enlargement of thyroid gland

Homogeneous or diffuse uptake

No significant focal abnormalities (nodules)

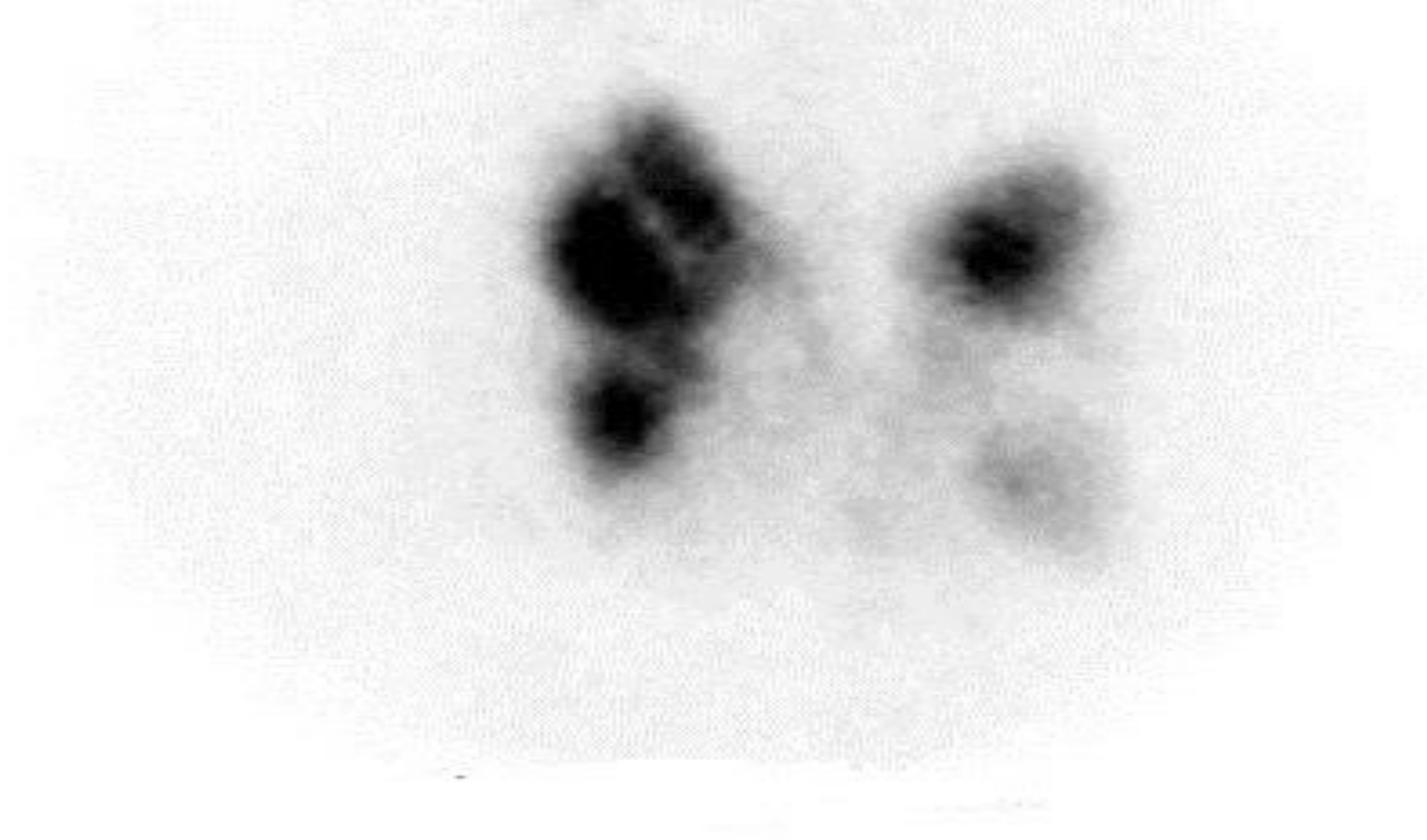
24-hour RAIU is elevated, typically above > 30% (usually above 60%)

Confirmed by TSH Receptor Antibody (TRAb)

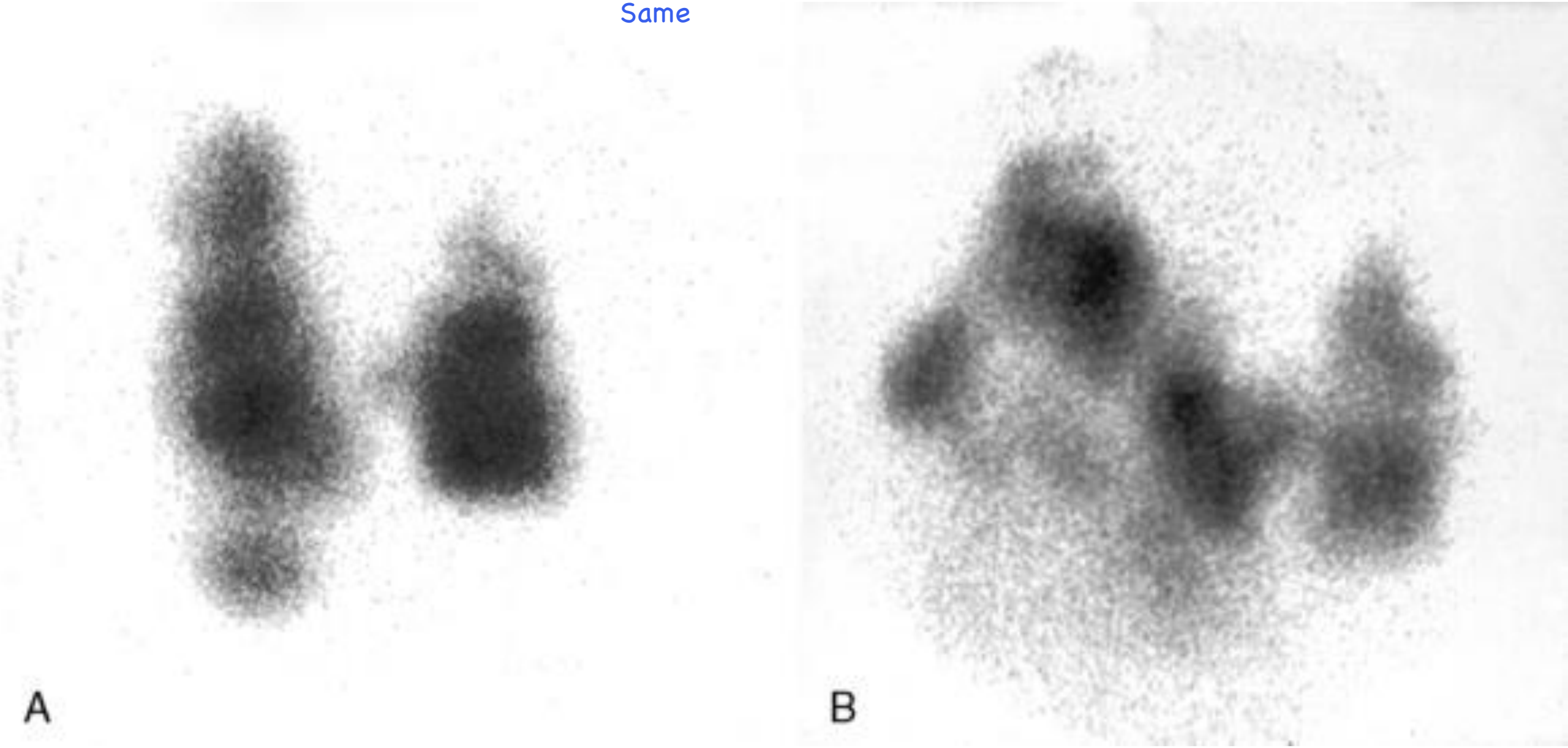


Thyroid scan shows heterogeneous uptake with multiple hot nodules, and a single cold nodule

Dx: Toxic multi-nodular goiter



Same



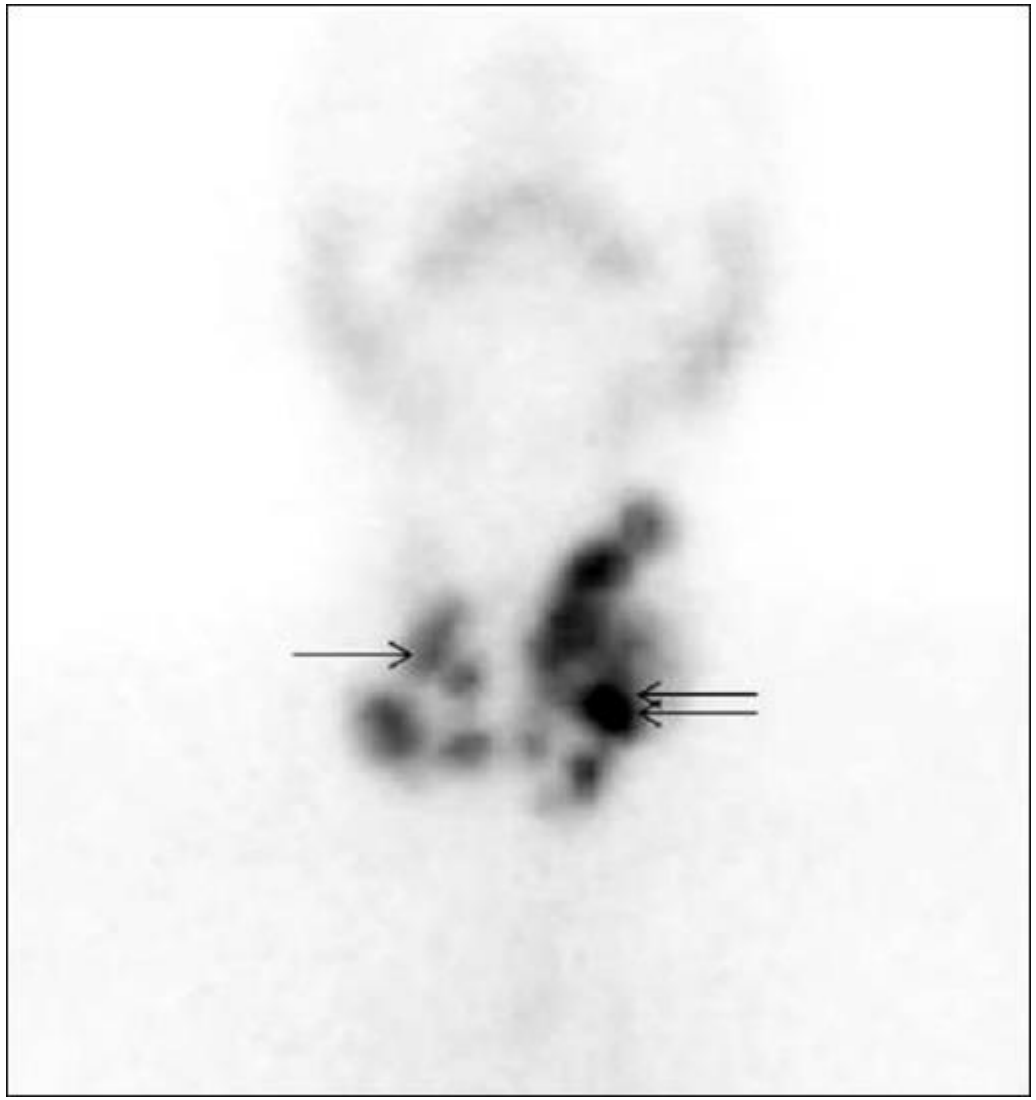
Toxic or Autonomous Multinodular Goiter

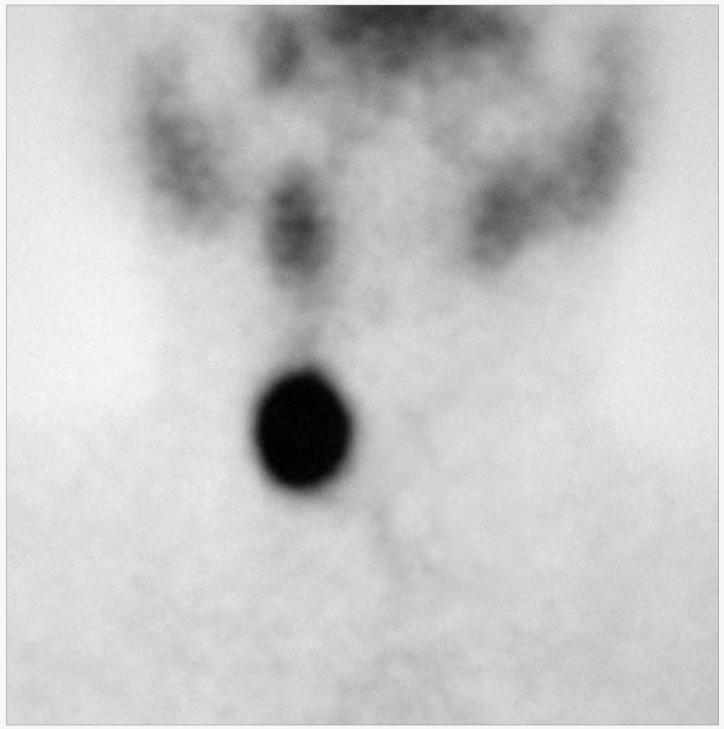
Also known as Plummer disease

Inhomogeneous or heterogeneous uptake in thyroid gland.

Multiple cold and/or hot nodules in both thyroid lobes.

24-hour RAIU is usually mildly elevated > 30% (usually between 40% and 50%)





Hot nodule (increased uptake)

- Surrounding thyroid tissue usually shows suppressed uptake because the hot nodule is producing excess thyroid hormone.
- Most hot nodules are benign.

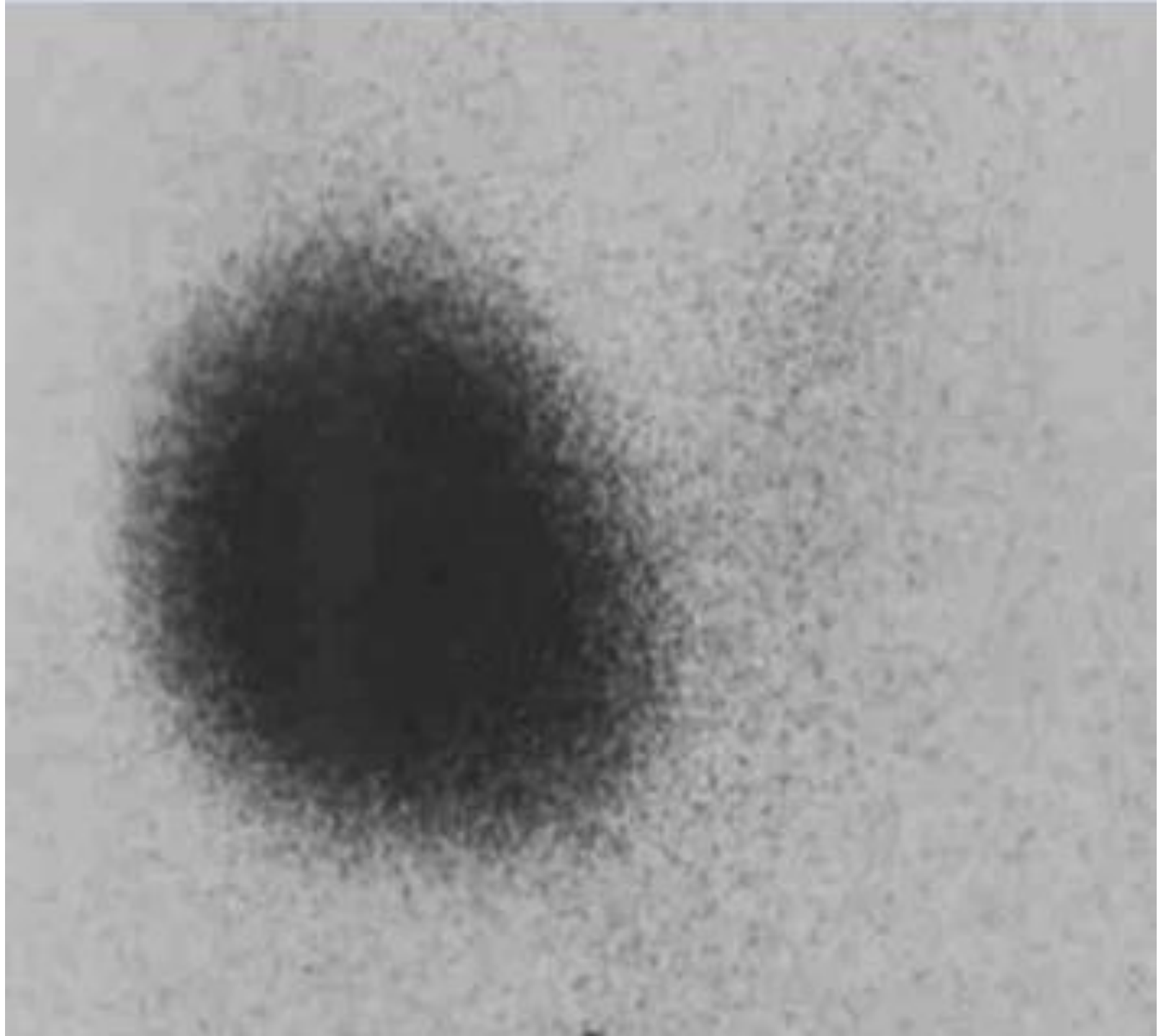
📌 In a thyroid scan:

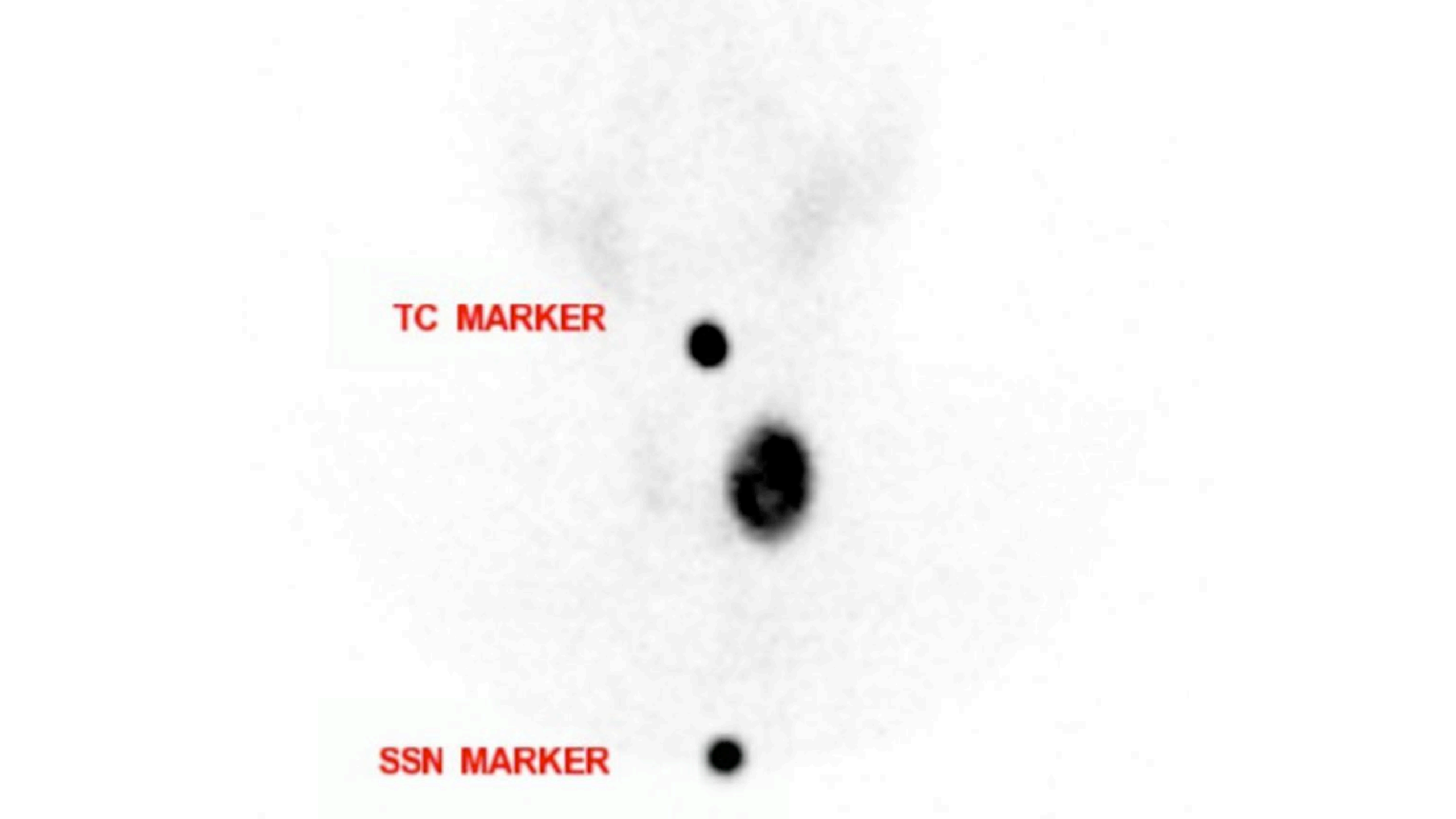
Single toxic nodule (toxic adenoma / autonomous hot nodule):

- The nodule appears "hot" = increased uptake
- The rest of the thyroid tissue is suppressed → shows very little or no uptake, because the nodule is producing excess thyroid hormones and suppressing the normal thyroid tissue.

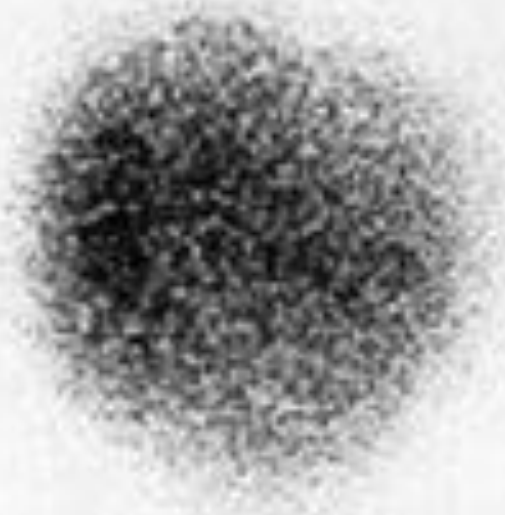
Single non-toxic nodule:

- The nodule appears "cold" or with normal uptake.
- The rest of the thyroid tissue shows normal uptake, because there is no excess hormone production to suppress the surrounding thyroid tissue.




TC MARKER
SSN MARKER

patient has
Toxic Adenoma

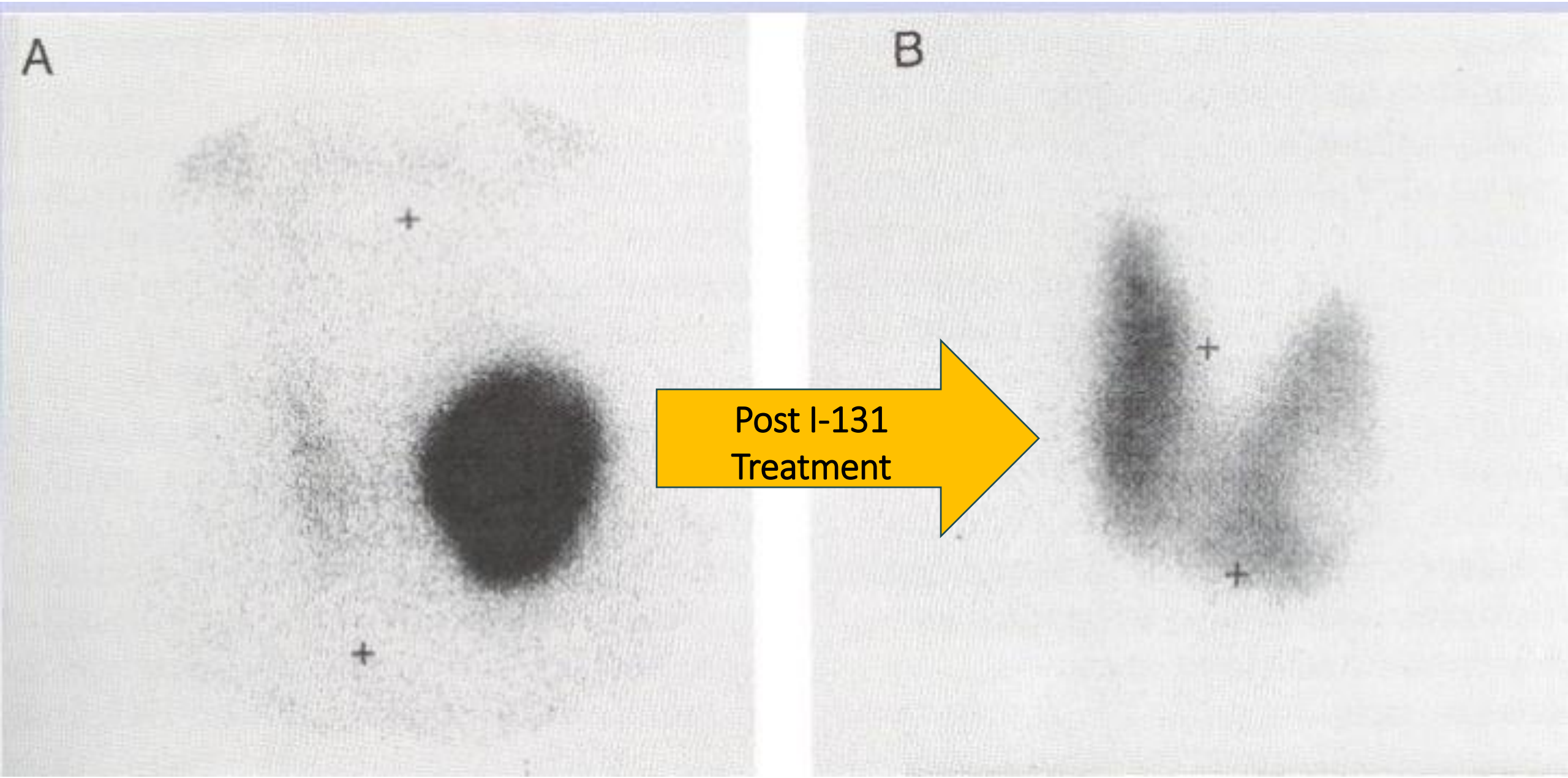


Post I-131 Treatment

8 days

A

B

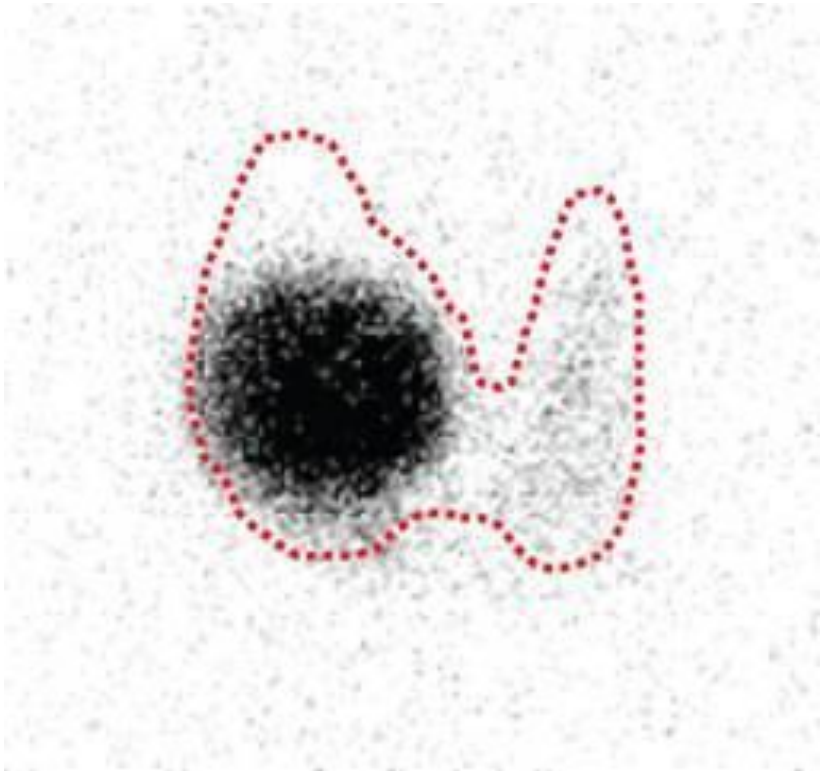

A
B
Post I-131
Treatment

Toxic Adenoma

Single hot nodule (independent of TSH or autonomous).

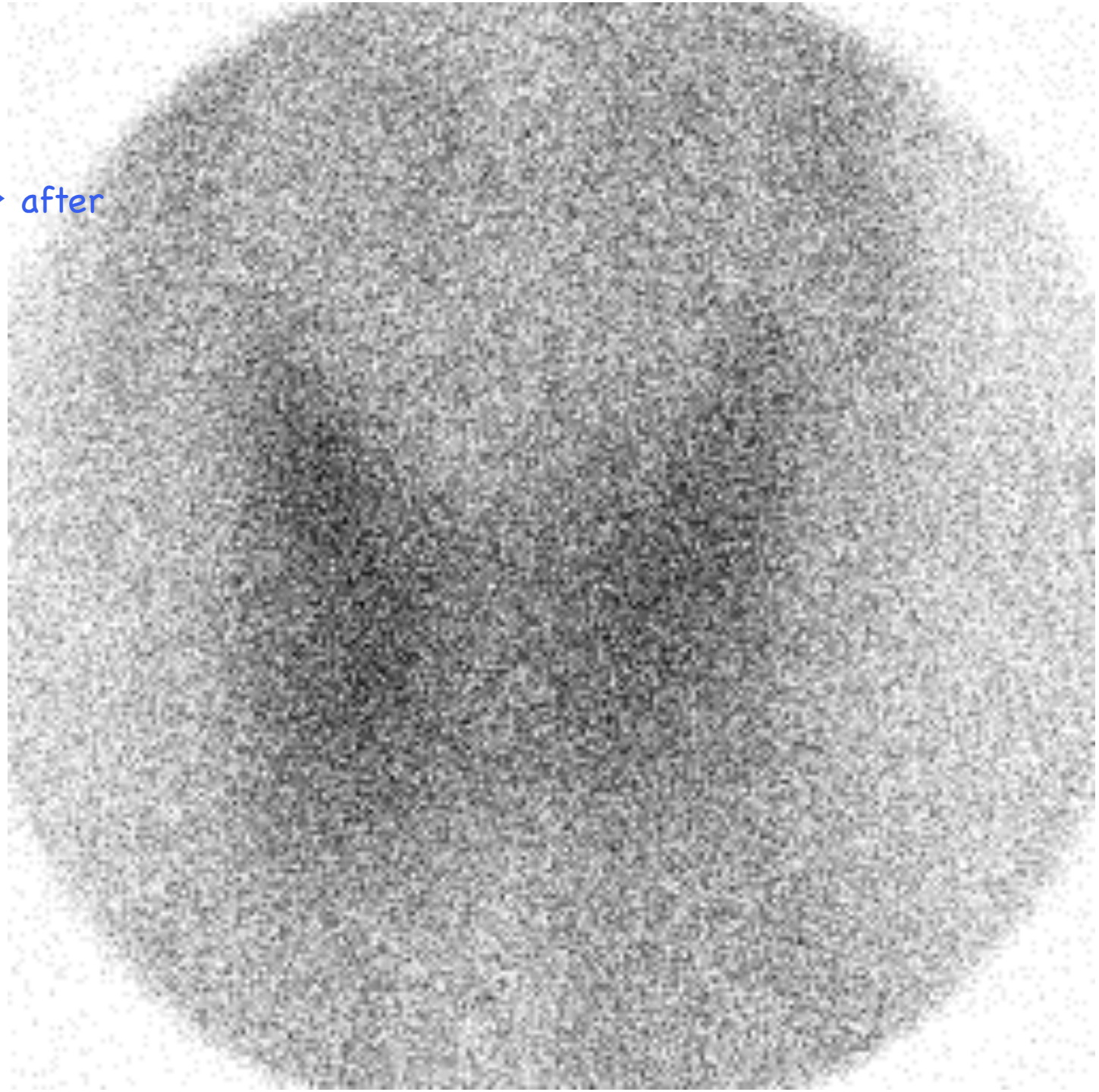
Rest of thyroid gland is poorly visualized due to low TSH level (TSH dependent).

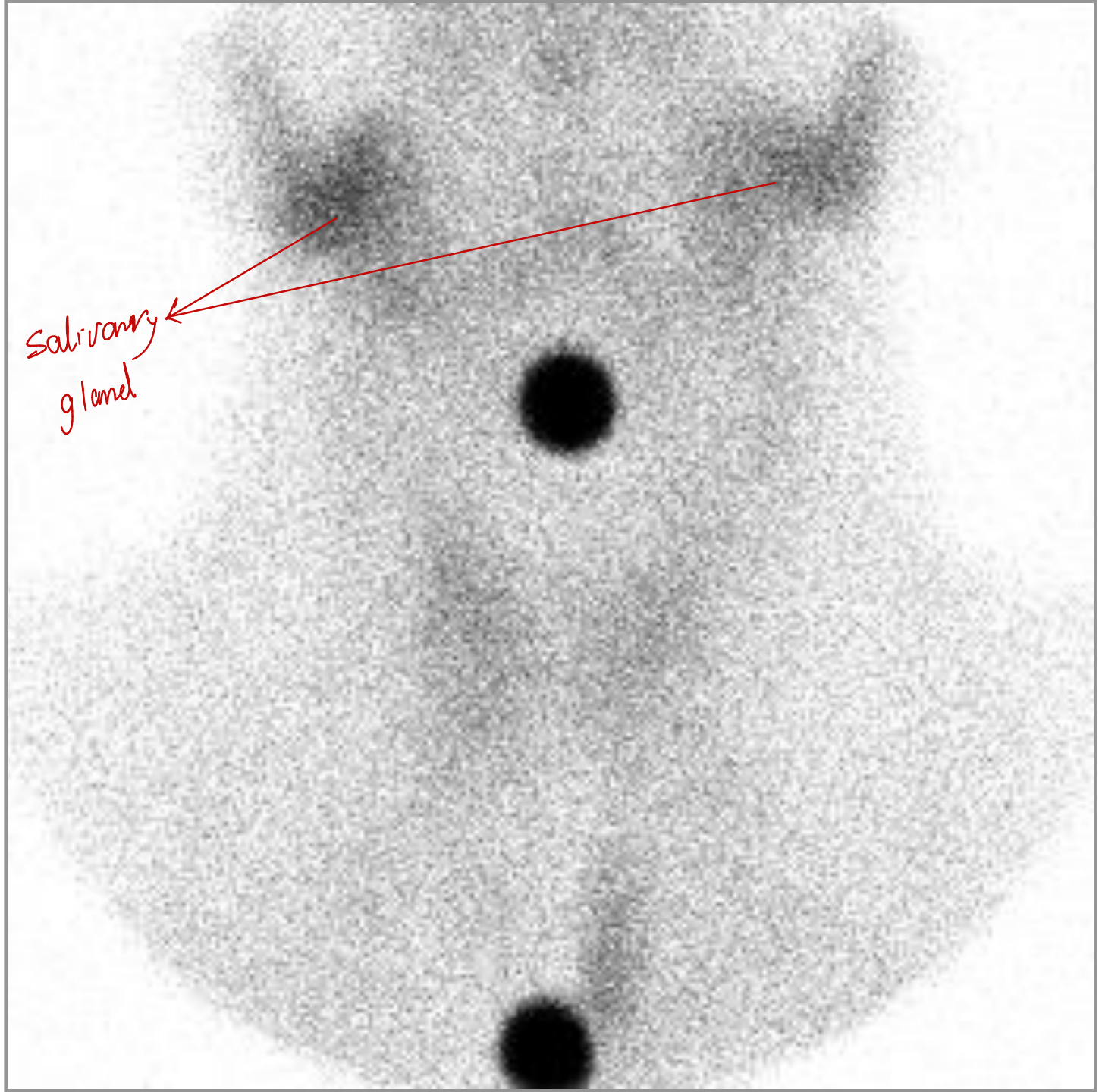
24-hour RAIU is slightly elevated, > 30%.



Low uptake

Subacute thyroiditis → after viral infection





Bilateral
decreased uptake

Subacute thyroiditis

Inflammation of thyroid gland that leads to release of stored thyroid hormone due to follicular cell destruction It might be painful or painless

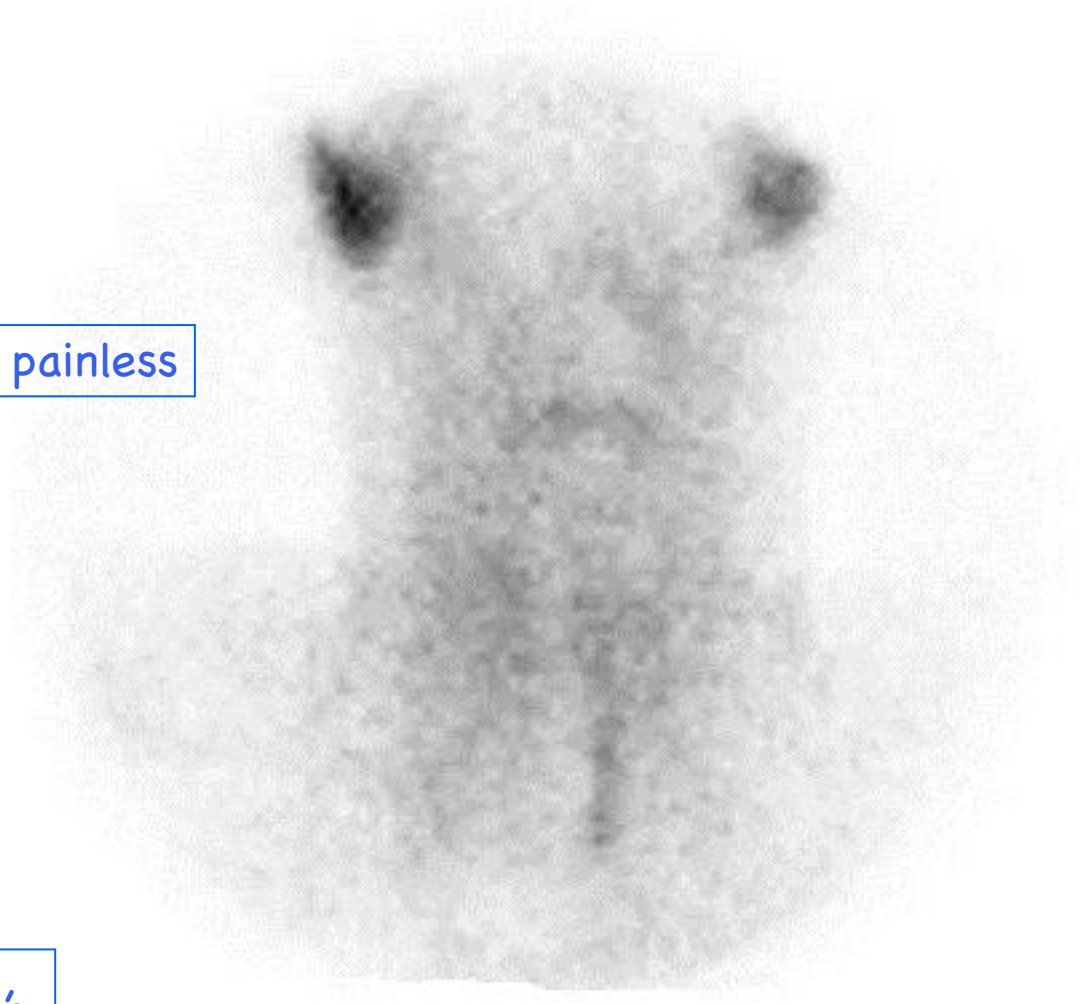
Heterogeneous uptake, could be mild or severe

In some cases, thyroid gland is not visualized

No significant focal abnormalities (nodules)

24-hour RAIU is low, usually < 5%.

Treatment is supportive with beta blockers and NSAID's



Cold nodules

Focally decreased uptake

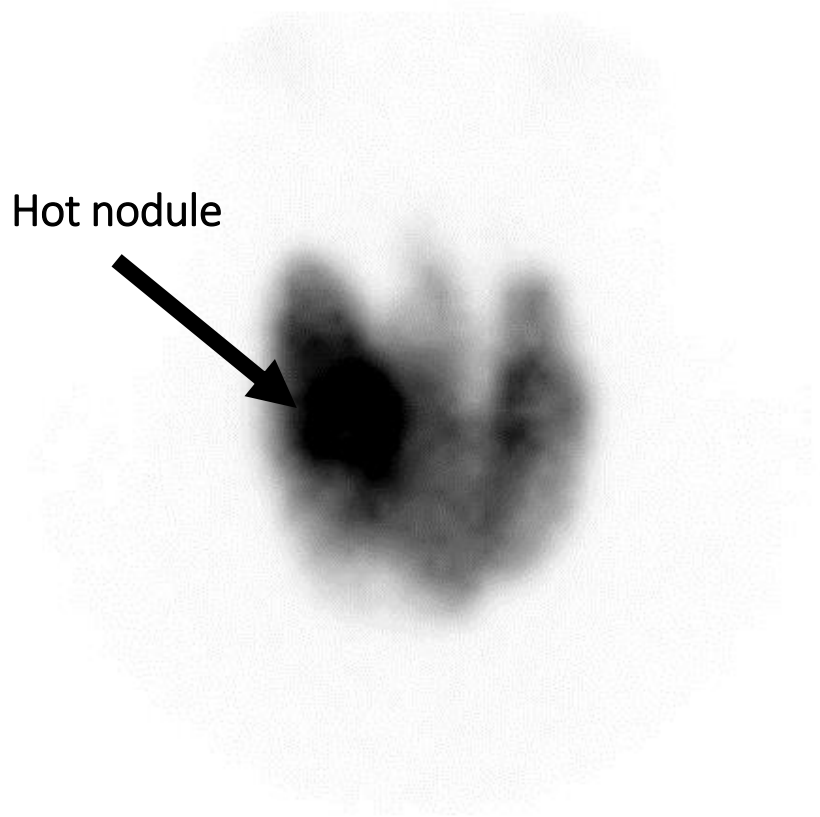
15% malignancy risk

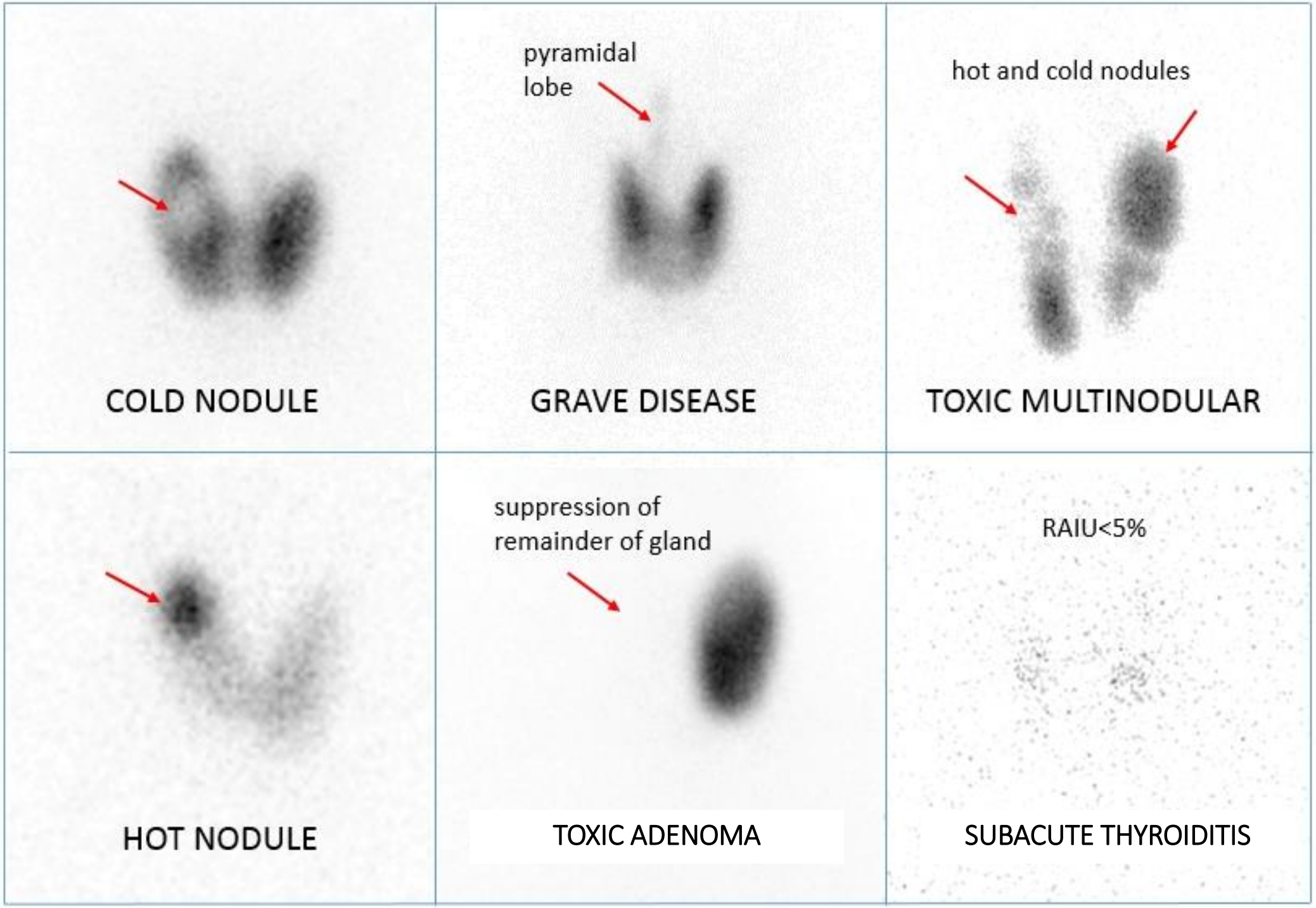
Next step is correlate with ultrasound to see if there is need for FNA or biopsy

Hot nodules

Focally increased uptake

Next step is reassurance




pyramidal
lobe
hot and cold nodules
COLD NODULE
GRAVE DISEASE
TOXIC MULTINODULAR
suppression of
remainder of gland
RAIU<5%
HOT NODULE
TOXIC ADENOMA
SUBACUTE THYROIDITIS

^{131}I Treatment

Beta-emitting radionuclide

Energy level 606 keV (beta) and 364 keV (gamma)

Produced by reactor (fission)

Half life of 8 days

Used as primary or secondary after medications or surgery

Indications

1. Hyperthyroidism
   - *Graves' disease*
   - *Toxic multinodular goiter*
   - *Toxic adenoma*
2. Differentiated thyroid cancer
   - *Papillary thyroid cancer*
   - *Follicular thyroid cancer*

Myocardial Perfusion

2 types of test → Rest
stress

Radiopharmaceuticals

^{99m}Tc-sestamibi

^{99m}Tc-tetrofosmin

^{201}Thalium

When do we use a myocardial perfusion scan?

- In high risk patients, a myocardial perfusion scan is useless. These patients need to be admitted and catheterized in order to detect the abnormality
- In low risk patients, catheterization would be too invasive. Therefore, we use a myocardial nuclear perfusion scan.

Extra from dossier

Methods used to study the heart, its anatomy, and its function:

- CT scan is excellent for visualizing the anatomy of the heart.
- However, it requires a high dose of contrast (contraindicated in diabetics) and it requires high expertise for interpreting the problem. It does not show subtle changes
- Echocardiogram: great for the evaluation of cardiac contractility.
- Stress echocardiogram: We measure cardiac contractility before administration of a stressing agent (dobutamine or adenosine); then, we measure cardiac contractility after the administration of the material. A decrease in contractility in one of the parts of the heart after the administration of dobutamine indicates ischemia.
- Stress ECG: shows ST depression when the heart is stressed by exercise or dobutamine. However, this procedure is somewhat invasive.

Normal physiology:

• In a normal heart, there is a large amount of cardiac reserve.

Therefore, if you increase the heart's activity, the heart can compensate using the reserve flow. Therefore, there will be no decrease in perfusion.

• In a diseased heart, the patient uses most of the cardiac reserve during rest. Therefore, during exercise, perfusion cannot be increased. This will appear as an ischemic area on a perfusion

stress scan.

• Note: exercises increases cardiac flow by 3 times; adenosine increases cardiac flow by 5 times.

The ischemic cascade (early to late)

- Change in perfusion: the first apparent abnormality is a decrease in perfusion in response to stress testing. Therefore, a nuclear scan is the most sensitive test to detect cardiac disease. At the this stage, the patient is usually asymptomatic or complains of non-specific symptoms.
- Altered contractility: systolic, then diastolic, followed by global dysfunction (both systolic and diastolic). This can be detected using an echocardiogram.
- ST depression on stress testing: ECG
- Angina pectoralis: indicates severe ischemia

How is the test done?

- Administer radioactive material; take image before applying a stress
- Take image after applying stress (adenosine or dobutamine)

How to interpret the result:

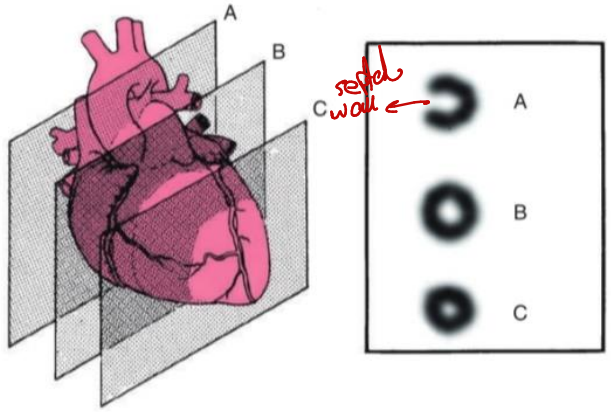
- If an area receives perfusion during rest and after stress, the test is negative and perfusion is normal
- If the area receives perfusion before stress, and perfusion stops after stress: ischemia, patient referred for catheterization (cath) lab to evaluate and treat possible coronary artery blockage.
- If the area does not receive perfusion before stress and still doesn't receive perfusion after stress: infarct, the patient generally does not need urgent cath lab intervention because revascularization will not restore dead tissue.

Using a PET scan, we can also calculate the contractility of the heart and ejection fraction.

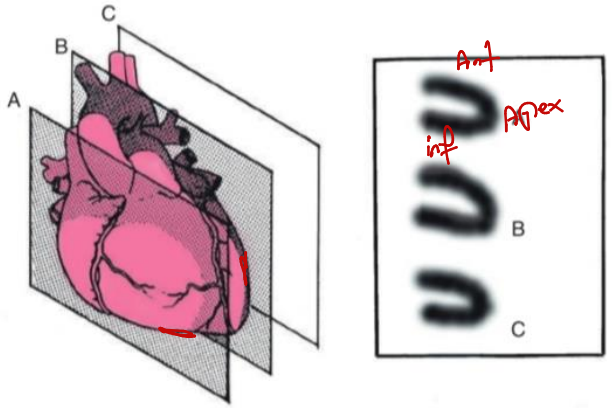
Methods of Inducing Stress

- Pharmacologic
  - Adenosine
  - Dobutamine
  - Dipyridamole
  - Regadenosone
- Exercise
  - Treadmill
  - Bicycle

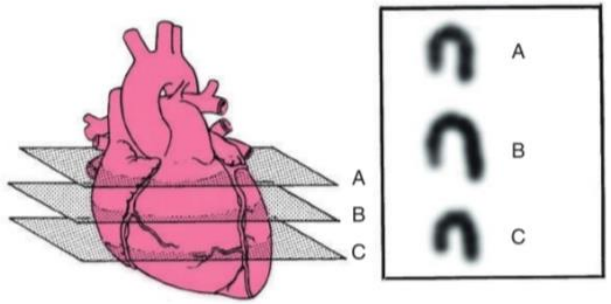
3d image



• **Fig. 5.8** Short-Axis Anatomy and Images. Short-axis sections through the left ventricle from the base of the heart to the apex are shown with corresponding single-photon emission computed tomography slices of the myocardium. Note the considerable thinning of the proximal septal wall in plane *A* (the base of the heart) as a result of the membranous septum.

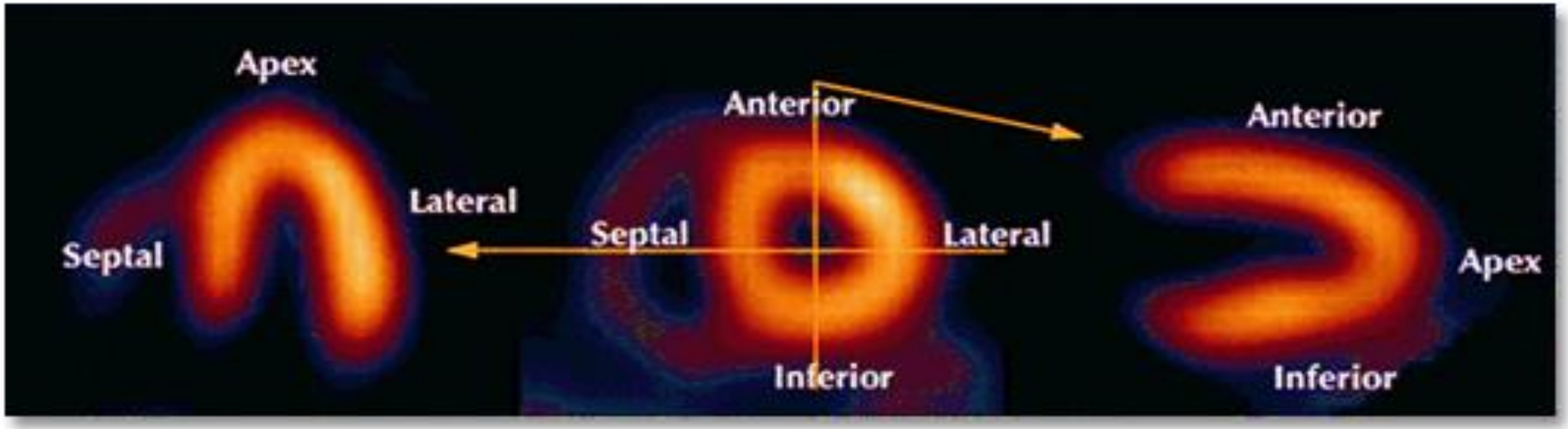


• **Fig. 5.9** Vertical Long-Axis Anatomy and Images. Vertical long-axis sections through the left ventricle from septum to free (lateral) wall are shown with corresponding single-photon emission computed tomography slices of the myocardium.



• **Fig. 5.10** Horizontal Long-Axis Anatomy and Images. Horizontal long-axis sections through the left ventricle from the anterior to the inferior wall are shown with corresponding single-photon emission computed tomography slices of the myocardium.

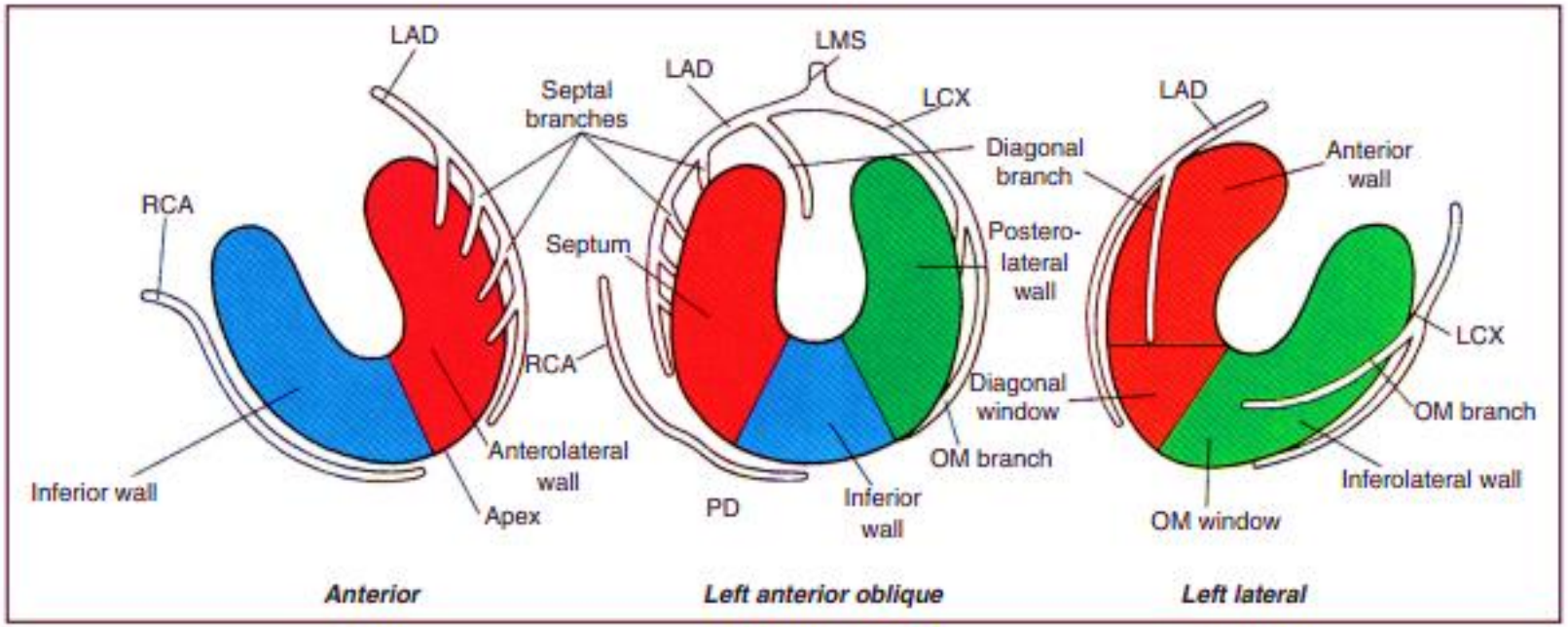
SPECT Reoriented Views



Horizontal Long Axis

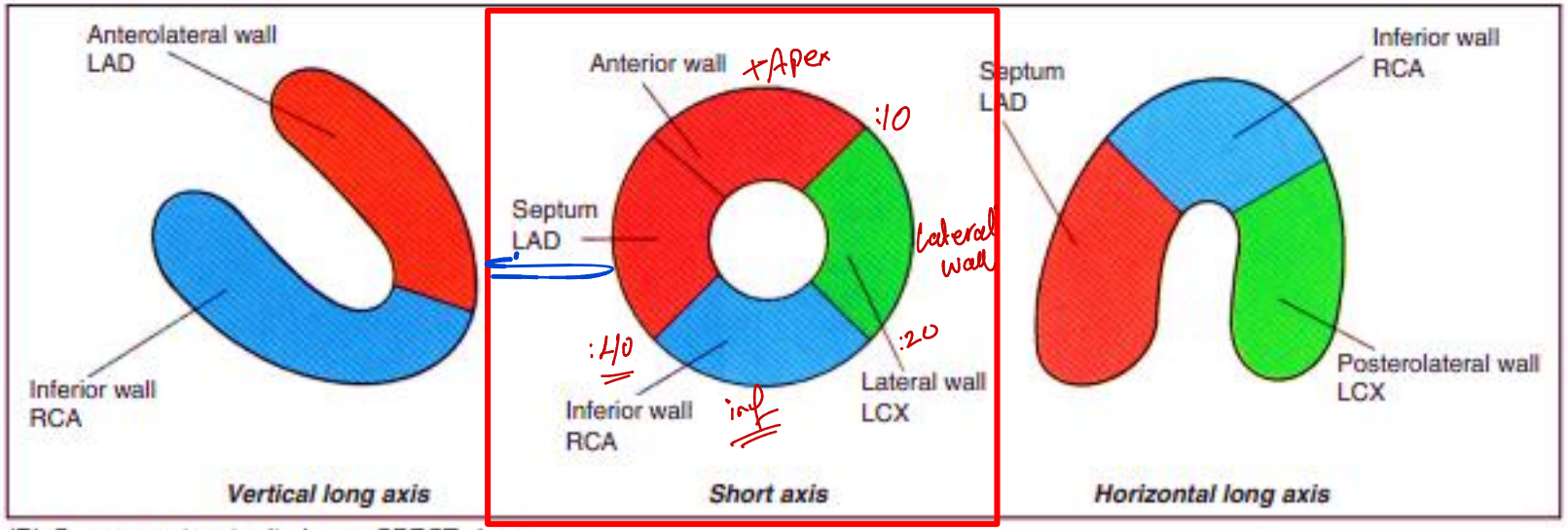
Short Axis

Vertical Long Axis



(A) *Coronary artery territories on planar views*

Look at short axis



(B) *Coronary artery territories on SPECT views*

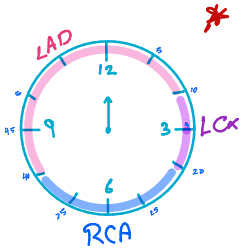
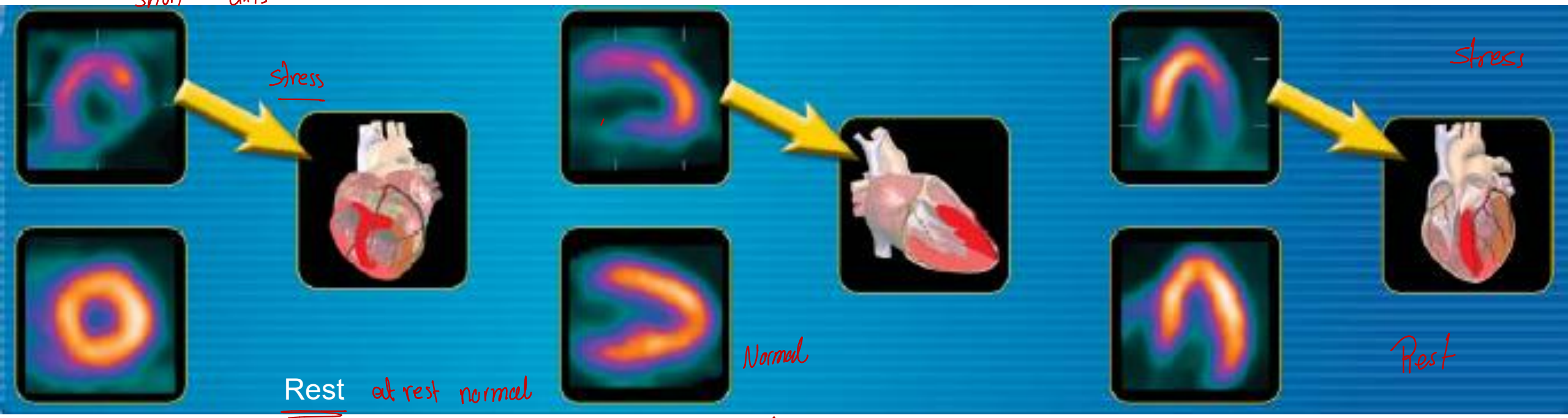


Figure 6.3 Normal coronary artery territories in the left ventricle corresponding to myocardial SPECT views.



Decreased uptake in Lateral and inferior wall

Reversible defect → ischemia

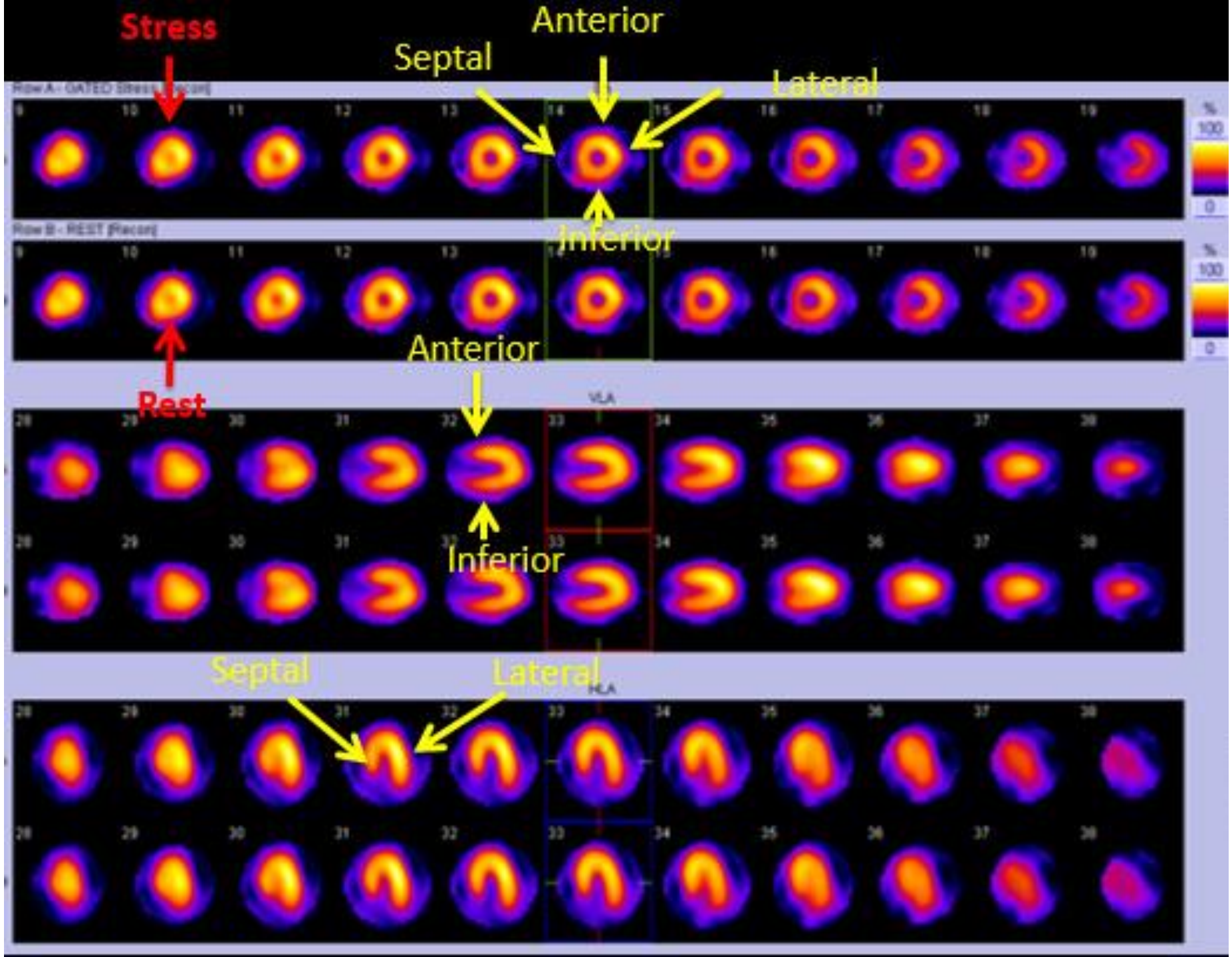
Next step → Cath

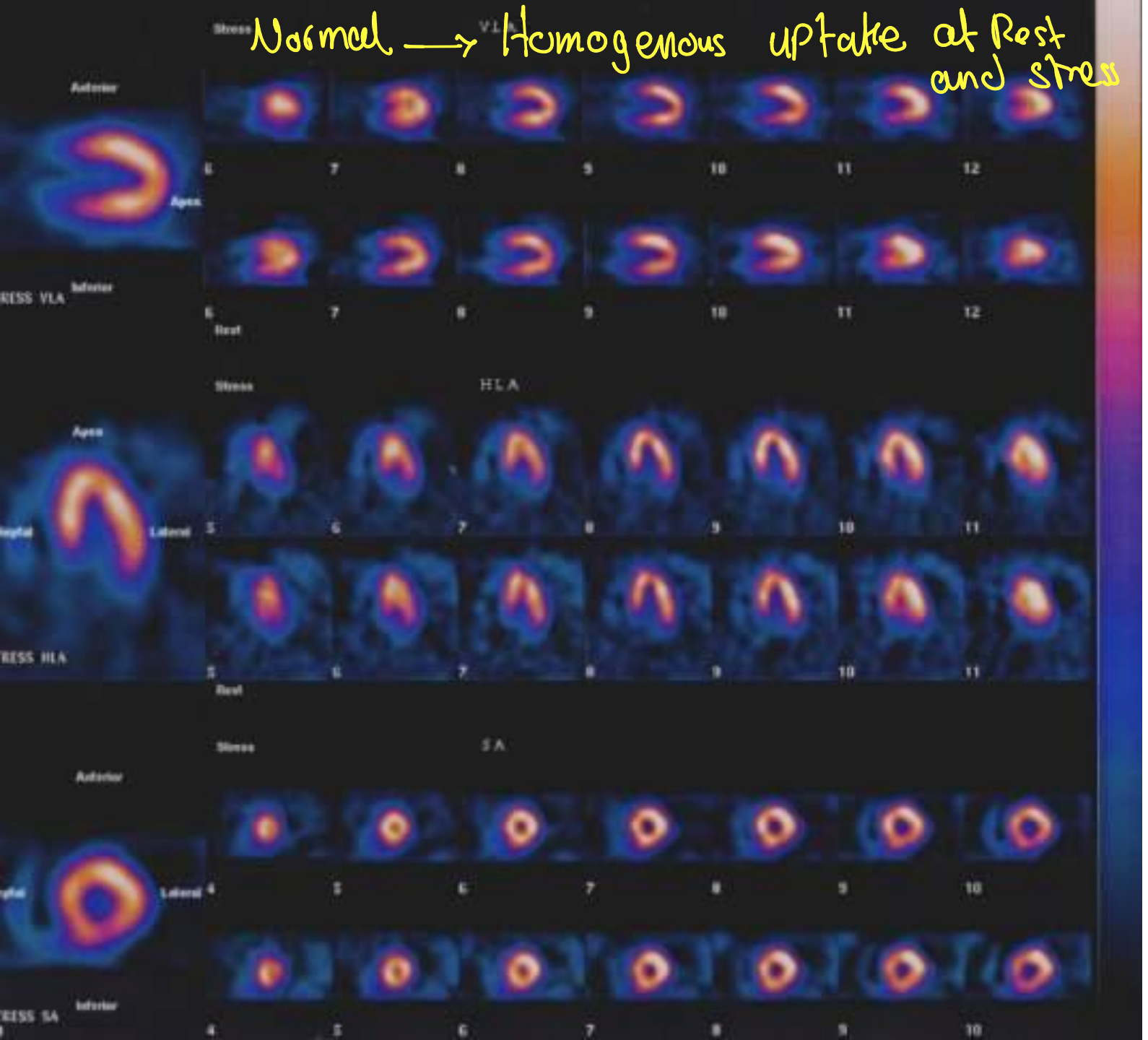
Decreased uptake in inferior wall

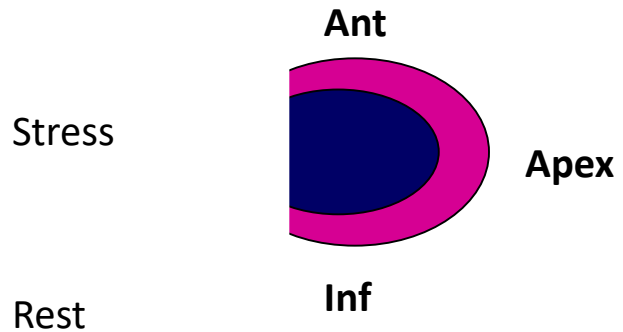
Reversible → ischemia

Decreased uptake in Lateral wall

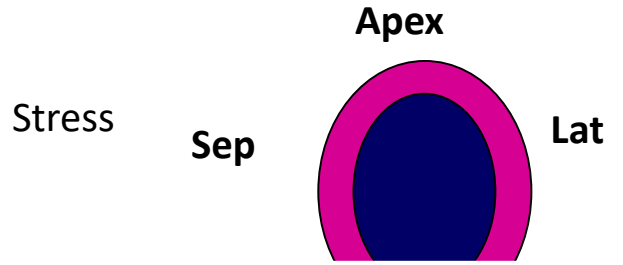
Reversible → ischemia


Stress
Anterior
Septal
Lateral
Inferior
Rest
Anterior
Inferior
Septal
Lateral

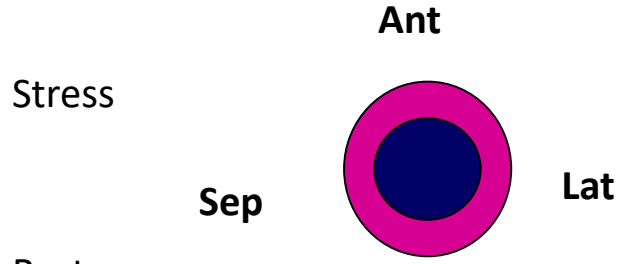




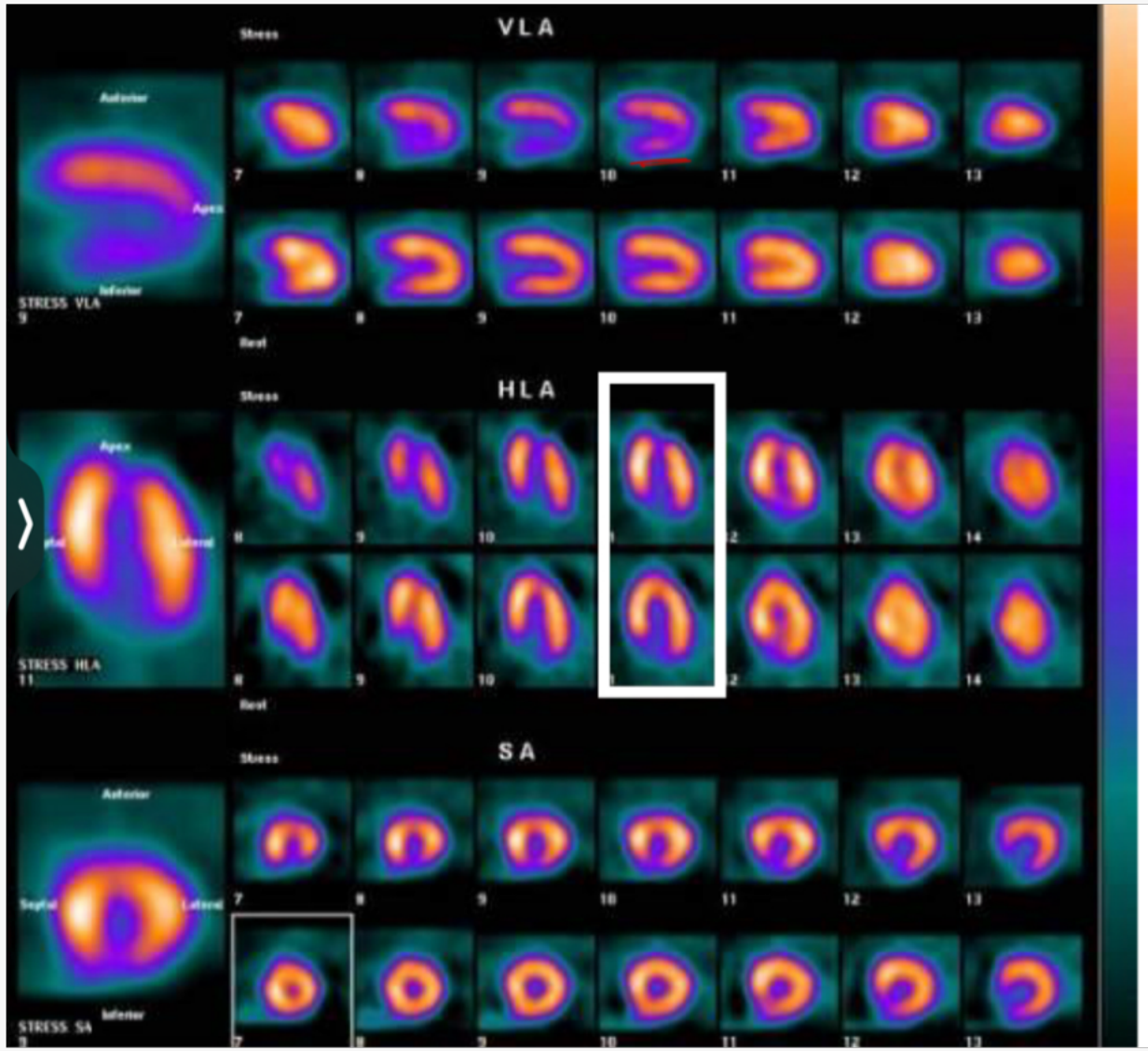
Septum → Lateral

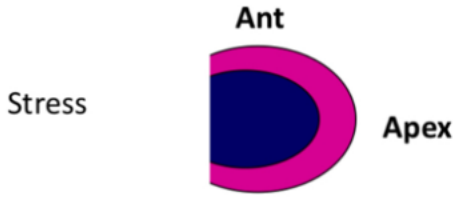


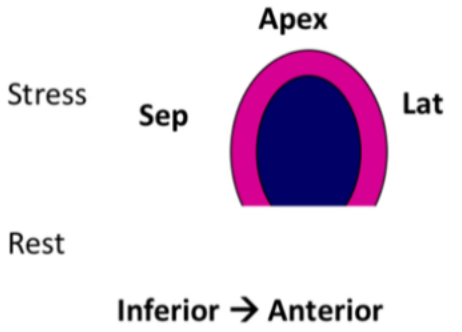
Inferior → Anterior

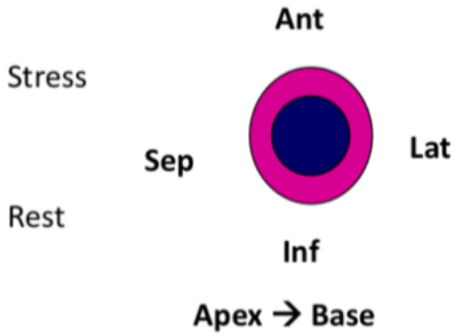


Apex → Base





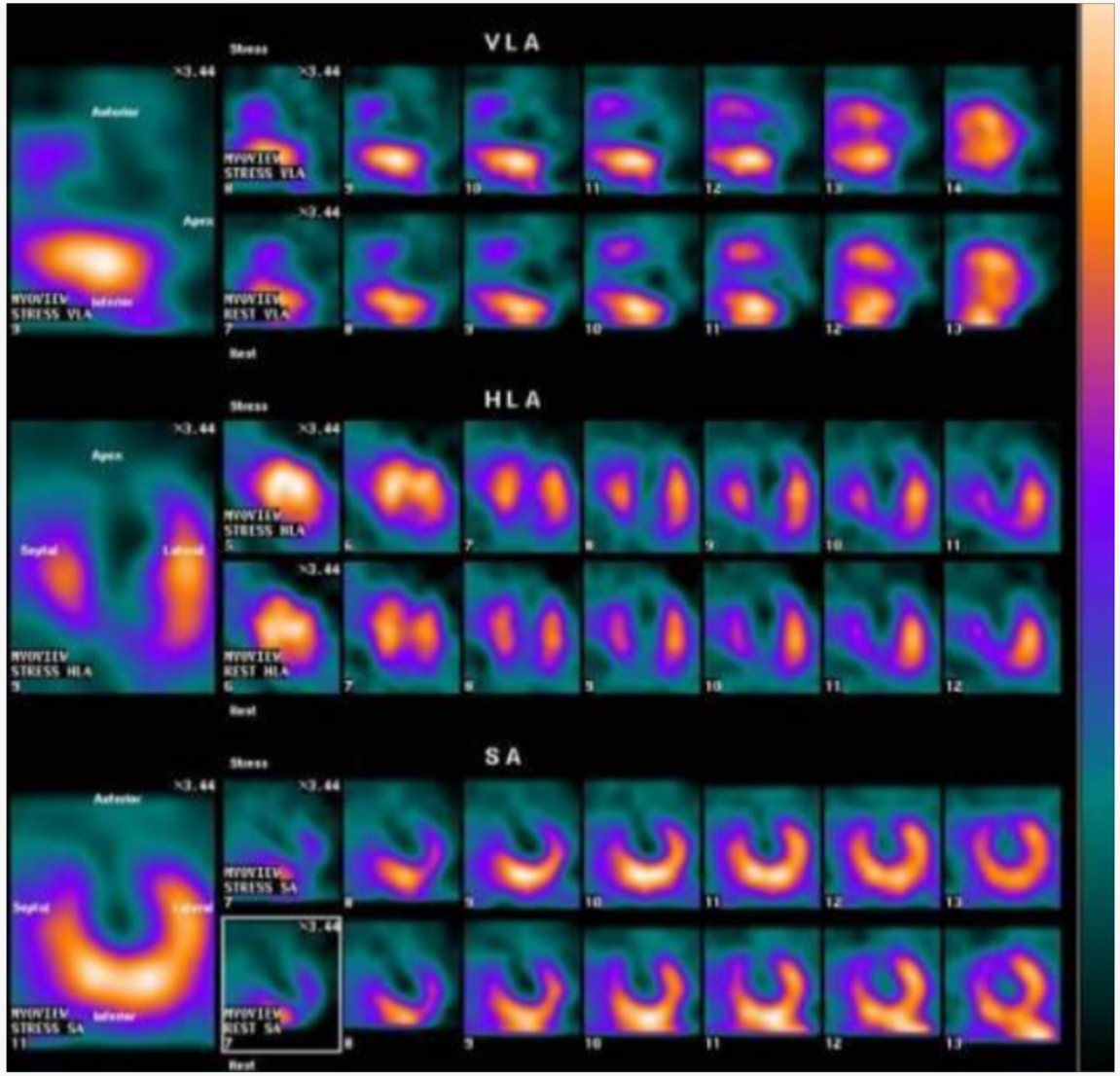




Decreased uptake in Apex

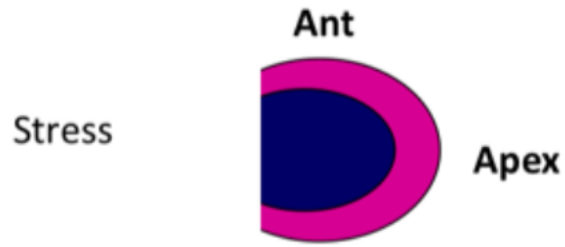
→ inferior wall ischemia involving apex

→ Reversible

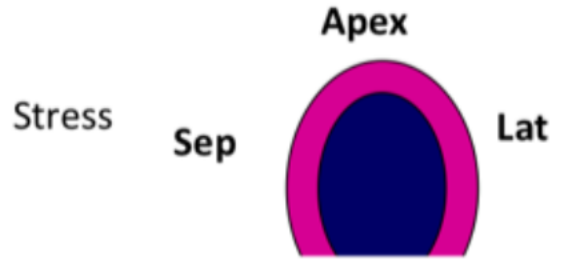


Anterior wall infarction

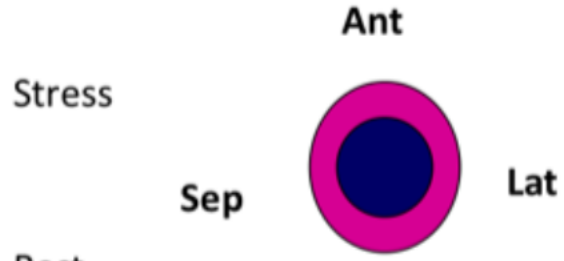
Irreversible ——→ x Cath



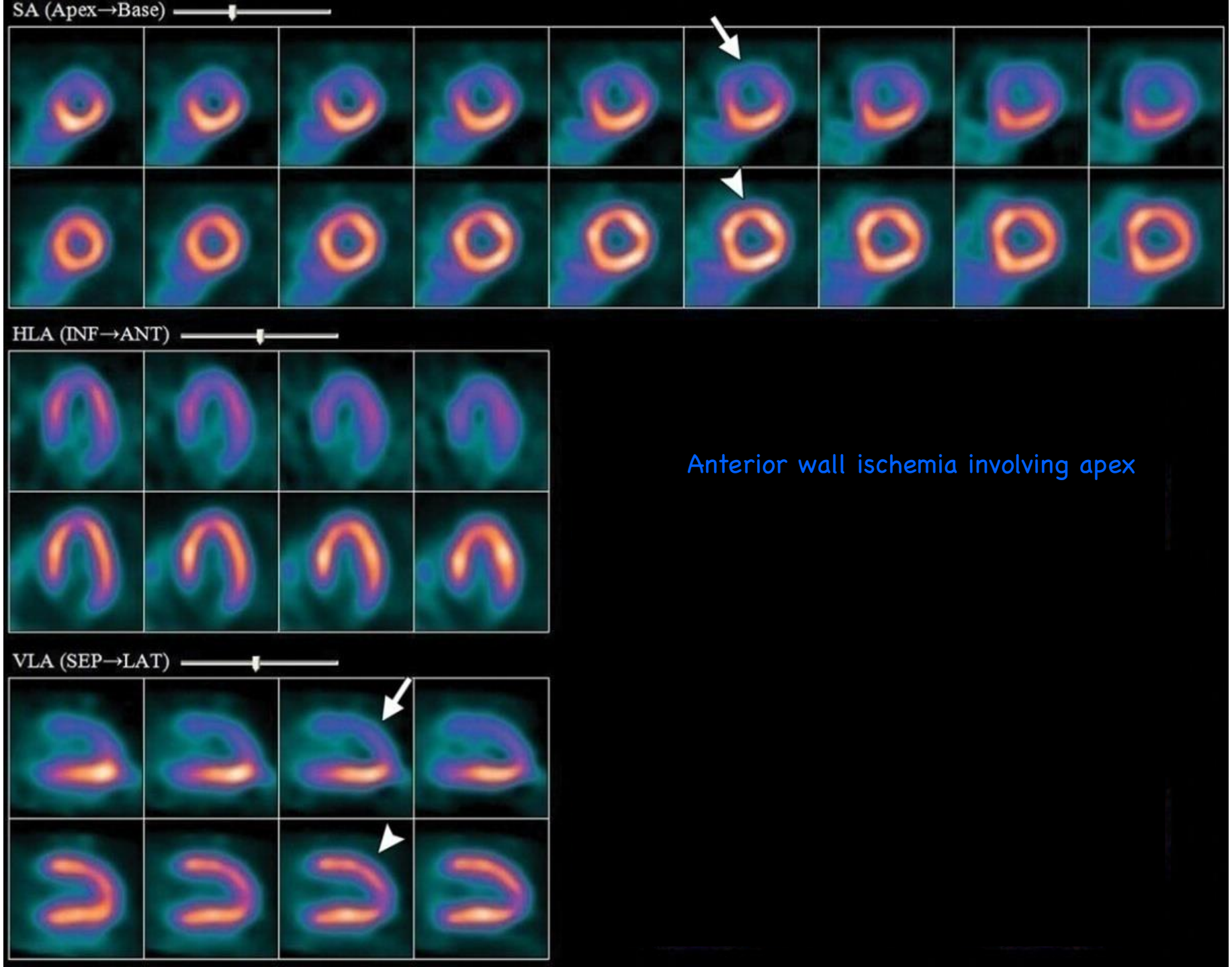
Septum → Lateral



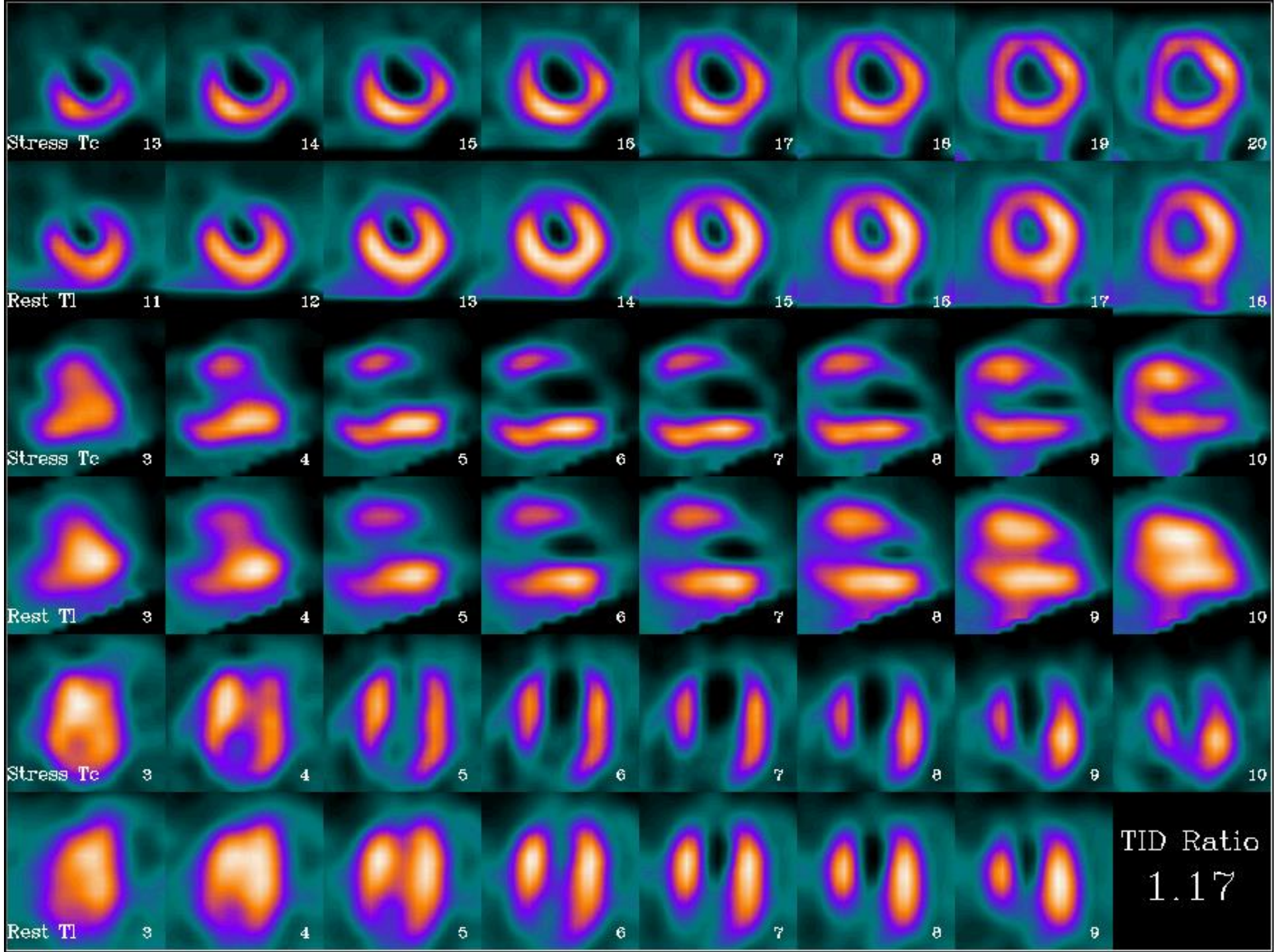
Inferior → Anterior



Apex → Base



Anterior wall ischemia involving apex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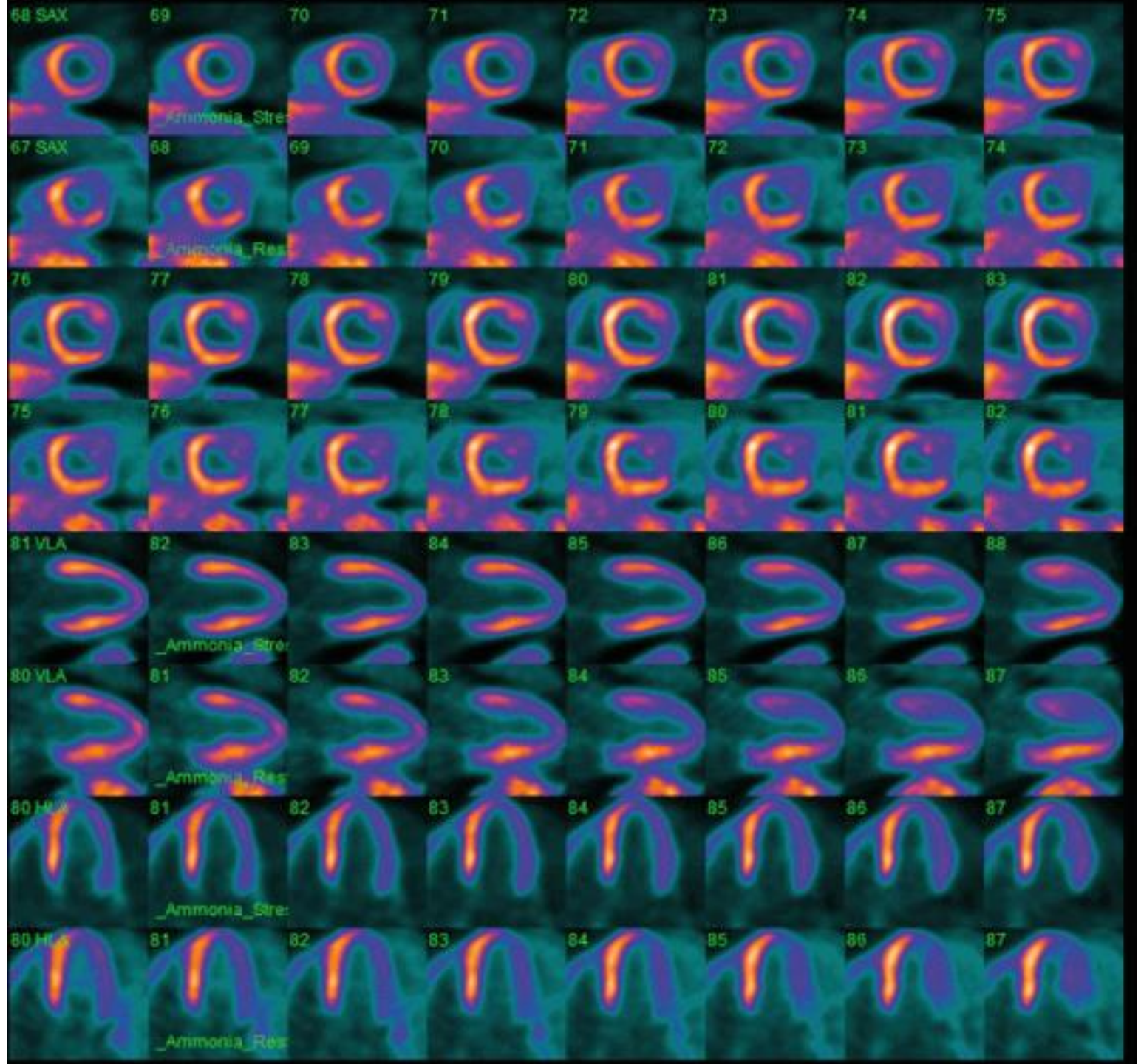
Rest Tl 11 12 13 14 15 16 17 18
Stress Tc 3 4 5 6 7 8 9 10
Rest Tl 3 4 5 6 7 8 9 10
Stress Tc 3 4 5 6 7 8 9 10
Rest Tl 3 4 5 6 7 8 9
TID Ratio
1.17


72.8 SAX
73.8
74.8
75.8
76.8
77.8
78.8
79.8
_Ammonia_Stress_
72.0 SAX
73.0
74.0
75.0
76.0
77.0
78.0
79.0
_Ammonia_Rest_St
80.8
81.8
82.8
83.8
84.8
85.8
86.8
87.8
80.0
81.0
82.0
83.0
84.0
85.0
86.0
87.0
80.2 VLA
81.2
82.2
83.2
84.2
85.2
86.2
87.2
_Ammonia_Stress_
80.4 VLA
81.4
82.4
83.4
84.4
85.4
86.4
87.4
_Ammonia_Rest_St
80.1 HLA
81.1
82.1
83.1
84.1
85.1
86.1
87.1
_Ammonia_Stress_
80.2 HLA
81.2
82.2
83.2
84.2
85.2
86.2
87.2
_Ammonia_Rest_St


68 SAX
69
70
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72
73
74
75
67 SAX
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81 VLA
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80 VLA
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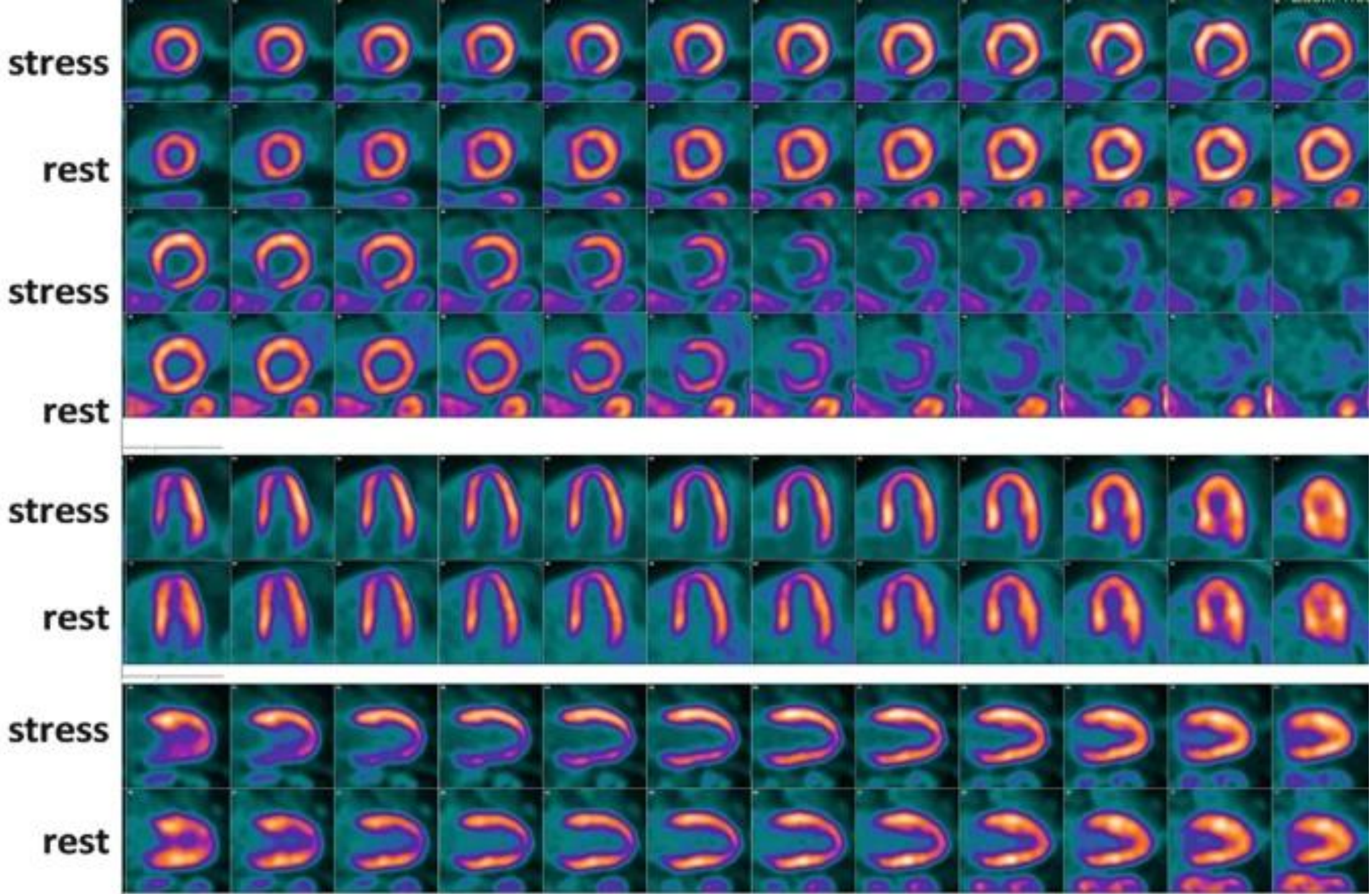
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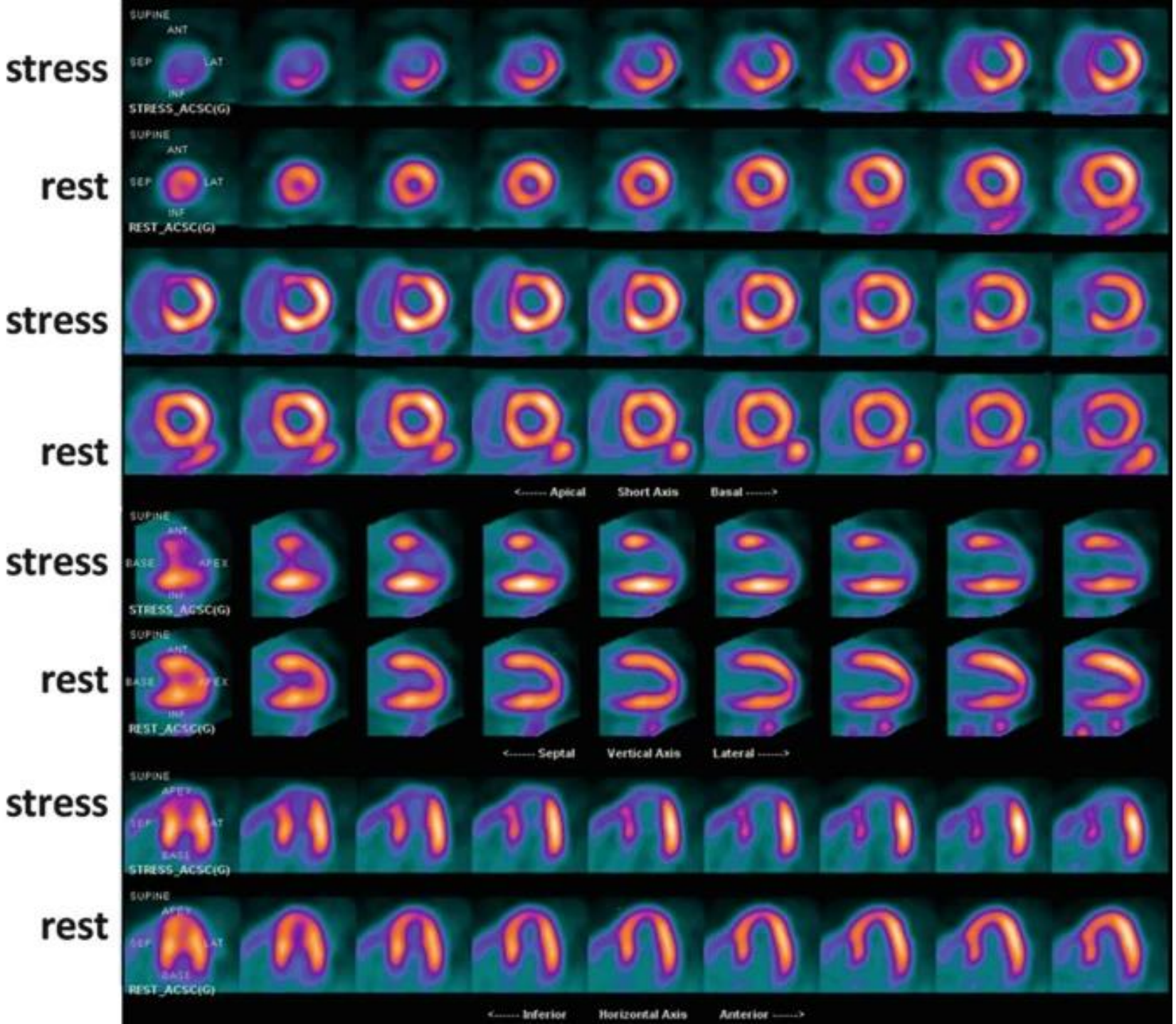
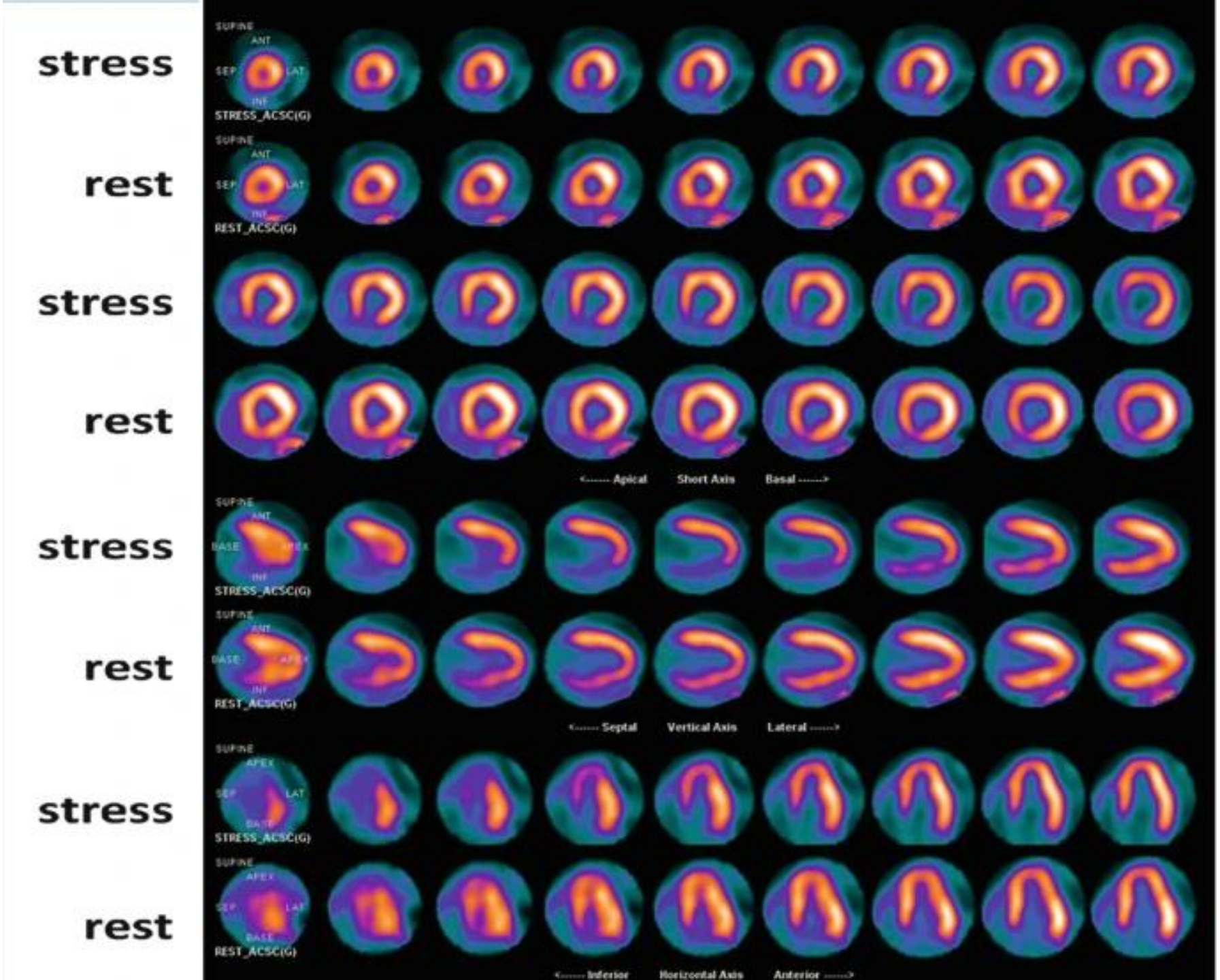
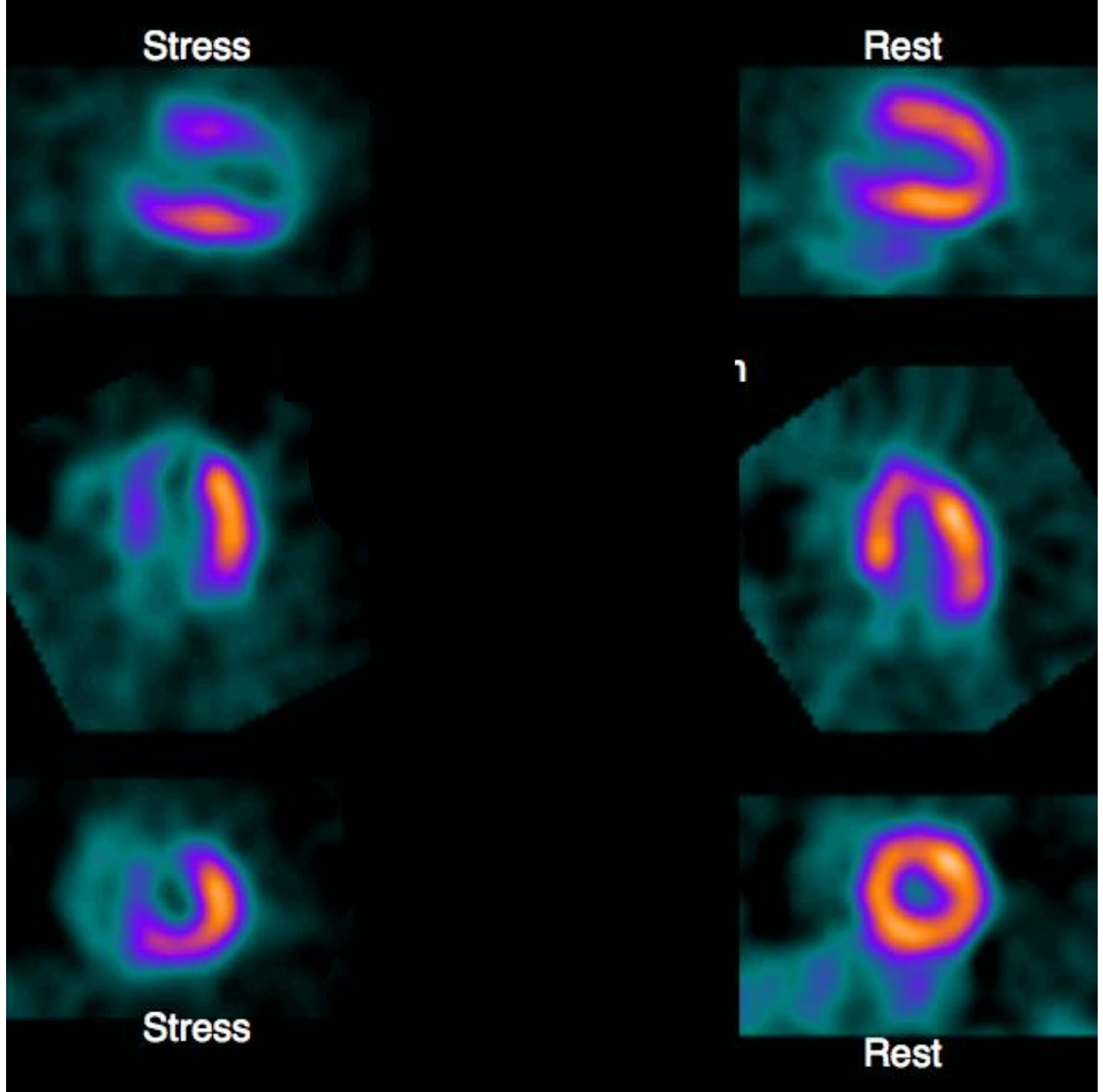
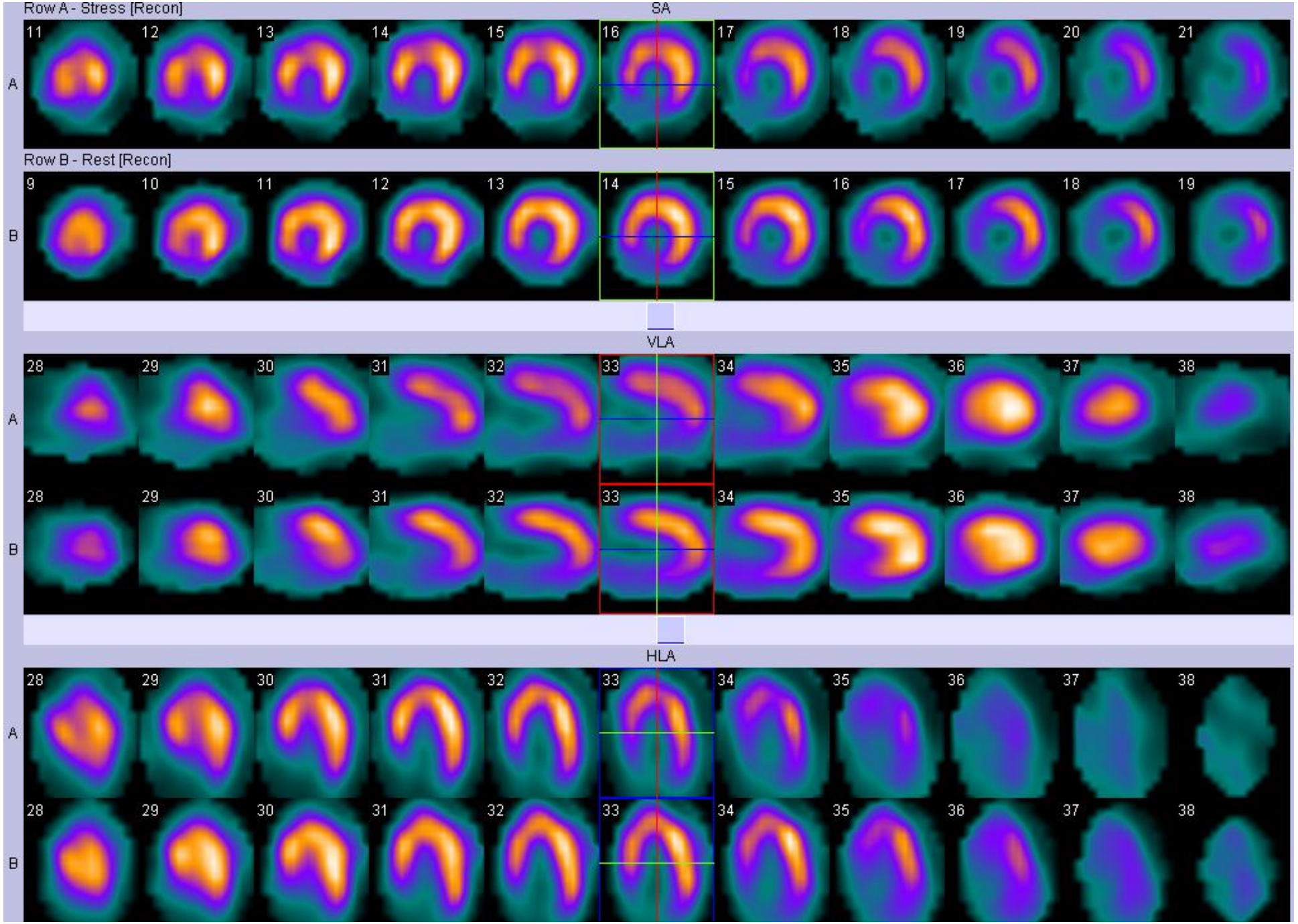
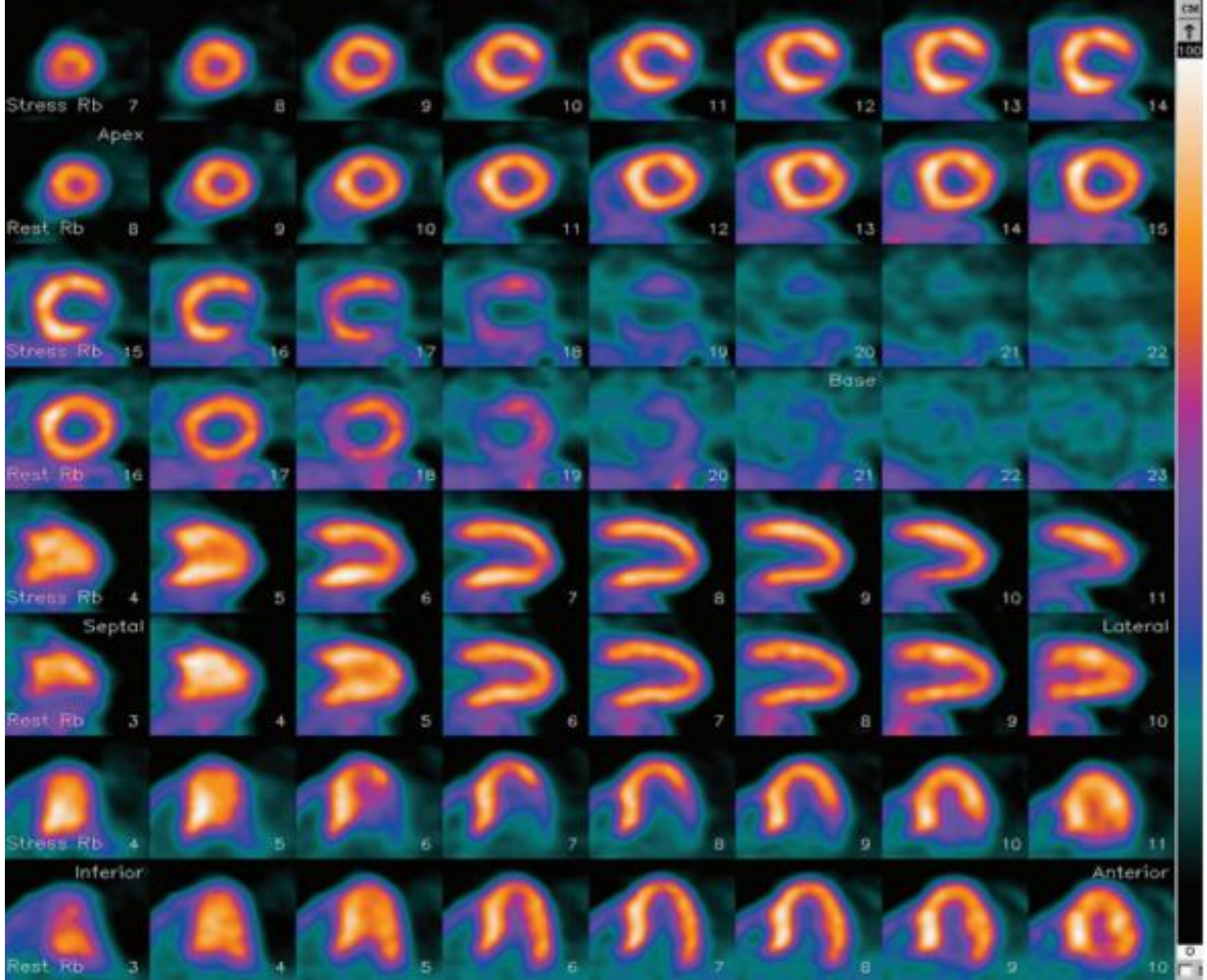
rest
stress
rest
stress
rest
stress
rest

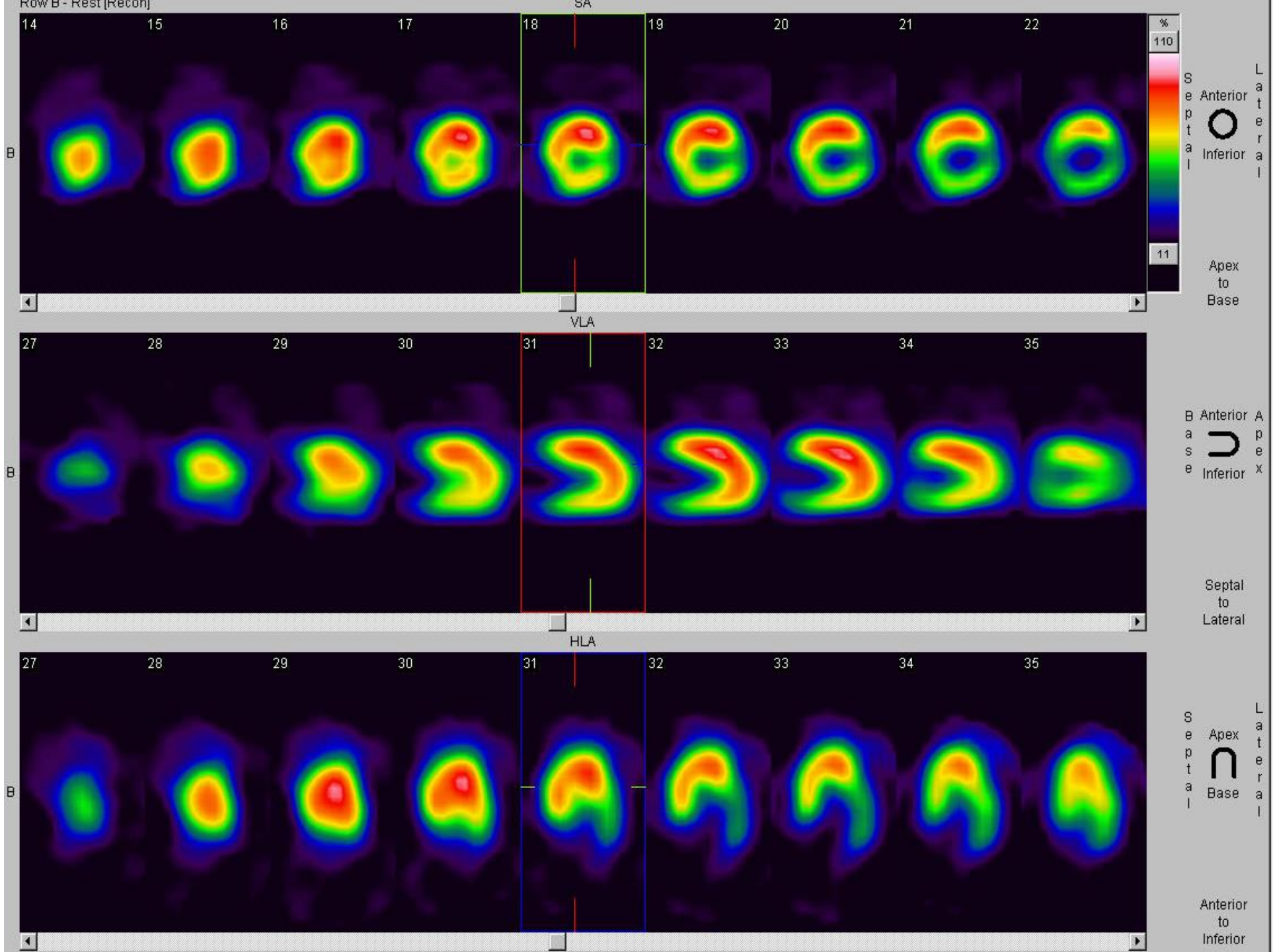

stress
rest
stress
rest
SUPINE
ANT
SEP
LAT
INF
STRESS_ACSC(G)
REST_ACSC(G)
<------ Apical
Short Axis
Basal ------>
stress
rest
BASE
APEX
<------ Septal
Vertical Axis
Lateral ------>
stress
rest
<------ Inferior
Horizontal Axis
Anterior ------>


stress
rest
stress
rest
stress
rest
stress
rest
SUPINE
ANT
SEP
LAT
INF
STRESS_ACSC(G)
REST_ACSC(G)
<------ Apical Short Axis Basal ------>
BASE
APEX
<------ Septal Vertical Axis Lateral ------>
<------ Inferior Horizontal Axis Anterior ------>


Stress
Rest
Stress
Rest


Row A - Stress [Recon]
SA
A
11 12 13 14 15 16 17 18 19 20 21
Row B - Rest [Recon]
B
9 10 11 12 13 14 15 16 17 18 19
VLA
A
28 29 30 31 32 33 34 35 36 37 38
B
28 29 30 31 32 33 34 35 36 37 38
HLA
A
28 29 30 31 32 33 34 35 36 37 38
B
28 29 30 31 32 33 34 35 36 37 38


Stress Rb 7
8
9
10
11
12
13
14
Apex
Rest Rb 8
9
10
11
12
13
14
15
Stress Rb 15
16
17
18
19
20
21
22
Base
Rest Rb 16
17
18
19
20
21
22
23
Stress Rb 4
5
6
7
8
9
10
11
Septal
Lateral
Rest Rb 3
4
5
6
7
8
9
10
Stress Rb 4
5
6
7
8
9
10
11
Inferior
Anterior
Rest Rb 3
4
5
6
7
8
9
10


Row B - Rest [Recon]
SA
14
15
16
17
18
19
20
21
22
%
110
11
B
Septal
Lateral
Anterior
Inferior
Apex
to
Base
VLA
27
28
29
30
31
32
33
34
35
B
Base
Apex
Anterior
Inferior
Septal
to
Lateral
HLA
27
28
29
30
31
32
33
34
35
B
Septal
Lateral
Apex
Base
Anterior
to
Inferior

Lung Scintigraphy

Radiopharmaceuticals

- Radiopharmaceuticals
  - Perfusion
    - ^{99m}*Tc-MAA (macroaggregated albumin)*
  - Ventilation
    - ^{99m}*Tc-DTPA*
    - *Sulfur colloid aerosols*

Indications

Pulmonary embolism

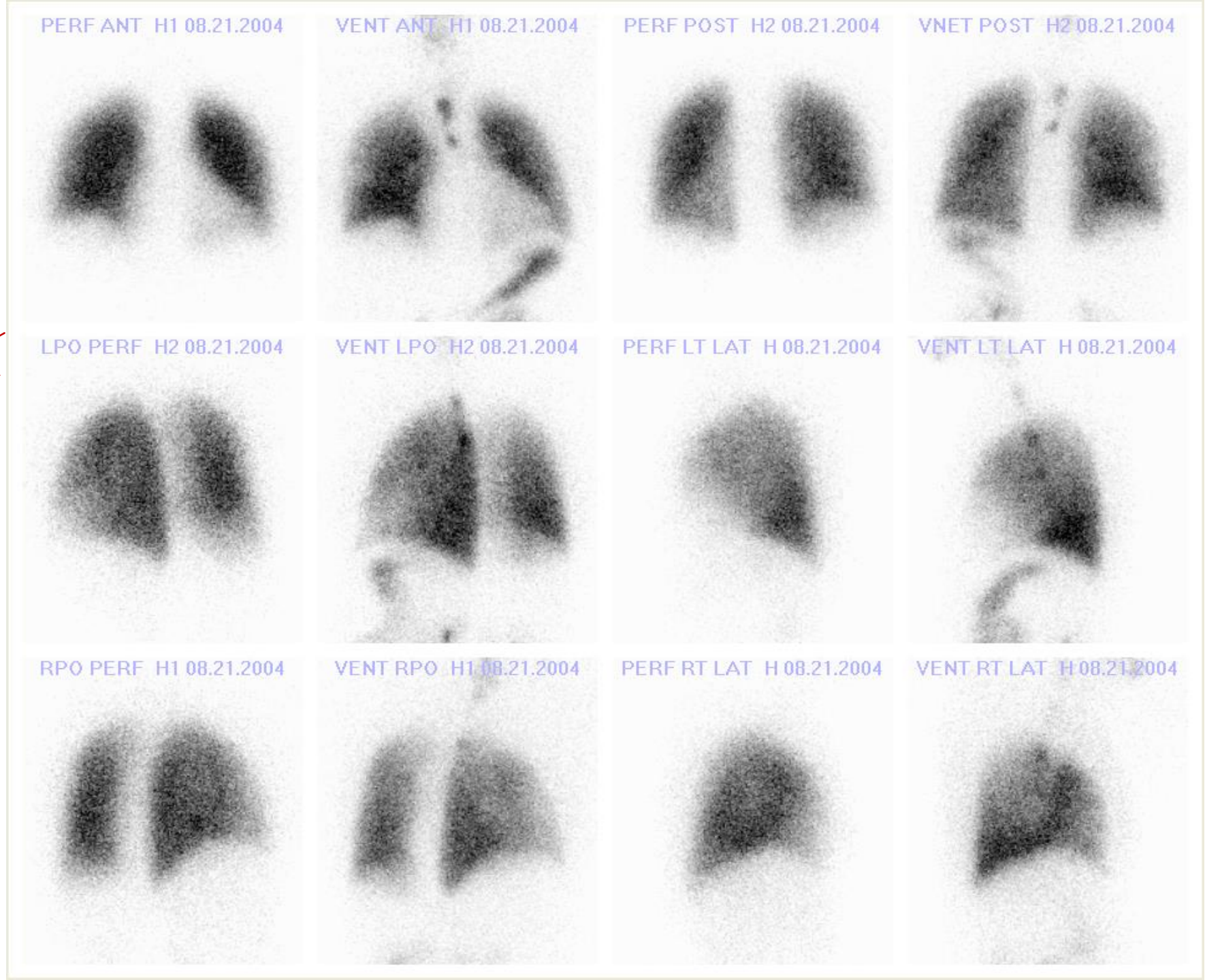
- CTPA is the gold standard for diagnosis
- V/Q scans are typically used when a patient has contrast allergy, chronic kidney disease, or pregnant

Chronic thrombo-embolic pulmonary hypertension (CTEPH)

- V/Q has higher sensitivity in the diagnosis of CTEPH than CTPA

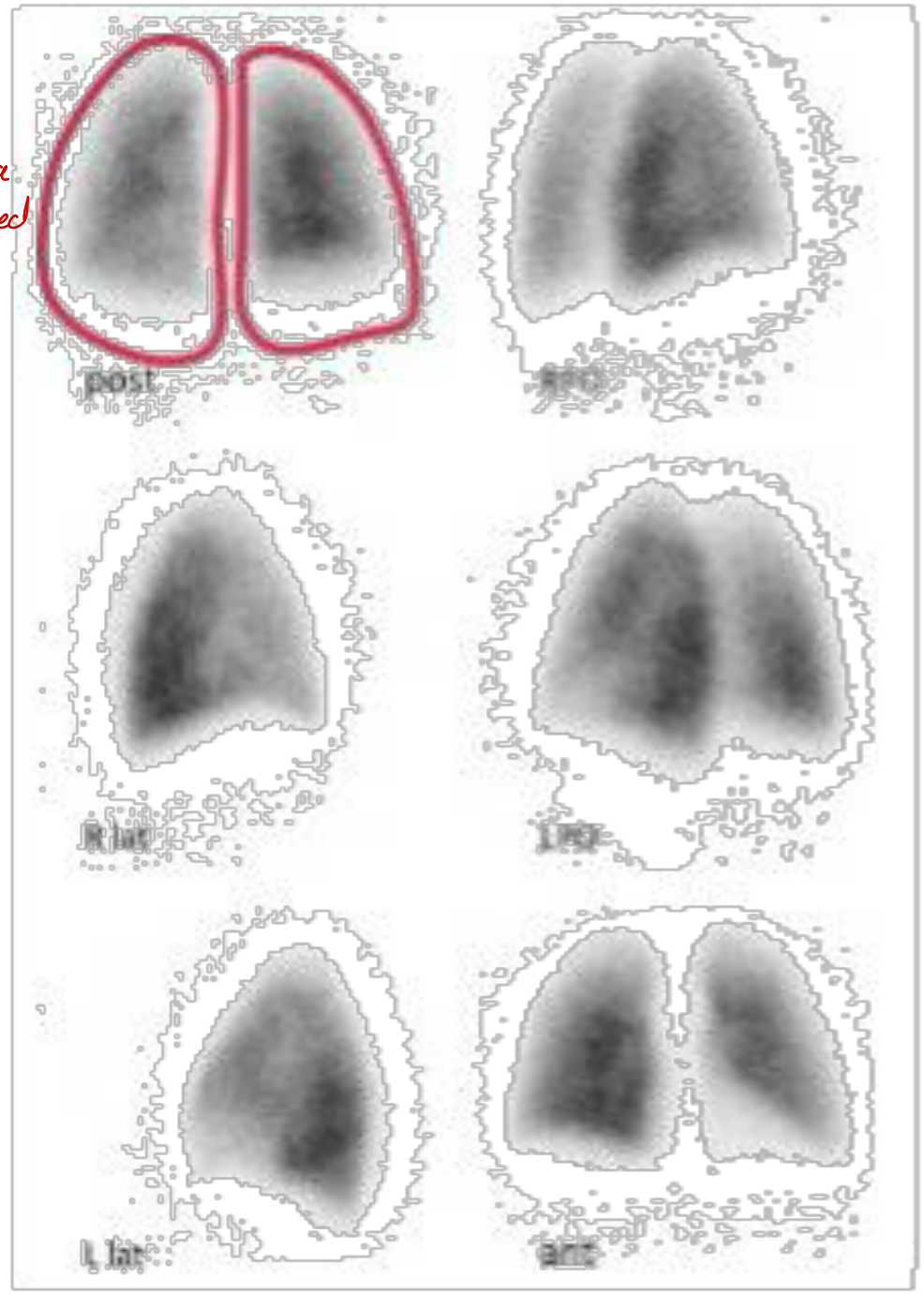
Quantitative function

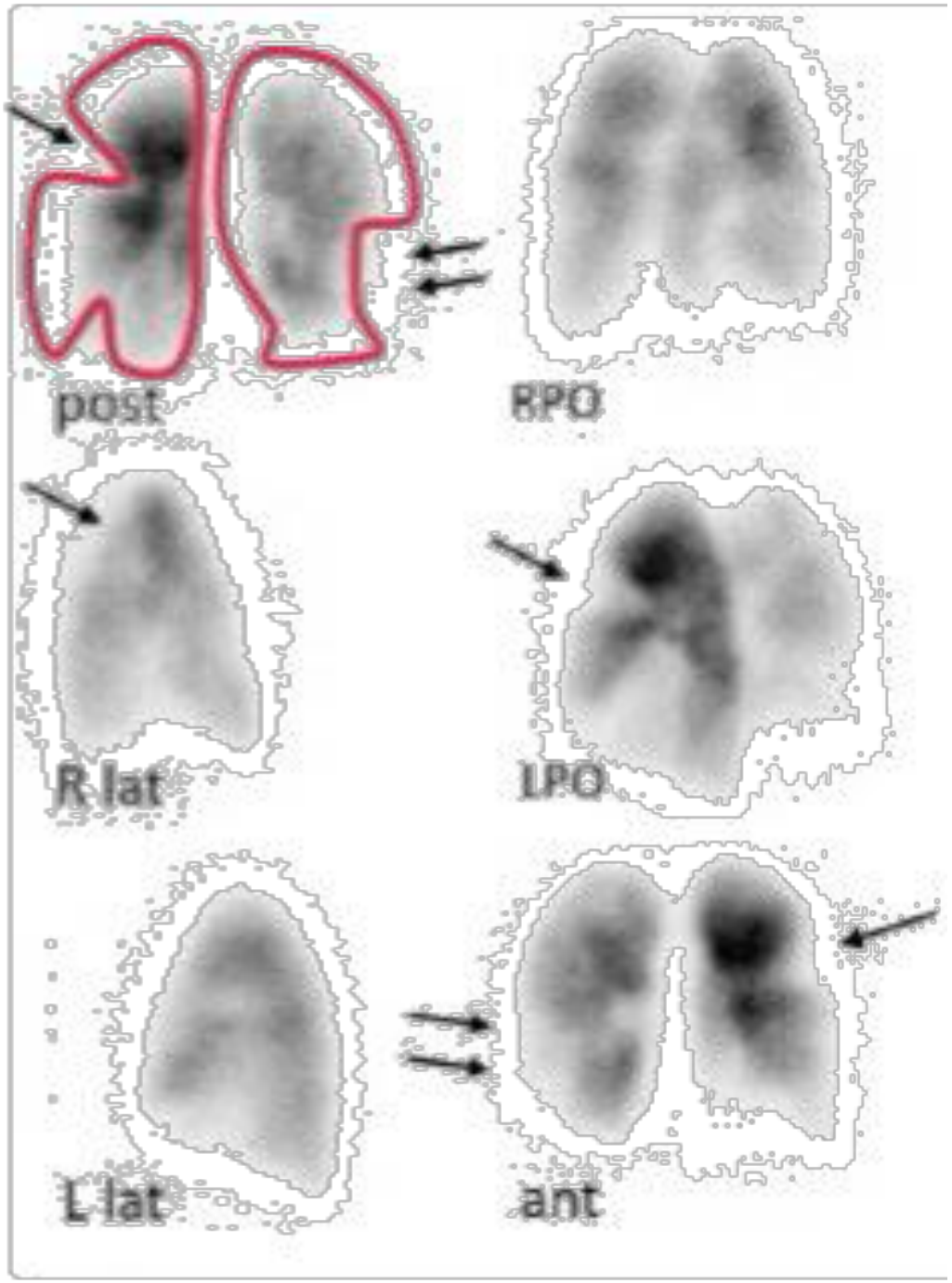
- Ventilation/perfusion match: not a PE
- If the ventilation is high, this is known as ventilation perfusion mismatch, which is highly suggestive of a PE.


PERF ANT H1 08.21.2004
VENT ANT H1 08.21.2004
PERF POST H2 08.21.2004
VNET POST H2 08.21.2004
LPO PERF H2 08.21.2004
VENT LPO H2 08.21.2004
PERF LT LAT H 08.21.2004
VENT LT LAT H 08.21.2004
RPO PERF H1 08.21.2004
VENT RPO H1 08.21.2004
PERF RT LAT H 08.21.2004
VENT RT LAT H 08.21.2004

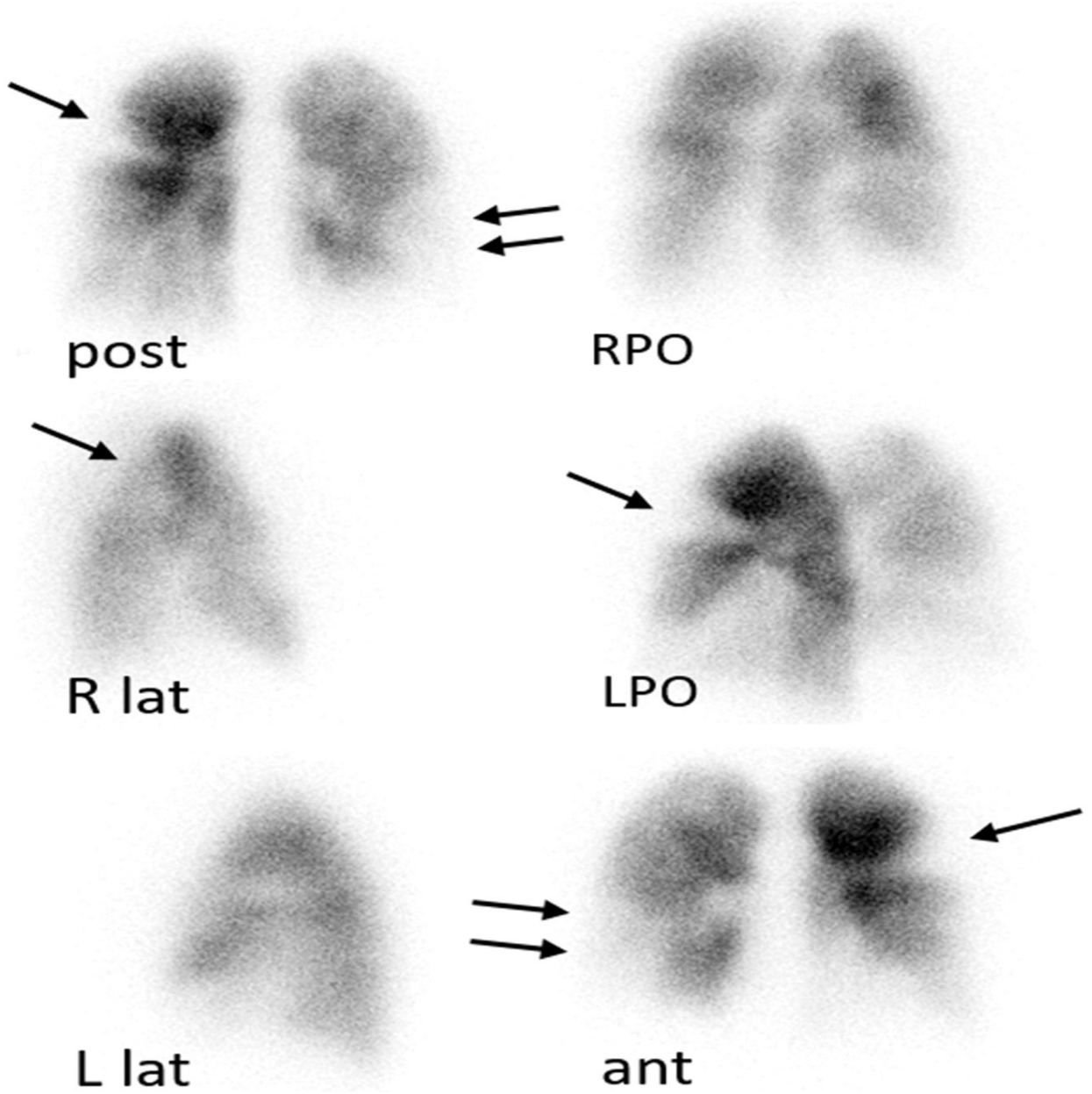
normal

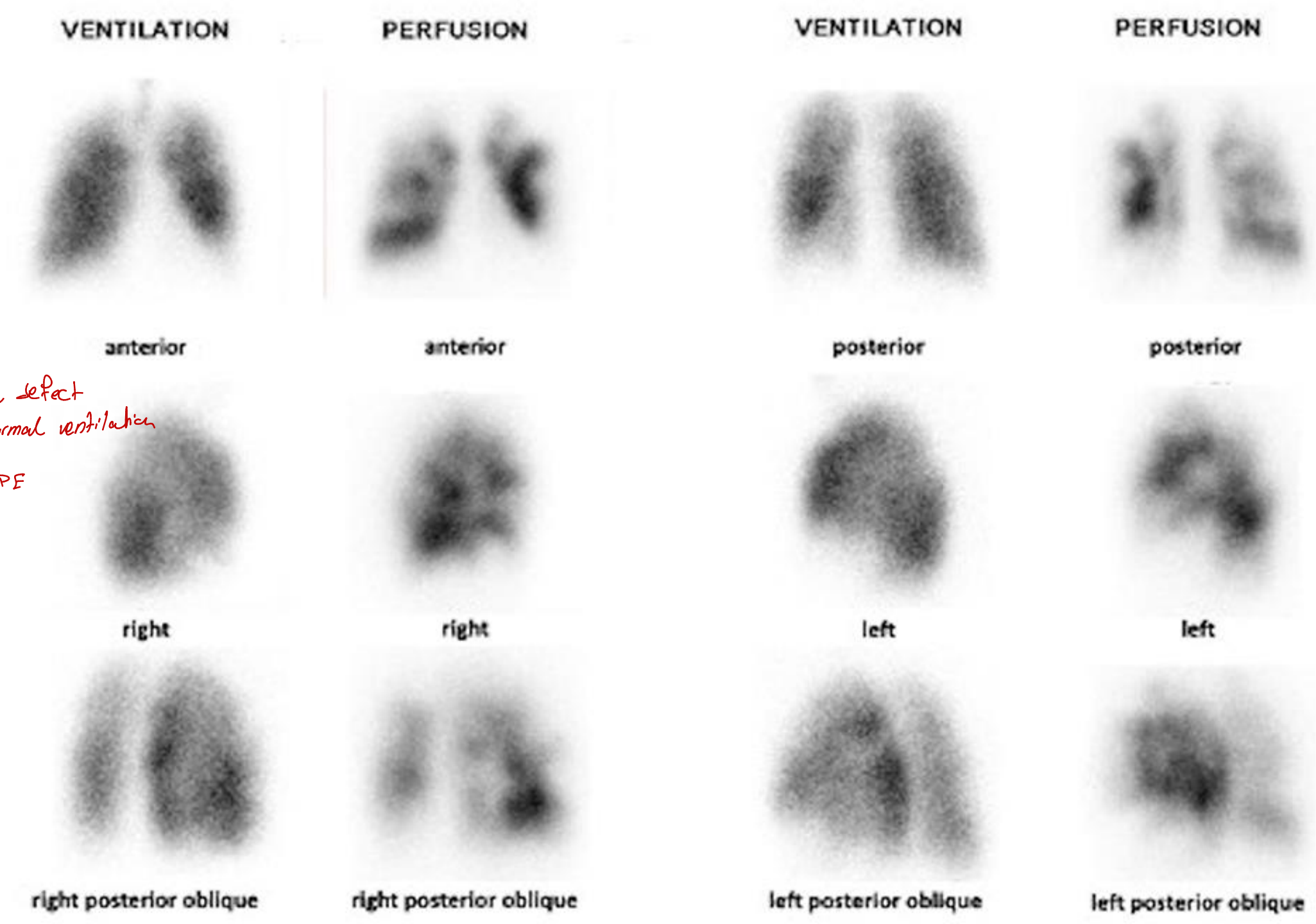
multiple areas with decreased uptake





Perfusion

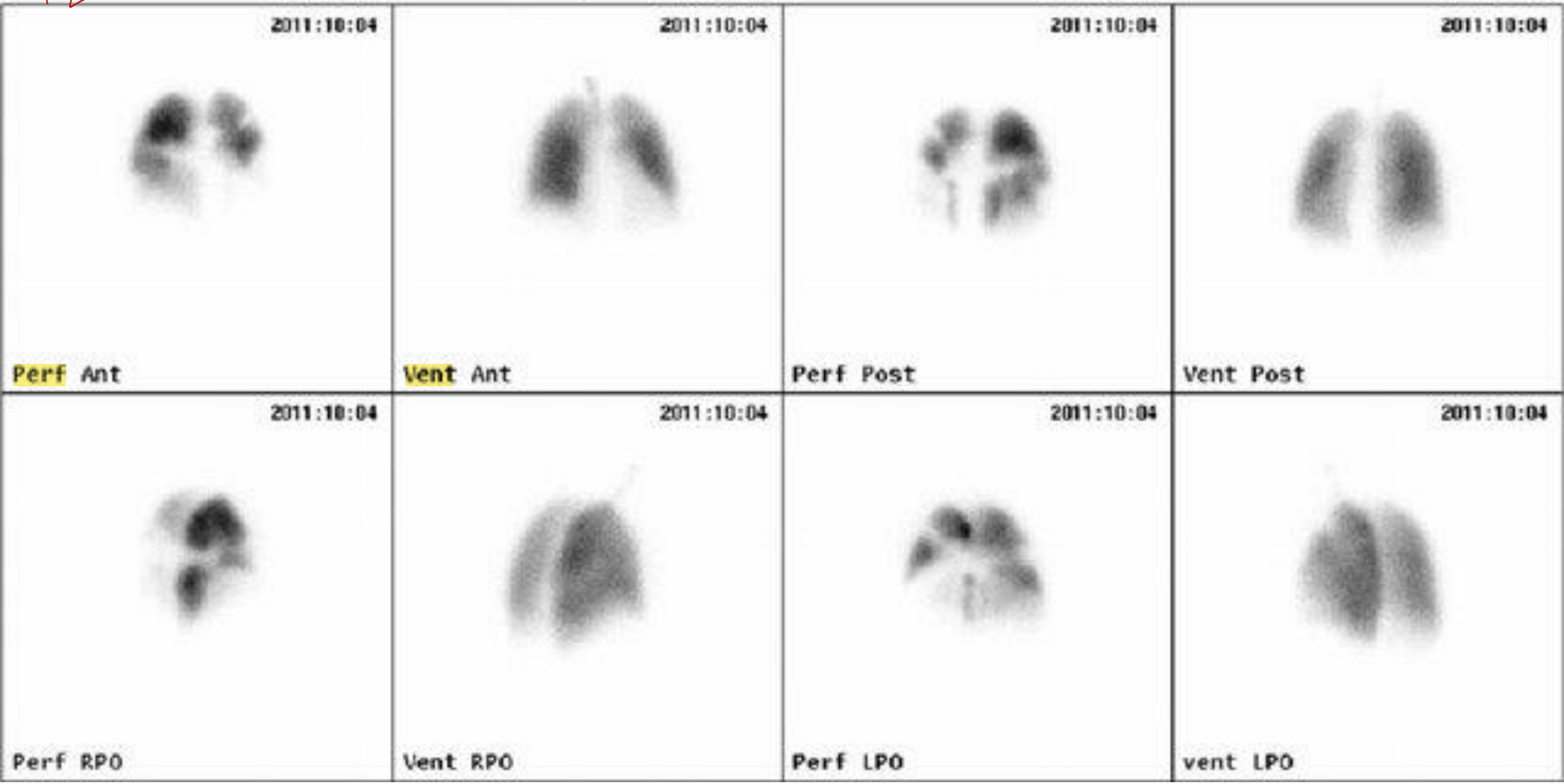


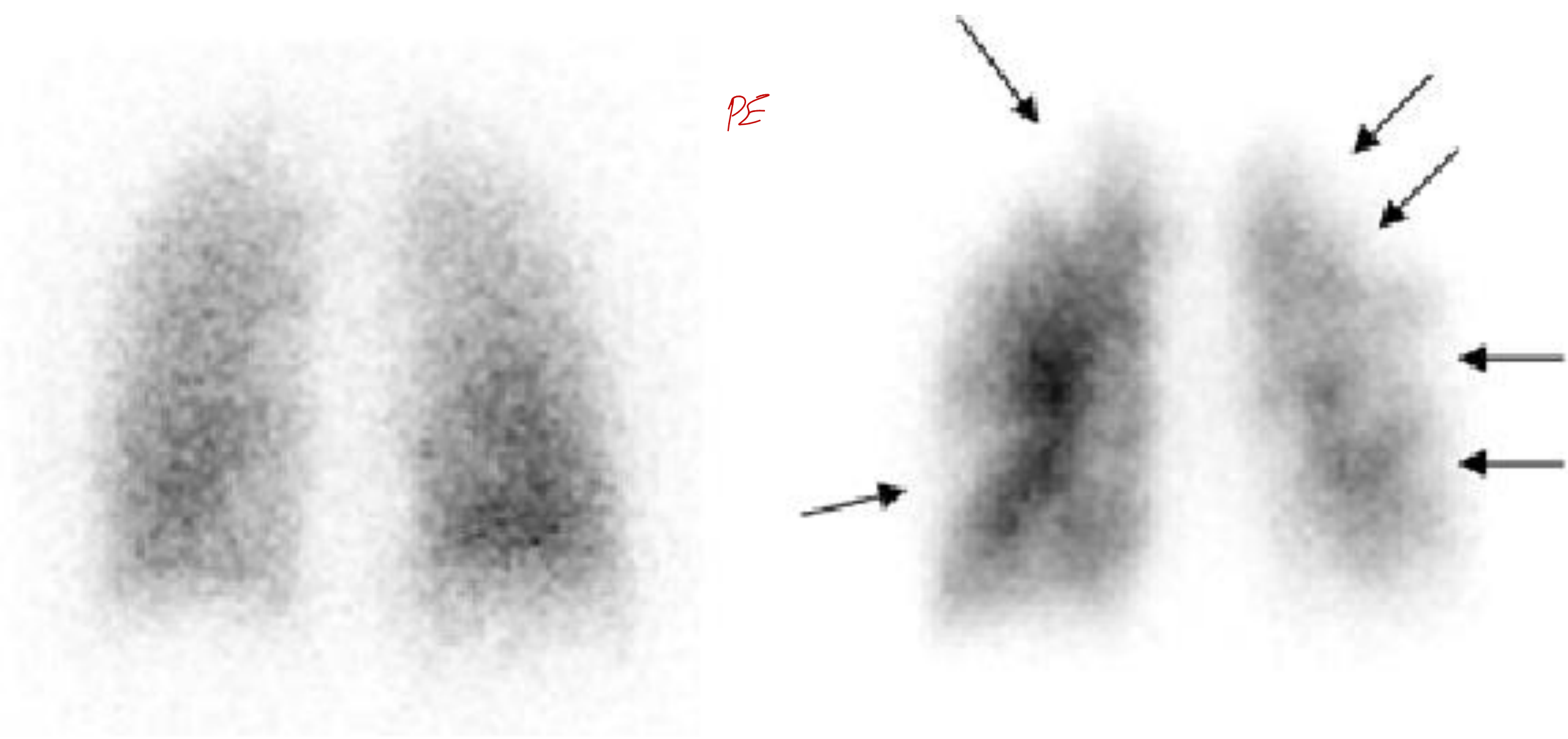


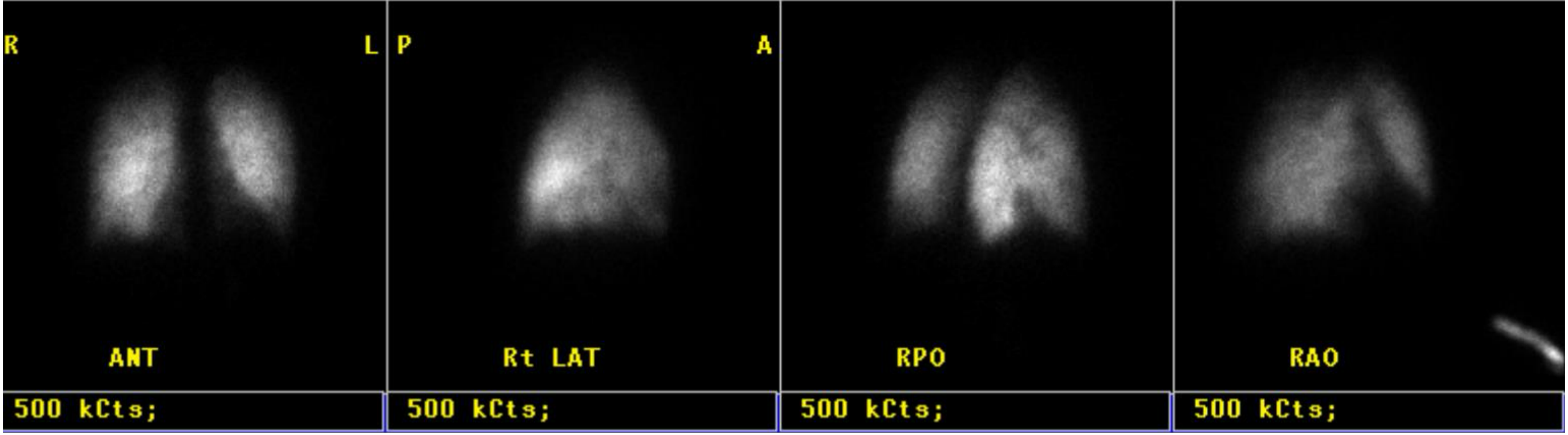
* multiple defect with normal ventilation

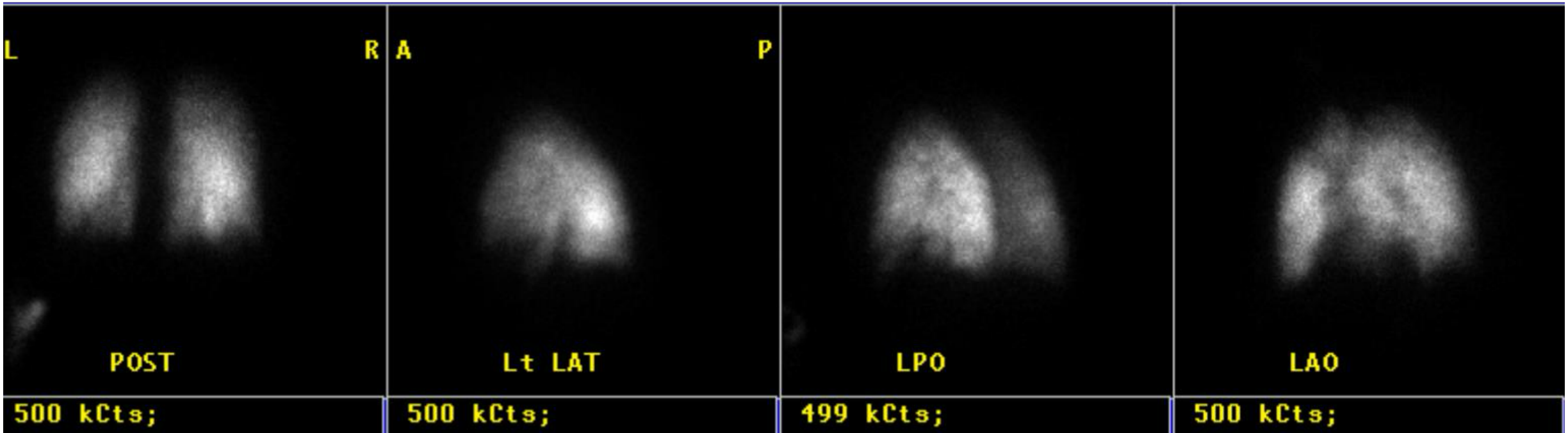
* Dx → PE

PE → Normal ventilation / abnormal perfusion




PE
Ventilation
Normal
Perfusion
Defect


R
L
ANT
500 kCts;
P
A
Rt LAT
500 kCts;
RPO
500 kCts;
RAO
500 kCts;


L
R
POST
500 kCts;
A
P
Lt LAT
500 kCts;
LPO
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LAO
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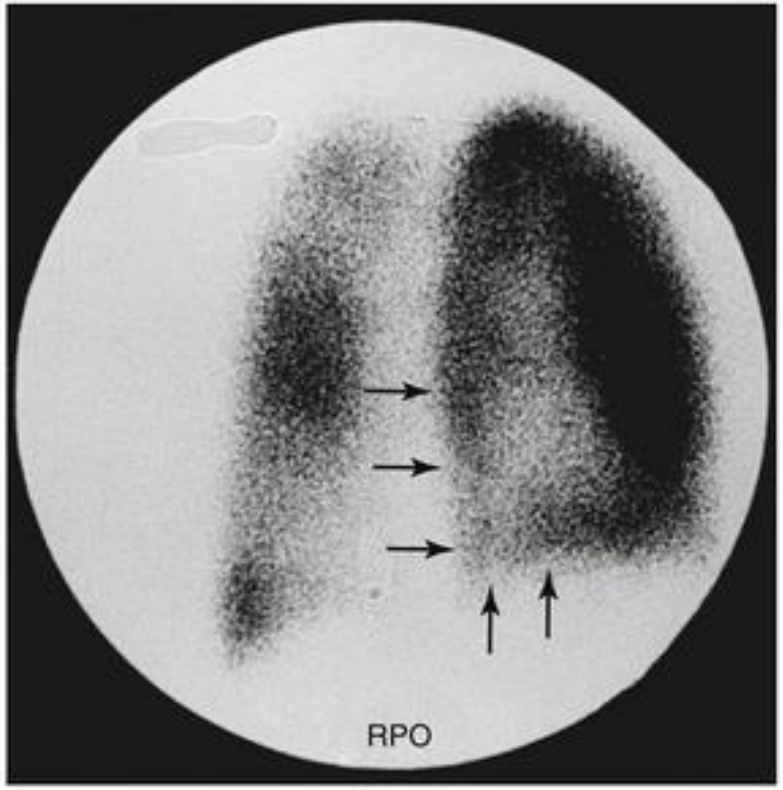


FIGURE 6-13 **Stripe sign.** Single view from a perfusion lung scan in a patien...

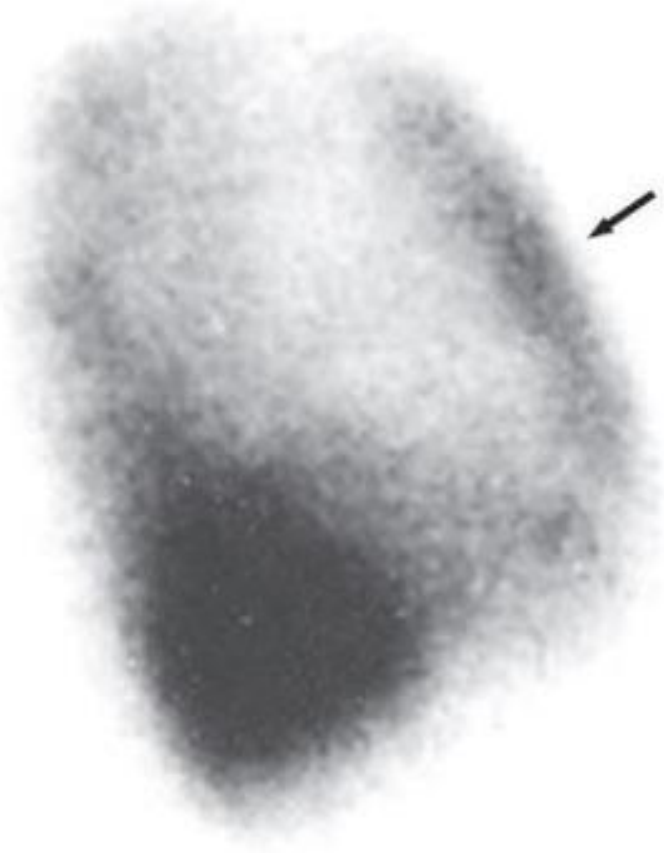
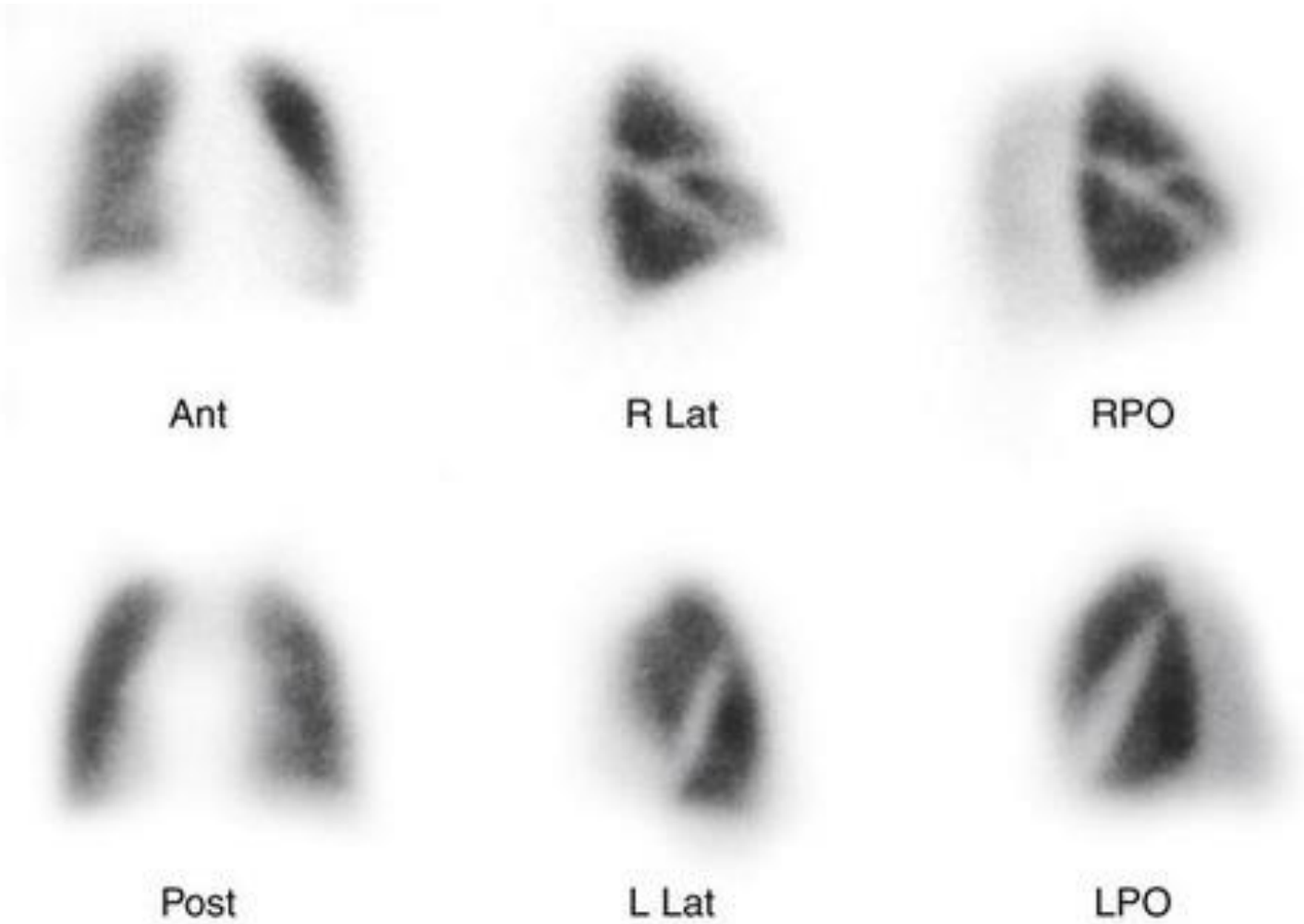
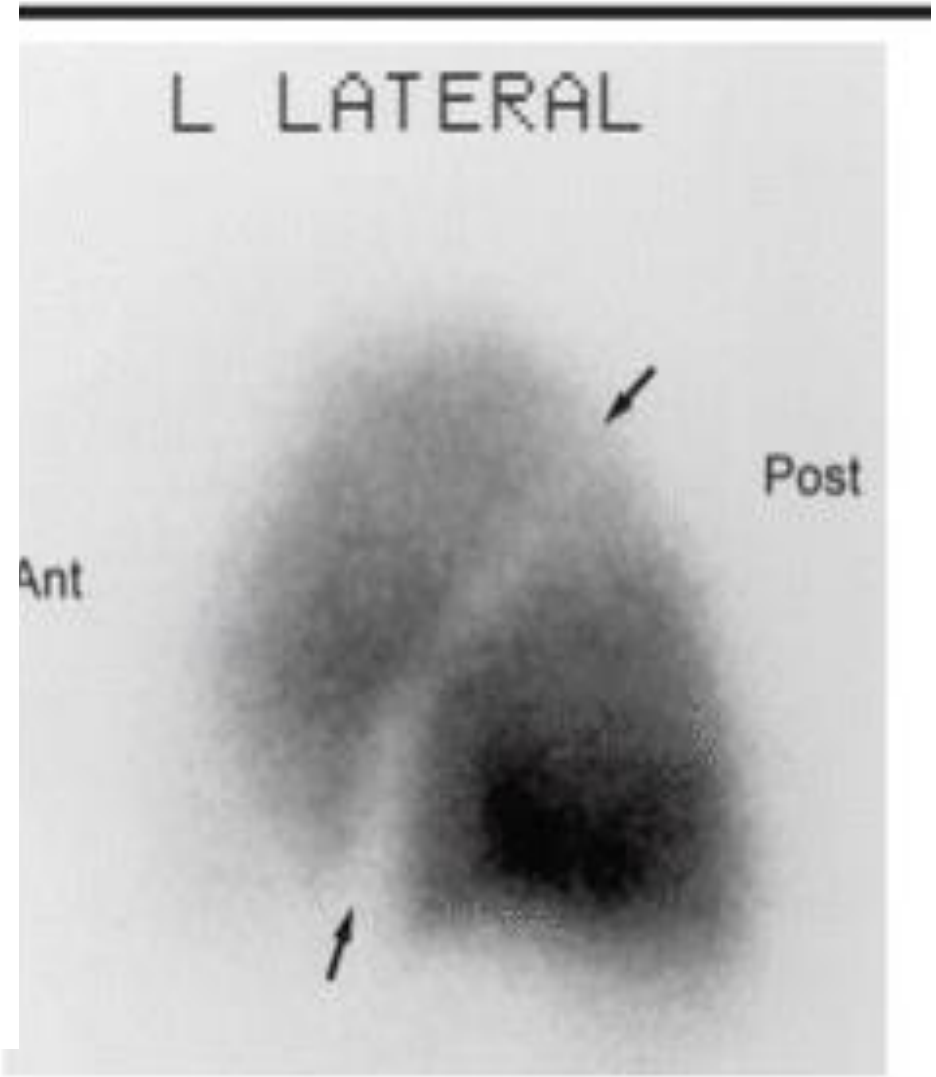


FIGURE 10-13. Stripe sign. Perfusion on the right lateral view is seen anteriorly along the periphery of the lung *(arrow)*, beyond an extensive area of decreased perfusion posterior to it strongly suggesting that the decreased perfusion in the upper lobe is not caused by PE.

The Fissure Sign[1]





Bone Scintigraphy

^{99m}Tc-MDP

Basics

Radiopharmaceutical

^{99m}Tc Methylene Diphosphonate (MDP) IV

Which tumors do we get bone scans for?

Breast, prostate, most others use PET scan

Breast cancer often sends solitary metastases to the sternum

Prostate cancer metastases often start in the spine

Detects areas of osteoblastic activity (new bone formation)

We don't use it for the detection of osteolytic lesions. Osteolytic lesions cannot be visualized using a bone scan. The most important example is multiple myeloma. In cases of multiple myeloma, we use a PET scan. A PET scan will detect the increased metabolism at the tumor site

Primary bone response to some tumors

Predominantly osteoblastic
Prostate
Carcinoid
Gastrinoma
Small cell lung cancer
Hodgkin's disease
Medulloblastoma
Predominantly osteolytic
Renal cell cancer
Melanoma
Squamous cell cancers of the aerodigestive tract
Multiple myeloma
Non-small cell lung cancer
Thyroid cancer
Non Hodgkins lymphoma
Mixed osteoblastic and osteolytic
Breast cancer
Gastrointestinal cancers
Squamous cancers at most primary sites

Bone Scan Tracer Distribution

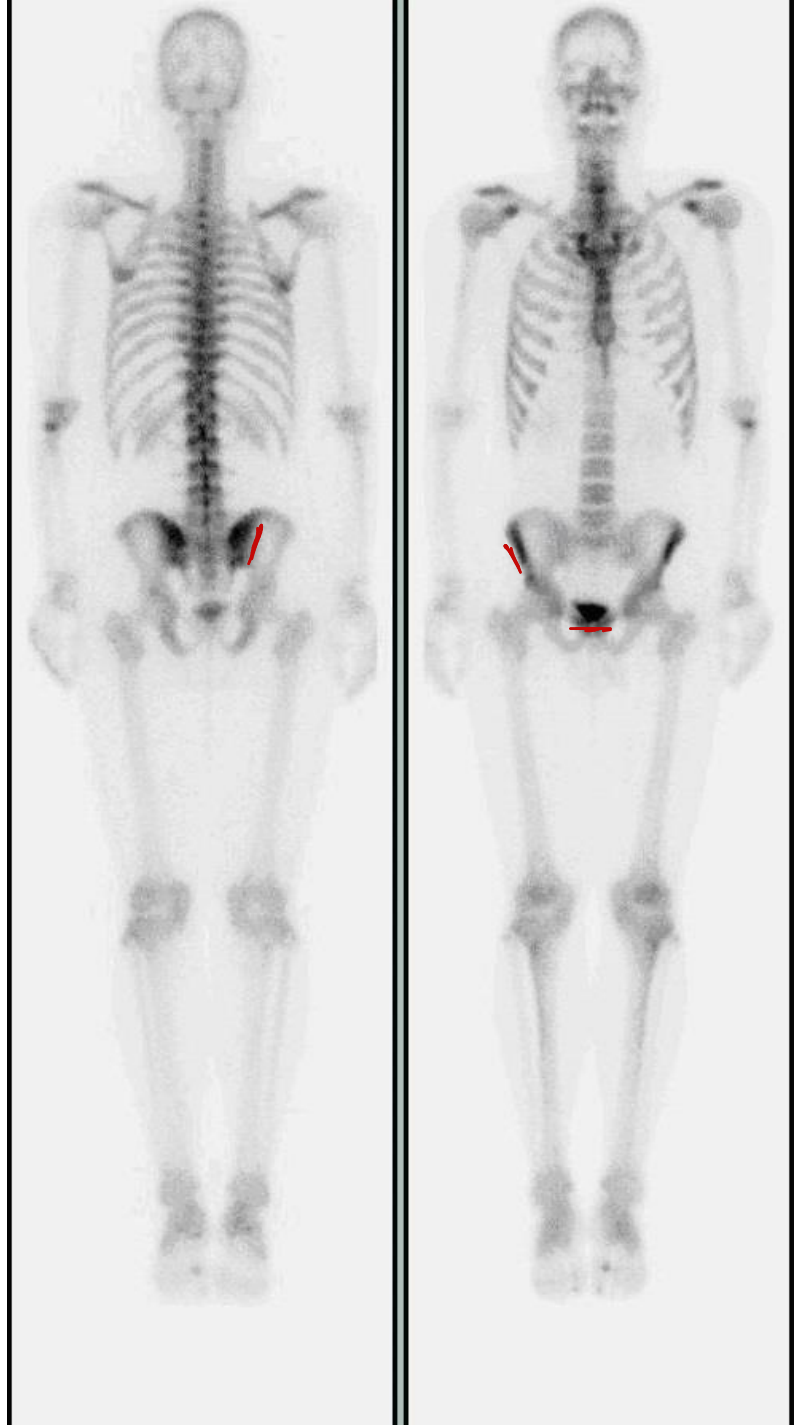
After injection of the radiopharmaceutical (Tc-99m), the tracer distributes according to blood flow and bone turnover.

Physiological uptake (normal "dark" areas):

1. Joints and cartilage – due to active bone remodeling and vascularity.
2. Urinary bladder and kidneys – because the tracer is excreted through the urinary system.
3. Sometimes growth plates (in children/adolescents) and sternum/ribs (due to higher bone turnover).

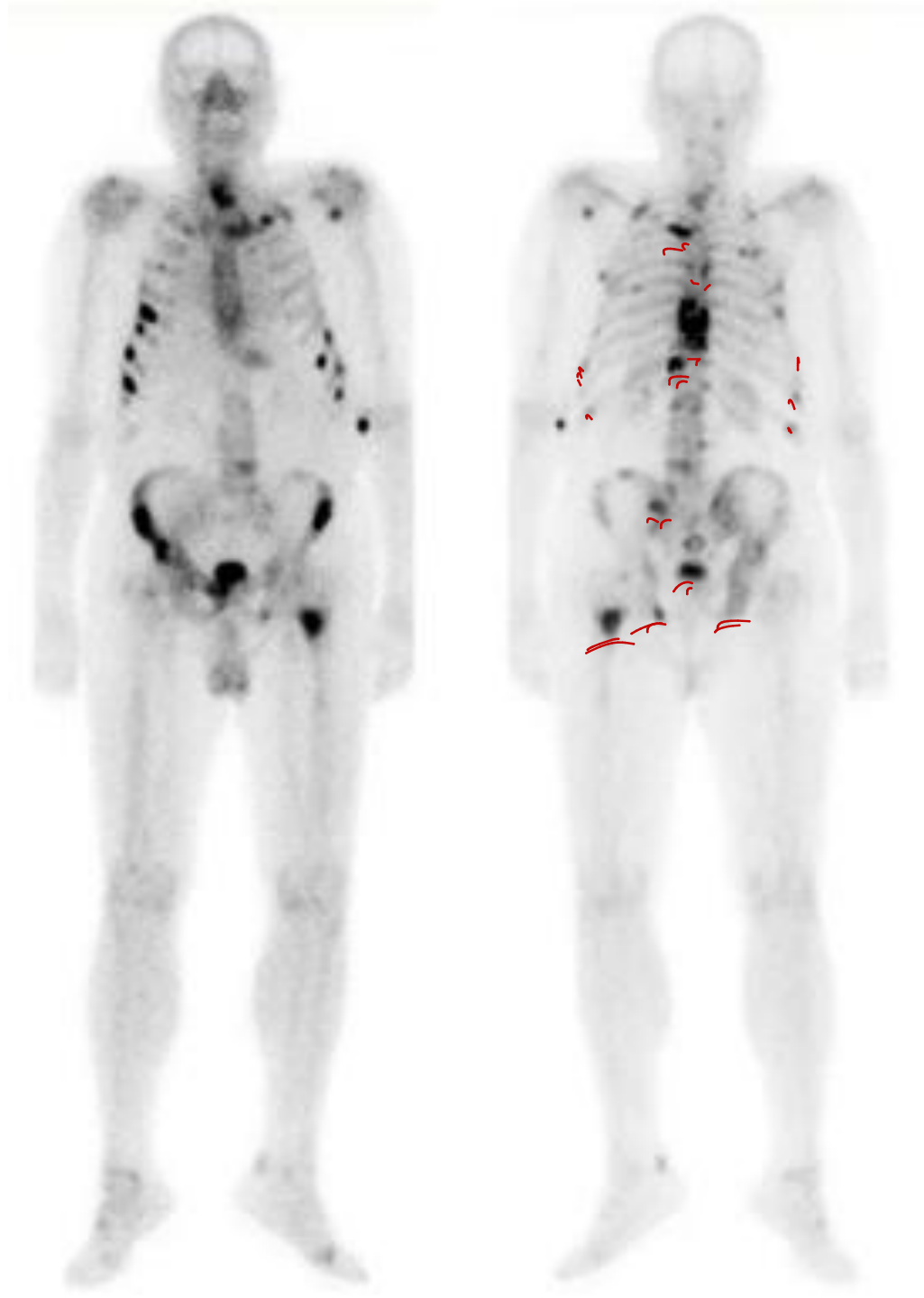
- These appear more dark (hot spots) on the scan because of increased tracer concentration.
- Abnormal uptake:

Areas with increased osteoblastic activity (e.g., fracture, metastasis, infection, arthritis) also appear dark, so we must differentiate them from normal distribution sites.



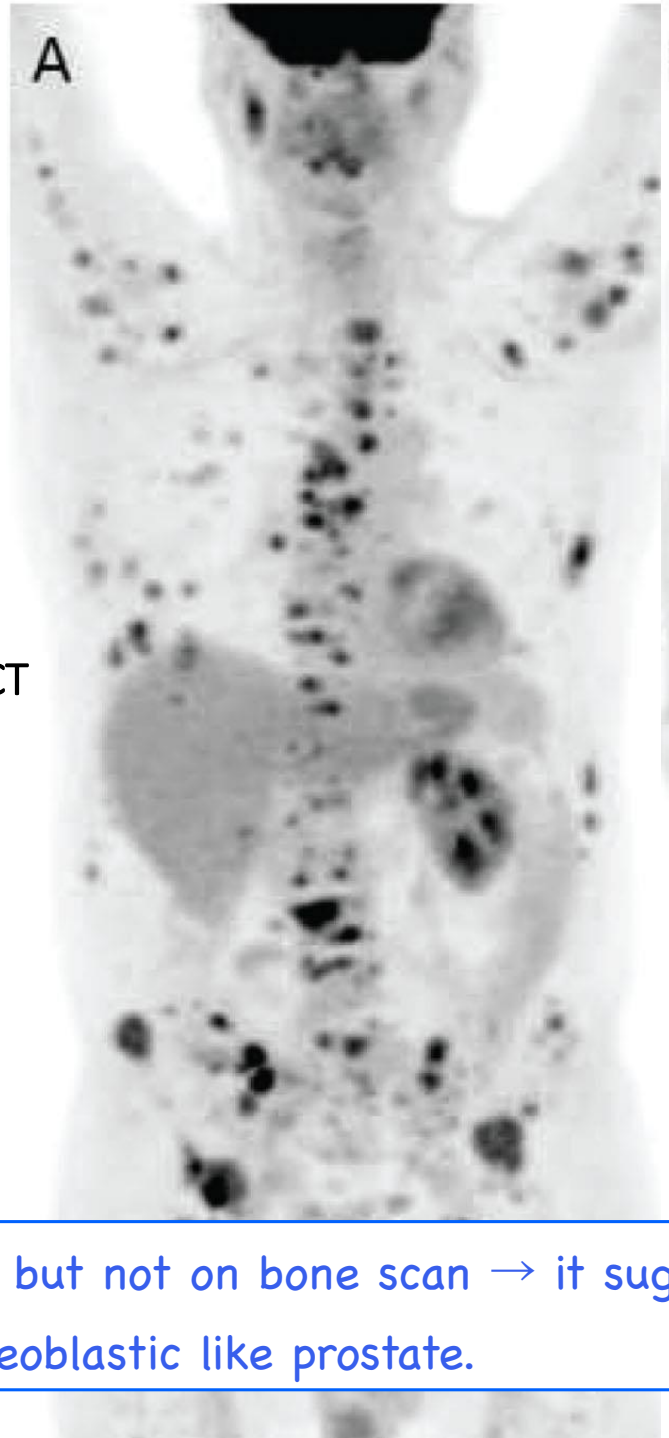
71-year-old male recently diagnosed with prostate cancer was referred to nuclear medicine to rule out bony metastases

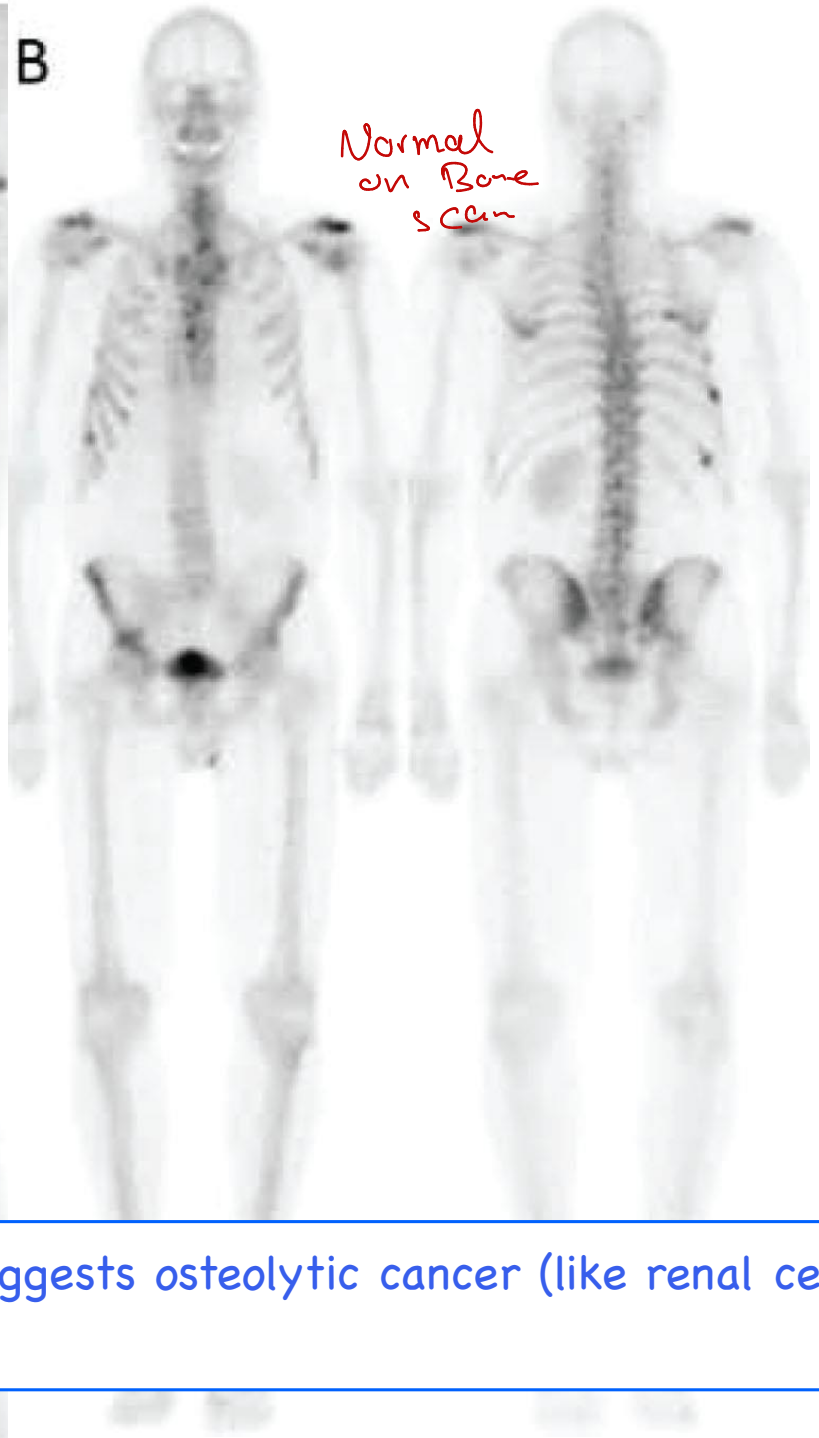
Normal —> symmetrical homogenous uptake



68-year-old male recently diagnosed with prostate cancer was referred to nuclear medicine to rule out bony metastases

multiple focal lesion



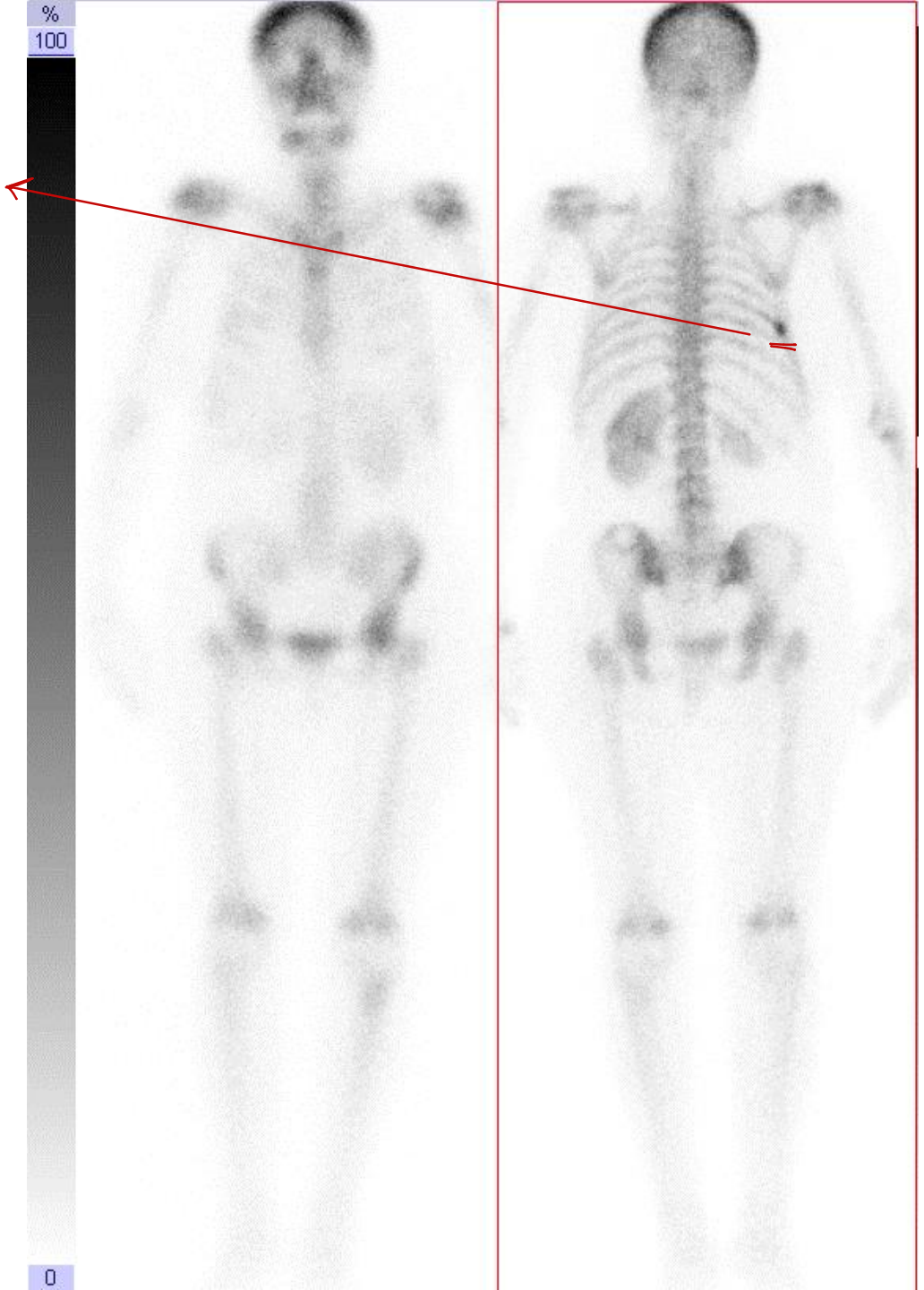


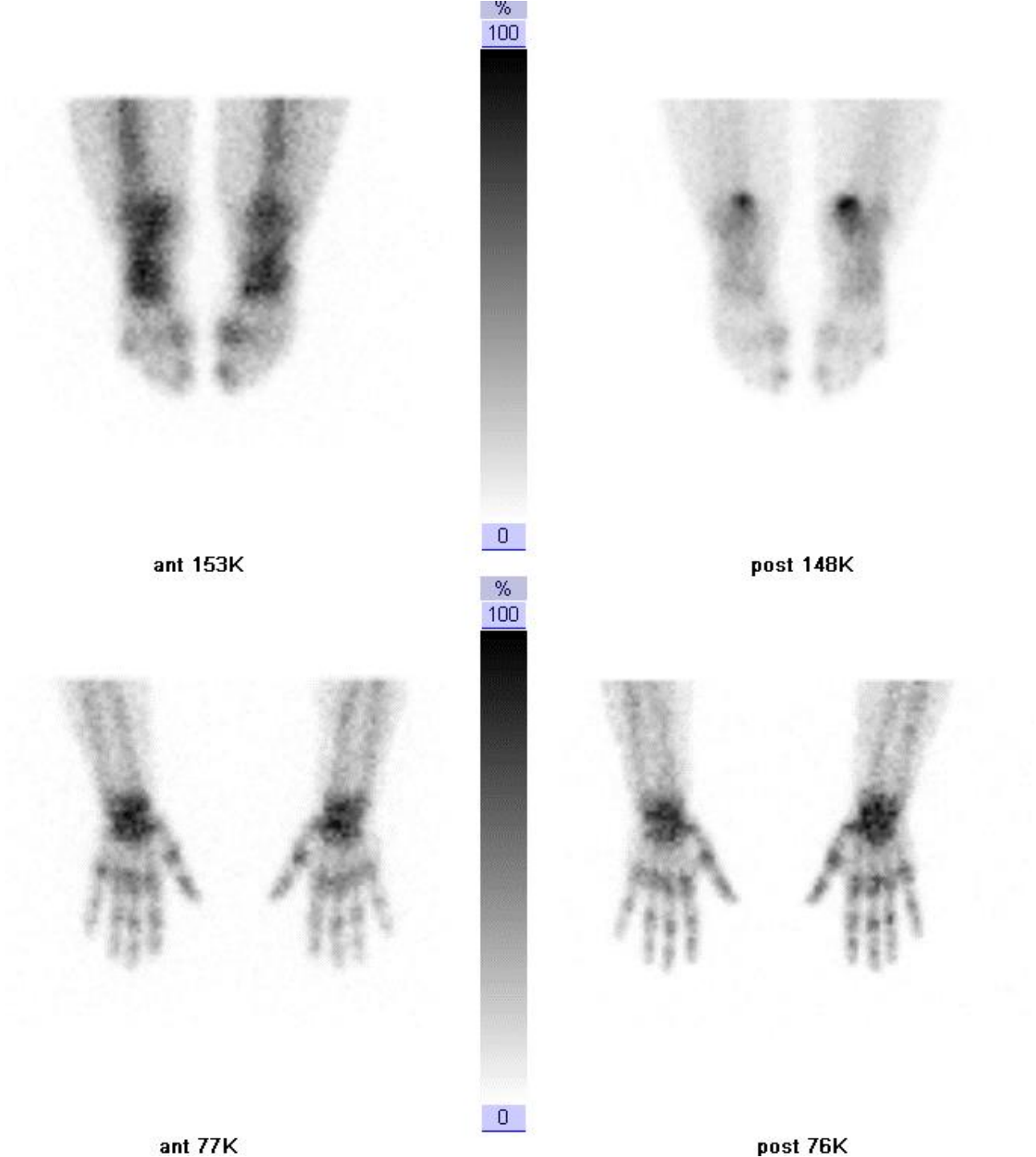
^{18}F-FDG PET/CT

Bone Scan

If mets are seen on PET but not on bone scan → it suggests osteolytic cancer (like renal cell or multipley myeloma), not purely osteoblastic like prostate.

A single focal hot spot on a rib is much more often trauma (fracture or injury) than metastasis.



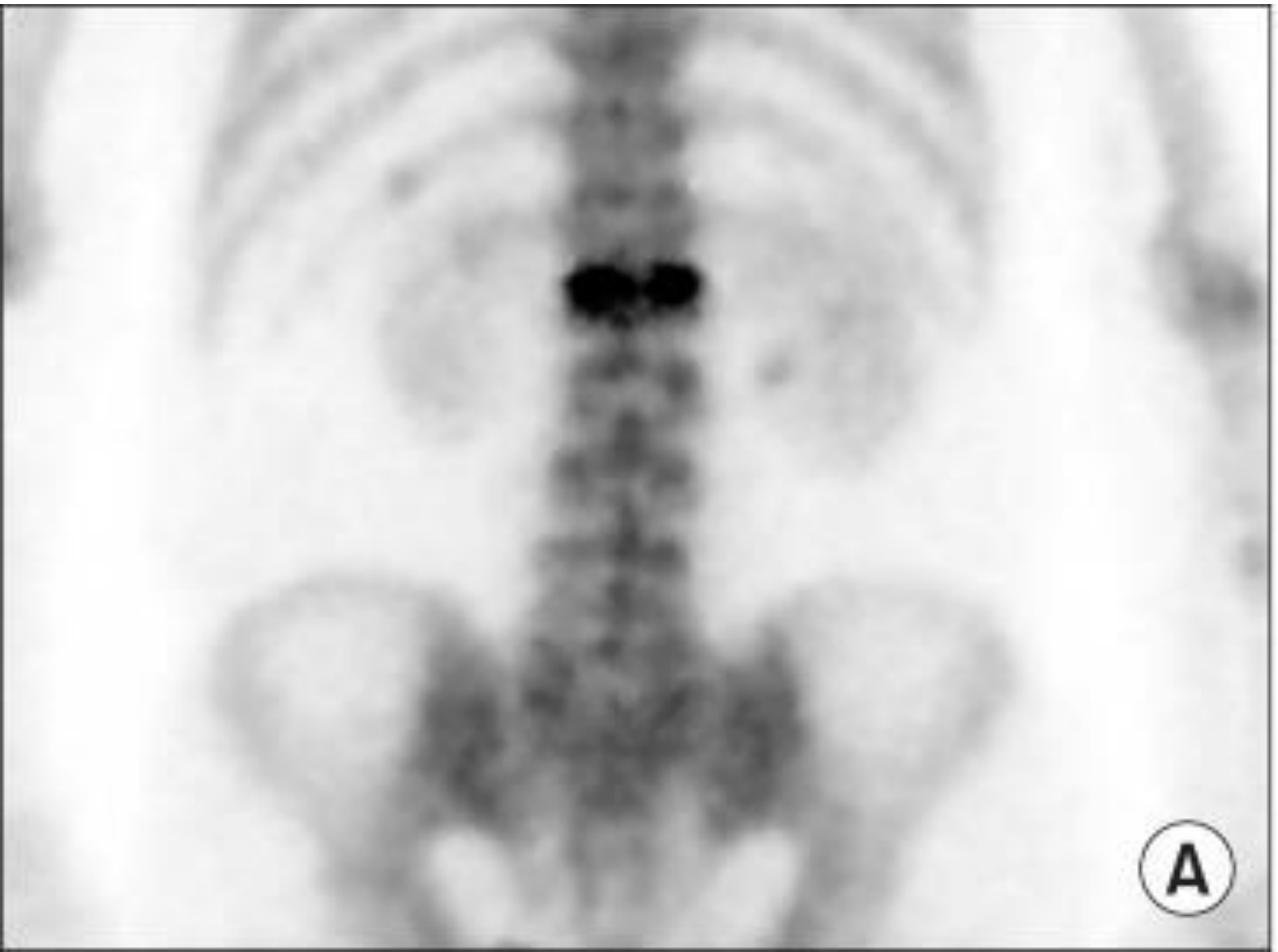


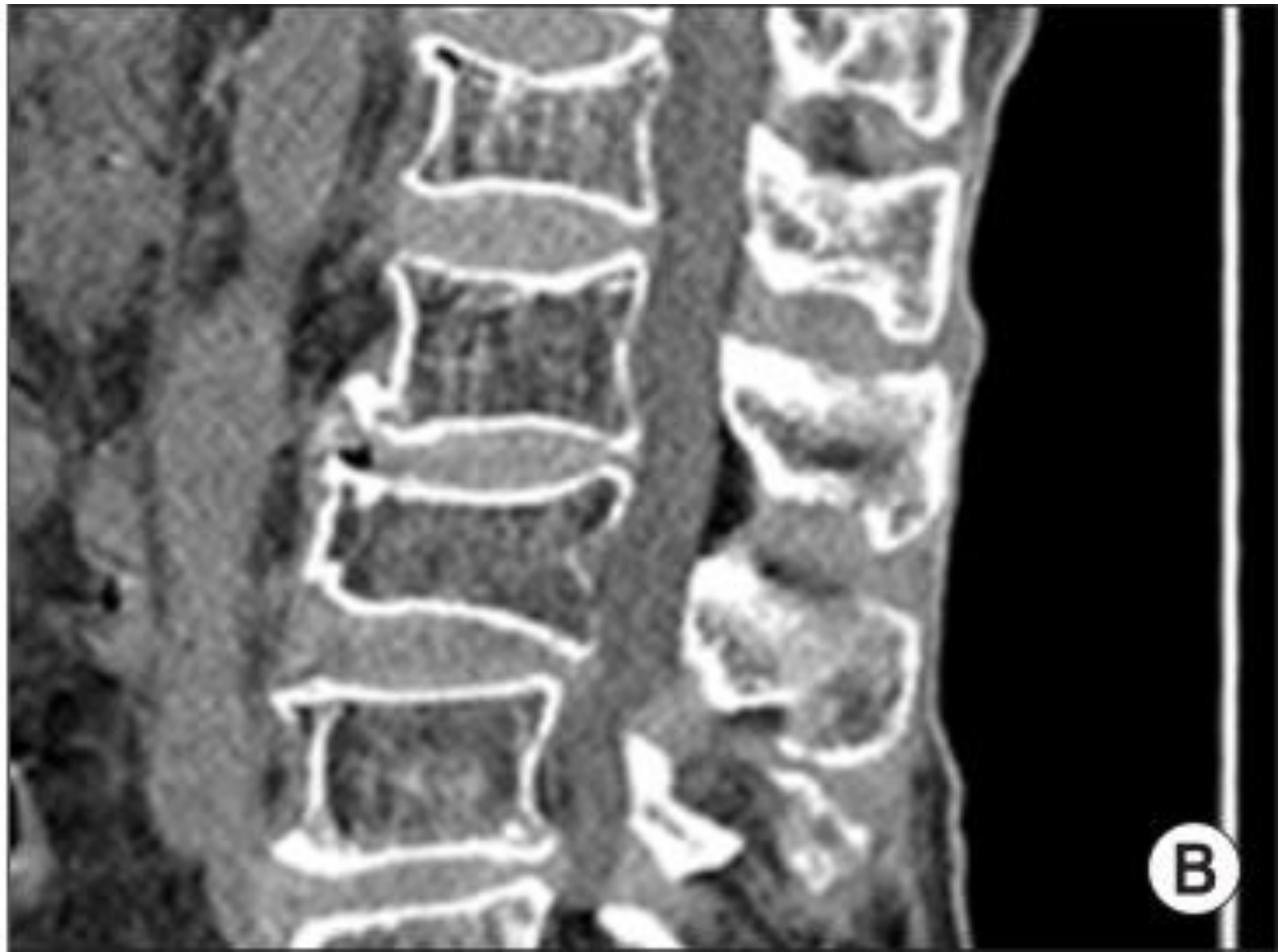
41-year-old female was referred to nuclear medicine to evaluate bilateral joint pain and morning stiffness

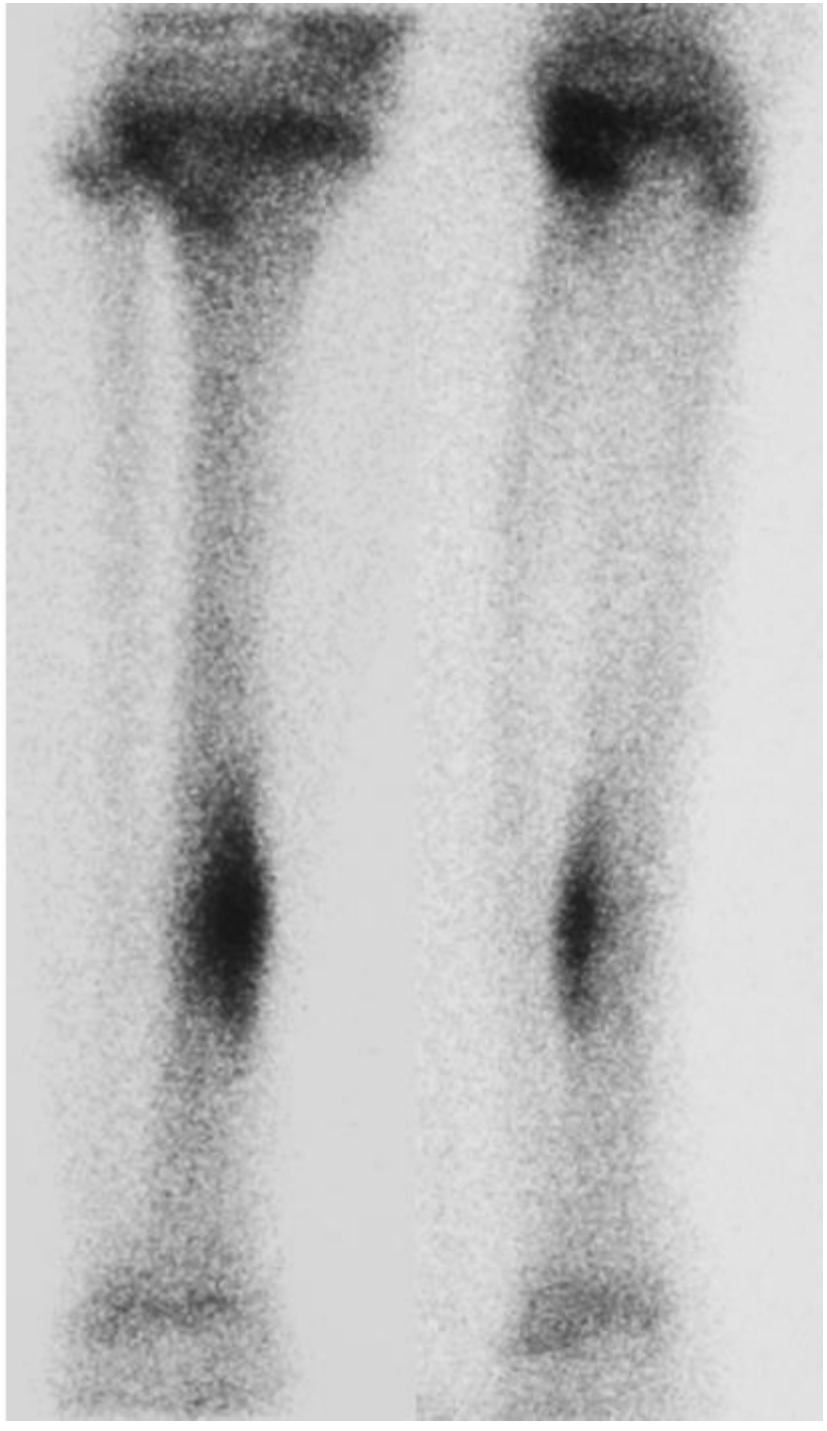
Rheumatoid arthritis

79-year-old female with back pain and vertebral loss of height on CT

Compression fracture







26-year-old female who recently started having to walk 15 km twice a day to get to and from work is now complaining from bilateral shin pain not responding to analgesia.

Bilateral increased uptake on the medial sides of tibiae

Dx: shin splints (medial tibial stress syndrome, MTSS).

Renal Scans

Diuretic Renography

Radiopharmaceuticals

- ^{99m}Tc MAG3
- ^{99m}Tc DTPA

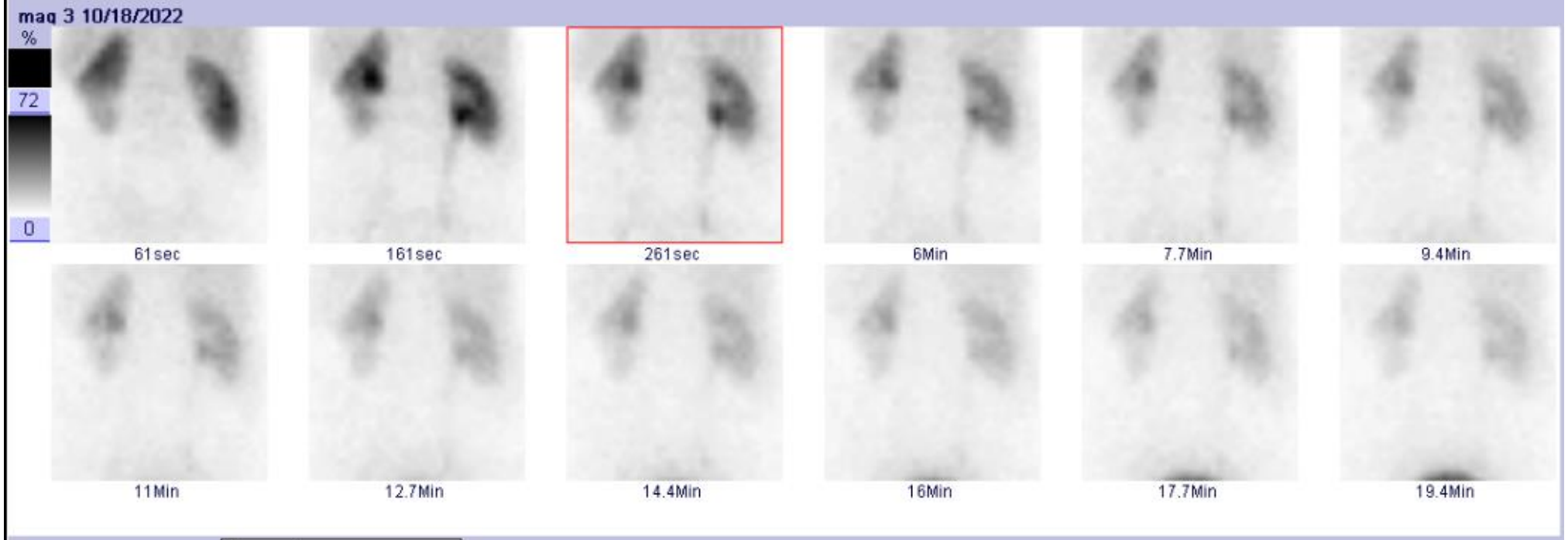
Pharmacologic protocols: diuretics (e.g. furosemide)

Indications

Obstructive vs nonobstructive hydronephrosis

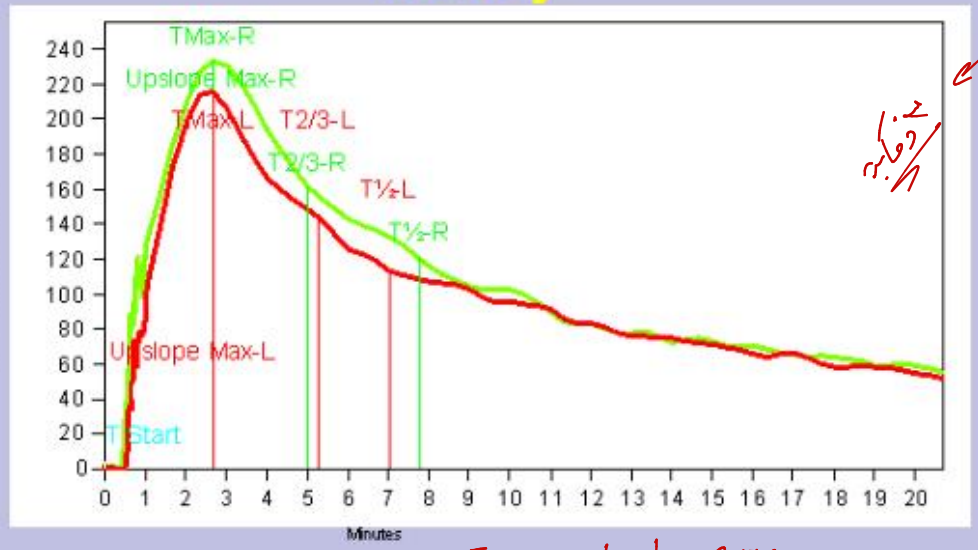
Stent function

Renal artery stenosis / thrombosis



Phase 2

Kidney



Time activity curve

Table of Result Summary

Parameters	Left	Right	Total
Split Function (%)	47.4	52.6	
Kidney Counts (cpm)	8383.3	9315.8	17699
Renal Retention	0.246	0.244	
Time of Max (min)	2.685	2.685	
Time of ½ Max (min)	6.986	7.783	
Time from Max to ½ Max (min)	4.300	5.098	
Time of 2/3 Max (min)	5.254	5.021	
Time from Max to 2/3 Max (min)	2.569	2.335	
Upslope Time Interval (min)	0.501	2.685	
Max Counts (cps)	219.1	239.7	458.8
Slope from Max to ½ Max (cps²)	0.387	0.377	
Upslope (cps²)	0.019	0.612	

1. Split Function (Relative Function) - first 3 min

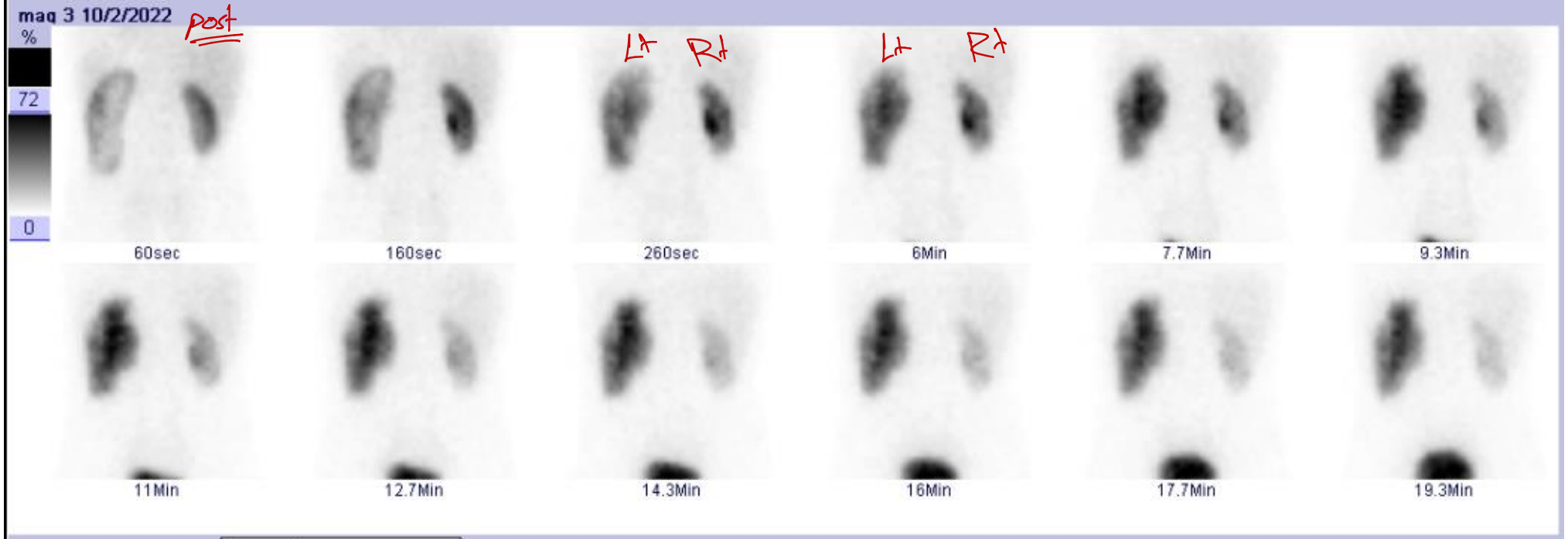
- Each kidney contributes a percentage of the total renal function.
- Calculated from the area under the curve (uptake phase) of each kidney.
- Normal: 45–55% for each kidney (roughly equal).

2. Time to Maximum (Tmax)

- The time from tracer injection to the peak activity of the curve.
- Reflects how fast tracer is taken up.
- Normal: 3–5 minutes.

3. Time of Half-Maximum (T½ or Clearance Half-Time)

- The time it takes for activity to fall to 50% of the peak value after Tmax.
- Reflects how well the kidney can excrete tracer.
- Normal: T½ < 20 minutes.



Phase 2

→ obstruction
hydronephrosis

Kidney

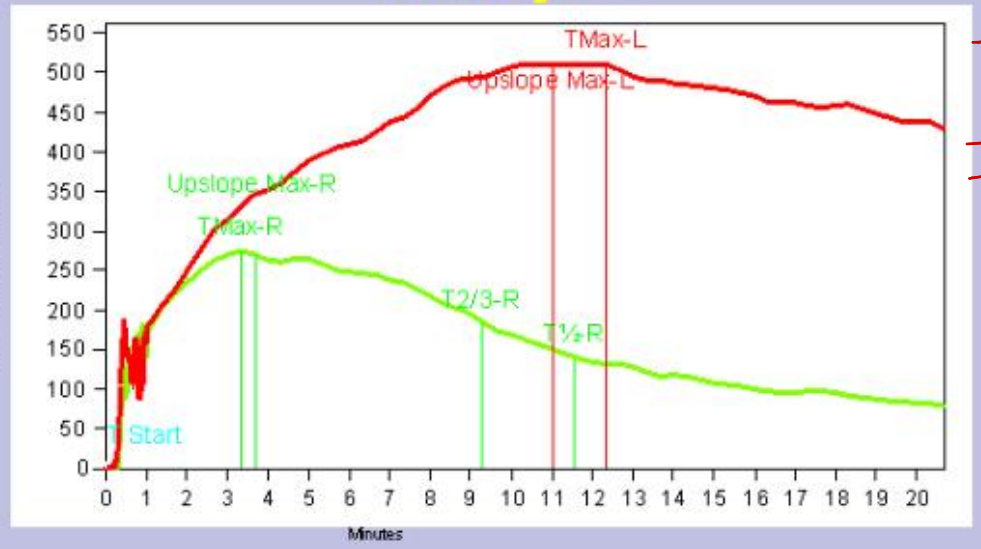


Table of Result Summary

Parameters	Left	Right	Total
Split Function (%) normal	49.9	50.1	
Kidney Counts (cpm)	12038	12065	24103
Renal Retention	0.846	0.293	
Time of Max (min) more than 5 min	12.3	3.336	
Time of ½ Max (min)		11.6	
Time from Max to ½ Max (min)		8.218	
Time of 2/3 Max (min)		9.239	
Time from Max to 2/3 Max (min)		5.903	
Upslope Time Interval (min)	11.0	3.669	
Max Counts (cps)	521.4	277.5	798.9
Slope from Max to ½ Max (cps²)		0.290	
Upslope (cps²)	1.107	1.784	

DMSA → For cortical defect only

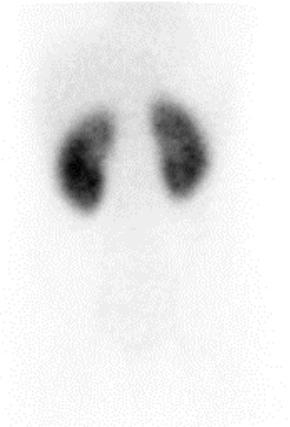
Radiopharmaceutical

- ^{99m}Tc dimercaptosuccinic acid (DMSA)

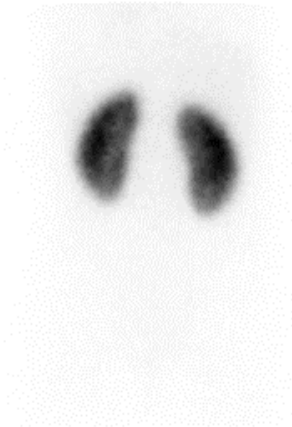
Indications

- Relative function
- Scarring
- Pre nephrectomy assessment

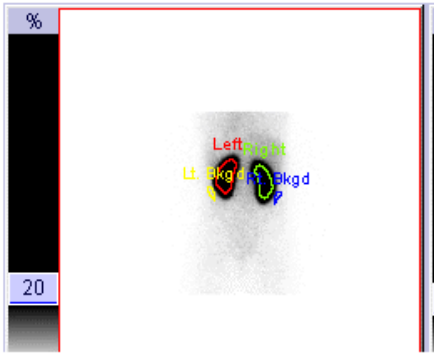
Normal

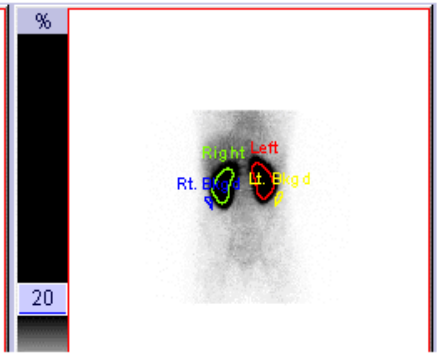


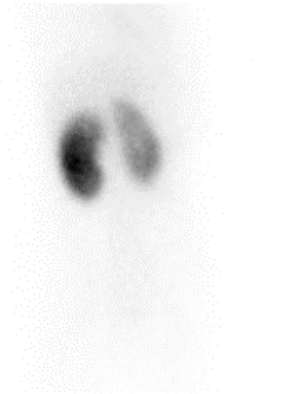
Anterior 404K



Posterior 407K



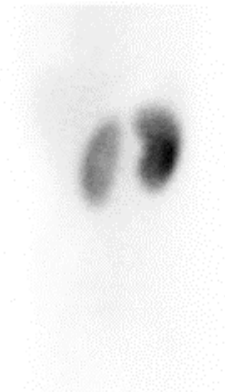




RAO 352K

LPO 426K

RPO 391K



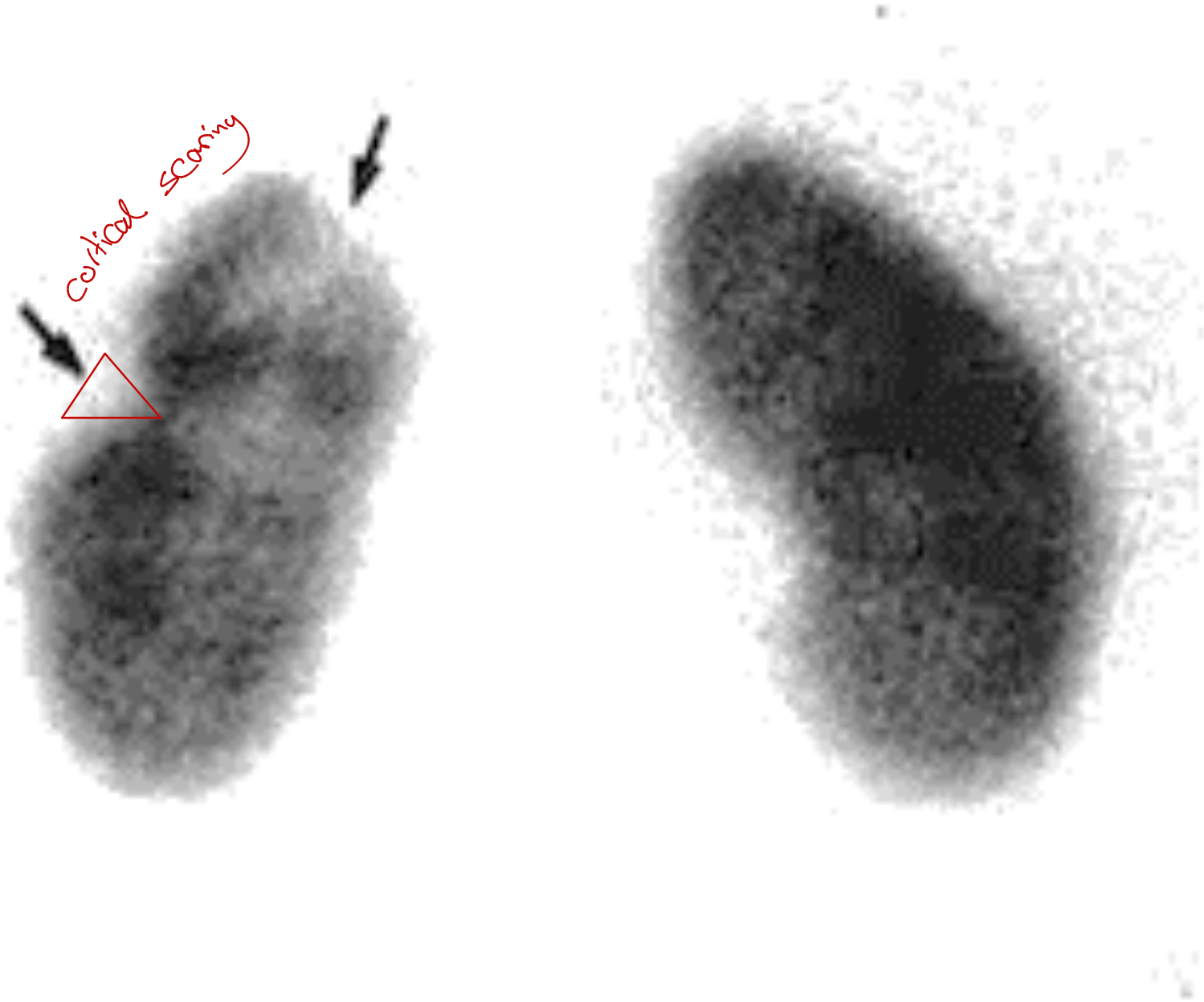
LAO 384K

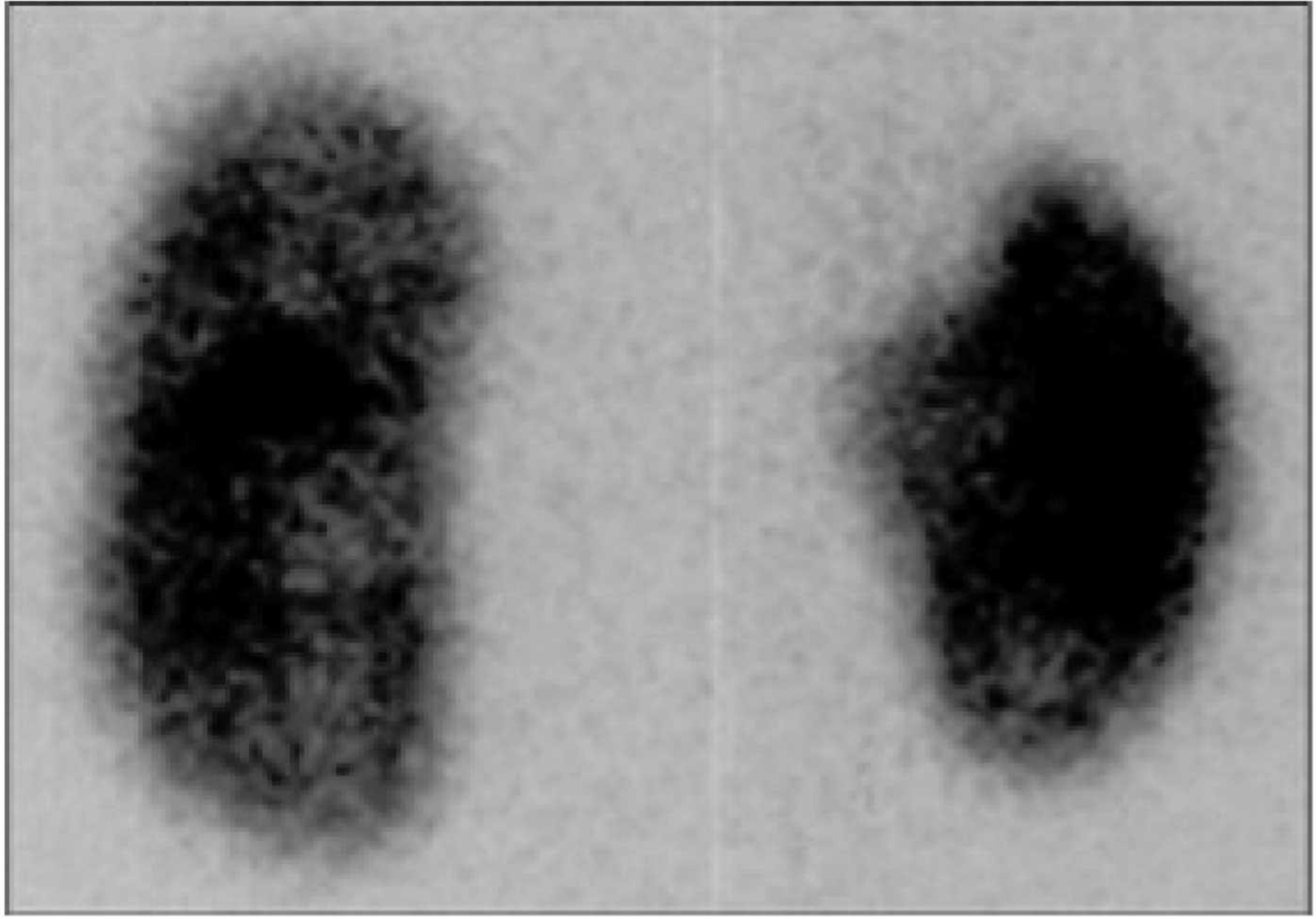
All Images

(% Ratios)	Left	Right
	50.26	49.74
Total	50.26	49.74

Normal DMSA scan:

- split function 45 - 55%
- symmetrical hemogenois uptake without wedge shape defect


cortical scarring



Posterior

Anterior

LPO

Left

Right

RPO

HIDA Scan

Uses ^{99m}Tc-mebrofenin or disofenin

Indications

- Acute cholecystitis
- Chronic acalculous cholecystitis
- Sphincter of Oddi dysfunction
- Biliary leak
- Biliary atresia
- Biliary stent patency

PET Imaging

It's a nuclear medicine imaging technique that shows metabolic activity in tissues, not just anatomy.

A PET is either taken with an MRI scan or a CT scan. This means that we never perform a PET scan alone. The machine itself has a CT or an MRI apparatus with it. This technique is called hybrid imaging.

Positron Emitting Tomography

Radioactive fluorine is the most widely used (^{18}F-FDG)

Also uses ^{11}C, ^{15}O, ^{13}N, ^{68}Ga

Indications

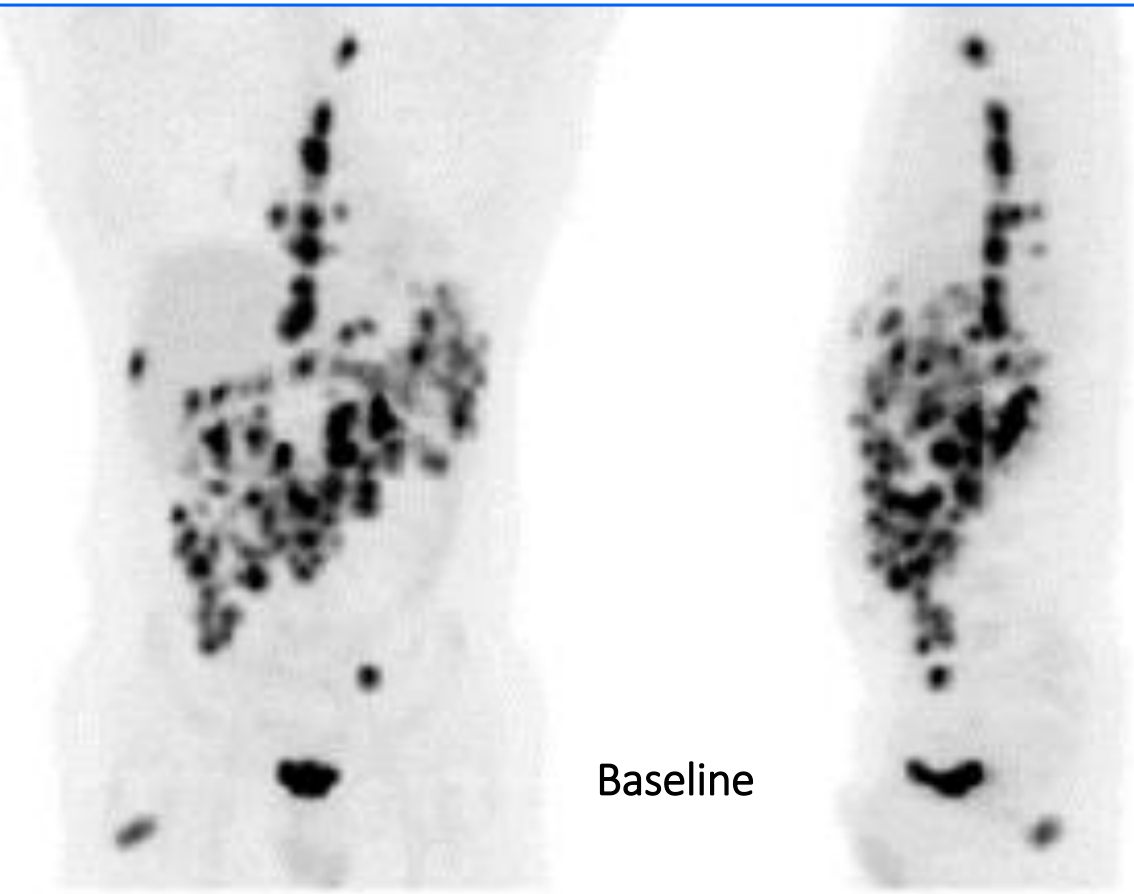
- Staging
- Response assessment
- Interim evaluation of treatment (lymphoma)
- Evaluation of suspected disease recurrence, relapse and/or residual disease
- Evaluation of indeterminate lesion
- Myocardial viability
- Localizing seizure foci

High uptake → "hot spots" (areas of increased metabolism).

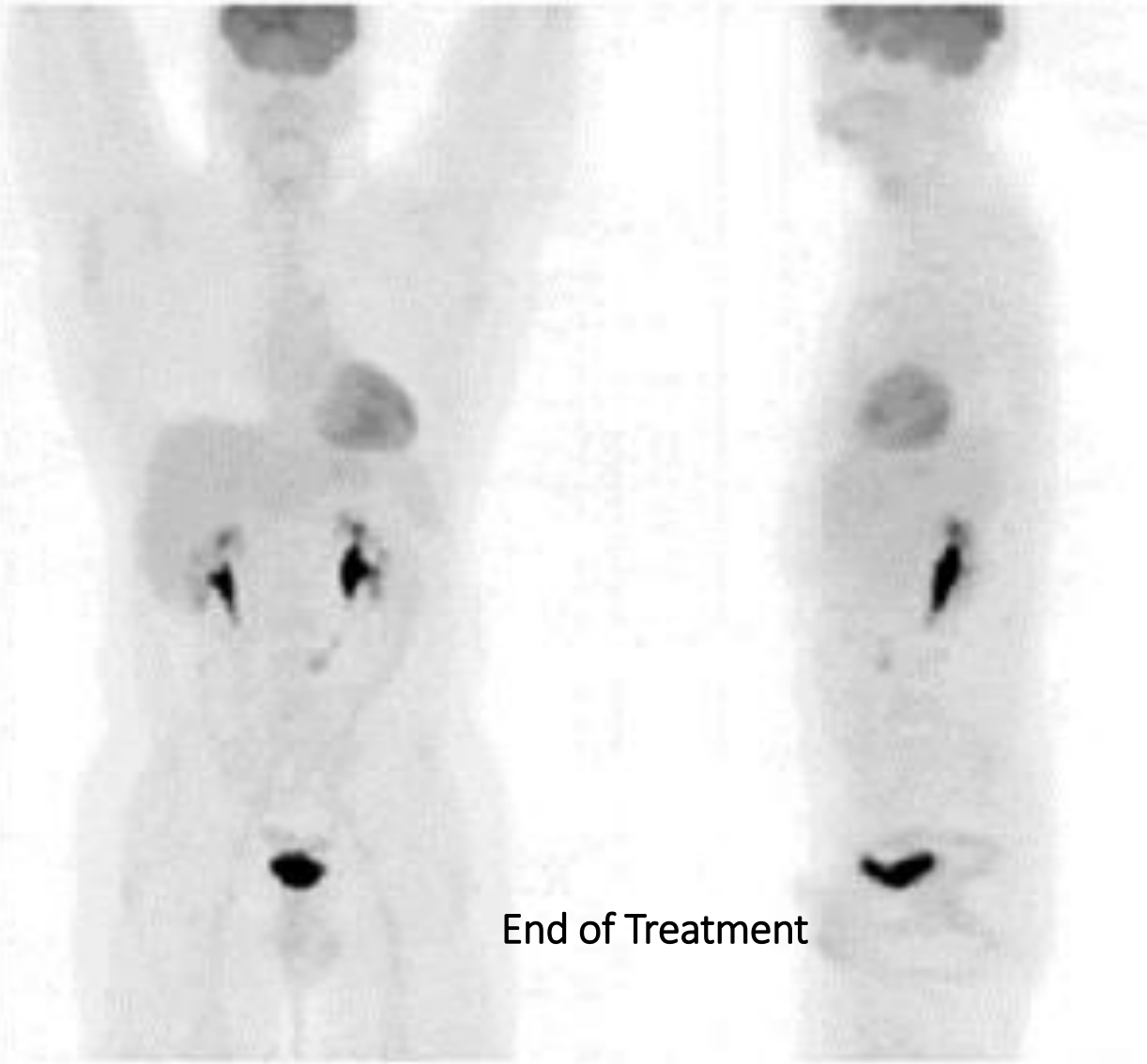
Low uptake → "cold spots" (areas of reduced metabolism).

Complete Metabolic Response

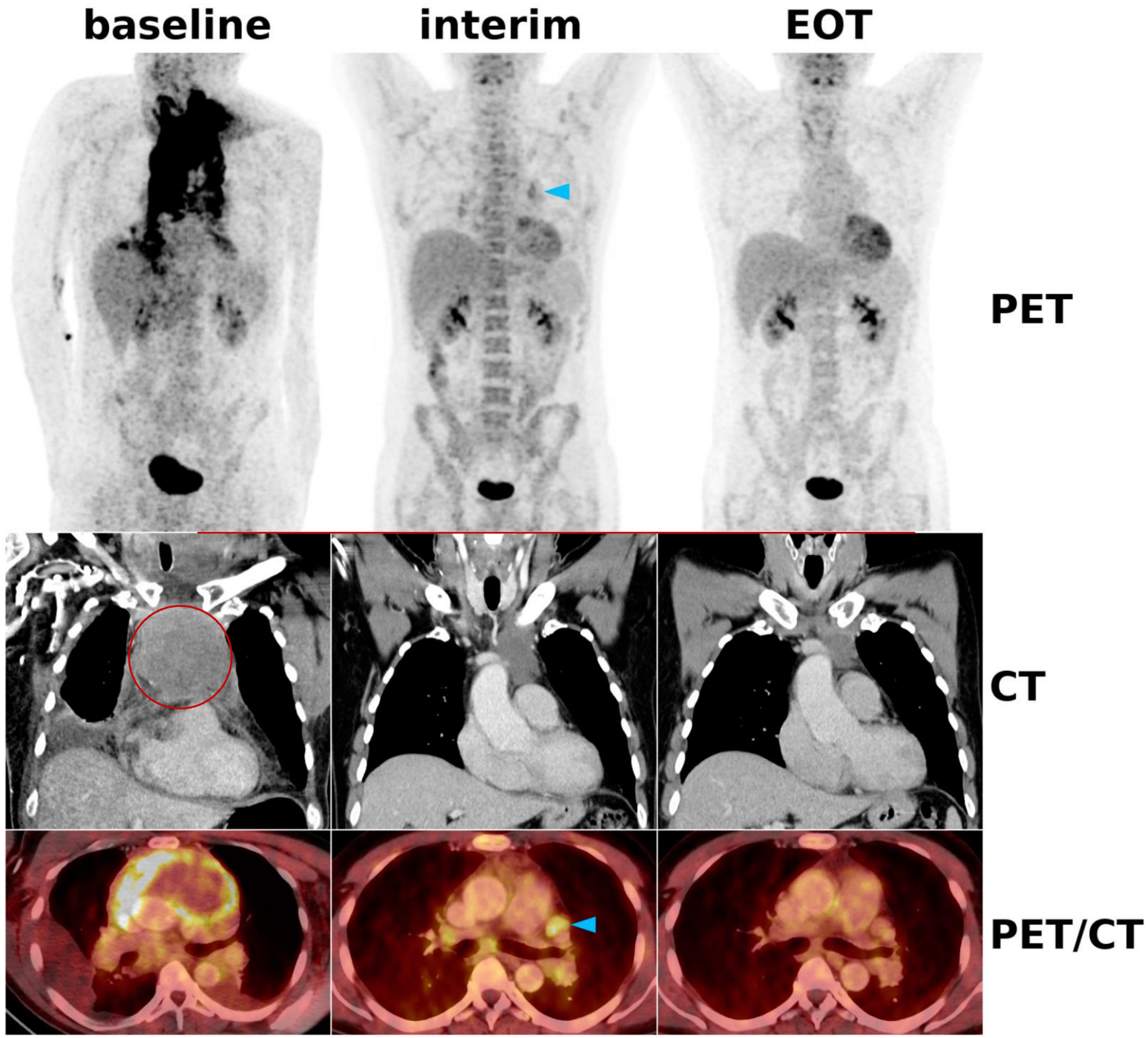
The picture shows Multiple black areas all over the chest, abdomen, and pelvis show increased FDG uptake. This means the cancer cells are highly metabolically active and taking up a lot of glucose.



Baseline

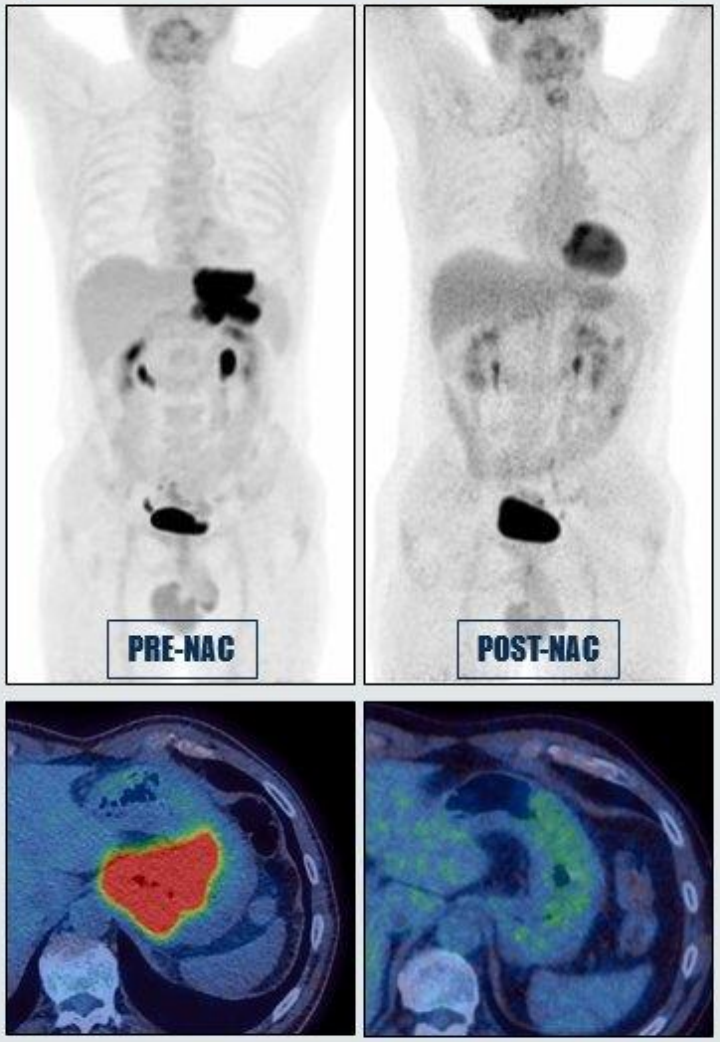


End of Treatment

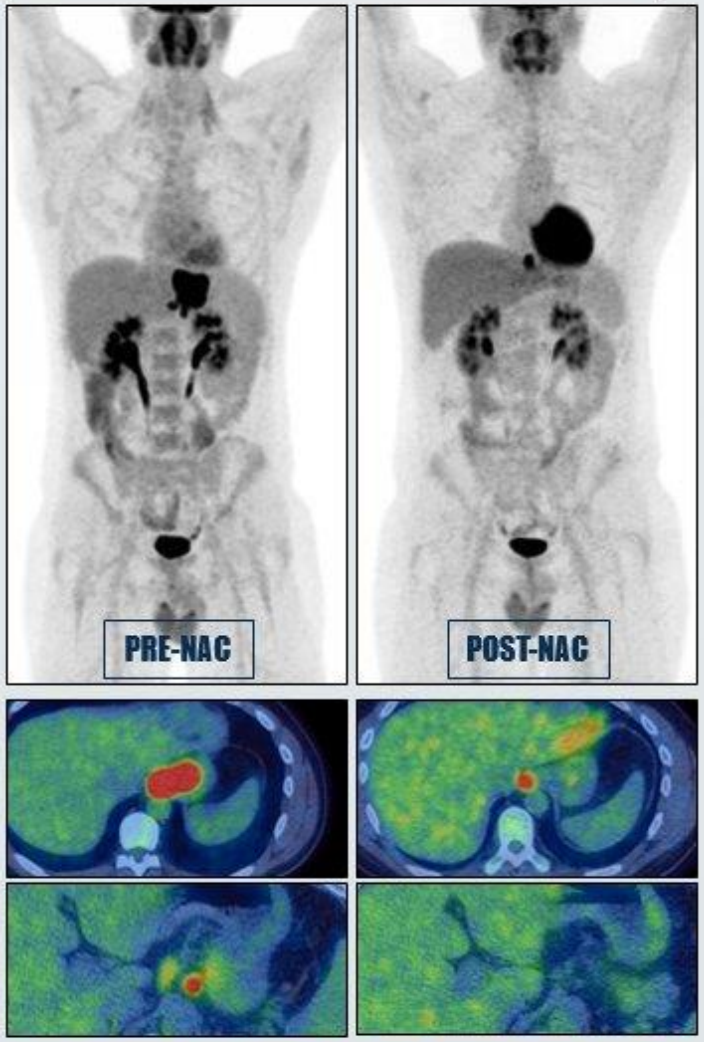


Anterior mediastinal mass with soft density

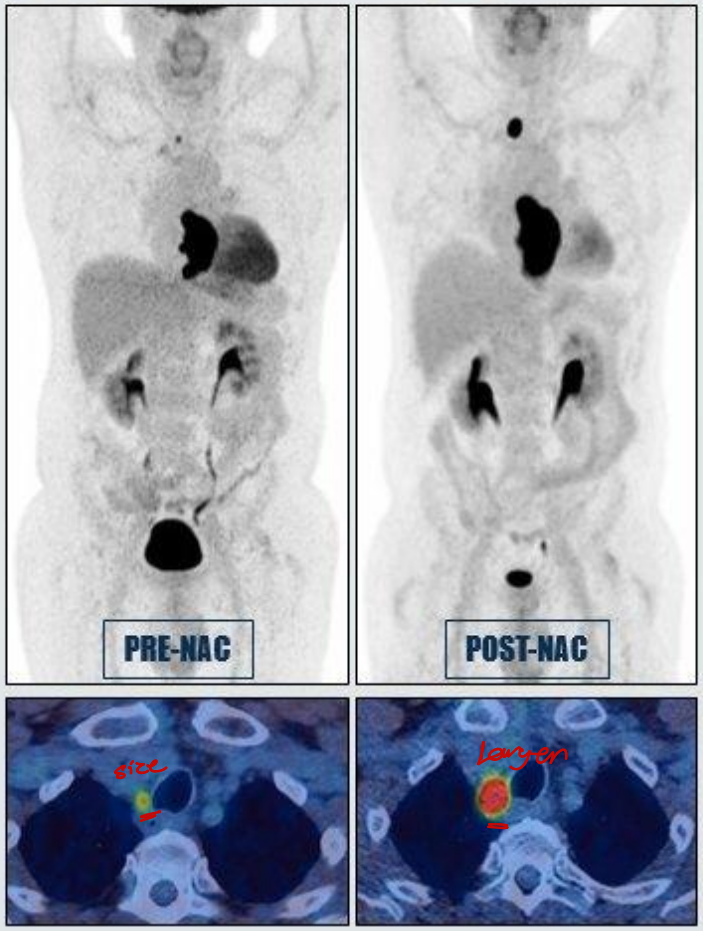
COMPLETE METABOLIC RESPONSE



PARTIAL METABOLIC RESPONSE



PROGRESSIVE METABOLIC DISEASE



King's College London & Guy's and St Thomas' PET Centre