UNNOTICED BUT IMPORTANT TWO IN ONE

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ABSTRACT

Introduction: Nuclear medicine is a branch of medicine that uses small amounts of radioactive material to diagnose and determine the severity of some diseases and on the other hand treat a variety of diseases.

Diagnostic Part: This involves administration of a radionuclide with an affinity for an organ or tissue of interest followed by the recording of the distribution of radioactivity with a stationary or scanning external scintillation camera (commonly a Gamma camera). Basing on the radioactivity pattern, a disease condition is diagnosed and/or its severity (or distribution) determined.

Interventional Nuclear Medicine: This involves use of ionizing radiation energy (short range beta rays) from a radioactive material introduced into the body to kill cancer cells and shrink tumors. An important example is radioactive iodine (I^{131}) therapy in thyroid hyperactivity.

Conclusion: The resolution of structures of the body when using nuclear medicine may not be as high as with other imaging modalities such as CT or MRI but is more sensitive especially when coupled with CT such as in PET/CT; and the functional information gained from it is often unobtainable when other imaging modalities are used.

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NUCLEAR MEDICINE

Nuclear medicine is a branch of medicine that uses small amounts of radioactive material to diagnose and determine the severity of or treat a variety of diseases. The resolution of body structures when using nuclear medicine may not be as high as with other imaging modalities, such as CT or MRI but it is more sensitive; and the functional information gained from it is often unobtainable when other imaging modalities are used [1].

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INTRODUCTION

Nuclear medicine is a branch of medicine that uses small amounts of radioactive material to diagnose and determine the severity of or treat a variety of diseases including many types of cancers, heart diseases, gastrointestinal, endocrine, neurological disorders and other abnormalities within the body. Nuclear medicine procedures are able to detect molecular activity within the body; as a result they offer the potential to identify disease at its earliest stage as well as a patient's immediate response to therapeutic interventions.

Nuclear medicine (or radionuclide) diagnostic imaging procedures are minimally invasive and, with the exception of intravenous injections, are usually painless medical tests that help physicians diagnose and evaluate medical conditions. These imaging scans use radioactive materials called radiopharmaceuticals or radiotracers.

Depending on the type of nuclear medicine examination, the radiotracer is either injected into the body, swallowed or inhaled as a gas and eventually accumulates in the organ or area of the body being examined. Radioactive emissions from the radiotracer are detected by a special camera or imaging device that produces images andor detailed molecular information. [2]

PART ONE: DIAGNOSTIC MEDICAL IMAGING

Overview

In nuclear medicine imaging, radiopharmaceuticals are introduced and external detectors (gamma cameras) capture and form images from the radiations (scints) emitted. This process is unlike a diagnostic X-ray where external radiation is passed through the body to form an image.

There are several techniques used in diagnostic nuclear medicine grouped in two categories.

- Two Dimensional Imaging techniques like Scintigraphy
- Three Dimensional Imaging technique like Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET)

Scintigraphy

A diagnostic procedure that involves administration of a radionuclide with an affinity for the organ or tissue

of interest, followed by recording of the distribution of radioactivity with a stationary or scanning external scintillation camera (commonly Gamma camera).[3]

Ocean Road Cancer Institute Gamma camera

By organ or organ system

Cholescintigraphy: It is also known as hepatobiliary imaging. It helps evaluate the liver, gallbladder and the biliary ducts that are part of the hepatobiliary system[2].

Lung Scintigraphy: The most common use of lung Scintigraphy is diagnosing pulmonary embolism using the ventilation and perfusion scan; Less commonly indicated for evaluation of lung transplantation, preoperative evaluation and evaluation of right-to-left shunts[4].

Bone Scintigraphy: Any increased physiological function such as a healing bone fracture will usually show increased concentration of the tracer.

Heart scan: A thallium stress test is a form of Scintigraphy. The amount of thallium^{-201} detected in cardiac tissues correlates with cardiac tissue blood supply. Viable cardiac cells have normal Na+/K+ ion exchange pumps. Thallium binds to the K+ pumps and is thus transported into the cells. Exercise or dipyridamole induces widening (vasodilation) of normal coronary arteries. This produces coronary steal from areas where arteries are maximally dilated. Areas of infarction or ischemia will remain "cold". Pre and post-stress thallium may indicate areas that will benefit from myocardial revascularization. Redistribution indicates the existence of coronary steal and the presence of ischaemic coronary artery disease[5].

Parathyroid Scintigraphy: Sestamibi parathyroid Scintigraphy is used to detect parathyroid adenomas.

Full body: Examples are Gallium scans and MIBG scan which detect adrenergic tissue and thus can be used to identify the location of tumors such as phaeochromocytomas and neuroblastomas.

Function tests: Certain tests, such as the Schilling test and Urea breath test, use radioisotopes but they are not used to produce specific images.

Thyroid Scan and Uptake

A thyroid scan is used in imaging. The radioactive iodine uptake test (RAIU) is also known as a thyroid uptake. It is a measurement of thyroid function, but does not involve imaging.

Common Uses of the Procedure

The thyroid scan is used to determine the size, shape and position of the thyroid gland. The thyroid uptake is performed to evaluate the function of the gland. A whole-body thyroid scan is typically performed on people who have had thyroid cancer before therapy to look for metastasis and after therapy for response.

Preparing the patient

The patient may wear a gown or their own clothing during the examination.

Important information to be known by the physician before the procedure

- Any possibility that the patient is pregnant or breastfeeding.
- If the patient is taking any medications including vitamins and herbal supplements or has an allergy. Recent medical history of illnesses or other medical conditions should be known.
- If patient has had any tests such as an X-ray or CT scan, surgeries or treatments using iodinated contrast material within the last two months
- If the patient is taking medications or ingesting other substances that contain iodine, including kelp, seaweed, cough syrups, multivitamins or heart medications.

A few days prior to the examination, blood tests may be performed to measure the level of thyroid hormones in the patient's blood. The patient may be told not to eat for several hours before the exam because eating can affect the accuracy of the uptake measurement.

- Jewelry and other metallic accessories should be left at home or removed prior to the exam as they may interfere with the procedure.

How does the procedure work?

A radioactive material called a radiopharmaceutical or radiotracer is either injected into the bloodstream, swallowed or inhaled as a gas. This radioactive material accumulates in the organ or area of the body to be examined, where it gives off a small amount of energy in the form of gamma rays. A gamma camera detects this energy and with the help of a computer creates images offering details on both the structure and the function of organs and tissues concerned in the body.

Thyroid Scan

The patient is positioned on an examination table. A nurse or technologist inserts an intravenous (IV) line into a vein in the patient's arm.

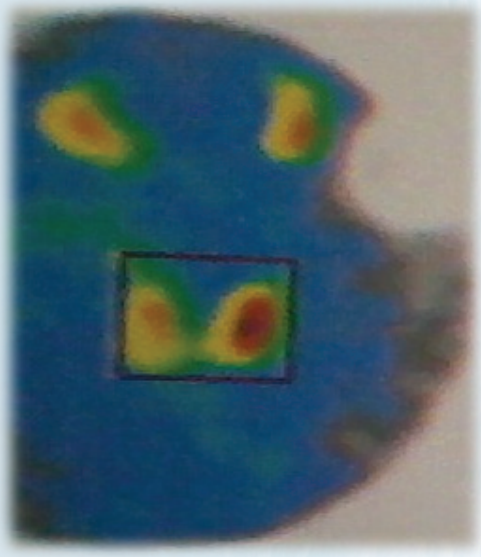
The dose of radiotracer is either swallowed in liquid or capsule 24 hours before the scan, injected intravenously 30 minutes before the scan or inhaled as a gas.

When it is time for the imaging to begin, the patient will lie down on a moveable examination table with the head tipped backward and neck extended. The gamma camera

will then take a series of images, capturing images of the thyroid gland. The patient will need to remain still for brief periods of time while the camera is taking pictures.
If the patient had an intravenous line inserted for the procedure, it will usually be removed unless he/she is scheduled for an additional procedure that same day that requires an intravenous line.
Actual scanning time for a thyroid scan is 30 minutes or less [2].

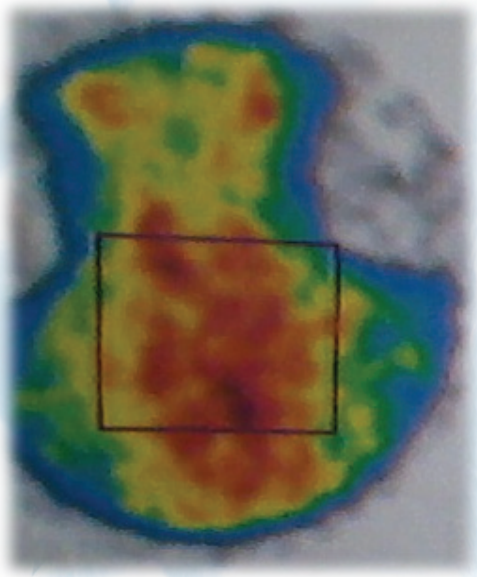
Thyroid Uptake

The patient will be given radioactive iodine (I^{-123} or I^{-131}) in liquid or capsule form to swallow. The thyroid uptake will begin several hours to 24 hours later. Often, two separate uptake measurements are obtained at different times.
When it is time for the imaging to begin, the patient will sit in a chair facing a stationary probe positioned in front of her/his thyroid gland in the neck.
Actual scanning time for each thyroid uptake is five minutes or less [2].

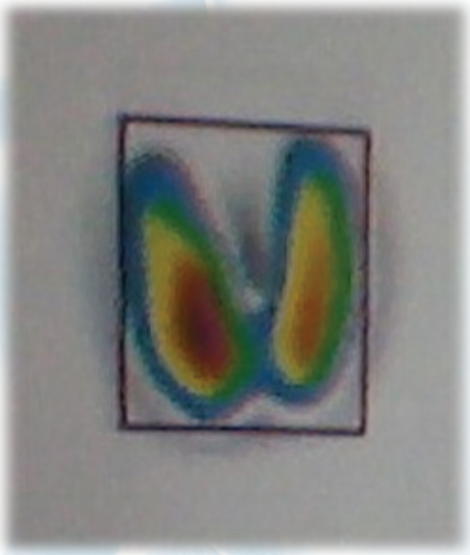


Cold right lobe of the thyroid
thyroid uptake is 0.38%(0.36%-5.00%)

Simple goiter with thyroid uptake 1.43%
(0.36%-5.00%)



Non-toxic multinodular goiter
Thyroid uptake is 0.93%(0.36%-5.00%)



Graves Disease

Thyroid uptake is 29.86%(0.36-5.00%)

Images after being captured by a gamma camera and processed by a computer [6].

What will the patient experience during and after the procedure?

The procedures are painless. During thyroid scanning, the patient may feel uncomfortable when lying completely still with the head extended backward.
The patient may feel a slight pin prick when an intravenous line is being inserted or an intravenous radiotracer is being introduced.
When swallowed, the radiotracer has little or no taste. When inhaled, it feels no different than when breathing room air or holding your breath.
The radiotracer in the body will lose its radioactivity over time via the natural process of radioactive decay. Some may pass out via urine or stool. Drinking plenty of water may also help flush the radioactive material out [2].

Benefits

•Nuclear medicine examinations offer information that is unique including details on both function and structure; often unattainable using other imaging procedures.

•For many diseases, nuclear medicine scans yield the most useful information needed to make a diagnosis or to determine the appropriate treatment.

•Nuclear medicine is less expensive and may yield more precise information than exploratory surgery in some medical conditions [2].

Risks

•Because the doses of radiotracer administered are small, diagnostic nuclear medicine procedures result in low radiation exposure. The amount of radiation is kept within a safe limit relative to the established "ALARA" (As Low As Reasonably Achievable) principle.

•Nuclear medicine diagnostic procedures have been used for more than five decades, and there are no known long-term adverse effects from such low-dose exposure.

• The risks are always weighed against the potential benefits. The patient will be informed of all significant risks prior to the treatment and have an opportunity to ask questions.

•Allergic reactions to radiopharmaceuticals may occur but are extremely rare and are usually mild.

•Slight pain and redness after injection of the radiotracer which should rapidly resolve[2].

Limitations of the Thyroid Scan and Uptake

•It is not performed on pregnant women and not recommended for breastfeeding women.

•It can be time consuming from radiotracer introduction to imaging; though in some cases, newer equipment is available that can substantially shorten the procedure time.

•The resolution of structures of the body with nuclear medicine may not be as high as with other imaging techniques, such as CT or MRI[2].

PART TWO: INTERVENTIONAL NUCLEAR MEDICINE

Radiation therapy also called internal radiation therapy is the use of ionizing radiation (short range beta rays) energy to kill cancer cells and shrink tumors. External Beam Radiation Therapy (EBRT) involves high-energy X-ray beams generated by a machine that are directed at the tumor from outside the body [2].

Unsealed Source Therapy

These are therapeutic interventions in which the radioactive source is applied directly orally, via inhalation or intravenously. Radiopharmaceuticals used emit ionizing radiation that travels only a short distance, thereby minimizing unwanted side effects and damage to normal organs or nearby structures.

This therapeutic intervention can be used in hyperthyroidism and thyroid cancer, refractory lymphoma, neuroendocrine tumours and palliative bone treatment.

Most of these are outpatient procedures since there are few side effects from the treatment and the radiation exposure to the general public is kept within safe limits [2].

Radioiodine (I^{-131}) Therapy for Hyperthyroidism

Radioactive Iodine I^{-131} (also called Radioiodine I^{-131}) therapy is a treatment for an overactive thyroid, a condition called hyperthyroidism. Hyperthyroidism can be caused by Graves' disease, in which the entire thyroid gland is overactive, or by nodules within the gland which are locally overactive in producing too much thyroid hormone.

Radioactive iodine (I^{-131}), an isotope of iodine that emits radiation, is used for medical purposes. When a small dose of I^{-131} is swallowed, it is absorbed into the bloodstream in the gastrointestinal tract and concentrated from the blood by the thyroid gland, where it begins to destroy the gland's abnormal cells.

Radioactive iodine I^{-131} may also be used to treat thyroid cancer [2].

Important precautions to the patient

Radioiodine therapy is not used in a patient who is pregnant as the mother may damage the baby's thyroid gland.

It is also contraindicated in breastfeeding women unless they are willing to cease breastfeeding [2].

Side effects from the procedure

Patients may experience some pain in the thyroid after I^{-131} therapy similar to a sore throat thus analgesics are recommended.

Some or most of the thyroid gland will be destroyed by this procedure. Hormones produced by the thyroid are essential for metabolism thus most patients will need to take thyroid pills for the rest of their lives following the procedure. Thyroid pills are inexpensive, and patients will typically be instructed to take one per day [2].

CONCLUSION

Nuclear medicine is very important as it can be used for diagnosis as well as for treatment. During imaging of a part of the body, it uses functional and anatomical changes to reach the diagnosis. Nuclear medicine can detect functional and anatomical abnormalities which is an advantage over other imaging modalities. In treatment, short range ionizing radiations are used and as such these radiations are limited to the targeted tissues only. Radiopharmaceuticals used are linked to a tracer which is taken preferentially by a certain tissue or organ, thus decreasing the risk of radiation effect to other tissues which are not under investigation.

Medical doctors should be encouraged to request for these diagnostic and treatment procedures as they are safe, have reasonable cost and are more sensitive than other imaging modalities.

When nuclear medicine is properly used for medical conditions, diagnosis will not be missed, and treatment results and follow up will be remarkable.

The government should consider providing more funds to this field so that it can have more advanced and refurbished equipment. The Government should also ensure training of the required professionals to manage the installed nuclear medicine facilities within the country.

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