22 MAR 1988

License No. 20-01212-10
Docket No. 030-01833
Control No. 108090

Massachusetts Eye and Ear Infirmary
ATTN: Ephraim Friedman, M.D.
President
243 Charles Street
Boston, Massachusetts 02114

Gentlemen:

This is in reference to your application dated November 30, 1987 to renew License No. 20-01212-10. In order to continue our review, we need the following additional information:

1) Your described training program includes formal and informal training. The one semester formal training appears to meet or exceed the necessary training to handle byproduct materials as authorized on your license, however, it appears not all independent researchers must attend this training. You have not specified a minimum number of hours and content which would be included for any researcher who will supervise byproduct material use. Please also describe the minimum number of hours and content of the training provided for users that are not supervisors.

2) You have not responded to question 5 of our January 20, 1988 letter. Please respond. Monthly surveys as performed by your consultant would not by themselves be adequate in many situations.

3) In question 7 of our January 20, 1988 letter we were referring to personnel whole body and extremity monitoring. Please provide the requested information.

4) If your minimum laboratory radiation safety procedures are described in a Safety Manual as explained in your February 88' letter, please submit a copy of these procedures for our review.

5) Your response to question 9 of our January 20, 1988 letter is incomple Please specify those laboratories were diagnostic and therapeutic medi use of byproduct material will be performed under the Massachu: .tts General Hospital license 20-03814-80.

6) You have failed to provide the attached documents referenced in your answer to question 10. Please provide the missing information.

We will continue our review upon receipt of this information. Please reply in duplicate to my attention at the Region I office and refer to Mail Control No. 108090.

OFFICIAL RECORD COPY ML 293 THOMPSON - 0001.0.0
03/16/88

ML10

D/33

In order to continue prompt review of your application, we request that you submit your response to this letter within 30 calendar days from the date of this letter.

Sincerely,

Original signed by:
Thomas K. Thompson

Thomas K. Thompson
Nuclear Materials Safety Section B
Division of Radiation Safety
and Safeguards

Enclosure: 10 CFR Part 35

RI:DRSS
Thompson/mjh
03/17/88

OFFICIAL RECORD COPY

ML 293 THOMPSON - 0002.0.0
03/16/88

A HEALTH PHYSICS GUIDE FOR PATIENT CARE UNITS: THE RADIATION PRECAUTIONS ASSOCIATED WITH PATIENTS UNDERGOING DIAGNOSTIC RADIOPHARMACEUTICAL PROCEDURES

MGH Isotope Committee

Subcommittee on Radiodiagnostic Health Physics Procedures

Frank P. Castronovo, Jr., Ph.D., Chairperson
Radiation Safety Officer

Edward W. Webster, Ph.D.

H. William Strauss, M.D.

Catherine P. Breen, R.N.

Kyle J. Holley, III

Frank J. Folding, Ex. Officio

June 4, 1982

OK 13 Sept 82
7PC

D/34 18.

TABLE OF CONTENTS

The increase of radiodiagnostic imaging procedures in nuclear medicine is best exemplified by the number of procedures performed in the past several years as illustrated by the following Table 1:

Table 1. Radiodiagnostic Imaging Procedures*

Organ	1976	1979	1982
Brain	2.4 million	1.4 million	1.4 million
Lung	0.8	1.4	2.0
Thyroid	0.5	0.6	0.6
Bone	0.8	1.4	2.3
Liver, Spleen	1.2	1.3	1.5
Soft Tissue	0.2	0.5	1.1
Heart	0.2	0.6	2.0
Other	0.2	0.3	0.5
Total	6.3 million	7.6 million	11.4 million

* projected

Radiopharmaceuticals are currently one of the most sensitive indicators of normal and diseased organ structure and function. The primary reason for this sensitivity lies with the ability of the nuclear methods to measure small physiological changes in organ function with scintillation detectors. These detectors, or gamma cameras, produce pictures illustrating a map of the photon distribution with a particular organ or series of organs. These scans may show structure (skeleton, liver, etc) or function (blood flow, cardiac ejection fraction, etc). In all cases however, the informational content of the scan relates to the "magic bullet" qualities of the radiopharmaceutical and the ability to accurately detect the photons emitting from the radionuclide within the organ. Gamma camera imaging is performed in a centralized nuclear medicine area or, when necessary, by a mobile gamma camera which performs the study at the patient's bedside. Prior to all scanning studies a radioactive drug (radiopharmaceutical) is administered either parenterally or by mouth, with the intravenous route being the most common. These agents are either purchased "ready for injection" (Ga-67 gallium citrate, Tl-201 thallium chloride)

* Cardiac Imaging Sets the Pace, Diagnostic Imaging, April 1980, p. 13, Vol 2, No. 2, Miller Freeman Publications, Inc., San Francisco.

or formulated in a radiopharmacy from prefabricated kits (Tc-99^m Diphosphonate, Tc-99^m-DTPA). In all cases the result of administering these materials is a radioactive patient who is a source of radiation exposure. The extent of exposure depends upon the species of radionuclide, the class of radiopharmaceutical, the quantity of radioactivity administered, and the time after the administration. Specific radiation precautions may, therefore, be indicated to provide a maximum of patient care with a minimum of radiation exposure. At a distance of 1 meter (≈3 feet) from the patient the exposure rate will rarely exceed 2 mRem/hr and if so, only for a brief time period (Appendix A). Consequently, there is no reason for personnel to wear radiation badges.

II. FACTORS AFFECTING RADIATION EXPOSURE

A. Classification

Types of Exposure

1. external exposure - Exposure from radiation emitted from within the patient or from the patient's radioactive excreta (urine, blood, stools, perspiration, etc.). The radiations may be absorbed in the skin or internal tissues of the body.

2. contamination - Deposition of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful to personnel by transfer to hands or clothing.

3. internal exposure - Exposure from radiation sources within the body as a result of either ingestion, usually from a contaminated hand which transfers the radioactivity to the mouth during eating or drinking, etc., or inhalation of radioactive vapors, gases or airborn particles in the room.

B. Species of Radionuclide

Each species of radionuclide will exhibit a set of physical properties which will determine its "potency" after administration. These properties include:

1. physical half life - The time required for a radioactive substance to lose 50% of its activity by radioactive decay. Each radionuclide has a unique half life: Tc-99^m (6.06 hr), Ga-67 (78.1 hrs), etc.

1. The type of radioactive emission - The ideal type of radioactive emission from a diagnostic radiopharmaceutical is photon emission. Photons are either gamma rays (from the nucleus)or x-rays (from the electron shells surrounding the nucleus) and they have the ability to penetrate the body. However, photons are stopped and detected by a special crystal in a gamma camera during a scanning procedure. Less ideal emissions are particulates, like beta particles and electrons, which don't penetrate tissue and offer no diagnostic information at all. For example, I-131 emits both photons and beta particles. The radiation dose to a patient receiving a quantity of I-131 is primarily from the absorption of beta particles (90%) and not the photons (10%). The radiation dose to personnel around the patient would be from the lesser abundant photons.

3. Quantity of radioactivity administered - Each radiopharmaceutical is administered with a precalibrated quantity of radioactivity associated with it. This quantity is usually expressed in millicuries. One millicurie provides radiation generated by 37 million atoms decaying every second. The strength of the radiation is proportional to the activity in millicuries, but also depends on the species of radionuclide.

C. Class of Radiopharmaceutical

The chemical structure of the radiopharmaceutical determines which organ of the body will be imaged and how long the radioactivity will remain in the body after injection.

Immediately after intravenous administration of a radiopharmaceutical, the blood is the body compartment containing all the radioactivity. Thereafter the following courses are possible:

1. Remain in blood - If a blood pool radiopharmaceutical is administered ($Tc\text{-}99^{m}$ Red Blood Cells) then greater than 80% of the radioactivity will remain in the blood stream for a period of time (>4 hours).

Since the blood will be radioactive the possibility for contamination exists. Blood samples should be taken prior to injection if possible. However, the amount of radiation in 5 ml of blood from an average sized adult is <1/1000 of the administered dose and does not represent a radiation hazard.

2. Cleared from blood rapidly - If a radioactive colloid is administered (Tc-99^{m} Sulfur Colloid) them 95% of the agent is cleared from the blood by the reticuloendothelial system (RES) in the liver, spleen and bone marrow. As soon as 15-30 minutes after injection all the radioactivity is in the RES where it will stay until it has decayed completely. There are no precautions in this example.

3. A portion excreted by the kidneys - Several radiopharmaceuticals have structures which dictate early excretion by the kidneys into the urine. (Tc-99^{m} DTPA, Tc-99^{m} Diphosphonate) In each case radioactive urine results and precautions (gloves) are necessary when handling this urine.

4. Studies having no precautions - Several radiopharmaceutical procedures have no potential for radioactive exposure or contamination. One example is when the patient inhales, and then exhales, a radioactive gas in the imaging area (Xenon-133) and another is when the physical half life of the radionuclide is so short that it will all decay in a short period of time. The latter group includes cyclotron studies with various positron emitters such as C-11, N-13, O-15, which have physical half lives of 20.3 minutes, 10 minutes and 2 minutes respectively.

III. RADIATION SAFETY PROCEDURE PROFILES

The Radiation Safety Procedure Profiles, (RSPP), which appear in Appendix C give the following information regarding radiodiagnostic procedures: Radiation Safety Procedure Profile #; study; purpose; Radiopharmaceutical agent used; usual dose; half life of Radionuclide; patient preparation; imaging procedure post radiopharmaceutical administration; scan time; precautions.

A separate table : Appendix B shows the radiation posure from radioactive patients relative to time after administration.

IV. RADIATION PRECAUTION GUIDELINES

A. Introduction

After administration of a radionuclide for diagnostic purposes, the patient becomes slightly radioactive. The excreta from these patients are potential sources for radionuclidic contamination, especially when handling the urine, feces, and blood of these individuals shortly after injection. Whereas it is almost impossible to outline a "radiation safety procedure profile: (RSPP) for each patient, it is quite possible to give a list of general handling practices for the nurse to follow relative to a RSP for a given radiopharmaceutical.

B. General Practices

1. The following information relative to radioactive patients should be readily available for each patient via the nuclear medicine technologist:

a. Radiopharmaceutical administered and amount in millicuries

b. Time of day injected

Copies of the RSPP for radiopharmaceutical (Appendix C) should be available at the nursing station on all floors (Unit coordinator).

2. Radiation Safety Procedure

a. Review RSPP for patient (Appendix C)

(1) If urine precaution and the urine does not have to be saved wear disposable gloves and empty into toilet.

(2) If urine precaution and the urine is being saved, store the urine.

(3) If blood is radioactive, wear disposable gloves when drawing bloods.

3. Labeling of Precautions

When indicated, a "Radiopharmaceutical Precautions" form will be posted on the patient's door or bed (Appendix D) The Nuclear Medicine Technologist will be responsible for filling out the form. If the patient is given the radiopharmaceutical in the imaging area, the form will accompany the patient to the floor.

If the patient is given the radiopharmaceutical in the health care unit, the floor supervisor will receive the information.

C. Informing the Patient

A list of questions commonly asked by patients about their nuclear medicine study is contained in Appendix E. Typical answers are provided to assist the health care representitive when conversing with the patient.

V. SUMMARY

The health physics precautions outlined pertain to those diagnostic radiopharmaceuticals currently being administered to patients. Any future changes will be immediately included or deleted as necessary.

APPENDIX A

Exposure Rates at Various Distances from Typical Patients Immediately after Radiopharmaceutical Administration

STUDY	PP#	mRem/hr at 1 ft.	mRem/hr at 3 ft.	mRem/hr at door
Bone Scan	1	5	0.9	0.06
Liver Scan	3	1	0.2	0.06
Gated Blood Pool Scan	9	10	1.4	0.06
Thallium Scan	8	0.4	0.35	0.06
CSF Scan	7	0.1	0.08	0.06

Exposure rates outside rooms containing these patients are equivalent to background levels.

Normal Background radiation from living in Boston is between 0.02 mRem/hr to 0.06 mRem/hr.

Instrument: Eberline, Model E-120, GM Counter

APPENDIX B

Effect on Time on Radiation Exposure at 3 Feet from Patient

TIME AFTER ADMINISTRATION	BONE SCAN*		LIVER SCAN**	
	mRem/hr	mRem/5 min	mRem/hr	mRem/5 min
0	0.9	0.075	0.21	0.018
1 hr	0.63	0.053	0.19	0.016
2 hr	0.47	0.039	0.12	0.010
3 hr	0.35	0.029	0.11	0.009

* Decrease is due to urinary excretion and physical half life of ^{99m}Tc (6.06 hr)

** Decrease is due to physical half life of ^{99m}Tc (6.06 hr). There is no excretion of the radiopharmaceutical.

APPENDIX C

Radiation Safety Procedure Profiles Associated with the Administration of Radiopharmaceuticals

No.	Study Ordered	Imaging Indications	Radiopharmaceutical
1	Bone Scan	Skeletal	^{99m}Tc Diphosphonate
2	G.I. Bleed	G.I. Hemorrhage	^{99m}Tc Red Blood Cells
3	Liver Scan	R.E.S.	^{99m}Tc Sulfur Colloid
4	Infarct Scan	Myocardial Infarction	^{99m}Tc Pyrophosphate
5	Gallium Scan	Soft Tissue Tumor	^{67}Ga-Gallium Citrate
6	WBC Scan	Infection	^{111}In-White Blood Cells
7	CSF Scan	Cisternography	^{111}In-DTPA
8	Thallium Scan	Normal Myocardium	^{201}Tl-Thallium Chloride
9	Gated Blood Pool Scan	Blood Pool (heart)	^{99m}Tc Red Blood Cells
10	Brain Scan	Brain Perfusion	^{99m}Tc -DTPA
11	Lung Scan	Lung Perfusion	^{99m}Tc MAA
12	Kidney Scan	Kidney Function	^{99m}Tc DTPA
13	Ventilation (V/Q) Scan	Lung Ventilation	^{133}Xe gas
14	Gall Bladder Scan	Biliary System	^{99m}Tc PIPIDA
15	Thyroid Scan	Thyroid Uptake	^{99m}Tc Sodium Pertechnetat
16	Testicular Scan	Testicular Blood Flow	^{99m}Tc Sodium Pertechnetat
17	Thyroid Scan	Throid Uptake	^{123}I Sodium Iodide
18	Deep Vein Thrombosis	Blood Clot Detection	^{125}I Fibrinogen
19	G.I. Bleed	G.I. Hemorrhage	^{111}In Red Blood Cell
20	Ocular Scan	Ocular Tumor	^{32}P Sodium Phosphate
21	Bone Marrow Study	Bone Marrow Distribution	^{111}In Indium Chloride
22	Thyroid Scan	Thyroid Uptake	^{131}I - Sodium Iodide

RADIATION SAFETY PROCEDURE PROFILE # 1

STUDY: BONE SCAN

PURPOSE: Diagnosis of skeletal pathology

RADIOPHARMACEUTICAL AGENT USED: ^{99m}Tc Diphosphonate, ^{99m}Tc MDP

USUAL DOSE: 20 mCi (0.740 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2eff): 6 hr.

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: Patient scanned 2 to 4 hours post injection
24 hr. study (optional)
Quantitative study (optional)

SCAN TIME: 1 hour

PRECAUTIONS:

URINE: Urine is considered radioactive up to 4 hours post injection. Wear gloves when handling urine.

BLOOD: Wear gloves when drawing blood samples until 1 hour post injection

OTHER: Urine bags on the side of beds or stretchers will contain radioactive urine. Wear gloves when dispensing of this urine. Urine collected up to 4 hours past administration must be stored 24 hours prior to being sent for analysis.

STUDY: G.I EED

PURPOSE: Diagnosis of gastrointestinal bleeding

RADIOPHARMACEUTICAL AGENT USED: ^{99m}Tc - Red Blood Cells

USUAL DOSE: 20 mCi (0.740 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 6 hrs.

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: up to 24 hours

SCAN TIME: 1 hour initially, then sequentially images up to 24 hours. Each image takes 1 hour.

PRECAUTIONS:

URINE: Urine is considered radioactive up to 1 hour post injection.

BLOOD: Wear gloves when taking blood upto 4 hours.

OTHER: Wear gloves handling fecal material or when changing bandages upto 4 hrs. post injection.

STUDY: LIVER SCAN

PURPOSE: To visualize the RES

RADIOPHARMACEUTICAL AGENT USED: ^{99m}Tc - Sulfur Colloid

USUAL DOSE: 3 mCi (0.111 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2β): 6 hrs.

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: image 30 minute post injection

SCAN TIME: 45 minutes

PRECAUTIONS: NONE

URINE:

BLOOD:

OTHER:

STUDY: INFARCT SCAN

PURPOSE: To visualize a myocardial infarct

RADIOPHARMACEUTICAL AGENT USED: ^{99m}Tc - Pyrophosphate

USUAL DOSE: 20 mCi (0.740 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2β): 6 hrs.

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: 3 - 4 hours post injection

SCAN TIME: 1 hour

PRECAUTIONS:

URINE: Urine is considered radioactive up to 4 hours post injection. Wear gloves when handling urine.

BLOOD: Wear gloves when handling blood samples until 1 hour post injection.

OTHER:

STUDY: GALL SCAN

PURPOSE: Diagnosis of soft tissue tumors

RADIOPHARMACEUTICAL AGENT USED: Ga-67 - gallium citrate

USUAL DOSE: 3 - 5 mCi (0.111 - 0.185 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2Ef): 78.1 hr.

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: Up to 3 days post injection.

SCAN TIME: 1 hour per session. May have 1 session per day up to 3 days

PRECAUTIONS: NONE

URINE:

BLOOD:

OTHER:

STUDY: CSF W

PURPOSE: To visualize and to determine the rate of movement of cerebral spinal fluid

RADIOPHARMACEUTICAL AGENT USED: ^{111}Indium - DTPA

USUAL DOSE: 0.5 mCi (18.5 MBq)

HALF LIFE OF RADIONUCLIDE (T1/2β): 67.2 hrs

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: Up to 4 days post intrathecal injection

SCAN TIME: 1 hour per session. May have one session per day up to 4 days.

PRECAUTIONS: NONE

URINE:

BLOOD:

OTHER:

RADIATION SAFETY PROCEDURE PROFILE # 8

STUDY: THALLIUM SCAN

PURPOSE: To visualize the heart wall to detect areas which have decreased perfusion (Note: An infarct would have no activity).

RADIOPHARMACEUTICAL AGENT USED: ^{201}TL (Thallium Chloride (TlCl)

USUAL DOSE: 1.5 mCi (55.5 MEq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 73 hours

PATIENT PREPARATION: Patient may be given stress (treadmill) test first followed by radiopharmaceutical conjection and a series of images by a gamma camera. Procedure takes approximately 1 1/2 hours.

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: To 6 hours

SCAN TIME: Two scans initially (1/2 hour each), then a delayed scan (optional) (1/2 hour) 3 to 6 hours post adminis*ration

PRECAUTIONS:

NONE

URINE:

BLOOD:

OTHER:

RADIATION SAFETY PROCEDURE PROFILE # 9

STUDY: GATED BLOOD POOL SCAN

PURPOSE: To visualize the blood pool within the heart

RADIOPHARMACEUTICAL AGENT USED: Technetium Tagged Red Blood Cells (Tc^{-99m} RBC)

USUAL DOSE: 20 mCi - Adult dose (0.740 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 6 hours

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: To 3 hours, scan may be performed in Nuclear Medicine or on the Health Care Unit.

SCAN TIME: 1 hour

PRECAUTIONS:

URINE: Urine is considered radioactive up to 1 hour post injection. Wear gloves when handling urine.

BLOOD: Wear gloves when obtaining blood samples up to 4 hours post injection.

OTHER: Wear gloves when changing a bandage up to 4 hours post injection.

RADIATION SAFETY PROCEDURE PROFILE #10

STUDY: BRAIN SCAN

PURPOSE: To measure perfusion and vasculature of brain.
To detect tumors, entracranial suppuration.

RADIOPHARMACEUTICAL AGENT USED: Technetium 99^{m} ($Tc-99^{m}$) DTPA

USUAL DOSE: 20 mCi - Adult dose (0.740 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 6 hours

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: To 3 hours post injection

SCAN TIME: Two post study; Initial flow (½ hour) followed by a delayed scan (½ hour) at 3 hours post injection.

PRECAUTIONS:

URINE: Urine is considered radioactive up to 2 hours post injection. Wear gloves in handling urine up to 2 hours post scan.

BLOOD:

OTHER:

RADIATION SAFT PROCEDURE PROFILE # 11

STUDY: LUNG SCAN

PURPOSE: To study perfusion of lungs and determine abnormalities such as pulmonary emboli.

RADIOPHARMACEUTICAL AGENT USED: Technetium Macro Aggregated Albumin (Tc-99^{m} MAA)

USUAL DOSE: 3 mCi - Adult dose (0.111 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 6 hours

PATIENT PREPARATION: No special preparation prior to procedure.

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: Patient is always injected in Nuclear Medicine. Approximately 2-3 minutes post injection, patient will have imaging of anterior and posterior chest. Study takes approximately 30 minutes to complete.

SCAN TIME: Usually a 2 radiopharmaceutical studies consisting of a perfusion scan (½ hour) and a ventilation scan (½ hour) (see pp #13)

PRECAUTIONS: NONE

URINE:

BLOOD:

OTHER:

RADIATION SAFETY PROCEDURE PROFILE #12

STUDY: KIDNEY SCAN

PURPOSE: To measure perfusion of kidneys

RADIOPHARMACEUTICAL AGENT USED: Technetium 99^{m} ($Tc-99^{m}$) - DTPA

USUAL DOSE: 20 mCi - Adult dose (0.740 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 6 hours

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: To 3 hours post injection

SCAN TIME: 45 minutes

PRECAUTIONS:

URINE: Urine is considered radioactive up to 2 hours post injection. Wear gloves in handling urine up to 8 hours post scan.

BLOOD:

OTHER:

RADIATION SAFETY ' CEDURE PROFILE # 13

STUDY: VENTILATION (V/Q) SCAN

PURPOSE: To determine structure and : nction of lung ventilation.

RADIOPHARMACEUTICAL AGENT USED: ^{133}Xe gas

USUAL DOSE: 10 - 15 mCi (0.370 - 0.555 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 127 hr.

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: immediately and up to 1 hour

SCAN TIME: 3/4 to 1 hour

PRECAUTIONS: NONE

URINE:

BLOOD:

OTHER:

RADIATION SAFETY CEDURE PROFILE # 14

STUDY: GALL BLADDER SCAN

PURPOSE: To determine the structure and function of the Biliary System

RADIOPHARMACEUTICAL AGENT USED: ^{99m}Tc PIPIDA

USUAL DOSE: 1 mCi (0.037 GBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 6 hours

PATIENT PREPARATION: none or stimulation of gall bladder emptying

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: up to 6 hours

SCAN TIME: 1 hour to 2-3 hours of sequential images

PRECAUTIONS: NONE

URINE:

BLOOD:

OTHER:

RADIATION SAFETY PROCEDURE PROFILE # 15

STUDY: THYROID SCAN

PURPOSE: To determine the structure and function of the thyroid gland.

RADIOPHARMACEUTICAL AGENT USED: $99^{m}Tc$ pertechnetate

USUAL DOSE: 10 mCi (370 MBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 6 hours

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: Image 30 minutes post injection

SCAN TIME: 45 minutes

PRECAUTIONS:

URINE: Urine radioactive up to 24 hours. Wear gloves when handling urine.

BLOOD:

OTHER:

RADIATION SAFETY PROCEDURE PROFILE # 16

STUDY: TESTICULAR SCAN

PURPOSE: Perfusion of testicular region

RADIOPHARMACEUTICAL AGENT USED: $99^{m}Tc$ pertechnetate

USUAL DOSE: 10 mCi (370 MBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 6 hours

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: Image 30 minute post injection

SCAN TIME: 45 minutes

PRECAUTIONS:

URINE: Urine radioactive up to 24 hours. Wear gloves when handling urine.

BLOOD:

OTHER:

RADIATION SAFETY CEDURE PROFILE # 17

STUDY: THYROID SCAN

PURPOSE: To determine structure and function of the throid gland.

RADIOPHARMACEUTICAL AGENT USED: ^{123}I - Sodium iodide

USUAL DOSE: 0.2 mCi (7.40 MBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 17 hours

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: At 30 minutes.

SCAN TIME: 1 hour

PRECAUTIONS: NONE

URINE:

BLOOD:

OTHER:

RADIATION SAFETY PROCEDURE PROFILE # 18

STUDY: DEEP VEIN THROMBOSIS

PURPOSE: To determine presence of clots post operatively

RADIOPHARMACEUTICAL AGENT USED: ^{125}I-Fibrinogen

USUAL DOSE: 0.1 mCi (3.7 MBq)

HALF LIFE OF RADIONUCLIDE (T1/2P): 60 days

PATIENT PREPARATION: KI to block thyroid (MGH Pharmacy Formulation)

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: up to 2 weeks post injection

SCAN TIME: If patient remains in bed then each hand held survey will take 15 minutes. If a scan with a gamma camera is indicated, it will take 1 hour.

PRECAUTIONS: NONE

URINE:

BLOOD:

OTHER:

RADIATION SAFETY PROCEDURE PROFILE # 19

STUDY: G.I. BLEED

PURPOSE: To diagnose gastrointestinal bleeding and/or kinetic studies

RADIOPHARMACEUTICAL AGENT USED: Indium 111 (In-111) Red Blood Cells

USUAL DOSE: 0.5 mCi (18.5 MBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 67.2 hours

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: Up to 72 hours post administration

SCAN TIME: 30 min - 1 hour

PRECAUTIONS:

URINE:

BLOOD:

OTHER: Slight fecal contamination by G.I. blood. Wear gloves.

RADIATION SAFETY OCEDURE PROFILE # 20

STUDY: OCULAR TUMOR STUDY (MEEI)

PURPOSE: To diagnose ocular tumors

RADIOPHARMACEUTICAL AGENT USED: P-32 Sodium Phosphate

USUAL DOSE: 0.5 mCi (18.5 MBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 350 hrs (14.5 days)

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: Ocular area is counted with a specially designed counting instrument.

SCAN TIME: 15 - 30 minutes

PRECAUTIONS: gloves when handling urine and/or feces.

URINE: Following intravenous administration, 5-10% of P-32 is excreted in the urine during the first 24 hours, and about 20% within one week. A minimal amount is found in the feces.

BLOOD: Following oral administration, 15-20% of P-32 is excreted in urine and feces during the first 4-6 days. The fecal activity represents primarily unabsorbed material.

OTHER:

RADIATION SAFETY PROCEDURE PROFILE # 21

STUDY: BONE MARROW SCAN

PURPOSE: To diagnosis bone marrow pathology

RADIOPHARMACEUTICAL AGENT USED: In-111 Indium Chloride

USUAL DOSE: 3 mCi (0.111 MBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 67.2 hours.

PATIENT PREPARATION: NONE

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: 24-72 hours post administration

SCAN TIME: 30 minutes to 1 hour

PRECAUTIONS: NONE

URINE:

BLOOD:

OTHER:

RADIATION SAFETY PROCEDURE PROFILE # 22

STUDY: THYROID SCAN

PURPOSE: To determine thyroid function

RADIOPHARMACEUTICAL AGENT USED: I-131 - Sodium Iodide

USUAL DOSE: Less than 1 mCi (37 MBq)

HALF LIFE OF RADIONUCLIDE (T1/2p): 8.08 days

PATIENT PREPARATION: Medications which effect thyroid metabolism may be prescribed prior to the study.

IMAGING PROCEDURE POST RADIOPHARMACEUTICAL ADMINISTRATION: 24 hours post administration

SCAN TIME: 1 hour

PRECAUTIONS:

URINE: Slight urine contamination up to 24 hours post administration. Wear gloves.

BLOOD:

OTHER:

APPENDIX D

MASSACHUSETTS GENERAL HOSPITAL

RADIOPHARMACEUTICAL PRECAUTIONS

PATIENT NAME: _____ NAME OF SCAN: _____

UNIT NUMBER: _____ TIME OF ADMINISTRATION: _____

_____ NO PRECAUTIONS NECESSARY

_____ URINE PRECAUTIONS FOR _____ HOURS

N.B. Wear gloves when handling urine. If patient has Foley Catheter or Ostomy Drainage Bag do not measure urine until precautions are discontinued. In the event of any urinary spill, notify Radiation Safety Officer immediately.

_____ BLOOD PRECAU FOR _____ HOURS

N.B. If blood sample must be drawn before precautions are discontinued, wear gloves when handling blood.

_____ STOOL PRECAUTIONS FOR _____ HOURS

N.B. Wear gloves when handling stools.

THE ABOVE PRECAUTION(S) WILL BE DISCONTINUED AT _____ AM/PM, ON _____
DATE

COMMENTS

NOTE: If any questions regarding above precautions contact Radiation Safety Officer at extension 8328 (Page Operator #3264) or Nuclear Medicine at extension 8350.

APPENDIX E

WHAT EVERY PATIENT SHOULD KNOW ABOUT A NUCLEAR MEDICINE DEPARTMENT

(Reference: The American College of Radiology

WELCOME TO NUCLEAR MEDICINE

You were referred to a nuclear medicine facility because your doctor, in order to diagnose your medical problems, desires information which is most easily acquired by using radioactive compounds, sometimes called "isotopes." The physician who sees you has had special training in nuclear medicine, is a graduate of a medical college, and has completed several years of intensive postgraduate training to qualify as an expert in diagnosis. The nuclear medicine specialist has extensive technical knowledge of the machinery employed, as well as the chemistry of the radioactive compounds and the knowledge of the machinery employed, as well as the chemistry of the radioactive compounds and the knowledge of nuclear physics and radiation safety. The specialist interprets the results of the examination and assists your doctor in diagnosing your problem.

THE NUCLEAR MEDICINE TECHNOLOGIST

Assisting the nuclear medicine physician is a highly trained technologist. It is the technologist who will position you and operate the equipment during your examination. This person is a competent technologist with special training and experience in nuclear medicine technology.

SCANS AND X-RAYS ARE DIFFERENT

Diagnostic x-ray procedures such as the chest film involve passing radiation through your body from an external source, the x-ray tube. These x-rays record an image of your anatomy on a film, called a radiograph, which is then examined by a radiologist. But in nuclear medicine, tiny amounts of substances which give off radiation are introduced into your body - usually by injection into a vein, and special machinery detects the radiation and translates it into spots of light that expose the film. The developed film, called a scan or scintigram, is then examined by the nuclear medicine physician.

SCANS GIVE VALUABLE INFORMATION

The radioactive compounds used in making scans circulate thoughout your body to those areas in which your doctor is interested. During the hourney, the compounds are altered by or attached to certain tissues by the body's complex physiologic and chemical mechanisms. By observing how and where the radioactive compounds go, the nuclear medicine physician is able to gain unique and valuable information about changes in your body's biological processes as well as alterations in anatomy. Although scans and radiographs are different they complement each other, since radiographs primarily locate areas of altered anatomy and scans primarily locate areas of altered function.

SCANNERS AND CAMERAS

There are two principal types of instruments which produce images for the nuclear medicine physician. One type, the "scanner," moves back and forth in straight lines, recording images of the emitted radiation as it moves across the part of your body in which your doctor is interested. The other useful instrument is much larger than the scanner and is able to record the radiation emitted from selected areas of your body without roving. This device is called a "camera." Either a "scanner" or a "camera" or both, may be used to perform your nuclear medicine examination.

READING THE SCAN

The nuclear physician uses a wide variety of radioactive compounds which travel to different parts of your body because of their specific properties. The doctor can investigate the brain, the liver, the thyroid gland, the lung, the bones, and many other body systems. When the radioactivity has concentrated in the region of interest, it will be recorded by the camera or scanner as dots on the film. Regions of high activity will have more dots, while regions of low activity have fewer dots. The nuclear physician is trained to recognize abnormal patterns in distribution of dots, and this process is called "reading the scan." You should remember that the pattern of dots is really a special type of "map" of the body area "seen" by the scanner or camera.

AN EXAMPLE: THE BRAIN SCAN

One of the most frequently performed nuclear medicine examinations is a study of the brain. This may be done either with the camera or the scanner. After injection of a radioactive compound into a vein, perhaps while seated with your head next to the camera to identify the blood supply to your brain, there is a period of waiting for the compound to circulate in the brain. Then in succession, the front, back, each side, and sometimes the top of your head will be imaged by the camera or scanner. The scan reveals information about the brain. Changes in local brain physiology may lead to an area of increased radioactivity, recognized by the nuclear physician by its pattern of dots. Several different types of brain abnormalities can be identified by specific dot patterns.

BLOOD AND URINE TESTS

Not all examinations in nuclear medicine involve exposing films. Certain tests are performed by giving you either pills or an injection, and later obtaining a blood, urine, or stool sample in which the radiation can be counted. The amount of radio-activity in the sample reflects certain aspects of your body's physiology. While scans are usually made the same day you receive the radioactive compound, blood, urine and stool test may require that you return to the nuclear medicine department on another day to complete your exam or that your bring samples of urine or stool with you. You must always take any prescribed pills in the correct way, and get complete urine or stool collections if requested, otherwise the results of the test may be incorrect.

WHAT ABOUT RADIATION?

The nuclear medicine physician and technologist are trained in radiation safety procedures and employ various means to minimize your exposure to radiation. Radioactive compounds are kept separate from patient areas, and lead barriers are employed to shield you from radiation sources. The amount of radiation used in nuclear medicine examinations is small, and the doses for patients are selected to provide minimal exposure while still allowing for an adequate examination. Indeed, the amount of radiation you will receive is less than that received in may x-ray examinations.

CHILDREN STUDIES

Nuclear medical exams also may be used for the diagnosis of childhood diseases, wince the radiation dose is so small. The ability of the radioactive substances to investigate body physiology may provide very helpful information to the pediatrician. In most cases, the examinations are simple to perform, only requiring that the child remain still for a few minutes at a time, and most children tolerate the procedures

TIME AND COSTS

Nuclear medicine examinations take longer to complete than routine x-ray examinations. From the time you receive the injection until the time your test is completed, an hour or more may elapse. Due to the length of time the camera or scanner is used for each patient, as well as the complexity and expense of the equipment and the cost of radioactive compounds, nuclear medicine procedures are somewhat more costly than routine x-ray exams. As in other areas of medical care, you may be billed as part of a hospital bill, or by the nuclear medicine physician directly. The physician will answer any questions about the examination and the costs.

AT YOUR SERVICE

After your visit to Nuclear Medicine, your scans or ther studies will be interpreted by the nuclear medicine physician, who will tell your doctor the results. Your scans will be retained as part of your permanent filed in the Nuclear Medicine department. In this way, the scans will be readily available to your doctor and the nuclear medical physician for future referral, or if you should return for further examinations.

SPECIAL QUESTIONS

Q. Should a pregnant woman tell the nuclear physician about her pregnancy?

A. Yes. This is very important, since the radioactive compound may be carried to the baby through the mother's circulation. Even though the amounts of radiation are small, we do not wish to deliver any unnecessary radiation to your unborn baby. Please inform the nuclear physician if you are pregnant or think you might be pregnant. Appropriate action will be taken to minimize your unborn baby's exposure.

Q. What are some other uses of radioactive compounds in medicine?

A. Radioactive iodine is used at times in treatment of the overactive thyroid gland, and more powerful radioactive sources, such as cobalt, have been used to treat diseases like cancer. Special radioactive drugs can be used as a tracer to indirectly measure the concentration of drugs in your body, or the concentrations o certain hormones.

Q. Are radioisotopes useful in research?

A. Yes. Because the very small amount of radioactive chemical compound needed for investigation of physiological mechanisms does not disturb the usual function, research in animals and patients can be carried out in an attempt to identify abnormal metabolism, detect tumors, and trace the pathway of certain drugs and chemicals in the body.

Q. Are any new nuclear medicine examinations being developed?

A. Yes. The development of new radioactive compounds, as well as the designing of new machinery for imaging radioactivity is occurring all over the world. The result of this development will be both an improvement in present nuclear medicine examinations and identification of new, useful examinations.

DOROTHY J. ROOF

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Ohio State	1 Yr	Yes	No
	UCSF	5 Yrs		No
	Princeton	1 Yr		No
	Purdue	3 Yrs		Yes
Measurement and monitoring of radioactivity				
Calculations basic to use and measurement of radioactivity				
Biological effects of radiation				

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
125 I	5 mCi	Ohio State, Princeton, Purdue	12 Yrs	RIA prote iodi-nation
45 Ca	100 uCi	Ohio State, UCSF	3 Yrs	Bindi Assay
32 P	1 mCi	UCSF, Purdue	6 Yrs	Enzym Assay
14 C	1 mCi	UCSF, Purdue	5 Yrs	Enzym Assay
3 H	1 mCi	UCSF, Purdue	5 Yrs	Enzym Assay
35 S	100 uCi	Purdue	1 Yr	Cell label

JOYCE RAPPAPORT

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Harvard Univ. Study Program in the Safe Use of Radioisotopes in Research	7 Weeks	No	Yes
Measurement and monitoring of radioactivity				
Calculations basic to use and measurement of radioactivity				
Biological effects of radiation				

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
32 P	10 mCi	Children's Hospital, Boston	12/82 to 4/83	Labell DNA
		Mass Eye and Ear Infirmary	4/83 to Present	Same

		Duration	On the Job	Formal Course
[illegible] practices in radiation protection	Ohio State Univ. Columbus, Ohio	[illegible] Yrs	Yes	Yes

	Maximum Amount	Where experience was gained	Duration	Type of use
[illegible]	[illegible]	Ohio State [illegible]	[illegible] yrs	Cytogenetic Assay
[illegible]	[illegible]	[illegible]	[illegible]	Lymphocyte proliferation

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Harvard Univ.	7 Weeks		Yes
Measurement and Evaluation of Radioactivity	Same	7 Weeks		Yes
Use of radiation counting instruments for measurement of radioactivity	[illegible]	[illegible]		Yes
Effects of radiation on radiation	[illegible]	[illegible]		Yes

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
[illegible]	[illegible] uCi	University of [illegible]	[illegible] yrs	Biochemical Analysis
[illegible]	[illegible] uCi	University of California		
[illegible]	[illegible]	University of [illegible]		
[illegible]	10 mCi	Mass Eye and Ear Infirmary	7 yrs	
^{14}C	250 uCi	Mass Eye and Ear Infirmary		

[illegible]	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Harvard Univ. Study Program in the Safe Use of Radio isotopes in Research	7 Weeks	No	Yes
Measurement and monitoring of radioactivity	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
[illegible]	10 mCi	Children's Hospital Med. Ctr. Boston, MA.	2 yrs	Labelli of DNA
[illegible]	1 mCi	Same as above	2 yrs	Same

Type of Training

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Duke Univ. Durham, N.C. (graduate training)	4 yrs	Yes	Yes
Measurement and monitoring of radioactivity	MGH Radiation Safety Course	10 weeks	No	
Calculations basic to use and measurement of radioactivity				
Biological effects of radiation				

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
[illegible]	5 mCi	Duke Univ.	4 Yrs	Enzymology
[illegible]	1 mCi	Mass Eye & Ear Infirmary	3 Yrs	Cell Cultures
[illegible]	1 mCi	U. Conn Health Center	3 yrs	Metabolism

P. [illegible] ANDERSON

Type of training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Harvard Univ Health Services	3 Weeks		Yes Yes
Measurement and [illegible] of radioactivity	Univ. of Otago New Zealand	4 Yrs	Yes	
	Harvard Univ Health	3 Weeks		Yes
	Boston Biochemical Institute	4 Yrs	Yes	Yes
Mathematics basic to the measurement of radioactivity	Same	Same	Yes	Yes
Biological effects of radiation	Harvard Univ. Health	3 Weeks		Yes

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
[illegible]	100 mCi	University of Otago, Dundein New Zealand	3 yrs	Tracer
[illegible]	50 mCi	Indiana Univ. School of Med. Indianapolis, IN.	4 yrs	Tracer
14 C	100 mCi	Boston Biomedical Research Institute, Boston, Ma.	3 yrs	Tracer
14 C	50 mCi	Mass Eye and Ear Infirmary	1977 to Present	Tracer
32 P	50 mCi	Mass Eye and Ear Infirmary	1977 to Present	Enzyme Assay

PETER WELLS

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Wayne State Univ. Harvard University	1980-84 1985-87	Yes Yes	Yes
Measurement and monitoring of radioactivity	Same Same	Same Same	Yes Yes	Yes
Calculations basic to use and measurement of radioactivity	Same Same	Same Same	Yes Yes	Yes
Biological effects of radiation	Same Same	Same Same	Yes Yes	Yes

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
3 H	5 mCi	Michigan Cancer Foundation Detroit, Michigan	3 yrs	Autoradiography
51 Cr	5 mCi	Harvard University Mass Eye & Ear Infirmary	3 yrs	Chromium Release Assay
3 H	5 mCi	Harvard University Mass Eye & Ear Infirmary	3 yrs	Cell Proliferation Assay
125 I	5 uCi	Harvard University Mass Eye & Ear Infirmary	3 yrs	RIA

JOHN T. GUINAN

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Harvard University Environmental Health & Safety-University Health Services	Fall Semester 1979		Yes
Measurement and monitoring of radioactivity	Same	Same		Yes
Calculations basic to use and measurement of radioactivity	Same	Same		Yes
Biological effects of radiation	Same	Same		Yes

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
3 H	2 mCi	MEEI	5 yrs	Light Microscope Autoradiography
35 S	2 mCi	MEEI	5 yrs	Same

TERRI MCGEE

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	MGH	6 Weeks	Yes	Basic radiation
Measurement and monitoring of radioactivity	MGH & On Job	Same	Yes	Protection for Lab and Hospital personnel
Calculations basic to use and measurement of radioactivity	MGH	Same		MGH Course
Biological effects of radiation	MGH	Same		MGH Course

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
S-35	120 mCi	MEEI - On the Job	8/87 to Present	Research Labs
P-32	1 mCi	MEEI - On the Job	Same	Same

STANLEY SCHEIN

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	N I H		7 Yrs	Radiation Safety for authorized
Measurement and monitoring of radioactivity	N I H		7 Yrs	users (8 day, 55 hr course)
Calculations basic to use and measurement of radioactivity	N I H		7 Yrs	
Biological effects of radiation	N I H		7 Yrs	

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
3 H	50 mCi	N I H MEEI	6 yrs 3 yrs	Autorad Chemistry
14 C	2 mCi	N I H MEEI	Same Same	Same
125 I		N I H	1 yr	Chemistry
133 Ba	1 mCi	N I H	1 mo	Autorad Chemistry

MARK LATINA

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Harvard Medical School Course	3 Session Course		
Measurement and monitoring of radioactivity	Same	Same		
Calculations basic to use and measurement of radioactivity	Same	Same		
Biological effects of radiation	Same	Same		

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of Use

VALERIE WHITE

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	MGH	8 Weeks		Yes
Measurement and monitoring of radioactivity	Same	8 Weeks		Yes
Calculations basic to use and measurement of radioactivity	Same	8 Weeks		Yes
Biological effects of radiation	Same	8 Weeks		Yes

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
35 S	250 mCi	Mass Eye and Ear Infirmary	4 Mos	Experimental Nonanimal Nonhuman

SUSAN SCHMIDT

Type of Training	Where Trained	Duration	On the Job	Formal Course
Principles and practices of radiation protection	Audited Course at University of B.C., Vancouver, B.C.	10 Weeks	Yes	Yes
Measurement and monitoring of radioactivity	Same	10 Weeks	Yes	Yes
Calculations basic to use and measurement of radioactivity	Undergraduate studies California State Univ.	4 Months	Yes	Yes
Biological effects of radiation	M.S.C. in Biology Graduate Studies	4 Months	Yes	Yes

Experience with Radionuclides

Isotope	Maximum Amount	Where experience was gained	Duration	Type of use
P-32	10 mCi	University of British Columbia	1 yr.	Metabolic Studies
Tritium	1 mCi	UCLA California	4 yrs	Enzyme Analysis
Carbon-14	1 mCi	Dept. Anatomy	1 yr	Invitro
Tritium	10 mCi	Dept. Anatomy		Protein
Carbon-14	Amino Acids	Mass Eye & Ear Infirmary	8 yrs	Synthesis
NA-22	LO.1 mCi	Mass Eye & Ear Infirmary	8 yrs	
K-42	LO.1 mCi	Mass Eye & Ear Infirmary	8 yrs	
S-35	1 mCi	Mass Eye & Ear Infirmary	8 yrs	