Nuclear medicine in oncology

Lecture 27

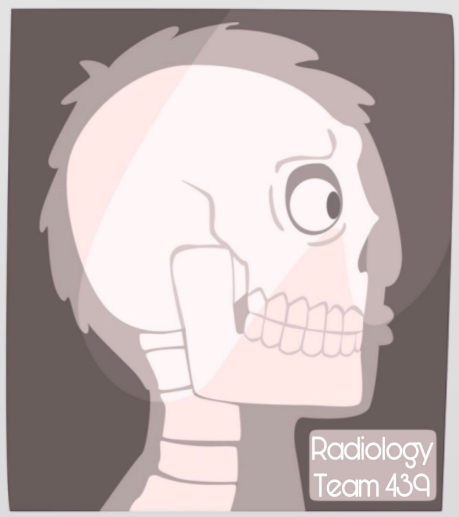
Objectives

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

- What are the tumor imaging and therapeutic radiopharmaceuticals?
- 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?

Color index:

Black: Main text
Red: Important
Yellow: Golden notes
Green: Drs notes 439
Dark green: Drs notes 438
Gray: Extra



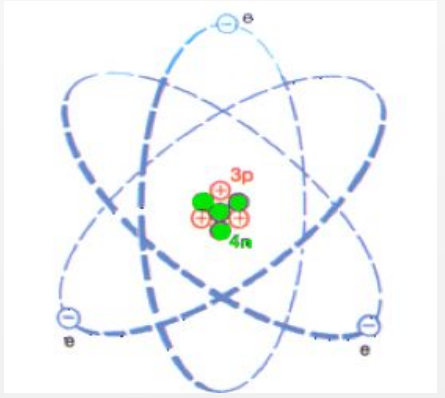
Tumor Imaging

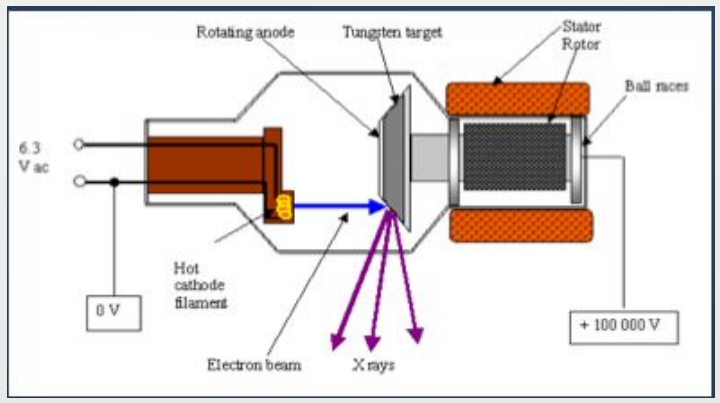
Isotopes show function not structure

Tumor metabolic properties (changes in function)

To access how active is the tumor

- Increased **vascularization**
- Increased capillary **permeability** allow tracer perforation to tumor
- Newly **proliferated** capillaries
- Increased **blood flow**
- Metabolically **active** cells; Consumes more protein and glucose for its growth which is the cause of weight loss so if we labeled glucose with a nuclear material their will be more concentration inside the tumor cells
- Increased energy demand





Tumor Specific useful properties

- High density of some **common receptors .**e.g : somatostatin tumors
- Expression of several **specific receptors**
- Expression of **some specific tumor antigens** Access antigen×antibody reaction

All these properties could be used for **imaging** and **therapy**

Tumor Imaging

IMP SLIDE FOR EXAM

Tumor Non-specific Diagnostic radiopharmaceuticals

PET or PET-CT:

- **F-18 FDG** (Fluorodeoxyglucose) – anaerobic metabolism

When there is a tumor with increased glucose consumption, there will be increased F-18 FDG concentration

Planar, SPECT or SPECT-CT:

- **Diphosphonates** – bone scan
- **Ga-67 citrate** – similar to FDG – localising agent
- **Tc99m Nanocolloid** – bone marrow scan
- **Tc99m MIBI / Thallium 201** – several tumors

Demonstrate tumor sites but are not specific for malignancy;Tells us there is a tumor but not what is it exactly

Tumor Specific Diagnostic radiopharmaceuticals

PET or PET/CT:

★ **Gallium -68 – Octreotide analogues (Ga-68 DOTA) = somatostatin agent:**
  - For **neuroendocrine tumors**
- **Fluorine -18-fluorodeoxythymidine(F-18-FLT):** For tumor proliferation
- **Fluorine -18-fluoromisonidazole(F-18-FMISO):** For tumor hypoxia

Planar, SPECT or SPECT-CT:

- **I-123/131 MIBG** for neuroendocrine tumours
- **I-131** for differentiated thyroid carcinomas
- **In-111 or Tc99m octreotide** for tumours expressing somatostatin receptors.
- **Monoclonal antibodies labelled with In-111, I-123/131 or Tc-99m**

Binds directly to special tumor **antigens or receptors** or are accumulated by **special metabolic pathway**

Therapeutic radiopharmaceutical

Non-specific

- **Sr-89, Sm-153, Re-189**
- **Bone pain palliation** (any metastatic pain is relieved)

Specific

- **I-131 : Thyroid cancer**, as specific diagnostic if tumor significantly accumulates
- **Y-90:** Zevalin monoclonal antibody for **B-cell lymphomas**

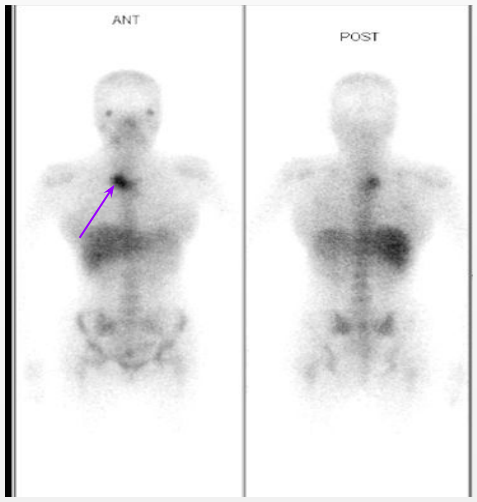
Tumor Imaging

NM Imaging modalities

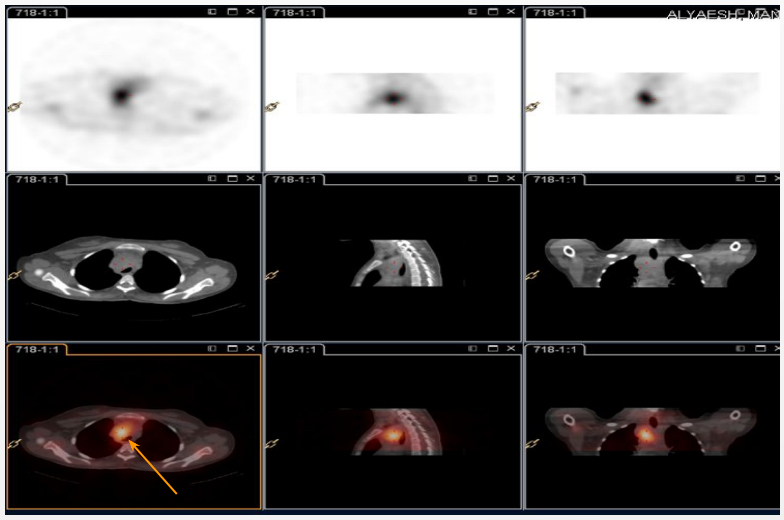
SPECT: **S**ingle **P**hoton **E**mission **C**omputed **T**omography **and SPECT CT**

(there is Abnormal uptake as seen in the arrow, but exact location unknown we use SPECT-CT)

Planar imaging
(Two dimensions)



Whole body Gallium scan:planar image of a patient with lymphoma

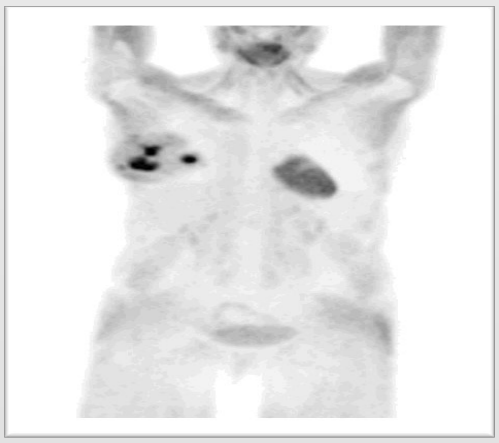


SPECT/CT Shows precise location which is ,in this case, deep in the mediastinum(arrow)

SPECT

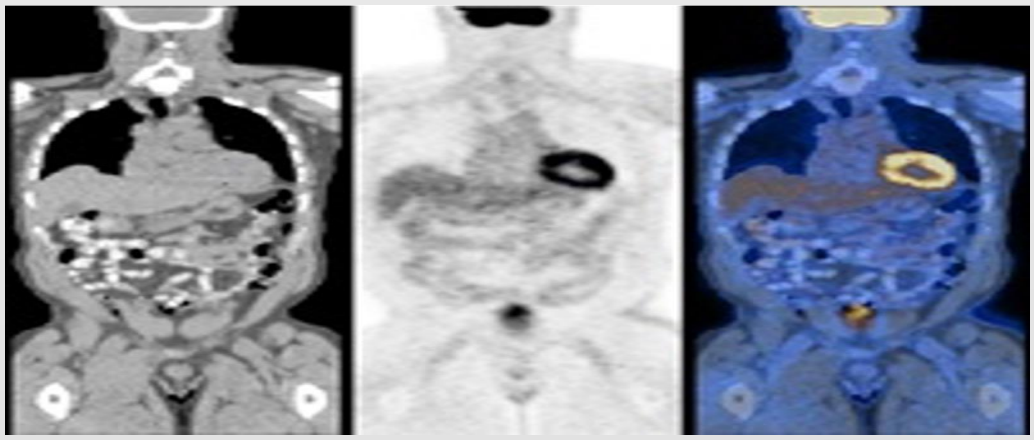
PET:: **P**ositron **E**mission **T**omography **and PET CT**

PET



planar;it's a gif :)

PET/CT



CT **Plane PET** **Fused CT + PET**

Role for Nuclear Medicine In Oncology

Diagnosis
- Specific or non-specific

Follow-up
- Early detection of recurrence

Staging
- Important for proper therapy

Treatment
- Specific or non-specific

Tumor Imaging

Non specific tumor imaging agents:

- **Tc-99m MDP bone scan:** Detection and follow up of bone metastasis
- **Gallium 67** (Replaced by **F18-FDG**) **:** Staging ,Restaging & therapy assessment of HD , NHL , Lung cancer
- **Thallium 201 :** Tumor viability & tumor seeking. **{Tc-99 m Agents (MIBI ,TETRO.)**
- **F18 – FDG (Gold standard for tumour imaging) :** Staging ,Restaging & therapy assessment of HD , NHL , Lung cancer

Specific tumor imaging agents:

- **In–111 (TC99m) Octreotide :** Neuroendocrine tumors
- **I -123 MIBG :** Neuroendocrine tumor
- **I -131 :** Lung mets. thyroid carcinoma

Bone Scan In Oncology

Procedure

Radiopharmaceuticals:

- Technetium 99m Methylene DiPhosPhonate (Tc-99m MDP) has High sensitivity **but non specific**

Tissue accumulation depends on:

- Blood flow
- Capillary permeability
- Metabolic activity of osteoblasts and osteoclasts
- Mineral turnover

Dose: 500 to 800 MBq (Megabecquerel) / 15- 20 mCi (millicurie)
Imaging time: 2 to 3 hours postinjection – WB + SPECT
Potentials of bone scan: Positivity many months before an abnormality can be detected on X ray

Indications

1 **Metastatic disease: (**Lung cancer, prostate, breast, thyroid, and renal tumours)

- Diagnosis.
- Initial staging.
- Restaging.
- Asses response to therapy.

2 **Primary Bone Tumor:** Main diagnosis is done by radiology (CT / MRI)

- Malignant or Benign
- Therapy planning for patients with primary bone malignancy (e.g. Osteogenic & Ewings sarcoma)

3 **Soft tissue tumors :** Main diagnosis is done by radiology (CT / MRI)

- Primary
- Metastases

Tumor Imaging

Imaging features

A. **Hot lesions :** Majority of bone tumors.
Doesn't show the metastasis itself but shows the osteopathic reaction around the tumor

B. **Cold lesions** : Purely osteolytic tumors (renal cell carcinoma,thyroid cancer, **anaplastic** tumors), radiation therapy

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

F. **Flare phenomenon:** increased number of lesions in the case of effective therapy Healing process, indicate good response to treatment

Bone Scan : In Metastatic Disease

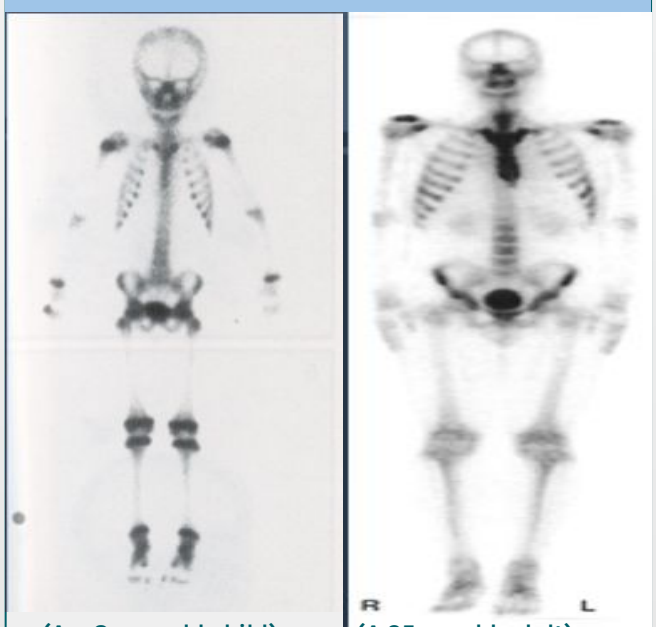
Access of Non Osseous Tumors To Bone:

- Direct Extension.
- Retrograde venous flow.
- Arterial Circulation (after venous or lymphatic access).

Epithelial Tumors:

- Reach red marrow of axial skeleton via venous and arterial flow.
- ★ Distribution of red marrow in adult : calvarium, spine , pelvis , and proximal femurs and humerus
- 90% of metastasis from epithelial tumors are found in **red marrow**. In adults the red marrow is confined in the axial skeleton, therefore there is no red marrow below the knee and elbow. The metastasis is only in the axial skeleton. With some exception in lung CA where there is metastits to the big toe and nobody can explain this.

Normal whole body bone scan



(An 8 year old child) (A 25 yrs old adult)

(Look at the symmetry. In children the growth plate is open [active] while in adults it is closed)

Metastatic Foci:

- Grows in red marrow space.
- The surrounding bone remodels through osteoclastic (resorption) and osteoblastic (deposition) activity.
- The relative balance between resorption and deposition determine whether the lesion is hot (sclerotic), cold (lytic) or mixed pattern.
- The tracer does not concentrate in the metastatic foci (cancerous tissue) but in the surrounding reactive bone.

Sensitivity:

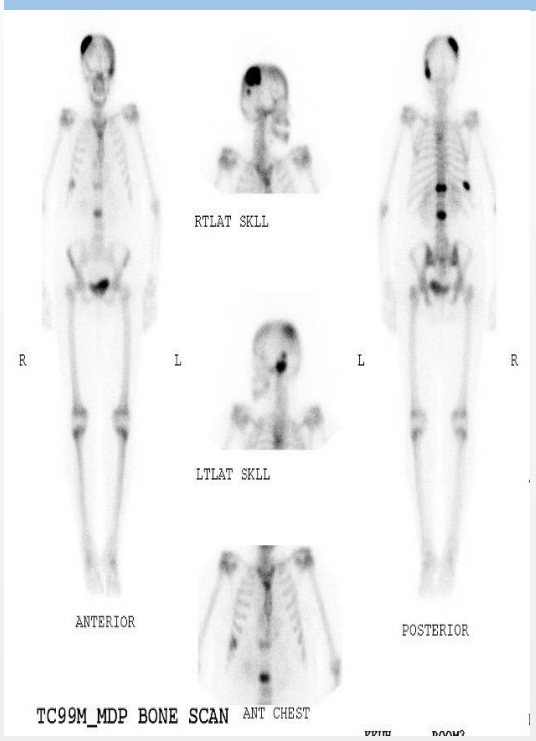
- In early stage superior to x-ray. Functional changes are faster than structural changes
- In advanced stage both have high sensitivity.
- The accuracy of bone scan not known because of the lack of reference standard.
- The sensitivity is agreed to be 90% or more.

Scan Patterns:

1. Solitary lesions.
2. Multiple focal lesions.
3. Diffuse involvement (Superscan).
4. Photon deficient lesions (cold lesions).
5. Flare phenomenon.
6. Normal (false negative).
7. Soft tissue lesions (tracer uptake in tumor).

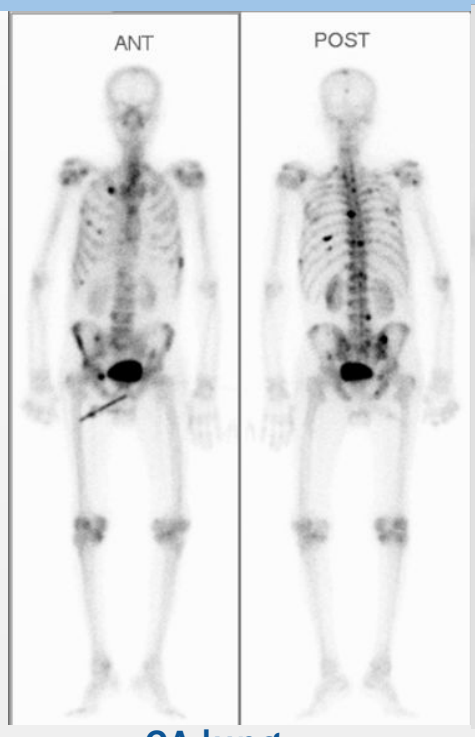
Tumor Imaging

Tumor staging

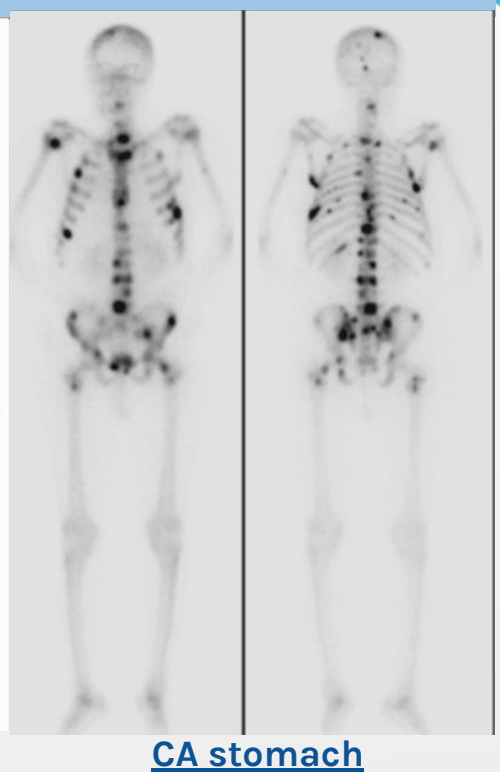


CA breast

hot spots represents bone metastasis



CA lung



CA stomach

Diffuse involvement (Superscan)

Definition : Bone scan with diffuse symmetrical increased uptake and almost absence of soft tissue activity, lack of kidney activity and bone uptake seen in blood pool images.

Causes :

a. Bone metastases : Prostate, breast, lung, bladder and lymphoma.

b. Non tumor causes: HPT, osteomalacia, Paget's disease and fibrous dysplasia

Important clues : In metabolic bone disease the calvarium and long bones are involved unlike in bone metastases witch is confined to axial skeleton.

Superscan

CA prostate.

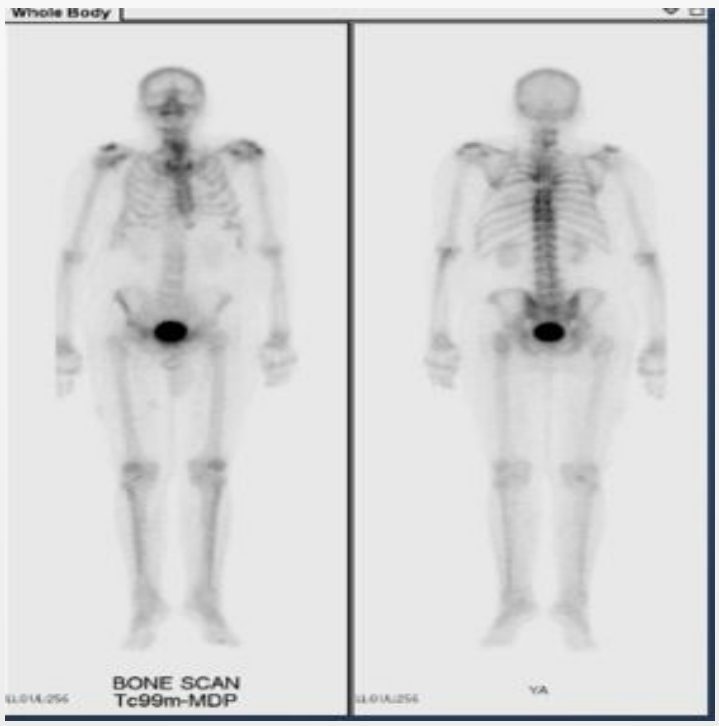
Diffuse increased uptake in the **axial skeleton**, nothing below knee or elbow

HPT

Diffuse increased uptake in the mandible and below
knee and elbow

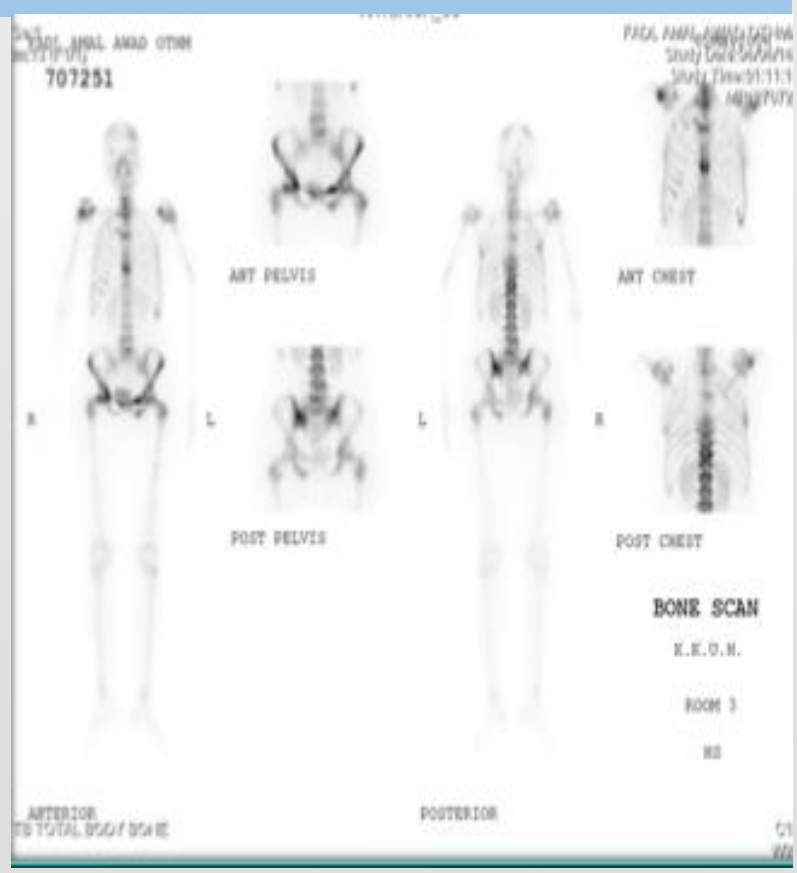
Tumor Imaging

Pure Lytic Lesions Caused by multiple myeloma, renal cell carcinoma,radiation, or by past surgery like this patient [tumor was removed(arrow)]



Bone Scan : Radiation Effect

Patient with bone metastasis

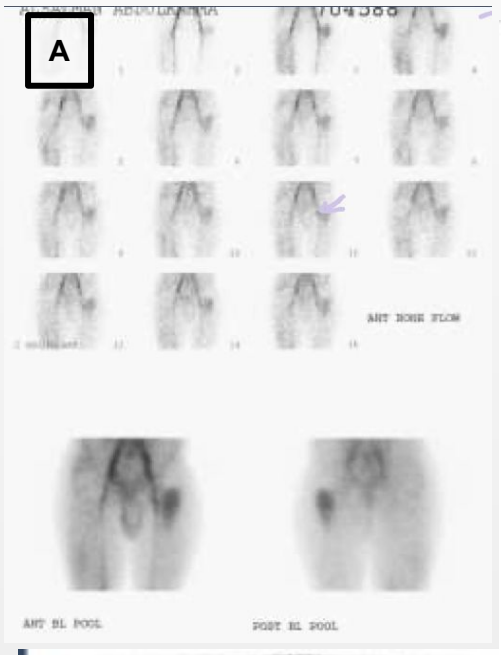


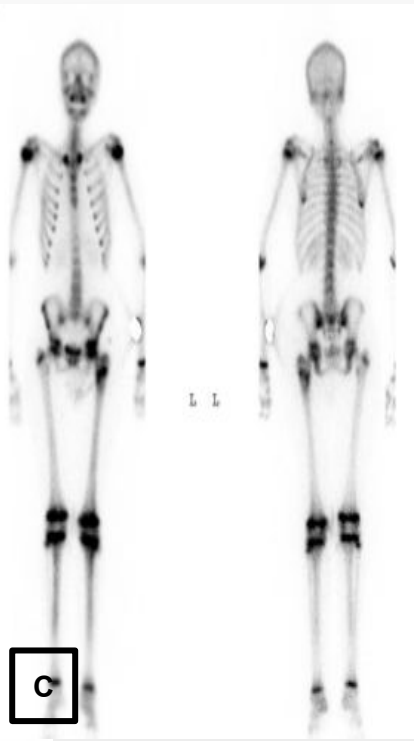
Follow up bone scan, shows cold areas, good response to radiation

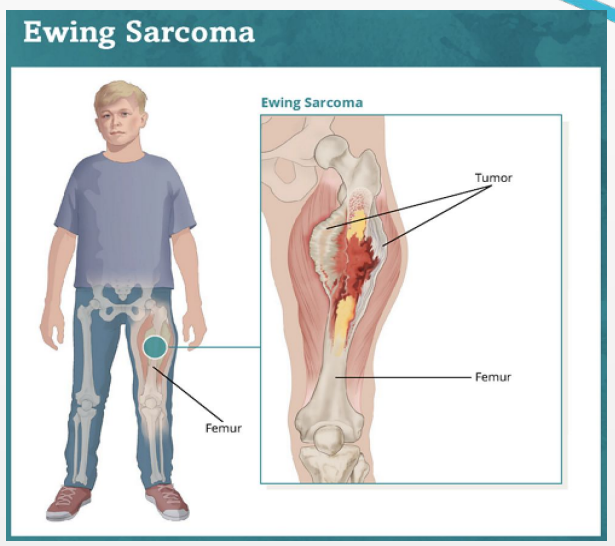
- **A:** **Hours** following radiation : **Increased** uptake due to increased blood flow and vascular permeability.
- **B:** **3-6 months** post radiation : **Decreased** uptake due to microvascular injury. Dose related (>2000 rads).
- **Following Radiotherapy :** Spontaneous ribs fracture may occur.

Tumor Imaging

Ewing's Sarcoma







A= Increased vascularity of tumor

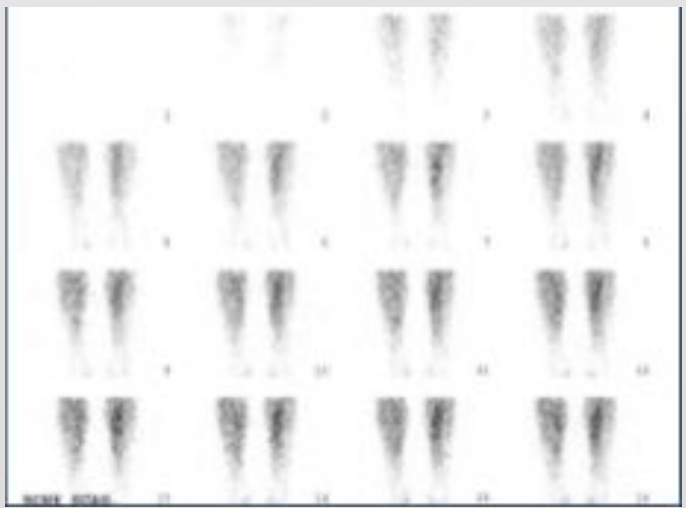
B= Metabolic delayed phase, increased uptake

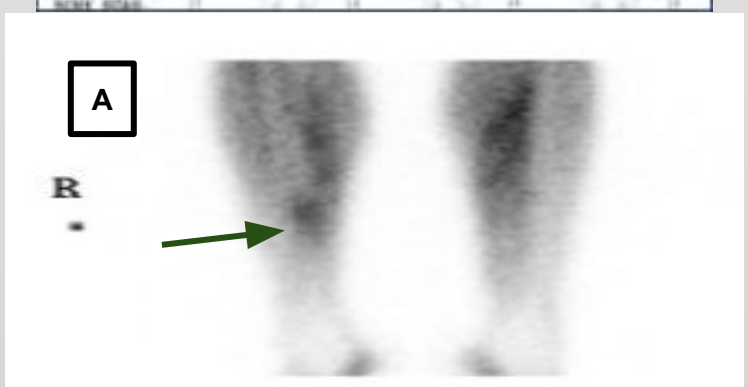
C= No distant metastasis

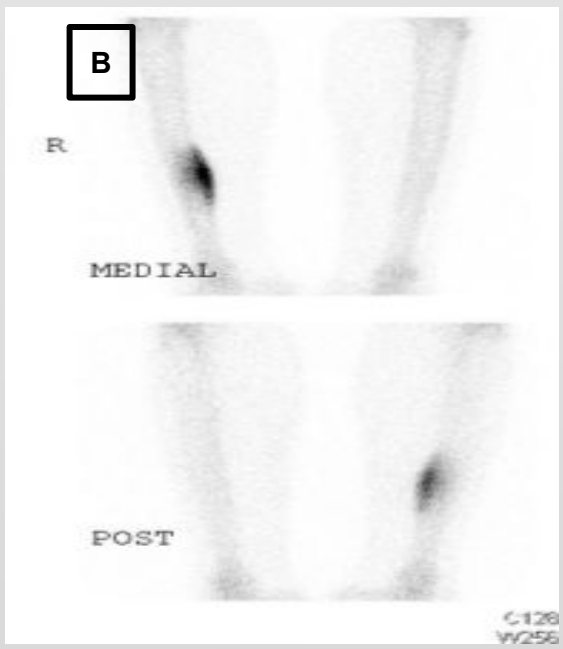
Bone Scan In Bone Tumors

Osteoid Osteoma

(Benign bone tumor. Usually affects **children**, present as **pain** in the site of the tumor relieved by aspirin)







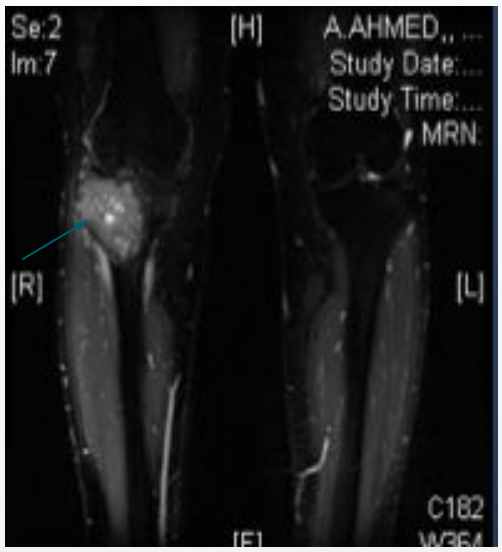
A=Focal area of increased blood flow

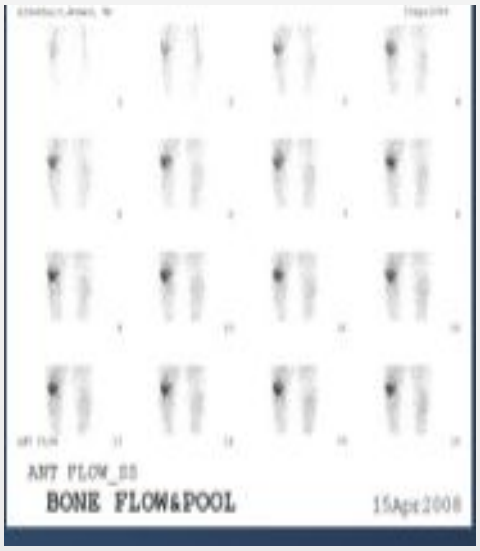
B=Delayed scan shows nodes of intense uptake

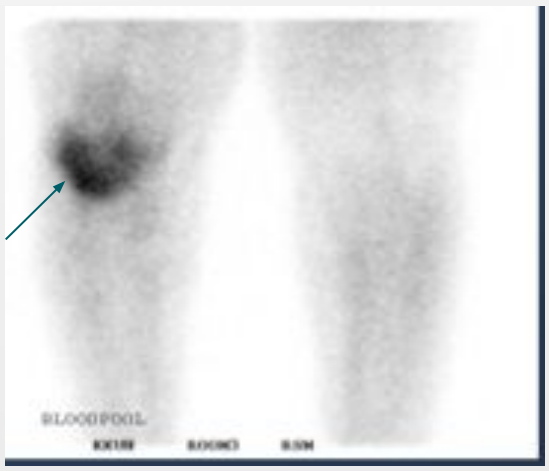
Bone scan is very sensitive to osteoid osteoma , typical appearance central area of increased uptake surrounded by area of less uptake

Tumor Imaging

Giant Cell Tumor Diagnosis by MRI



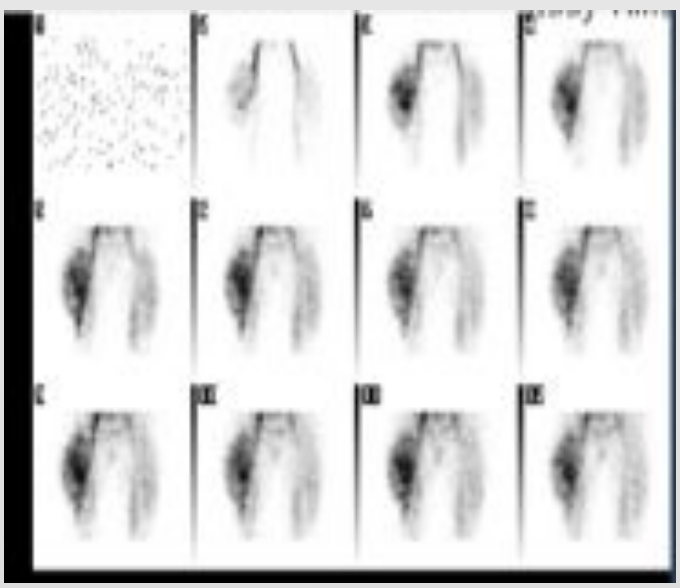


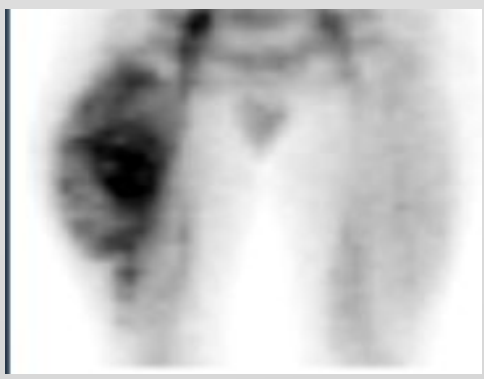


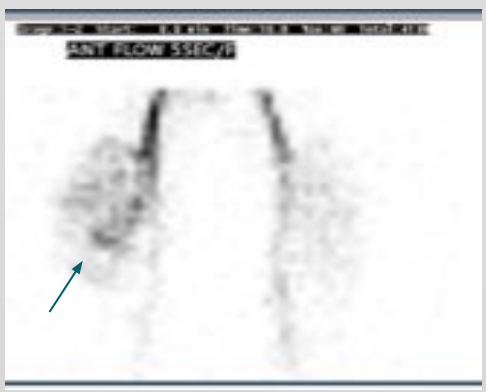
Increased blood flow , vascularity and uptake , the tumor is confined to the proximal right tibia with no distant metastasis

Soft Tissue Sarcoma
Diagnosis by MRI

(Goal is to see is there the local extent of the tumor and is there any distant metastasis)







Increased blood flow and vascularity , there is no underlying bone disease , no distant metastasis

Gallium 67 (Ga-67) scan

(no longer used)

Properties: (Introduced in seventies of 20th century for lymphomas)

1) Mechanisms of accumulation:

- Tumour viability
- Blood flow
- Capillary permeability
- Lymphatic drainage
- Binds to Transferrin receptors on the tumour cells

2) Non specific for infection-inflammation and tumors

3) Excretion: Kidneys and large bowel

Imaging Protocol:

- **Patient preparation:** Laxatives for bowel preparation post injection, nothing else
- **Several weeks post tumor therapy (FN)** Radiation therapy and chemotherapy can alter the normal pattern of gallium distribution
- **180 MBq (4-5 mCi) is usually administered** Imaging follows after 48 – 72 hours WB + SPECT/SPECT CT, medium-energy collimator

Normal Ga-67 scan

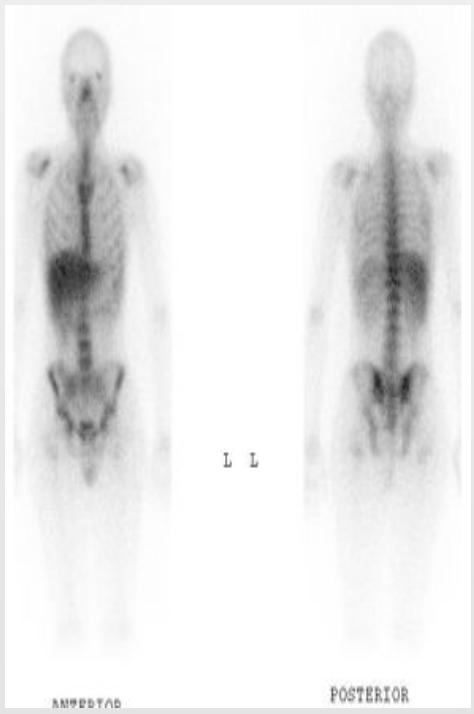
Normal scan

Accumulates in bone marrow and liver. Splenic uptake is variable. The kidneys are usually visualized and also lacrimal, salivary, nasopharyngeal and genital activity is often present.Female breasts can be visualized, but accumulation is physiologically symmetrical Radioactivity is commonly seen in the colon

Any uptake outside these structures is abnormal

Clinical indications

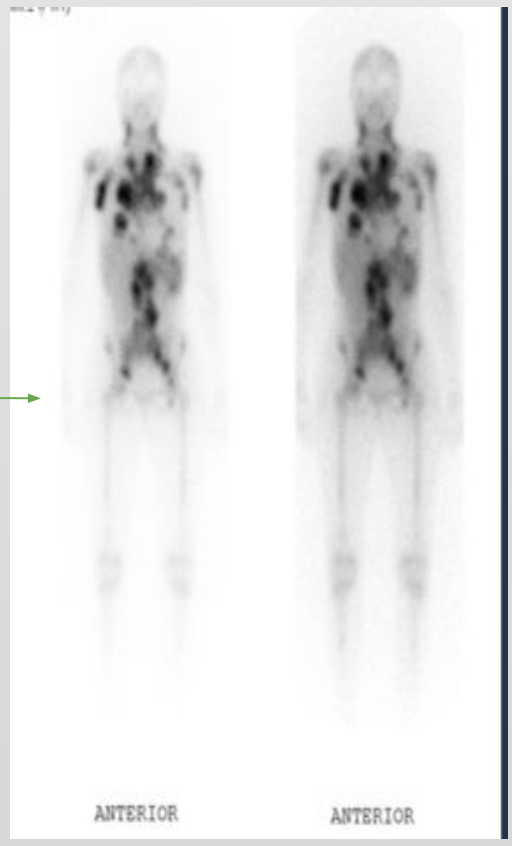
- Lymphoma
- Melanoma
- Lung cancer
- Hepatoma



Gallium Scan in Lymphoma

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

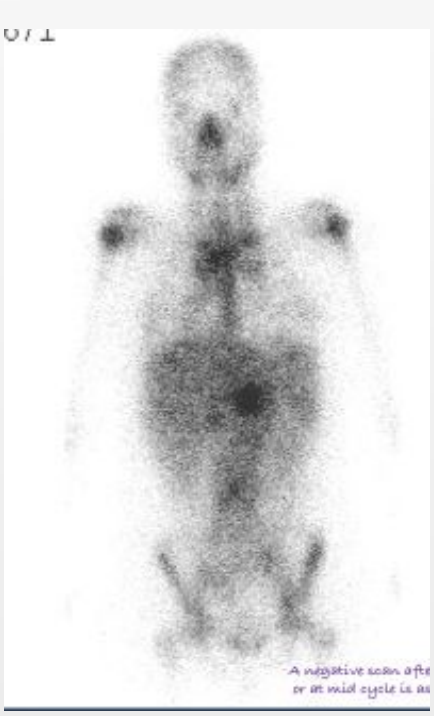
Affected lymph nodes above and below the diaphragm
Stage 4 lymphoma



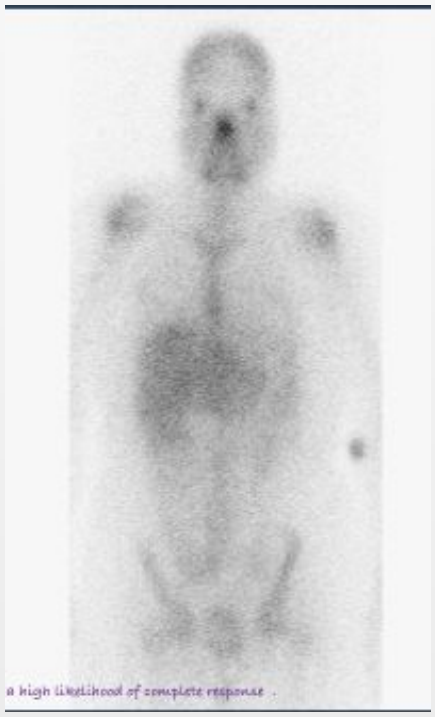
Gallium 67 (Ga-67) scan

Gallium Scan in Lymphoma (Continue..)

Prediction of response to therapy

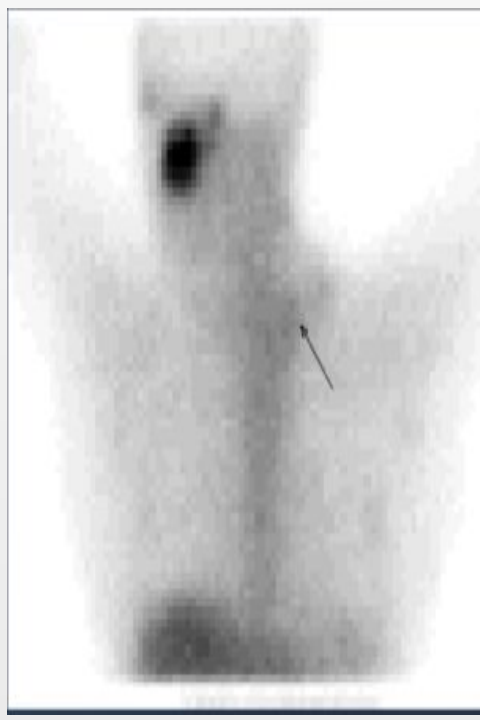


Before chemotherapy



After chemotherapy

Prediction of outcome



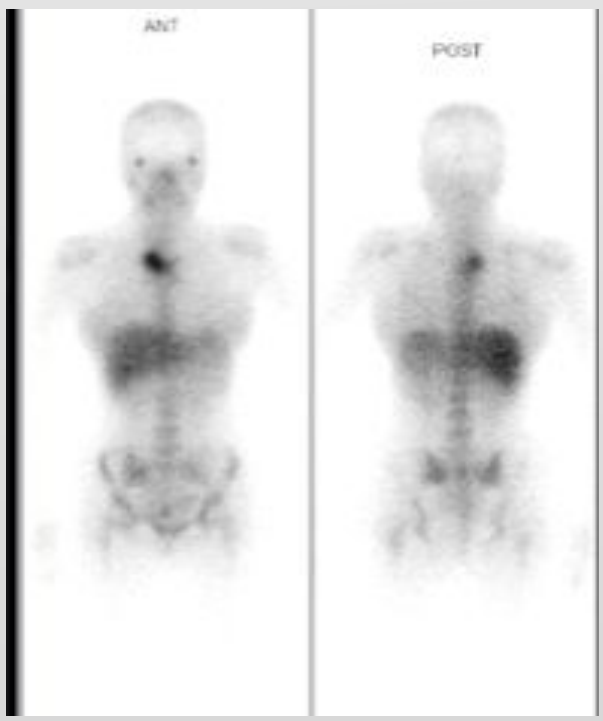
Partial response

Normalization of a positive pre-therapy scan : A negative scan after one cycle

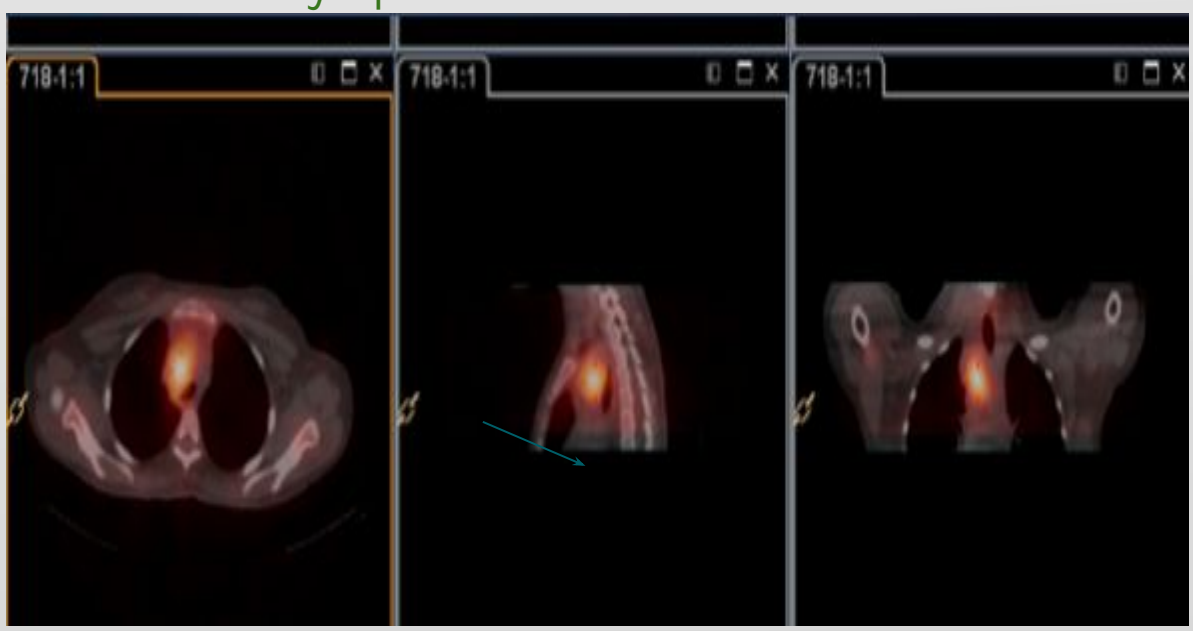
Residual gallium uptake after treatment is a poor prognostic sign, indicates viable tumor and treatment should be modified.

Gallium Scan NHL

Planar Vs SPECT CT



Lymph nodes in the mediastinum



Neuroendocrine Tumors

In-111 octreoscan.

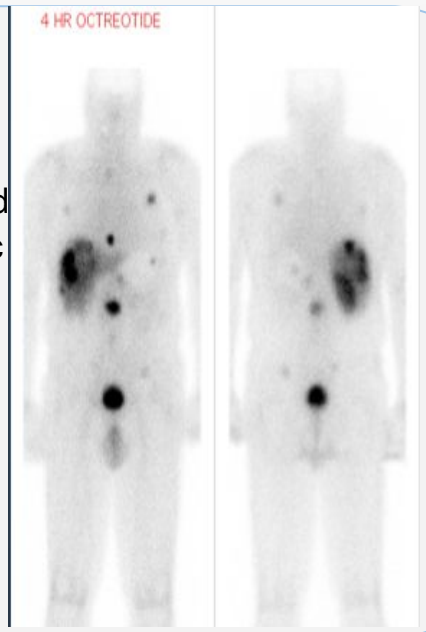
I123 MIBG Scan.

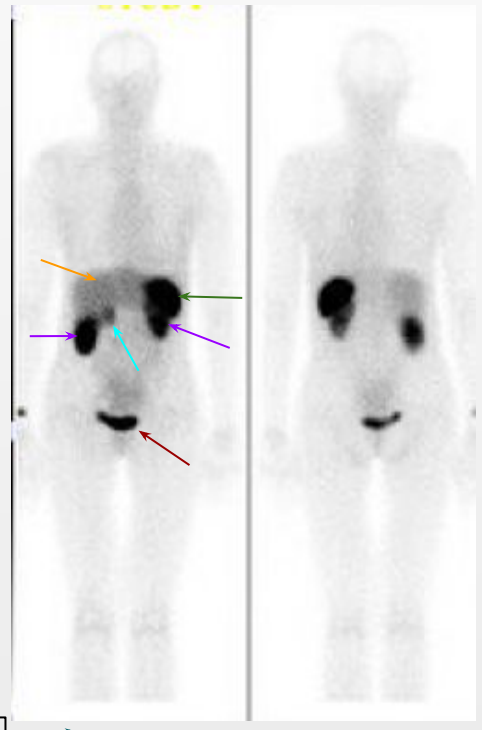
Somatostatin Receptor Imaging (Indium-111 Octreoscan)

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.





Labeling: Liver,Spleen, Kidneys,Urinary bladder, Gallbladders

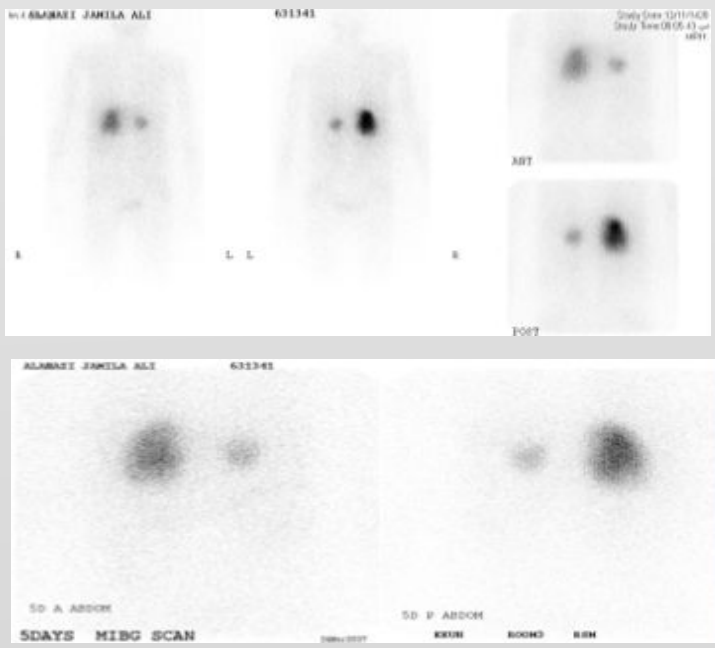
NORMAL STUDY

I123 MIBG Scan (MIBG : Meta Iodo Benzyl Guanidine)

- 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

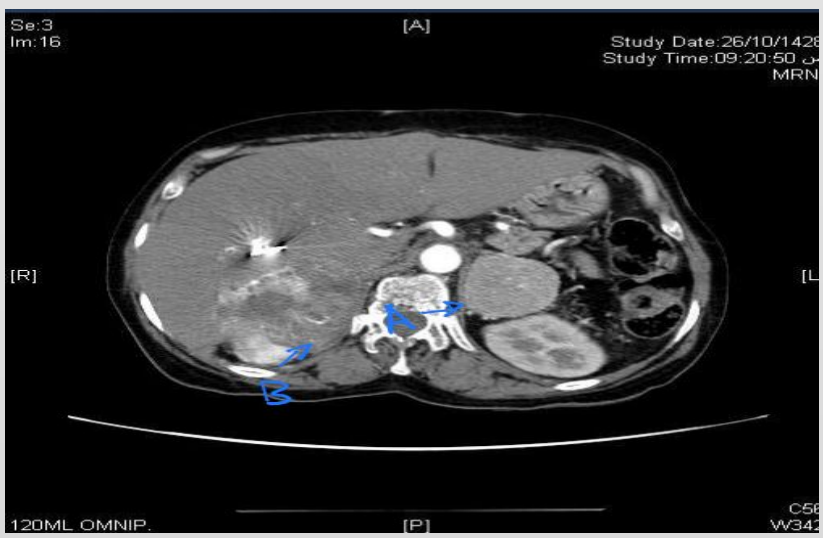
Indications: Neuroendocrine tumors
(Pheochromocytoma, Paraganglioma, Insulinoma, Neuroblastoma ,Medullary thyroid carcinoma, Carcinoid tumors)

MIBG In Pheochromocytoma



Bilateral Pheochromocytoma

Bilateral Disease

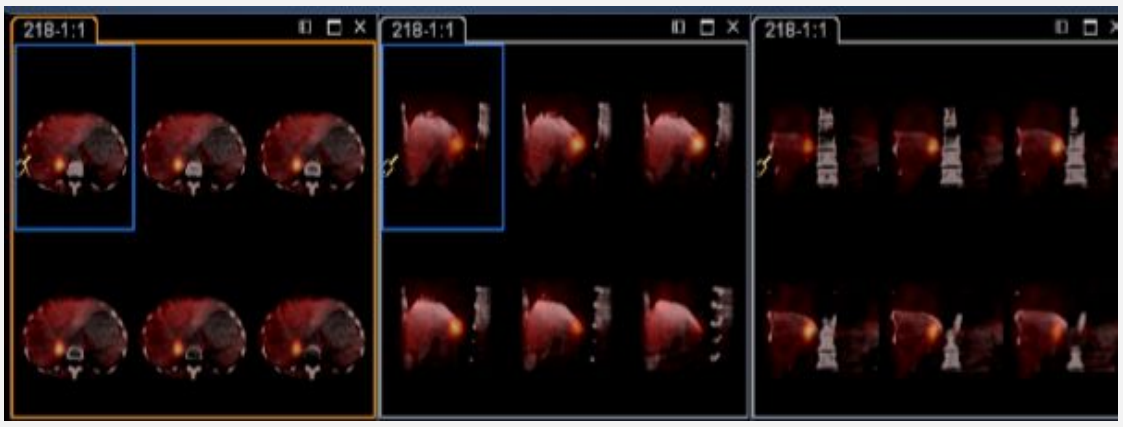


A: large left adrenal tumor
B: smaller on the right

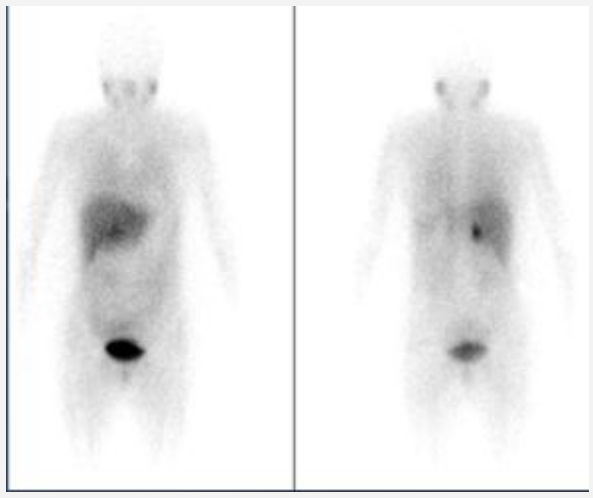
Neuroendocrine Tumors

MIBG In Pheochromocytoma (Continue..)

Clinical History A 41 years old female patient with 2ndary hypertension. Right adrenal mass.?**Pheochromocytoma**.



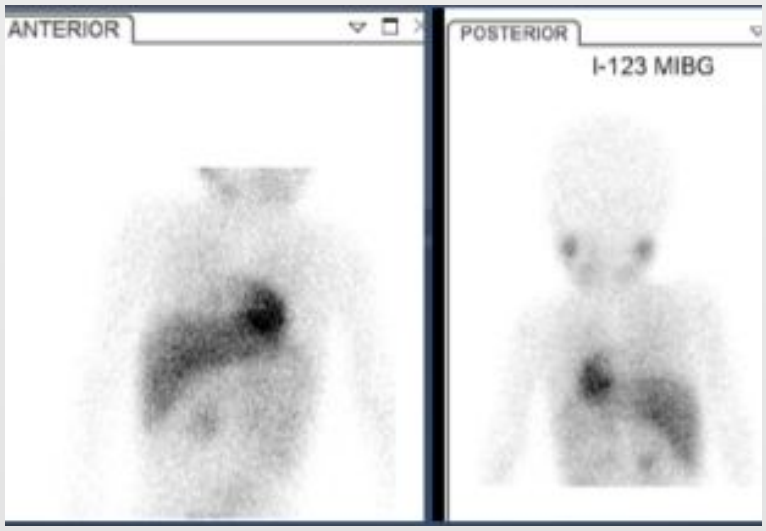
Tumor is paraspinal, supranational.



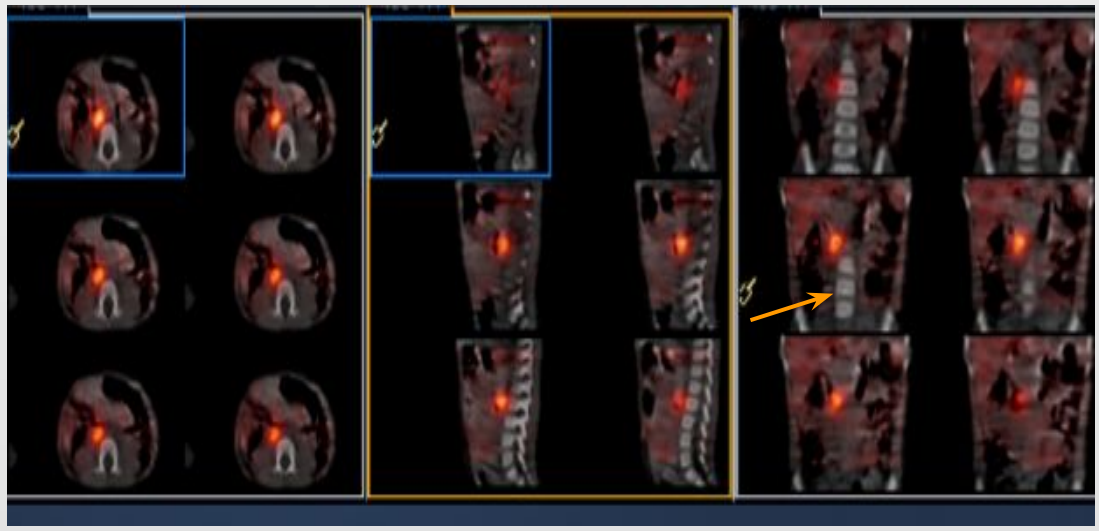
Planar Vs SPECT CT

MIBG In Nephroblastoma (Wilms' tumour)

(effects children under 7 years, can be removed)



Abnormal uptake in the right upper abdomen



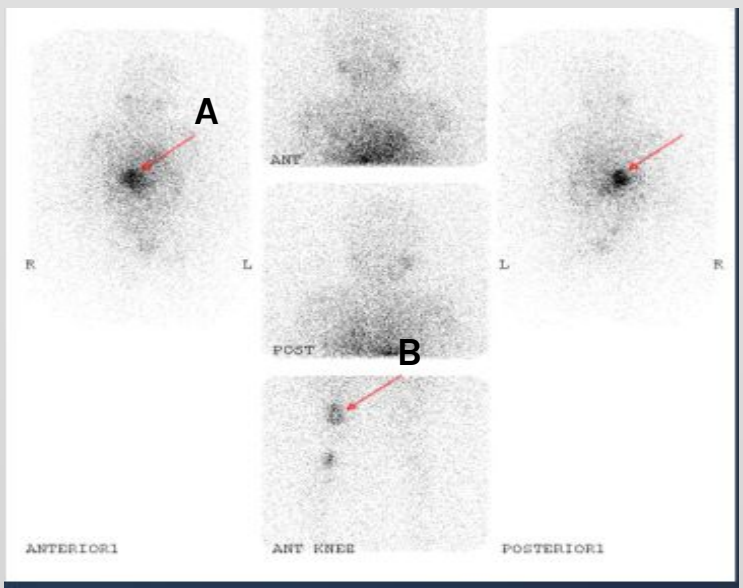
Intense MIBG uptake, in the right paraspinal and subhepatic (arrow)

I131 MIBG Total body scan

1ry neuroblastoma /bone mets

1131 MIBG:when we label MIBG with 1131 we can use it to treat,so MIBG is used in both **treatment** and **diagnosis**

A: Primary
B: Metastasis treated with I131 MIBG



Thyroid Metastases Study

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

(**I-123** is the gold standard for **imaging** while **1-131** is used for **therapy)**

Indications

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

Patient Preparation

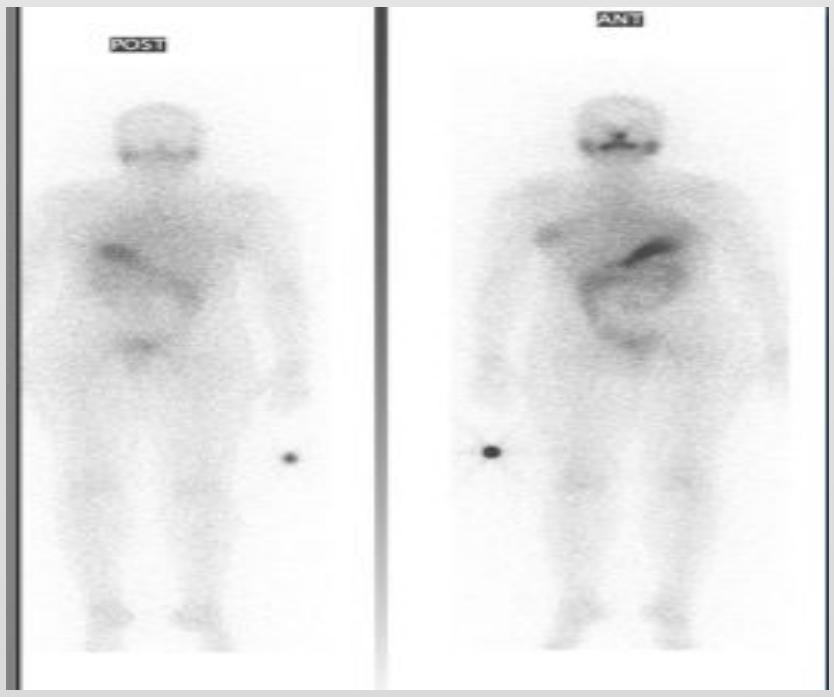
1)Stimulation of potentially functioning thyroid tissue:
A. Inject **recombinant human thyrotropin** on 2 consecutive days and administer the iodine on the third day .
B. Withdraw thyroid replacement hormones :
1. Thyroxine (T-4) for at least 4 weeks.
2. Triiodothyronine (T-3) for at least 10 days.
2)The patient must not have had i.v iodinated contrast material (IVP, CT with contrast, myelogram, angiogram) for at least 3 weeks .
3)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

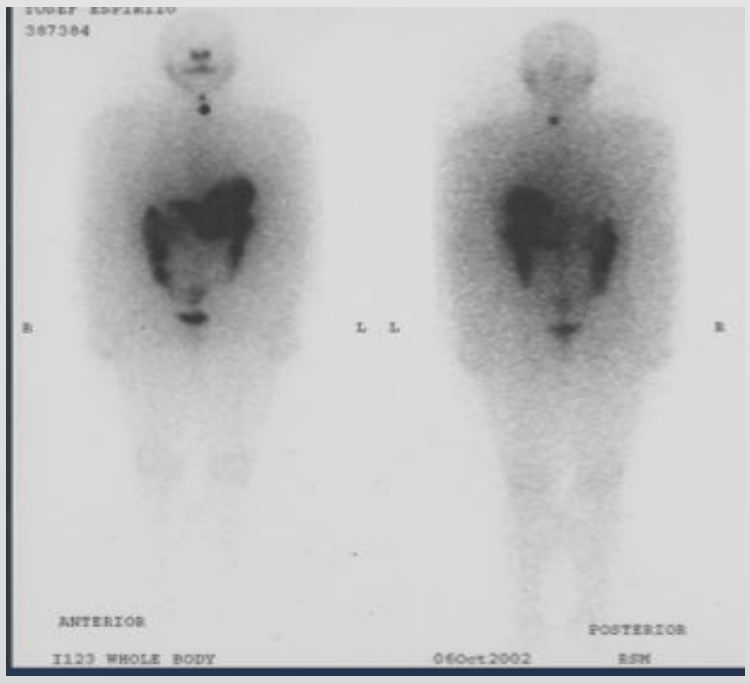
Radiopharmaceutical: **Oral** administration
a. I-123 as sodium iodide : 2 mCi
b. I-131 as sodium iodide : 2-10 mCi
Imaging using Gamma camera : Whole body scan

Thyroid Cancer

I-123 WB Scan



Negative I-123 WB



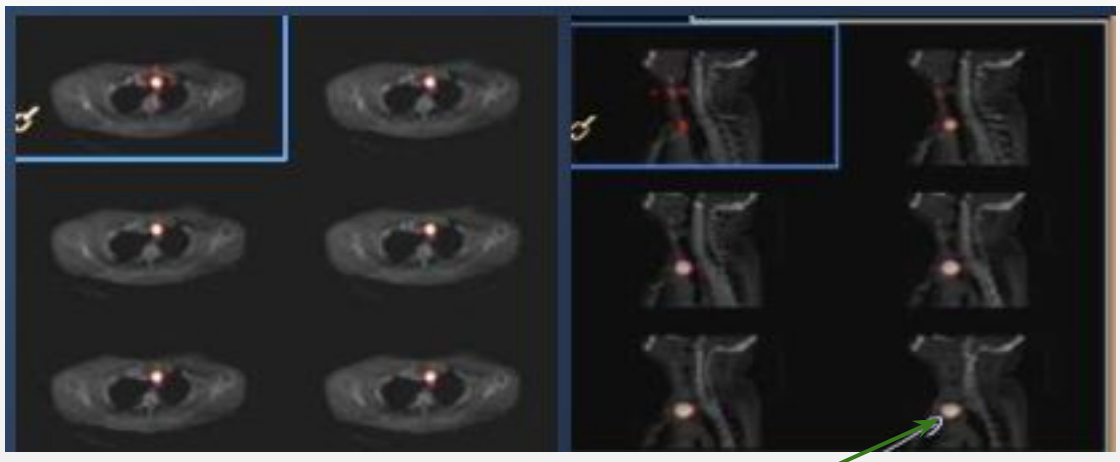
I-123 WB Scan : Postoperative Thyroid remnants

Thyroid Metastases Study

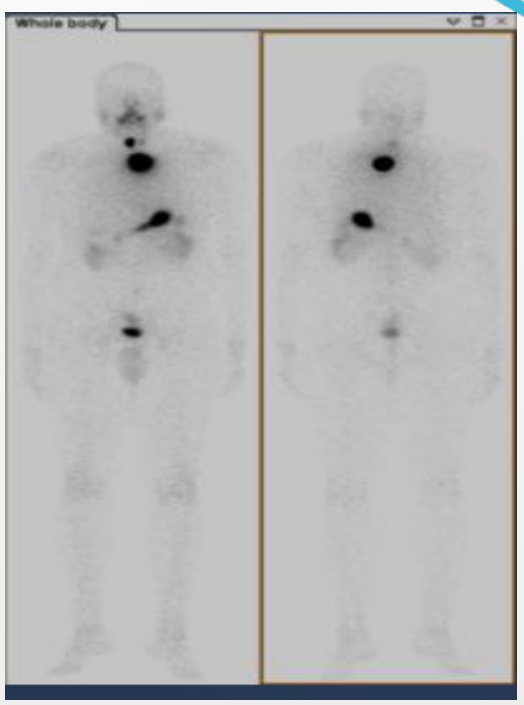
Thyroid Cancer (Continue…)

I-123 WB Scan:Postoperative Thyroid remnants

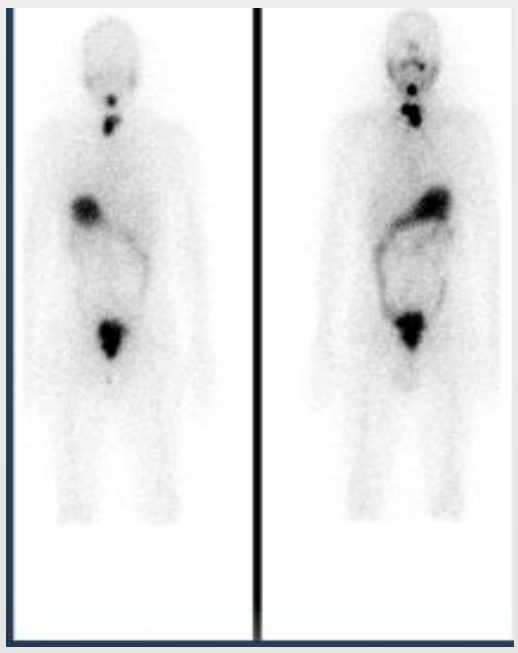
Planar Vs SPECT CT



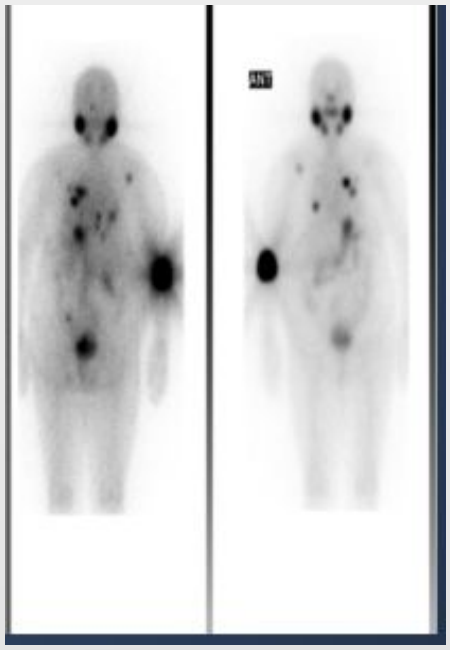
Localized retrosternally



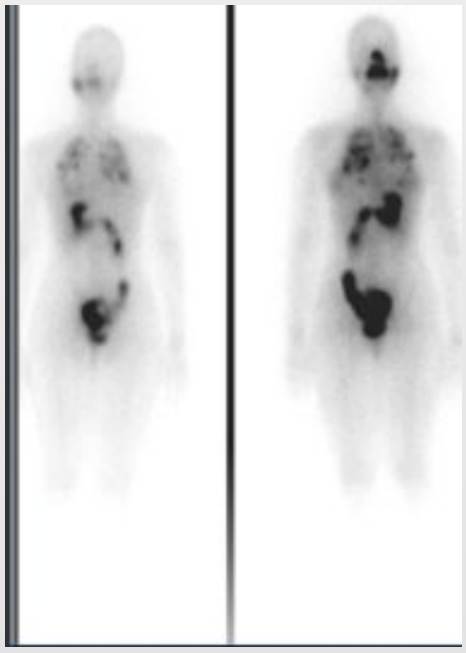
Thyroid metastases study: (I-123 or I-131 as Sodium Iodide)



Local recurrence

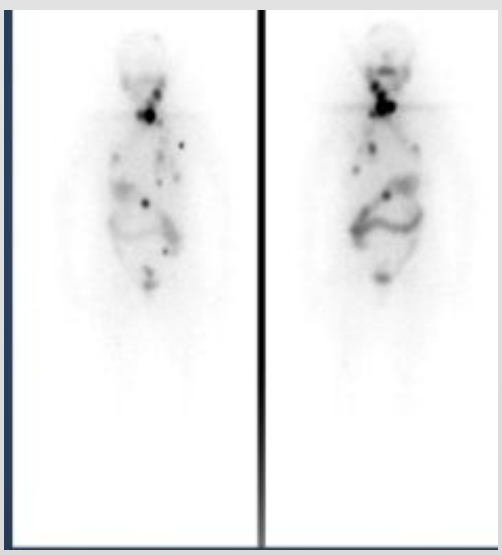


Bone metastases

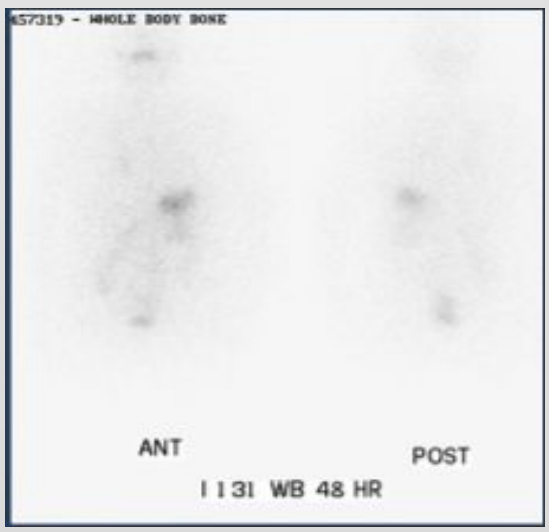


Lung metastases

I-131 Pre & Post therapy



Dec 04



(Resolution) March 06

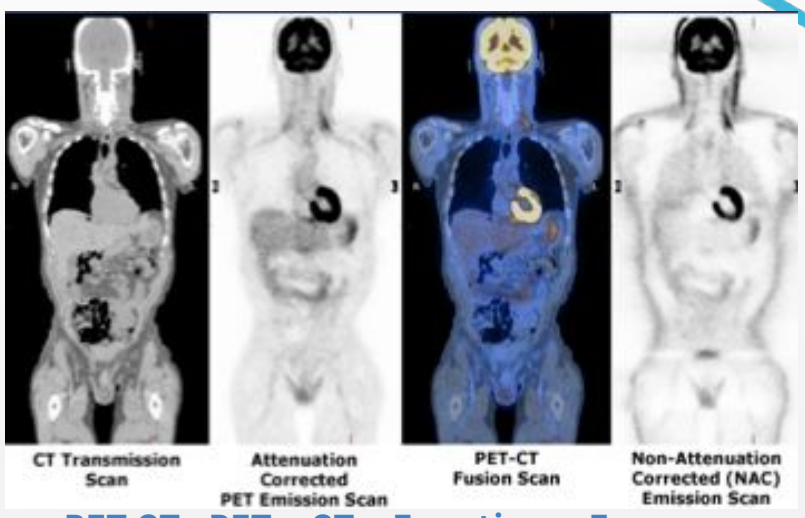
Metastasis depends on the histological type :
1- papillary - confined to lymph nodes (lymphatic spread)
2- follicular- bone and lung (hematogenous spread)

Onco PET (PET and PET CT)

The gold standard for oncology patients

What is PET - CT?

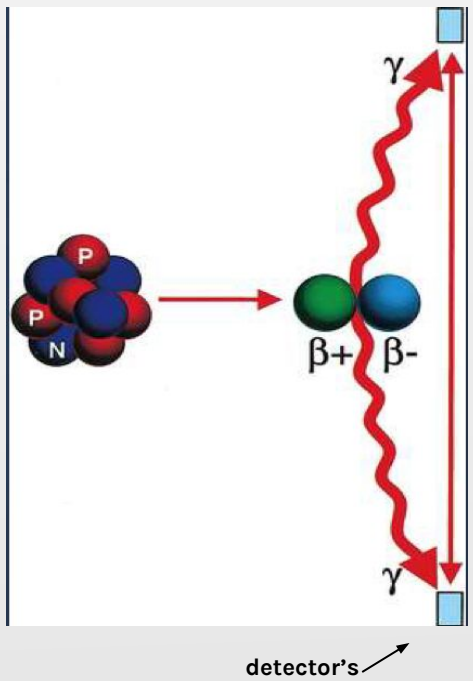
PET: Positron Emission Tomography.
CT : Computerized Tomography.
PET-CT is the fusion of functional and anatomic information acquired almost simultaneously from which we are able to visualize form and function.



PET CT= PET + CT = Function + Form

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.



Positron Emitting Isotopes:

1.Cyclotron produced isotopes:

Isotope	T/2
Oxygen-15	2 min
Nitrogen-13	10 min
Carbon-11	20 min
Fluorine-18	**110 min**

2.Generator produced isotopes:

Parent	T/2	daughter	T/2
Strontium -82	25 days	Rubidium-82	75 seconds
Zin-62	9.3 hrs	Copper-62	10 min
Germanium-68	**288 days**	**Gallium-68**	**68 min**

*The ones in the red are the most used agents. Important to know them

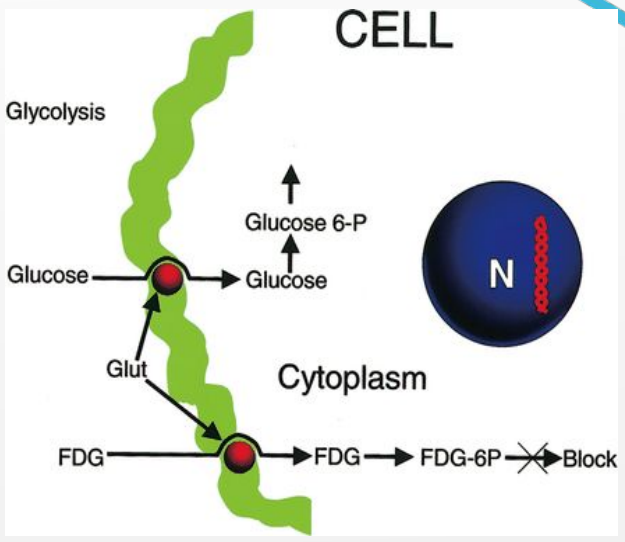
FDG

FDG : Fluoro-2-deoxy-D-Glucose

Uptake mechanism:
FDG is a glucose analogue used to assess glucose metabolism. FDG gets transported from intravascular space to the cells by the same mechanism as the glucose. In the cell, hexoKinase acts on both **FDG and glucose to form:**

- FDG-6-phosphatase (FDG-6-PO4-)
- Glucose-6-phosphatase.

FDG-6-PO4- cannot progress further into glucose metabolism and remains trapped intracellularly in proportion to glycolytic rate of the cell.



In tumors, there is high rate of glycolysis compared to normal cells as well as higher level of hexoKinase. FDG is labeled with F18

Normal distribution

Heart in non fasting state

Brain & heart	High uptake
Liver	Less uptake
Kidneys	Unlike glucose, FDG is excreted with urine
GI	Mild clearance, faintly seen
Muscles	Low, increase with exercise

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.

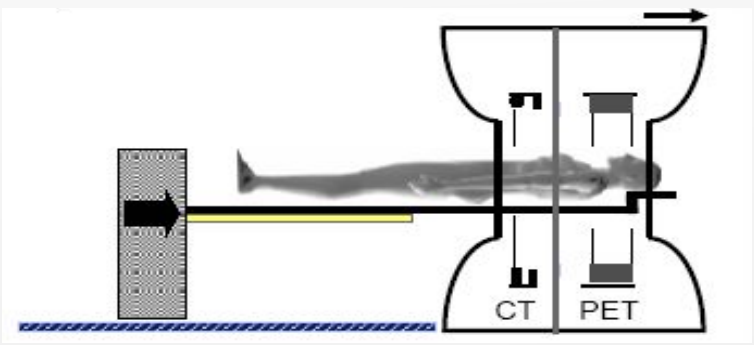
Applications of FDG: Patient should be fasting

- 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

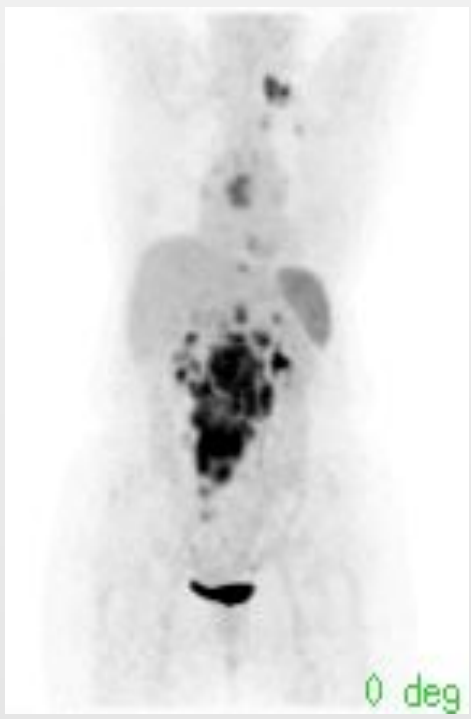
PET CT F18 FDG imaging protocol

Fasting : 4 – 6 hours
Dose : 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)



FDG PET

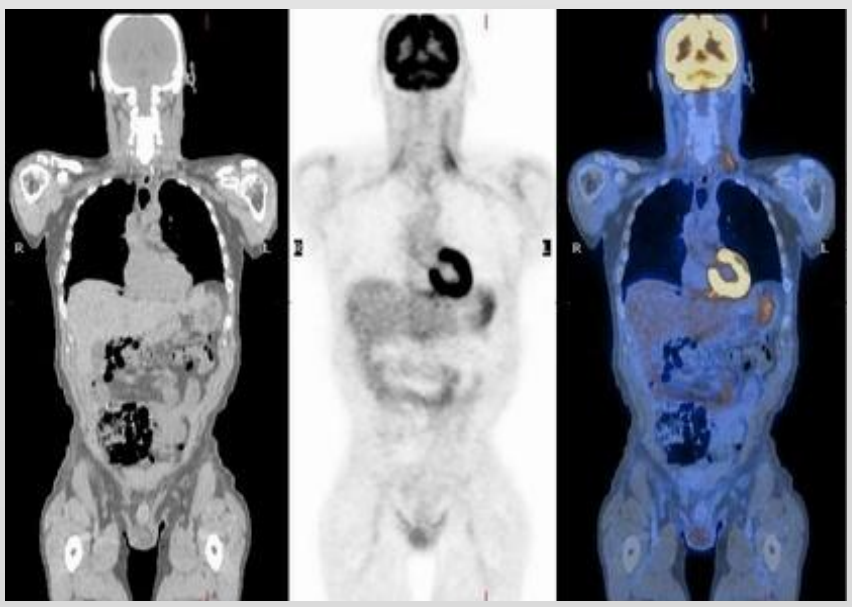
FDG PET
Normal



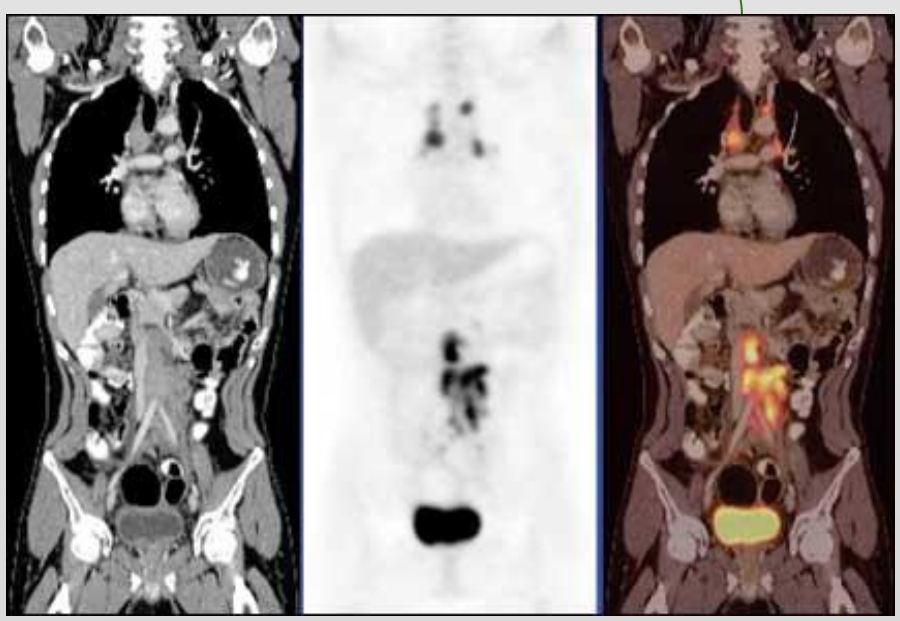
FDG PET
Staging of NHL
(stage 4 lymphoma)

Bilateral mediastinum and hilarious lymph nodes para aortic lymph nodes in the abdomen

FDG PET CT



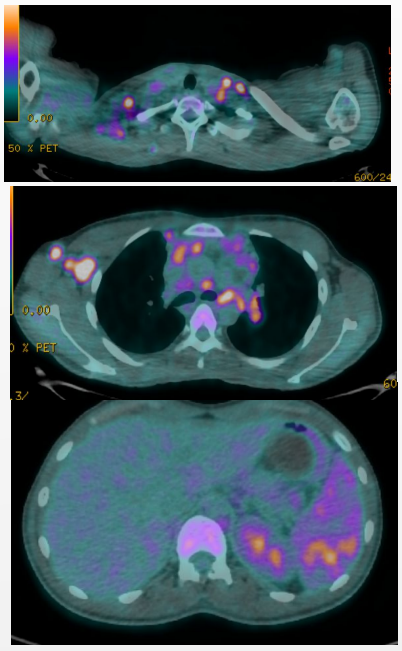
FDG PET-CT
Normal



FDG PET-CT
Staging Of Lymphoma

FDG

FDG PRT CT NHL: stage IV



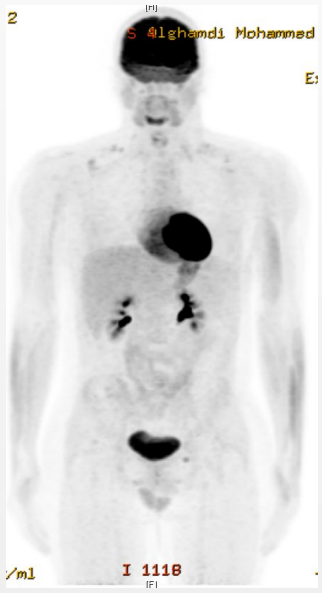
- Extensive lymph nodes involvement
- Spleen involvement
- Para aortic involvement

Hodgkin's lymphoma

FDG PETCT : Hodgkin's lymphoma

- Post 6 cycles of chemotherapy for assessment.

Baseline
(24.10.2018) =Lymph nodes with spleen involvement

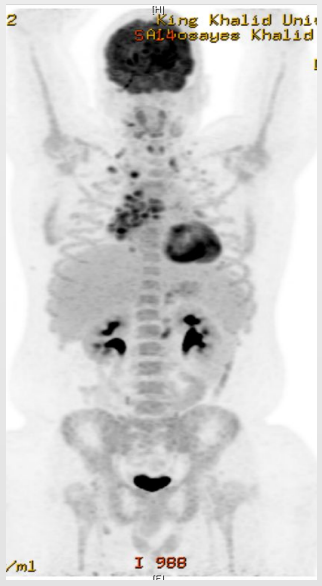


Interim
(1.1.2019)=Few remnants

Final
(19.5.2019)=Complete Resolution

- Partial metabolic response (Deauville Score 5).

Baseline
(31.3.2019)

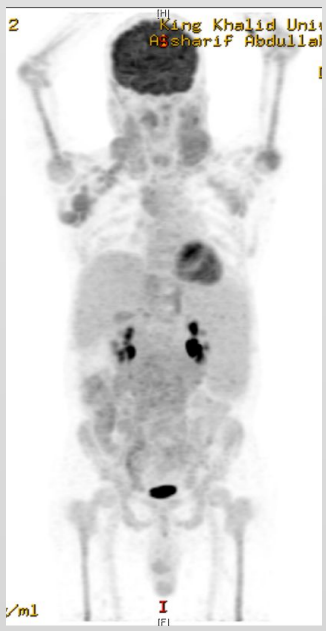


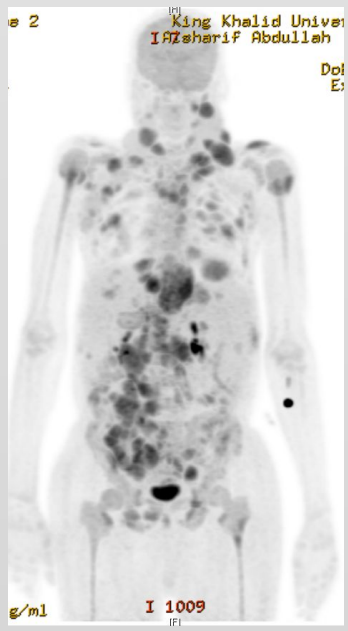
Interim
(9.6.2019)=Partial response

Final
(4.8.2019)=Not completely resolute

- Progressive disease (Deauville Score 5)

Baseline
(19.2.2019)



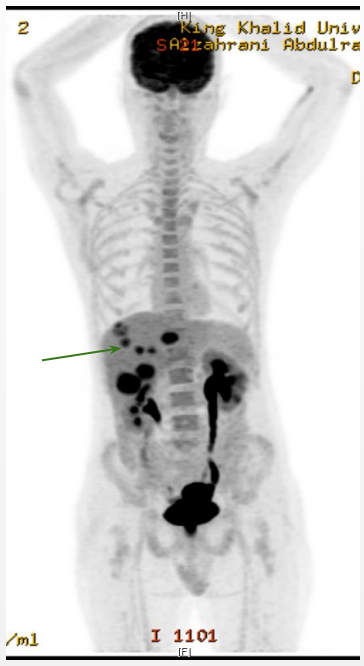


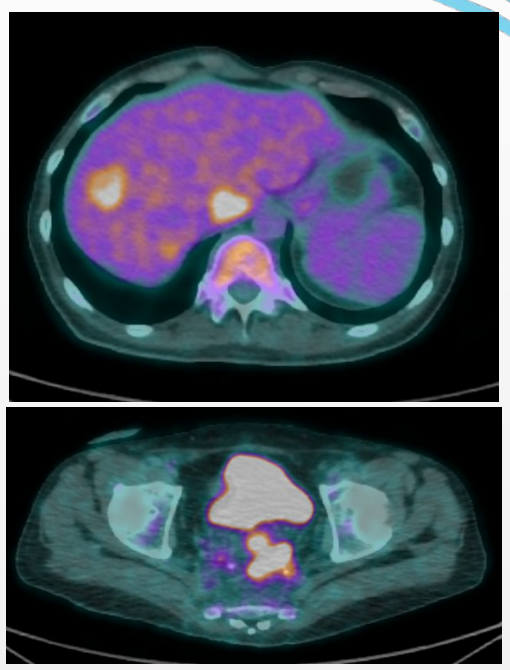
Interim
(17.7.2019)
=Got worse

FDG PET CT

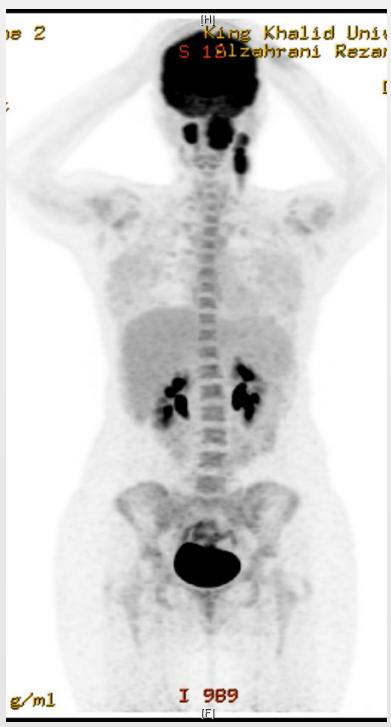
FDG PET CT Rectal cancer with liver metastases

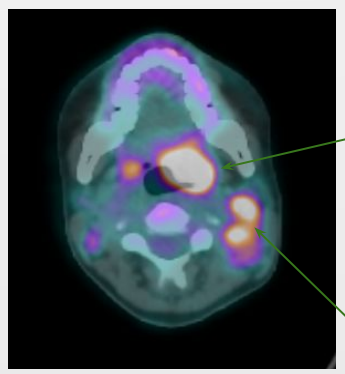
Liver metastasis





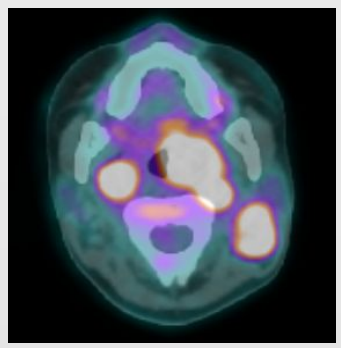
FDG PET CT : Nasopharyngeal cancer with LN metastasis





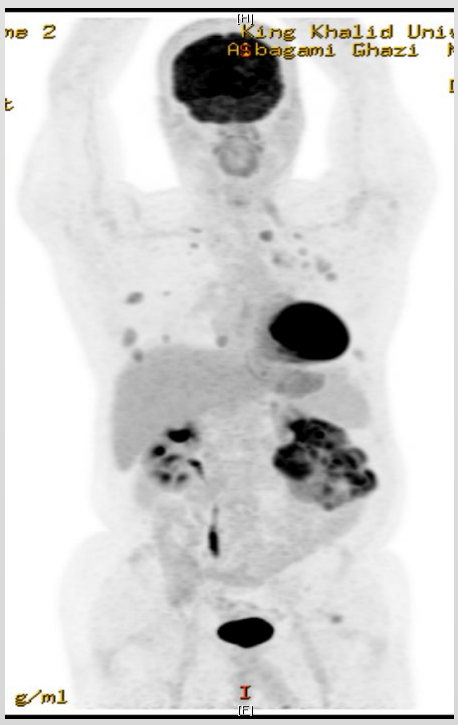
Primary nasopharyngeal tumor

Left cervical lymph nodes involvement

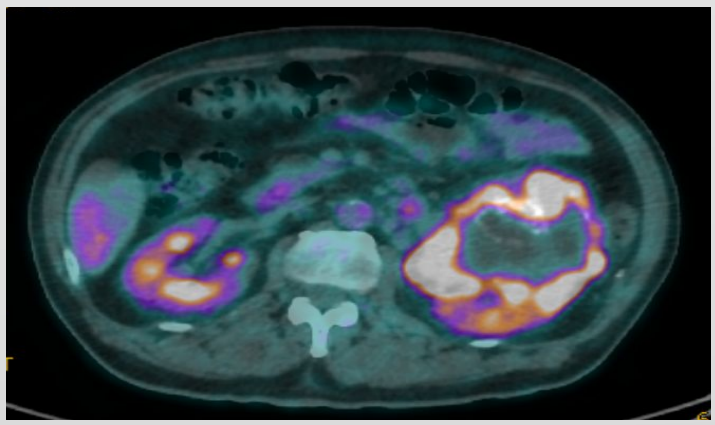


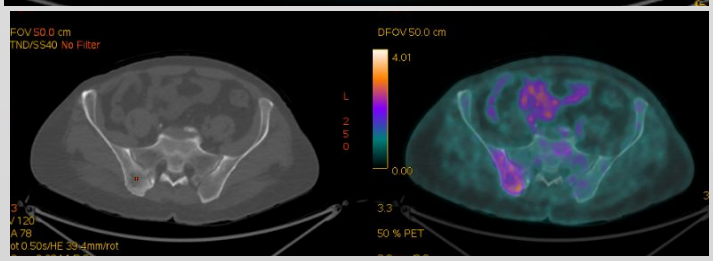
FDG PET CT : RCC with bone and lung metastases

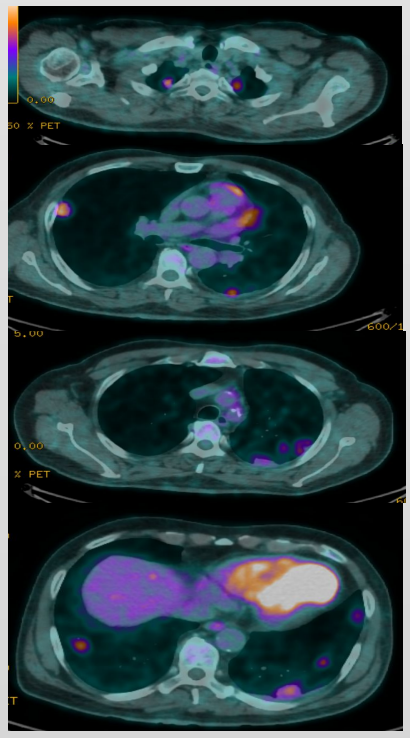
309756 FDG-avid left renal mass coupled with FDG-avid locoregional nodal disease and multiple FDG avid pulmonary metastasis. Solitary sclerotic area of hypermetabolism at the right iliac bone, worrisome for bone metastasis. Stage 4 renal cell carcinoma



A=lymph node metastasis, B=bone



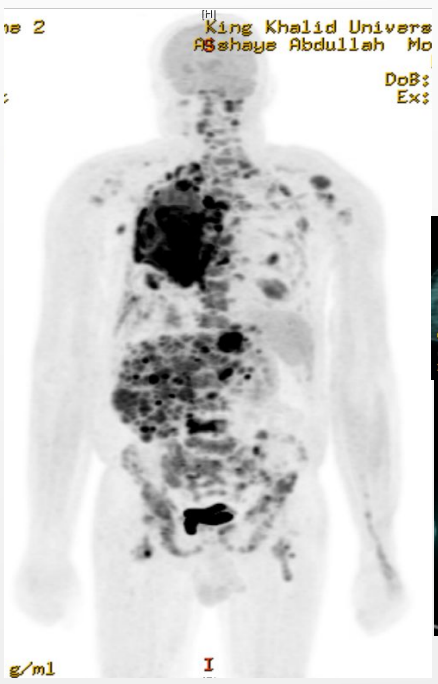


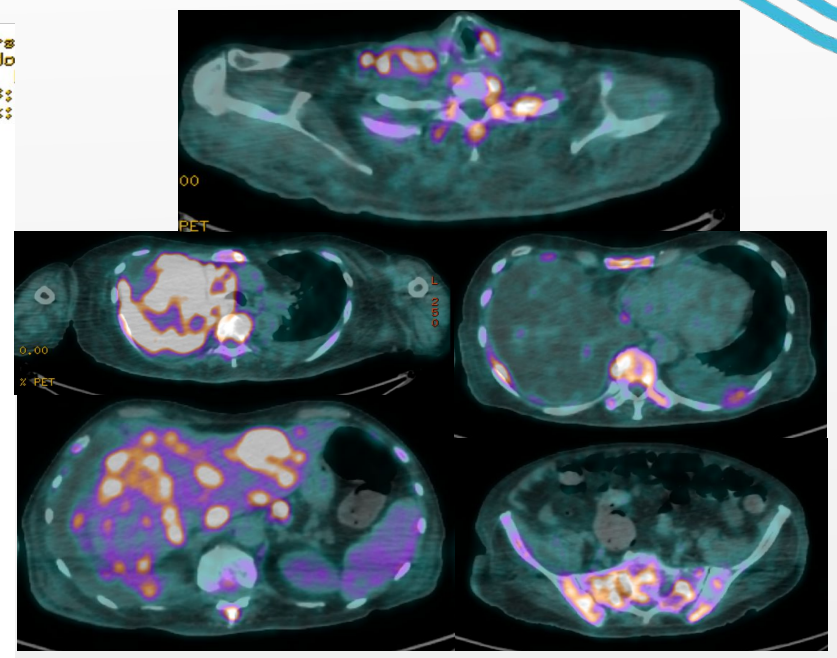


FDG PET CT

FDG PET CT : Metastatic Lung Cancer

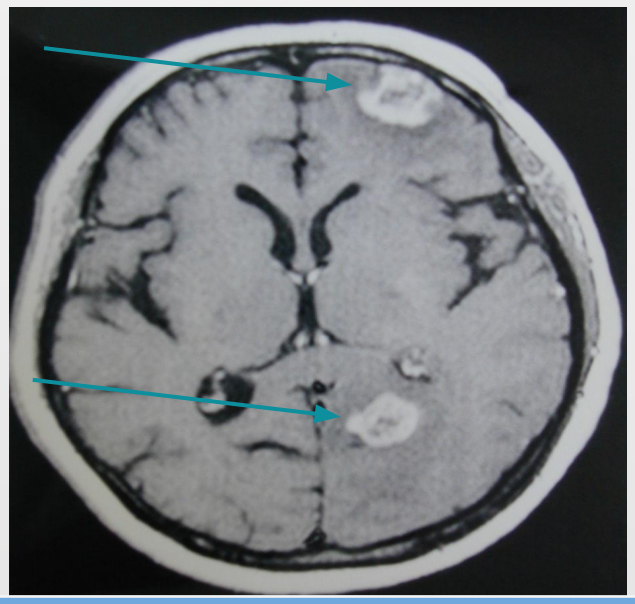
Multiple distant metastasis in the lung, liver, cervical and bone

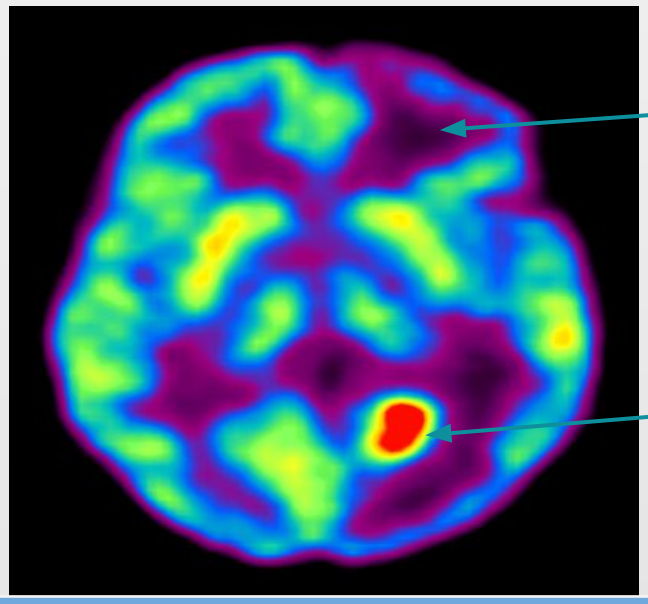




FDG PET – brain tumor

post therapy Two foci on CT, only one viable tumor





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

Somatostatin receptor tracer

Somatostatin receptor PET tracers Ga-68 DOTANOC

(Gold standard for somatostatin receptor)

Radiopharmaceutical: DOTANOC , DOTATOC or DOTATATE is labeled with Ga-68
Dose: 3-5 mCi given intravenously.
PET Imaging time: 45-60 min postinjection
Clinical value: higher lesion detection rate than is achieved with (18)F-fluorodihydroxyphenyl-l-alanine PET, somatostatin receptor SPECT, CT, or MR imaging.
Sensitivity: 70-100% (depends on density of somatostatin receptors in the tumor)
Indications:

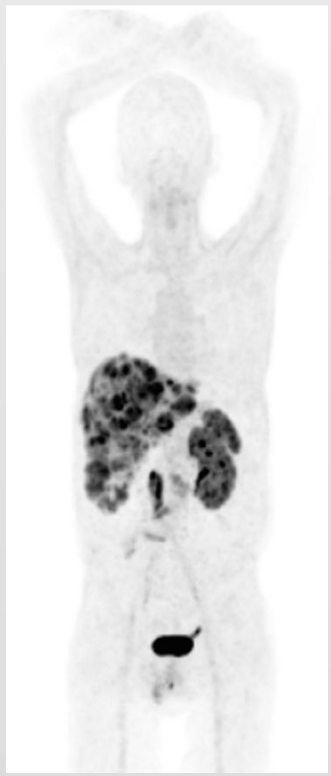
Tumours with high expression of receptors of somatostatin

- Gastroenteropancreatic tumours
  - e.g. carcinoids,gastrinoma, insulinoma, glucagonoma, VIPoma, etc.
- Sympathoadrenal system tumours
  - pheochromocytoma, paraganglioma, neuroblastoma, ganglioneuroma
- Medullary thyroid carcinoma
- Pituitary adenoma
- Medulloblastoma
- Merkel cell carcinoma
- Small-cell lung cancer
  - mainly primary tumours
- Meningioma

Normal distribution 68Ga-DOTA peptide PET/CT

- Normal tracer uptake is seen in the pituitary, salivary glands, thyroid, liver, spleen, adrenals, pancreas, kidneys, ureters, and bladder

68Ga-DOTA PET



- NET with multiple metastatic disease confined to the liver and abdominal cavity

- NET with extensive metastatic lesions throughout the body

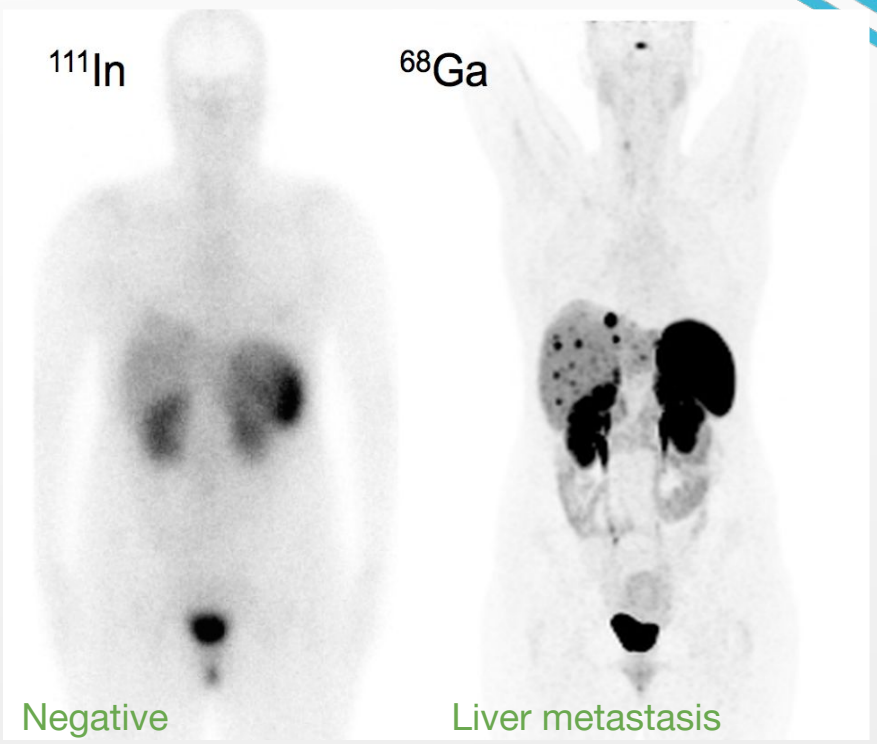
Somatostatin receptor tracer

Ga-68 DOTANOC PET superior to In- 111 Octreoscan

- **Carcinoid tumor :**
  Positive ^{68}Ga-DOTA-NOC and
  Negative ^{111}In-Octreoscan.

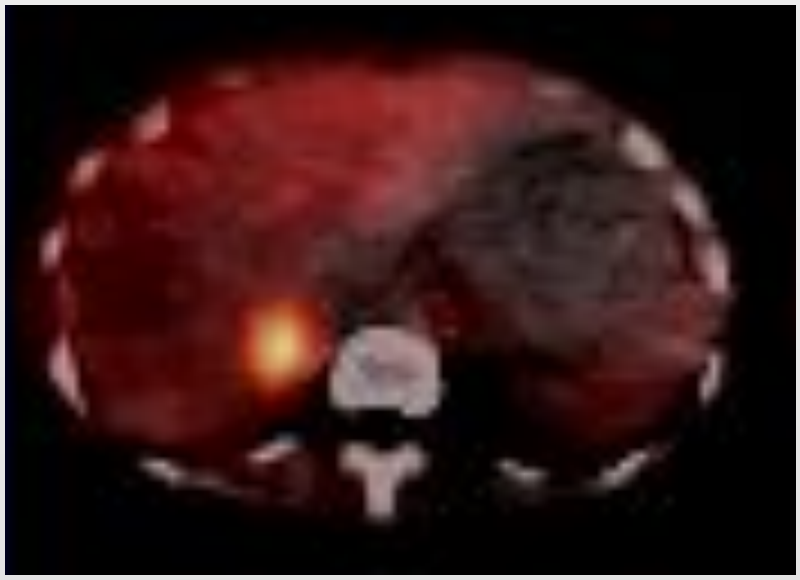
- **^{68}Ga DOTA-NOC Findings:**
  Multiple metastatic lesions in the liver.
  (The pituitary also expresses somatostatin receptors and is visualized in the ^{68}Ga PET image, along with normal uptake in the spleen, kidneys, and bladder.)

- **Indication of ^{68}Ga DOTA-NOC:** The ^{68}Ga PET scan was performed because the patient's symptoms were inconsistent with the ^{111}In-Octreoscan findings.

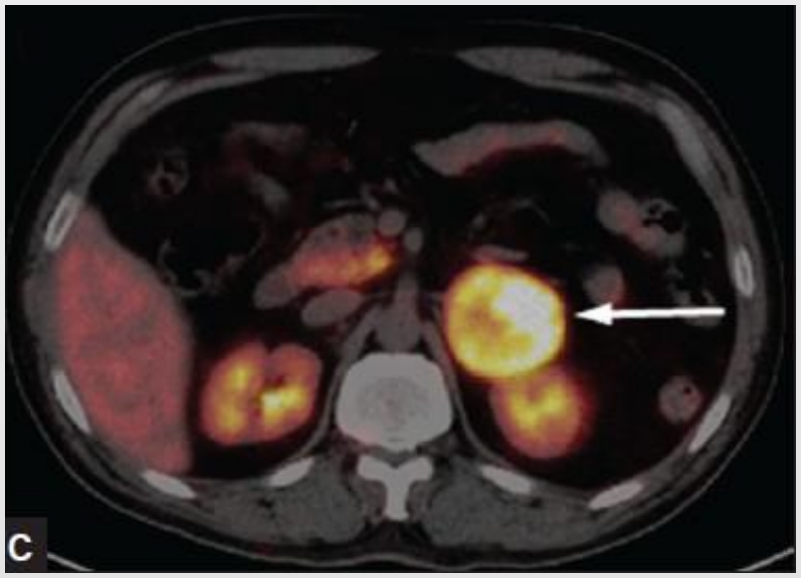


Pheochromocytoma

Ga68 DOTANOC superior to I-123 MIBG



SPECT CT - I123 MIBG



PET CT Ga68 DOTANOC
(Higher sensitivity)

Radionuclide Therapy

Properties of the Ideal Therapeutic Radiopharmaceutical

1. **Pure beta minus emitter.** =(All I want you to know from this section)
2. Medium/high energy (>1 meV).
3. Effective half-life = moderately long, e.g., days.
4. High target:non-target 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

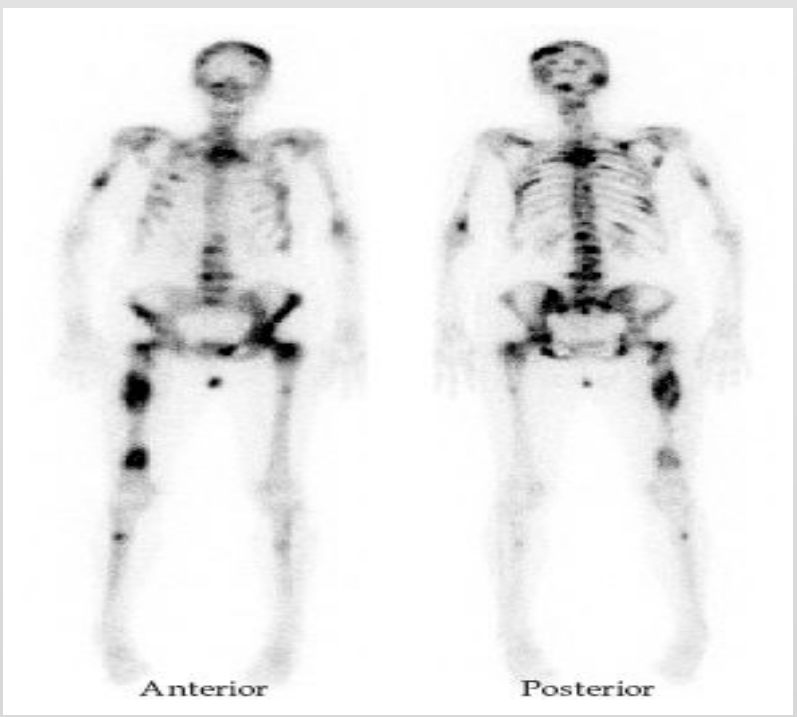
Radionuclide Therapy (cont)

Doses are not important

Agent	Indication	Dose
★ I131 :	Thyroid cancer	100-200 mci
131 MIBG :	Neuroblastoma	100-300 mCi
Strontium-89	Bone metastasis	40-60uCi/kg
Sm-153-EDTMP:	Bone metastasis	1.0 mCi per kg
Phosphorus- 32 :	Polycythaemia	2.3 mCi/m2
Y-90-Ibritumomab Tiuxetan [Zevalin®]:	B-Cell NHL	0.3 mCi/kg

> Platelet count > 150,000 cells/mL: 0.4 mCi/kg
> Platelet count 100,000-150,000 cells/mL:
The dose should never exceed 32 mCi (1,184 MBq)

Strontium-89 Therapy for Palliation of Bony Metastases



History :
A 65 Ys ,M, with CA prostate and widespread bone metastases and severe bony pain.
Admitted for palliative Strontium-89 therapy.
Procedure :
•Bone metastases was confirmed by bone scan.
The patient was given 40 mCi of **Strontium-89** I.V.according to body weight of the patient.
The patient experienced one day of exacerbated pain which was controlled by opiates but the following day showed gradual pain relieve.

Summary

NM tumor imaging

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

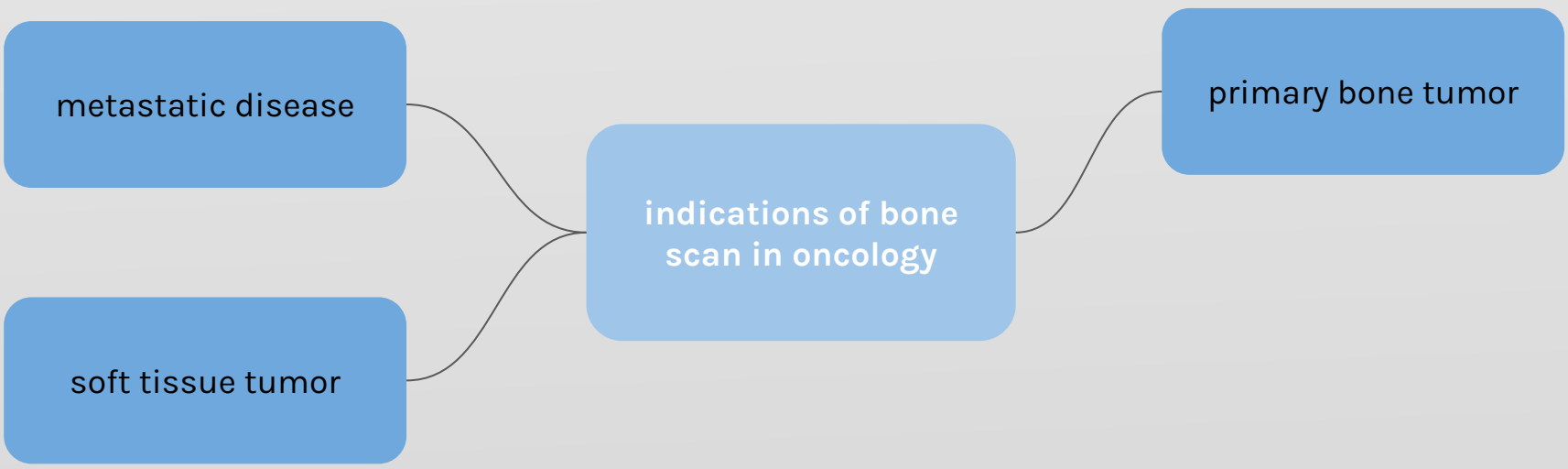
objectives of NM tumor imaging

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

tumor non- specific diagnostic radiopharmaceuticals	tumor specific diagnostic radiopharmaceuticals	therapeutic radiopharmaceuticals

• F-18 FDG
• Diphosphonates
• ga-67 citrate
• tc99m nanocolloid
• Tc99m NIBI/ thallium 201
	• (Ga-68 DOTA)
	  • (F-18-FLT)
	  • (F-18-FMISO)
		• non- specific:
		  ○ Sr-89, Sm-153, Re-189
		• specific
		  ○ I-131
		  ○ Y-90

Demonstrate tumor sites but are not specific for malignancy	Binds directly to special tumor antigens or receptors or are accumulated by special metabolic pathway	



Quiz

1-Which of the following radiopharmaceuticals is the gold standard for tumor imaging?

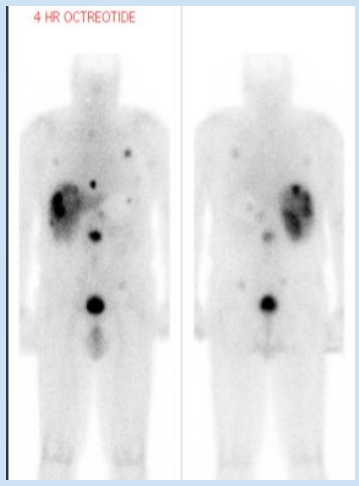
a. Iodine-111 octreotide
b. Thallium chloride 201
c. Gallium 67 citrate
d. Fluorine 18 FDG

2-in the normal distribution of FDG which of the following represents the uptake from highest to lowest?

a. kidneys> brain> heart> liver
b. brain> heart> liver> GI
c. liver> kidneys> brain> heart
d. brain>liver> GI> heart

3 -A 55 year old male came with insulinoma and an Indium-111 Octreoscan was done and showed metastasis to the?

a. Liver
b. Kidney
c. Gallbladder
d. Urinary bladder



4- which type of radiation is therapeutic

a. Alpha
b. Beta
c. Gamma
d. Positron

Answers
1)D
2)B
3)A
4)B

Team leaders

- Reem Alamri
- Alwateen Alaradi
- Abdulaziz Alamri

Team members

- Reema Alhadlq
- Farah Albakr
- Sara Alrashidi
- Nouf Albrikan
- Renad Alosaimi
- Duaa Alhumoudi
- Norah Almasaad
- Manual Altwaim
- Arwa Alkahtani
- Hind Almotyewa
- Ibrahim Alabdulkarim
- Mohamed Albabtain
- Abdulaziz Alamri
- Abdulrahman Alswat
- Munib Alkhateb
- Mohammed Alkathiri
- Omar Alhalabi
- Homoud Algadheb
- Nasser Almutawa
- Salem Alshihri

Work done by