21.5.2003

IAEA Post Graduate Educational Course on Radiation Protection and Safety of Radiation Sources
Greek Atomic Energy Commission, Athens 2003

Radiation Protection in Radionuclide Therapy

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OBJECTIVE

To be able to apply the principle of optimization of radiation protection to therapeutic procedures including design, operational consideration, quality control and clinical dosimetry.



Content

- Basic requirements
- Administration of therapy
- The radioactive patient. Dose constraints
- The hospitalized patient
- Emergency procedures



Optimization of Protection in Medical Exposure.

Basic requirements

JUSTIFICATION OF MEDICAL EXPOSURES (BSS)

Weigh diagnostic and therapeutic benefits against radiation detriment, and benefits and risks of alternative techniques.

Use WHO guidelines

JUSTIFICATION (BSS)

Decision on administration of therapy must be taken by a physician who has proper training and sufficient knowledge of radionuclide therapy.

RESPONSIBILITIES

With regard to responsibilities for medical exposure, registrants and licensees shall ensure that (BSS II.1–3):

- no patient is administered a diagnostic medical exposure unless the exposure is prescribed by a medical practitioner;
- medical practitioners are assigned the primary task and obligation of ensuring overall patient protection and safety in the prescription of, and during the delivery of, medical exposure;
- medical and paramedical personnel are available as needed, and are either health professionals or have appropriate training to discharge their assigned tasks in the conduct of the diagnostic or therapeutic procedure that the medical practitioner prescribes;
- the exposure of individuals incurred knowingly while voluntarily helping (other than in their occupation) in the care, support or comfort of patients undergoing medical diagnosis or treatment is constrained as specified in Appendix C; and
- training criteria are specified or subject to approval, as appropriate, by the Regulatory Authority in consultation with relevant professional bodies.

RESPONSIBILITIES

The licensee shall ensure that workers (medical practitioner, medical physicist, technologist):

- follow any applicable rules and procedures for the protection and safety of patients, as established by the licensee;
- are competent in the operation and use of the equipment and sources employed in nuclear medicine, of the equipment for radiation detection and measurement, and of the safety systems and devices, commensurate with the significance of the workers' functions and responsibilities; and
- know their expected response in the case of patient emergencies.

CLINICAL DOSIMETRY (BSS)

Registrants and licensees shall ensure that the following items be determined and documented:

in diagnosis and treatment with unsealed sources, representative absorbed doses to relevant organs

Medical physicist

A qualified medical physicist should be responsible for measurement of radionuclide activity, identification of radionuclides and internal radiation dosimetry

ABSORBED DOSE-ADMINISTERED ACTIVITY I-131

Example of method to calculate administered activity from Prescribed absorbed dose to the thyroid

Thyroid mass (g)	30
Prescibed dose (Gy)	100

Uptake measurements

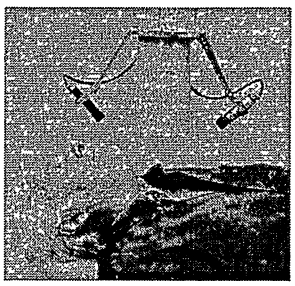
Time (h)	Standard (cpm)	Patient (cpm)	Bg (cpm)	Uptake (%)
0	-	-	-	73,5
2	21736	5521	100	25 1
24	18286	12338	100	67,3
48	17165	10565	100	61,3
144	13171	5754	100	43,3

Effective half-life (d):	4,0
Activity to administer (MBq):	240

$$\text{Activity (MBq)} = \frac{23.4 * \text{mass(g)} * \text{dose (Gy)}}{\text{uptake at t=0 (\%)} * T_{eff}\text{ (d)}}$$

Berg GEB et al. J Nucl Med 1996; 37:228-232

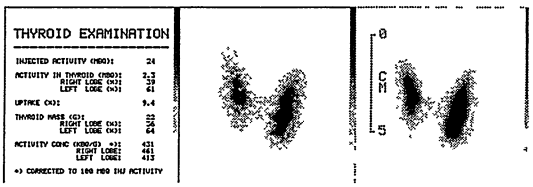
UPTAKE MEASUREMENT



GAMMA CAMERA EXAMINATION



GAMMA CAMERA EXAMINATION



Used to determine the size of the organ

Factors affecting safety in radionuclide therapy

Safe handling of radionuclides
- ordering
- receipt and unpacking
- storage
- dispensing
- internal transports
- radioactive waste

Safe administration
- identification
- pregnancy
- breastfeeding

Patient preparation

The radioactive patient and dose constraints

The hospitalized patient
- instructions to nursing staff
- visitors instructions
- discharge of the patient
- decommissioning of hospital ward
- radioactive waste

Emergency procedures

ORDERING, RECEIPT & UNPACKING

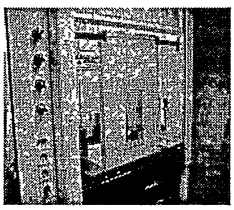
- The hospital routines for ordering radionuclides should be followed.
- When ordering, be sure the delivery service knows where in the hospital to deliver the material.
- Make sure that the package is expected and that no unauthorized person will open it upon arrival.
- Before unpacking, check the package. In case of damage, contact your RPO.



Storage of I-131

- The radionuclide should be stored in a controlled area, according to national regulations and local rules.
- The radionuclide should always be stored in a lead container and preferably in a fridge to prevent evaporation
- To reach an acceptable external dose rate, a thickness of 1-4 cm lead is generally required.

DISPENSING



- Protective clothing
- Lead shields (bench top shield, vial shield, syringe shield)
- Keep the vial in the fume hood and on a tray with lips, lined with plastic backed absorbent pads.
- Handle the vial with forceps or similar long handled instruments.
- Cover the vial with lead after use.
- Check the activity
- Fill in the necessary records

Internal transport

If the administration of radiopharmaceutical to the patient takes place far from the dispensing room, use a transport container with absorbent pads.

Make sure that a warning sign is on the container together with patient name, activity and date.

Travel by the most direct route avoiding more heavily occupied areas



RADIOACTIVE WASTE

Shall be collected, segregated and disposed of according to national regulations and local rules.

Optimization of Protection in Medical Exposure

Administration of therapy

PRECAUTIONS BEFORE ADMINISTRATION

- Be prepared for an emergency situation.
- Careful identification of the patient (hospital routines shall be followed).
- Questions to the patient:
  - -Pregnant?
  - -Breastfeeding?
  - -Incontinent?
  - -Nausea?
  - -Living conditions?
  - -Type of work?
  - -Public transportation back home?
- Oral and written **individual** instructions to the patient.

PREGNANCY (BSS)

Registrants and licensees shall ensure for nuclear medicine that:

Administration of radionuclides for diagnostic or radiotherapeutic procedures to women pregnant or likely to be pregnant be avoided unless there are strong clinical indications.

PREGNANCY

A pregnant woman should not be treated with a radioactive substance unless the therapy is required to save her life; in that event the potential absorbed dose to the fetus should be estimated and consideration should be given to terminating the pregnancy.

Radiopharmaceutical	All activities up to (MBq)	Avoid pregnancy (months)
Au-198 colloid	10000	2
I-131 iodide (thyroid ca)	5000	4
I-131 iodide (thyrotoxicosis)	800	4
I-131 MIBG	5000	4
P-32 phosphate	200	3
Sr-89 chloride	150	24
Y-90 colloid (arthritic joints)	400	0
Y-90 colloid (malignancy)	4000	1

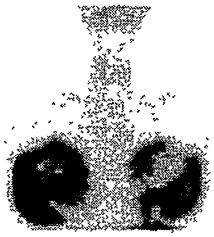
BREASTFEEDING (BSS)

Registrants and licensees shall ensure for nuclear medicine that:

- For mothers in lactation, discontinuation of nursing be recommended until the radiopharmaceutical is no longer secreted in an amount estimated to give an unacceptable effective dose to the nursling

BREASTFEEDING





Patient information needed:

•Nausea	-intravenous administration to be considered?
•Living conditions	-number of people in house? -children? -separate room?
•Type of work	-working close to other people? -working with children? -pregnant coworkers?
•Public transport	-time?

ADMINISTRATION OF THERAPY CALIBRATION OF SOURCES (BSS)

"Registrants and licensees shall ensure that:

unsealed sources for nuclear medicine procedures be calibrated in terms of activity of the radiopharmaceutical to be administered, the activity being determined and recorded at the time of administration;"

SAFE ADMINISTRATION

- I-131 should be administered in a controlled area (hot lab or the patient's hospital bedroom).
- A plastic bag for contaminated items should be available as well as paper tissues.
- The patient is asked to sit at a table covered with adsorbent pads and the floor beneath the patient should also be covered by adsorbent pads.
- If the I-131 is administered in capsules they should be transferred to the patient mouth by tipping from a small shielded (>1 cm Pb) container.
- I-131 administered in an oral solution (50 ml) should be sucked up through a straw from the shielded vial by the patient. The vial should be flushed with water several times. The patient should drink several glasses of water to clean the mouth.

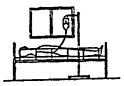
SAFE ADMINISTRATION



Safe administration

Procedure for intravenous administration:

- Dispense the radionuclide into a shielded syringe
- Put the radionuclide in an infusion bottle
- Line the bottle to the patient using an intravenous catheter
- Keep the patient in bed until the bottle is empty
- Remove the bottle and the catheter and dispose of them as radioactive waste



Optimization of Protection in Medical Exposure

The radioactive patient. Dose constraints

Shall the patient be hospitalized?





Can the patient leave?
Any restrictions?

Dose constraints (BSS)

"Registrants and licensees shall constrain any dose to

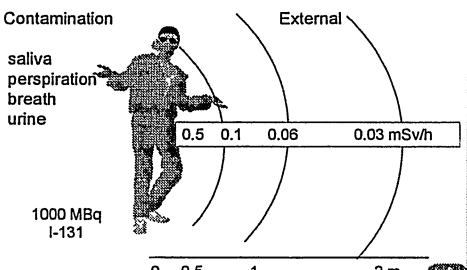
individuals incurred knowingly while voluntarily helping (other than in their occupation) in the care, support or comfort of patients undergoing medical diagnosis or treatment and to visitors to patients who have received therapeutic amounts of radionuclides or are being treated with brachytherapy sources"

Dose limitation for comforters and visitors of patients (BSS Schedule II.9)

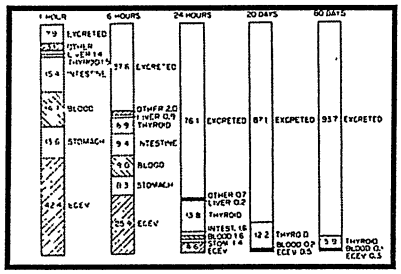
..The dose shall be constrained so that it is unlikely that his or her dose will exceed 5 mSv during the period of a patient's diagnostic examination or treatment. The dose to children visiting patients who have ingested radioactive materials should be similarly constrained to less than 1 mSv



The Radioactive Patient



Biodistribution of I-131



(MIRD)

CONTAMINATION

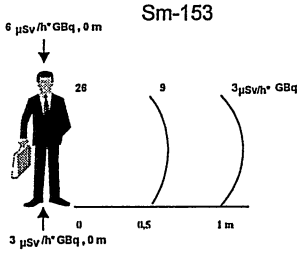
Administered activity: 1000 MBq I-131

Excretion	Concentration	Contamination	
Saliva	<2 MBq/g	utensils	2 kBq
Perspiration	<20 Bq/cm²	surfaces	10 Bq/cm²
Breathing	100 Bq/l	air	1 Bq/l
Urine	< 500 kBq/ml	toilet	2 kBq/cm²

Generally larger than the derived limits for contamination given by ICRP (publ 57)

The Radioactive Patient

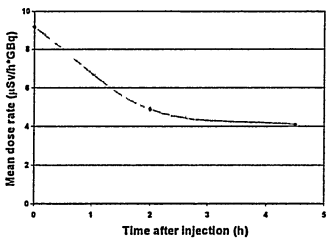
Sm-153



Actvity concentration in urine: 0.3 MBq/ml*GBq

The Radioactive Patient
Sm-153

Dose rate at 0.5 m



RESTRICTIONS

Patient with iodine-131

Behaviour restriction	Activity of I-131 administered (MBq) 30-200	200-400	400-600	600-800
	Period of restrictions (d)			
Stay at least 1 metre away from all members of the household except for very brief periods (a few minutes every day)	5	9	12	14
Restrict close contact ("cuddling" with all members of the household to less than 15 minutes per day, and sleep separately from them	15	21	25	27
Sleep separately from "comforters and cares"	-	-	4	8
Avoid prolonged close contact (more than 3 hours at <1 metre) with other adults	-	-	-	1

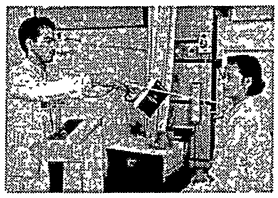
NOTE THAT:
The restriction times in the first two rows run concurrently e.g. for 30-200MBq category, a child should only be cuddled for brief periods for 5 days, then cuddling must be restricted to 15 min per day for a further 10 days.
The dose constraint for the third row is 5 mSv
The fourth row only covers on single event whereas the other categories assume daily contact

RESTRICTIONS

Patient with iodine-131

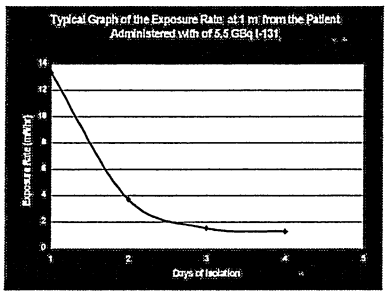
Activity (MBq)	Public travel allowed per day 1:st w (h)	2:nd w (h)	Off work (d)	Sleep apart from partner pregn. (d)	no (d)	Restricted close contact with children <2 y (d)	2-5 y (d)	5-11 y (d)
200	3,5	24	0	15	1	15	11	5
400	1,5	14	3	20	8	21	16	11
600	1	9	6	24	11	25	20	14
800	0,5	7	8	26	13	27	22	16

The Radioactive Patient
I-131



The patient should be kept at least 2h, and if possible one day in the hospital.
In the case of cancer treatment, the patient should generally be hospitalized for several days.
In all cases, the dose rate at 1 m from the patient should be down to an acceptable level established by the RPC.

PATIENT SURVEY



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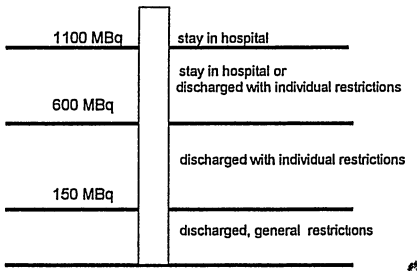
Guidance level for maximum activity for patients in therapy on discharge from hospital

Iodine-131 1100 MBq

HOSPITALIZATION OR NOT

I-131



INSTRUCTIONS TO OUT-PATIENTS

- No eating and drinking during the first hour after treatment.
- During the following two days you should drink more than usual.
- Use only a WC and flush 2-3 times. Keep the toilet and the floor clean.
- Wash your hands frequently and take a shower every day.
- Avoid close contact with members of the family, children and pregnant women according to the time table attached
- Avoid solid waste

Contact the Nuclear medicine department in case of problems or questions. Phone: .....

AVOIDING SOLID WASTE

Sensitive detectors at sanitary landfills and solid waste transfer and processing sites have identified contaminated articles from nuclear medicine patients.

- Do not use paper plates or disposable cups or flatware.
- Use regular dishes, glasses and utensils. Wash them in the sink or dishwasher.
- Tissues and paper napkins should go in the toilet, not the garbage.
- Food residues should be avoided during the first week (apple cores, chicken bones etc).
- Articles contaminated with body fluids that cannot be washed clean or disposed of in the toilet should be stored for decay.

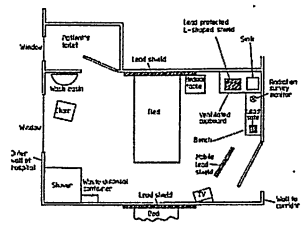
Optimization of Protection in Medical Exposure

The hospitalized patient.

Hospitalized patient

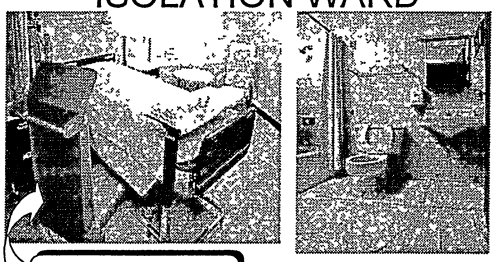
- separate room with toilet and shower
- patient instructions (verbal and written)
- local rules for nursing the patient
- local rules for visitors
- local rules for decontamination
- local rules for emergency situations

Room for iodine therapy (controlled area)



- only one patient in the room
- easily cleanable surfaces and utensils
- extra lead shields
- door closed
- warning sign outside
- restrictions for visitors
- decontamination equipment

ISOLATION WARD



Bed shield is positioned

Areas are covered with plastic backed absorbent material.

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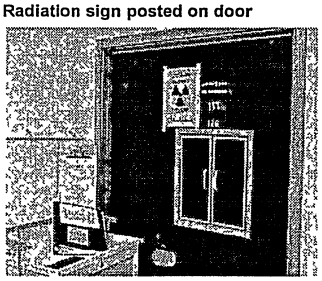
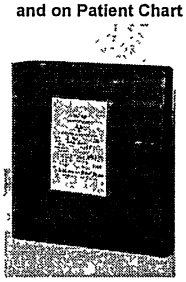
WARNING SIGNS

Radiation sign posted on door

and on Patient Chart





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PATIENT INSTRUCTIONS

- Stay in the room.
- Drink as much as possible.
- Eat lemon slices.
- Use only the private toilet and flush 3 times. (Men should sit down to avoid splashing.)
- Wash hands well in soapy water after using toilet.
- Wear footwear when leaving the bed.
- In event of vomiting or incontinence notify the nurse immediately.

INSTRUCTIONS TO NURSING STAFF

- Reduce time spent with patient by planning ahead and working efficiently.
- Work as far from patient as possible.
- Practice preventative measures against contamination.
  - -wear impermeable protection gloves
  - -wear shoe covers
  - -wear a protective gown
- Remove protection clothing before leaving the room.

VISITORS WARNING CARD

The patient you are about to visit has received a therapeutic dose of radioactive iodine. It is in your own best interest to protect yourself as much as possible from receiving more radiation than is necessary. To assist you in meeting that end we offer the following recommendations:

- Visitors are discouraged for a 48 hour period after the patient receives the treatment.
- Pregnant women and children under the age of 18 are not permitted to visit.
- You should keep your visit short (<30 min).
- Keep a reasonable distance (e.g. 2 m) away from the patient.
- Do not kiss the patient.
- Do not eat, drink or smoke in the patient's room
- Do not touch the toilet or sink in the patient's room

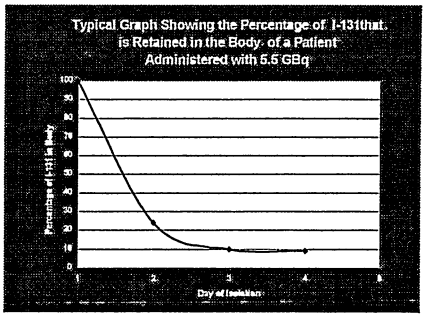
If you have any questions, please ask the nursing staff.

DISCHARGE OF PATIENT

The patient may leave the hospital when his/her radiation level has dropped below the equivalent activity level specified by the Regulatory Authority or the dose constraints specified by the local RPC. E.g. 20uSv/h which corresponds to an activity of about 500 MBq

The patient should be instructed about the general precautions for out-patients

DISCHARGE OF PATIENT



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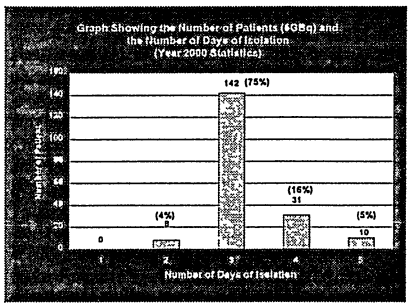
DISCHARGE OF PATIENT



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DECONTAMINATION

The RPO should supervise the removal of contaminated waste, the decontamination of the room and equipment and should make a documented final survey of the room.

Monitoring and decontamination must be done prior to entry of nursing and housekeeping staff to prepare the room for the next patient.

When survey and decontamination procedures are complete, the RPO will remove the radiation warning sign and notify the nursing and housekeeping staff that the room is now clear for general use.

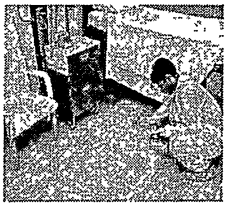


MONITORING

Furniture and telephone sets are surveyed.



Areas suspected to be contaminated are surveyed.



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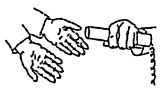
MONITORING

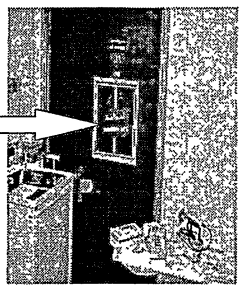
Area or item	Initial (Bq/cm²)	After cleaning (Bq/cm²)
Toilet		
Washroom floor		
Sink and Faucets		
Shower		
Bed		
Armchair		
Bedroom floor		
TV/Telephone		
Bedside table		
Doorknobs		
Lamp switches		

Derived limit: 3 Bq/cm²

METHODS
- wipe testing
- direct surveying



READY FOR A NEW PATIENT



A "Radiation Safe" sign is posted at the door after decontamination and clearing of room

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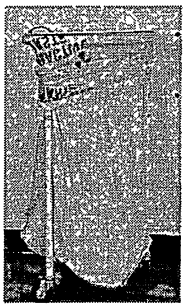
RADIOACTIVE WASTE



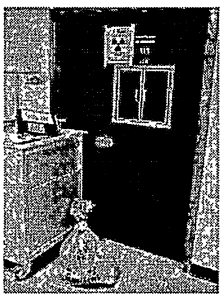
Faeces, urine and other liquids should be disposed of via the toilet.

Contaminated clothing, linen, food items etc which can not go into the toilet should be stored in a separate plastic bag labeled 'RADIOACTIVE', and should be removed daily to the designated radioactive waste storage facility.

Cutlery and dishes should be washed in the patient's room and reused by the patient.

RADIOACTIVE WASTE

All patient radioactive wastes are placed in a plastic bag and the bag is properly tagged.



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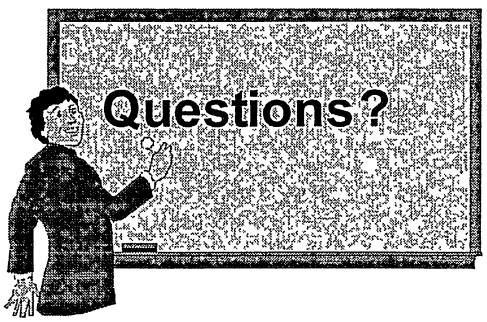

DISCUSSION

1. Who should prescribe a thyroid treatment with I-131?
2. Who should perform the treatment?

