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Estimation of patient's radiation diagnostic doses in nuclear medicine

تقييم الجرعة الاشعاعية التشخيصية للمرضى في الطب النووي

Agraduation project submitted t as to complete all requirements

Of Bsc degree in scientific laboratories- Physics

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الآيـــــــــــــــة

قال تعالى:

﴿ قُلْ سِيرُوا فِي الْأَرْضِ فَانْظُرُوا كَيْفَ بَدَأَ الْخَلْقَ ثُمَّ اللَّهُ يُنْشِئُ النَّشْأَةَ الْآَخِرَةَ إِنَّ اللَّهَ عَلَى كُلِّ شَيْءٍ قَدِيرٌ ﴾

سورة العنكبوت الآية(20)

Dedication

To my mother Wesel AlTayeb AlMubarak

To my father Gamal Eldeen Adam Mubarak

To my uncle Ammar AlTayeb AlMubarak

To my uncle Khalid adam mubarak

To my sisters ,my brother and To all my family

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List of contents

ID	Items	Page No.
	الآيه	I
	Dedication	II
	Acknowledgements	III
	Contents	IV
	List of tables	V
	List of figures	VII
	Abstract [English]	VIII
	Abstract [Arabic]	IX
	Chapter one: Introduction	
	1.1 Nuclear medicine	1
	1.2 Diagnostic Nuclear Medicine	1
	1.2.1 Diagnostic techniques in nuclear medicine	2
	1.2.2 Diagnostic radiopharmaceuticals	2
	1.3 he benefits and risk of nuclear medicine	3
	1.3.1Benefits of nuclear medicine	3
	1.3.2 The risks of nuclear medicine	4
	1.4 Problem of the study	4
	1.5 objectives of the study	5
	1.5.1Main objectives	5
	1.5.2specific objectives	5
	1.6Thesis out lines	5
	Chapter two: literature view	
	2.1Thyroid Scan and Uptake	6
	2.1.1Thyroid Scan	6

	2.1.2Thyroid Uptake	6
	2.1.3 The limitations of the Thyroid Scan and Uptake	6
	2.2 Bone scan	7
	2.2.1 The effects of a Bone Scan	7
	2.2.2 The risks of a Bone Scan	7
	2.2.3The benefits of a Bone Scan	8
	2.3 Renal scan	8
	2.3.1The effects of a renal scan	9
	2.3.2 The risks of a renal scan	9
	2.3.3 The benefits of a renal scan	9
	2.4 Radiation dosemetry	10
	2.4.1 Radiation Units and Radiation Quantities	10
	2.4.1.1 Radiation Units	10
	2.4.1.1.1 Roentgen	10
	2.4.1.1.2The Rad	11
	2.4.1.1.3 The roentgen equivalent in man	11
	2.4.1.1.4 Gray (Gy)	11
	2.4.1.1.5 Sievert (Sv)	11
	2.4.1.1.6 Rem	12
	2.4.1.1.7Curie	12
	2.4.1.1.8Becquerel (Bq)	12
	2.4.1.2 Radiation Quantities	12
	2.4.1.2.1 Exposure	12
	2.4.1.2.2 Absorbed dose, D	13
	2.4.1.2.3Equivalent dose H	14
	2.4.1.2.4Radiation weighting factor, W_R	14
	2.4.1.2.5 Effective dose, E	15
	2.4.1.2.6 Entrance dose	16
	2.4.1.2.7Dose Area Product	16

	2.4.1.2.8 Air kerma	17
	2.5 previous studies	17
	Chapter three: Material and method	
	3.1 Patient samples	18
	3.2 Gamma camera Machines	18
	3.3 dose calibrator	18
	Chapter four: Results	
	4.1Results	20
	Chapter five: Discussion	
	5.1 Discussion	25
	5.2 Conclusion	26
	5.3 Recommendations	27
	References	28

List of tables

Table	Item	Page No
2.1	**weighting factor for some organ or tissue W_T**	15
3.1	**Type and main characteristics of Gamma camera machine**	18
4.1	**gender of patients distribution in two hospitals**	20
4.2	**patient demographic data in two hospitals**	21
4.3	**distribution of organ scan in two hospitals**	23
4.4	**patient doses for some diagnostic organs in nuclear medicine**	24

List of figures

Figure	Item	Page No
4.1	**Figure 4.1: distribution of gender patient in two hospitals**	20
4.2	**Figure 4.2: age of gender patient in two hospitals**	21
4.3	**Figure 4.3: weight of gender patient in two hospitals**	22
4.4	**Figure 4.4: height of gender patient in two hospitals**	22
4.5	**Figure 4.5: organs scan distribution in two hospitals**	23
4.6	**Figure 4.6: organs scan doses distribution in two hospitals**	24

Abstract

This study intends to estimate the patients radiation diagnostic doses in nuclear medicine.

A total of 60 patients were examined in two Hospitals. The data were collected using a sheet for all patients in order to maintain consistency of the information. The following parameters were recorded age, weight and height to estimate the dose for thyroid scan, renal scan and bone scan. The examinations were collected according to the availability.

The mean age, weight and height are 77.37, 66.76 and 1.64 respectively for male in elneelian center.The mean age, weight and height are 59.70, 67.86 and 1.61 respectively for female in elneelain center. The mean age, weight and height are 70.17, 69.34 and 1.62 respectively for male in elmek nimer hospital. The mean age, weight and height are 51.33, 62.40 and 1.68 respectively for female in elmek nimer hospital

The mean doses of thyroid, renal and bone scan are 5.04, 9.19 and 20.10 respectively in elneelain center. The mean doses of thyroid, renal and bone scan are 5.24, 8.05 and 22.10 respectively in elmek nimer hospital.

Patient doses were measuring during this study used on two hospitals to three types of organ diagnosed.

demographic data (age, weight, height, sex, clinical indication, and type of organ diagnosed) were **meausured**. Dose calibrator were used to measure organ doses.

Two different gamma camera machines were used throughout this study.

In this study bone scan doses values were higher than the other two types of diagnosed while thyroid scan diagnosed is lowest one.

ملخص البحث

عزمت هذه الدراسة لتقييم الجرعات الاشعاعية التشحيصية للمرضى في الطب النووي لثلاثة عمليات هي : مسح الغدة , مسح الكلى , ومسح العظام في مستشفيين في السودان , 60 من المرضى 12 من الذكور و 18 من الاناث في مركز النيلين التشخيصي وعدد 9من الذكور و21 من الاناث في مستشفى الملك نمر الجامعي .

متوسط العمر, الوزن والطول للذكور 77.37 , 66.76 , 1.64 في مركز النيلين التشخيصي.

متوسط العمر, الوزن والطول للاناث 59.70 , 67.86 , 1.61 في مركز النيلين التشخيصي.

متوسط العمر, الوزن والطول للذكور 70.17 , 69.34 , 1.61 في مستشفى الملك نمر الجامعي.

متوسط العمر, الوزن والطول للاناث 5.24 , 8.05 , 22.10 في مستشفى الملك نمرالجامعي.

متوسط الجرعة الاشعاعية للغدة 5.04, للكلى 9.19 , للعظام 22.10في مركز النيلين التشخيصي.

متوسط الجرعة الاشعاعية للغدة 5.24 , للكلى 8.05 , للعظام 22.10 في مستشفى الملك نمرالجامعي.

وجد في هذه الدراسة أن الجرعة الاشعاعية التشخيصية للعظام الأعلى من الجرعتين الأخرتين بينما الجرعة الاشعاعية التشخيصية للغدة هي الأدنى.

Chapter one

Introduction

1.1 Nuclear medicine

Nuclear medicine is the medical specialty that involves the use of radioactive isotope in the diagnosis and treatment of disease. Nuclear medicine began only after the discovery by Enrico Fermi in 1935 that stable elements could be made radioactive by bombarding them with neutrons. The atoms of the elements so bombarded capture these neutrons, thus assuming a different nuclear form while remaining the same elements. These radioisotopes have unstable nuclei, however, and dissipate excess energy by emitting radiation in the form of gamma and other rays.In isotope scanning, a radioisotope is introduced into the body, usually by means of intravenous injection. The isotope is then taken up in different amounts by different organs. Its distribution can be determined by recording the radiation it emits, and through charting its concentration it is often possible to recognize the presence, size, and shape of various abnormalities in body organs. The radiation emitted is detected by a scintillation count.er, which is moved back and forth over the organ being scanned; these messages can then be electronically recorded and studied by clinicians. The radioisotope usually has a short half-life and thus decays completely before its radioactivity can cause any damage to the patient's body. Different isotopes tend to concentrate in particular organs: for example, iodine-131 settles in the thyroid gland and can reveal a variety of defects in thyroid functioning. Another isotope, carbon-14, is useful in studying abnormalities of metabolism that underlie diabetes, gout, anemia, and acromegaly. Various scanning devices and techniques have been developed, including tomography (q.v.) and magnetic resonance imaging. . (1)(5)(7)(8).

1.2 Diagnostic Nuclear Medicine

Diagnostic nuclear medicine involves the use of radioactive tracers to image and/or measure the global or regional function of an organ. The radioactive tracer (radiopharmaceutical) is given to the patient by intravenous injection, orally or by other routes depending on the organ and the function to be studied. The uptake, turnover and/or excretion of the tracer substance is then studied with a gamma camera, positron mission tomography (PET) camera or another instrument, such as a simple stationary radiation detector. The uptake of the tracer is generally a measure of the organ function or metabolism or the organ blood flow. .(2)(9)(11).

1.2.1 Diagnostic techniques in nuclear medicine

Diagnostic techniques in nuclear medicine use radioactive tracers which emit gamma rays from within the body. These tracers are generally short-lived isotopes linked to chemical compounds which permit specific physiological processes to be scrutinised. They can be given by injection, inhalation or orally. The first type are where single photons are detected by a gamma camera which can view organs from many different angles. The camera builds up an image from the points from which radiation is emitted; this image is enhanced by a computer and viewed by a physician on a monitor for indications of abnormal conditions. .(2)(13)

1.2.2 Diagnostic radiopharmaceuticals

Every organ in our bodies acts differently from a chemical point of view. Doctors and chemists have identified a number of chemicals which are absorbed by specific organs. The thyroid, for example, takes up iodine, the brain consumes quantities of glucose, and so on. With this knowledge, radiopharmacists are able to attach various radioisotopes to biologically active substances. Once a radioactive form of one of these substances enters the body, it is incorporated into the normal biological processes and excreted in the usual ways.

Diagnostic radiopharmaceuticals can be used to examine blood flow to the brain, functioning of the liver, lungs, heart or kidneys, to assess bone growth, and to confirm other diagnostic procedures. Another important use is to predict the effects of surgery and assess changes since treatment.

The amount of the radiopharmaceutical given to a patient is just sufficient to obtain the required information before its decay. The radiation dose received is medically insignificant. The patient experiences no discomfort during the test and after a short time there is no trace that the test was ever done. The non-invasive nature of this technology, together with the ability to observe an organ functioning from outside the body, makes this technique a powerful diagnostic tool.

A radioisotope used for diagnosis must emit gamma rays of sufficient energy to escape from the body and it must have a half-life short enough for it to decay away soon after imaging is completed.

The radioisotope most widely used in medicine is technetium-99m, employed in some 80% of all nuclear medicine procedures. It is an isotope of the artificially-produced element technetium and it has almost ideal characteristics for a nuclear medicine scan. These are:

- It has a half-life of six hours which is long enough to examine metabolic processes yet short enough to minimise the radiation dose to the patient.
- Technetium-99m decays by a process called "isomeric"; which emits gamma rays and low energy electrons. Since there is no high-energy beta emission the radiation dose to the patient is low.
- The low energy gamma rays it emits easily escape the human body and are accurately detected by a gamma camera. Once again the radiation dose to the patient is minimised.
- The chemistry of technetium is so versatile it can form tracers by being incorporated into a range of biologically-active substances to ensure that it concentrates in the tissue or organ of interest. (4)(10)(11)(12)

1.3 he benefits and risk of nuclear medicine

1.3.1Benefits of nuclear medicine

- 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.
- Nuclear medicine is less expensive and may yield more precise information than exploratory surgery.

1.3.2 The risks of nuclear medicine

- Because the doses of radiotracer administered are small, diagnostic nuclear medicine procedures result in relatively low radiation exposure to the patient, acceptable for diagnostic exams. Thus, the radiation risk is very low compared with the potential benefits.
- 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.
- Allergic reactions to radiopharmaceuticals may occur but are extremely rare and are usually mild. Nevertheless, you should inform the nuclear medicine personnel of any allergies you may have or other problems that may have occurred during a previous nuclear medicine exam.
- Injection of the radiotracer may cause slight pain and redness which should rapidly resolve.
- Women should always inform their physician or radiology technologist if there is any possibility that they are pregnant or if they are breastfeeding.(36).

1.4 Problem of the study

a. The dose is taken through several stages:
   - The stage of determining examination by a nuclear doctor.
   - Stage of the dose calculated by a medical physicist.
   - Technical stage.
   - Pathogen stage.
b. No Diagnostic reference level in nuclear medicine.
c. No quality control.
d. No training for major staff.
e. Few ware less of staff for some hospital.

1.5 objectives of the study

1.5.1Main objectives

Estimation of patient radiation doses in diagnostic nuclear medicine.

1.5.2specific objectives

1. Identify associate in the diagnostic radiation dose in nuclear medicine.
2. Determine patients radiation doses in nuclear medicine.
3. Determine the effect of the radiation danger diagnostic examination on patients.
4. Identification of irradiated tissue area.

1.6Thesis out lines

This thesis is concerned with the estimation of patients radiation doses in diagnostic nuclear medicine. Accordingly, it is divided into the following chapters:

Chapter one is the introduction to this thesis. This chapter discusses the objectives and scope of work and introduces necessary background. It also provides an outline of the thesis.

Chapter two contains the literature and theoretical background material for the thesis. Specifically it discusses the dose for some organs to be diagnose . This chapter also includes a summary of previous work performed in this field.

Chapter three describes the materials and a method used to measure dose in nuclear medicine.

Chapter four reveals and demonstrates the results of this study.

Chapter five presents the discussion, conclusion and recommendations of the thesis and gives suggestions for future work.

Chapter Two

Literature view

2.1Thyroid Scan and Uptake

A thyroid scan is a type of nuclear medicine 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. .(13)

2.1.1Thyroid Scan

Depending on the type of nuclear medicine exam you are undergoing, the dose of radiotracer is then injected intravenously, swallowed or inhaled as a gas.

When radiotracer is taken by mouth, in either liquid or capsule form, it is typically swallowed up to 24 hours before the scan. The radiotracer given by intravenous injection is usually given up to 30 minutes prior to the test.

When it is time for the imaging to begin, you will lie down on a moveable examination table with your head tipped backward and neck extended. The gamma camera will then take a series of images, capturing images of the thyroid gland from three different angles. You will need to remain still for brief periods of time while the camera is taking pictures.(13)

2.1.2Thyroid Uptake

By giving 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. For example, you may have uptake measurements at four to six hours and 24 hours. .(6)

2.1.3 The limitations of the Thyroid Scan and Uptake

The thyroid scan and thyroid uptake are not performed on patients who are pregnant because of the risk of exposing the fetus to radiation. These tests are also not recommended for breastfeeding women.

Nuclear medicine procedures can be time consuming. It can take several hours to days for the radiotracer to accumulate in the body part of interest and imaging may take up to several hours to perform, 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. However, nuclear medicine scans are more sensitive than other techniques for a variety of indications, and the functional information gained from nuclear medicine exams is often unobtainable by other imaging techniques. .(6)(4)

2.2 Bone scan

A nuclear medicine bone scan shows the effects of injury or disease (such as cancer) or infection on the bones. A nuclear medicine bone scan also shows whether there has been any improvement or deterioration in a bone abnormality after treatment.

A radioactive material (radiopharmaceutical) is injected into a vein, attaches to the bones and is detected by a special camera (gamma camera) that takes images or pictures that show how the bones are working.(6)(5)

2.2.1 The effects of a Bone Scan

Normally, there are no after effects of a nuclear medicine bone scan.

The radiopharmaceutical used in a bone scan is not known to have any adverse interaction with food or medication you might be taking. You should feel no effect from the injection of radiopharmaceutical. You can carry out normal activities between the injection and the delayed images, and after the scan.

If you are breast-feeding or caring for young children, see the ‘how do I prepare’ section for more information about special precautions you might need to take.(6)

2.2.2 The risks of a Bone Scan

There are minimal risks involved in the nuclear medicine bone scan procedure.

The scan involves a small dose of radiation from the radiopharmaceutical injected into your vein. The dose is similar to CT and fluoroscopy procedures.

2.2.3The benefits of a Bone Scan

A bone scan helps your doctor evaluate how your bones are working, and provides information to help diagnose and treat your condition. It can show injury to the bones, the effects of disease such as cancer or infection, as well as any improvement or deterioration in a bone abnormality after any treatment you might be having.

2.3 Renal scan

The kidneys filter the blood to remove waste substances such as urea (a nitrogen compound) and salt. The body discharges these wastes mixed in water as urine. The fluid is collected in the kidneys and discharged through the ureters which join the kidneys to the bladder. The top of the ureter is called the renal pelvis and this joins the kidney to the ureters.

In a nuclear medicine (NM) renal scan, images are made of the delivery of fluid into the kidneys via the bloodstream, concentration of wastes in the kidney and excretion or flow from the kidneys through the ureters and filling of the bladder.

A nuclear medicine renal scan can be performed with 2 different substances - DTPA or MAG3. DTPA is the radiopharmaceutical used in a DTPA renal scan, but sometimes the nuclear medicine specialist will decide that another radiopharmaceutical called MAG3 should be used. These radiopharmaceuticals are similar, but MAG3 gives significantly better images in some patients, particularly very young children and those patients with poor kidney function. The descriptions and explanations below for a DTPA renal scan apply also to a MAG3 renal scan. A nuclear medicine DTPA or MAG3 renal scan is performed to look at the blood supply, function and excretion of urine from the kidneys. The test can find out what percentage each kidney contributes to the total kidney function. A DTPA Scan may also be undertaken to evaluate:

- renal tubular function and perfusion (how the body fluids circulate through the kidneys);
- renovascular hypertension (high blood pressure in the arteries of the kidneys);
- renal artery stenos is (narrowing of the arteries that take blood to the kidneys);
- renal tubular obstruction and trauma or damage (blockage or interruption of the ureters);

- renal transplant perfusion and function.

2.3.1The effects of a renal scan

There are no after effects of a DTPA Scan. You will not feel any different. If a dose of a diuretic (frusemide) is given to cause an increased flow of urine, you may feel thirsty and need to drink plenty of fluids for the rest of the day so that your body does not dry out and you become dehydrated. You may also need to visit the toilet more often to empty your bladder .

2.3.2 The risks of a renal scan

There are no known associated risks involved in the DTPA scan itself. The test involves a small dose of ionising radiation which is relatively small and similar to many other routine medical imaging tests. For more detailed information .

If you are pregnant or breast feeding, please inform your doctor before booking the scan. Some of the medications that are used in nuclear medicine studies can pass into the mother's milk and to the baby. You may be asked to discontinue breast feeding for a short time after the scan and will need to express from both breasts. Please discuss with the nuclear medicine physician or technologist when feeding can resume and if you need to limit contact with your baby for a short time.(22)

2.3.3 The benefits of a renal scan

This test provides information on the blood supply, function and excretion of urine from the kidneys.

A DTPA Scan can help your doctor assess how each of your kidneys is working and find out what percentage each kidney contributes to the total kidney function. It is important for your health that your kidneys are functioning properly(22)

2.4 Radiation dosemetry

Radiation dosemetry is the calculation of the absorbed dose in matter and tissue resulting from the exposure to indirectly and directly ionizing radiation. It is a scientific subspecialty in the fields of health physics and medical physics that is focused on the calculation of internal and external doses from ionizing radiation.(1)

2.4.1 Radiation Units and Radiation Quantities

They include the many quantities that can be used to express the amount of radiation, the different units that are used, and the generally uneven distribution of the radiation within the patient's body. Also, some medical imaging procedures expose the staff to radiation. It is necessary to determine their exposure so that the risk can be managed in the context of ALARA programs. Determining and expressing the radiation to the staff and other persons in an imaging facility is also somewhat complex because of the reasons mentioned above. (15)(16)

2.4.1.1 Radiation Units

Throughout the course of history there have been many different systems of units developed to express the values of the various physical quantities. In more recent times the metric system has gradually replaced some of the other more traditional or classic systems. This is also true for the units used for many of our radiation quantities.(14)

2.4.1.1.1 Roentgen

The quantity of X-radiation which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produce in 1 cc of atmospheric air at 0°C and 76cm of mercury pressure such a degree of conductivity that 1 esu of charge is measured at saturation current. (1)(17)

2.4.1.1.2The Rad

Is a deprecated unit of absorbed radiation dose, defined as 1 rad = 0.01 Gy = 0.01 J/kg. It was originally defined in (SI Unit) in 1953 as the dose causing 100 ergs of energy to be absorbed by one gram of matter. It has been replaced by the gray in most of the world. A related unit, the roentgen, was formerly used to quantify the number of rad deposited into a target when it was exposed to radiation. The F-factor can be used to convert between rad and roentgens.

2.4.1.1.3 The roentgen equivalent in man

The rem is defined since 1976 as equal to 0.01 sievert, which is the more commonly used SI unit outside of the United States. A number of earlier definitions going back to 1945 were derived from the roentgen unit, which was named after Wilhelm Röntgen, a German scientist who discovered X-rays. The acronym is now a misleading historical artifact, since 1 roentgen actually deposits about 0.96 rem in soft biological tissue, when all weighting factors equal unity. Older units of rem following other definitions are up to 17% smaller than the modern rem**.(1)**

2.4.1.1.4 Gray (Gy)

One gray is the absorption of one joule of energy, in the form of ionizing radiation, perkilogram of matter.

$$\mathbf{1}\boldsymbol{Gy} = \mathbf{1}\,\frac{\mathbf{J}}{\mathbf{kg}} = \mathbf{1}\,\frac{\mathbf{m^2}}{\mathbf{s^2}}$$

2.4.1.1.5 Sievert (Sv)

The gray and sievert units are both special names for the SI derived units of joules per kilogram (m^2/s^2 if expressed in base units), though they are not interchangeable.

1 Sv = 1 J/kg = 1 Gy

The gray is used with quantities of absorbed dose in any material, while the sievert is used with equivalent, effective, and committed dose in biological tissue. The latter quantities are weighted averages of absorbed dose designed to be more representative of the stochastic health effects of radiation, and use of the sievert implies that appropriate regulatory weighting factors have been applied to the original measurement. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv=100 rems).(18)

2.4.1.1.6 Rem

Rem is the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem=0.01 sievert). (18)

2.4.1.1.7Curie

The original unit for measuring the amount of radioactivity was the (Ci)–first defined to correspond to one gram of radium-226 and more recently defined as: 1 curie = $3.7x10^{10}$ radioactive decays per second .[15]

2.4.1.1.8becquerel (Bq)

In the International System of Units (SI) the curie has been replaced by the Becquerel where:

1 becquerel = 1 radioactive decay per second = $2.703x10^{-11}$Ci.

2.4.1.2 Radiation Quantities

Radiation quantities used to describe a beam of x-radiation fall into two general categories as shown here. One category comprises the quantities that express the total amount of radiation, and the other comprises the quantities that express radiation concentration at a specific point. We need to develop this distinction before considering specific quantities.

2.4.1.2.1 Exposure

Exposure is a radiation quantity that expresses the concentration of radiation delivered to a specific point, such as the surface of the human body. The conventional unit is the roentgen (R) and the SI unit is the coulomb/kg of air (C/kg of air). Theunit, the roentgen, is officially defined in terms of the amount of ionization produced in a specific quantity of air. The ionization process produces an electrical charge that is expressed in the unit of coulombs. So, by measuring the amount of ionization (in coulombs) in a known quantity of air the exposure in roentgens can be determined. It is just about the right size for expressing exposure values encountered in medical imaging and it has a very convenient relationship to absorbed dose in rads for most soft tissues.The usual and appropriate use of the quantity, exposure, is to express the concentration of radiation delivered to a specific point, such as the Entrance Surface Exposure for a patient. Although knowing the surface entrance exposure to a patient does not give a complete description of the radiation delivered to all tissues, it does provide useful information for several purposes. Entrance Surface Exposure values can be used to

- Compare different imaging techniques with respect to radiation delivered to patients, especially for the same anatomical coverage.
- Calculate the absorbed dose to underlying tissues and organs.

Exposure is a dosimetric quantity for ionizing electromagnetic radiation, based on the ability of the radiation to produce ionization in air.This quantity is only defined for electromagnetic radiation producing interactions in air.Before interacting with the patient (Direct beam) or with the staff (scattered radiation), X- Rays interact with air The quantity “exposure” gives an indication of the capacity of X- Rays to produce a certain effect in air The effect in tissue will be, in general, proportional to this effect in air The exposure(x) is the absolute value of the total charge of the ions (Q) of one sign produced in air when all the electrons liberated by photons per unit mass (m) of air are completely stopped in air.

$$\mathbf{X = dQ / dm}$$

The SI unit of exposure is Coulomb per kilogram [C kg-1]the former special unit of exposure was Roentgen [R]

1 R = 2.58 x 10^{-4} C kg-1

1 C kg-1 = 3876 R (9)(29)(37)

2.4.1.2.2 Absorbed dose, D

X-rays or gamma rays are indirectly ionizing radiation because energy is released into the Tissue through the electrons set in motion by the X-rays or gamma rays, which in turn will make a very large number of ionizations. The energy these electrons deposit per unitMass of tissue, T, or organ is called the absorbed dose and is denoted DT. This is the basic Physical quantity used to measure the biological effects expected. It has the dimension of One joule per kilogram (J kg-1) and is expressed in gray (Gy). This quantity is used to control the deterministic effects with a threshold of 0.5 Gy.**(19)**

2.4.1.2.3Equivalent dose H

The equivalent dose H is the absorbed dose multiplied by a dimensionless radiation weighting factor, wR which expresses the biological effectiveness of a given type of radiation

- To avoid confusion with the absorbed dose, the SI unit of equivalent dose is called the sievert (Sv). The old unit was the “rem”
- **1 Sv = 100 rem**

To reflect the fact that all types of radiation for a given absorbed dose, do not produce the same affect in humans the concept of dose equivalent in a tissue, T, or organ, denoted HT Was introduced. It is the product of DT and a weighting factor, wR, which depends on the Type of radiation and expresses its effectiveness.

HT = Σ W_R . DT,R

HT has the same dimension as DT (J kg-1), but is expressed in sievert (Sv).
W_R is Therefore equal to unity. Thus, an adsorbed dose of 1 mGy is equivalent to a dose equivalent(19)

2.4.1.2.4Radiation weighting factor, W_R

For most of the radiation used in medicine (X Rays,γ and e-) W_R is = 1, so the absorbed dose and the equivalent dose are numerically equal**.** The exceptions are:

Alpha particles (W_R = 20)

Neutrons (W_R = 5 - 20).

Table 2.1: weighting factor for some organ or tissue W_T

Organ/Tissue	W_T	Organ/Tissue	W_T
Bone marrow	0.12	Lung	0.12
Bladder	0.05	Oesophagus	0.05
Bone surface	0.01	Skin	0.01
Breast	0.05	Stomach	0.12
Colon	0.12	Thyroid	0.05
Gonads	0.20	Remainder	0.05
Liver	0.05		

2.4.1.2.5 Effective dose, E

The effective dose (E) The aim of the E was to define a quantity that could be directly related to the probability of a detriment from low-dose exposure to ionizing radiation where only stochastic effects occur.

E is defined by the weighed sum of mean tissue and organ doses with radiation weighting Factors taking into account a) the different radio-biological effectiveness of various Radiations and b) the different sensitivity of tissue and organs with respect to stochastic

Effects. E is defined as:

$$\mathbf{E = \Sigma\ T\ W_T\ .\ HT = \Sigma\ T{,}RW_T\ .\ W_R\ .\ D_{T,R}}$$

Where

E: effective dose

W_T: weighting factor for organ or tissue T

HT: equivalent dose in organ or tissue T

To reflect the combined detriment from stochastic effects due to the equivalent doses in all the organs and tissues of the body, the equivalent dose in each organ and tissue is multiplied by a tissue weighting factor, wT, and the results are summed over the whole body to give the effective dose E(20)(21)

2.4.1.2.6 Entrance dose

For radiographic examinations, theabsorbed dose at the surface at the entrance of the beam in the patient and abbreviated as ESD. The ESD is expressed in mGy and is converted into effective dose, in mSv, by multiplying it by the wT factors.

The entrance surface dose is defined by the BSS as the absorbed dose in the center of the field at the surface of entry of radiation for a patient undergoing a radiodiagnostic examination, expressed in air and with backscatter.[22]

The entrance skin dose (ESD) is the absorbed dose in the skin at a given location on the patient. It includes the backscattered radiation from the patient. [22]

Absorbed dose is a property of the absorbing medium as well as the radiation field, and the exact composition of the medium should be clearly stated. Usually ESD refers to soft tissue (muscle) or water

Absorbed dose in muscle is related to absorbed dose in air by the ratio of the mass energy coefficients(23)

2.4.1.2.7Dose Area Product

Dose area product (DAP) is a quantity used in assessing the radiation risk from diagnostic x-ray examinations and interventional procedures. Itis defined as the absorbed dose multiplied by the area irradiated, expressed

($Gy*cm^2$) (sometimes $mGy*cm^2$ or $cGy*cm^2$).

Manufacturers of DAP meters usually calibrate them in terms of absorbed dose to air. DAP reflects not only the dose within the radiation field but also the area of tissue irradiated. Therefore, it may be a better indicator of the overall risk of inducing cancer than the dose within the field. It also has the advantages of being easily measured, with the permanent installation of a DAP meter on the x-ray set. Due to the divergence of a beam emitted from a 'point source', the area irradiated (A) increases with the square of distance from the source ($A \propto d^2$), while radiation intensity (I) decreases according to the inverse square of distance ($I \propto 1/d^2$). Consequently, the product of intensity and area, and therefore DAP, is independent of distance from the source. [23]

2.4.1.2.8 Air kerma

Air kerma is another radiation quantity that is sometimes used to express the radiation concentration delivered to a point, such as the entrance surface of a patient's body. The quantity, kerma, originated from the acronym, KERMA, for Kinetic Energy Released per unit Mass of Air. It is a measure of the amount of radiation energy, in the unit of joules (J), actually deposited in or absorbed in a unit mass (kg) of air. Therefore, the quantity, kerma, is expressed in the units of J/kg which is also the radiation unit, the gray (G). (24)

It is easy to measure with an ionization chamber. Since the ionization produced in air by radiation is proportional to the energy released in the air by the radiation, ionization chambers actually measure air kerma as well as exposure. An ionization chamber can be calibrated to read air kerma, or a conversion factor can be used to convert between air kerma and exposure values. It is expressed in a practical metric SI unit. Air kerma (energy released in a unit mass of air) is expressed in the units of joule per kilogram, J/kg. This is also the unit gray, Gy, used for absorbed dose. Here is the easy part. If we know air kerma measured (or calculated) at a point where soft tissue is located, the absorbed dose in the tissue will be just about equal to the air kerma(25)

2.5 previous studies

Many authors target this way for examples ICRP team, dose estimates for nuclear medicine scans they found that the dose limitation for all persons and all organs also wine sager et al dose monitor for diagnostic nuclear medicine they give a protocol for American human to be diagnose in nuclear medicine. (28)(30)(31)(32)(33).

Chapter Three

Materials & Methods

3.1 Patient samples

A total of 60 patients were examined in two Hospitals. The data were collected using a sheet for all patients in order to maintain consistency of the information. The following parameters were recorded age, weight and height to estimate the dose for thyroid scan, renal scan and bone scan. The examinations were collected according to the availability.

3.2 Gamma camera Machines

In the present study, two different modalities gamma camera machines, from two different manufacture were used as described in Table 3.1

Table 3.1 Type and main characteristics of Gamma camera machine

Center	Manufacturer	Manufactu-ring Date	Type	Year install
Elneelain center	Phlip	1/2004	Fixed	2009
E-lMekNimer) university hospital	Mediso	11/2009	Fixed	8/2010

3.3 dose calibrator

The dose calibrator use in two hospitals are different modalities but same manufacture one is ATOMLAB™ 400 DOSE CALIBRATOR and the other is ATOMLAB™ 100 DOSE CALIBRATOR

- Designed for Facilities Receiving Unit Doses Including PET and Beta.
- Pre-programmed for 88 most commonly used radionuclides.
- Large, easy-to-read backlit LCD.
- Small footprint economizes workspace.
- Ultra-fast response.
- Automatic range selection; ranges up to 40 Curies of Tc-99m or 10 Curies of F-18.
- Displays in Curies or Becquerels.

- Remote Ionization Chamber.
- Self-Diagnostic Software.
- Desktop or wall mount display.

Chapter Four

Results

4.1: Results

Data were collected on two centers of diagnostic nuclear medicine elneelain nuclear medicine center in Khartoum state and ElmekNimer University Hospital (E.N.U.H) in Shendi in river Nile state to estimate the doses of 60 patients for different diagnostic organs.

Table 4.1 gender of patients distribution in two hospitals

Hospital	Gender	Elneelain	E.N.U.H
Patient	Male	12	9
	Female	18	21

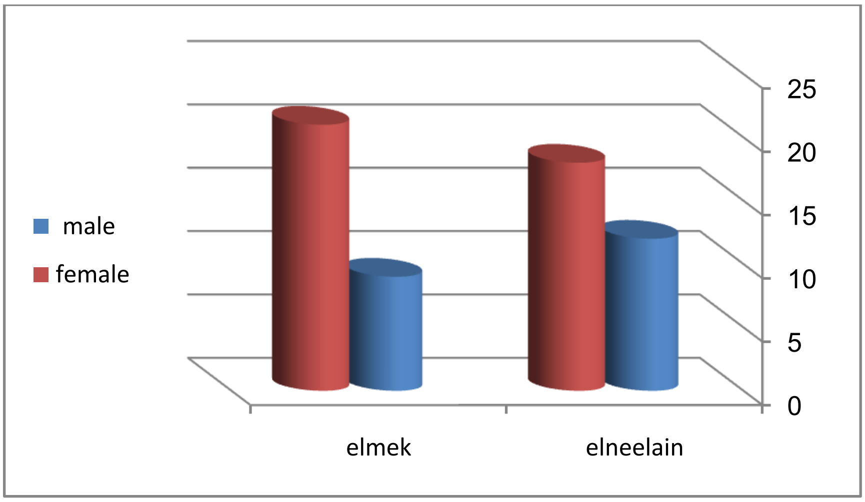

Figure 4.1: distribution of gender patient in two hospitals

Table 4.2 patient demographic data in two hospitals

Hospital	Gender	Age	Weight	height
Elneelain	Male	77.37±13.21 (15-86)	66.76±24.04 (20-72)	1.64±0.07 (1.53-1.80)
	Female	59.70±29.01 (21-73)	67.86±14.82 (45-101)	1.61±0.03 (1.31-1.80)
E.N.U.H	Male	70.17±6.09 (65-80)	69.34±5.03 (21-91)	1.62±0.32 (1.49-1.63)
	Female	51.33±9.51 (27-96)	62.40±1.11 (51-73)	1.68±0.04 (1.23-1.90)
Total		63.93±13.29 (15-96)	68.17±11.62 (20-115)	1.61±0.14 (1.23-1.90)

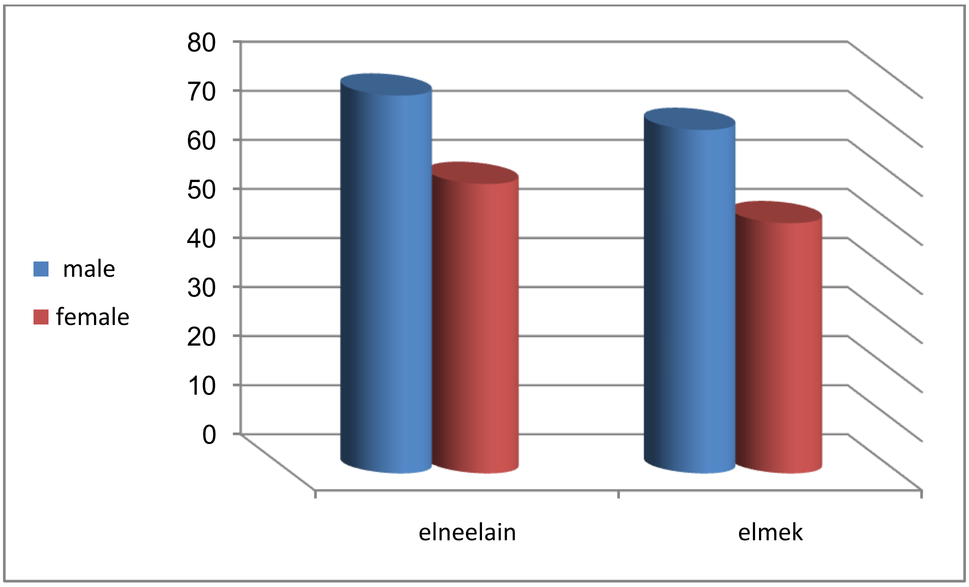

Figure 4.2: age of gender patient in two hospitals

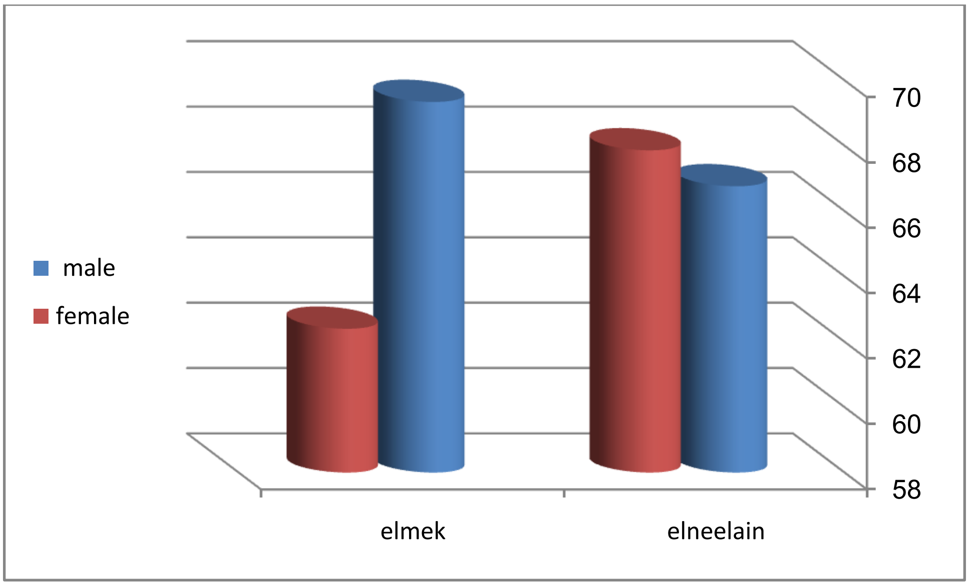

Figure 4.3: weight of gender patient in two hospitals

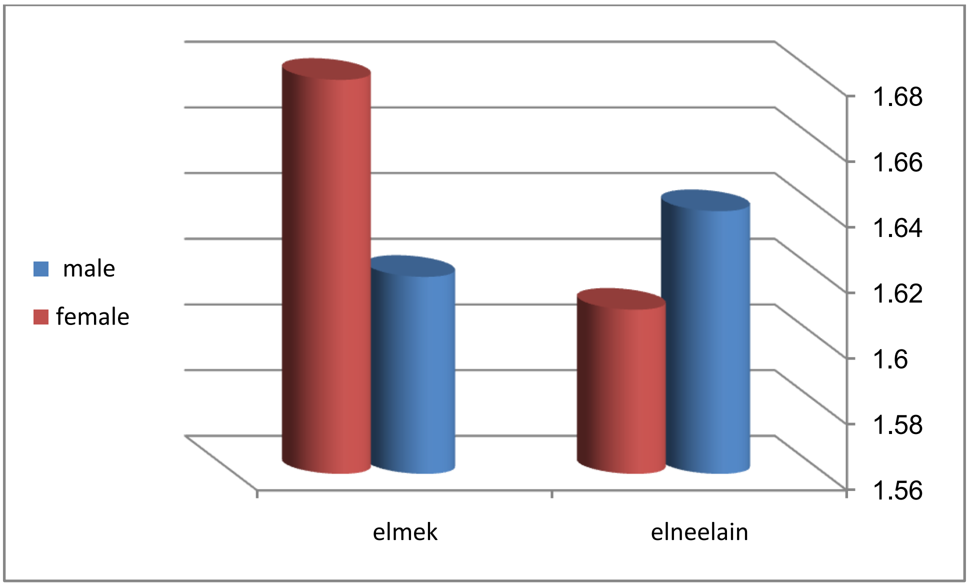

Figure 4.4: height of gender patient in two hospitals

Table 4.3 distribution of organ scan in two hospitals

Diagnostic	paient in elneelain	patient in elmek
Thyroid scan	15	14
Renal scan	3	2
Bone scan	12	14

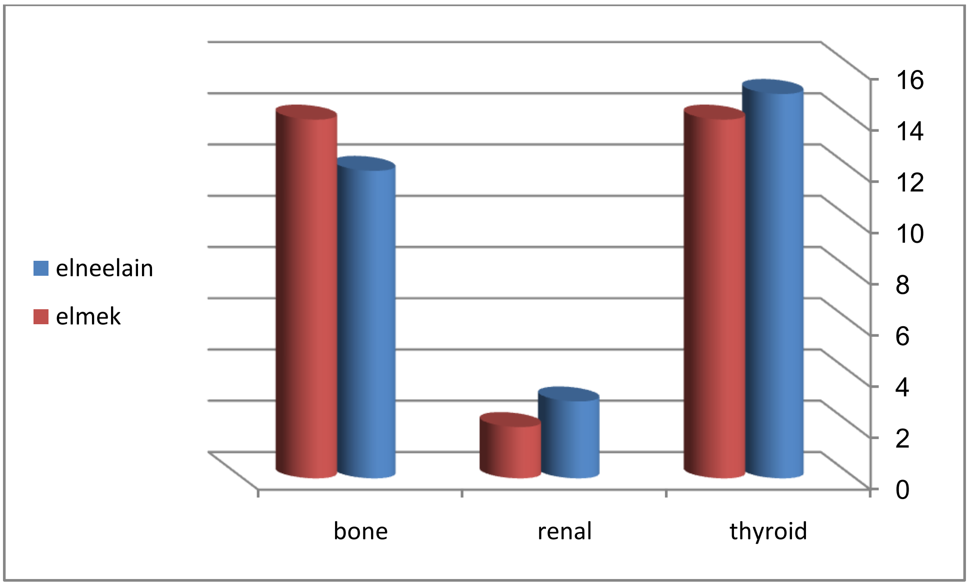

Figure 4.5: organs scan distribution in two hospitals

Table 4.4 patient doses for some diagnostic organs in nuclear medicine

Diagnostic	Dose in elneelain	Dose in elmek
Thyroid scan	5.04±0.9 (4-7)	5.24±0.1 (4-7)
Renal scan	9.19±0.02 (9-10)	8.05±0.17 (9-10)
Bone scan	20.10±0.74 (20-22)	22.10±3.74 (20-25)

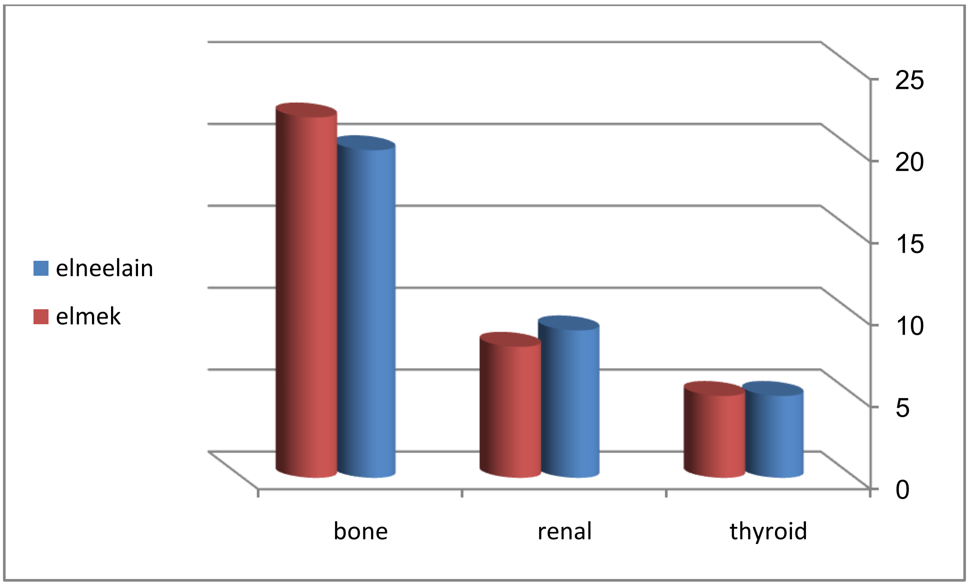

Figure 4.6: organs scan doses distribution in two hospitals

Chapter Five

Discussion

5.1 Discussion

Most diagnostic studied can result in clinically significant radiation dose to the patient, even when performed by trained operators with use of dose-reducing technology and modern amma camera equipment. Patient doses to thyroid, renal and bone scans at minimum, patient dose data should be recorded in the medical record for these three types of diagnostic in nuclear medicine. (Wagner et al.1999).

This study intends to estimate the patient radiation doses in diagnostic nuclear medicine for three organs thyroid, renal and bone scan in two hospitals in Sudan Elneelain diagnostic center and ElmekNimer University hospital.

A total of 60 patients were examined after injection with technetium in two hospitals equipped with gamma camera imaging modalities, 30 patients are exposure in in elneelain diagnostic center and 30 patients in ElmekNimer University Hospital. Show in Tables (4.3).

The mean age, weight and height are 77.37, 66.76 and 1.64 respectively for male in elneelian center. The mean age, weight and height are 59.70, 67.86 and 1.61 respectively for female in elneelain center. The mean age, weight and height are 70.17, 69.34 and 1.62 respectively for male in elmek nimer hospital. The mean age, weight and height are 51.33, 62.40 and 1.68 respectively for female in elmek nimer hospital

The mean doses of thyroid, renal and bone scan are 5.04, 9.19 and 20.10 respectively in elneelain center. The mean doses of thyroid, renal and bone scan are 5.24, 8.05 and 22.10 respectively in elmek nimer hospital.

The doses were the highest in bone scan this because of long duration for dose to reach bone so the biological half life need high dose as measured by J R WILLIAMS et, al, and the Department of Radiology in USA, et al,.

Bone scan dose which is highest organ diagnosed agrees with Ioannis Pantos et-al and Donadl.Miller et alwhile in orthopedicintervention radiology agrees with Osman.H, et, al Abdelmoneim Sulieman, et, al.

5.2 Conclusions

Nuclear medicine is the medical specialty that involves the use of radioactive isotope in the diagnosis and treatment of disease. Nuclear medicine began only after the discovery by Enrico Fermi in 1935 that stable elements could be made radioactive by bombarding them with neutrons. The atoms of the elements so bombarded capture these neutrons, thus assuming a different nuclear form while remaining the same elements. These radioisotopes have unstable nuclei, however, and dissipate excess energy by emitting radiation in the form of gamma and other rays. This study intends to estimate the patients radiation diagnostic doses in nuclear medicine.

Patient doses were measuring during this study used on two hospitals to three types of organ diagnosed.

demographic data were measured (age, weight, height, sex, clinical indication, and type of organ diagnosed). used dose calibrator to measure organ doses.

Two different gamma camera machines were used throughout this study.

In this study bone scan doses values were higher than the other two types of diagnosed while thyroid scan diagnosed is lowest one figure (4.5).

5.3 Recommendations

- Advices the staff to use minimum dose as low as possible.

- More cases, more patients and more types of diagnostic can be used to reach more accuracy.
- More diagnostic must be used.
- More regulatory training can be done to staff in order togive accuracy dose thus reduce dose to the patients .
- An experience one in any field can be found in the in nuclear medicine to minimize the radiation dose to the patient.
- More studies in diagnostic nuclear medicine can be done to reach to best result and best expected.

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