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Review Article

Radiation Protection in Nuclear Medicine in Eastern Province, KSA

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Abstract

In nuclear medicine, radiopharmaceuticals are administered to the patient either for the production of diagnostic images or with the intention to treat using the emitted radiation from the radiopharmaceutical. The increased use of PET-imaging causes a need for new planning of radiation protection. In radionuclide therapy, the activities are higher and the radionuclides used are often different from those used in diagnostic nuclear medicine and constitute a greater radiation protection problem. In both diagnostic and therapeutic nuclear medicine, the patient becomes a source of radiation not only for him/herself but also for staff, caregivers and the general public. All categories of staff members involved in nuclear medicine must have good knowledge of radiation protection. This is vital for patient safety as well as for the staff's own security, for caregivers and the general public.

Introduction

What is nuclear medicine?!

Nuclear medicine specialists use safe, painless, and cost-effective techniques to image the body and treat disease. Nuclear medicine imaging is unique, because it provides doctors with information about both structure and function. It is a way to gather medical information that would otherwise be unavailable, require surgery, or necessitate more expensive diagnostic tests. Nuclear medicine imaging procedures often identify abnormalities very early in the progress of a disease—long before many medical problems are apparent with other diagnostic tests.

Nuclear medicine uses very small amounts of radioactive materials (radiopharmaceuticals) to diagnose and treat disease. In imaging, the radiopharmaceuticals are detected by special types of cameras that work with computers to provide very precise pictures about the area of the body being imaged. In treatment, the radiopharmaceuticals go directly to the organ being treated. The amount of radiation in a typical nuclear imaging procedure is comparable with that received during a diagnostic x-ray, and the amount received in a typical treatment procedure is kept within safe limits. Today, nuclear medicine offers procedures that are essential in many medical specialties, from paediatrics to cardiology to psychiatry. New and innovative nuclear medicine treatments that target and pinpoint molecular levels within the body are revolutionizing our understanding of and approach to a range of diseases and conditions.

Radiation safety and health physics deals primarily with the exposure of personnel that work in nuclear medicine (NM) clinics and research laboratories and who are exposed to radiation in their normal working environment.

Radiation Protection Standards set fundamental requirements for safety. They are regulatory in style and may be referenced by regulatory instruments in State, Territory or Commonwealth jurisdictions. They may contain key procedural requirements regarded as essential for best international practice in radiation protection, and fundamental quantitative requirements, such as exposure limits. Recommendations provide guidance on fundamental principles for radiation protection.

Where there are related Radiation Protection Standards and Codes of Practice, they are based on the fundamental principles in the Recommendations.

The use of radionuclides in medicine that is therapeutic and diagnostic radiopharmaceuticals as well as positron emission tomography (PET) imaging are becoming more common in the clinical environment.

As the Code makes clear, the fundamentals of justification and 3ptimization must apply when undertaking nuclear medicine procedures. Exposure to radiation during a medical procedure needs to be justified by weighing up the benefits against the detriments that may be caused.

This includes considering the benefits and risks of alternative methods that do not involve any exposure to radiation. In the case of

3ptimization, practitioners need to ensure that the minimum amount of radiation is used to achieve the intended diagnostic objective.

This Safety Guide encourages the use of Diagnostic Reference Levels (DRLs) as a tool to support 3ptimization of protection to the patient.

The protection of occupationally exposed staff and the general public are also an important aspect of the optimal use of ionizing radiation in medicine.

Special concern in relation to radiation protection is afforded to children, and pregnant or potentially pregnant females. Medical practice involving the use of ionizing radiation (hereinafter referred to as radiation) is by far the largest contributor to human exposure from human-made sources of radiation; it accounts worldwide for about 95% of the total dose from such sources 32 million nuclear medicine procedures.

In nuclear medicine, radiopharmaceuticals are administered to the patient either for the protection of diagnosis images (diagnosis nuclear medicine or molecular imaging) or with the intention to treat using the emitted radiation from the radiopharmaceutical (nuclear medicine therapy) the most common way for administration is through an intravenous injection.

The radiopharmaceutical is sometimes swallowed by the patient. Alternatively, the patient may breathe a radioactive gas or aerosol.

Impressive progresses have taken place within diagnostic nuclear medicine during the last few years, Diagnostic procedures are now more and more performed using PET/CT and SPECT/CT units.

Especially the PET units require specific site planning and shielding.

In radionuclide therapy, still dominated by radioiodine therapy for thyreotoxicosis and thyroid cancer, there is also an increasing use of radionuclide-labeled monoclonal antibodies and peptides. At therapy, the activities are higher, and the radionuclides used are often different from those used in diagnostic nuclear medicine. They are usually beta emitters (sometimes also low-energy electron or alpha emitters) with longer physical and biological half-lives and therefore constitute a greater radiation protection problem. Therapy radionuclides may require different facilities than radionuclides used for diagnostic procedure, to ensure the safe preparation and administration of the radiopharmaceutical.

In both diagnostic and therapeutic nuclear medicine, The patient becomes a source of radiation not only for him/herself but also for staff, Caregivers, And the general public and remains so until the radioactive material has decayed or is excreted from the body . personnel involved in nuclear medicine must have good knowledge of radiation protection .This is vital for patient safety as well as for the staff own security For patients, radiation protection is ensured (1) by performing only those tests and treatments that are necessary (justification) and (2) by optimization, using the best radiopharmaceuticals, optimally adjusted and calibrated equipment to provide the best test results or treatment outcomes, using standard tests, procedures, And administrative controls, and having knowledgeable and trained personnel . The overriding principle is that any test or treatment should offer the maximum benefit to the patient and limit the radiation exposure [1-3].

When considering the justification for a medical exposure, the benefit is weighed against the detriment, including radiation effects, For diagnostic procedures, the potential detriment is the risk of inducing cancer .This risk is greater in children and decreases with age . For adults, the overall lifetime risk of fatal cancer is estimated to be 5% per Sv.

For an effective dose of 20 mSv, the nominal risk is about 1 in 1,200 for adults aged 30-60 years at the time of exposure. For adults aged 70 or more the risk falls to < 1 in 3000. However, for children up to 10 years old, the risk is about 1 in 450 most diagnostic procedures expose the patient to considerably less than 20 mSv.

It is important to plan the examination, including the requirement for image quality, To fit the clinical problem. This ensures that the investigation has the best opportunity to address the diagnostic question at hand. The size and age of the patient, and the time for which the patient can comfortably remain still for the study, Will influence the activity required to be administered. There are wide variations in the activity administered to patients of standard body size, suggesting that there may be scope for optimization.

Single-Photon Emission Computed Tomography (SPECT)

SPECT/CT has recently emerged as a valuable adjunct to standard techniques in clinical nuclear radiology. This technique provides significantly improved scintigraphic localization and characterization of disease, increasingly important in this era of minimally invasive surgery and targeted radiotherapy [4].

The integration of SPECT and CT in a single imaging device facilitates anatomical localization of the radiopharmaceutical to differentiate physiological uptake from that associated with disease and patient-specific attenuation correction to improve the visual quality and quantitative accuracy of the SPECT image [5].

Definition of SPECT/CT:

A single-photon emission computerized tomography (SPECT) scan lets the physician analyzes the function of some of the internal organs. A SPECT scan is a type of nuclear imaging test, which means it uses a radioactive substance and a special camera to create 3-D pictures [6].

While imaging tests such as X-rays can show what the structures inside the body look like, a SPECT scan produces images that show how organs work. For instance, a SPECT scan can show how blood flows to the heart or what areas of the brain are more active or less active [6].

Why it is Done:

The most common uses of SPECT are to help diagnose or monitor brain disorders, heart problems and bone disorders.

Brain Disorders
SPECT can be helpful in determining which parts of the brain are being affected by:
- Dementia
- Clogged blood vessels
- Seizures
- Encephalitis

Heart Problems
Because the radioactive tracer highlights areas of blood flow, SPECT can check for:
- Clogged Coronary Arteries: if the arteries that feed the heart muscle become narrowed or clogged, the portions of the heart muscle served by these arteries can become damaged or even die.
- Reduced Pumping Efficiency: SPECT can show how completely each heartbeat empties blood from the lower chambers of the heart.

Bone Disorders
Areas of bone healing or cancer progression usually light up on SPECT scans, so this type of test is being used more frequently to help diagnose hidden bone fractures. SPECT scans can also diagnose and track the progression of cancer that has spread to the bones [6].

Principle
The basic technique requires delivery of a gamma-emitting radioisotope (called radionuclide) into the patient, normally through injection into the bloodstream. On occasion, the radioisotope is a simple soluble dissolved ion, such as a radioisotope of gallium (III), which happens to also have chemical properties that allow it to be concentrated in ways of medical interest for disease detection. However, most of the time in SPECT, a marker radioisotope, which is of interest only for its radioactive properties, has been attached to a specific ligand to create a radioligand, which is of interest for its chemical binding properties to certain types of tissues. This marriage allows the combination of ligand and radioisotope (the radiopharmaceutical) to be carried and bound to a place of interest in the body, which then (due to the gamma-emission of the isotope) allows the ligand concentration to be seen by a gamma-camera [6].

Risks
For most people, SPECT scans are safe. If a patient receives an injection or infusion of radioactive tracer, he/she may experience:
- Bleeding, pain or swelling where the needle was inserted in the arm
- Rarely, an allergic reaction to the radioactive tracer.

-Note that SPECT scans aren't safe for women who are pregnant or breast-feeding because the radioactive tracer may be passed to the developing fetus or the nursing baby [6].

How to Prepare
Preparation for a SPECT scan depends on patients' particular situation. Patients should ask health care team whether they need to make any special preparations before the SPECT scan [6].

In general, patients should:
- Leave metallic jewellery at home.
- Inform the technologist if they are pregnant or breast-feeding.

Bring a list of all the medications and supplements they take [6].

What Patients Can Expect During SPECT Scan
SPECT scans involve two steps: receiving a radioactive dye (called a tracer) and using a SPECT machine to scan a specific area of the body.

Receiving a Radioactive Substance
Patients will receive a radioactive substance through an intravenous (IV) infusion into a vein in the arm. The tracer dose is very small, only a few drops, and patients may feel a cold sensation as it enters their body. Patients may be asked to lie quietly in a room for 15 minutes or more before the scan while their bodies absorbs the radioactive tracer. In some cases, patients may need to wait several hours between the injection and the SPECT scan [6].

Undergoing the SPECT Scan
The SPECT machine is a large circular device containing a camera that detects the radioactive tracer patients' body absorbs. During the scan, patients lie on a table while the SPECT machine rotates around them. The SPECT machine takes pictures of their internal organs and other structures. The pictures are sent to a computer that uses the information to create 3-D images of their body [6].

How long the scan takes depends on the reason of the procedure.

Here we have some procedure:

مستشفى سعد التخصصي
SAAD SPECIALIST HOSPITAL

	PRODUCT	DAY OF PRODUCTION	CALIBRATION	EXPIRATION
1	Thallous Chloride (5.0mCi)	Sunday	Thursday	Sunday
2	Gallium Citrate Inj. (5.0mCi)	Wednesday	Tuesday	Thursday
3	Sodium Iodide (I-131) Capsule	Monday	Friday	9 days post calibration
4	Sodium Iodide (I-131) Solution	Monday	Friday	14 days post calibration
5	Meta-Iodobenzylguanidine (I-131) Inj. – (Diagnostic)	Tuesday	Saturday	Tuesday
6	Meta-Iodobenzylguanidine (I-131) Inj. – (Therapeutic)	Monday	Noon following day	24 hours post calibration
7	Sodium Iodide (I-123) Capsule	Daily (Sun-Tues)	Noon-following day	24 hours post calibration
8	Sodium Iodide (I-123) Solution	Daily (Sun-Wed)	Noon-day of production	24 hours post calibration
9	Meta-Iodobenzylguanidine (I-123) Inj. – (Diagnostic)	Monday	6:00pm –day of production	24 hours post calibration
10	Krypton Generator	Daily (Sun-Thurs)	Noon day of production	8 hours post calibration
11	2-Fluorodeoxyglucose (2F-18-FDG) Inj.	Sun -Thursday	Daily 2 runs (On Thursday only one run)	

For any queries please do not hesitate to call us on this number: (+966-11-442-7856).

Thank you.

After The SPECT Scan
Most of the radioactive tracer leaves the body through urine within a few hours after the SPECT scan. The physician may instruct the patient to drink more fluids, such as juice or water, after the SPECT scan to help flush the tracer from the body. The body breaks down the remaining tracer over the next day or two [6].

Results
The physician analyzes the results of the SPECT scan. Pictures from the scan may show colors that tell the physician what areas of the body absorbed more of the radioactive tracer and which areas absorbed less.

Patients may ask health care team how long to expect to wait for their results [6].

Advantages of SPECT/CT

Advantages are represented by better attenuation correction, increased specificity, and accurate depiction of the localization of disease and of possible involvement of adjacent tissues. Endocrine and neuroendocrine tumours are accurately localized and characterized by SPECT/CT, as also are solitary pulmonary nodules and lung cancers, brain tumours, lymphoma, prostate cancer, malignant and benign bone lesions, and infection. Furthermore, hybrid SPECT/CT imaging is especially suited to support the increasing applications of minimally invasive surgery, as well as to precisely define the diagnostic and prognostic profile of cardiovascular patients. Finally, the applications of SPECT/CT to other clinical disorders or malignant tumours is currently under extensive investigation, with encouraging results in terms of diagnostic accuracy [5].

SPECT/CT is especially useful as a guide to surgery. In particular, SPECT/CT is highly appreciated for correctly localizing ectopic glands by providing topographic correlation with adjacent anatomical structures, as well as in patients in whom prior neck surgery guided by planar imaging had failed to identify the adenoma [5].

Applied either selectively or routinely to planar scintigraphy, studies include accurate anatomic localization and characterization of radioiodine foci as benign (such as thyroid remnant tissue or physiologic activity in normal structures) or malignant in cervical nodal or distant metastases. When unusual radioiodine biodistributions are encountered and a physiologic mimic:

- Improved attenuation correction from accurate attenuation map produced by CT.
- Improved diagnostic performance of SPECT studies with coregistered anatomic images.
- Complementary diagnostic CT studies in the same setting.

Disadvantages of SPECT/CT:

Disadvantages include additional imaging time and possible patient discomfort and claustrophobia from lying in a fixed position for approximately 20 min in the tightly enclosed space of the SPECT/CT gantry, and additional radiation exposure from the CT component of the study (1–4 mSv with each acquisition). The benefits and potential risks associated with the study should be assessed for each patient [5]:

- Increased cost of SPECT/CT scanner, as compared to SPECT only.
- Increased cost of SPECT/CT room due to necessary shielding in some configurations.
- During CT scan:
- Metal artifacts
- Sensitivity to patient motion
- Regulatory issues: nuclear medicine technologist are not certified to operate CT.
- Need for new normal databases with normals obtained using AC.
- Additional training necessary for nuclear medicine physicians.
- Additional radiation dose to the patients and the personnel.

PET/CT

A positron emission tomography (PET) scan is an imaging test that uses a radioactive substance called a tracer to look for disease in the body.

Unlike magnetic resonance imaging (MRI) and computed tomography (CT), which reveal the structure of and blood flow to and from organs, a PET scan shows how organs and tissues are working [7].

Equipment

A PET scanner is a large machine with a round, doughnut 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. The CT scanner is typically a large, box-like machine with a hole, or short tunnel, in the center. Patients will lie on a narrow examination table that slides into and out of this tunnel. Rotating around them, the x-ray tube and electronic x-ray detectors are located opposite each other in a ring, called a gantry. The computer workstation that processes the imaging information is located in a separate control room, where the technologist operates the scanner and monitors the examination in direct visual contact and usually with the ability to hear and talk with patients with the use of a speaker and microphone.

Combined PET/CT scanners are combinations of both scanners and look similar to both the PET and CT scanners. A computer aids in creating the images from the data obtained by the camera or scanner [8].

Cyclotron

A cyclotron is required to generate the positron-emitting radionuclides that are used in PET imaging. Ideally cyclotrons are located as close as possible to the PET scanner because the positron-emitting radionuclides tend to have short half-lives [9].

How CT Works

CT stands for Computerized Tomography. During the CT scan, the scanner emits X-rays, which go through the patient to detectors. The computer uses this information to generate cross-sectional images of anatomical structures. The body will not come in contact with the scanner itself. Patients will be lying on a narrow table, which will move through the scanner or detectors. Each cross-sectional picture or slice gives detailed anatomic location and changes in the anatomy. The use of oral and IV contrast agents can enhance the details by highlighting the gastrointestinal tract (filled by oral contrast) and other organs and blood vessels (filled with IV contrast) [8].

How PET Works

PET stands for Positron Emission Tomography. PET scans measure metabolic activity and molecular function by using a radioactive glucose injection. The F-18 FDG is injected into the patient. The PET scanner detects the radiation emitted from the patient, and the computer generates three-dimensional images of tissue function or cell activity in the tissues of the body. These functional images can detect disease earlier than the anatomic information gained from CT alone. Like the CT scanner, the body will never come in contact with scanner itself. There are no side effects from this injection and procedure [8].

All cells use glucose as an energy source. However, cancer cells grow faster than normal healthy cells and they use glucose at much higher rate than normal cells. This is the basis of imaging with F-18 FDG for cancer detection in PET scan [8].

How the Test Is Performed

A PET scan requires a small amount of radioactive material (tracer). This tracer is given through a vein (IV), usually on the inside of the elbow. It travels through blood and collects in organs and tissues. The tracer helps the radiologist see certain areas or diseases more clearly [10].

Patients will need to wait nearby as the tracer is absorbed by their body. This usually takes about 1 hour. Then, the patient will lie on a narrow table, which slides into a large tunnel-shaped scanner. The PET scanner detects signals from the tracer. A computer changes the results into 3-D pictures. The images are displayed on a monitor for the physician to read [10].

Patients must lie still during test. Too much movement can blur images and cause errors. How long the test takes depends on what part of the body is being scanned.

How to Prepare For the Test

Patients may be asked not to eat anything for 4 - 6 hours before the scan. They will be able to drink water.

Patients must tell their health care providers if:

- They are afraid of close spaces (have claustrophobia). Physicians may give them a medicine to help them feel sleepy and less anxious.
- Patients are pregnant or think they might be pregnant.
- They have any allergies to injected dye (contrast).

Patients should always tell their health care providers about the medicines they are taking, including those bought without a prescription. Sometimes, medications may interfere with the test results.

How the Test Will Feel

- Patients may feel a sharp sting when the needle containing the tracer is placed into the vein.
- A PET scan causes no pain. The table may be hard or cold, but patients can request a blanket or pillow.
- An intercom in the room allows patients to speak to someone at any time.
- There is no recovery time, unless patients were given a medicine to relax.

Why the Test Is Performed

A PET scan can reveal the size, shape, position, and some function of organs.

This test can be used to:

- Check brain function
- Diagnose cancer, heart problems, and brain disorders
- See how far cancer has spread
- Show areas in which there is poor blood flow to the heart

Several PET scans may be taken over time to determine how well patients are responding to treatment for cancer or another illness [10].

Normal Results

A normal result means there were no problems seen in the size, shape, or position of an organ. There are no areas in which the tracer has abnormally collected [10].

What Abnormal Results Mean

Abnormal results depend on the part of the body being studied. Abnormal results may be due to:

- Change in the size, shape, or position of an organ
- Cancer
- Infection

Problem with organ function [10]

What Affects the Test

Reasons you may not be able to have the test or why the results may not be helpful include:

- Being pregnant. A PET scan is not usually done during pregnancy because the radiation could harm the unborn baby (fetus).
- Using caffeine, tobacco, or alcohol in the past 24 hours.
- Not being able to lie still for the test.
- Being too anxious.
- Using sedatives.
- Taking medicines, such as insulin, that change your metabolism.
- Having recently had surgery, a biopsy, chemotherapy, or radiation therapy [11].

Risks

- 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. Patients 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, patients should inform the nuclear medicine personnel of any allergies they 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 [8].

Benefits

- Nuclear medicine examinations offer information that is unique— including details on both function and structure—and 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.
- By identifying changes in the body at the cellular level, PET imaging may detect the early onset of disease before it is evident on other imaging tests such as CT or MRI [8].
- The benefits of a combined PET/CT scanner include:
- greater detail with a higher level of accuracy; because both scans are performed at one time without the patient having to change positions, there is less room for error.
- Greater convenience for the patient who undergoes two exams (CT & PET) at one sitting, rather than at two different times [8].

Limitation
Nuclear medicine procedures can be time consuming. It can take hours to days for the radiotracer to accumulate in the part of the body under study 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.

Test results of diabetic patients or patients who have eaten within a few hours prior to the examination can be adversely affected because of altered blood sugar or blood insulin levels.

Because the radioactive substance decays quickly and is effective for only a short period of time, it is important for the patient to be on time for the appointment and to receive the radioactive material at the scheduled time. Thus, late arrival for an appointment may require rescheduling the procedure for another day [8].

Justification
All exposures to ionizing radiation are subject to the principles of justification and optimization. For radiation doses received by a patient undergoing medical diagnosis or treatment.

Nuclear medicine specialist
Personal radiation monitoring and dose limits:

That requires that the Responsible Person provides an personal radiation monitor to all employees who are likely to receive an annual effective dose of more than 1 mSv, which is the case for the majority of professional staff in nuclear medicine centres.

Should endeavor to keep individual doses as low as reasonably achievable (ALARA principle), economic and social factors being taken into account.

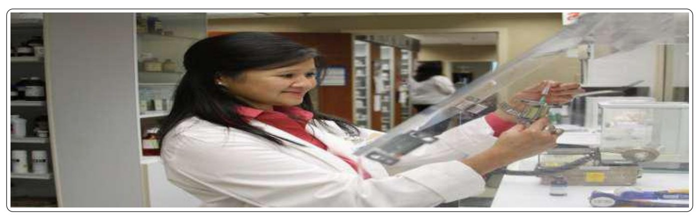
Qualified expert
The Responsible Person needs to ensure that a qualified expert is available, either as an employee or retained as a consultant, for consultation on optimization and to give advice on matters relating to radiation protection, as required. The qualified expert is a medical physicist with suitable training and experience, usually in nuclear medicine physics.

The ultimate decision to perform or reject each individual nuclear medicine procedure lies with the specialist responsible for overseeing the nuclear medicine exposure.

This decision should be based on the specialist's knowledge of the potential risks and benefits of the procedure, taking into account the clinical information, and the sensitivity and specificity of the procedure. The specialist may need to consult with the patient and liaise with the referrer. The decision to proceed, or not to proceed, with a diagnostic procedure should be made after consideration of the timely availability of alternative tests, which involve less or no exposure to ionizing radiation. This is particularly pertinent in cases involving a pregnant woman or young child.

The nuclear medicine specialist should:
- consider current practices in relation to the appropriate use of imaging investigations and therapeutic procedures including their advantages and disadvantages, and the approximate dose of radiation each modality will deliver;
- ensure, when approving a diagnostic or therapeutic nuclear medicine procedure, that the procedure is clinically needed;
- prior to commencing a therapeutic procedure, undertake a consultation with the patient, including counselling for the patient (or guardian), on the potential radiation-related risks associated with the procedure; and
- Make available a copy of relevant images and reports, when requested by another medical practitioner, consistent with the centre's policy on requests for information.

Nuclear Medicine Technologist Safety
The nuclear medicine technologist is responsible for performing nuclear medicine procedures as prescribed by the nuclear medicine specialist in accordance with the centre's written standard protocols.



This will include one or more of the following duties:
- perform imaging and in vitro protocols to ensure optimal data acquisition and analysis;
- prepare, dispense and administer radiopharmaceuticals;
- perform quality assurance procedures for radiopharmaceuticals, instrumentation and image quality. The nuclear medicine technologist's role may include the responsibilities of the administering person and, depending on the size and scope of the centre where he/she is employed, the departmental radiation safety officer, and some of the duties of the person preparing radiopharmaceuticals and of the nuclear medicine physicist.

There some things to technologist:
- Patient identification;
- Patient information;
- Information to accompanying persons and staff nursing a patient after a nuclear medicine examination or therapy;
- Verifying that the female patient is non-pregnant;
- Assure that a mother in lactation is given information about discontinuation of nursing;

- Make the calculation of administered activity to a child according to the local rules;
- Verify the administered radiopharmaceutical and its activity;
- Perform regular quality control of activity meter and other relevant equipment;
- Perform regular workplace monitoring;
- Correct handling of the equipment and safety accessories;
- Inform the RPO in the case of accident or incident;
- Inform the Nuclear Medicine Physician in the case of misadministrations;
- Participate in education and training of new personnel.

The technologist may have the following additional responsibilities, which - alternatively - may be the responsibility of a radiochemist or radiopharmacist:

- Elution of sterile pertechnetate from a 99Mo/99mTc generator;
- Preparation of radiopharmaceuticals from lyophilized kits according to the manufacturer's instructions; and
- Performance of quality control procedures on the prepared radiopharmaceuticals.

The Responsible Person needs to ensure that a Radiation Management Plan is in place to ensure radiation safety. The nuclear medicine component of the Radiation Management Plan will normally be developed by the RSO working with the nuclear medicine specialist and other relevant staff.

The plan should be signed and dated by the Responsible Person and the RSO, where appointed. It should be viewed as a 'living document' so that as changes occur to equipment, operators or work practices, it is updated to reflect the changing nature of the use of radiation at the centre. The Radiation Management Plan should be reviewed within a designated timeframe of no longer than every 5 years and there is some things new record the extra dose in the same time. Revisions should be signed and dated by the Responsible Person and the RSO.

The relevant sections of the Radiation Management Plan should form part of an orientation program for new staff.

Schedule A of the Code lists the requirements for the Radiation Management Plan and Annex A of this Guide provides guidelines for the preparation of the Plan specific for nuclear medicine. It includes the following issues:

- storage, handling and disposal of radioactive materials;
- the protection of employees, patients and members of the public;
- the protection of health professionals, other than those with nuclear medicine training, who may have close contact with patients undergoing nuclear medicine procedures;
- the protection of individuals (carers), who voluntarily help in the care, support or comfort of patients undergoing nuclear medicine procedures;
- the accidental, abnormal or unplanned exposures to radiation; and
- the relevant regulatory requirements that need to be satisfied.

The technologist must wears ring to measure dose during inject the patient, and should be wear shielding when do position to the patient, and do all scan in control room if staff work together to get less dose so must all work quickly.

From all this things this means that the role is technical Prepare, administer, and measure radioactive isotopes in therapeutic, diagnostic, and tracer studies using a variety of radioisotope equipment. Prepare stock solutions of radioactive materials and calculate doses to be administered by radiologists. Subject patients to radiation. Execute blood volume, red cell survival, and fat absorption studies following standard laboratory techniques.

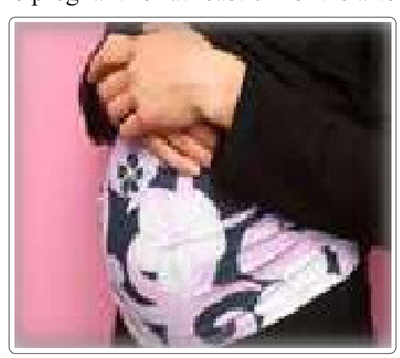
Sample of reported job titles: Certified Nuclear Medicine Technologist (CNMT), Lead Nuclear Medicine Technologist (Lead Nuc Med Tech), Nuclear Cardiology Technologist, Nuclear Medicine PET-CT Technologist (Nuclear Medicine Positron Emission Tomography - Computed Tomography Technologist), Nuclear Medicine Technologist (Nuclear Med Tech), Radiation Safety Officer, Registered Nuclear Medicine Technologist, Senior Nuclear Medicine Technologist, Staff Nuclear Medicine Technologist, Supervisor Nuclear Medicine.

Patient Safety in Nuclear Medicine

There are strict regulations in most countries regarding the treatment of patients with radioisotopes. This includes the provision of special precautions for staff and visitors while such patients are in hospital. Precautions for such patients are given when they leave the hospital or return to work. Hospital staff will provide you with full safety instructions.

Very Important

For female if you are, or could be, pregnant or are breast feeding, please notify staff before proceeding with the therapy dose. You must also not become pregnant for at least 6 months after therapy dose.



There are some things to the patient must be do it:

1. Avoid close or prolonged contact with pregnant women or very small children. A good guide is to stay more than one arm's length away from people.
2. Avoid unnecessary trips on public transport and attending public entertainment (you could be sitting next to someone pregnant).
3. Flush toilet twice after use. Wash hands copiously.
4. Do not attend work if this involves prolonged contact with people.
5. If convenient, sleep in a single bed if partner is less than 50 years of age.
6. Wash hands carefully before preparing food. Do not share your utensils with other family members and avoid activities which may involve exchange of saliva (e.g. kissing).
7. If you are admitted to hospital within 4 weeks of the dose, please arrange for the Nuclear Medicine department to be notified.

Radiotracer may be given to patients of any age but is less frequently given to children under 10. Long term follow-up of children who have been treated with radiotracer for Graves' disease has not shown any adverse effects such as thyroid cancer, leukaemia or congenital malformation in subsequent offspring.

We are all exposed to radiation in our life from the earth, buildings and space. This is called background radiation. People living in the mountains or flying in planes are exposed to higher background radiation than those living near sea level. The amount of radiation used during a nuclear medicine test is small. However, it is still important to keep radiation exposure as low as possible. Nuclear medicine doctors want your child exposed to the smallest amount of radiation possible during their test. The Image Gentlysm campaign and the Pediatric Imaging Council of the Society of Nuclear Medicine are committed to delivering the lowest radiation dose while making sure the pictures are good. Doctors balance the benefit and potential risks of imaging tests. Your doctor and the nuclear medicine physician will work together to decide which test is best for your child. Different tests are done based on facts of your child's illness. Kidney scan Brain scan here are some examples of other nuclear medicine scans.

Breast feeding must stop before starting radiotracer treatment as there is a risk of damaging the infant's thyroid causing permanent hypothyroidism and increasing the risk of thyroid cancer.

The patient should be far away from all family (e.x : i saw patient in Congregational prayer after he had FDG).

After the scan the tracer still in the body to end of half life, then the patient can remove tracer pharmaceutical by drink more water so needs to more urine and some hospital like US used vitamin C.

Here has a form of all procedure to do for patient in nuclear medicine department to protect patient:

Patient instruction card (post-therapy)

The following is an example of an information card which should be given to the patient at the time of discharge, and which the patient should carry with them at all times for as long as the hospital has recommended (usually up to 4 weeks).

THIS CARD SHOULD BE CARRIED AT ALL TIMES UNTIL: / /

PATIENT INFORMATION			
Patient's last name:	First:	Middle:	❑ Mr. ❑ Mrs. ❑ Miss ❑ Ms.
Address:			
Street address:			Home phone no.: ( )
P.O. box:	City:	State:	ZIP Code:
Treating hospital:			
Hospital record number:			
Treating doctor:			
Radionuclide and form:			
Activity:			
Administered on (date):	/ /		
In case of difficulty, please contact:			
Telephone:	( )	or the doctor named above	

PATIENT INSTRUCTIONS		
1	Avoid all close contact with children or pregnant women until (date).	/ /
2	Avoid extended periods of close contact with children or pregnant women until (date).	/ /
3	Avoid prolonged personal contact with adults at home until (date).	/ /
4	Avoid prolonged close personal contact with adults away from home until (date).	/ /
5	You may return to work on (date).	/ /
6	Do not sleep with an adult in the same bed until (date).	/ /

Signed: (treating doctor)	/ / Date

Radioactive Materials in nuclear medicine

The purpose of NRC regulation of the medical use of radioactive material is to prevent needless radiation exposures of both patients and medical workers while not interfering with treatment established by the physician.

Medical use of radioactive materials falls broadly into two categories: diagnostic and therapeutic procedures. About one-third of all patients admitted to hospitals are diagnosed or treated using radiation or radioactive materials. This branch of medicine is called nuclear medicine, and the radioactive materials are called radiopharmaceuticals.

For most diagnostic nuclear medicine procedures, a small amount of radioactive material is administered, either by injection, inhalation or oral administration. The radiopharmaceutical collects in the organ or area being evaluated, where it emits photons. These photons can be detected by a device known as a gamma camera. The gamma camera produces images that provide information about the organ function and composition, and help physicians locate and identify tumors, size anomalies, or other physiological or functional organ problems. Two examples of nuclear medicine procedures are the use of technetium-99m in the diagnosis of bone, heart or other organ problems and radioactive iodine in the imaging of the thyroid gland.

In USA

The increase was primarily a result of the growth in the use of medical imaging procedures, explained Dr. Kenneth R. Kase, senior vice president of NCRP and chairman of the scientific committee that produced the report. "The increase was due mostly to the higher utilization of computed tomography (CT) and nuclear medicine. These two imaging modalities alone contributed 36 percent of the total radiation exposure and 75 percent of the medical radiation exposure of the U.S. population." The number of CT scans and nuclear medicine procedures, performed in the United States during 2013 was estimated to be 67 million and 18 million, respectively.

NCRP is working with some of its partners like the American College of Radiology (ACR), World Health Organization and others to address radiation exposure resulting from the significant growth in medical imaging and to ensure that referrals for procedures like CT and nuclear medicine are based on objective, medically relevant criteria (e.g., ACR appropriateness criteria).

Results

Some health care professionals, who work in nuclear medicine, provided useful practical practices regarding the protection from radiation that are supported by the literature. These practices include wearing a lead apron, rings, or gloves; sitting as far as possible from patients; using lead wall during exam; and using less radionuclide as possible. Further, the nuclear medicine has a great impact in patients 'outcomes. For example, no harm or damage in any another organ other than the one targeted for treatment. Thus, the use of nuclear medicine is recommended in Eastern Province hospitals.

Conclusion

In this research project, we expect the hospitals that utilizing the multimodality imaging system have the advantage of improving their patients' care through early detection and management of certain diseases, such as caners. Consequently, better health outcomes for those patients are anticipated. Nuclear medicine is a practical and effective approach to diagnose and treat patients. However, it may have some hazardous effect in patients' health as well as providers, and other co-workers' health, which emphasizes the need to enhance their awareness about how to protect self from its harmful effects. This enhanced technology will, in turn, be reflected in the level of services provided to the community. Nevertheless, those hospitals that do not have multimodality system, looking forward to get it but they have resources limitation. Also, the students gain experience through their work in nuclear medicine field for the first time as nuclear medicine technologists in Eastern province, KSA.

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