Medical Imaging

Presented by

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Second-year students

Nuclear Medicine

- Images can only be made when appropriate radioactive substances (called radiotracer) are introduced into the body that emit gamma rays.
- A nuclear medicine image reflects the local concentration of a radiotracer within the body
- Three types
  - Conventional radionuclide imaging or scintigraphy
  - Single photon emission computed tomography (SPECT)
  - Positron emission tomography (PET)

Questions

- **What is it?**
- **How does it work?**
- **What good is it?**

Single Photon Emission Computed Tomography (SPECT) What is it?

- SPECT stands for " **Single Photon Emission Computed Tomography** " is a nuclear medicine tomographic imaging technique using two gamma cameras.
- SPECT imaging, while reflecting **the functional status** of a disease process, lacks the ability to provide accurate anatomical localization of an abnormality.
- It is able to provide 3D information. This information is typically presented as cross-sectional slices through the patient, but can be freely reformatted or manipulated as required.

Implementation Considerations

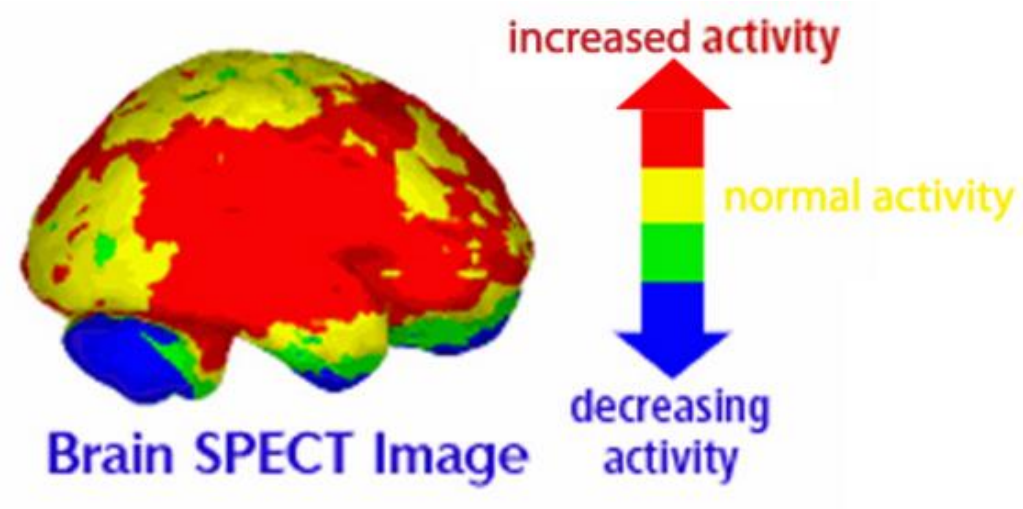
- Room Renovations and Lead Shielding
- Camera Weight Concerns
- Increased Power Demands
- Cooling Requirements
- Equipment Costs

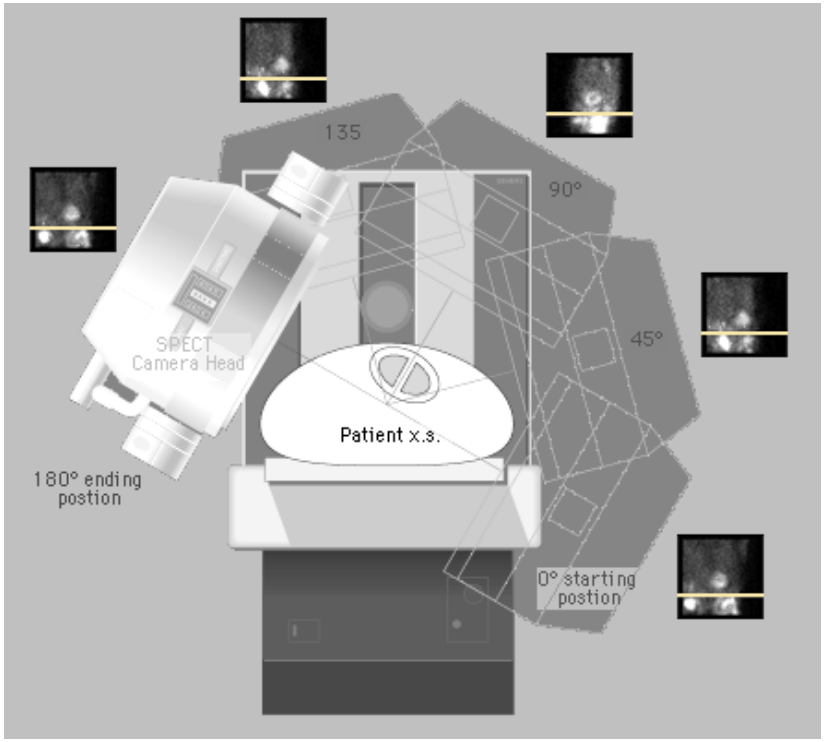
SPECT
How Does It Work?

- A radioactive tracer is injected into the bloodstream.
- As tumor cells rapidly grow, compared to neighboring cells, they require large amounts of glucose. Blood carries glucose throughout the patient but it is absorbed mostly at the tumor site, carrying the isotope with it.
- The isotope then decays, emitting gamma rays.
- To acquire SPECT images, the gamma camera is rotated around the patient and the gamma rays are collected in the detectors (placed around the patient).
- Projections are acquired at defined points during the rotation, typically every 3–6 degrees. In most cases, a full 360-degree rotation is used to obtain an optimal reconstruction.
- The time taken to obtain each projection is also variable, but 15–20 seconds is typical. This gives a total scan time of 15–20 minutes.

SPECT
How Does It Work?

- The computer collects the information from the gamma rays and forms a 3 Dimensional visual of the brain on the computer screen.
- This projection data provided information of where they came from, **locating the tumor position and shape**.
- Then, the visuals of the blood flow within the brain are studied by doctors.





What are the risks of cardiac SPECT?

SPECT is safe for most people. The amount of radiation is small, and your body will get rid of it through your kidneys in about 24 to 72 hours.

What do we need after SPECT imaging test?

- Drink plenty of water for the next couple of days. This will help flush the radioactive material from your body.

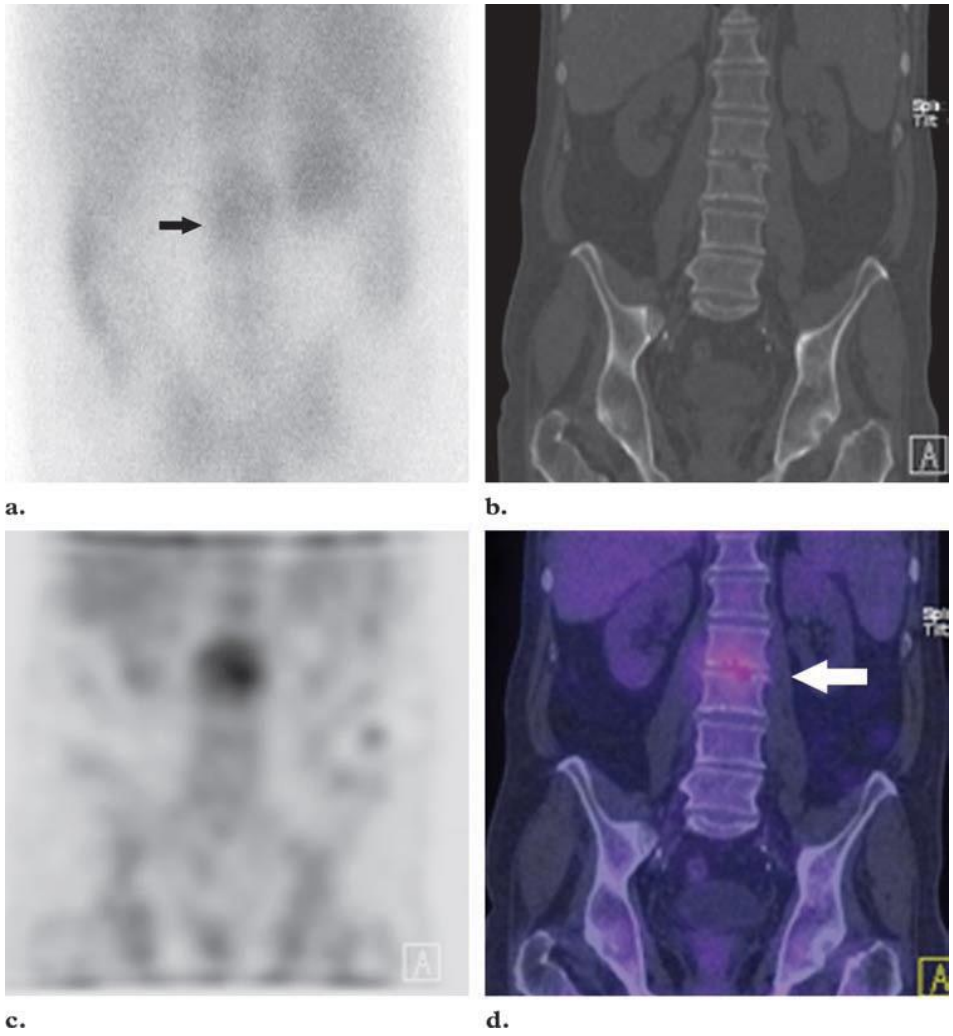
CLINICAL APPLICATIONS

- Bone Imaging
- Imaging in Infection
- Oncology Imaging
- Sentinel Node Localization
- Body Imaging
- General Nuclear Medicine Imaging

Bone Imaging

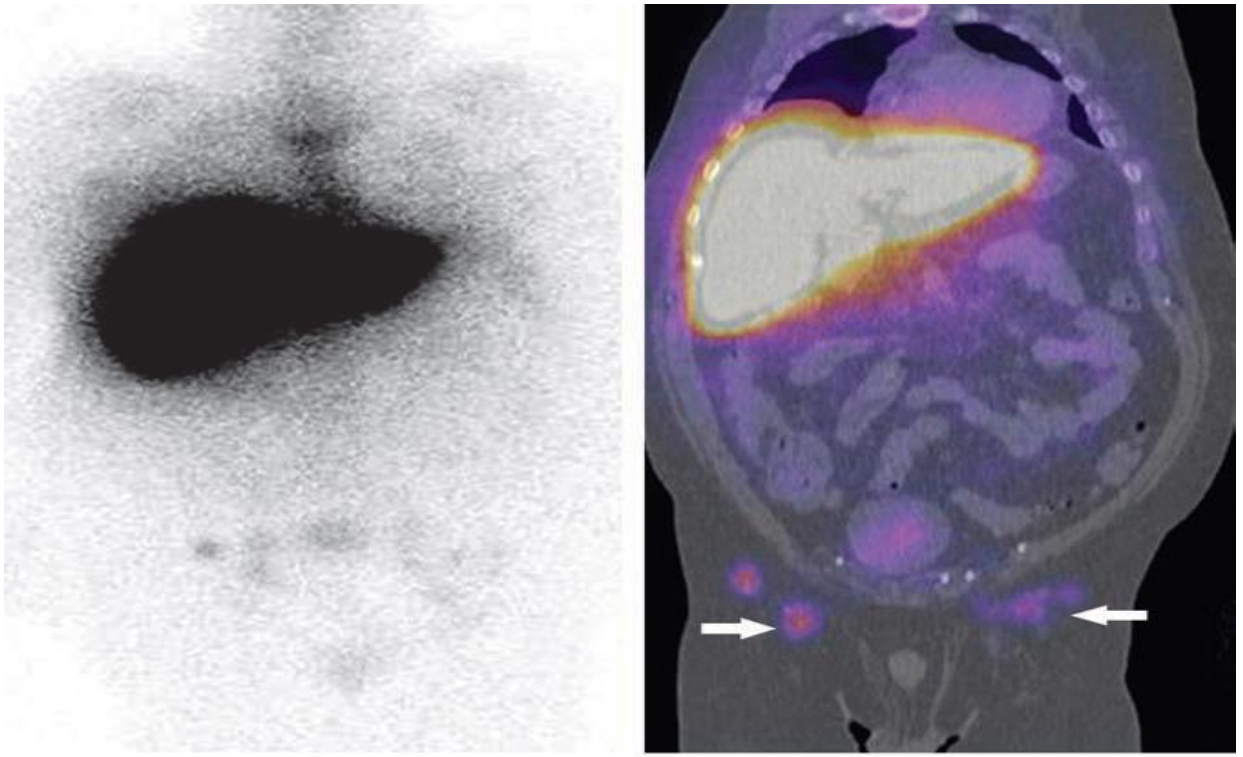
- Demonstration of the extent of malignancy in patient with sarcoma. **Anterior (a)** whole-body scan shows involvement of the medial soft tissue in the lower right thigh. Presence of bone involvement is less certain. **Anterior (b) and lateral (c) fused SPECT/CT images** show soft-tissue involvement (arrowhead) along with osseous disease (arrow).

Imaging in Infection



Gallium uptake in SPECT/CT in suspected spinal infection. **Planar image (a)** shows findings indicative of a spine infection (arrow). The location of the infection is not clear. **CT (b), SPECT (c),** and **Fusion (d)** images show correlation between abnormal SPECT findings and the defects seen on CT (arrow in **d**). The diagnosis of discitis with associated bone involvement was made using both modalities.

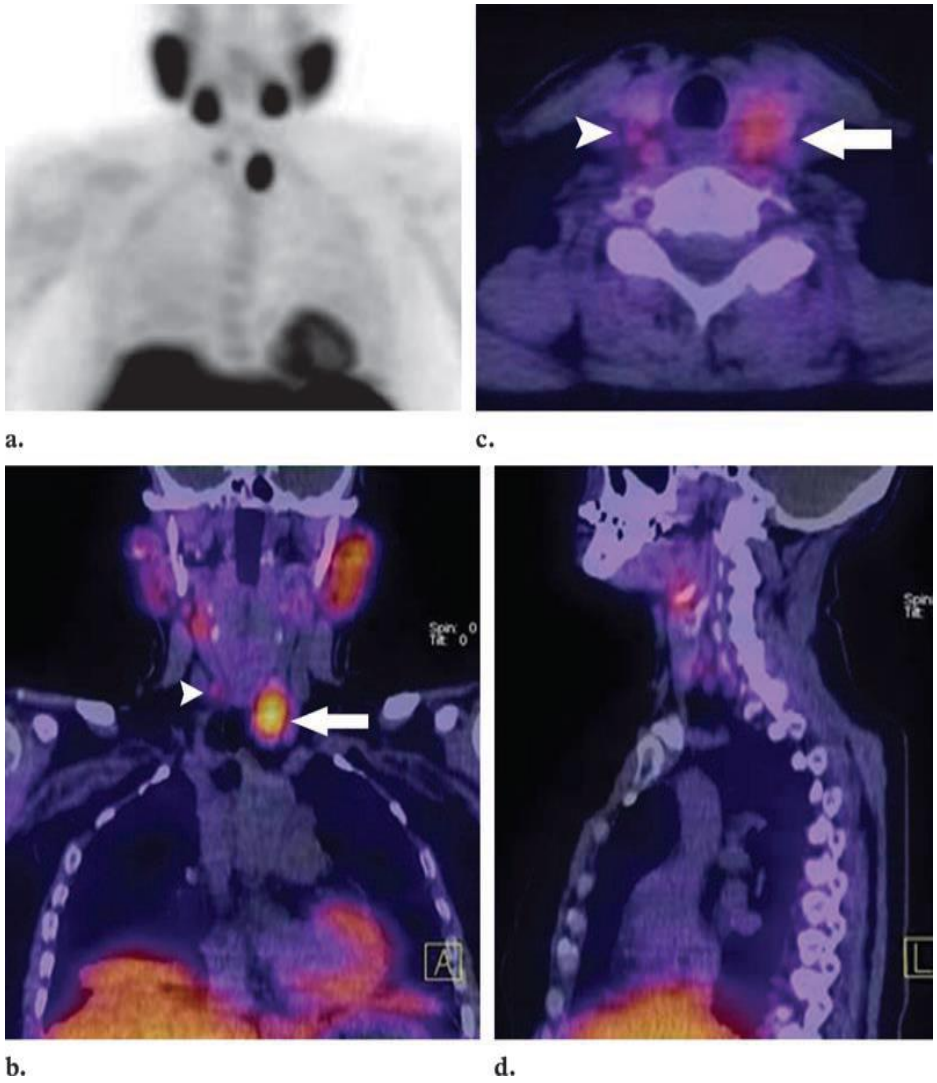
Oncology Imaging



a. b.

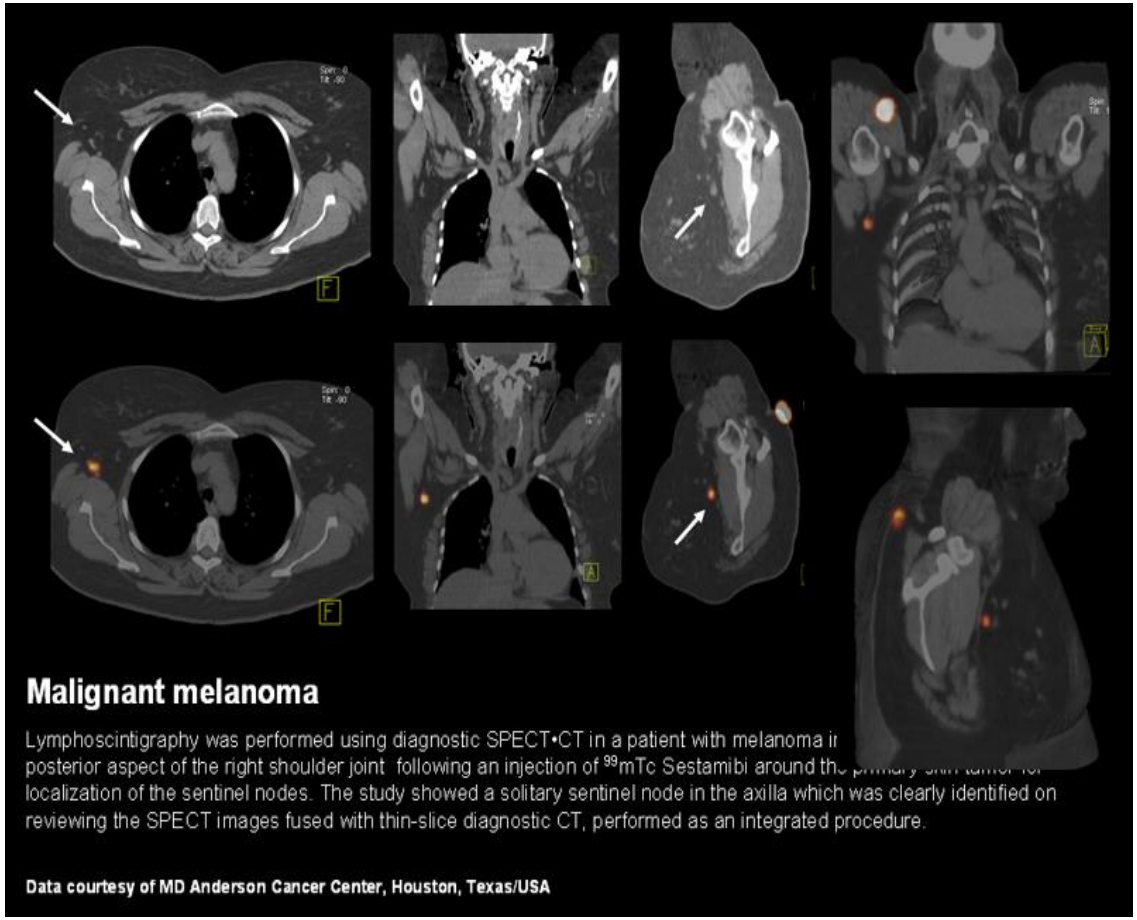
Localization of malignant disease in patient with a history of prostate cancer and an increasing PSA level. **Anterior 111In ProstaScint (a)** whole-body scan shows subtle uptake in the pelvis. **Fused SPECT/CT image (b)** shows probable metastatic disease in bilateral inguinal lymph nodes (arrows).

General Nuclear Medicine Imaging

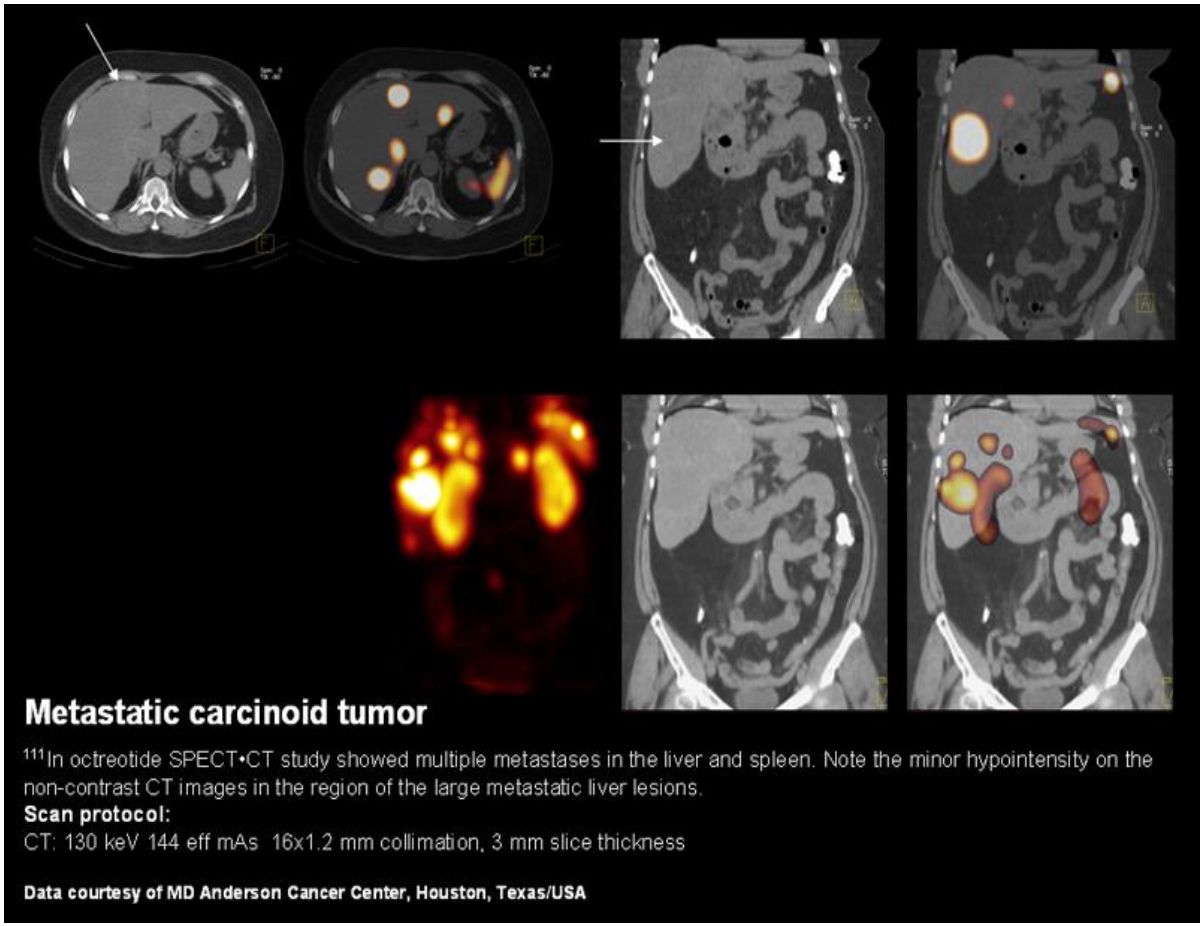


True-positive and false-positive findings in a patient with hyperparathyroidism. **Subtraction planar image(a)** shows two foci of uptake. **Coronal (b), axial (c), and sagittal (d) SPECT/CT** images show the large left-sided focus corresponds to thyroid tissue (arrow in **b** and **c**). The right-sided activity (arrowhead in **b** and **c**) is external to the thyroid. At surgery, the right-sided abnormality was a parathyroid adenoma; the left-sided abnormality was a thyroid adenoma.

MORE APPLICATIONS OF SPECT/CT



MORE APPLICATIONS OF SPECT/CT



Metastatic carcinoid tumor

^{111}In octreotide SPECT•CT study showed multiple metastases in the liver and spleen. Note the minor hypointensity on the non-contrast CT images in the region of the large metastatic liver lesions.

Scan protocol:

CT: 130 keV 144 eff mAs 16x1.2 mm collimation, 3 mm slice thickness

Data courtesy of MD Anderson Cancer Center, Houston, Texas/USA

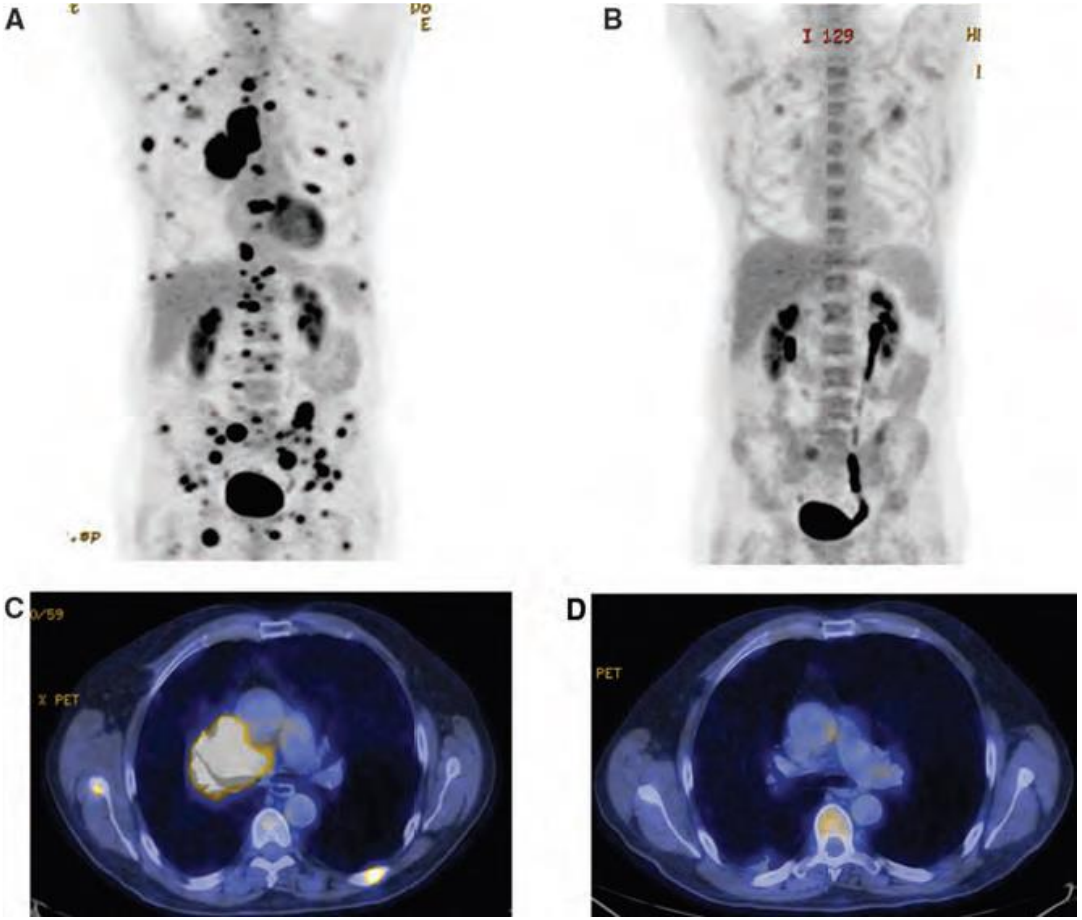
Combined SPECT/CT system

- A combined SPECT/CT system can acquire anatomic and functional data sequentially and can accurately correct and fuse the data in a single exam session.
- Separately acquired SPECT and CT studies cannot be accurately fused, would require multiple exams for the patient, and decrease departmental productivity.
- Each of the imaging modalities has strengths (e.g., very high spatial resolution in radiography) and limitations (e.g., anatomical superposition in radiography).
- In particular, nuclear medicine imaging, whether with a camera or PET, often shows abnormalities with high contrast, but with insufficient anatomic detail to permit identification of the organ or tissue with the lesion.
- Furthermore, in nuclear medicine, attenuation by the patient of emitted radiation degrades the information in the images. Combining a nuclear medicine imaging system (SPECT or PET) with another imaging system providing good definition of anatomy

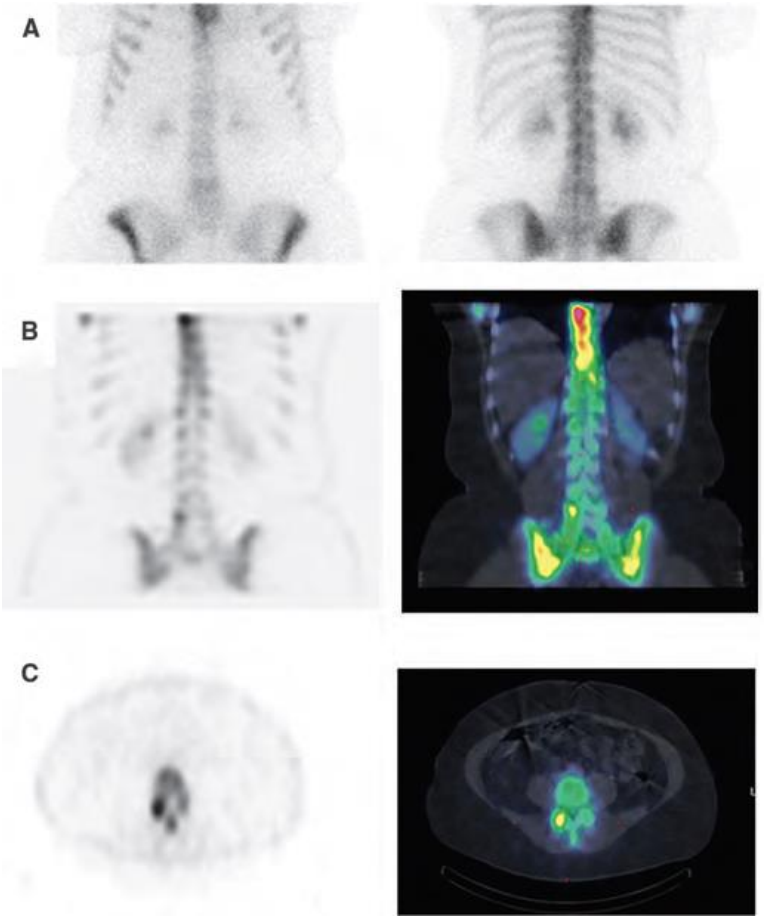
What are the benefits vs. risks?

- Because PET allows study of body function, it can help physicians detect alterations in biochemical processes that suggest disease before changes in anatomy are apparent with other imaging tests, such as CT or MRI.
- Because the radioactivity is very short-lived, your radiation exposure is low. The substance amount is so small that it does not affect the normal processes of the body.
- PET imaging has been shown to improve detection of a variety of cancers, and earlier tests have suggested this technique may be useful in identifying small tumors in patients with paraneoplastic neurological disorders.
- The radioactive substance may expose radiation to the fetus in patients who are pregnant or the infants of women who are breast-feeding. The risk to the fetus or infant should be considered in relation to the potential information gain from the result of the PET examination.

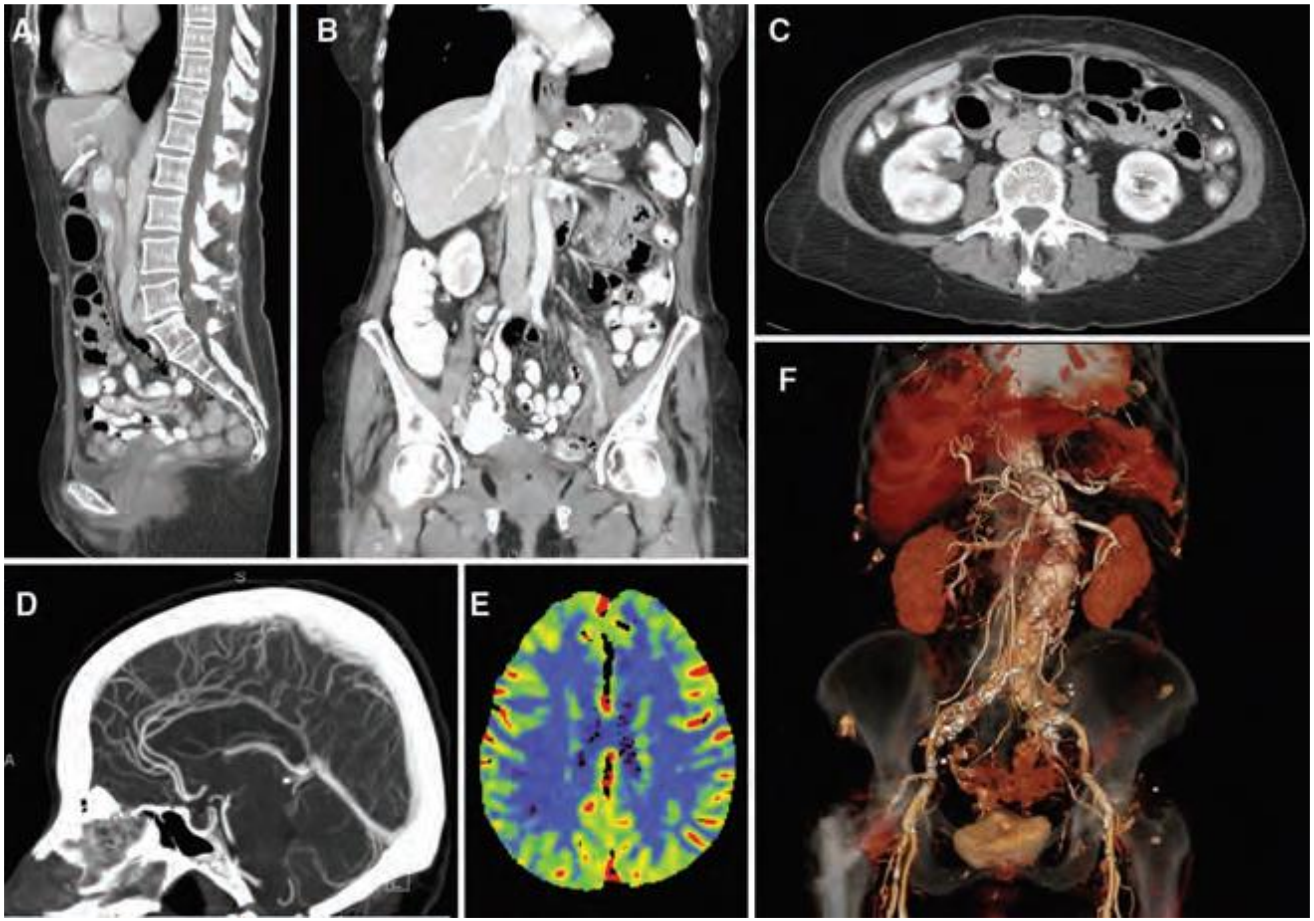
Example:
Combined Imaging Modalities



Combined Imaging Modalities



CT and Nuclear Medicine



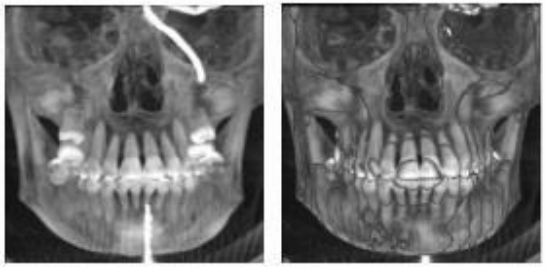
CT and Nuclear Medicine

3D Visualization

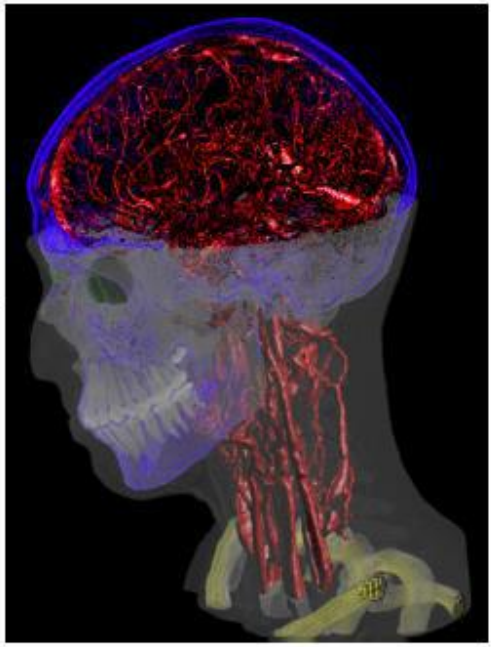
Reconstructed object enables:

- Enhanced X-ray visualization from novel views:

- Maximum Intensity (MIP) visualization:



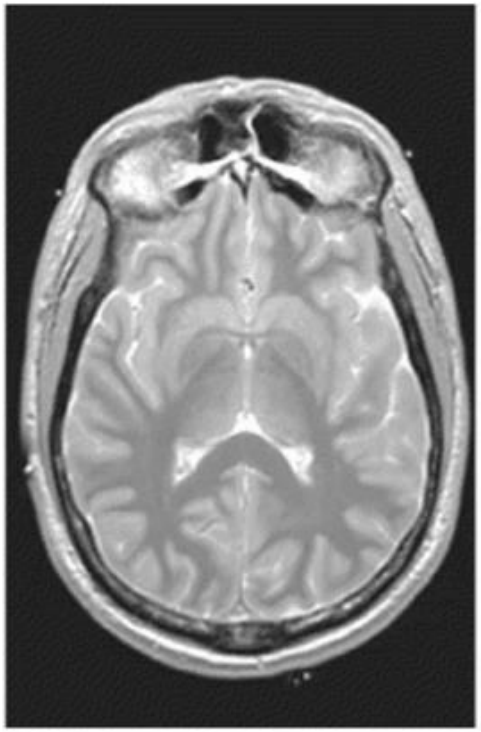
- Shaded object display:



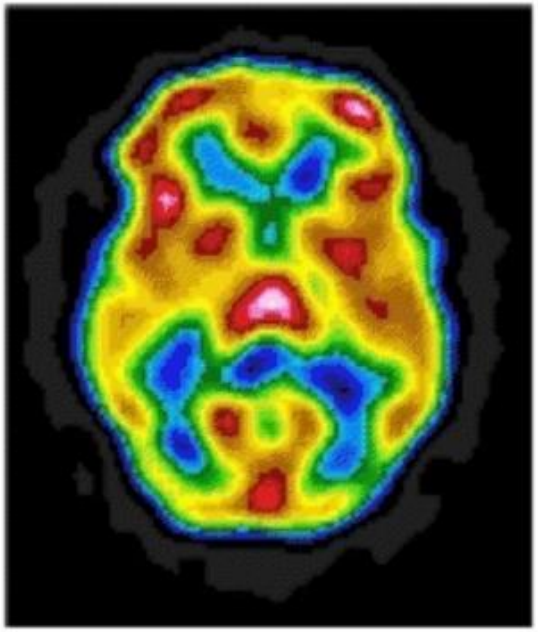
Example:

Anatomy

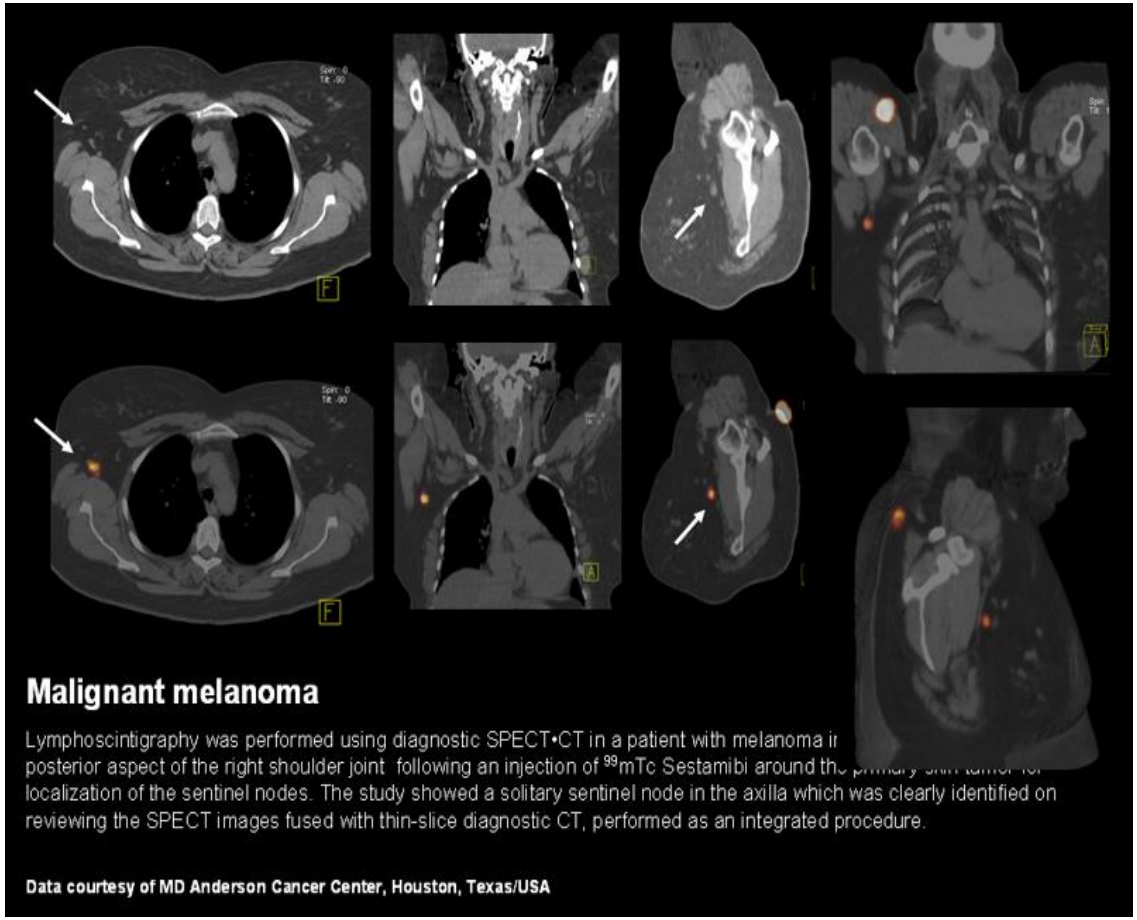
MRI



SPECT



Example: SPECT/CT



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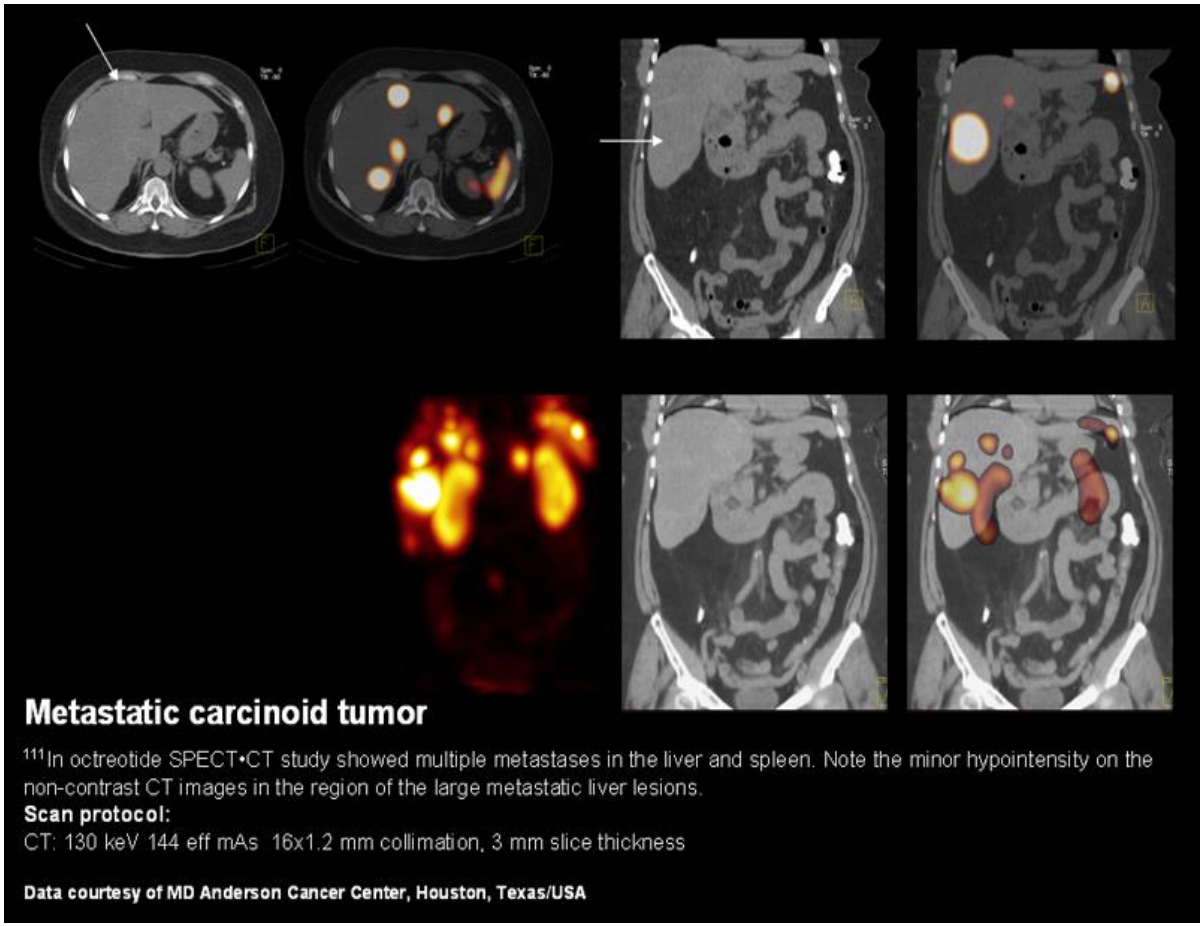

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