ISSN 2229-5518

THE IMPORTANCE OF USING RADIOTRACER IN DIAGNOSING CANCER

James, D[1*] and B JAMES[2]

[1]Department of Physics University of Maiduguri, PO box 1069, Bama Road Maiduguri, Borno State, Nigeria.

Corresponding author: Email: d1j2a3a4@gmail.com or danieljames0332015@gmail,com

Abstract

Nuclear Medicine is a medical specialty that allows modern diagnosis and treatment of cancer using radiopharmaceuticals original radiotracers (drugs linked to a radioactive isotope). Radiopharmaceuticals are considered a special group of drugs and thus their preparation and use are regulated by a set of policies that have been adopted by individual member of countries. The radiopharmaceuticals used in diagnostic examinations are administered in very small doses. So, in general, they have no pharmacological action, side effects or serious adverse reactions. In contrast, nuclear medicine procedures use a radioactive material, called a radiopharmaceutical or radiotracer, which is injected into the bloodstream, swallowed or inhaled as a gas. This radioactive material accumulates in the organ or area of the body being examined, where it gives off a small amount of energy in the form of gamma rays. Special cameras detect this energy, and with the help of a computer, create pictures offering details on both the structure and function of organs and tissues in the body. The biggest problem associated with their use is the alteration in their bio distribution that may cause diagnostic errors. Nuclear Medicine is growing considerably influenced by the appearance and development of new radiopharmaceuticals in both diagnostic and therapeutic fields and primarily to the impact of new multimodality imaging techniques (SPECT-CT, PET-CT, PET-MRI, etc.). It is mandatory to know the limitations of these techniques, distribution and eventual physiological alterations of radiopharmaceuticals, contraindications and adverse reactions of radiologic contrasts, and the possible interference of both. **Keywords**: Radiopharmaceuticals, radiotracers, SPECT-CT, PET-CT, and PET-MRI.

1.1 Introduction

Nuclear medicine imaging uses small amounts of radioactive materials called radiotracers that are typically injected into the bloodstream, inhaled or swallowed.

The radiotracer travels through the area being examined and gives off energy in the form of gamma rays which are detected by a special camera and a computer to create images inside the body. Nuclear medicine imaging provides unique information that often cannot be obtained using other imaging procedures and offers the potential to identify disease in its earliest stage. Nuclear medicine is a branch of medicine that uses small amount of bioactive material to diagnose and determine the severity of or treat a variety of diseases, including many types of cancers, heart diseases, gastrointestinal conditions, endocrine disorders, neurological disorders and other abnormalities within the body. Because nuclear medicine procedures are able to pinpoint molecular activity within the body, they offer the potential to identify disease in its earliest stage as well as a patient's immediate response to therapeutic interventions (Radiology info et al. 2018).

1.2 Diagnosis: Nuclear medicine imaging procedures are noninvasive and, with the exception of intravenous injections, are usually painless medical investigations that help physicians diagnose and evaluate medical conditions. These imaging scans use radioactive materials called radiopharmaceuticals or radiotracers.

2.1 Methodology

2.2 Some common procedures

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:

2.2.1 Heart

visualize heart blood flow and function (such as a myocardial perfusion scan) detect coronary artery disease and the extent of coronary artery 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)

2.2.2 Lungs

Scan lungs for respiratory and blood flow problems

Assess differential lung function for lung reduction or transplant surgery **Detect** lung transplant rejection

2.2.3 Bones

Evaluate bones for fractures, infection and arthritis, evaluate for metastatic bone disease, evaluate painful prosthetic joints, and evaluate bone tumors Identify sites for biopsy

2.2.4 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.

2.3.1 Cancer

Stage cancer by determining the presence or spread of cancer in various parts of the body, localize sentinel lymph nodes before surgery in patients with breast cancer or skin and soft tissue tumor, plan treatment evaluate response to therapy, detect the recurrence of cancer, and detect rare tumors of the pancreas and adrenal gland

3.3.2 Renal

Analyze the nature and transplant kidney blood flow and function Detect urinary tract obstruction, evaluate for hypertension (high blood pressure) related to the kidney arteries, evaluate kidneys for infection and follow-up urinary reflux

2.3.4 Nuclear medicine therapies include:

Radioactive iodine (I-131) therapy used to treat some causes of hyperthyroidism (overactive thyroid gland, for example, Graves' disease) and thyroid cancer.

2.4 Preparations

You may be asked to wear a gown during the examination or you may be allowed to wear your own clothing. Women should always inform their physician or the technologist if there is any possibility that they are pregnant or if they are breastfeeding. You should inform your physician and the technologist performing the examination of any medications you are taking, including vitamins and herbal supplements. You should also inform them if you have any allergy to certain medications and about recent illnesses or other medical conditions.

SPECT involves the rotation of the gamma camera head around the patient's body to produce more detailed, three-dimensional images (Radiology info et al. 2018).

A PET scanner is a large machine with a round, donut shaped hole in the middle, similar to a CT or MRI unit. Within this machine are multiple rings of detectors that record the emission of energy from the radiotracer in the body.

3.6 How does the procedure work?

With ordinary x-ray examination, an image is made by passing x-rays through the patient's body. In contrast, nuclear medicine procedures use a radioactive material, called a radiopharmaceutical or radiotracer, which is injected into the bloodstream, swallowed or inhaled as a gas. This radioactive material accumulates in the organ or area of the body being examined, where it gives off a small amount of energy in the form of gamma rays. Special cameras detect this energy, and with the help of a computer, create pictures offering details on both the structure and function of organs and tissues in the body.

3.7 How is the procedure performed?

Nuclear medicine imaging is usually performed on an outpatient basis, but is often performed on hospitalized patients as well. You will be positioned on an examination table. If necessary, a nurse or technologist will insert an intravenous catheter into a vein in your hand or arm. Depending on the type of nuclear medicine examination you are undergoing, the dose of radiotracer is then injected intravenously, swallowed or inhaled as a gas. It can take duration of time from several seconds to several days for the radiotracer to travel through the body and accumulate in the organ or area being studied. As a result, imaging may be done immediately, a few hours later, or even several days after you have received the radioactive material.

3.8 What will I experience during and after the procedure?

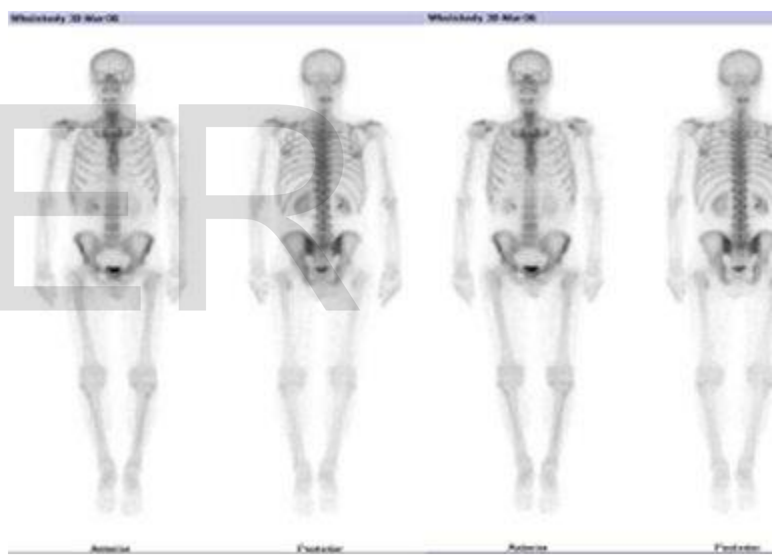
Except for intravenous injection, most nuclear medicine procedures are painless and are rarely associated with significant discomfort or side effects. When the radiotracer is given intravenously, you will feel a slight pin prick when the needle is inserted into your vein for the intravenous line. When the radioactive material is injected into your arm, you may feel a cold sensation moving up your arm, but there are generally no other side effects. When swallowed, the radiotracer has little or no taste. When inhaled, you should feel no differently than when breathing room air or holding your breath. With some procedures, a catheter may be placed into your bladder, which may cause temporary discomfort. It is important that you remain still while the images are being recorded. Though nuclear imaging itself causes no pain, there may be some discomfort from having to remain still or to stay in one particular position during imaging.

4.1 Result and Discussion

Analysis

The end result of the nuclear medicine imaging process is a "dataset" comprising one or more images. In multi-image datasets the array of images may represent a time sequence (i.e. cine or movie) often called a "dynamic" dataset, a cardiac gated time sequence, or a spatial sequence where the gamma-camera is moved relative to the patient. SPECT (single photon emission computed tomography) is the process by which images acquired from a rotating gamma-camera are reconstructed to produce an image of a "slice" through the patient at a particular position. A collection of parallel slices form a slice-stack, a three-dimensional representation of the distribution of radionuclide in the patient. The nuclear medicine computer may require millions of lines of source code to provide quantitative analysis packages for each of the specific imaging techniques available in nuclear medicine.

In some centers the nuclear medicine department may also use implanted capsules of isotopes (brachytherapy) to treat cancer.



Nuclear medicine is an imaging modality that involves injection, inhalation or injection of radioactive tracers to visualize various organs. The tracer or radiopharmaceutical is produced through addition of a radioactive isotope to a pharmaceutical specific to the organ being imaged. The radioactive tracer emits gamma radiation, which is then imaged using a gamma camera.

4.3 Safety

Pregnancy status must be established prior to procedure. Performance of a Nuclear Medicine study on a pregnant woman must be clinically justified, with the administered dose minimized. Breastfeeding women may need to cease breastfeeding dependent on the procedure being performed. This is due to excretion of the radiotracer in the breast milk. Children are particularly radiosensitive; therefore non radiation imaging modalities such as ultrasound and MRI should be utilized if possible. When performing Nuclear Medicine studies on paediatric patients the radioactive dose is scaled according to the patient's weight.

This modality can be combined with CT-scanning in order to obtain both functional and morphological data during the same examination.

If Nuclear Medicine is mostly used for diagnostic purposes, it can also be used in therapeutic applications. It is for example the case with the treatment of hyperthyroidism (Who et al, 2018).

4.3 What are the benefits vs. risks?

Benefits

Nuclear medicine examinations provide unique information—including details on both function and anatomic structure of the body that is 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 appropriate treatment, if any.

A nuclear medicine scan is less expensive and may yield more precise information than exploratory surgery.

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.

Risks

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 of the treatment are always weighed against the potential benefits for nuclear medicine therapeutic procedures. You will be informed of all significant risks prior to the treatment and have an opportunity to ask questions.

5.1 Conclusion and Recommendations

In conclusion, Nuclear Medicine does not mean you suffer from a fatal disease, it means obtaining complementary information in addition to CT-Scan or MRI: namely, functional information.

A patient undergoing a nuclear medicine procedure will receive a radiation dose. Under present international guidelines it is assumed that any radiation dose, however small, presents a risk. The radiation dose delivered to a patient in a nuclear medicine investigation, though unproven, is generally accepted to present a very small risk of inducing cancer. In this respect it is similar to the risk from X-ray investigations except that the dose is delivered internally rather than from an external source such as an X-ray machine, and dosage amounts are typically significantly higher than those of X-rays The radiation dose from a nuclear medicine investigation is expressed as an effective dose with units of sieverts (usually given in millisieverts, mSv). The effective dose resulting from an investigation is influenced by the amount of radioactivity administered in megaBecquerels (MBq), the physical properties of the radiopharmaceutical used, its distribution in the body and its rate of clearance from the body.

Effective doses can range from 6 μSv (0.006 mSv) for a 3 MBq chromium-51 EDTA measurement of glomerular filtration rate to 37 mSv (37,000 μSv) for a 150 MBq thallium-201 non-specific tumour imaging procedure. The common bone scan with 600 MBq of technetium-99m-MDP has an effective dose of approximately 3.5 mSv (3,500 μSv) (1).

Formerly, units of measurement were the curie (Ci), being 3.7E10 Bq, and also 1.0 grams of Radium (Ra-226); the rad(radiation absorbed dose), now replaced by the gray; and the rem (Rontgen), now replaced with thesievert. The rad and rem are essentially equivalent for almost all nuclear medicine procedures, and only alpha radiation will produce a higher Rem or Sv value, due to its much higher Relative Biological Effectiveness (RBE). Alpha emitters are nowadays rarely used in nuclear medicine, but were used extensively before the advent of nuclear reactor and accelerator produced radionuclides. The concepts involved in radiation exposure to humans are covered by the field of Health Physics; the development and practice of safe and effective nuclear medicinal techniques is a key focus of Medical Physics.

5.2 Recommendation

Due to scarcity of Radiotracer, I recommend government should make the element and Machines available.

Acknowledgement

I would like to express my special gratitude to my Supervisor Dr Bitrus James as well as my wife Vasty Joseph and my son and daughter, Lemuel and Zipporah respectively who gave me the golden opportunity to do this wonderful project on the topic IMPORTANCE OF USING RADIOTRACER IN DIAGNOSING CANCER. Which also helped me in doing a lot of Research and i came to know about so many new things I am really thankful to them. Secondly I would also like to thank my parents and friends who helped me a lot in finalizing this project within the limited time frame.

5.3 References

"Nuclear Medicine". Retrieved 20 August 2015. scintigraphy Citing: Dorland's Medical Dictionary for Health Consumers, 2007 by Saunders; Saunders Comprehensive Veterinary Dictionary, 3 ed. 2007; McGraw-Hill Concise Dictionary of Modern Medicine, 2002 by The McGraw-Hill Companies

"Nuclear Wallet Cards". Retrieved 20 August 2015.

^ Hertz S, Roberts A 1946 Radioactive iodine in the study of thyroid physiology. VII the use of radioactive iodine therapy in hyperthyroidism.JAMA 131:81-86

^ Seidlin, S. M., L. D. Marinelli, and Eleanor Oshry. "Radioactive iodine therapy: effect on functioning metastases of adenocarcinoma of the thyroid." Journal of the American Medical Association 132.14 (1946): 838-847.

^ Henkin R. et al: Nuclear Medicine. First edition 1996. ISBN 978-0-8016-7701-4.

^ *Ingvar, David H.; Lassen, Niels A. (1961). "Quantitative determination of regional cerebral blood-flow in man". The Lancet.* ***278*** *(7206): 806–807. Doi:10.1016/s0140-6736(61)91092-3.*

Jump up to: [a] [b] Edwards Cl: Tumor localizing radionuclide's in retrospect and prospect. Semin Nucl Med 3:186–189, 1979.

^ Donner Laboratory: The Birthplace of. Nuclear Medicine

^ Important Moments in the History of Nuclear Medicine

^ *Ingvar, David H.; Franzén, Göran (1974). "Distribution of cerebral activity in chronic schizophrenia". The Lancet.* ***304****(7895): 1484–1486. Doi:10.1016/s0140-6736(74)90221-9.*

^ *Lassen, Niels A.; Ingvar, David H.; Skinhøj, Erik (October 1978). "Brain Function and Blood Flow" (PDF). ScientificAmerican.* ***239*** *(4): 62–71. Doi:10.1038/scientificamerican1078-62.*

^ *Roland, Per E.; Larsen, B.; Lassen, Niels A.; Skinhøj, Erik (1980). "Supplementary Motor Area and Other Cortical Areas in Organization of Voluntary Movements in Man". Journal of Neurophysiology.* ***43*** *(1): 118–136.*

^ *Roland, Per E.; Friberg, Lars (1985). "Localization of cortical areas activated by thinking". Journal of Neurophysiology.* ***53****(5). pp. 1219–1243.*

^ *"What is nuclear medicine" (PDF). Society of Nuclear Medicine.*

^ *"News". Retrieved 20 August 2015.*

^ Eckerman KF, Endo A: MIRD: Radionuclide Data and Decay Schemes. Society for Nuclear Medicine, 2008. ISBN 978-0-932004-80-2

^ Table of Radioactive Isotopes Archived 2004-12-04 at the Way back Machine

^ *"Sodium Fluoride F 18 Injection". Retrieved 20 August 2015.*

^ *"Ammonia N-13". Retrieved 20 August 2015.*