Nuclear Medicine Physics

The very nature of nuclear medicine depends on physics since it deals with the interaction of the radiation emitted from within the patient with the detectors used to provide the images as well as with the patient him or herself. The operation of nuclear medicine equipment is dependent on complex physical principles.

Nuclear Medicine is the use of small amounts of radioactive compounds to diagnose and treat various disorders in humans. It measures, or "traces", the radioactive compounds as they move around the body, often using specialised imaging equipment. Most of the studies and treatments assess the physiological activity of the body non-invasively, making them very attractive and sensitive to use, such that now they are an essential component of an advanced health care system

The role of nuclear medicine in modern therapy of cancer

Nuclear medicine is a multidisciplinary field that develops and uses instrumentation and tracers (radiopharmaceuticals) to study physiological processes and noninvasively diagnose, stage, and treat diseases. Particularly, it offers a unique means to study cancer biology in vivo and to optimize cancer therapy for individual patients. A tracer is either a radionuclide alone, such as iodine-131 or a radiolabel in a carrier molecule such as (18)F in fluorodeoxyglucose ((18)F-FDG), or other feasible radionuclide attached to a drug, a protein, or a peptide, which when introduced into the body, would accumulate in the tissue of interest. Nuclear medicine imaging, including single-photon emission computer tomography and positron emission tomography, can provide important quantitative and functional information about normal tissues or disease conditions, in contrast to conventional, anatomical imaging techniques such as ultrasound, computed tomography, or magnetic resonance imaging. For treatment, tumor-targeting agents, conjugated with therapeutic radionuclides, may be used to deposit lethal radiation at tumor

sites. Nuclear medicine plays a crucial role in the modern approach to cancer treatment by providing means to the following :

- Determine the extent or severity of the disease, including metastases
- Select the most effective therapy based on the unique biologic characteristics of the patient and the molecular properties of a tumor
- Accurately assess the effectiveness of a treatment regimen
- Adapt treatment plans quickly in response to changes in molecular and biochemical characteristics of the tumor
- Assess disease progression
- Identify recurrence of disease and help manage ongoing care

Diagnosis by using nuclear medicne

Nuclear medicine is noninvasive. Except for intravenous injections, it is usually painless. These tests use radioactive materials called radiopharmaceuticals or radiotracers to help diagnose and assess medical conditions.

Radiotracers are molecules linked to, or "labeled" with, a small amount of radioactive material. They accumulate in tumors or regions of inflammation. They can also bind to specific proteins in the body. The most common radiotracer is F-18 fluorodeoxyglucose (FDG), a molecule similar to glucose. Cancer cells are more metabolically active and may absorb glucose at a higher rate. This higher rate can be seen on PET scans. This allows to detect disease before it may be seen on other imaging tests. FDG is just one of many radiotracers in use or in development

usually receive the radiotracer in an injection. Or you may swallow it or inhale it as a gas, depending on the exam. It accumulates in the area under examination. A special camera detects gamma ray emissions from the radiotracer. The camera and a computer produce pictures and supply molecular information.

Many imaging centers combine nuclear medicine images with computed tomography (CT) or magnetic resonance imaging (MRI) to produce special views. Doctors call this image fusion or co-registration. Image fusion allows the doctor to connect and interpret information from two different exams on one image. This leads to more precise information and a more exact diagnosis. Single-photon emission CT/CT (SPECT/CT) and positron emission tomography/CT (PET/CT) units can perform both exams at the same time. PET/MRI is an emerging imaging technology. It is not currently available everywhere.

Therapy by nuclear medicine

Nuclear medicine also offers therapeutic procedures, such as radioactive iodine (I-131) therapy that use small amounts of radioactive material to treat cancer and other medical conditions affecting the thyroid gland, as well as treatments for other cancers and medical conditions.

Non-Hodgkin's lymphoma patients who do not respond to chemotherapy may undergo radioimmunotherapy (RIT).

Radioimmunotherapy (RIT) is a personalized cancer treatment that combines radiation therapy with the targeting ability of immunotherapy, a treatment that mimics cellular activity in the body's immune system.

Common uses of nuclear medicine imaging

Physicians use nuclear medicine imaging procedures to visualize the structure and function of an organ, tissue, bone or system within the body.

In adults, nuclear medicine is used to

1-Heart

- visualize heart blood flow and function (such as a myocardial perfusion scan)
- detect coronary artery disease and the extent of coronary stenosis
- assess damage to the heart following a heart attack
- evaluate treatment options such as bypass heart surgery and angioplasty

- evaluate the results of revascularization (blood flow restoration) procedures
- detect heart transplant rejection
- evaluate heart function before and after chemotherapy (MUGA)

2-Lungs

- scan lungs for respiratory and blood flow problems
- assess differential lung function for lung reduction or transplant surgery
- detect lung transplant rejection

3-Bones

- evaluate bones for fractures, infection and arthritis
- evaluate for metastatic bone disease
- evaluate bone tumors
- identify sites for biopsy

4-Brain

- investigate abnormalities in the brain in patients with certain symptoms or disorders, such as seizures, memory loss and suspected abnormalities in blood flow
- detect the early onset of neurological disorders such as Alzheimer's disease
- assist in surgical planning and identify the areas of the brain that may be causing seizures
- evaluate for abnormalities in a chemical in the brain involved in controlling movement in patients with suspected Parkinson's disease or related movement disorders
- evaluation for suspected brain tumor recurrence, surgical or radiation planning or localization for biopsy

Benefits of nuclear medicine

- Nuclear medicine exams provide unique information that is often unattainable using other imaging procedures. This information may include details on the function and anatomy of body structures.

- Nuclear medicine supplies the most useful diagnostic or treatment information for many diseases.

- Nuclear medicine offers the potential to identify disease in its earliest stage, often before symptoms occur or abnormalities can be detected with other diagnostic tests.

- By detecting whether lesions are likely benign or malignant, PET scans may eliminate the need for surgical biopsy or identify the best biopsy location.

- PET scans may provide additional information that is used for radiation therapy planning