

Chapter One

1.1 Introduction

Nuclear medicine is a medical specialty involving the application of radioactive substances in the diagnosis and treatment of disease. In nuclear medicine procedures, radionuclides are combined with other elements to form chemical compounds, or else combined with existing pharmaceutical compounds, to form radiopharmaceuticals. These radiopharmaceuticals, once administered to the patient, can localize to specific organs or cellular receptors. This property of radiopharmaceuticals allows nuclear medicine the ability to image the extent of a disease-process in the body, based on the cellular function and physiology, rather than relying on physical changes in the tissue anatomy. In some diseases nuclear medicine studies can identify medical problems at an earlier stage than other diagnostic tests. Nuclear medicine, in a sense, is "radiology done inside out" or "endo-radiology" because it records radiation emitting from within the body rather than radiation that is generated by external sources like X-rays. Treatment of diseased tissue, based on metabolism or uptake or binding of a particular ligand, may also be accomplished, similar to other areas of pharmacology. However, the treatment effects of radiopharmaceuticals rely on the tissue-destructive power of short-range ionizing radiation. (www.nuclearcardiologyseminars.net/history.htm April 2017)

In the future, nuclear medicine may provide added impetus to the field known as molecular medicine. As understanding of biological processes in the cells

Many historians consider the discovery of artificially produced radionuclides by Frederic Joliot-Curie and Irene Joliot-Curie in 1934 as the most significant milestone in nuclear medicine. In 1934, they reported the first artificial production of radioactive material in the journal *Nature*, after discovering radioactivity in aluminum foil that was irradiated with a polonium preparation.

1.2 Nuclear Heart Scan:

A nuclear heart scan is a test that provides important information about the health of the heart. For this test, a safe, radioactive substance called a tracer is injected into the bloodstream through a vein. The tracer travels to the heart and releases energy. Special cameras outside of the body detect the energy and use it to create pictures of the heart. Nuclear heart scans are used for two main purposes: To check how blood is flowing to the heart muscle. If part of the heart muscle isn't getting blood, it may be a sign of coronary heart disease (CHD). CHD can lead to chest pain called angina, a heart attack, and other heart problems. When a nuclear heart scan is done for this purpose, it's called myocardial perfusion scanning. to look for damaged heart muscle. Damage might be the result of a previous heart attack, injury, infection. It is called myocardial viability testing. to see how well the heart pumps blood to the body. it's called ventricular function scanning. Usually, two sets of pictures are taken during a nuclear heart scan. The first set is taken right after a stress test, while your heart is beating fast. During a stress test, an exercise to make the heart work hard and beat fast. If the patient exercises, he might be given medicine to increase the heart rate. This is called a pharmacological stress test. The second set of pictures is taken later, while the heart is at rest and beating at a normal rate.

www.nuclearcardiologyseminars.net/history.htm April 2017

California San Francisco (UCSF), and the first PET/CT prototype by D. W. Townsend from University of Pittsburgh in 1998

PET and PET/CT imaging experienced slower growth in its early years owing to the cost of the modality and the requirement for an on-site or nearby cyclotron; however, an administrative decision to approve medical reimbursement of limited PET and PET/CT applications in oncology has led to phenomenal growth and widespread acceptance over the last few years, which also was facilitated by establishing ¹⁸F-labelled tracers for standard procedures, allowing work at non-cyclotron-equipped sites. PET/CT imaging is now an integral part of oncology for diagnosis, staging and treatment monitoring. A fully integrated MRI/PET scanner is on the market from early 2011.

1.3 Radiation dose and risks in nuclear medicine:

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 doses 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 mega Becquerel's (MBq), (www.nuclearcardiologyseminars.net/history.htm April 2017)

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 pSv (0.006 mSv) for a 3 MBq chromium-51 EDTA measurement of glomerular filtration rate to 37 mSv (37,000 μ Sv) for a 150 MBq thallium-201 non-specific tumor imaging procedure. The common bone scan with 600 MBq of technetium-99m-MDP has an effective dose of approximately 3.5 mSv (3,500 μ Sv) (1).

(www.nuclearcardiologyseminars.net/history.htm April 2017)

Formerly, units of measurement were the curie (Ci), being 3.7×10^{10} Bq, and also 1.0 grams of Radium (Ra-226); the rad (radiation absorbed dose), now replaced by the gray; and the rem (Röntgen equivalent man), now replaced with the sievert. 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 radioactive tracer used during nuclear heart scanning exposes the body to a very small amount of radiation. No long-term effects have been reported from these doses.

Radiation dose might be a concern for people who need multiple scans. However, advances in hardware and software may greatly reduce the radiation dose people receive. Some people are allergic to the radioactive tracer, but this is rare. If you have coronary heart disease, you may have chest pain during the stress test while you're exercising or taking medicine to raise your heart rate. Medicine can relieve this symptom. If you're pregnant,

tell your doctor or technician before the scan. It might be postponed until after the pregnancy.

1.4 Problem of study:

The nuclear medicine is very important in the diagnosis and hence treatment of various diseases, as well as in the formulation of the treatment plan for the patient_ and the examinations characterized easily and there is no damage to the body. But the radioactive material injected in the patient for heart examination had potential hazard to the patient and the working staff this required investigation for conformation of radiation hazard.

1.5 Objectives:

General objective : to evaluate the effective radiation dose in myocardial infarct study using Tc-99m pyrophosphate agent

Specific objectives :

- To determine patient effective dose in myocardial infarct imaging study
- To calculate radiation effective dose to patients of study sample
- To find association between effective dose and body variable++(weight,height,age,and BMI)

1.6 Importance of study:

the radiation dose that is given to the patient and reduced the radiation hazard in the diagnosis of heart disease using Technetium-99m in the presence of a gamma camera .

1.7 study outlines:

This study was concerned with measurement and evaluation of patient dose in heart scintigraphy and estimation of organ dose and radiation risk, and is presented into the following chapters:

Chapter one contains the introduction and discusses the problem, importance of study and objectives.

Chapter two contains the theoretical background and also includes previous studies in this work and methods of dose estimation in nuclear medicine.

Chapter three described the materials and the methods

Chapter four presented the results of this study.

Chapter five represented the discussion, conclusion and recommendations.

2.1 Theoretical background

2.1.1 The Gamma Camera:

A gamma camera, also called a scintillation camera or Anger camera, is a device used to image gamma radiation emitting radioisotopes, a technique known as scintigraphy. The applications of scintigraphy include early drug development and nuclear medical imaging to view and analyze images of the human body or the distribution of medically injected, inhaled, or ingested radionuclide's emitting gamma rays.



Figure 2.1: Gamma camera

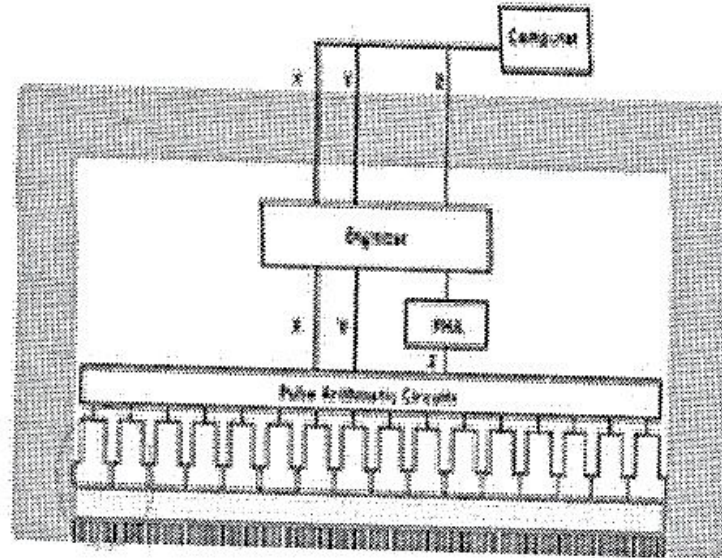


Figure 2.2: Diagrammatic cross section of a gamma camera detector

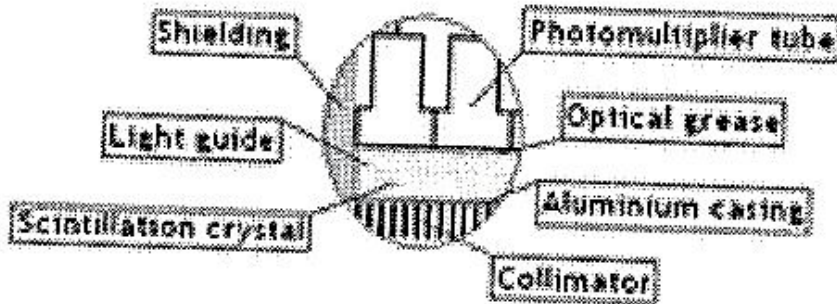


Figure 2.3: details of the cross section of a gamma camera

A gamma camera consists of one or more flat crystal planes (or detectors) optically coupled to an array of photomultiplier tubes, the assembly is known as a "head", mounted on a gantry. The gantry is connected to a computer system that both controls the operation of the camera as well as acquisition and storage of acquired images.

The system accumulates events, or counts, of gamma photons that are absorbed by the crystal in the camera. Usually a large flat crystal of sodium

iodide with thallium doping in a light-sealed housing is used. The highly efficient capture method of this combination for detecting gamma rays was discovered by noted physicist Robert Hofstadter in 1948).

The crystal scintillates in response to incident gamma radiation. When a gamma photon leaves the patient (who has been injected with a radioactive pharmaceutical), it knocks an electron loose from an iodine atom in the crystal, and a faint flash of light is produced when the dislocated electron again finds a minimal energy state. The initial phenomenon of the excited electron is similar to the photoelectric effect and (particularly with gamma rays) the Compton effect. After the flash of light is produced, it is detected. Photomultiplier tubes (PMTs) behind the crystal detect the fluorescent flashes (events) and a computer sums the counts. The computer reconstructs and displays a two dimensional image of the relative spatial count density on a monitor. This reconstructed image reflects the distribution and relative concentration of radioactive tracer elements present in the organs and tissues imaged. (www.nuclearcardiologyseminars.net/history.htm April 2017)

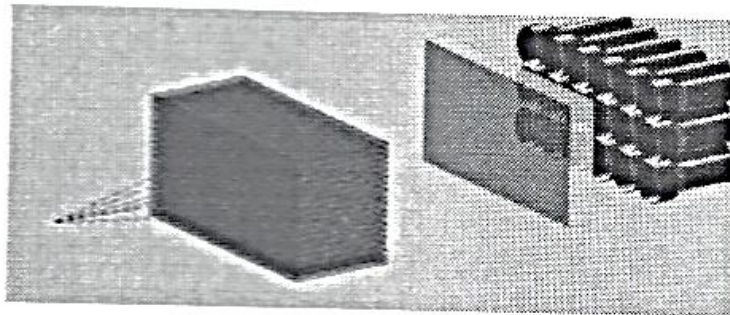


Figure 2.4: Animated schematic of gamma-camera physics and main constituents

2.1.2 Signal processing:

Hal Anger developed the first gamma camera in 1957. His original design, frequently called the Anger camera, is still widely used today. The Anger camera uses sets of vacuum tube photomultipliers (PMT). Generally each tube has an exposed face of about 7.6 cm in diameter and the tubes are arranged in hexagon configurations, behind the absorbing crystal. The electronic circuit connecting the photodetectors is wired so as to reflect the relative coincidence of light fluorescence as sensed by the members of the hexagon detector array. All the PMTs simultaneously detect the (presumed) same flash of light to varying degrees, depending on their position from the actual individual event. Thus the spatial location of each single flash of fluorescence is reflected as a pattern of voltages within the interconnecting circuit array. The location of the interaction between the gamma ray and the crystal can be determined by processing the voltage signals from the photomultipliers; in simple terms, the location can be found by weighting the position of each photomultiplier tube by the strength of its signal, and then calculating a mean position from the weighted positions. The total sum of the voltages from each photomultiplier is proportional to the energy of the gamma ray interaction, thus allowing discrimination between different isotopes or between scattered and direct photons. (www.nuclearcardiologyseminars.net/history.htm April 2017)

2.1.3 Heart scans procedures:

A nuclear heart scan is a test that provides important information about the health of the heart. For this test, a safe, radioactive substance called a tracer is injected into the bloodstream through a vein. The tracer travels to the heart and releases energy. Special cameras outside of the body detect the energy and use it to create pictures of the heart. Nuclear heart scans are used for two main purposes: To check how blood is flowing to the heart muscle. If part of the heart muscle isn't getting blood, it may be a sign of coronary heart disease (CHD). CHD can lead to chest pain called angina , a heart attack, and other heart problems. When a nuclear heart scan is done for this purpose, it's called myocardial perfusion scanning. to look for damaged heart muscle. Damage might be the result of a previous heart attack, injury, infection. It is called myocardial viability testing. to see how well the heart pumps blood to the body. it's called ventricular function scanning. Usually, two sets of pictures are taken during a nuclear heart scan. The first set is taken right after a stress test, while your heart is beating fast. During a stress test, an exercise to make the heart work hard and beat fast. If the patient exercise, he might be given medicine to increase the heart rate. This is called a pharmacological stress test. The second set of pictures is taken later, while the heart is at rest and beating at a normal rate.

The two main types of nuclear heart scans are single photon emission computed tomography (SPECT) and cardiac positron emission tomography (PET).

2.1.4 Single Photon Emission Computed Tomography:

Doctors use SPECT to help diagnose coronary heart disease (CHD). Combining SPECT with a stress test can show problems with blood flow to

the heart. Sometimes doctors can detect these problems only when the heart is working hard and beating fast.

Doctors also use SPECT to look for areas of damaged or dead heart muscle tissue. These areas might be the result of a previous heart attack or other cause.

SPECT also can show how well the heart's lower left chamber (left ventricle) pumps blood to the body. Weak pumping ability might be the result of a heart attack, heart failure, and other causes. Tracers commonly used during SPECT include thallium-201, technetium-99m sestamibi (Cardiolite®), and technetium-99m tetrofosmin (Myoview™). (www.nuclearcardiologyseminars.net/history.htm April 2017)

2.1.5 Positron Emission Tomography:

Doctors can use PET for the same purposes as SPECT—to diagnose CHD, check for damaged or dead heart muscle tissue, and check the heart's pumping strength.

Compared with SPECT, PET takes a clearer picture through thick layers of tissue (such as abdominal or breast tissue). PET also is better at showing whether CHD is affecting more than one of your heart's blood vessels.

Right now, however, there's no clear advantage of using one scan over the other in all situations. Research into advances in both SPECT and PET is ongoing.

PET uses different tracers than SPECT. Other Names for a Nuclear Heart Scan

Nuclear stress test, SPECT scan, PET scan and Radionuclide scan

2.1.6 Expectation before a Nuclear Heart Scan:

A nuclear heart scan can take a lot of time. Most scans take between 2-5 hours, especially if your doctor needs two sets of pictures.

Discuss with your doctor how a nuclear heart scan is done. Talk with him or her about your overall health, including health problems such as asthma, COPD (chronic obstructive pulmonary disease), diabetes, and kidney disease. If you have lung disease or diabetes, your doctor will give you special instructions before the nuclear heart scan.

If you're having a stress test as part of your nuclear heart scan, wear comfortable walking shoes and loose-fitting clothes for the test. You may be asked to wear a hospital gown during the test. Let your doctor know about any medicines you take, including prescription and over-the-counter medicines, vitamins, minerals, and other supplements. Some medicines and supplements can interfere with the medicines that might be used during the stress test to raise your heart rate.(www.nuclearcardiologyseminars.net/history.htm April 2017)

2.1.7 Expectation during a Nuclear Heart Scan:

Many nuclear medicine centers are located in hospitals. A doctor who has special training in nuclear heart scans- a cardiologist or radiologist—will oversee the test.

Cardiologists are doctors who specialize in diagnosing and treating heart problems. Radiologists are doctors who have special training in medical imaging techniques.

Before the test begins, the doctor or a technician will use a needle to insert an intravenous (IV) line into a vein in your arm. Through this IV line, he or she will put radioactive tracer into your bloodstream at the right time.

You also will have EKG (electrocardiogram) patches attached to your body to check your heart rate during the test. (An EKG is a simple test that detects

and records the heart's electrical activity.)(www.nuclearcardiologyseminars.net/history.htm April 2017)

2.1.8 Expectations During the Stress Test:

If you're having an exercise stress test as part of your nuclear scan, you'll walk on a treadmill or pedal a stationary bike. During this time, you'll be attached to EKG and blood pressure monitors.

Your doctor will ask you to exercise until you're too tired to continue, short of breath, or having chest or leg pain. You can expect that your heart will beat faster, you'll breathe faster, your blood pressure will increase, and you'll sweat.

Tell your doctor if you have any chest, arm, or jaw pain or discomfort. Also, report any dizziness, light-headedness, or other unusual symptoms

If you're unable to exercise, your doctor may give you medicine to increase your heart rate. This is called a pharmacological stress test. The medicine might make you feel anxious, sick, dizzy, or shaky for a short time. If the side effects are severe, your doctor may give you other medicine to relieve the symptoms. Before the exercise or pharmacological stress test ends, the tracer is injected through the IV line.

(www.nuclearcardiologyseminars.net/history.htm April 2017)

2.1.9 Expectations During the Nuclear Heart Scan:

The nuclear heart scan will start shortly after the stress test. You'll lie very still on a padded table. The nuclear heart scan camera, called a gamma camera, is enclosed in metal housing. The camera can be put in several positions around your body as you lie on the padded table.

For some nuclear heart scans, the metal housing is shaped like a doughnut (with a hole in the middle). You lie on a table that slowly moves through the hole. A computer nearby or in another room collects pictures of your heart .

Usually, two sets of pictures are taken. One will be taken right after the stress test and the other will be taken after a period of rest. The pictures might be taken all in 1 day or over 2 days. Each set of pictures takes about 15-30 minutes.

Some people find it hard to stay in one position during the test. Others may feel anxious while lying in the doughnut-shaped scanner. The table may feel hard, and the room may feel chilly because of the air conditioning needed to maintain the machines.

Let your doctor or technician know how you're feeling during the test so he or she can respond as needed(www.nuclearcardiologyseminars.net/history.htm April 2017)

2.1.10 Expectations After a Nuclear Heart Scan:

Your doctor may ask you to return to the nuclear medicine center on a second day for more pictures. Outpatients will be allowed to go home after the scan or leave the nuclear medicine center between the two scans.

Most people can go back to their daily routines after a nuclear heart scan. The radioactivity will naturally leave your body in your urine or stool. It's helpful to drink plenty of fluids after the test, as your doctor advises.

The cardiologist or radiologist will read and interpret the results of your test. He or she will report the results to your doctor, who will contact you to discuss them. Or, the cardiologist or radiologist may contact you directly to discuss the results. (www.nuclearcardiologyseminars.net/history.htm April 2017)

2.1.3.1 Radio nuclides in heart scan: Technetium Heart Scan:

The technetium heart scan is a noninvasive nuclear scan that uses a radioactive isotope called Technetium to evaluate blood flow after a heart attack.

2.1.3.2 Purpose:

The technetium heart scan is used to evaluate the heart after a heart attack. It can confirm that a patient had a heart attack when the symptoms and pain usually associated with a heart attack were not present; identify the size and location of the heart attack; and provide information useful in determining the patient's post-heart attack prognosis. The scan is most useful when the electrocardiogram and cardiac enzyme studies do not provide definitive results- after heart surgery, for example, or when chest pain occurred more than 48 hours before the patient was examined. It is also used to evaluate the heart before and after heart surgery.

2.1.3.3 Precautions:

Pregnant women and those who are breastfeeding should not be exposed to technetium.

2.1.3.4 Description:

The technetium heart scan is a nuclear heart scan, which means that it involves the use of a radioactive isotope which targets the heart, and a radionuclide detector that traces the absorption of the radioactive isotope. The isotope is injected into a vein and absorbed by healthy tissue at a known rate during a certain time period. The radionuclide detector, in this case a gamma scintillation camera, picks up the gamma rays emitted by the isotope. The technetium heart scan uses technetium Tc-99m stannous pyrophosphate (usually called technetium), a mildly radioactive isotope that binds to calcium. After a heart attack, tiny calcium deposits appear on diseased heart valves and damaged heart tissue. These deposits appear within 12 hours of the heart attack. They are generally seen two to three days after the heart

attack and are usually gone within one to two weeks. In some patients, they can be seen for several months. After the technetium is injected into a blood vessel in the arm, it accumulates in heart tissue that has been damaged, leaving "hot spots" that can be detected by the scintillation camera. The technetium heart scan provides better image quality than commonly used radioactive agents such as thallium, because it has a shorter half-life and can thus be given in larger doses. During the test, the patient lies motionless on the test table. Electrocardiogram electrodes are placed on the patient's body for continuous monitoring during the test. The test table is rotated so that different views of the heart can be scanned. The camera, which looks like an x-ray machine and is suspended above the table, moves back and forth over the patient. It displays a series of images of technetium's movement through the heart and records them on a computer for later analysis. The test is usually performed at least 12 hours after a suspected heart attack, but it can also be done during triage of a patient who goes to a hospital emergency room with chest pain but does not appear to have had a heart attack. Recent clinical studies demonstrate that technetium heart scans are very accurate in detecting heart attacks while the patient is experiencing chest pain. They are far more accurate than electrocardiogram findings. The technetium heart scan is usually performed in a hospital's nuclear medicine department but it can be done at the patient's bedside during a heart attack if the equipment is available. The scan is done two to three hours after the technetium is injected. Scans are usually done with the patient in several positions, with each scan taking 10 minutes. The entire test takes about 30 minutes to an hour. The scan is usually repeated over several weeks to determine if any further damage has been done to the heart. The test is also called technetium 99m pyrophosphate scintigraphy, hot-spot myocardial imaging, infarct avid

imaging, or myocardial infarction scan. The technetium heart scan is not dangerous. The technetium is completely gone from the body within a few days of the test.(www.nuclearcardiologyseminars.net/history.htm April 2017)

The scan itself exposes the patient to about the same amount of radiation as a chest x-ray. The patient can resume normal activities immediately after the test. (www.nuclearcardiologyseminars.net/history.htm April 2017)

2.1.3.5Preparation:

Two to three hours before the scan, technetium is injected into a vein in the patient's forearm.

2.1.3.6Normal results:

If the technetium heart scan is normal, no technetium will show up in the heart.

2.1.3.7Abnormal results:

In an abnormal technetium heart scan, hot spots reveal damage to the heart. The larger the hot spots, the poorer the patient's prognosis

2.1.3.8 Risks of a Nuclear Heart Scan:

The radioactive tracer used during nuclear heart scanning exposes the body to a very small amount of radiation. No long-term effects have been reported from these doses.

Radiation dose might be a concern for people who need multiple scans. However, advances in hardware and software may greatly reduce the radiation dose people receive. Some people are allergic to the radioactive tracer, but this is rare.

If you have coronary heart disease, you may have chest pain during the stress test while you're exercising or taking medicine to raise your heart rate.

Medicine can relieve this symptom. If you're pregnant, tell your doctor or technician before the scan. It might be postponed until after the pregnancy. (www.nuclearcardiologyseminars.net/history.htm April 2017)

2.4.1 Previous Studies :

In Mexico by SPECT has a high sensitivity for the diagnosis of coronary artery disease. Dual isotope protocol using rest thallium and stress MIBI was introduced in of both radiotracers for the study of myocardial perfusion. We present our experience of the first three years. One thousand six hundred patients were studied with suspected myocardial ischemia; 288 were excluded because of an absence of a proper follow up. In 895 of the 1312 patients a coronariography was performed. Images were evaluated by dividing the heart in 20 segments using a 5 points scale (0 = normal to 4 = absence of perfusion). It was considered a perfusion defect when a segment had a score greater or equal to 2 and the SPECT study was considered abnormal if two or more segments had a MIBI stress score equal or greater than 2. The global sensitivity for diagnosis of ischemia was 96.28%. Dual isotope method is appropriate for the diagnosis of ischemic heart disease. It has a high sensitivity and specificity for the recognition of global coronary disease and for specific coronary territories. This work constitutes the greatest series in Latin America that uses this diagnosis method.

In USA Gated SPECT imaging has allowed the simultaneous assessment of both perfusion and function through one study. The popularity of this is amply shown by the unprecedented growth of this imaging modality throughout the country. In addition to the benefits that ventricular function adds to perfusion, gated SPECT imaging also adds to the specificity of perfusion imaging. With recent studies showing the benefit of medical therapy to interventional approaches for the treatment of patients with angina, in particular, patients with chronic stable angina, there has been an increased dependence on noninvasive imaging to assess their ischemic burden. Perfusion, with technetium-99m sestamibi SPECT imaging together with gated SPECT imaging has been the modality of choice in the majority of cases because of the ease of performance of these studies and the increased information provided. This has in large part been attributable to the ability of gated SPECT imaging to provide functional data, significantly increasing the use of radionuclide perfusion imaging. This article reviews the method of acquisition, validation, clinical use, and the newer advances of gated SPECT imaging.

It gives an appreciation of the benefit that gated SPECT imaging has added in terms of risk stratification and prognosis in many cardiac patients. Under the more recent uses are myocardial viability and the increased utility of gating in this scenario, ischemic versus no ischemic cardiomyopathies, and the quandary that this testing poses to physicians and the dilemma of gated thallium imaging with its inferior image quality.

Chapter three

3.1 Materials

Introduction:

Nuclear medicine involves the use of small amounts of radioactive materials (or tracers) to help diagnose and treat a variety of diseases. Nuclear medicine determines the cause of the medical problem based on the function of the organ, tissue or bone. This is how nuclear medicine differs from an x-ray, ultrasound or any other diagnostic test that determines the presence of disease based on structural appearance.

this study to evaluate patient dose in heart scan and estimate the radiation dose that is given to the patient. The data used in study were collected from Alnilein Medical Diagnostic Center in Khartoum.

3.1.1 Study sample:

in this study were calculate radiation dose to diagnose heart disease by using a gamma camera and the process of photography in to phases filming under influence of voltage and imaging at rest and survey was conducted for 50 patients by injecting the patient element Tc-99m being by ECG continued during examination voltage or when give some medicine hearty alternative to exercise that increase heart rate and during which inject the patient a radioactive elements then taken image of the heart muscle directing gamma camera to capture the radioactive material which inhabited the cells of the heart muscle while taken second image in the same way to take first picture after two to four hour .

we found that the weights vary between patient (70-140) and was in test dose of rest between (3.75-5.56) as in the case of voltage between (3.33-6.33) depending on the weights of patients and the average doses in the case of two tests together (0.98-4.47) and the average equal weight (14.67-95.44) and results demonstrated that the dose in the big weights are high with a different type of scan.

3.1.2 Gamma camera Machine:

the gamma camera used in the study was of the type (MIE) for data collection and includes the following specifications: Type: orbiter 37(single head 37 PMTs/FOV387mm) Camera console: scinttron VI-VME Patient bed: carbon fiber pallet Collimatter: low energy general purpose Manuals: hard/electron copy, Printer: HP2300business inkjet Gamma Camera: Generators system:

3.1.3 $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ generators:

Parent: ^{99}Mo as molybdate ($^{99}\text{MoO}_4$)

Half-life:66hr

Decays by β emission,gamma:740,780kev

High affinity to alumina compared to $\text{Tc-}^{99\text{m}}$

Absorbent material: alumina

Eluent $\text{Al}_2\text{O}_3(0.9\%\text{NaCl})$

Eluate : ($^{99\text{m}}\text{TcO}_4$)

3.2 Methods :

3.2.1patient Preparation:

Three hours before the scan, technetium was injected into a vein in the patient's forearm. No Caffeine for 24 Hours prior to your Myocardial Perfusion Scan (i.e. No coffee, tea, chocolate, Cola or energy drinks or any other beverages or food containing caffeine).

3.2.3 Patient data

Patient data in this study included body characteristic (age, weight, height and body mass index (BMI)), and radioactive source include(material, activity, half life, quantity, manufacturer, start time, end time, time of injections, scan time, end of scan time and patient instructions)

3.2.4 Data duration:

This study was conducted in Khartoum state at Alnileen Diagnostic Center during the period from January 2017 to march 2017.

3.2.5 Method of dose calculation:

According to a special report published in Radiology, in 2008 , Nuclear Medicine effective dose can be calculated by using an administered activity schedule based on body surface area in relation to adult reference values of 1.73 m² surface area and 1100 MBq administered activity, as (0.0079 for rest study and 0.009 for stress) msv per MBq

Effective dose:

Effective dose equivalent (Now replaced by Effective Dose) is used to compare radiation doses on different body parts on an equivalent basis because radiation does not affect different parts in the same way. The effective dose is the sum of weighted equivalent doses in all the organs and tissues of the body.

Effective dose = sum of [organ doses x tissue weighting factor].

The effective dose (E) to an individual is found by calculating a weighted average of the equivalent dose (H) to different body tissues, with the weighting factors (W) designed to reflect the different radio sensitivities of the tissues:

$$E = \sum_i H_i W_i$$

One Sievert is a large dose. The effects of being exposed to large doses of radiation at one time (a acute exposure) vary with the dose. Here are some Examples:

10 Sv - Risk of death within days or weeks.

1 mSv- Risk of cancer later in life (5 in 1000).

100 mSv-TLV for annual dose for radiation workers in any one year. 20 mSv-TLV for annual average dose, averaged over five years

3.2. 6 Data analysis :

All recorded information after a specific test for the screening and follow the method of calculating the dose by radioactive material and used the data statistical analysis program (SPSS) and Microsoft excel for analysis.

Chapter four Results

4.1 Introduction

The results were tabulated in the Tables (mean \pm standard deviation (std)) and the range of the readings in parenthesis (min-max). The dose values in diagnostic radiology are small, therefore the dose were presented in MBq. The mean and the standard deviation were calculated using the excel software. For dose calculation, patient individual exposure parameters were recorded (activity and weight).

Table 4.1 shows (Mean \pm SD range) for patient effective dose and body characteristics; (weight, age, height, and effective dose) in heart examination.

Variable	Mean	Max and min
Weight	95.4 \pm 14.6	140-70(kg)
Age	60.1 \pm 8.2	72 -37(year)
High	169.4 \pm 6.04	176-156(cm)
Activity	524.5 \pm 102.9	753.2-370 (mCi)
Effective dose	(7.47 \pm 0.98).	(3.33- 6.77) (mSv)

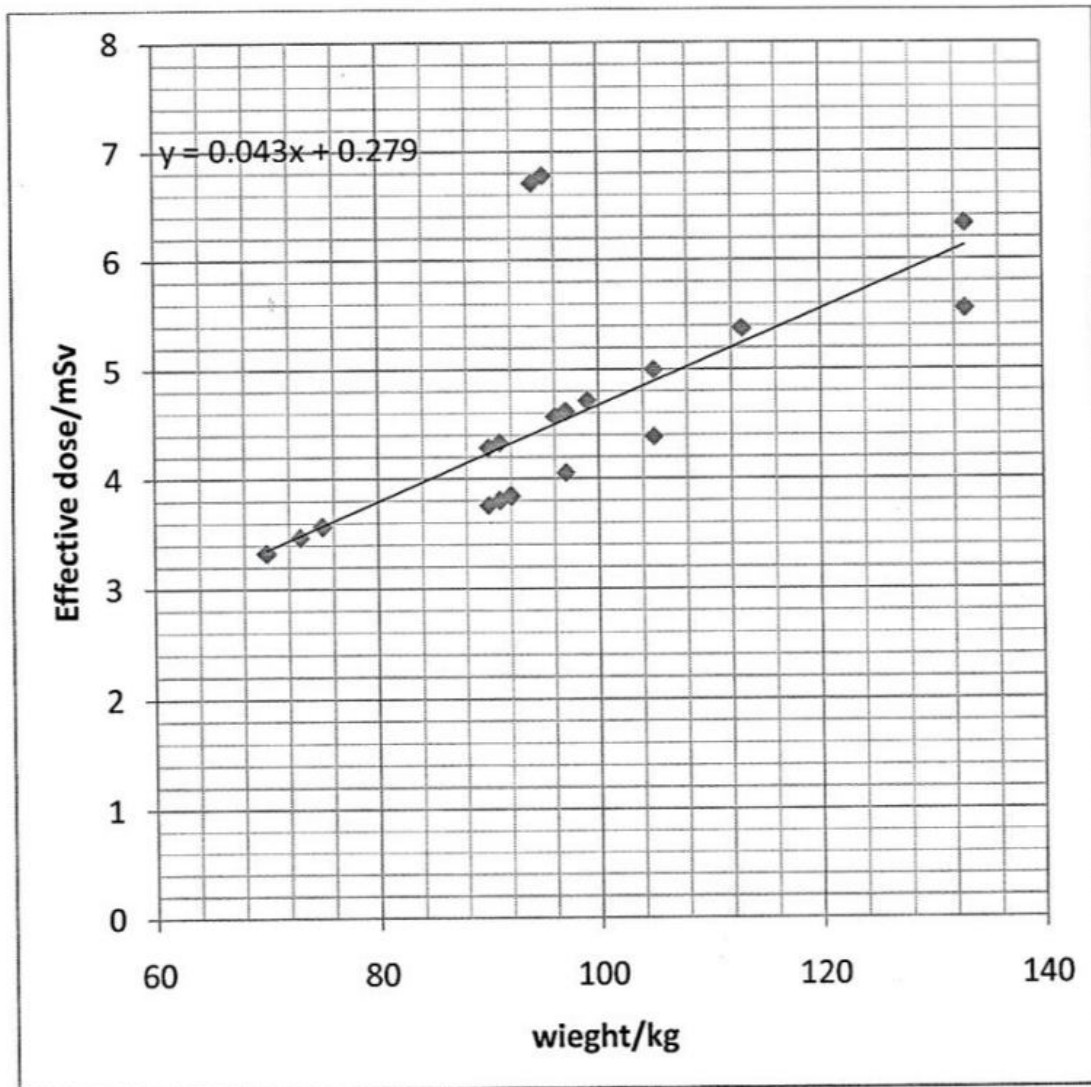


Figure 4.1 direct linear association between the patient weight and effective dose with a coefficient of 0.04mSv/kg i.e for each kilogram of weight the effective dose increased by 0.04 mSv

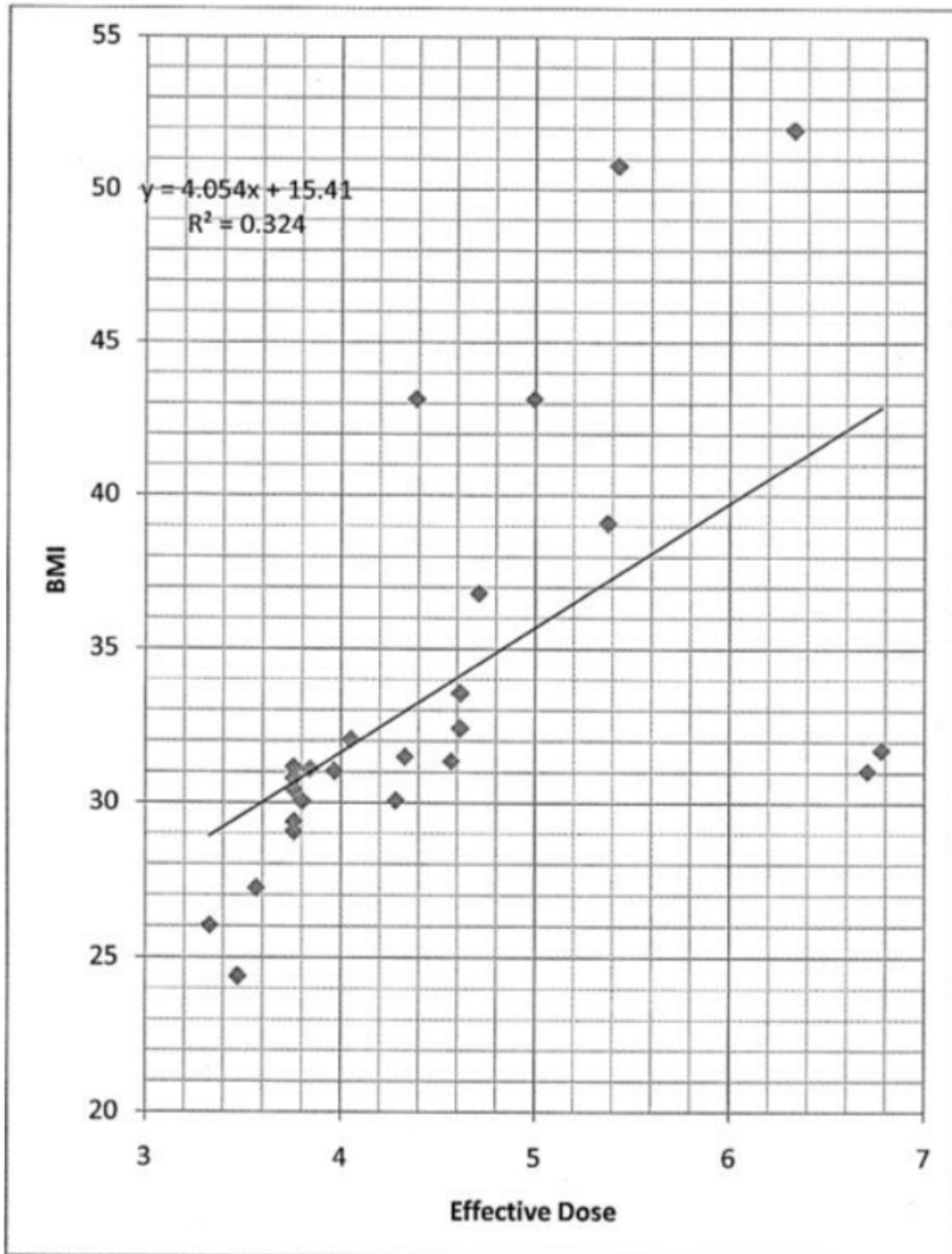


Figure4.2: direct linear association between the BMI and effective dose with a coefficient of 4.05 msv

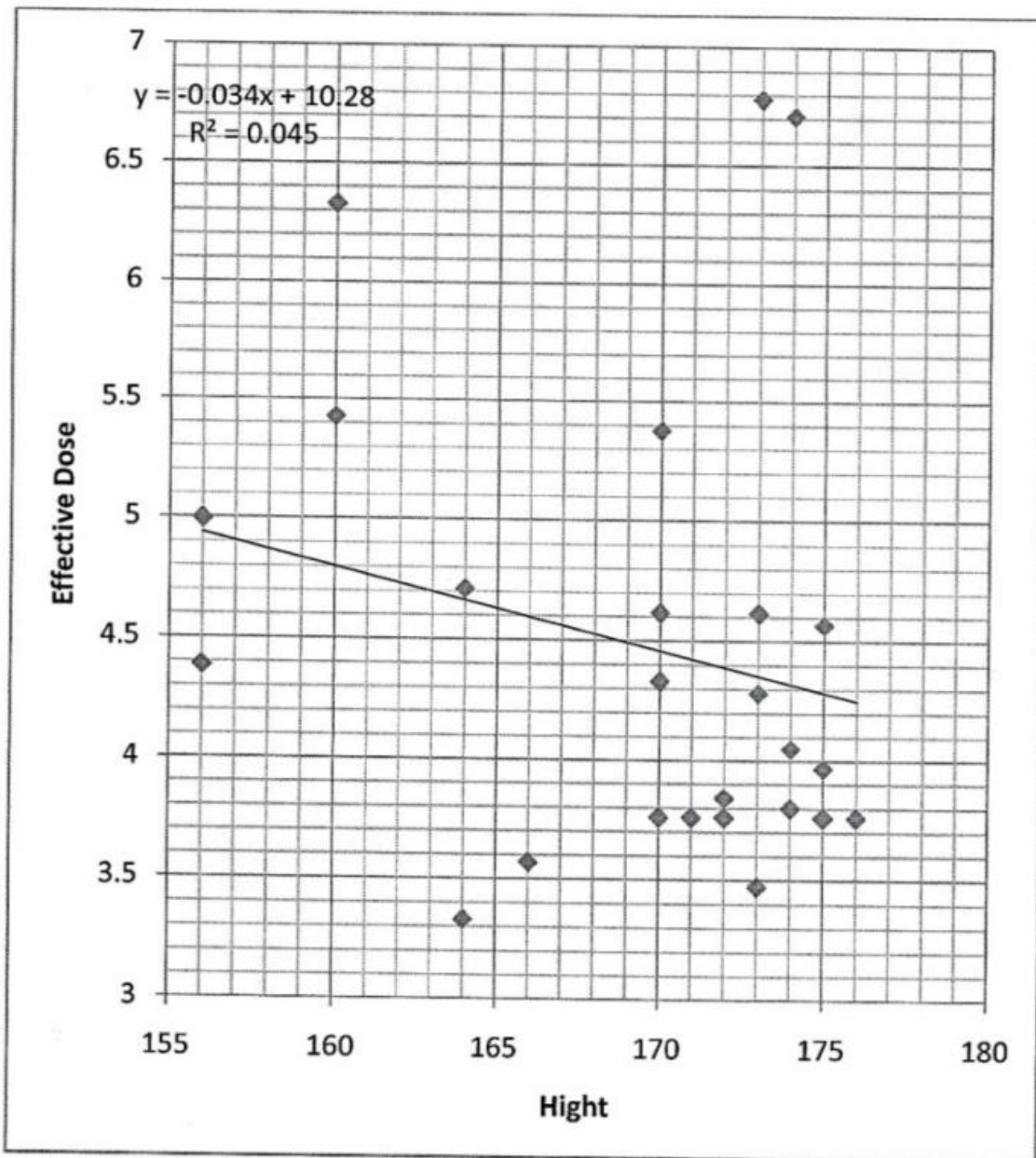


Figure (4.3) direct linear association between the patient hieght andeffective dose with a coefficient of 0.03nsv/cm

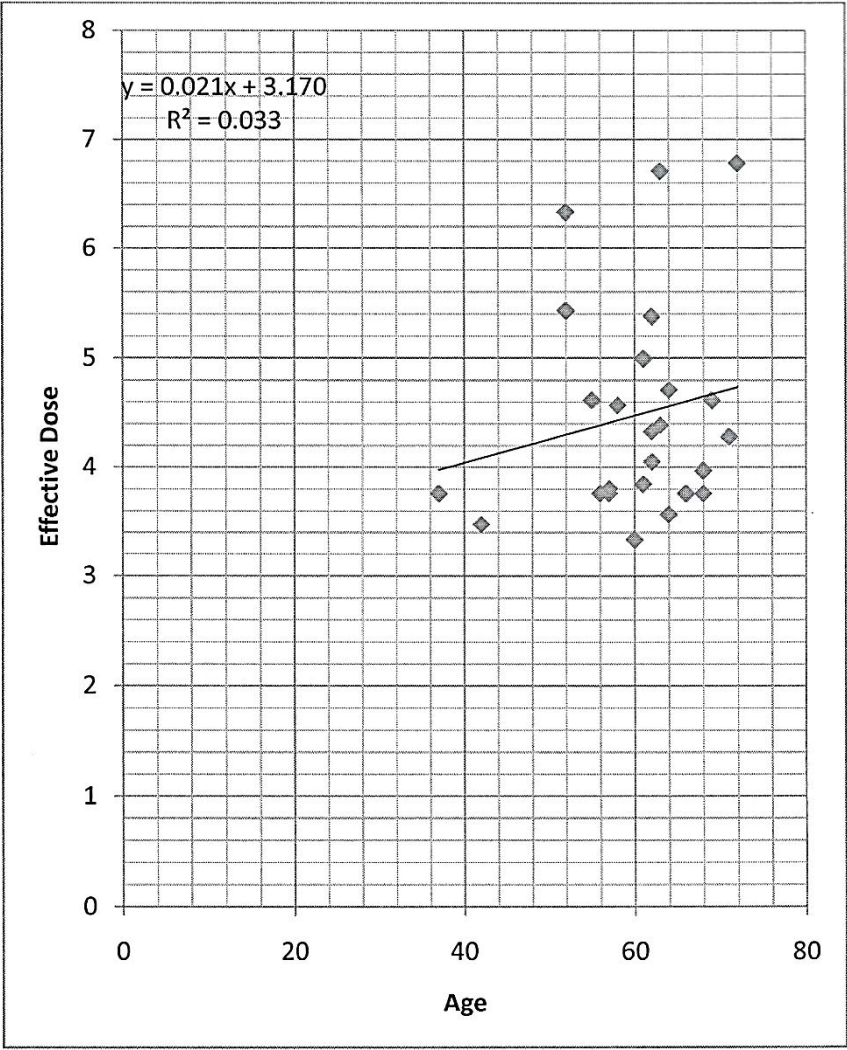


Figure (4.4) direct linear association between the patient age and effective dose with a coefficient of 0.02nsv/cm

ff

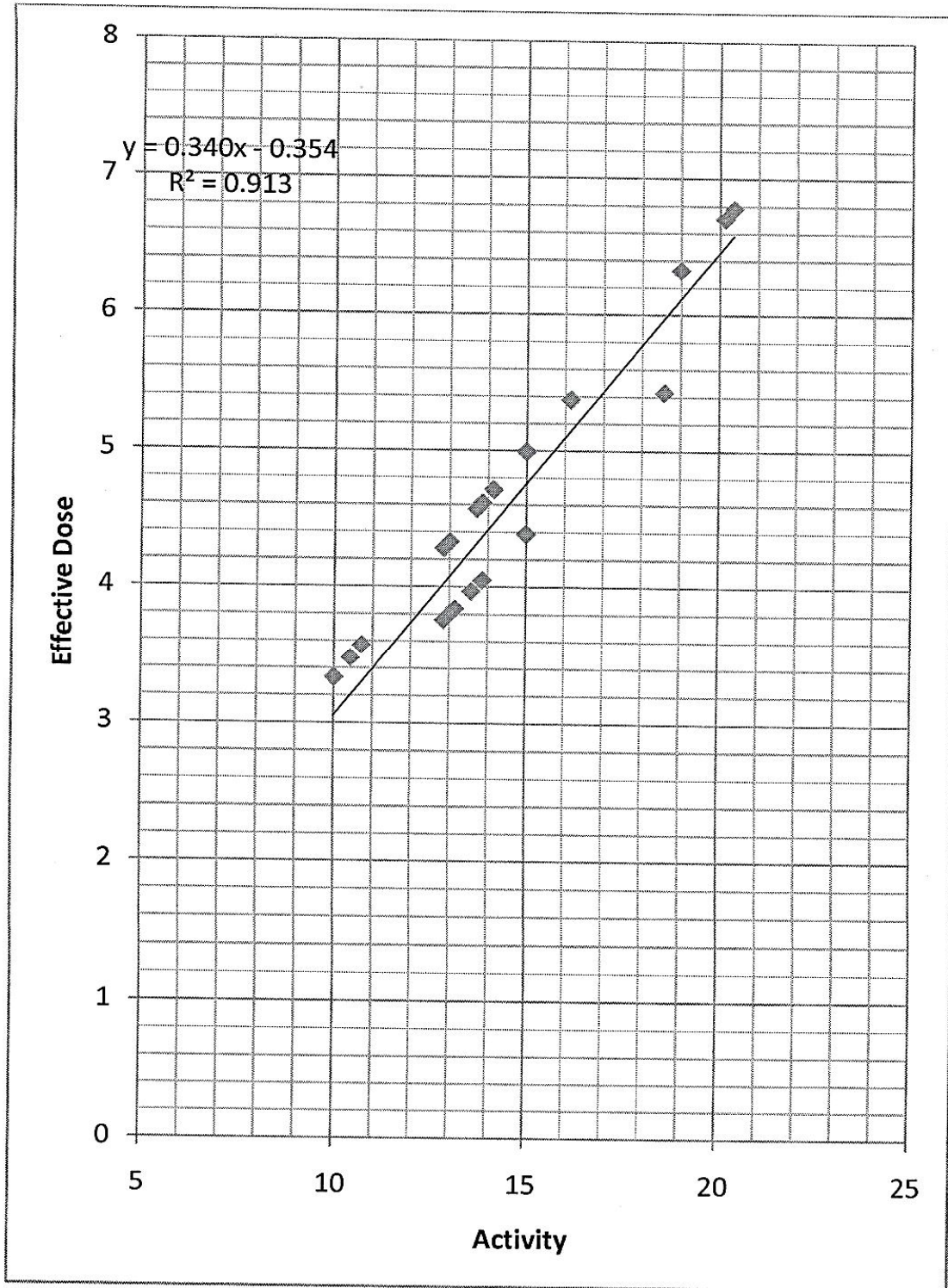


Figure (4.5) direct linear association between the Activity and effective dose with a coefficient of 0.34mSv/cm

Chapter Five

Discussion, Conclusion and Recommendations

5.1 Discussion:

The general objective of this study was to measure the patient dose in heart scintigraphy examination to evaluate the risk of radiation. The data used in study was collected from Al Nilein medical diagnostic center in Khartoum and also in this study, the use of two types of examination of the so-called Stress and rest test. Studies are usually performed using a 1-day protocol this requires administration of a low dose, one-third of the total dose or 8-12 mCi, for the first study (gated image acquired for 20 to 30 image) and a larger dose, two thirds of the total dose or 20-30 mCi, (gated image acquired for 20 to 30 image) for the second study and waiting as long as possible between studies, usually 1.5-2.5 h, to allow for physical decay of Tc- 99m.

In this study, data were collected from 50 patients and calculate the radiation dose by injection patients element technetium and compare the results with previous studies in Mexico by SPECT has a high sensitivity for the diagnosis of coronary artery disease. Dual isotope protocol using rest thallium and stress MIBI was introduced in of both radiotracers for the study of myocardial perfusion and The study confirmed that there is a high sensitivity in the diagnosis of coronary artery disease by element thallium compared to the diagnosis of heart disease by element technetium and also in USA there has been an increased dependence on noninvasive imaging to assess their ischemic burden. Perfusion, with technetium-99m sestamibi SPECT imaging together with gated SPECT imaging has been the modality of choice in the majority of cases because of the ease of performance of these studies and the increased information provided.

The acquired the result from Nilien Center proved that there is a significant exposure to the radiation dose, as especially for patients with great weight where the average patient weight was (95 ± 14.66) kg(70-133)ke ,for activity and effective dose it was (524.45 ± 102.88) Mpq and (4.47 ± 0.98) msv respectively.

generally there is a direct linear association between the patient weight and effective dose with a coefficient of 0.04msv/kg i.e for each kilogram of weight the effective dose increased by 0.04 msv as show (4-1).

And The rest examination weight (96 ± 13.06) , activity (508.38 ± 69.07) , effective dose (4.01 ± 0.55) and stress examination weight (94.91 ± 17.69) , activity (13.55 ± 2.52) , effective dose (4.51 ± 0.84) .and addition to maximum effective dose 6.77, minimum effective dose 3.33.

5.2 Conclusion:

This study aims to measurement of patient dose in heart scan and estimates the radiation dose that is given to the patient and reduces the radiation hazard in the diagnosis of heart disease using Technetium-99mpyrophosphate in the presence of a gamma camera and access to the correct results. Used in this study, a gamma camera of the type (MIE) for data collection.

The results were given by calculating the radiation dose and the patient's weight to get the dose and the average results were as follows: $(4.47 \pm 0.98 \text{ msv})$ and patient weight $(95 \pm 14.66 \text{ Kg})$. and effective dose calculated by using an administered activity schedule based on body surface area in relation to adult reference values of 1.73 m^2 surface area and 1100 MBq administered activity According to a special report published in Radiology, in 2010.

,average effective dose as $(0.079 \text{ for rest study and } 0.09 \text{ for stress}) \text{ msv per MBq}$.

5.3 Recommendations:

- reduce the dose of radiation to reduce the danger of radioactivity and dose proportional to the age and weight of the patient.
- Recommended to measure the dose of radiation in other organs in the measurement of heart scan and exposure to what extent was to protect patients.
- Researchers recommended the work of this study again in Sudan and compared with previous studies.

A patient undergoing a nuclear medicine procedure will receive a radiation dose.

The radioactive tracer used during nuclear heart scanning exposes the body to a very small amount of radiation. No long-term effects have been reported from these doses.

Radiation dose might be a concern for people who need multiple scans. However, advances in hardware and software may greatly reduce the radiation dose people receive.

Some people are allergic to the radioactive tracer, but this is rare.

Tabl 2.1 data collection

Age 52	Weight 133	Height 160	Activity 19	activity/Mbq 703
63	105	156	15	555
61	92	172	13.14286	486.2857
57	90	175	12.85714	475.7143
66	90	170	12.85714	475.7143
68	90	176	12.85714	475.7143
68	90	175	12.85714	475.7143
62	97	174	13.85714	512.7143
57	91	174	<u>13</u>	481
56	90	171	12.85714	475.7143
37	90	172	12.85714	475.7143
62	113	170	16.14286	597.2857
52	133	160	19	
61	105	156	15	555
58	96	<u>175</u>	13.71429	507.4286
55	97	173	13.85714	512.7143
69	97	170	13.85714	512.7143
71	90	173	12.85714	475.7143
64	99	164	14.14286	523.2857
62	91	170	13	481
64	75	166	10.71429	396.4286
60	70	164	10	370
42	73	173	10.42857	385.8571
72	95	173	20.35714	753.2143
63	94	174	20.14286	745.2858
66	107	155	16	555
62	95	173	12.14286	586.2857
50	92	174	12.85720	465.7143
63	90	170	12.85724	475.7143
68	95	176	13.85714	512.7143
60	99	175	12.85714	475.7143
62	97	174	13.85714	512.7143

57	91	174	<u>15</u>	481
56	90	171	12.85714	475.7143
39	93	172	13.85714	475.7143
62	113	170	16.14286	597.2857
52	133	160	19	
62	105	156	16	555
59	96	<u>175</u>	11.71429	507.4286
55	97	173	13.85714	512.7143
69	95	170	12.85714	512.7143
72	90	173	12.85714	475.7143
69	99	164	14.14286	523.2857
66	91	170	13	481
64	75	166	10.71429	396.4286
60	70	164	11	370
44	73	173	10.42857	385.8571
73	95	173	21.35714	753.2143
63	94	174	22.14286	745.2858

Table 2.2 Tissue Weighting Factors for Individual Tissue and Organ (ICRP 60: 1990 recommendation).

Tissue or Organ	Tissue Weighting Factor (WT)
Gonads (testes or ovaries)	0.20
Red bone marrow	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Esophagus	0.05
Thyroid gland	0.05
Skin	0.01
Bone surfaces	0.01
Remainder* *	0.05
Whole body	1.00

5.6 References:

Alexanderson E, Rubinstein J, Unzek S, Serratset al.

Mansoor MR, Heller GV.1999.Nuclear Cardiology Laboratory et al.,

Benoit T, Vivegnis D, Foulon J, Rigo P.1996.Division of Nuclear Medicine, C.H.U et al.,

H. Anger. A new instrument for mapping gamma-ray emitters. et al.,

PF Sharp, et al., Practical Nuclear Medicine, et al.,

Schwochau, Klaus. Technetium. Wiley-VCH (2000).
www.molecularimagingcenter.org, et al.,

Donner Laboratory: The Birthplace of Nuclear Medicine Important Moments in the History of Nuclear Medicine Henkin Ret al.,

www.interactive.snm.org/docs/whatisnucmed.pdf from the Society of Nuclear Medicine.

www.nuclearmedicine.stanford.edu/patient_care
www.medical-dictionary.thefreedictionary.com/heart+scan April 2017

www.nuclearcardiologyseminars.net/history.htm April 2017

www.nhlbi.nih.gov/health/health-topics/topics/nscan/ April 2017

www.cmlhealthcare.com/patients/all-medical-imaging/general-and-cardiac-nuclear-medicine.html April 2017

www.en.wikipedia.org/wiki/Gamma_camera April 2017 1:4pm Anger

HO. 1964 Scintillation camera with multichannel collimators. J N. Med Sharp, 1996., Practical Nuclear Medicine, IRL Press, oxford.

www.sciencedaily.com/releases/2010/07/100708111326.htm