

NUCLEAR MEDICINE

OBJECTIVES FOR THE FIRST YEAR RESIDENT

A checklist and assigned responsibility list is attached.

A. Knowledge Base

1. Basic science and instrumentation
2. Pathophysiology of diseases
3. Radiation safety and protection
4. Indications, patient preparation of nuclear medicine procedures

B. Technical Skills

1. Maintenance and organization of the reading room.
2. Able to pull out old reports from the RadNet or Powerchart and patient information from Powerchart. Able to dictate reports using PowerScribe 360.
3. Get information from labs, physician's office, etc.
4. Dictate all the studies read using the organized format and report templates in PowerScribe 360.
5. Able to communicate the results of the studies effectively to the referring physician.
6. Able to use the Internet for literature search.
7. Able to use PowerPoint for slides, etc.

C. Interpretation Skills

1. Should have developed skills to describe positive findings in images performed.
2. Should be able to discuss the differential diagnoses for their findings.

D. Experience Goals

1. Practical laboratory exercises or "hot lab sheet".
2. Work up, consent, and participating in three (3) low- AND high-dose EACH oral I-131 therapies for hyperthyroidism and thyroid cancer, respectively and document on ABR Form B

E. Reading Recommendations

1. A Clinician's Guide to Nuclear Medicine 2nd Edition – Taylor, Schuster, Alazraki
2. Essentials of Nuclear Medicine - Mettler 6th edition.
3. The Requisites of Nuclear Medicine – Thrall, O'Malley & Ziessman. **Available online through Emory Health Sciences Library/MD Consult.**
4. Clinical Practice of Nuclear Medicine – Dr. Taylor, Dr. Datz
5. Fundamentals of Nuclear Pharmacy – Saha
6. Introduction of Physics of Nuclear Medicine – Chandra

**DIVISION OF NUCLEAR MEDICINE, EMORY UNIVERSITY HOSPITAL
RADIOLOGY RESIDENT DUTIES/RESPONSIBILITIES ON GENERAL NUCLEAR MEDICINE**

- A. Your responsibilities begin at 8:00am daily, Monday through Friday unless otherwise specified by conference schedule (see posted schedule). Your day ends with the completion of stated duties and responsibilities on General Nuclear Medicine. * **Important: Contact Ike Hall, Radiation Safety Officer, (2-7867 or pager 404-837-6204) for radiation safety training at the beginning of the month.**
- B. Duties/responsibilities
- I. General principles: The Radiology resident has the **primary** responsibility of overseeing all activities pertaining to the daily functions of the General Nuclear Medicine Service. He/she is to utilize the Nuclear Medicine Fellow/resident or the attending physician of the day for guidance and consultation as needed. The Nuclear Medicine fellow is to serve as an instructor and facilitator for the radiology resident.
 - II. Specific activities:
 1. **You** are to interview and examine (as appropriate) all patients seen in the Nuclear Medicine department and gather all data (history, physical exam, laboratory tests, imaging and reports when available) prior to the attending physician readout session. It is your job to obtain all existing correlative studies when available) **prior** to the attending physician readout session. Written reports are complimentary but never a substitute for the images themselves.
 2. Consult with the Nuclear Medicine fellow and/or attending for special considerations where and when assistance is needed such as obtaining additional SPECT or SPECT/CT imaging, special computer analyses, additional or delayed images. It is always appropriate to retain the patient in the department until all needed consultations are made.
 3. Personal communications with the referring physician are mandatory in situations where the test appropriateness and/or patient dispositions are involved (e.g., thyroid scan results, I-131 treatment dispositions and dosage recommendations) and especially, critical results, which also need to be documented in the dictation.
 4. The following procedures **always** require attending physician consultation and presence prior to dosing:
 - a. I-131 total body diagnostic scan (4 mCi) and I-131 treatment of thyroid disease.
 - b. All parenteral therapies including Sm-153 EDTMP, I-131 MIBG, Ra-223 dichloride, Lu-177 DOTATATE, and Y-90 labeled microspheres
- Also, **pregnancy must be excluded for all women of child-bearing potential under the age of 50.**
- The attending physician who scheduled the patient is to sign the written directive for dosing all patients for the total body I-131 diagnostic study (4 mCi) as well as all other I-131 and other treatment dispositions.
5. Following, the “readout” with the attending physician, the radiology resident dictates the reports unless otherwise arranged with the nuclear medicine resident or fellow.
 6. The radiology resident will complete the exercises outlined in the “hot lab sheet” and participate in the treatment of patients with thyroid disease and document such on the provided sheets.
 7. If admission for treatment is necessary, for instance, for I-131 for thyroid cancer with inappropriate home situation or I-131 MIBG therapies, contact Ike Hall Radiation Safety Officer to arrange for a room.
 8. All computer systems are to be used only for educational and patient services during work hours.
- C. All radiology and nuclear medicine residents are expected to attend the radiology noon conference (daily). However, specific ongoing patient evaluations and dispositions should be communicated to the attending physician when appropriate prior to your leaving the department.

Emory General NM Orientation Checklist

- Orient to NRC Requirements checklist and ABR Form B for I-131 therapies
- Orient to NM Divisional Website including learning material.
- Emphasize requirement for presence of AU and negative pregnancy test (or equivalent) for administration of any quantity of I-131**
- Introduce to fax machine and copier
- Introduce to Gail and Inez, Jim Fitz and technologist staff
- Orient to reading room Xeleris, Syntermed, PET, PC, and PACS workstations, bins for completed study paperwork and *bins for Approved and To be Approved exams on reading room door, to be checked daily*
- Orient to protocols and checklist packets (Division Website and thyroid in bins), Written Directives and (ondansetron) Zofran scripts.
- Orient to technologist work area white boards for all studies and Y90 therapies
- Orient to overhead rack and file drawer for patient folders and lab order sheets
- Orient to staff bathroom, imaging rooms, hospital PET area, uptake and portable rooms and consult room (Dr. Halkar's office and room off of the main DR waiting room)
- Orient to hot and cold labs

Important Numbers

NM Administration, Gail Foster	x24843
EUH Reading Room Coordinator, Inez Dupree	x28640
EUH General Nucs Reading Room	x27434
EUH Nucs Front Desk	x21075
EUH Nucs Fax	x20990
Midtown Nucs Reading Room	x61248
Midtown Nucs Technologists	x61225
Midtown Nucs Fax	x64982
Nucs Scheduling, Wanda Hogan	x85364
Emory Radiation Safety, Ike Hall	x27867, 404-819-4672 (mobile)
Grady Nucs Reading Room	404-616-1825
VA Nucs Reading Room	404-417-2966

NUCLEAR MEDICINE LABORATORY EXERCISES FOR CARDIOLOGY/RADIOLOGY/NUCLEAR MEDICINE TRAINEES

Trainee: _____ Date: _____

Trainees should make every effort to complete the listed activities in a timely manner. Each activity should be initiated by the supervising technologist or radiation safety officer. Once all activities have been completed, the total hours should be calculated and signed by either Dr. David Brandon or Dr. Daniel Lee. Keep one copy for your own records and turn in a copy to your program coordinator. *This for will be used as documentation to satisfy some of the NRC requirements for Authorized User (AU) eligibility status.*

Dose Administration Experience Coordinate with Jim Fitz, x25018, james.fitz@emoryhealthcare.org **1 hr.**

- _____ Using administrative controls to prevent a medical event with unsealed material
- _____ Administering dosages of radioactive materials

Radiation Safety Experience **2 hrs.**

- _____ Using procedures to safely contain spilled material and decontamination
- _____ Perform quality control procedures on instruments
- _____ Sealed source leak testing and inventory

Gamma Camera Quality Control **4 hrs.**

- _____ Obtain a flood field and check for uniformity
- _____ Check center of rotation for SPECT camera
- _____ Perform a bar phantom study
- _____ Set up camera for various energy windows (Tc99m, In-111, I-131) with collimators

General Imaging Procedures Set up patients for the following and participate in acquisition & processing **13 hrs.**

- _____ Thyroid uptake
- _____ Thyroid scan
- _____ Lung (ventilation and perfusion)
- _____ Bone scan
- _____ Body SPECT/CT scan
- _____ Bone density scan (DEXA)
- _____ Gastric emptying
- _____ Renal scan
- _____ Brain SPECT
- _____ Hepatobiliary scan
- _____ Body PET/CT scan

Coordinate bone density scan with Jennifer McCorkle x83441, Jennifer McCorkle@emoryhealthcare.org, Clinic C

Cardiac Imaging Procedures **6 hrs.**

- _____ Observe treadmill exercise test
- _____ Observe pharmacologic stress test
- _____ Participate in SPECT myocardial perfusion imaging
- _____ Participate in PET myocardial perfusion imaging
- _____ Participate in gated blood pool acquisition with manual and automated processing

Total hours (26) _____

Preceptor _____ **Preceptor signature** _____

Title _____ **Date** _____

Trainee Name: _____ Select Program: DR NM/NR Cardiology

EXTERNAL RADIOPHARMACY EXPERIENCE

This two (2) day course will present a focused radiopharmacy experience for Emory cardiology, diagnostic radiology, and nuclear medicine trainees. The course will allow trainees to participate in the preparation of commonly employed radiopharmaceuticals for clinical diagnostic and therapeutic nuclear medicine procedures. The course will also provide experience in various quality control measures for radiopharmaceutical production. Upon completion of these activities, trainees should have their forms signed by the Triad preceptor who will transmit the forms to Emory. This documentation is a **required** part of training for board certification examinations and Authorized User eligibility status.

- _____ Elute molybdenum-99/technetium-99m (Tc-99m) generator twice
- _____ Radionuclide purity quality control: Check for molybdenum breakthrough
- _____ Chemical purity quality control: Check for aluminum
- _____ Radiochemical purity quality control: Instant thin-layer chromatography

- _____ Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys

- _____ Calculating, measuring, and safely preparing patient or human research subject dosages

Observe the preparation of the following and performance of chromatography, as applicable:

- _____ Tc-99m MDP
- _____ Tc-99m DTPA
- _____ Tc-99m MAG-3
- _____ Tc-99m sestamibi (or tetrofosmin)
- _____ Tc-99m sulfur colloid
- _____ Tc-99m HIDA (or equivalent)
- _____ Tc-99m labelled-RBCs with the in-vitro method
- _____ Tc-99m MAA
- _____ Indium-111 Octreoscan

- _____ NaI-131 capsules

Triad Preceptor: _____

Date: _____

- _____ Fluorine-18 fluoro-deoxyglucose (F-18 FDG) production
- _____ FDG sterility & pyrogen testing

Triad Preceptor: _____

Date: _____

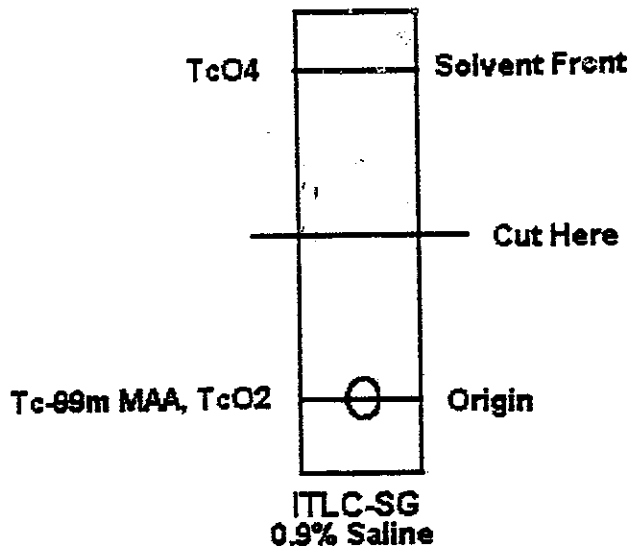
Triad: Please fax or email to Ms. Ranitta McDowell, Emory Radiology Residency Office at 404-712-7908; Tel: 404-778-2626; rsmcdow@emory.edu

Form B

I-131 Therapy Experience Log

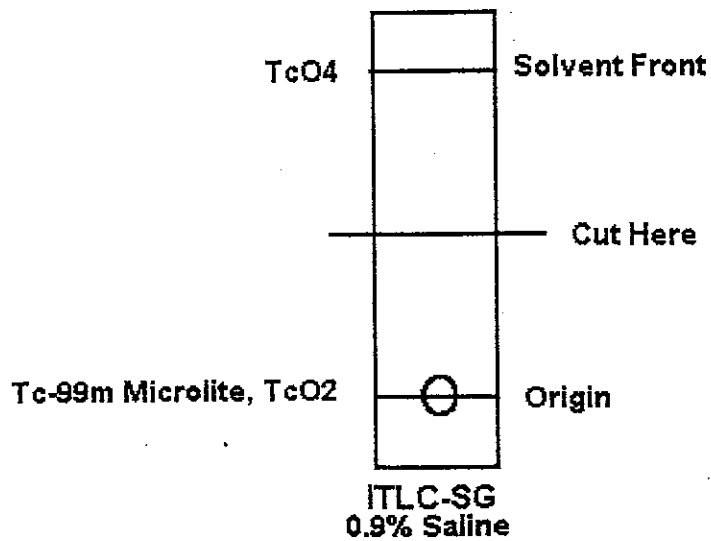
<u>Resident Name</u>		<u>Program & Number</u>
<u>Date</u>	<u>Dose Administered</u>	<u>Preceptor (AU) Print & Sign Name</u>
≤ 33mCi		
1. _____	_____	_____ Print Name
		_____ Sign Name
2. _____	_____	_____ Print Name
		_____ Sign Name
3. _____	_____	_____ Print Name
		_____ Sign Name
<u>Date</u>	<u>Dose Administered</u>	<u>Preceptor (AU) Print & Sign Name</u>
>33 mCi		
1. _____	_____	_____ Print Name
		_____ Sign Name
2. _____	_____	_____ Print Name
		_____ Sign Name
3. _____	_____	_____ Print Name
		_____ Sign Name

Tc-99m MAA



$$\% \text{ Radiochemical Purity} = \frac{\text{Bottom}}{\text{Top} + \text{Bottom}} \times 100\%$$

Tc-99m Microlite



Tc-99m MAG3

Prepare Sep-Pak C-18 cartridge

1. Flush with 10ml 100% ethanol
2. Flush with 10ml 0.001 N HCl
3. Flush with 5 ml air

Q.C. Test

1. Load 0.1 ml Tc-99m MAG3
2. Load 10ml 0.001 N HCl and collect eluant (vial A)
3. Load 10ml of 50:50 mixture of ethanol/0.9% NaCl and collect eluant (vial B)
4. Place Sep-Pak into counting vial (C)



Radiochemical Purity

$$\frac{\text{Vial B}}{\text{Vials A + B + C}} \times 100\%$$

$$\frac{\text{vial B } \text{TC}}{\text{vials A+B TC}} \times 100$$

Tc-99m HMPAO

Q.C. Procedure

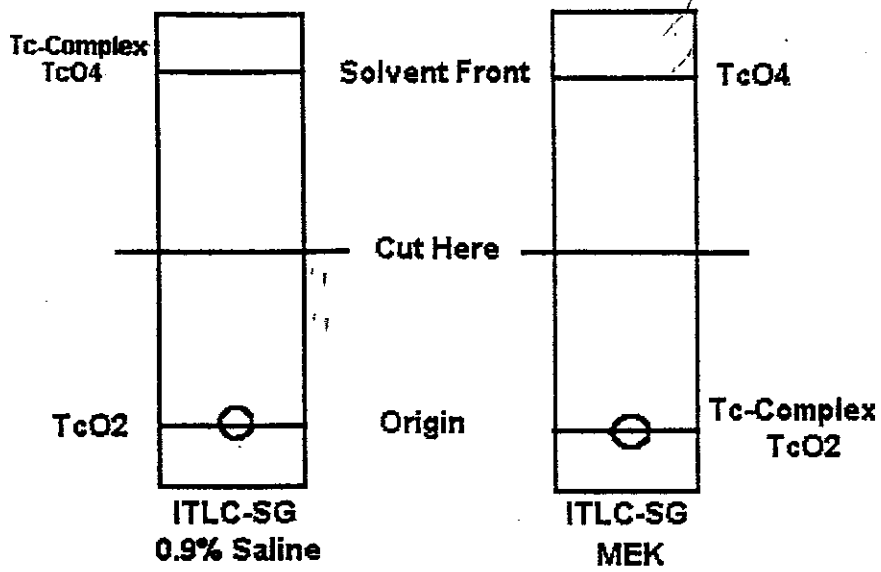
1. Mix in test tube
 - a. 2.3 mls ethyl acetate
 - b. 2.3 mls 0.9% NaCl
2. Add several drops of Tc-99m HMPAO
3. Cap tube and vortex for 1 minute
4. Allow the phases to separate
5. Transfer top layer (ethyl acetate) to a separate test tube
6. Measure activity in both layers



Radiochemical Purity

$$\frac{\text{Activity in Top Layer}}{\text{Activity in Top \& Bottom Layers}} \times 100\%$$

Tc-99m DTPA, MDP and PYP



Tc-Complex = Tc-99m DTPA, Tc-99m MDP or Tc-99m PYP

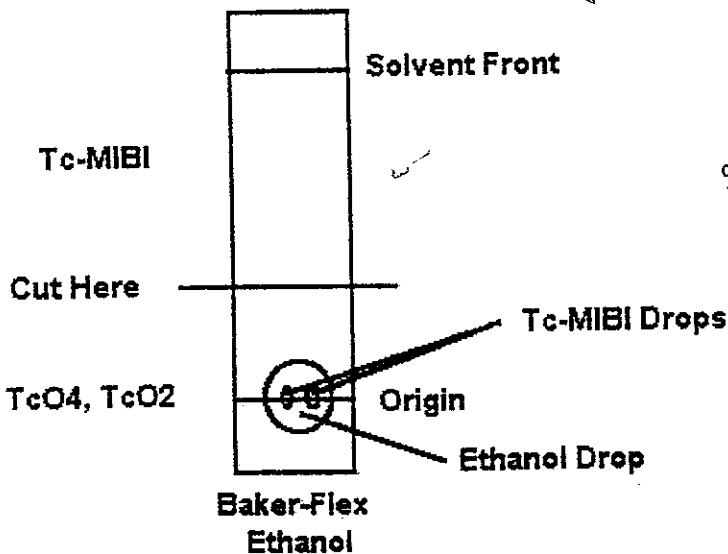
$$\% \text{ TcO2} = \frac{\text{Bottom}}{\text{Top} + \text{Bottom}}$$

$$\% \text{ TcO4} = \frac{\text{Top}}{\text{Top} + \text{Bottom}}$$

$$\% \text{ Radiochemical Purity} = 100\% - (\% \text{ TcO4} + \% \text{ TcO2})$$

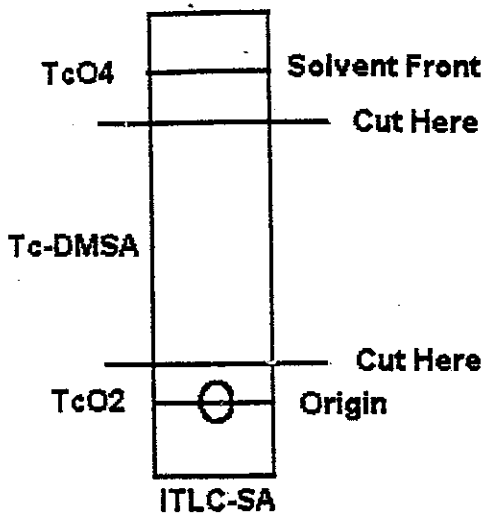
Tc-99m Sestamibi

*Aluminum
top-plate*



$$\% \text{ Radiochemical Purity} = \frac{\text{Top}}{\text{Top} + \text{Bottom}} \times 100\%$$

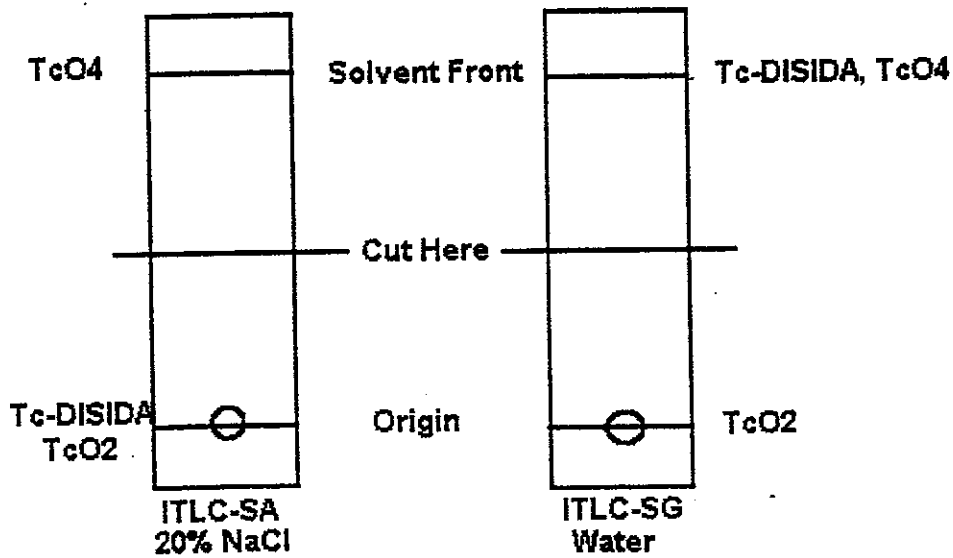
Tc-99m DMSA



n-butanol saturated with 0.3N HCl

$$\% \text{ Radiochemical Purity} = \frac{\text{Middle}}{\text{Top} + \text{Middle} + \text{Bottom}} \times 100\%$$

Tc-99m DISIDA



$$\% \text{ TcO4} = \frac{\text{Top}}{\text{Top} + \text{Bottom}}$$

$$\% \text{ TcO2} = \frac{\text{Bottom}}{\text{Top} + \text{Bottom}}$$

$$\% \text{ Radiochemical Purity} = 100\% - (\% \text{ TcO4} + \% \text{ TcO2})$$

LYMPHOSCINTIGRAPHY

TUMOR	DOSE	TYPE OF INJECTION	# OF INJECTIONS	Vol.
Melanoma	50-100 uCi	Intradermal (1)	4	0.1 ml
Breast (palpable)	50-100 uCi	Subdermal	3-4 (3)	0.1 ml
Breast (nonpalpable)	50-100 uCi	Deep interstitial (2)	3-4 (3)	1.0 ml
Breast (guided wire)	50-100 uCi	Approx. 0.5 to 1 cm. away from the wire.	3-4 (3)	1.0 ml

(1) Bleb must be created by the intradermal injection. Skull, palms & soles are exceptions.

(2) Sonographic or mammographic information must be retrieved by the Resident or Fellow the day before injection, in order to localize tumor to inner/outer and superior/inferior quadrant.

(3) If tumor is in the outer superior quadrant, 2-3 injections should be used.

AFTER COMPLETING THE INJECTIONS THE AREA SHOULD BE MASSAGED FOR APPROXIMATELY 5 MINUTES.

AVOID CONTAMINATION AND CLEAN ANY POSSIBLE CONTAMINATION PRIOR TO MASSAGE.

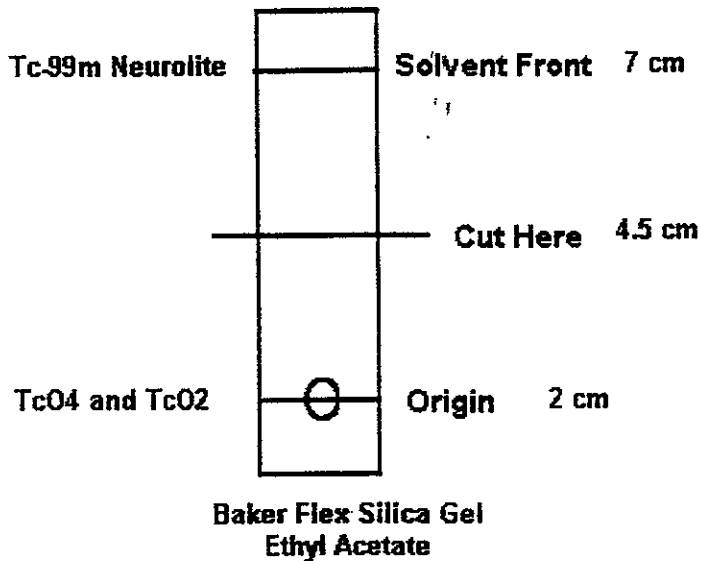
PREPARATION OF Tc-99m NEUROLITE

- 1. Add 100 mci of Tc-99m in 2 ml of saline to VIAL B.**
- 2. With a sterile syringe, rapidly inject 3 ml of saline into VIAL A.
Without withdrawing the needle, remove an equal volume of air.**
- 3. Shake the content of VIAL A for a few seconds.**
- 4. With another sterile syringe, IMMEDIATELY withdraw 1 ml of VIAL A and inject it into VIAL B**
- 5. Shake the content of VIAL B for a few seconds and allow this mixture to stand for 30 MIN at room tempt**

DETERMINATION OF RADIOCHEMICAL PURITY

- 1. Add 4 ml of saline and 6 ml of ethyl acetate (ALDRICH syringe; or use a 10 ml graduated cylinder) to a GLASS TEST TUBE**
- 2. Add several drops of Tc-99m Neurolite**
- 3. Cap the test tube and shake for 1 min**
- 4. Centrifuge for 5 min to allow phases to separate**
- 5. Transfer top layer (ethyl acetate) to a separate glass tube**
- 6. Measure activity in both layers**
- 7. Radiochemical Purity= [Activity in top layer/ Activity in in top layer plus activity in bottom layer] x 100**
- 8. Radiochemical purity must be equal or greater than 90 %**

Tc-99m Neurolite



1. Place ethyl acetate in TLC container at least 15 minutes prior to performing QC.
2. With a pencil, mark the Baker Flex plate with a line at 2 cm, 4.5 cm and 7 cm.
3. Spot the TLC plate with Tc-99m Neurolite at 2 cm and allow to dry for 5 minutes.
4. Place the strip into the TLC container and allow the solvent to migrate to the 7 cm mark which takes approximately 15 minutes.
5. Cut the strip at the 4.5 cm mark.

6. Radiochemical Purity = $\frac{\text{Top}}{\text{Top} + \text{Bottom}} \times 100$

Tc-99m MIBI QC (Cardiolite)

Sep-Pak Preparation

1. Flush 10 mls of 95% ethanol through an Alumina N Sep-Pak.
2. Flush 10 mls of air through the Sep-Pak.

MIBI QC

1. Place 2 drops of Tc-99m MIBI on the top of the Sep-Pak.
2. Flush 10 mls of ~~95%~~ ethanol through the Sep-Pak into a test tube.
3. Flush 10 mls of air through the Sep-Pak into the same test tube.
4. Flush 10 mls of ~~95%~~ ethanol through the Sep-Pak into a second test tube.
5. Flush 10 mls of air through the Sep-Pak into the same second test tube.
6. Place the Sep-Pak into a third test tube.
7. Assay the test tubes in the dose calibrator.

Calculations

$$\text{Radiochemical Purity} = \frac{\text{Test Tubes 1 + 2} \text{ (top)}}{\text{Test Tubes 1 + 2 + 3} \text{ (top)}} \times 100$$

filter = 3 (origin)

Radiochemical Purity must be greater than 90%.

Free Tc is on Sep Pak.



MODIFIED PREPARATION OF Tc-99m-SULFUR COLLOID FOR LYMPHOSCINTIGRAPHY

Specific Instructions For The Modified Preparation of Tc-99m Sulfur Colloid

1. Remove the central plastic disc from the vial and swab the top of the vial septum with alcohol to sanitize the surface.
2. Aseptically add approximately **150 mCi of sodium pertechnetate in 3 mls** to the lyophilized contents. After the addition of pertechnetate, withdraw approximately 3 mls of air from the space above the solution to normalize the pressure in the vial.
3. Shake the contents.
4. Aseptically add the contents of **syringe A** to the vial.
5. Shake the contents.
6. Heat the vial for **3 minutes** in the rolling water bath.
7. Cool the vial in a shielded container for **2 minutes** at room temperature.
8. Aseptically add the contents of **syringe B** to the vial.
9. Shake the contents.

Quality Control Factors

- Thin layer chromatography.

Support	Solvent	Complex	Rf
ITLC-SG	0.9% NaCl	Tc-SC	0.0
		TcO ₄	1.0
		TcO ₂	0.0

- Radiochemical purity must be greater than 92%.
- Expiration is 6 hours from time the kit preparation is completed.
- Store reconstituted kit at room temperature.

Patients Dose

1. Gently agitate reconstituted vial before withdrawing any radioactivity and before patient injection.
2. For the patient dose, withdraw a small fraction of the prepared kit into a 3 ml syringe through a 0.22 micron filter.
3. Remove the filter, exchange the needle for a Sub-Q needle.
4. Then dilute with sterile saline to the appropriate volume.

Recommended Kit Formulation

Kit	Maximum Activity	Volume Range	Expiration	Refrigerate After Reconstitution	Comments
Microlite	75 mCi	2-8 mls	6 hours	Yes	
DMSA	40 mCi	1-6 mls	4 hours		
DTPA	200 mCi	2-8 mls	6 hours		Not for GFR studies
Ceretec	10-54 mCi	5 mls	4-6 hours		Use Newest Tc
Choletec	100 mCi	1-5 mls	18 hours		Vial must sit for 15 min prior to QC
MAA	80 mCi	2-8 mls	5 hours	Yes	
MAG3	100 mCi	5 mls	12 hours		Tc must be < 6 hours old & not first elution off generator
MDP	350 mCi	2-8 mls	6 hours		
Pyrolite	200 mCi	3-7 mls	6 hours		
MIBI	25-300 mCi	1-3 mls	6 hours		
Cardiotec	10-100 mCi	1 ml	6 hours		
HSA	100 mCi	3 mls	6 hours	Yes	
Neurolite	100 mCi	2 mls	6 hours		Two vial kit---Read directions carefully

Selective Internal Radiation Therapy (SIRT), aka Y-90 therapies

SIRT is the selective delivery of radiolabeled microspheres into the capillary beds of tumors within the liver, thereby delivering local beta-radiation to the tumor deposit(s) in the liver only (theoretically) and sparing patients the toxicity of systemic therapies. Although the ideal patients for SIRT have tumor solely within their liver, patients with extrahepatic tumor burden as well may still be considered for SIRT.

There are two commercially available treatments, both involving Y-90 labeled microspheres. SIRSpheres® are made from resin and used for liver metastases (from colon, breast, melanoma, carcinoid, etc.). TheraSpheres® are made from glass and used for patients with HCC. Some patients with cholangiocarcinoma or metastases may also receive TheraSpheres under investigational protocols. In concept, these treatments are identical.

Patients undergoing these therapies will have been previously seen by Drs. Kies, Williams or Yamada (or another IR faculty) in Interventional Radiology for consultation. They should have anatomic and/or functional imaging such as CT, MRI, In-111 Octreoscan and/or FDG PET(-CT).

Patients undergo angiographic study of their vascular anatomy and coil embolization of selected vessels as indicated to prevent unintended treatment of extrahepatic organs such as the stomach and small bowel.

At the same time, IR faculty inject Tc-99m MAA selectively into the common/proper hepatic, right, or left hepatic artery for liver-lung shunt studies. The purposes of the liver-lung shunt studies are: 1) to model the expected distribution of microsphere therapy within the liver, 2) to determine the % fraction of the treatment that would go to the lungs, and 3) to demonstrate other potential extrahepatic organs at risk for unintended treatment. The SPECT/CT images of the MAA distribution (viewed on the Xeleris and/or MIMVista workstation; the MIMVista workstations may have more reliable image registration) should match the extent and distribution of tumor identified on anatomic and/or functional studies fairly closely. Some activity may be identified about the embolization coils immediately following their deployment and is therefore generally not a concern, whereas any additional areas outside the liver should be reported to the injecting Interventional Radiologist right away. Excessive shunting to the lungs (> 20%) is a relative contraindication to therapy and may be an absolute contraindication depending on the magnitude of the estimated dose to the lungs. Alternatively, the administered dose may be reduced to avoid excessive dose to the lung in a single treatment. The dose limit to the lungs for a single treatment is 30 Gy with a cumulative maximum dose limit of 50 Gy. These lung dose limits apply both to SIRSpheres and TheraSpheres. Prescribed doses may also be reduced for other reasons such as reduced liver function. In addition, the patient may undergo separate Tc-99m MAA liver-lung shunt studies for each side of the liver at the Interventionalist's discretion. The final disposition whether to treat the patient is determined by the NM physician and the appropriate Interventionalist.

The NM physician takes all of the available information including anatomic and/or functional imaging studies as well as LFTs (total bilirubin and albumin for SIRSpheres and also transaminases for TheraSpheres) to determine whether it is appropriate to treat the patient and select the appropriate dose. If patients have bilateral disease, generally the right hepatic lobe is treated first, and the contralateral lobe may be treated approximately 1 month later. If the predominant tumor burden involves the left hepatic lobe, then the left lobe may be treated before the right.

Prior to the treatment, the NM physician must determine that there are no contraindications to therapy such as (excessive) extrahepatic dose and/or impending liver failure. Last minute LFTs and/or functional studies such as a HIDA scan may be necessary to confirm that the patient has adequate hepatic functional reserve before undergoing therapy. For each treatment, the side of the liver to be treated and the number of "doses" (i.e., 1 or 2 aliquots) must be confirmed with the Interventionalist prior to the therapy. Two aliquots may be requested in the cases in which a lobe or segment has a dual vascular supply. For instance, segment 4 may be supplied by both the right and left hepatic lobes, and so the Interventionalist may request 2 aliquots or "doses" to attack the tumor from each side.

Communication of treatment plans between Interventional Radiology and Nuclear Medicine is important for efficient and accurate scheduling of Y-90 treatments. **Good communication is especially important in the case of TheraSpheres, as the doses are made up at the manufacturer and calibrated for administration on a specific date AND time.** Therefore, once the Interventionalist and Interventional Radiology have committed to treatment on a specific date and time, **changes to the planned treatment date and time are exceedingly difficult to accommodate** unless they are made before the dose is made up and shipped from the manufacturer. Changes to SIRSpheres administrations including the number of aliquots are more easily made as that treatment is shipped in bulk and the appropriate dose drawn up immediately before administration.

On the day of therapy, the dose and treatment apparatus are prepared by NM technologists and brought to the IR suite. The authorized user (IR or NM physician) must be present at the time of penetration of the vial septum. With SIRSpheres, vascular stasis as determined by the Interventionalist sometimes prevents administration of the full dose, and consequently the actual administered dose will be less than the intended/dispensed dose. In that case, vascular stasis should be documented in the treatment report. Stasis is generally not encountered with TheraSpheres due to the far fewer number of particles required for injection (since TheraSpheres microspheres have much higher specific activity than SIRSpheres).

Following the SIRT procedure, patients are brought to NM to undergo SPECT/CT Bremsstrahlung imaging (incidental x-rays produced by the decay of Y-90). These images should be inspected for: 1) distribution matching areas of tumor identified on other imaging studies and 2) undesired/unexpected extrahepatic activity such as stomach and small bowel which should be immediately reported to the Interventionalist as these may represent potentially life-threatening situations for the patient. On rare occasion, recanalized umbilical veins have also been observed and should also be reported to the Interventionalist.

Important Notes:

In the past, SIRSpheres and TheraSpheres were mutually exclusive therapies, i.e., patients would get treated with one or the other but not both. Our practice has evolved such that the Interventionalist may treat the first lobe with one and then the other side with the other therapy. Also, sometimes the plan changes from using one to the other. In that situation, good communication is critical to make sure that all of the stakeholders (patient, IR & NM scheduling, IR & NM faculty, and technologists) are aware of the change.

The NM physician consultation note is listed in RadNet as SIRSpheres therapy planning (regardless of whether the treatment is SIRSpheres or TheraSpheres), and it is usually dictated and finalized by the NM physician before the treatment date. If it happens not to have been completed prior to the treatment, do not dictate it and do not link any other accession #'s to it unless directed to do so by the NM physician.

Obtain dose information for dictation of TheraSpheres procedures from the treatment sheet provided by the technologist, usually available the day of (or day after the treatment if later in day). Dose information for SIRSpheres treatments is also available the day after, and this information should be plugged back into the Excel spreadsheet provided by the NM physician who planned the treatment, usually emailed ahead of the treatment date. If not obtained from that physician, it should be available from either the NM physician who was present at the treatment or from the chief technologist.

Lastly, do NOT link the treatment and Bremsstrahlung scan dictations to each other nor to the treatment planning note which will be dictated by the responsible NM faculty physician. (But note that the planning MAA planar and SPECT nuclear medicine studies are linked to each other.) Also ask the attending after the therapy if the treatment dictation should be sent to the IR (if they are the AU of record) or to the NM faculty (who may be the AU of record).

Thyrogen-stimulated I-123 Whole Body Scan (WBS) and Treatment

(Note that consults are usually performed 2 weeks in advance and with support of the NM Nurse Navigator)

Monday	Tuesday	Wednesday	Thursday	Friday
Baseline labs: TSH, TG, anti-TG antibody, pregnancy test Thyrogen injection 1 Consult	Thyrogen injection 2 I-123 dose	Repeat labs TSH, TG, anti-TG antibody I-123 WBS Confirm negative pregnancy test I-131 treatment		
OR,	Baseline labs: TSH, TG, anti-TG antibody, pregnancy test Thyrogen injection 1 Consult	Thyrogen injection 2 I-123 dose	Repeat labs TSH, TG, anti-TG antibody I-123 WBS Confirm negative pregnancy test I-131 treatment	

Thyrogen-stimulated I-131 WBS (without treatment)

Monday	Tuesday	Wednesday	Thursday	Friday
Baseline labs: TSH, TG, anti-TG antibody, pregnancy test Thyrogen injection 1 Consult	Thyrogen injection 2	Repeat labs: TSH, TG, anti-TG antibody Confirm negative pregnancy test I-131 dose		Repeat labs: TSH, TG, anti-TG antibody I-131 WBS

Thyroid Hormone Withdrawal (THW) Scan (and treatment)

Monday	Tuesday	Wednesday	Thursday	Friday
Confirm negative pregnancy test I-131 dose		I-131 WBS (48h) (Confirm negative pregnancy test I-131 treatment)	OR, I-131 WBS (72h) (Confirm negative pregnancy test I-131 treatment)	
OR,				Confirm negative pregnancy test I-131 dose
I-131 WBS (72h) (Confirm negative pregnancy test I-131 treatment)				

Note: timing of labs varies according to endocrinologist but may be ordered at the suggested times in the table

Department policy is for negative pregnancy test in all women of childbearing age (<50 yo) no longer than 72 hours or 3 days prior to administration of any dose of I-131 (even diagnostic doses), unless she has had a hysterectomy or tubal ligation >1 y prior to administration of I-131.

Patients prepare for scans and treatment with 2 weeks of a low-iodine diet, and most patients receive Thyrogen injections (recombinant human TSH) to elevate TSH and thereby increase avidity for iodine for scan sensitivity and treatment efficacy. Other patients undergo thyroid hormone withdrawal (THW) over a period of 4-6 weeks, during which patients usually take Cytomel (T3) for the first half of the withdrawal period, and then nothing (neither levothyroxine (T4) nor Cytomel) for the latter half of the withdrawal period. By convention, a TSH level of 30 mIU/mL is considered the minimum level for adequate preparation. Occasionally, patients never start levothyroxine replacement after thyroidectomy and go into a hypothyroid state over several weeks before radioactive iodine ablation. Patients subsequently resume (or start) thyroid hormone replacement/thyroid suppression therapy after their radioactive iodine whole body scan and/or treatment.

Dosing usually relates to known tumor burden at time of treatment:

- A. Disease limited to thyroid gland: 100 mCi I-131
- B. Spread to lymph nodes: 150 mCi
- C. Distant metastases: 200+ mCi at discretion of NM physician and endocrinologist

- D. For patients with significant thyroid bed remnant at preablation scan, possible 2 stage ablation with 30 mCi initially followed in about 6 months with original intended dose

Seven to 10 days following treatment, patients have a post-treatment scan to see where the treatment went. Thyroid bed remnant is almost always observed on the post-treatment scan following initial ablation after thyroidectomy and almost never observed on following diagnostic whole body scans due to high rate of successful ablation of the thyroid bed remnant with initial treatment.

FDG PET/CT scans are not routinely performed for thyroid cancer patients but may be done for certain patients suspected of having dedifferentiated tumor. PET scans may be performed around the same time as radioactive iodine whole body scans. Patients should either undergo Thyrogen preparation or have undergone THW. If the patient receives Thyrogen, then the PET scan may be done on the day of dosing of either I-123 or I-131, well before the patient returns for the diagnostic scan. If the patient has undergone THW, then the patient may have the PET scan on the same day as an I-131 WBS if the patient receives the FDG injection AFTER the WBS has been performed. Otherwise, the higher-energy (511 keV) gamma rays from PET will downscatter into the windows for I-131 (364 keV) scan.