

Nuclear Oncology



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Nuclear Oncology

LEARNING OBJECTIVES...



At the end of the lecture you will be able to answer the following questions:

- What are the nuclear medicine tumor imaging methods?
- What are the objectives of tumor imaging?
- What are the potential values of nuclear medicine tumor imaging methods?
- What is the role of nuclear medicine in the treatment of tumors?

What are the nuclear medicine tumor imaging methods?



- **Conventional tumor imaging :**

- Planar
- SPECT
- SPECT-CT

- **Onco PET :**

- PET
- PET -CT

Conventional tumor imaging



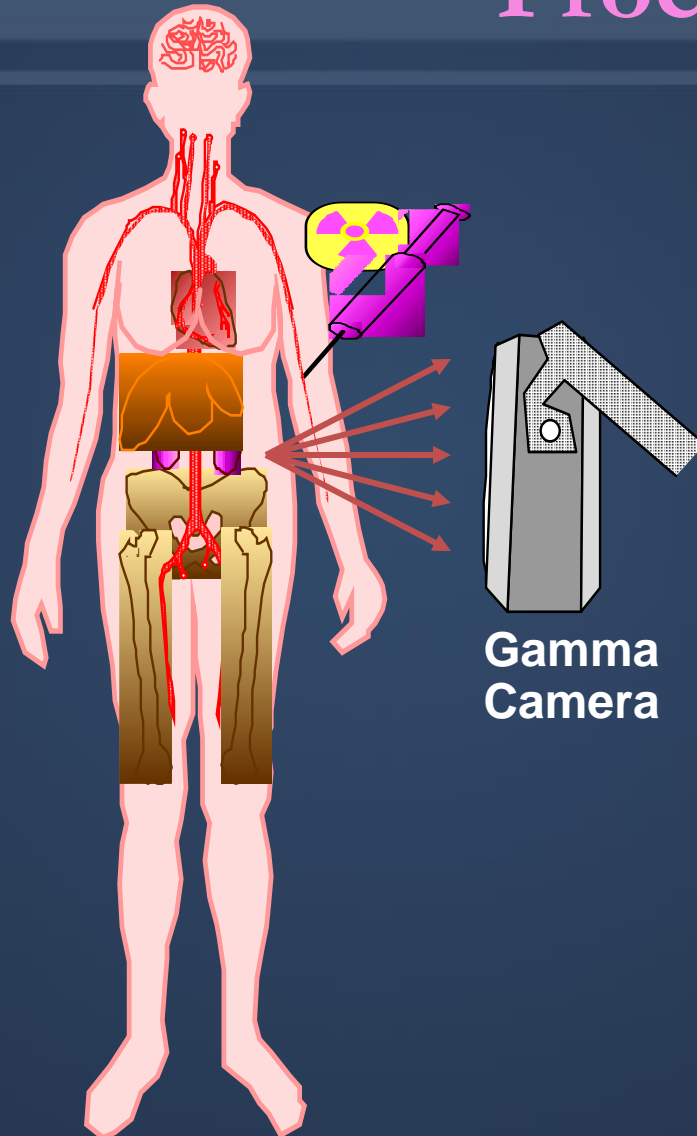
Non Specific

- Gallium 67 citrate (Ga-67)
- Tc-99m Methylenediphosphonate (Tc-99m MDP)
- Thallium Chloride 201 (Tl-201)
- Tc-99m SESTAMIBI

Specific

- Iodine 131 (I131)
- Iodine 123 MIBG(I123 MIBG)
- Radiolabelled monoclonal antibodies (MoAB)
- Receptor imaging : Somatostatin receptors

Nuclear Medicine Procedure



- *Patient injected with small amount of radioactive material .*
- *Radiopharmaceutical localizes in patient according to metabolic properties of that drug.*
- *Radioactivity decays, emitting gamma rays.*
- *Gamma rays that exit the patient are imaged.*

NM Imaging Systems



SPECT



PET CT

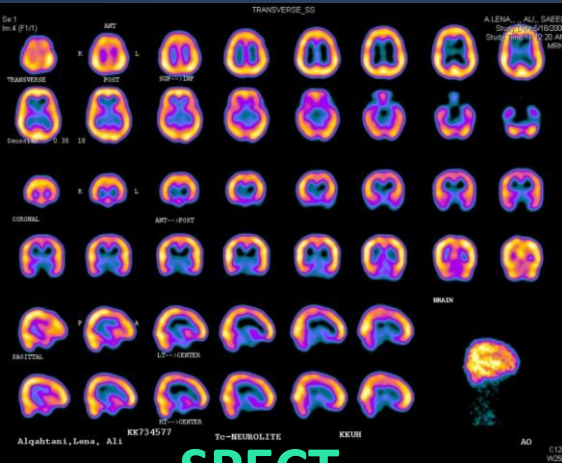


SPECT CT

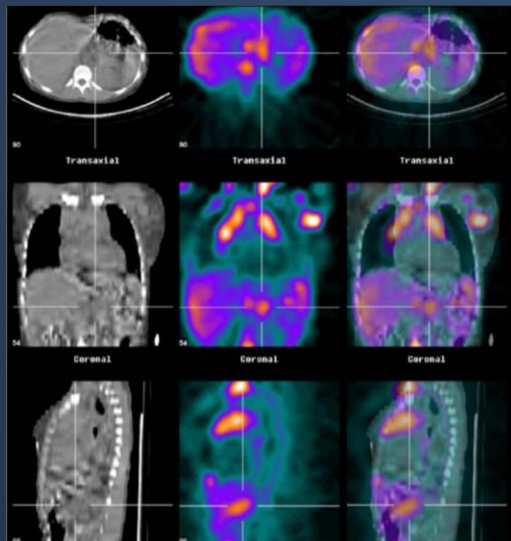
NM Imaging modalities

Single Photon Emission Computed Tomography (SPECT) and SPECT CT

Positron Emission Tomography (PET) and PET CT



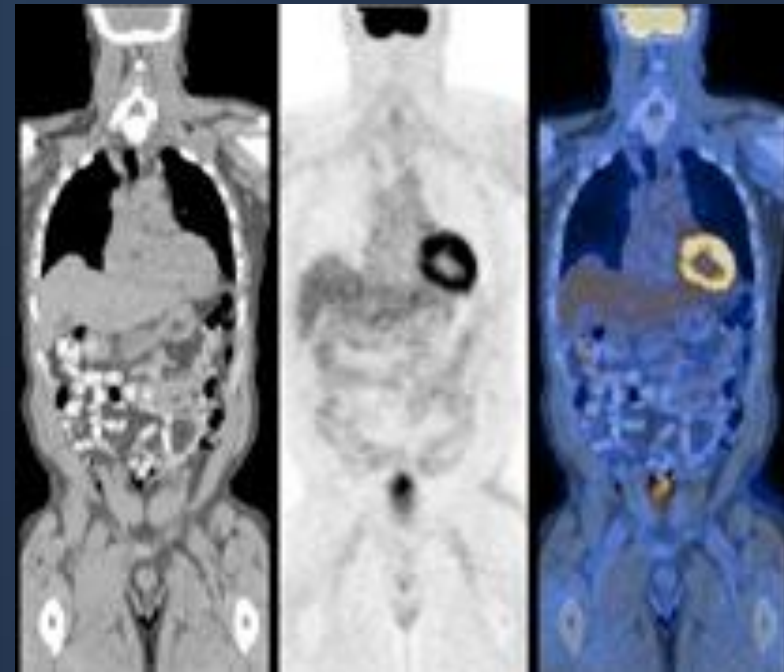
SPECT



SPECT/CT



PET



PET/CT

Tumor Imaging



- **Tc-99m MDP bone scan:** Detection and follow up of bone metastasis
- **Gallium 67 :** Staging ,Restaging & therapy assessment of HD , NHL , Lung cancer
- **Thallium 201 :** Tumor viability & tumor seeking.
{Tc-99 m Agents (MIBI ,TETRO.).}
- **In-111 (TC99m) Octreotide :** Neuroendocrine tumors
- **I -123 MIBG :** Neuroendocrine tumor
- **I -131 :** Lung mets. thyroid carcinoma
- **F18 – FDG :** Staging ,Restaging & therapy assessment of HD , NHL , Lung cancer

Bone Scan In Oncology “Procedure”



Agent : Technitium 99m Methylene
DiPhosPhonate (Tc-99m **MDP**)

Dose : 20 mCi for adults and minimum 2 mCi
(250 uCi/Kg) for children.

Imaging : Single phase : 3-4 hrs post iv inj.
Three phase : Flow, pool & delayed

Specific Instruction : Well hydration.



Normal Whole Body Bone Scan



An 8 year old child

A 25 yrs old adult

Bone Scan In Oncology



- **Metastatic Disease.**
- **Primary Bone Tumors :**
 - Malignant**
 - Benign**
- **Soft tissue tumors :**
 - Primary**
 - Metastases**

Bone Scan In Oncology

Imaging features



- a. Hot lesions :** Majority of bone tumors.
- b. Cold lesions :** Purely osteolytic tumors (renal cell carcinoma, thyroid cancer, anaplastic tumors).
- c. Superscan :** Diffuse increased skeletal uptake with no soft tissue or kidney activity (e.g. CA prostate ,breast ,..etc).
- d. Normal distribution :** Marrow tumors
(e.g. lymphomas, leukemia, multiple myeloma).
- e. Soft tissue uptake :** Soft tissue tumors may concentrate the tracer.

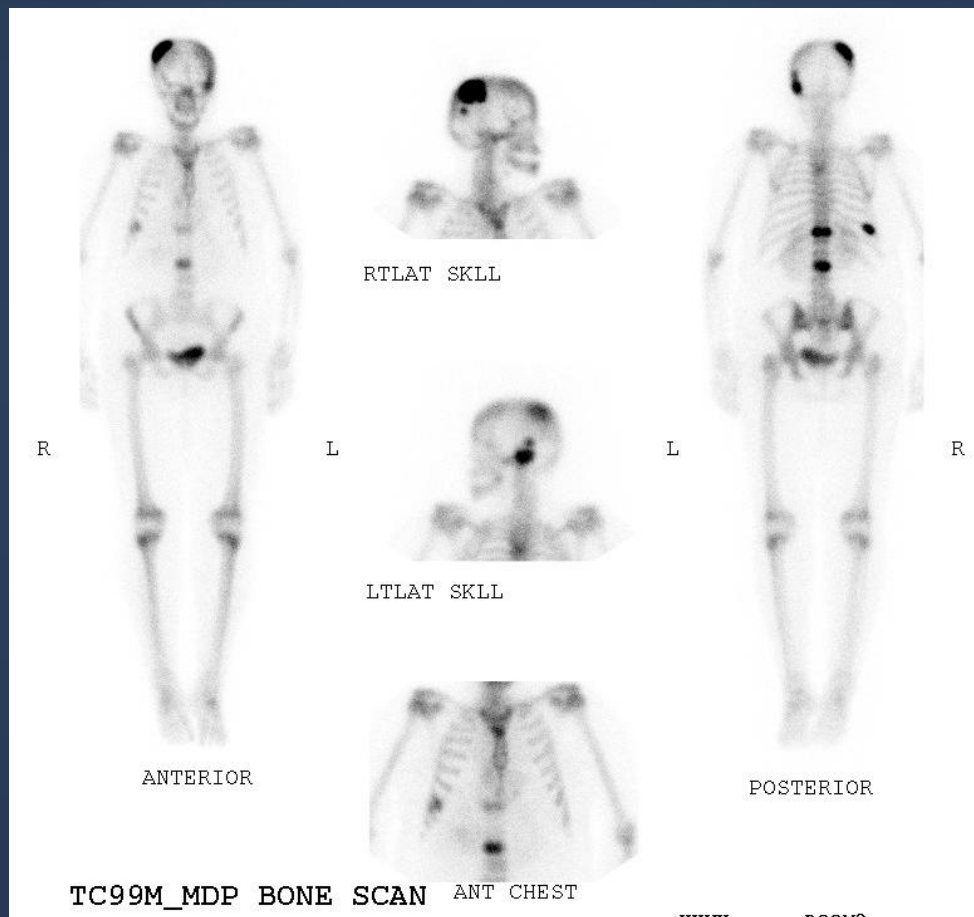
Bone Scan In Oncology

Indications

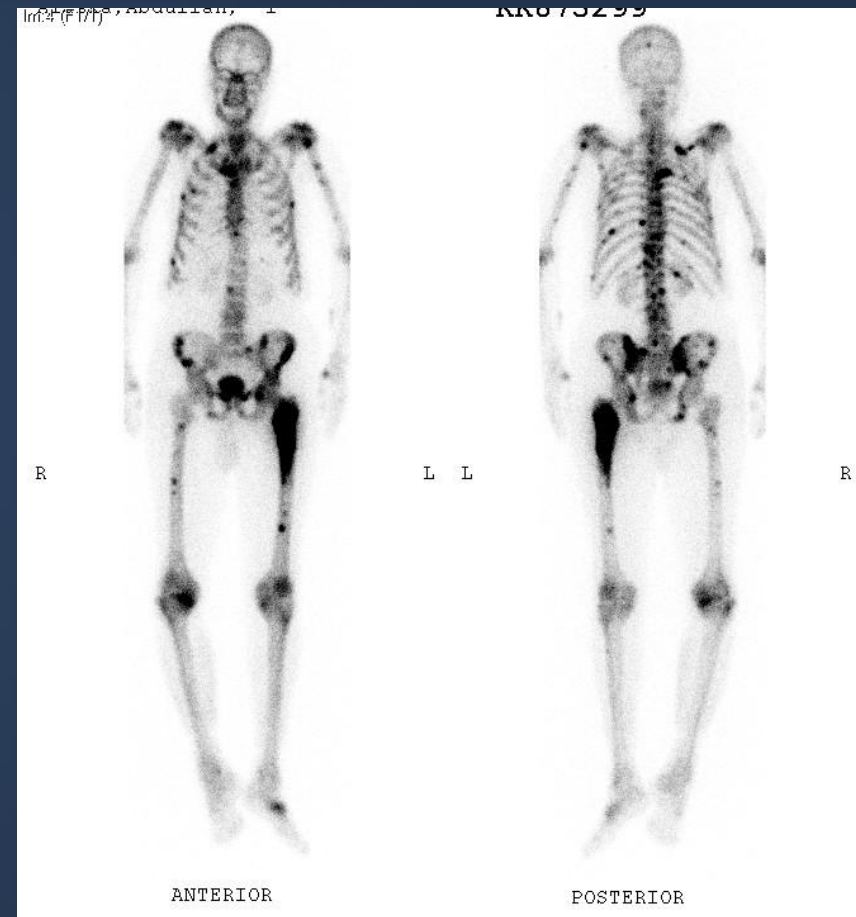


- **Diagnosis.**
- **Initial staging.**
- **Restaging.**
- **Asses response to therapy.**
- **Therapy planning for patients with primary bone malignancy (e.g. Osteogenic & Ewings sarcoma)**

TUMOR STAGING

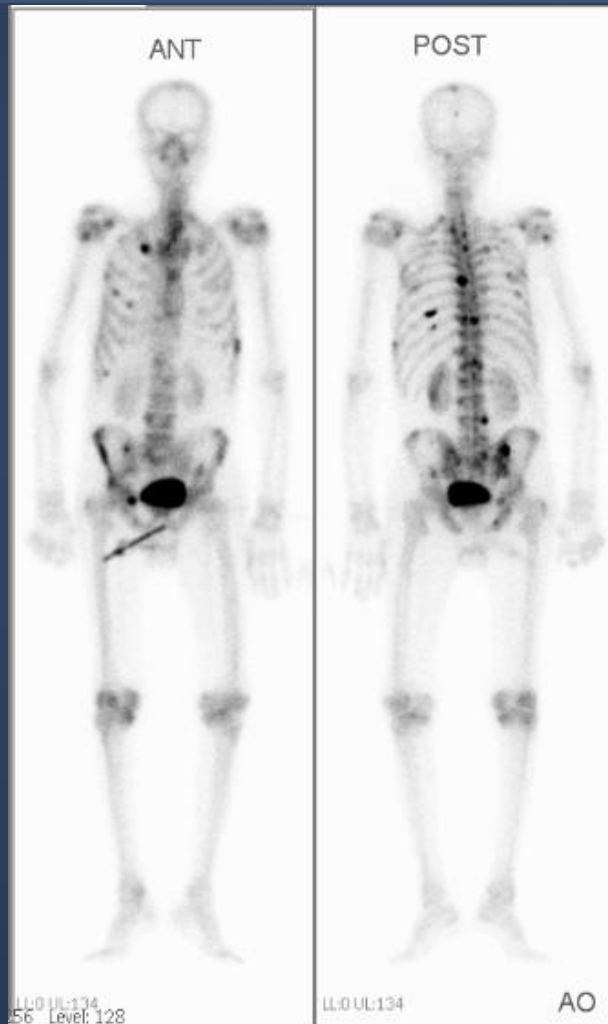


Ca Breast

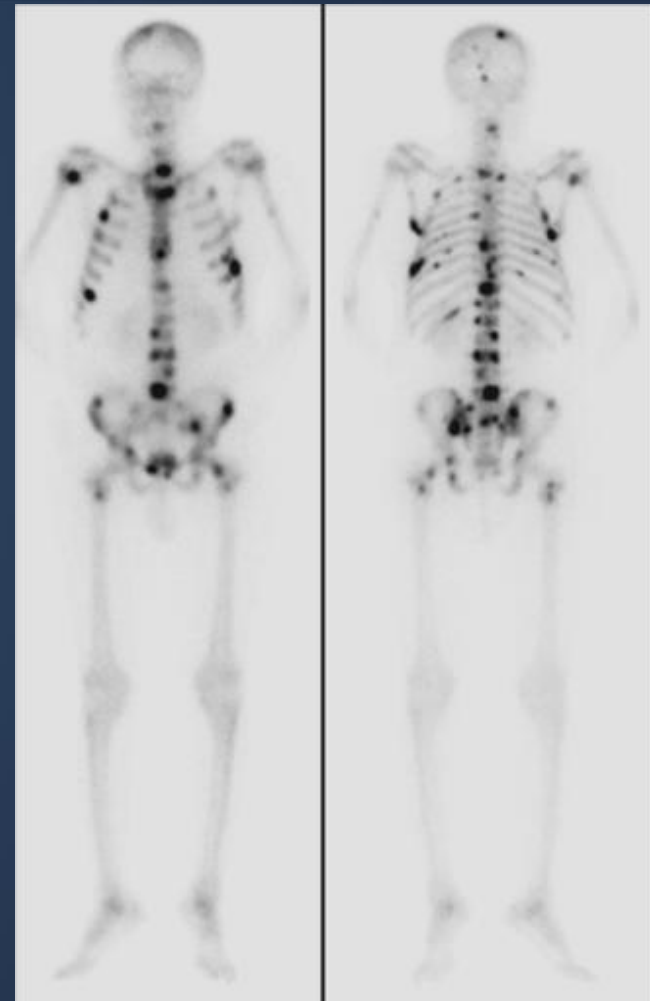


CA Prostate

TUMOR STAGING



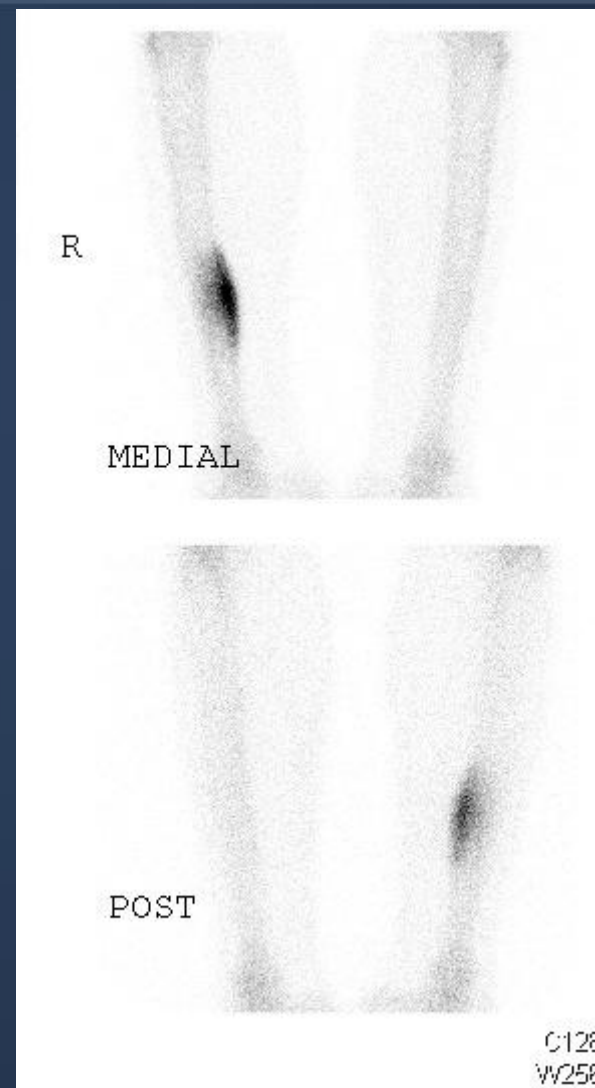
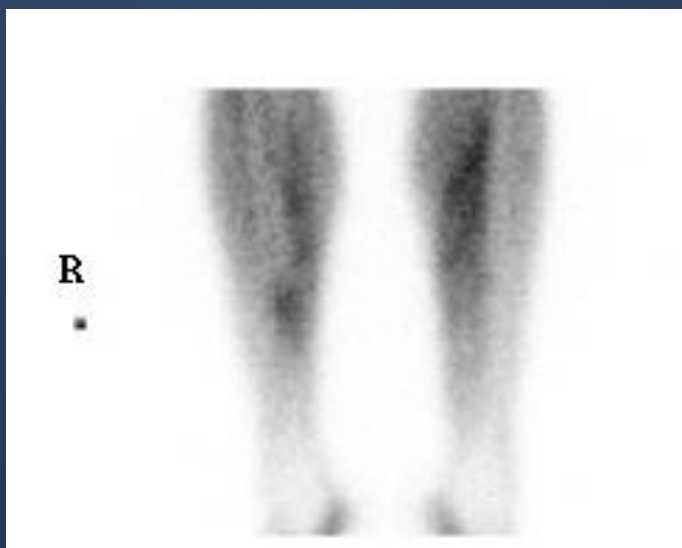
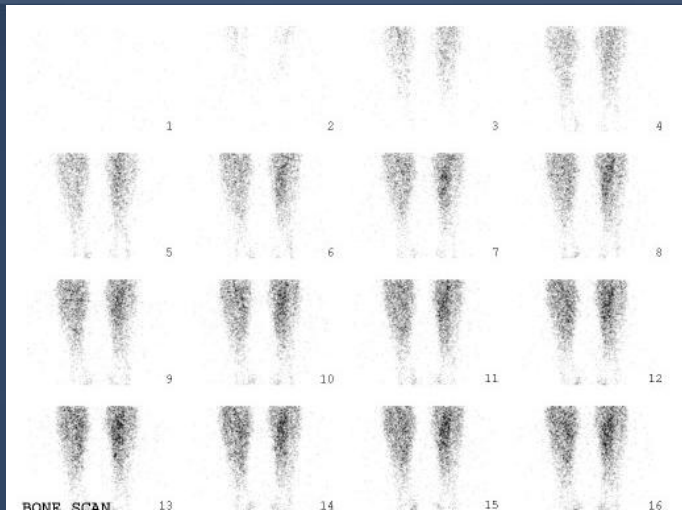
CA LUNG



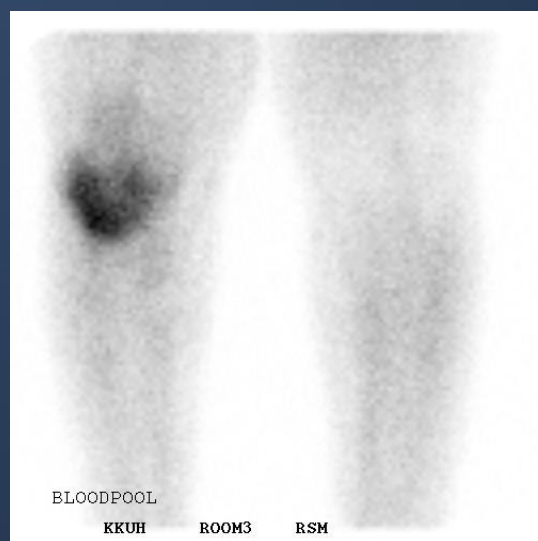
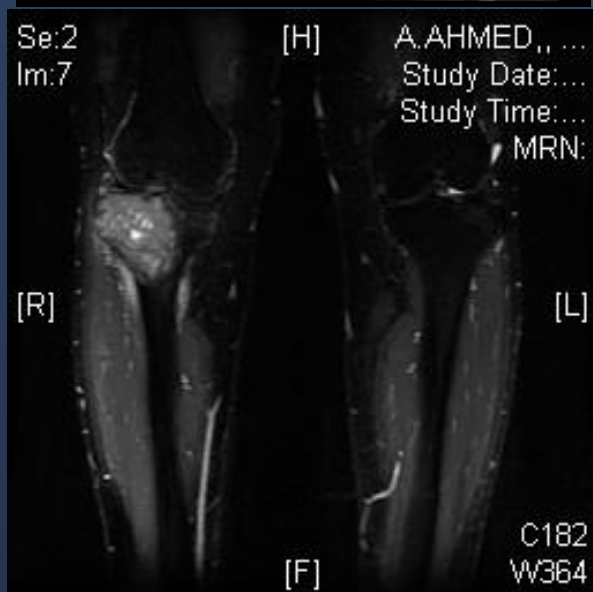
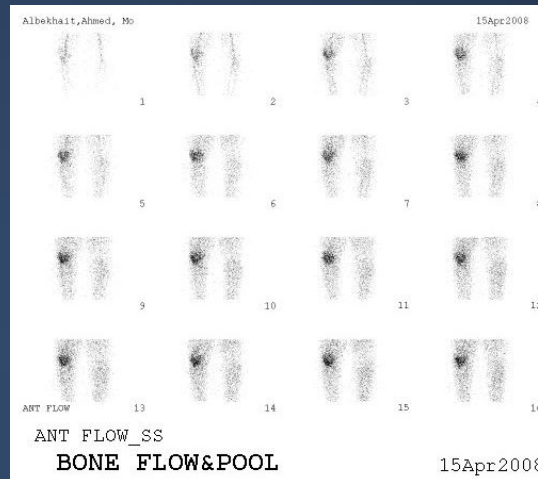
CA STOMACH

Bone Scan In Bone Tumors

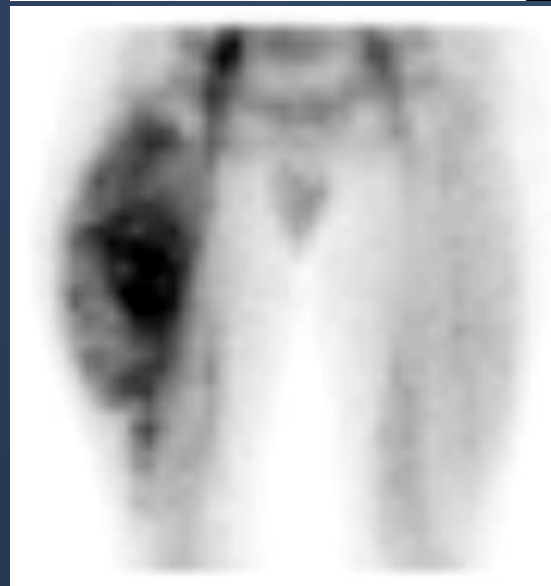
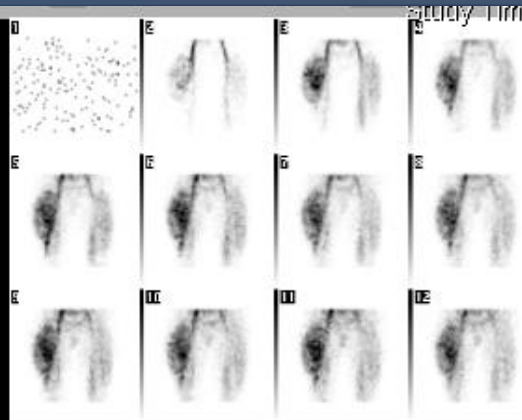
Osteoid Osteoma



Giant Cell Tumor



Soft Tissue Sarcoma



Gallium 67 Citrate (Ga-67)



- Non specific for infection-inflammation and tumors
- Mechanism : Binds to transferrin
- Excretion: Kidneys and large bowel
- Dose :5-10 mCi
- Imaging : 24-72 hours postinjection
- Tumors : Lymphoma, bronchogenic carcinoma , malignant melanoma , hepatoma

Gallium 67 Citrate (Ga-67) In Lymphoma

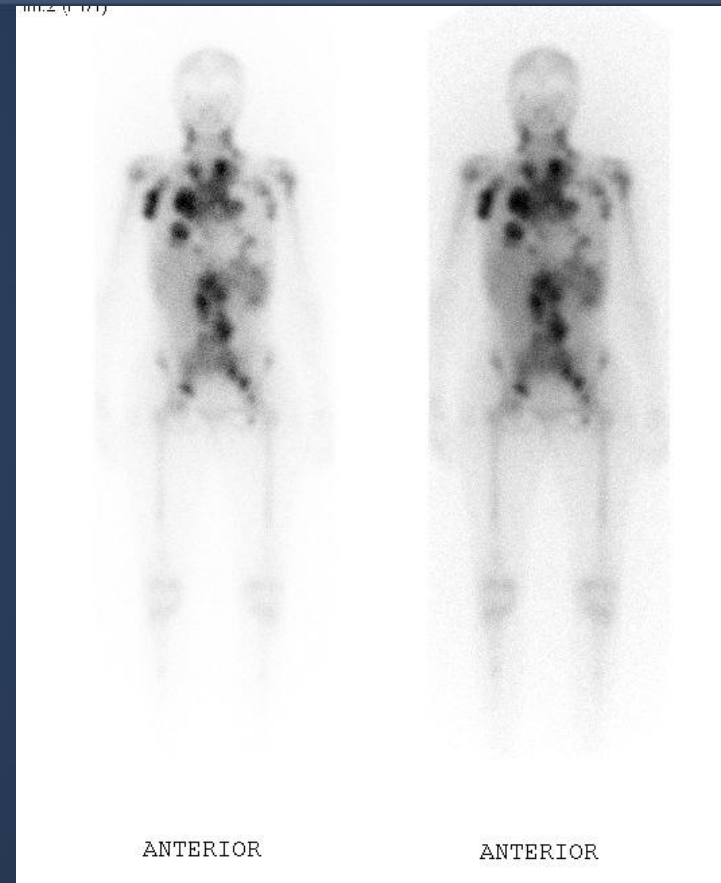


- Staging
- Follow up and monitoring of therapy
- Detection of tumor recurrence
- Differentiate posttherapy changes : tissue necrosis and fibrosis from local recurrence.

Gallium Scan in Lymphomas



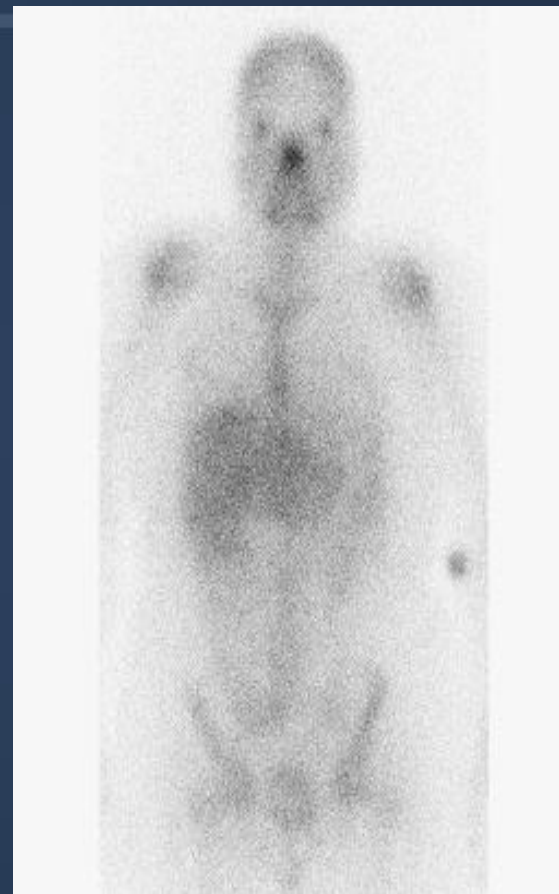
Normal Gallium Scan



Ga-67 Scan is useful in initial evaluation and monitoring response to treatment in HD and NHL.

Ga-67 Scan In Lymphoma

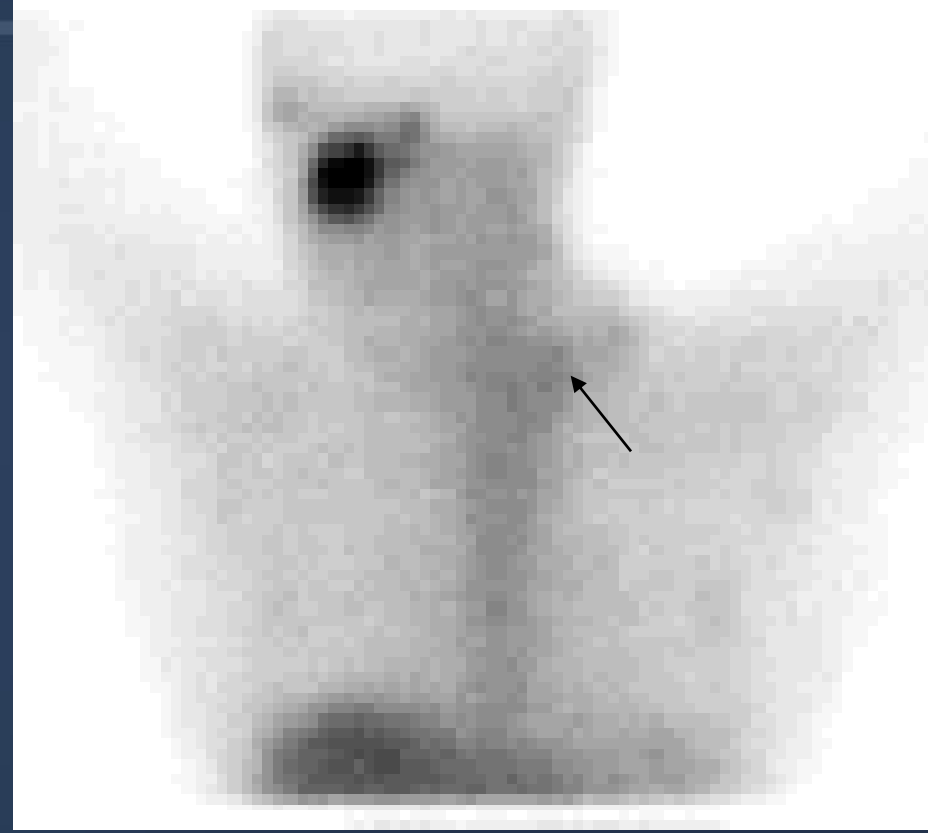
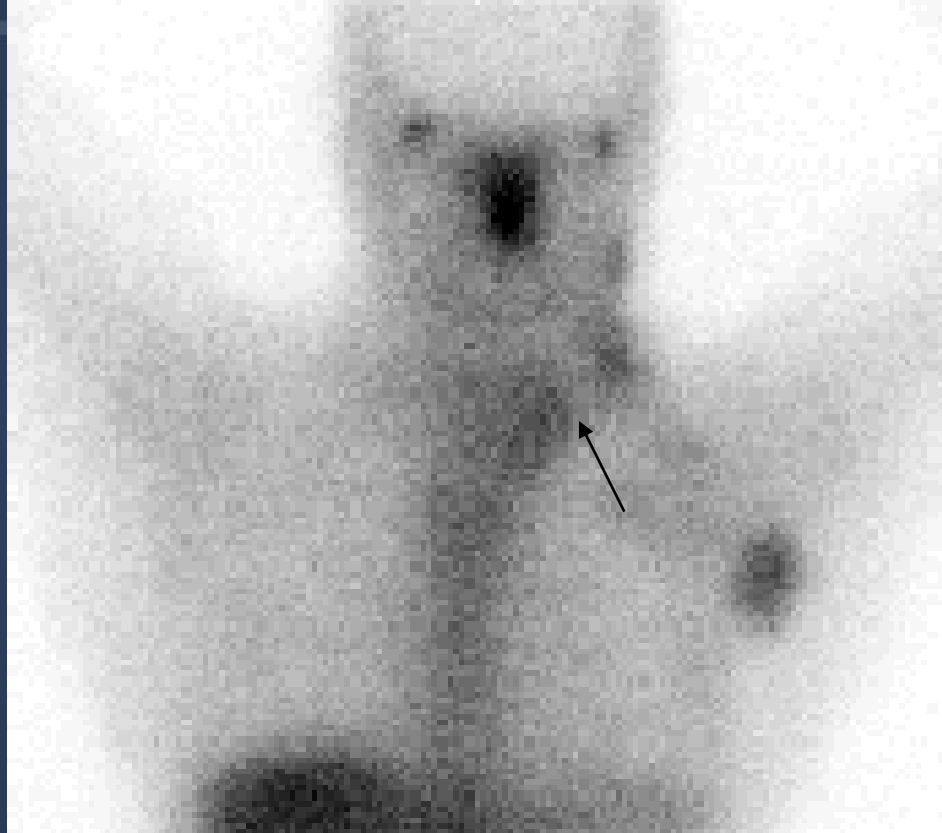
Prediction of response to therapy



Normalization of a positive pre-therapy scan : A negative scan after one cycle or at mid cycle is associated with a high likelihood of complete response .

Ga-67 Scan In Lymphoma

Prediction of outcome



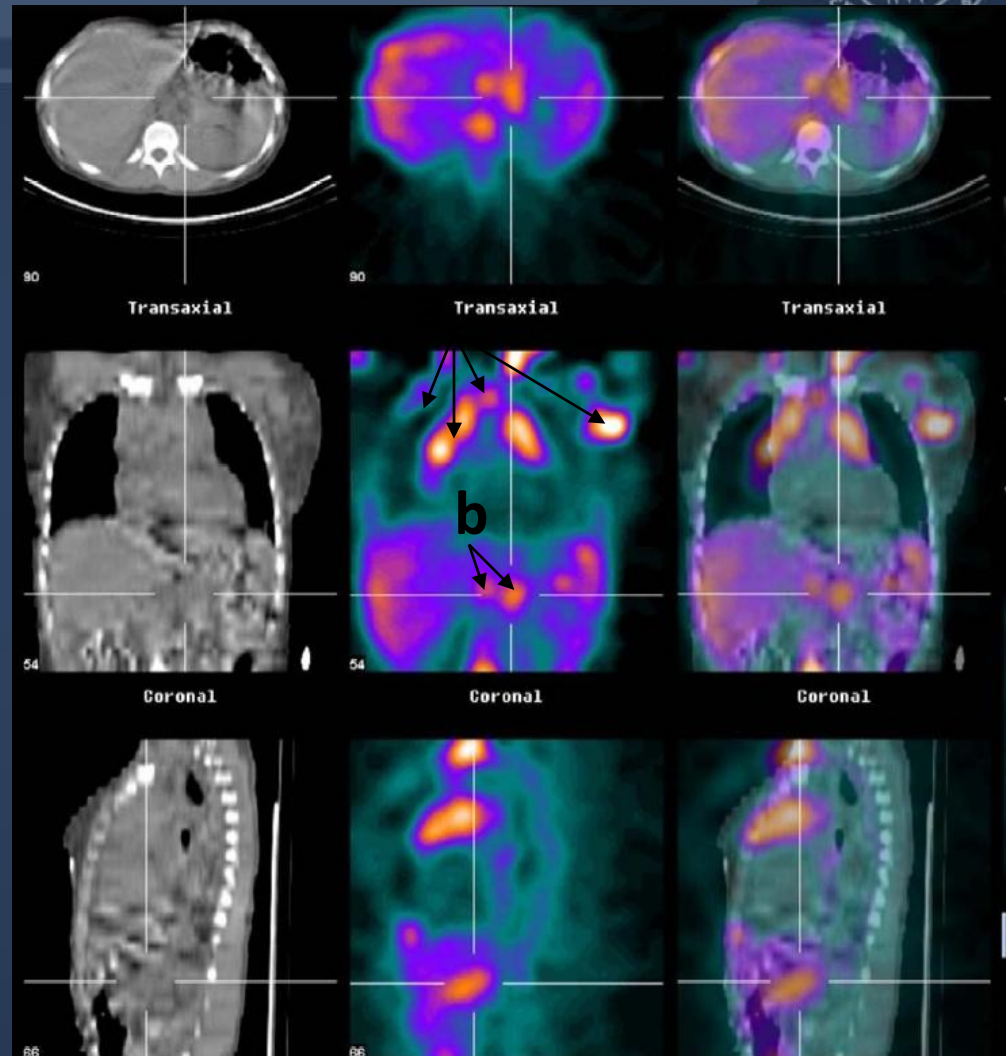
Residual gallium uptake after treatment is a poor prognostic sign, indicates viable tumor and treatment should be modified.

Ga-67 SPECT/CT : Staging HD



Abnormal Ga uptake (a) in supraclavicular, axillary, Paratracheal, parahilar and para-aortic lymph nodes and in the spleen, at lesion sites corresponding to those observed on CT.

The para-aortic lymph node uptake (b) combined with CT findings allowed the diagnosis of subdiaphragmatic disease and excluding bowel activity.



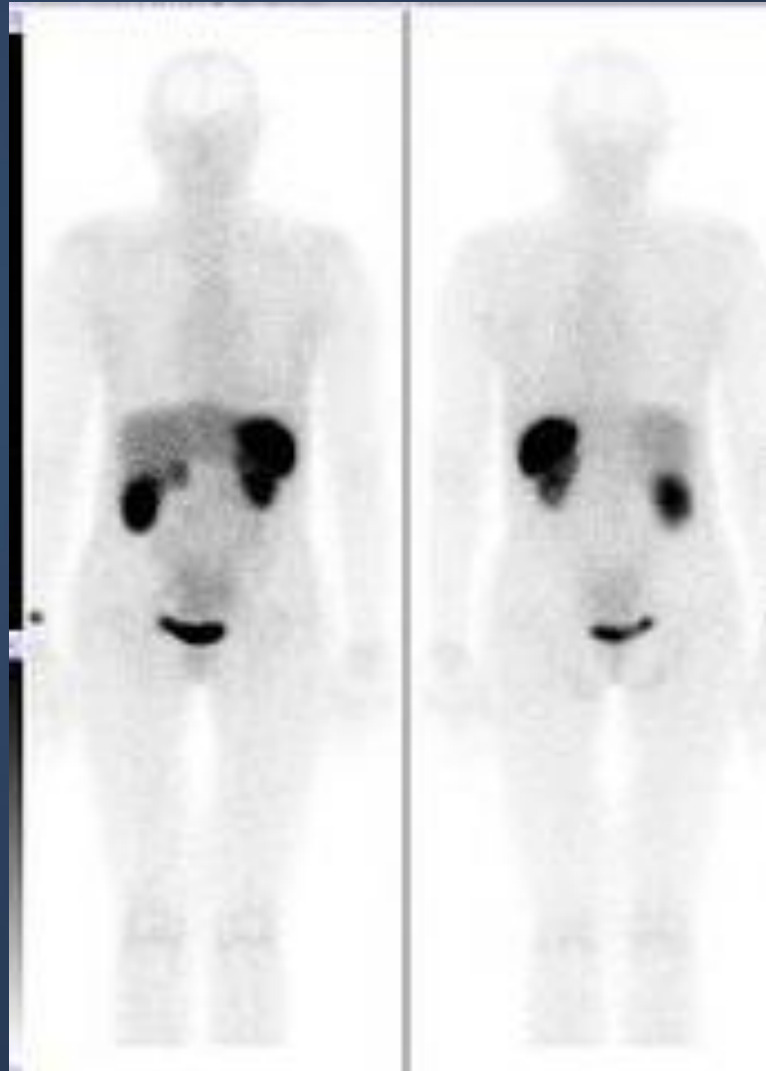
Neuroendocrine Tumors



- In-111 octreoscan.
- I123 MIBG Scan.

Somatostatin Receptor Imaging Indium-111 Octreoscan

NORMAL STUDY



In - 111 octreoscan

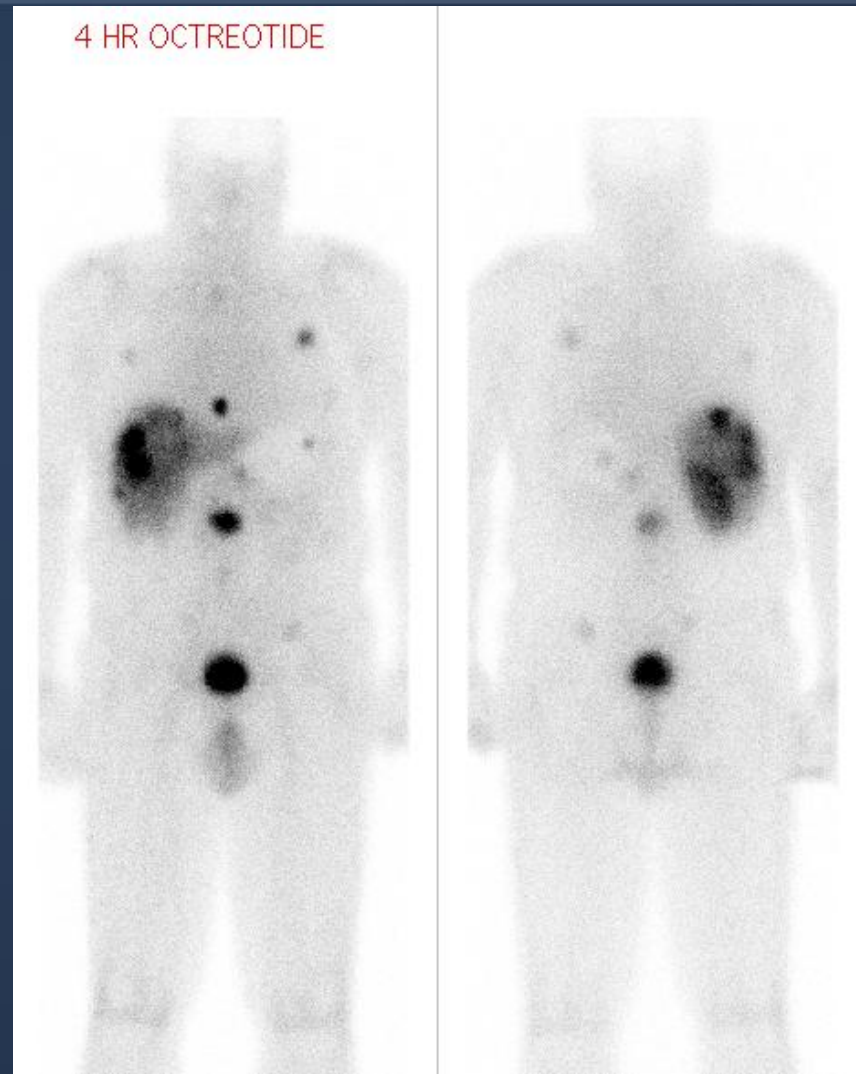
Insulinoma

Clinical History

The patient is a 66-ys male with insulinoma, now being evaluated for evidence of recurrent and/or metastatic disease.

Findings :

Multiple lung, mediastinum , liver and abdominal metastases.



I123 MIBG Scan



- MIBG : **M**eta **I**odo **B**enzyl **G**uanidine
- Is a nor adrenaline analog
- Localizes in adrenergic tissues: catecholamines producing tumors and their metastases.
- Patient preparation: stop drugs interfering with MIBG uptake. Lugols solution to protect thyroid gland

I123 MIBG Scan

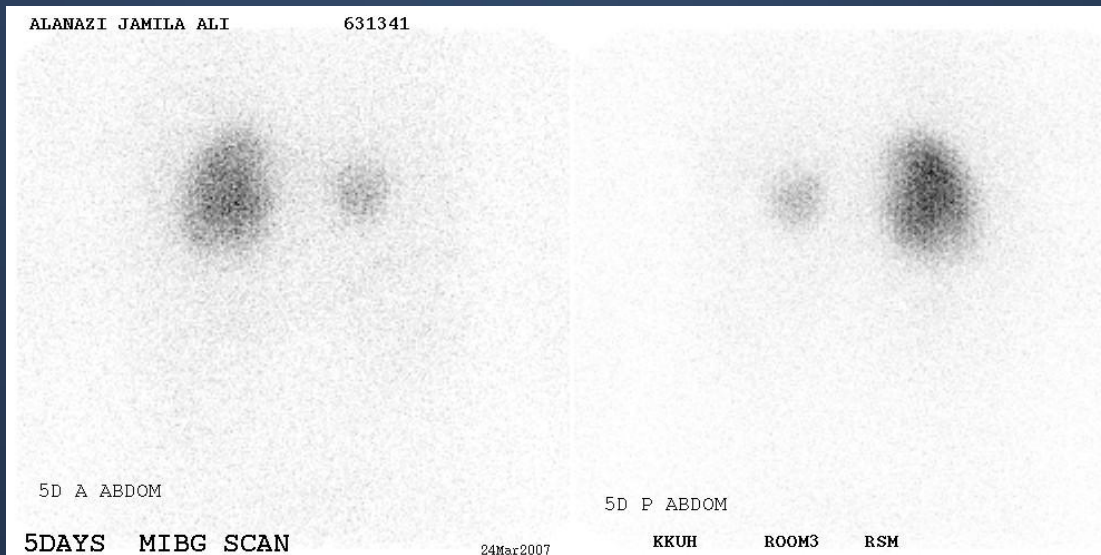
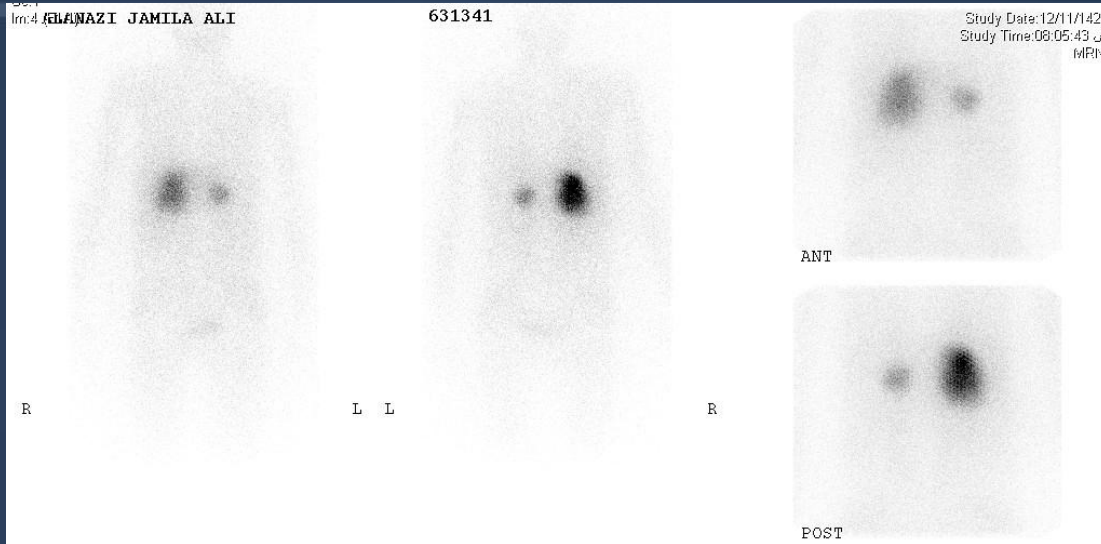
Indications



- Pheochromocytoma
- Paraganglioma
- Insulinoma
- Neuroblastoma
- Medullary thyroid carcinoma
- Carcinoid tumors

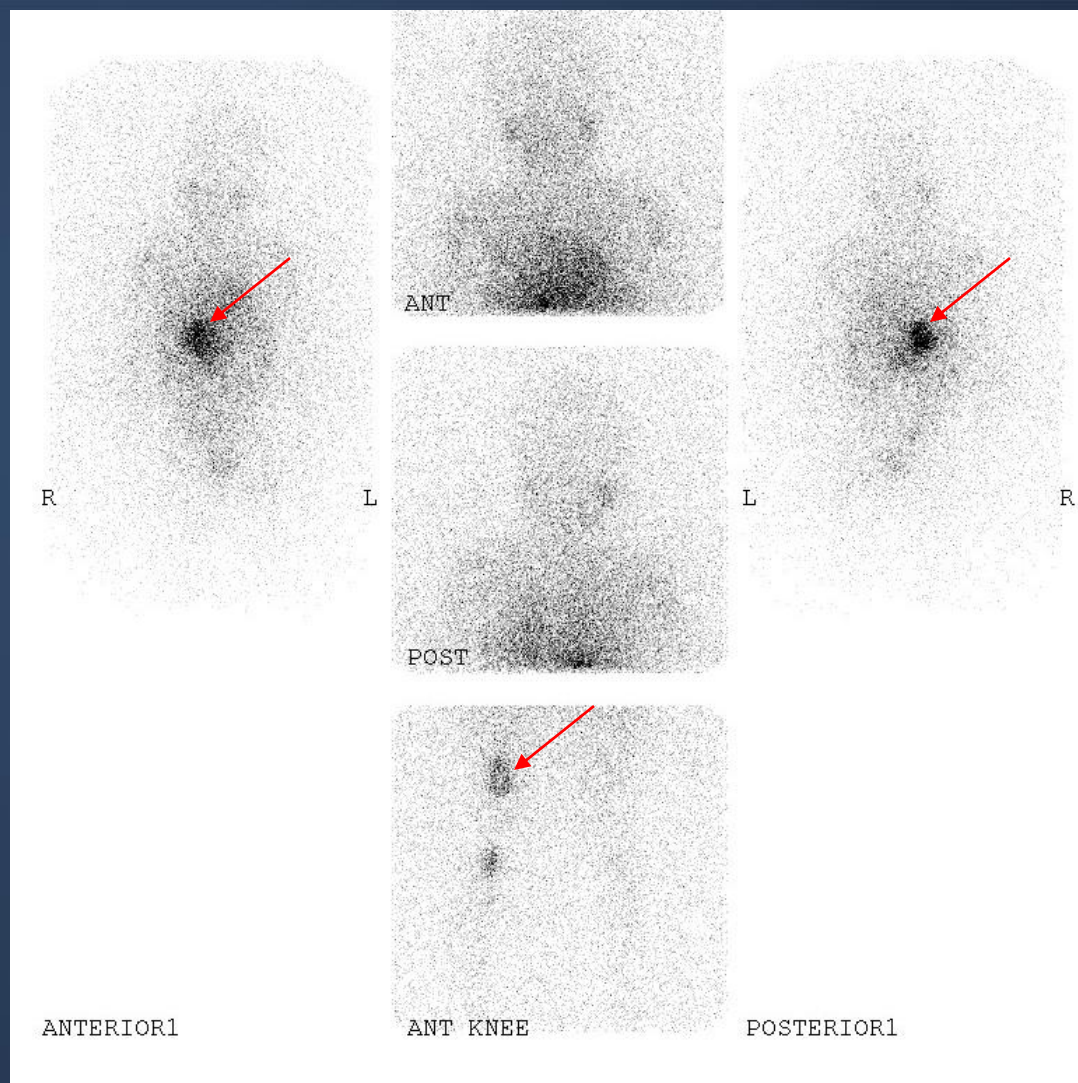
MIBG In Pheochromocytoma

Bilateral Disease



I131 MIBG Total body scan

1ry neuroblastoma /bone mets



THYROID METASTASES STUDY

(I-123 or I-131 as Sodium Iodide)



Indications

- Detection and localization of persistent or recurrent local or distant functioning thyroid cancer

Patient Preparation

- **Stimulation of potentially functioning thyroid tissue:**

A. Inject recombinant human thyrotropin on 2 consecutive days and administer the iodine on the third day .

B. Withdraw thyroid replacement hormones :

1. Thyroxine (T-4) for at least 4 weeks.
2. Triiodothyronine (T-3) for at least 10 days.

- **The patient must not have had i.v iodinated contrast material** (IVP, CT with contrast, myelogram, angiogram) for at least 3 weeks .

- The patient should be NPO for at least 4 hours prior to radiopharmaceutical administration and for at least 1 hour afterwards .

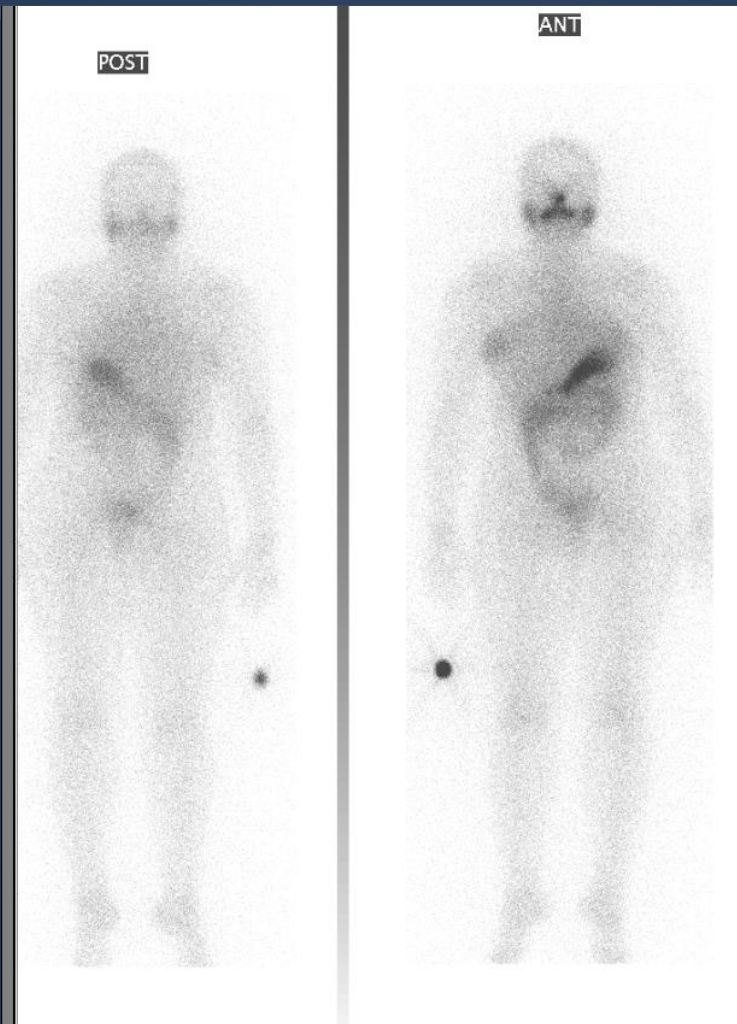
Tracer , Dose, & Technique of Administration

- Radiopharmaceutical: Oral administration
 - a. I-123 as sodium iodide : 2 mCi
 - b. I-131 as sodium iodide : 2-10 mCi

Imaging using Gamma camera : Whole body scan

Thyroid Cancer

I-123 WB Scan



Negative I-123 WB Scan



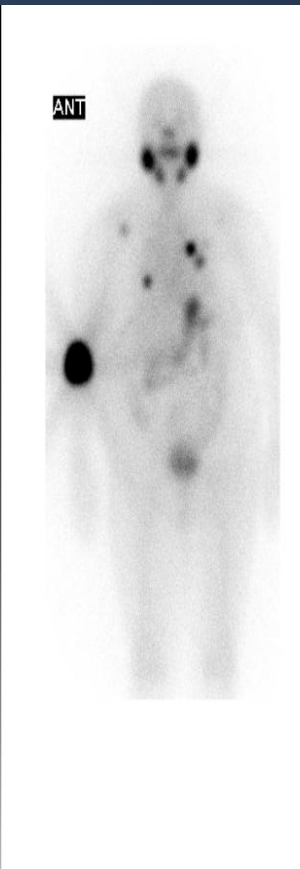
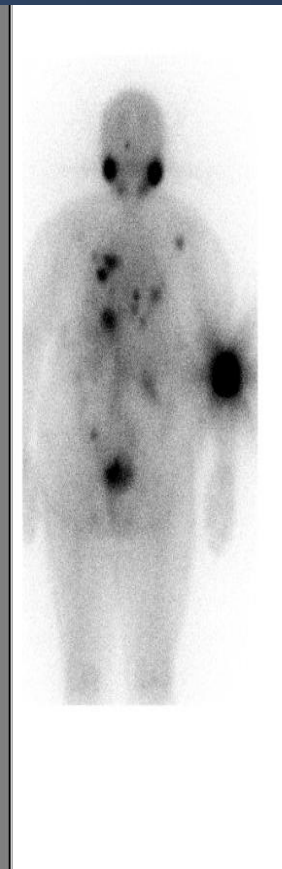
I-123 WB Scan : Post operative Thyroid remnants

THYROID METASTASES STUDY

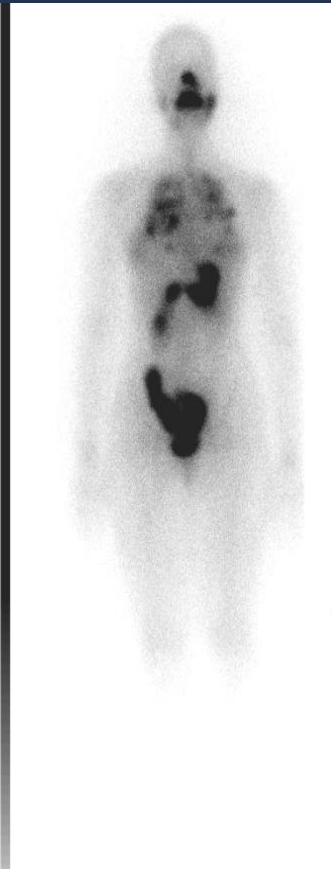
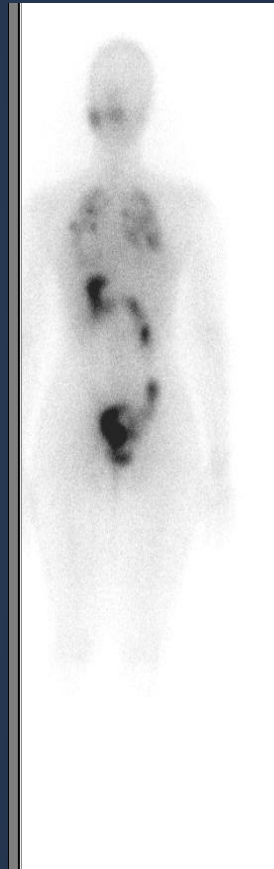
(I-123 or I-131 as Sodium Iodide)



Local Recurrence



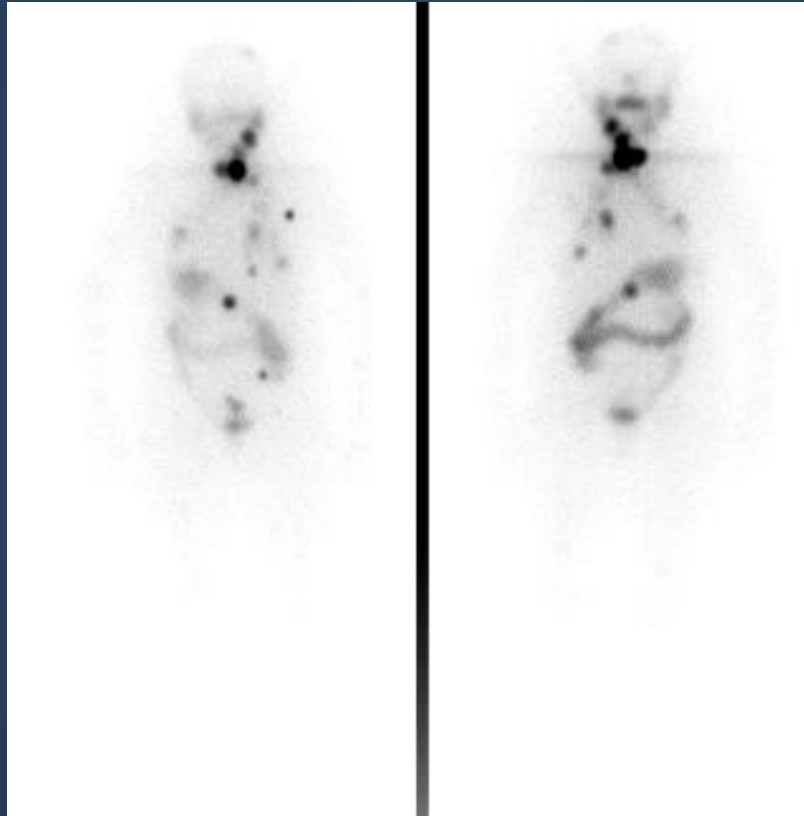
Bone Metastases



Lung Metastases

Thyroid Cancer

I-131 Pre & Post therapy



Dec04



March06

Onco PET (PET and PET CT)



What is PET - CT

- PET : Positron Emission Tomography.
- CT : Computerized Tomography.
- PET-CT is the fusion of functional and anatomic information acquired almost simultaneously from which we are able to visualize form and function.

PET : How it is performed...?



Positron emitters (e.g. F18) labelled with biologically active natural compounds such as oxygen, carbon or glucose given intravenously and reacting in the body identically to their non-radioactive counterparts.

Positrons are emitted from F18 and react with tissue electrons.....Annihilation occurs...

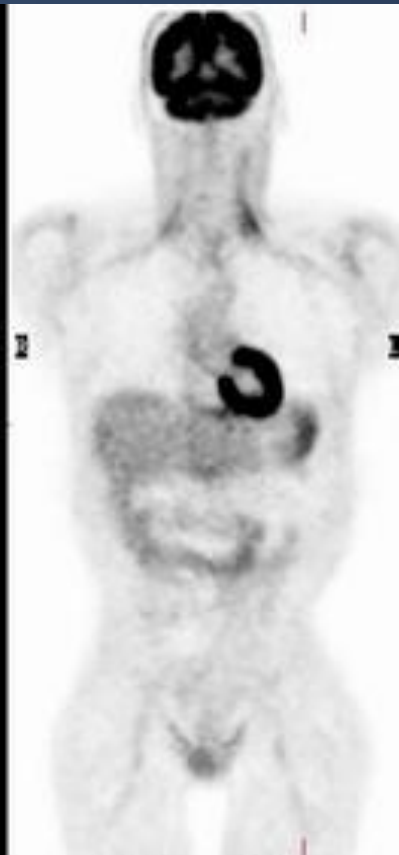
Two photons 511 kev each in opposite direction are emitted and detected by PET SCANNER giving an image of the normal and abnormal distribution of tracer in the body.

PET CT

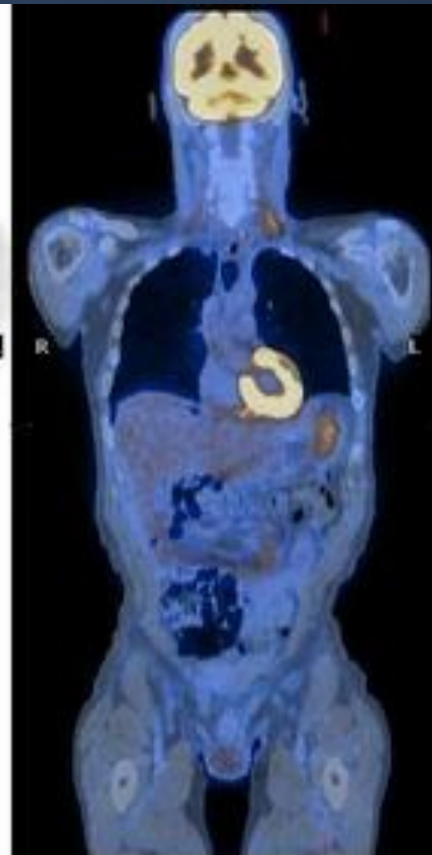
PET CT = PET + CT = Function + Form



**CT Transmission
Scan**



**Attenuation
Corrected
PET Emission Scan**



**PET-CT
Fusion Scan**



**Non-Attenuation
Corrected (NAC)
Emission Scan**

Positron Emitting Isotopes



Cyclotron produced isotopes:

Isotope

T/2

Oxygen-15

2 min

Nitrogen-13

10 min

Carbon-11

20 min

Fluorine-18

110 min

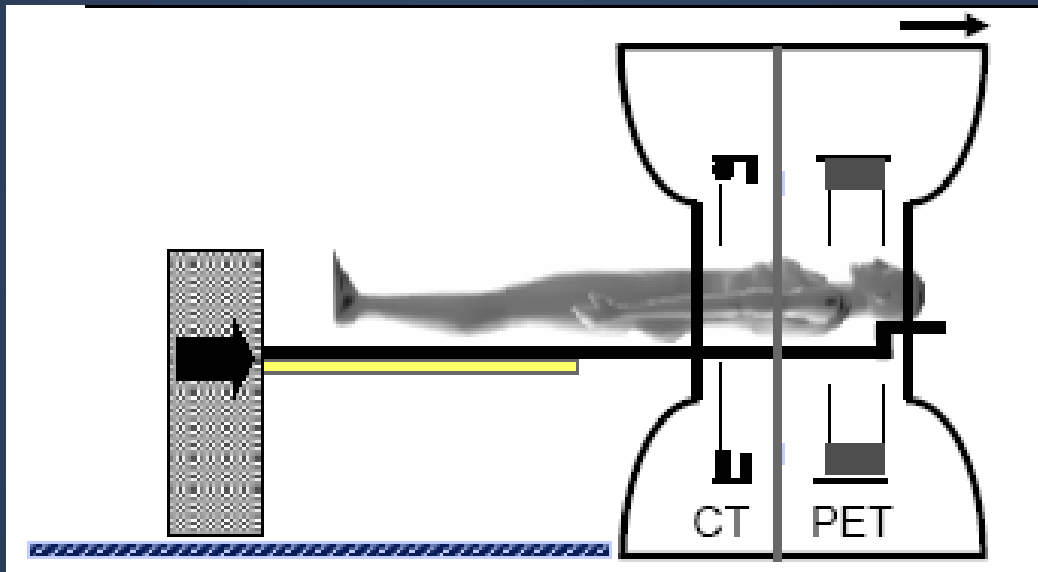
FDG PET CT : Procedure



- Fasting : 4 – 6 hours
- Inject 10 mCi F18 FDG
- Wait (uptake phase): 45 -60 min then scan
- Scanning time : 30 min to complete PET CT study
- SUV : Standard uptake value (N:0.5-2.5 and Tumors > 3.0)

PET CT

IMAGING PROTOCOL



FDG in Oncology



- Tumors do not have a blood tumor barrier
- FDG transport into tumors occurs at a *higher* rate than in the surrounding normal tissues.
- FDG is de-phosphorylated and can then leave the cell.
- The de-phosphorylation occurs at a *slower* rate in tumors.
- **Applications of FDG**
 - Locating unknown primaries
 - Differentiation of tumor from normal tissue
 - Pre-operative staging of disease (lung, breast, colorectal, melanoma, H&N, pancreas)
 - Recurrence vs necrosis
 - Recurrence vs post-operative changes (limitations with FDG)
 - Monitoring response to therapy

FDG PET

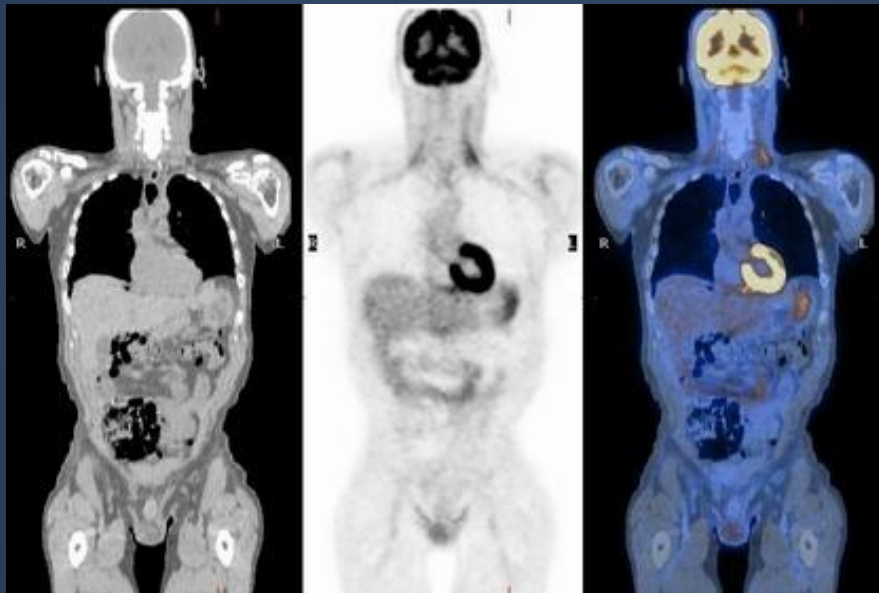


FDG PET : Normal



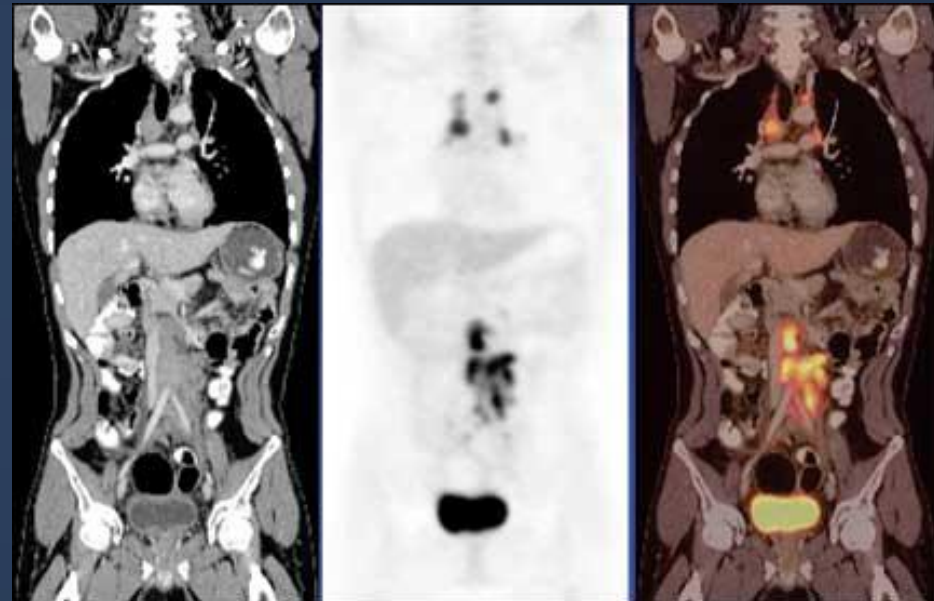
FDG PET : Staging of NHL

FDG PET-CT



FDG PET-CT

Normal

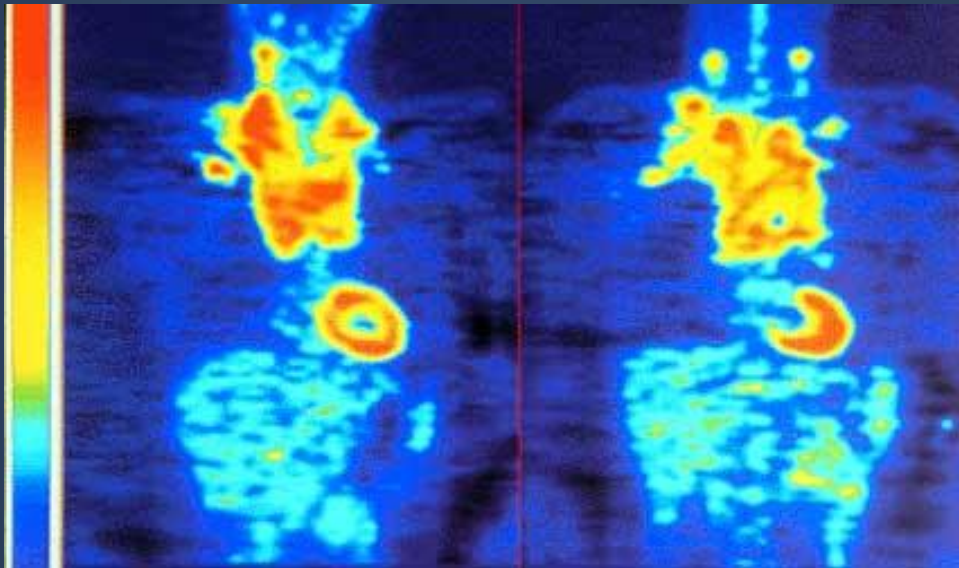


FDG PET-CT

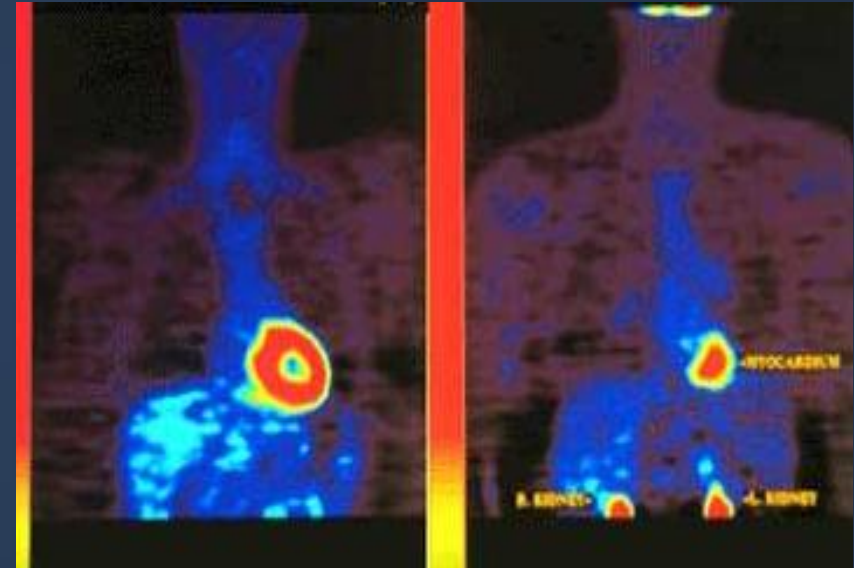
Staging Of Lymphoma

Assessment of therapy response

FDG PET in HD



Baseline

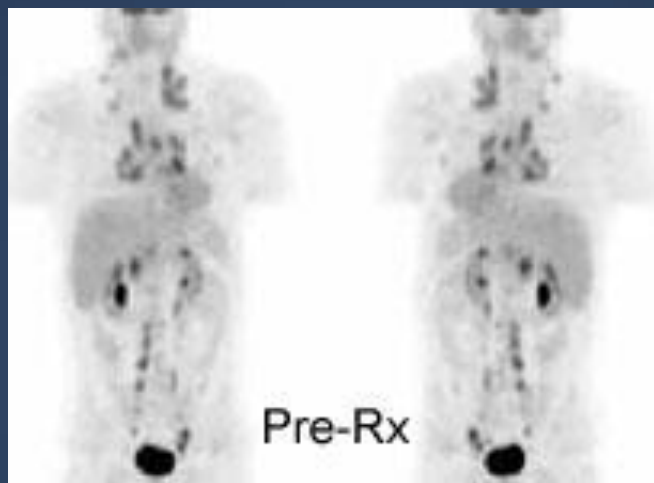


Post therapy

A 22 years old male patient with Hodgkin's lymphoma. Six months after chemotherapy, CT scan showed bilateral hilar abnormalities. FDG-PET scan did not show any activity in described CT changes.

FDG in Non-Hodgkin's lymphoma

Response to therapy

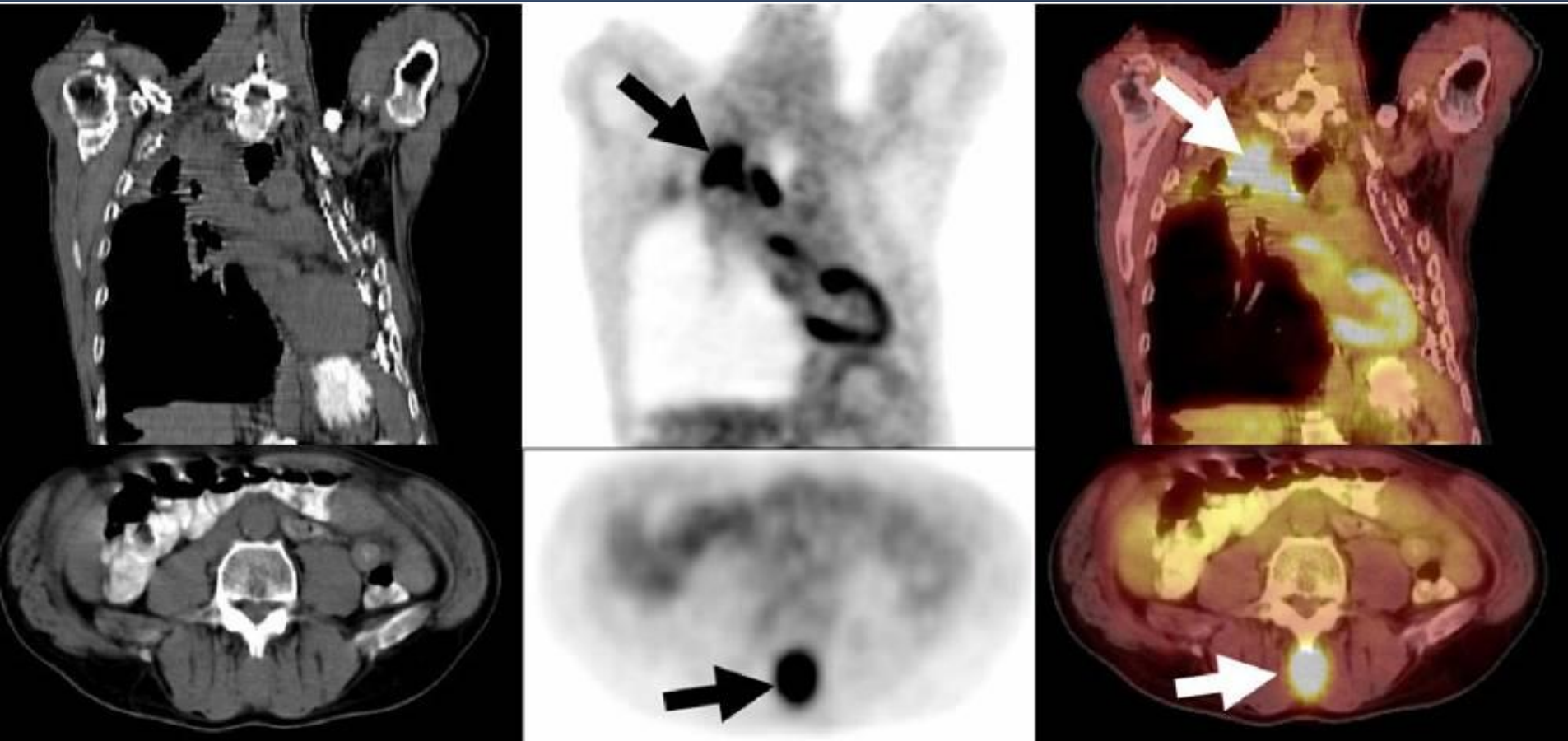


PET CT In Lymphoma



	Sensitivity (%)	Specificity (%)
CT	61	89
FDG-PET	78	98
FDG-PET and CT	91	99
FDG-PET/CT	96	99

PET CT Lung Cancer



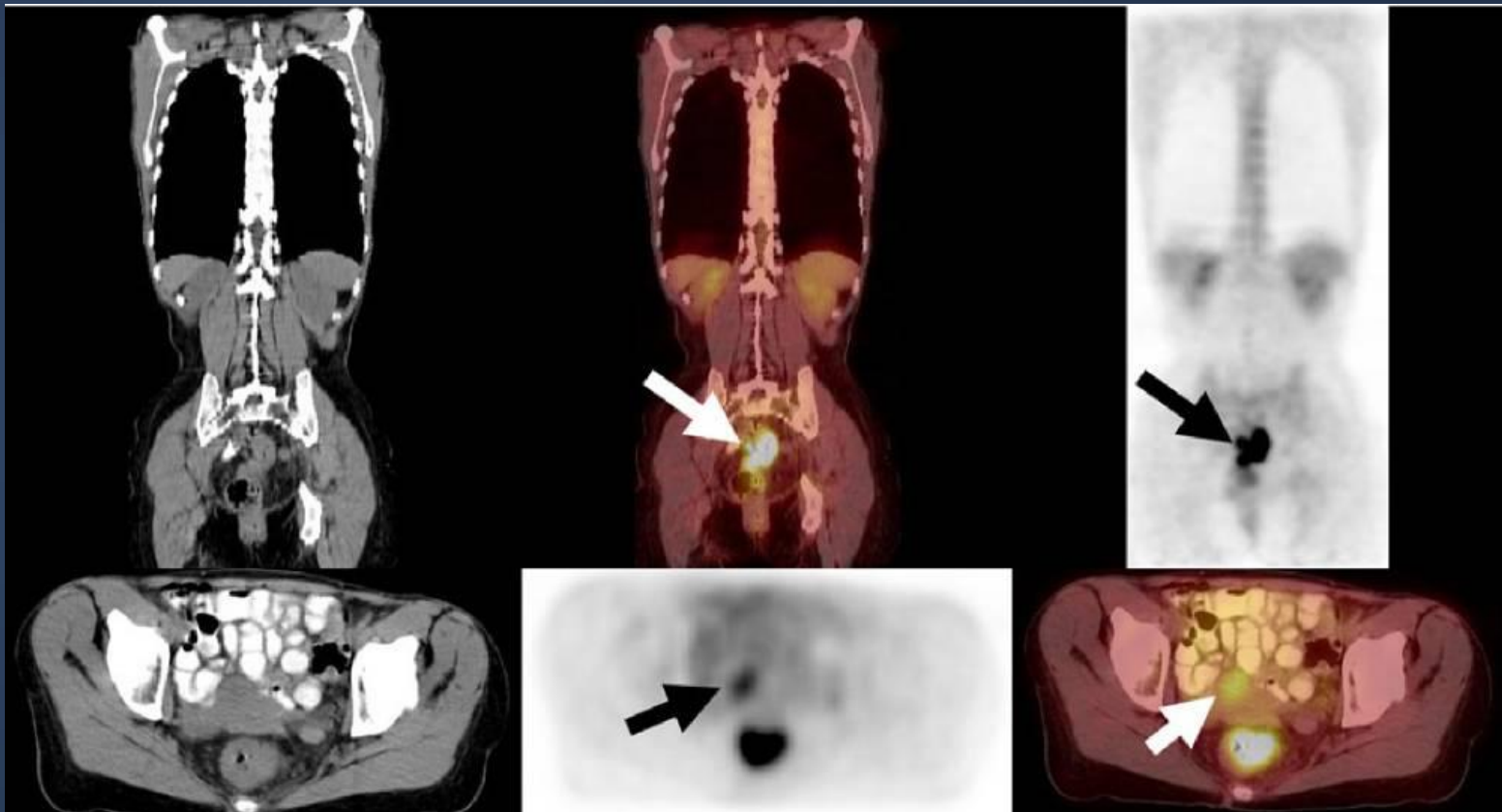
FDG avid soft tissue mass associated with a destructive L5 spinous process consistent with metastatic deposit (arrow).

FDG PET CT IN Solitary Pulmonary Nodule (SPN)



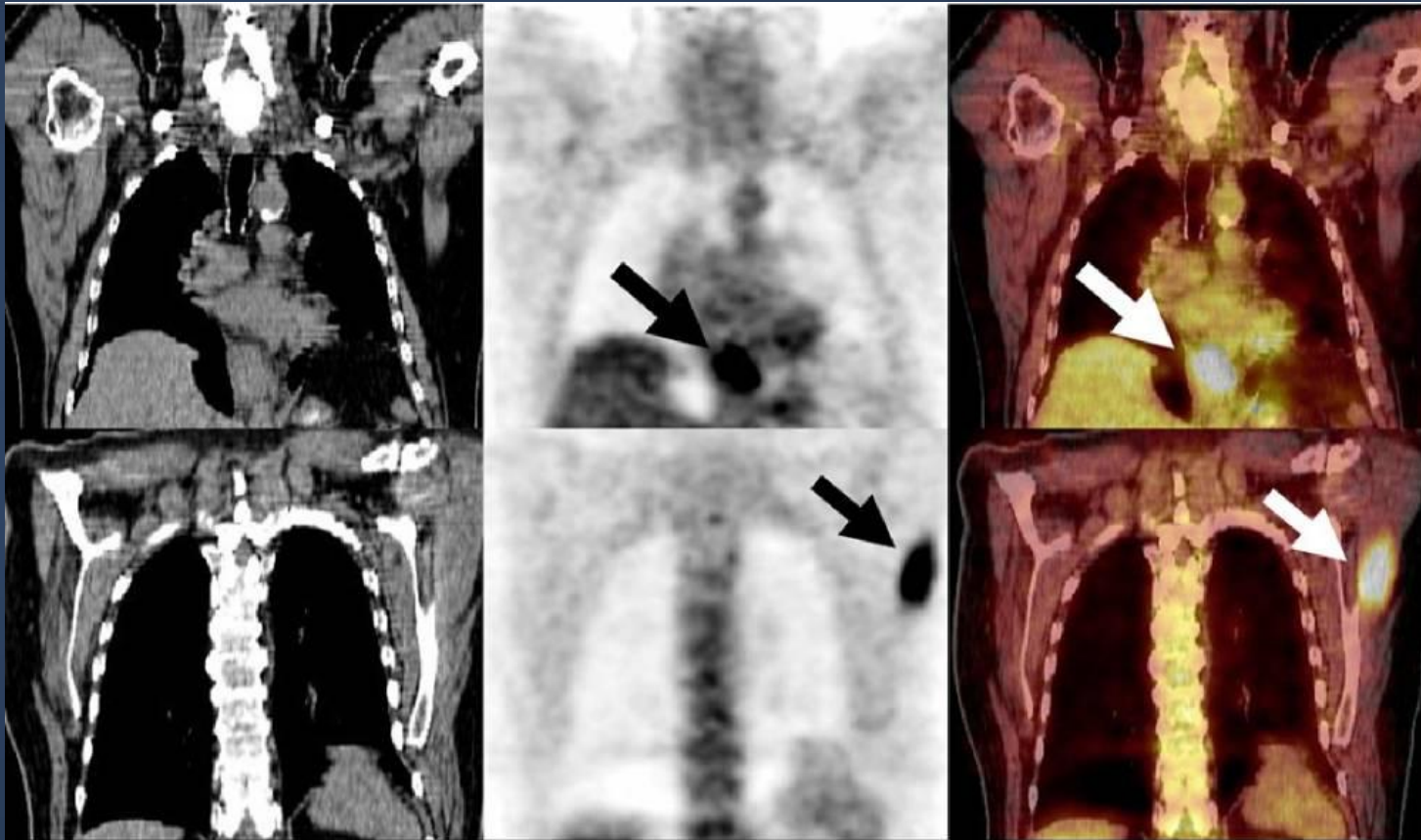
- Sensitivity : 82 – 100 %
- Specificity : 67 – 100 %

CA Rectum



A 57-year-old woman presented with pain and constipation and colonoscopy revealed an obstructing rectal mass. A staging FDG-PET/CT demonstrated intense FDG avidity in a circumscribed mass-like thickening of the proximal rectum (arrows in top row images) and a focus of mild metabolic activity anterior to the rectum (bottom row arrow) which was not avid as the rectal malignancy. This was located within the uterus as seen on CT images (bottom row), and was subsequently shown to be a uterine fibroid on other imaging studies.

CA Esophagus



Based on FDG-PET/CT results the clinical management of this patient was changed from surgical resection of the primary tumor to combined chemo-radiation therapy.

Indications of PET CT



Breast Cancer*	Staging*, restaging*, and monitoring response to therapy*
Colorectal Cancer	Diagnosis*, staging* and restaging*
Esophageal Cancer	Diagnosis*, staging* and restaging*
Head & Neck Cancers (excluding CNS and thyroid)	Diagnosis*, staging* and restaging*
Lung Cancer (Non-Small Cell)	Diagnosis*, staging* and restaging*
Lymphoma	Diagnosis*, staging* and restaging*
Melanoma (Excludes evaluation of regional nodes)	Diagnosis*, staging* and restaging*
Solitary Pulmonary Nodule	Characterization of indeterminate single pulmonary nodule
Thyroid Cancer*	Restaging
Cervical Cancer*	Staging as an adjunct to conventional imaging

Radionuclide Therapy

Properties of the Ideal Therapeutic Radiopharmaceutical



1. Pure **beta minus emitter**
2. Medium/high **energy** (>1 meV).
3. **Effective half-life** = moderately long, e.g., days.
4. High **target:nontarget ratio**
5. Minimal **radiation dose** to patient and Nuclear Medicine personnel
6. Patient Safety
7. **Inexpensive, readily available** radiopharmaceutical.
8. Simple **preparation and quality control** if manufactured in house.

Radionuclide Therapy



Agent

Indication

Dose

• I131	• Thyroid cancer	100-200 mCi
• 131 MIBG	• Neuroblastoma	100-300 mCi
• Strontium-89	• Bone metastasis	40-60uCi/kg 1.0 mCi per kg
• Sm-153-EDTMP		
• Phosphorus- 32	• Polycythaemia	2.3mCi/m2
• Y-90-Ibritumomab Tiuxetan [Zevalin®]	• B-Cell NHL	Y-90-ibritumomab tiuxetan. > Platelet count > 150,000 cells/mL: 0.4 mCi/kg > Platelet count 100,000-150,000 cells/mL: 0.3 mCi/kg The dose should never exceed 32 mCi (1,184 MBq).

Teaching Points

Objectives of NM tumor imaging



- Diagnosis
- Staging
- Guiding biopsy
- Follow up and therapy monitoring
- Detection of recurrence.

Teaching Points

NM tumor imaging



- Functional
- Sensitive
- Whole body evaluation
- Specific : Some tumors
- Targeted therapy

Reference book and the relevant page numbers..

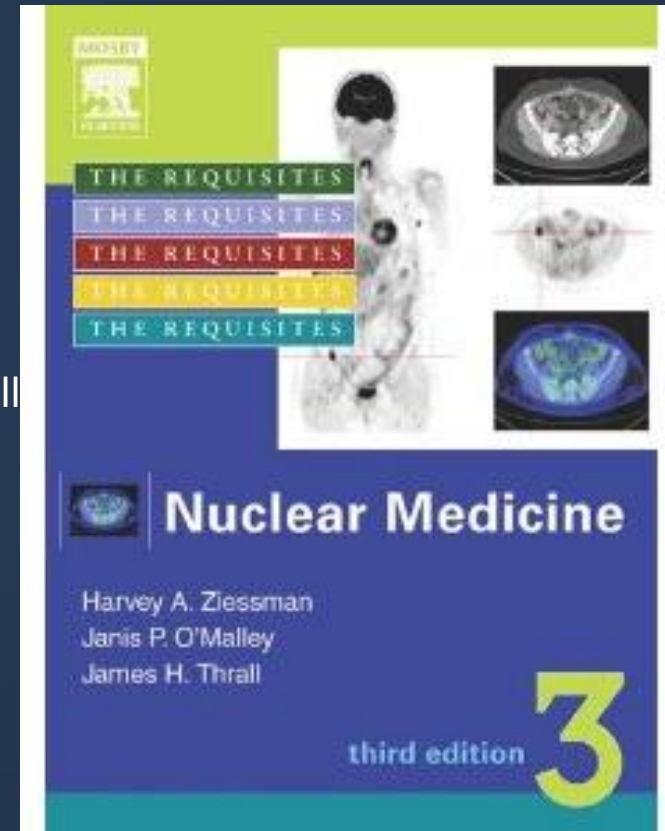


- **Aunt Minnie.com**
- **Nuclear Medicine: The Requisites, Third Edition (Requisites in Radiology) [Hardcover]**

Harvey A. Ziessman MD, Janis P. O'Malley MD, James H. Thrall MD

Relevant Pages :

**Oncology : 264-274 , 279 -283 ,302 -345 ,
119-133 , 109 -112 ,296 -299**



Thank You ☺



Radiology (Nuclear Medicine)

Dr. Saleh Othman

11-13 February 2012