WorldCare Clinical
A ProScan Imaging Company

The WCC Note™

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A Weekly Guide To Harmonizing Clinical Trial Imaging

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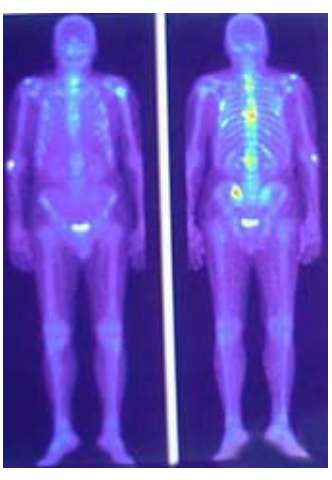
NUCLEAR MEDICINE

RADIOLOGY: THE BASIC MODALITIES
Part Seven: Nuclear Medicine

How It Works. Nuclear medicine can be thought of as almost the opposite of conventional radiology. In other fields of radiology, such as x-ray and CT, an outside source of radiation shoots x-rays through the patient, with a detector on the other side to see how much goes through. In nuclear medicine, however, the radiation comes from inside the patient!



In a nuclear medicine examination, first a "radiopharmaceutical" is prepared. This is a radioactive substance with known chemical properties, which can be injected directly into the patient. After it is injected, the substance localizes to a specific area in the body, depending on its chemical properties.

For example, the radiopharmaceutical technetium 99m-methylenediphosphanate (Tc 99m MDP) is used for bone scans. The technetium 99m is the radioactive part of the compound. Before injection into the patient, it is attached to molecules of MDP. Because MDP is a "phosphate," after injection into the patient's vein it localizes to areas that use a lot of phosphate, such as bone.

After giving enough time for the radiopharmaceutical to settle into the appropriate places, the patient is placed in a "gamma camera." This is a device that can detect the radiation coming from the patient's body (a "hot spot"), and localize where it is coming from. This machine then makes a map of where the radiation is in the patient's body.

From this map, radiologists and nuclear medicine physicians can determine a great deal about the *functions* of the body. This is another difference between nuclear medicine and traditional radiology, which depicts anatomy. In the example of Tc99m-MDP, a bone scan can tell us which parts of the body are using up a lot of phosphates – and how fast. In areas where the bone is rapidly remodeling (for example, the sites of tumors or fractures), it will take up a lot of the radiotracer, and thus will appear as very "hot" on a bone scan. Thus, nuclear medicine allows us to look for bone metastases, infections, and fractures. It gives some anatomic information, but also physiologic or functional data in some cases.

RADIATION DOSES

Radiation Doses (Measured in milliSieverts)

The radiation doses from a nuclear medicine exam are measured in the same way radiation from an x-ray or CT is measured, although the radiation comes from inside the patient. The following are some average doses from nuclear medicine exams:

Average background dose in the U.S.	3.6 mSv/yr
Chest X-ray (two views)	0.05 mSv
Brain blood flow scan (Tc99m-pertechnatate)	10 mSv
Bone scan (Tc99m-MDP)	1-2 mSv
Biliary scan (Tc99m-IDA)	2 mSv
Renal scan (Tc99m-MAG3)	0.7 mSv
Parathyroid scan (Tc99m-Sestamibi)	11 mSv
Heart scan (Tc99m-Tetrofosmin)	3-4 mSv
Thyroid Uptake and Scan (I-123)	4 mSv
Ventilation/Perfusion Scan (Xe-133 and Tc99m-MAA)	1-2 mSv
FDG-PET	10 mSv

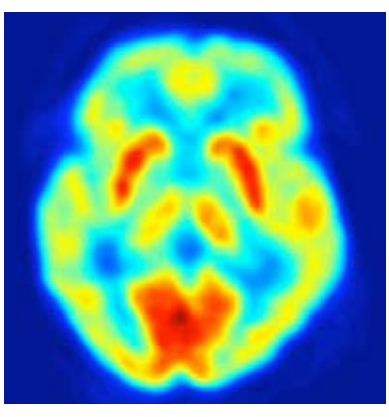
Source: Administration of Radioactive Substances Advisory Committee (ARSAC) 1998 Notes for Guidance on the Clinical Administration of Radiopharmaceuticals and Use of Sealed Radioactive Sources. Didcot, National Radiological Protection Board.

DIAGNOSTIC EXAMS

Common Diagnostic Nuclear Medicine Exams

Bone Scan

- Tc99m-methylene diphosphanate (MDP) localizes to area with increased turnover of bone
- Good for detecting metastatic disease, fractures, osteomyelitis



PET (Positron Emission Tomography)

- F18-Fluorodeoxyglucose (FDG) is the most common agent used
  - Localizes to very metabolically active areas (which use glucose), like a tumor or infection/inflammation
- Good for detection and staging of many cancers, such as lymphoma
- Standardized Uptake Value (SUV) is often used to quantify the amount of uptake to distinguish cancer from infection; this is debated and not always reliable

Thyroid Uptake

- Iodine-123 localizes to the thyroid gland, because it uses iodine to make thyroid hormones
- Thyroid uptake quantifies the amount (percentage) of the iodine administered that is taken up by the gland, to determine how active the gland is

Thyroid Scan

- Iodine-123 or Iodine-131 localizes to the thyroid gland
- Used for evaluation of thyroid masses or enlarged thyroid glands
  - Masses that take up iodine ("hot" nodules) are functioning nodules, and are thus much less likely to be malignant
  - Masses that do not take up iodine ("cold" nodules) are more likely to be malignant

Biliary Scan

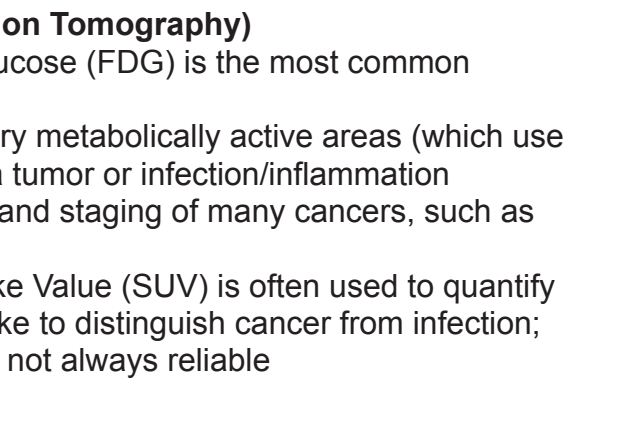
- Tc99m-immunodiacetic acid (IDA) localizes to the liver and then the biliary tract
- Used to evaluate for acute cholecystitis
  - If the IDA fills the gallbladder, that means the gallbladder is functioning normally
  - If the IDA does not fill the gallbladder, this implies that the duct to the gallbladder (cystic duct) is obstructed

Ventilation/Perfusion Scan

- The patient inhales Xe-133 to shows which parts of the lungs are getting oxygen (or "ventilated")
- Tc-99m-macroaggregated albumin (MAA) is injected and shows which parts of lungs are getting blood flow (or "perfused")
- Used to evaluate for pulmonary embolism
  - If an area is ventilated but not perfused, this indicates a clot in the pulmonary artery
  - Contrast-enhanced CT has replaced this exam in most cases

Heart Scan

- Tc99m-Tetrofosmin, Tc99m-Sestamibi, or Thallium-201 localizes to the myocardium
- Used to evaluate for heart ischemia (poor blood supply, which can lead to heart attacks)
  - Scans are done before and after exercise
  - If there is an area that has poor blood supply after exercise, but is normal at rest, this is considered "reversible," implying that this area of the heart can recover if the blood flow is restored to normal



Therapeutic Uses

Radiopharmaceuticals have the unique ability to deliver localized radiation therapy. For example, because iodine is known to localize to the thyroid gland and other thyroid tissue, high doses of Iodine-131 can be given to a patient with thyroid cancer. The Iodine-131, which emits a significant amount of radiation, will attach to thyroid tissue, both in the gland and in metastatic deposits.

Another example of therapeutic use of nuclear medicine is Strontium-89, which can be used to palliate bone pain in patients with multiple bone metastases.

PROS AND CONS

Pros and Cons of Nuclear Medicine

Pros

- Able to give information about the function and physiology of many organs

Cons

- Resolution is limited when compared to other forms of radiology
- The examinations are time-intensive
- The procedures are invasive (require injection of radiopharmaceuticals)
- Moderate radiation dose to the patient

NEXT ISSUE: COMPUTED TOMOGRAPHY (CT SCANS)

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