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# Review on Nuclear Medicine

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**ABSTRACT**

Nuclear Medicine is an advanced medical specialty that allows diagnosis and treatments in all fields of medicine. The radiopharmaceuticals used under these examinations forms the basic core of this specialty. Nuclear Medicine is the only radiology-based test that assess the functions of body parts. The present review tells us on initial basics of nuclear medicine and use of PET and SPECT in nuclear medicine with its wider significance in diagnosis.

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## INTRODUCTION

### WHAT IS NUCLEAR MEDICINE?

According to World Health Organization (WHO), Nuclear Medicine is a non-invasive type of imaging method involving the injection, inhalation of radioactive tracers to visualize various organs. The basic of this technique is the administration of chemical agent labelled with smaller molecules of radioactive tracers or radio nuclides which gets distributed accordingly their clearance kinetics and allows for the assessment of particular organ or tissue functions in vivo making it a wider tool for the diagnostic purpose. This type of technique is also highly beneficiary in therapy procedures such as cancer treatment or thyroid abnormality by administration of higher doses of radiations to specific targeted organs. The other radiological examination such as computed tomography (CT), computerized axial tomography (CAT), magnetic resonance imaging (MRI) and others assess only anatomy i.e. how the organ looks whereas nuclear medicine determines how the organ functions.

### RADIONUCLIDES OR RADIOACTIVE TRACERS IN NUCLEAR MEDICINE

A radioisotope is an unstable molecule of a chemical compound having same number of protons and the different number of neutrons in its nucleus. If one or more atoms in a particular chemical compound are replaced by a radioisotope it is called radioactive tracer which forms the core of nuclear medicine. After their administration into the body due to the radioactive decay process, emission of alpha, beta or gamma rays occurs. The emitted gamma rays are then imaged by conventional scintigraphic imaging using gamma camera as external detector which provides 2D images.

### DIFFERENCE BETWEEN NUCLEAR MEDICINE DIAGNOSTIC TEST AND OTHER IMAGING MODALITIES

The main difference between nuclear medicine diagnostic tests and other imaging modalities is that nuclear imaging techniques show the physiological function of the tissue or organ being investigated, while traditional imaging systems such as computed tomography (CT scan) and magnetic resonance imaging (MRI scans) show only the anatomy or structure. Nuclear medicine imaging techniques are also organ- or tissue-specific. While a CT or MRI scan can be used to visualize the whole of the chest cavity or abdominal cavity, for example, nuclear imaging techniques are used to view specific organs such as the lungs, heart or brain. Nuclear medicine studies can also be whole-body based if the agent used targets specific

cellular receptors or functions. Examples of these techniques include the whole-body PET scan or PET/CT scan, the Meta iodobenzylguanidine (MIBG) scan, the octreotide scans, the indium white blood cell scan, and the gallium scan.

**Nuclear medicine vs. common imaging procedures using x-rays: how they work**

| **Nuclear medicine** | **x-rays** |
|---|---|
| Radioactive material (tracer) is injected, ingested, or inhaled | Beams of radiation pass through the body |
| Images of the body show where and how the tracer is absorbed. | Images of the structure in the body are produced |
| Shows function | Shows structure |
| Used in diagnosis or treatment | Used in diagnoses |

## PRINCIPLES OF NUCLEAR MEDICINE IMAGING

The basic principle is the gamma scintigraphy imaging method. Due to charged current interactions among the ionizing radiations(emitted gamma rays),a pulse of electromagnetic radiations takes place briefly in a visible light range which is detected by suitable detectors such as photomultiplier tube or gamma camera and processed by computers to form two dimensional or three-dimensional images. In addition to this, Positron emission tomography (PET) and Single photon emission computed tomography (SPECT) are developed which are now regarded as a standard modality in nuclear medicine imaging.

## GAMMA CAMERA

The gamma camera also called as anger camera was developed by Hal Anger in 1957.It is used for imaging the emitted gamma rays from radioisotopes. Gamma camera is made up of flattened crystal planes which are optically coupled to series of photomultiplier tube called as head, mounted to bridge like structure called Gantry that is connected to computer which controls the camera operation also in acquiring and storing images. The gamma photons i.e. the electromagnetic radiations are absorbed by crystals normally sodium iodide doped with thallium. so the crystals gets scintillated due to the passage of these photons producing flash of light which is detected in the photo multiplier tube and the total number of flash produced is counted by computer. The computer then from the flash produced, reconstructs it and

displays as two-dimensional image. The 2D image produced reflects to the distribution and concentration of radioactive tracers in the particular organ imaged.

**Fig: 1. Gamma camera**

## WHOLE-BODY COUNTING SYSTEMS

"Whole-body counting" (WBC) refers to the measurement of radioactivity within the human body. The technique is only applicable to radioactive materials that emit gamma rays, although, in certain circumstances, beta emitters can also be measured. Usually, either a scintillation detector or a semiconductor detector would be used for such purposes. The person can be positioned for this measurement: sitting, lying, or standing. The detectors can be single or multiple, stationary or moving. The advantage of WBC is that it measures body contents directly. The disadvantages of WBC are that it can only be used for gamma emitters, except in special circumstances, and it is possible to misinterpret external contamination as an internal one. A well-designed counting system can detect levels of most gamma emitters at levels far below that would cause adverse effects on people's health. A WBC is calibrated with phantom containing a known distribution and a known activity of radioactive material. In radionuclide therapy, WBC may be useful in monitoring the patient's status referring to radioprotection or to dosimeters approach. In nuclear endocrinology, mainly in therapy departments, it is useful to set equipment for the evaluation of possible, hazardous contamination, so-called "hand and foot" monitor.

**Fig.2. The hand and foot monitors**

**POSITRON EMISSION TOMOGRAPHY (PET)**

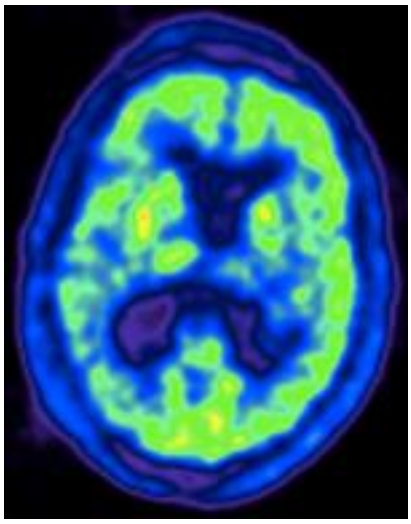


**Fig: 3. Positron emission tomography (PET)**

In PET, positron emitting radioactive tracers are used. when it undergoes radioactive decay, the pair of gamma rays emitted as positrons are detected. The most commonly used one is Fluorine 18. with the help of CT, the three-dimensional images are accomplished within. so that it can distinguish between normal and abnormal cellular activity.

## SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY

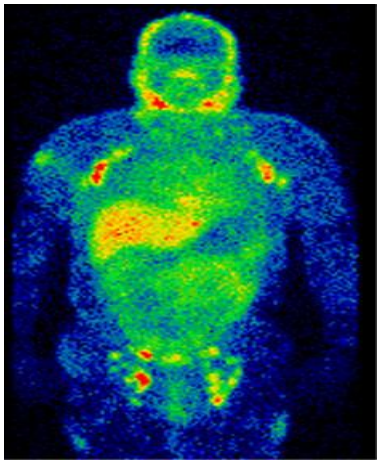


**Fig.4. Single photon emission computed tomography (SPECT)**

SPECT uses single photon emitters as radioactive tracers and the emitted gamma rays are detected using gamma camera. The head of the gamma camera is rotated around the patient's body to produce more detailed, three-dimensional images.

## INSTRUMENT FOR THYROID UPTAKE EVALUATION

The radioactive iodine uptake test (RAIU) is also known as thyroid uptake. It is a measurement of thyroid function, but does not involve imaging but provide information about the structure and function of the thyroid. The thyroid is a gland in the neck that controls metabolism, a chemical process that regulates the rate at which the body converts food to energy. They determine if the gland is working properly.And help to diagnose problems with the thyroid gland, such as an overactive thyroid gland, a condition called hyperthyroidism, cancer or other growths assess, The nature of a nodule discovered in the gland and to detect areas of abnormality, such as lumps (nodules) or inflammation, to determine whether thyroid cancer has spread beyond the thyroid gland evaluate changes in the gland following medication use, surgery, radiotherapy or chemotherapy.

## WORKING PROCEDURE IN NUCLEAR MEDICINE IMAGING

✓ The radioactive tracer suitably to the particular organ is injected into the bloodstream, swallowed or inhaled as a gas.

✓ The material accumulates in body parts under examination, where it releases off a small amount of energy in the form of gamma radiations.

✓ Gamma cameras detects this energy and, with the help of a computer, create pictures that offer details on the structure and function of organs and tissues.

✓ Nuclear medicine exams focus on processes within the body, such as rates of metabolism or levels of various other chemical activities. Areas of greater intensity, called "hot spots," indicate where large amounts of the radiotracer have accumulated and where there is a high level of chemical or metabolic activity. Less intense areas, or "cold spots," indicate a smaller concentration of radiotracer and less activity.

✓ The most common example is radioactive iodine (I-131) therapy for thyroid disease, In this radioactive iodine (I-131), is swallowed, absorbed into the bloodstream in the gastrointestinal (GI) tract, and absorbed from the blood by the thyroid gland where it destroys cells within that organ.

✓ The length of time for nuclear medicine procedures varies greatly, depending on the type of exam. Actual scanning time for nuclear imaging exams can take from 20 minutes to several hours and may be conducted over several days.

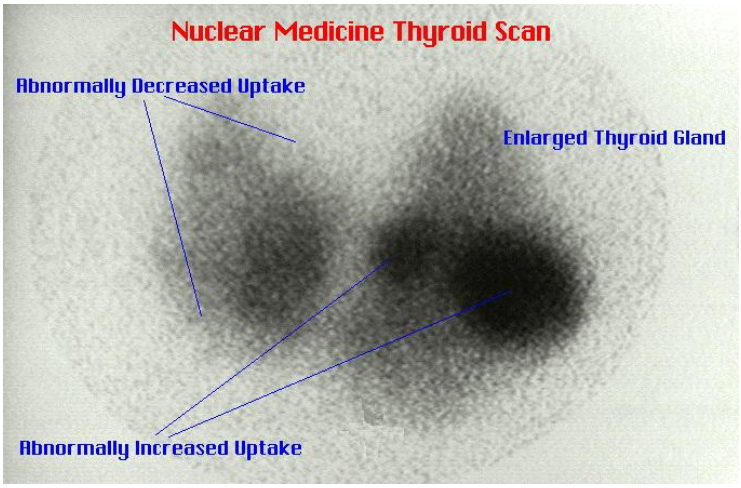
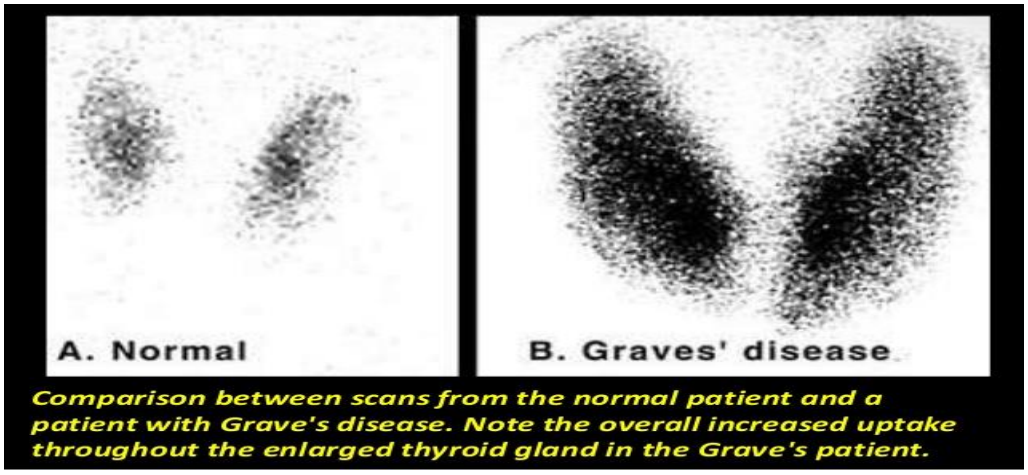



**Fig 5: Reported Nuclear medicine Imaging of thyroid gland**




**BENEFITS IN NM**

- Nuclear medicine examinations provide detailed information on the function and anatomy of body structures, often unattainable using any other procedures.
- Nuclear medicine scans provide the most useful diagnostic or treatment information for many diseases.
- A nuclear medicine scan is less expensive and provides us with more precise information than exploratory surgery.
- Nuclear medicine offers the major potential of identifying disease in its earliest stage.
- By detecting whether lesions are likely benign or malignant, PET scans may eliminate the need for surgical biopsy or identify the best biopsy location.

**RISKS IN NM**

- Because only a small dose of radiotracer is used, and thus the radiation risks are very low when compared with the potential benefits.
- Nuclear medicine diagnostic procedures have been used in practice for the past 40 years and there are no known long-term adverse effects to such low-dose exposure.
- Allergic reactions to radiotracers are extremely rare and usually mild.
- Injection of the radiotracer may cause slight pain and redness. This should rapidly resolvable one.

- Women when they are pregnant or breastfeeding should tell their condition before nuclear imaging diagnosis or treatment.

**DIAGNOSTIC APPLICATIONS OF NUCLEAR MEDICINE**

**IN HEART**

- Visualizes the functions of heart and blood flow.
- Detects the coronary artery extent and the coronary stenosis extent
- assess damage to the heart during heart attack
- evaluates the treatment options such as bypass heart surgery and also for cardiac angioplasty
- evaluate the results of procedures involving blood flow restoration
- detecting the rejections in heart transplantation
- evaluate heart functions before and after using antibiotics and chemotherapeutic agents

**IN LUNGS**

- used for the scanning of lungs to know the respiratory and blood flow problems
- assess differential lung function in lung volume reduction surgery or transplant surgery

**IN BONES**

- evaluate bones during fractures or in any infections and also in arthritis conditions
- evaluate for metastatic bone cancer
- evaluate prosthetic joints
- evaluate bone tumors and their exact locations

**IN BRAIN**

- Investigates abnormalities of the brain and suspected abnormalities in blood flow to the brain and its parts

- detect the very early onset of neurological problems such as *Alzheimer's disease*
- assists in surgical planning and identifies the areas of the brain causing seizures
- evaluate the abnormalities of some special chemicals in the brain involved in controlling movement in patients with suspected Parkinson's disease or any movement disorders
- For the evaluation of suspected brain tumor and its recurrence

**IN CANCER**

- Identifies the stages of cancer by determining the spread of cancer in various body parts
- localize lymph nodes before surgery in patients with breast cancer or skin tumors and soft tissue tumors
- evaluate response to a particular type of therapy maintained during various stages of treatment
- detect the recurrence of cancer
- detect rare tumors of the pancreas and adrenal glands
- Detects skeletal metastasis in breast cancer

**IN RENAL**

- analyze blood flow to the kidney and its normal function
- detecting obstruction in upper and lower urinary tract
- evaluate for hypertension (high blood pressure) related to the kidney arteries
- detect and follow-up urinary reflux in kidney disease patients

**IN DENTAL**

Identification of oral and maxillofacial diseases and in salivary gland studies such as its normal functioning, fistulas, lesions etc.

**IN OTHER SYSTEMS**

- identify any abnormalities in the gallbladder

- identify bleeding in the bowel mainly in severe stomach ulcer
- assess operative complications in gallbladder surgery
- evaluate lymphatic obstructions
- measure thyroid function to detect an overactive or underactive thyroid resulting in hyper and hypo thyroidic conditions
- help to diagnosis of blood cell disorders such as anemia, thalasemia, polycythemia
- Evaluate the overactive function of the parathyroid gland
- evaluate emptying of stomach
- Evaluate the flow and detects any leaks in spinal

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