Radiation Safety In-service

for

Nuclear Medicine Workers

Presented by:
Astarita Associates, Inc.
Medical Physics Consultants
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Radiation Safety Officer

- Any institution that uses radiation for diagnostic and/or therapeutic purposes must name a Radiation Safety Officer (R.S.O.).
- This individual is responsible for the day to day safe use of radiation at the institution and must be present *50%* of the time radioactive materials are being used.
- They are qualified through training and experience in radiological health to evaluate and mitigate radiation hazards.
- All unsafe conditions must be reported to the R.S.O.

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General Information about Radiation

- Often depicted by books, movies and news media as mysterious, deadly force.
- In truth:
  - Nothing mysterious at all
  - Radiation has been studied for over 100 years
  - Detection, measurement and radiation control are extremely common events
  - The more the public understands, the less frightening it becomes
  - A very beneficial diagnostic tool

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Radiation Units of Measurement:

- **Roentgen**: (R) Unit of radiation exposure in air
- **Rad**: Energy absorbed per gram of material/tissue
- **Rem**: Biological effect of a rad

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Radiation Units

- Conceptually, the 3 units of radiation described previously are entirely different.
- However, for the energy ranges used in Diagnostic Radiology, they are approximately equal.
  1R ~= 1 Rad ~=1Rem
- The standard unit of radiation protection is usually millirems (mrem).

  1 mrem = 1/1000 of a Rem
  1 Rem = 1000 mrem

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International System of Units (SI)

	US	SI	Relationship
Absorbed Dose	Rad	Gray (Gy)	100 Rad per Gy
Dose Equivalent / Effective Dose	Rem	Sievert (Sv)	100 Rem per Sv

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Background Radiation

- Definition: Relatively constant low-level radiation from environmental sources such as the earth (or building materials), cosmic rays, and naturally occurring radionuclide found in the body.
- Level of background radiation will vary depending upon location, altitude and the amount of natural radioactive material in the ground.
  - New York ~ 300mRem/yr
  - Denver ~ 500mRem/yr
- Highest known background levels recorded in mountains of South America - 1000 millirem (1 Rem) per year.

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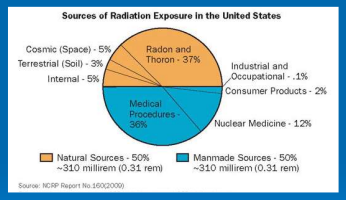
Background Radiation



Approximate natural background
~310mrem/year

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Background Radiation

- No known proven carcinogenic effects from radiation levels in the order of magnitude comparable to background radiation.
- Although the patient may receive several times their annual natural background radiation exposure from the diagnostic procedure performed, the occupational radiation worker exposure is typically within background radiation levels.

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Personnel Monitoring

- Procedure instituted to estimate the amount of radiation received by individuals who work around radiation. It simply measures the amount of radiation to which one was exposed.
- The monitor offers no protection against radiation exposure.

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Personnel Monitoring

- Required for all individuals who are occupationally exposed to radiation on a regular basis – whole body badge issued
- Required for all individuals who handle millicurie quantities of radioactive material on a regular basis –ring (extremity) badge issued
- Individuals who are occupationally exposed to radiation on an occasional basis, such as nurses caring for *radiopharmaceutical therapy or therapeutic implant* patients, will be issued a whole body monitor when caring for those patients.
- Other individuals who are exposed to radiation on an occasional basis who are not likely to receive 10% of the maximum annual dose limit are not issued exposure monitors. This includes secretarial staff, security personnel and nursing staff who infrequently work with patient's administered with radioactive materials

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Personnel Monitoring

- Personnel radiation monitors in Nuclear Medicine are exchanged monthly
- Monitors are typically on the chest or collar and are positioned outside of a protective apron (if worn).
- Pregnant workers are to wear their issued fetal monitor at the waist level, under the protective apron (if worn).
- Records of exposure are promptly reviewed by the Radiation Safety Officer and are maintained indefinitely.

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Occupational Dose Limits

Whole Body	5000 mrem/yr
Lens of Eye	15,000mrem/yr
Extremities	50,000 mrem/yr
Fetus	500 mrem for entire gestational period (50 mrem/month)

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Quarterly ALARA Investigational Levels (NYS Recommended)

	I	II
Whole body	125 mRem/q	375 mRem/q
Lens of the Eye	125 mRem/q	375 mRem/q
Skin	750 mRem/q	2250 mRem/q
Extremity	1875 mRem/q	5625 mRem/q

I. Notify and action taken at RSO discretion
II. Investigate and take action

NYS Radiation Guide 10.1 Rev 2

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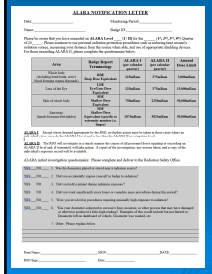
ALARA Letter



- Typical notification letter
- Signed by RSO and Employee
- ALARA levels can be changed by facility for specific groups of workers

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Exposure from Nuclear Medicine Patients

- Patients injected with radiopharmaceuticals emit relatively small amounts of radiation.
- The activity for diagnostic procedures is extremely low and poses no real danger.
- Typical Nuclear Medicine exposures
  - Tc99m MIBI 27mCi <0.2mR/hr at 1meter
  - Tl201 2.7mCi <0.05mR/hr at 1 meter
  - Tc99m MDP 24mCi <0.1mR/hr at 1 meter

Adapted from the Journal of Nuclear Medicine Technology Volume 30, Number 1, March 2002, pg 29

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Declared Pregnant Workers

- Worker has right to declare or not declare the pregnancy
- Once declared, a fetal monitor is issued and worn at waist level
- Dose limit is 500mRem over the gestation period
- Goal is to maintain exposure less than 50mRem per month
- Declaration should in writing using the appropriate form
  - i.e. "Declared Pregnancy of a Radiation Worker"

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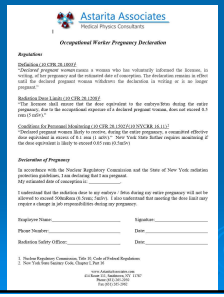
Declared Pregnant Worker Form



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Occupational Worker Pregnancy Declaration

Regulations

Definition (10 CFR 20.1003)
"*Declared pregnant woman* means a woman who has voluntarily informed the licensee, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant."

Radiation Dose Limits (10 CFR 20.1208)
"The licensee shall ensure that the dose equivalent to the embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv)."

Conditions for Personnel Monitoring (10 CFR 20.1502/10 NYCRR 16.11)
"Declared pregnant women likely to receive, during the entire pregnancy, a committed effective dose equivalent in excess of 0.1 rem (1 mSv)." New York State Bylaw requires monitoring if the dose equivalent is likely to exceed 0.05 rem (0.5mSv)

Declaration of Pregnancy

In accordance with the Nuclear Regulatory Commission and the State of New York radiation protection guidelines, I am declaring that I am pregnant.
My estimated date of conception is: _____

I understand that the radiation dose to my embryo / fetus during my entire pregnancy will not be allowed to exceed 500mRem (5.5mSv; 5mSv). I also understand that meeting the dose limit may require a change in job responsibilities during my pregnancy.

Employee Name:_____ Signature:_____
Phone Number:_____ Date:_____
Radiation Safety Officer:_____ Date:_____

1. Nuclear Regulatory Commission, Title 10, Code of Federal Regulations
2. New York State Sanitary Code, Chapter I, Part 16

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Authorization to Administer Radioactive Material

- Physician
- Registered Nurse
- Nurse Practitioner
- Physician Assistant
- Licensed Nuclear Medicine Technologist

Must be properly trained in radiation safety / safe handling techniques

Competency Observed

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Limitations of Nuclear Medicine Technologist Licensure (NYS Scope of Practice)

- May start IV line only for the purpose of radiopharmaceutical administration
- May use existing line and inject a saline flush
- May not administer other pharmaceuticals even if part of the nuclear medicine procedure (i.e Lasix, Dobutamine)
- Practitioner's who direct the technologist to administer other than radiopharmaceuticals are *aiding and abetting an unlawful practice*

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Authorized User

- An Authorized User is physician named on a radioactive materials license as an individual who uses and/or supervises the use of radioactive material.
- Does not need to be on premises during the administration of diagnostic radiopharmaceuticals by a licensed nuclear medicine technologist
- Must be on premises and in the room during the administration of therapeutic radiopharmaceuticals by a licensed nuclear medicine technologist

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- All unsafe conditions must be reported to the R.S.O.

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Radioactive Materials Use Areas

- Hot Lab
- Imaging Room
- Stress Room
- Preparation & Injection Room

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Restricted Areas

Post with a "Radioactive Materials" caution sign…

- Hot Lab
- Imaging Room
- Stress Room
- Preparation & Injection Room
- Waiting Room – optional and does not need to be separated from general waiting area

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Restricted Area House Rules

- NO EATING OR DRINKING
- NO STORING FOOD OR PERSONAL ITEMS

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Precautions for Occupational Workers

- Universal Precautions
  - Gloves
  - Remote Handling
  - Protective Clothing
- Three Cardinal Rules for Radiation Protection
  - Time
  - Distance
  - Shielding

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Time

- Minimize your time near a radioactive source (patients/isotopes) to only what it takes to complete the task.
- Minimize time manipulating unit doses

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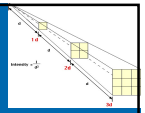
Distance



- Distance offers great protection from radiation.
- Radiation exposure follows the inverse square law: Move twice as far, the radiation is reduced by a factor of 4.

  10mR/hr at 1 meter = 2.5mR/hr at 2 meters

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Shielding

- Use appropriate shielding when reasonable such as:
  - syringe shields
  - unit dose carriers
  - lead lined waste & sharps receptacles
- Half Value Layer (HVL) of Tc99m is 0.3mm Pb.
  - Amount of material to reduce the exposure by one half

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General Nuclear Medicine Guidelines

- Only physicians listed on the license may approve the use of radiation in humans
- Radioactive material may only be used in designated areas.
  - i.e. Imaging Room, Hot Lab, Treadmill Room
  - "Radioactive Materials" sign
- No eating/drinking in radioactive material areas.
- Lab coats, syringe shields and gloves must be utilized when handling radioactive material.
- Educate & prepare patient prior to injection of radioactive material

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Instructions to Patients

Required for administered activities greater than ……

Radionuclide	Activity Requiring Instructions(mCi)	Typical Activity (mCi)
Tc99m	150	10-30
Tl201	85	3
Ga67	47	3-8
I123	33	0.2
In111	13	0.5
I131	7	0.5-200

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Instructions to Patients

- Not routinely needed for diagnostic exams
- Needed for patients breastfeeding
- Needed for patient receiving therapeutic doses
- Do not scare patient!

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Instructions to Patients

Dear Law Enforcement Official:

Mr./Ms._____was a recent patient at_____ and received a radioactive material injection as part of their procedure. This use of this material is authorized by Radioactive Materials License No. _____ issued by the New York State Department of Health.

The procedure involved an administration of _____mCi of _____ with a half-life of _____hours. Trace amounts of radioactivity may be detectable until _____.

The radiation exposure from this patient has been evaluated and this patient has been released in compliance with existing regulations. This patient poses no undue hazard to members of the public. If you need additional information, please contact this office at _____.

Respectfully,

_____
Radiation Safety Officer

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Breast Feeding Cessation

- NUREG 1556 Vol. 9 Appendix U
- Regulations in place to reduce the dose to a newborn infant to less than 1mSv (actual reg. is <5mSv)

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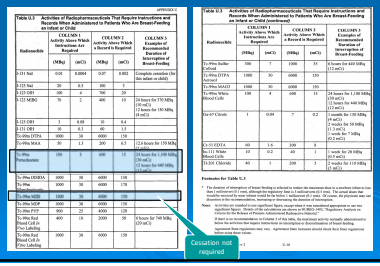
Breast Feeding Cessation



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Pregnant Patients

- Only after consultation with ordering physician and authorized user
- Risks explained
- Fetal exposure calculated

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General Environmental Services Guidelines

- Clean in authorized areas only
- Do not enter hot lab unless authorized to do so or under direct supervision
- Do not empty containers with radioactive label
- Conventional cleaning solvents are appropriate
- Mounted waste monitors
  - Designed to detect small quantities of radioactive material in waste/linen
  - Must walk slowly through detectors – 6 seconds is ideal
  - When alarm is sounded, store waste in designated area

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Guidelines for Engineering & Maintenance

- Only authorized personnel are to enter radioactive material storage areas.
- Access by non authorized personnel should be under the supervision of nuclear medicine staff.

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Receiving – A Note for Security

- During normal business hours, radioactive packages are routinely delivered to the designated area within the nuclear medicine suite, such as the hot lab or receiving closet.
- For off-hour delivery, the radioactive material transporter should check in with security personnel and be escorted to the designated receiving area in nuclear medicine.
- For off-hour deliveries in medical offices, the transporter is typically provided a key or entry code for direct access to the receiving area.

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Receiving – Nuclear Medicine

- Radioactive deliveries must be monitored within 3 hours of receipt
- In situations where the deliveries are made off-hour, packages must be monitored within 3 hours of staff arrival
- Wear gloves
- Visually inspect for problem
- Measure 1 meter exposure and at surface of package
- Wipe test must be performed whether or not contamination is suspected

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DOT Labels Shipping and Receiving

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Excepted Package, Limited Quantity

Maximum amounts for commonly used liquid material

Co57-27mCi	***Tc99m-11mCi***
Tl201-11mCi	Ga67-8.1mCi
I123-8.1mCi	I131-1.9mCi
F18-1.6mCi	In111-8.1mCi
P32-1.4mCi	Mo99-2.0mCi
Ba133-8.1mCi	Cs137-1.6mCi
Sr89-1.6mCi	Xe133-270mCi gas

Note: If a package has more than one isotope, the max quantity defaults to the lower limit.

Surface Exposure <0.5mR/hr
Surface Wipe Test <6600dpm/300cm^2

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Type I White

- Surface exposure <0.5mR/hr
- 1 meter exposure—not detectable
- Surface wipe test <6600dpm/300cm^2

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Type II – Yellow

- Surface exposure <50mR/hr
- 1 meter exposure <1mR/hr
  - TI Index
- Surface wipe test <6600dpm/300cm^2

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Type III – Yellow

- Surface exposure <200mR/hr
- 1 meter exposure <10mR/hr
- Surface wipe test <6600dpm/300cm^2

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Radioactive Package Monitoring

- Any radioactive package that appears damaged should be carefully assessed for contaminants.
- Should survey or wipe test results of any radioactive package exceed limits, the package should be set aside and the Radiation Safety Officer contacted
- In many cases, the supplier should be notified to remove the package.

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Radiation Surveys—Instrumentation

- Geiger Mueller meter (GM) —pancake attachment
- Scaler & Well

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Ambient Radiation Area Surveys

- Using GM meter

- Performed Daily – at the end of the work day
- Survey <1cm from surface as slowly as possible (LOW and SLOW)
- Use the most sensitive scale (0.1x) and keep the audio switch on

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Wipe Tests For Removable Contamination

- Use the well counter

- Performed Weekly
- Wipe 10x10cm area (100cm²)

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NYS State Contamination Limits

APPENDIX 16-A
TABLE 7
RADIOACTIVE SURFACE CONTAMINATION LIMITS

Application	Alpha (dpm/100cm²)		Beta-gamma	
	Total	Removable	Total (mR/hr)	Removable (dpm/100cm²)
Controlled area Basic guide	25,000 Max. 5,000 Av.	500	1.0	5,000
Clean area	1,000	100	0.5	1,000
Non-controlled area Skin, personal clothing	500	N.D.₂	0.1	N.D.₂
Release of material or facilities	2,500 (Max.) 500 (Av.)	100	0.2	1,000

¹ Measured at 1 cm from the surface.
² N.D. – non-detectable.

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Note on GM Meter

- Calibrated for Cs137 (662 keV)
- Sensitive but inaccurate for lower energies
- Excellent for finding contamination but not for true exposure measurements
- Ion chamber is used for accurate measurements of radiation exposure, usually performed by the Medical Health Physicist

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Major / Minor Spill

Use Table N.1 as general guidance to determine whether a major spill/contamination procedure or a minor spill/contamination procedure will be implemented. All spills/contaminations of radium-226 will be considered major spills.

Table N.1 Relative Hazards of Common Radionuclides

Radionuclide	Millicurie	Radionuclide	Millicurie
P-32	1	Tc-99m	100
Cr-51	100	In-111	10
Co-57	10	I-123	10
Co-58	10	I-125	1
Fe-59	1	I-131	1
Co-60	1	Sm-153	10
Ga-67	10	Yb-169	10
Se-75	1	Hg-197	10
Sr-85	10	Au-198	10
Sr-89	1	Tl-201	100

Tc-99m 100mCi

- NRC sets the standard – 100mCi for ^{99m}TC[1]
- NYS recommendation for major/minor spill determination: 10mCi as a general guide & 30mCi for ^{99m}TC[2]

1. NRC NUREG-1556 Vol 9, Rev 2 Table N
2. NYS Radiation Guide 10.1, Rev 2, App H

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Minor Spill

- NOTIFY all persons in area a spill has occurred
- PREVENT—cover with absorbent paper
- CLEAN using gloves, tongs (remote handling)
  - Clean outside to inside
  - place in plastic bag
- SURVEY—check spill and personnel
- Complete spill/decontamination report
  - Report to Nuclear Medicine Supervisor and RSO

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Major Spill

- CLEAR AREA: *all persons to vacate room*
- PREVENT: cover with absorbent paper
- SHIELD: only if it can be done without further contamination or increasing exposure to staff
- CLOSE ROOM: lock and prevent entry (signs)
- NOTIFY RSO
- PERSONNEL: survey and decontaminate
  - Use mild soap…luke-warm water…surgical sponge
- CLEAN—*under RSO supervision*
- Complete spill/decontamination report
  - RSO signs report

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Radioactive Waste Disposal Decay – In - Storage

- Waste with half life of <120 days
- Store in shielded container
- Label with date and longest lived isotope
- Hold for 10 half-lives
  - Tc99m – 60 hours; Tl201 – 30 days; F18 – 18 hours
- Survey to ensure indistinguishable from background
- Remove all radioactive labels prior to final disposal
- Maintain record of disposal for a minimum of 3 years

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Transfer to Authorized Recipient

- Generated waste if storage is limited
- Used unit doses may be returned to vendor
- Un-used doses may be returned to vendor
  - Following DOT guidelines

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Unused / Spent Dose Return Limitations

- Package surface survey < 0.5mR/hr
- Wipe <6600dpm/300cm^2
- Quantity Limitations
  (Total amount in package – all sources combined)
  - Tc99m-11mCi
  - Tl201-11mCi
- Package label
  - Limited Quantity, Excepted Package UN2910

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Medical Event (Misadministration)

- A radiopharmaceutical or radiation from a source other than ordered by the physician—**WRONG DRUG (i.e. Tc99m MDP vs Tc99m Sestamibi)**
- A radiopharmaceutical or radiation to the **WRONG PERSON**
- A radiopharmaceutical or radiation by route of administration or to a part of the body other than that intended by the ordering physician—**WRONG ROUTE (i.e. IV vs Oral)**
- Administration of a diagnostic radiopharmaceutical of more than 50% of intended activity
- Administration of a therapeutic radiopharmaceutical of more than 10% of intended activity

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Medical Event

- Reportable to the NRC / NYS Department of Radiological Health…
  - >5 Rem (0.05 Sv) to the whole body
  - >50 Rem (0.5 Sv) to any individual organ
  - >30uCi I125 / I131 iodide
- Typical Dose from 30mCi ^{99m}Tc – MIBI *Not Reportable*
  - Whole Body <2 Rem
  - Large Intestine <6 Rem

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Safe Use of Radioactive Material

1. Wear lab coat/protective clothing when in radioactive material area.
2. Wear gloves when handling radioactive material.
3. Monitor hands for contamination after each procedure and before leaving radioactive material area.
4. Always use syringe shields when preparing and administering doses (except when care is compromised).
5. Do not eat, drink, smoke, or apply cosmetics in radioactive material areas. Do not store food or personal items in radioactive material areas.
6. Assay all patient doses prior to administration. Ensure dose is within 10% of prescription.
7. Check patient ID by two methods (name and D.O.B).
8. Always wear monitoring devices when working with radioactive materials (whole body and ring if applicable). Store monitors in a non-radiation area when not in use.

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Safe Use of Radioactive Material

8. Dispose waste only in designated areas in properly shielded containers.
9. Never pipette by mouth. Separate radioactive pipettes from non-radioactive pipettes.
10. Survey generator, kit prep, and injection areas daily for contamination.
11. Confine radioactive solutions in clearly labeled shielded containers.
    Label with compound, isotope, date, time, assay.
12. Maintain flood sources, syringes, waste, and other material in properly shielded containers.
13. Use plastic backed absorbent pads when using radioactive aerosols to prevent contamination of surfaces.
14. Use a cart or wheeled device to move radioactive sources. Always transport source in shielded containers.

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References

Part 16 of the NYS Sanitary Code

Article 175 of the NYC Health Code

Title 10 of the Code of Federal Regulations – parts 20 and 35

NUREG 1556 Volume 9 – NRC Guidance for Radioactive Materials Licensing

Radiation Guide 10.1 – NYS Guidance for Radioactive Materials Licensing

Other references of interest:
Pharmacopeia Guidelines (i.e. USP 825)

Joint Commission

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