ICTP/IAEA Training Course
on Radiation Protection of Patients,

16-27 September 2013, Trieste, Italy

Radiation Protection Issues in Radionuclide Therapy

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History-Therapy

1936	Therapeutic use of Na-24 (leukemia)	Hamilton et al
1936	Therapeutic use of P-32 (leukemia and polycythemia vera)	Lawrence
1941	Therapeutic use of iodine in hyperthyroidism	Hertz et al
1942	Therapeutic use of iodine in treatment of metastasis from thyroid cancer	
1945	Therapeutic use of Au-198 in treatment of malignant effusion	Muller
1958	Treatment of bone metastasis with P-32	Maxfield
1963	Medical synovectomy using Au-198	Ansell

Properties of some radionuclides used in radionuclide therapy

Radio-nuclide	Half-life	Emission	E_α MeV	$E_{\beta max}$ MeV	E_γ keV
^{32}P	14.3 d	β		1.71	
^{67}Cu	2.58 d	βγ		0.58	185
^{89}Sr	50.5 d	β		1.49	
^{90}Y	2.67 d	β		2.28	
^{125}I	60.0 d	Auger e^-			(X:27)
^{131}I	8.04 d	βγ		0.61	364
^{153}Sm	1.95 d	βγ		0.81	103
^{165}Dy	2.33 d	βγ		1.29	95
^{169}Er	9.5 d	β		0.34	
^{177}Lu	6.71 d	βγ		0.50	208
^{186}Re	3.77 d	βγ		1.08	137
^{188}Re	20.0 h	βγ		2.1	155
^{198}Au	2.7 d	βγ		0.96	411
^{211}At	7.2 d	α	6.8		
^{212}Bi	1.0 h	α	7.8		
^{223}Ra	11.4 d	αβγ	5.8		82, 154, 270

Soren Mattsson, Lund University (Sweden)

Radionuclides

- The selection of the **appropriate radionuclide** depends on its nuclear decay properties, specifically, emission characteristics and physical half-life.
- The treatment of bulky tumors by radionuclides that emit high energy **alpha or beta** particles is the preferred approach;
- however, for the eradication of small clusters of cancer cells or small tumor deposits, radionuclides that emit **Auger electrons** are considered to be beneficial because of their high level of cytotoxicity and short-range biological effectiveness. (*Cancers* **2011**, *3*, 3838-3855)

Radiopharmaceuticals

(*Cancers* **2011**, *3*, 3838-3855)

Radiopharmaceutical	Targeting mechanism	Indications
I-131 as iodide	Thyroid hormone synthesis	Differentiated thyroid carcinomas
I-131 Tositumomab	CD20 Antigen binding	Non-Hodgkin's lymphoma
Y-90 **ZEVALIN**	CD20 Antigen binding	Non-Hodgkin's lymphoma
Y-90 microspheres	Intravascular trapping	Liver metastasis Hepatocellular carcinoma
Sr-89 chloride	Calcium analogue	Bone pain palliation
Sm-153 EDTMP	Chemoadsorption	Bone pain palliation
Y-90 Octreotide	Somatostatin receptor binding	Neuroendocrine tumors
I-131 MIBG	Active transport into neuroendocrine cells and intracellular storage	Neuroblastoma Pheochromacytoma Carcinoid Paraganglioma Medullary thyroid carcinoma

Typical activity and absorbed dose per administration

Substance	Typical adm. activity [MBq]	Tumor dose [Gy]	Critical organ 1 [Gy]	Critical organ 2 [Gy]
^{90}Y-Zevalin®	1000		Kidneys: 2.4	Red marrow: 2.7
^{131}I-Bexxar®	3000		Thyroid: 8.1	Kidneys: 5.9
^{153}Sm- EDTMP	2500		Bone surfaces: 17	Red marrow: 3.8
^{89}Sr - chloride	150		Bone surfaces: 2.6	Red marrow: 1.7
^{177}Lu -octreotate	7400	200	Kidneys: 23	
^{32}P- phosphate	185		Red marrow: 2.0	Bone surfaces: 2.0

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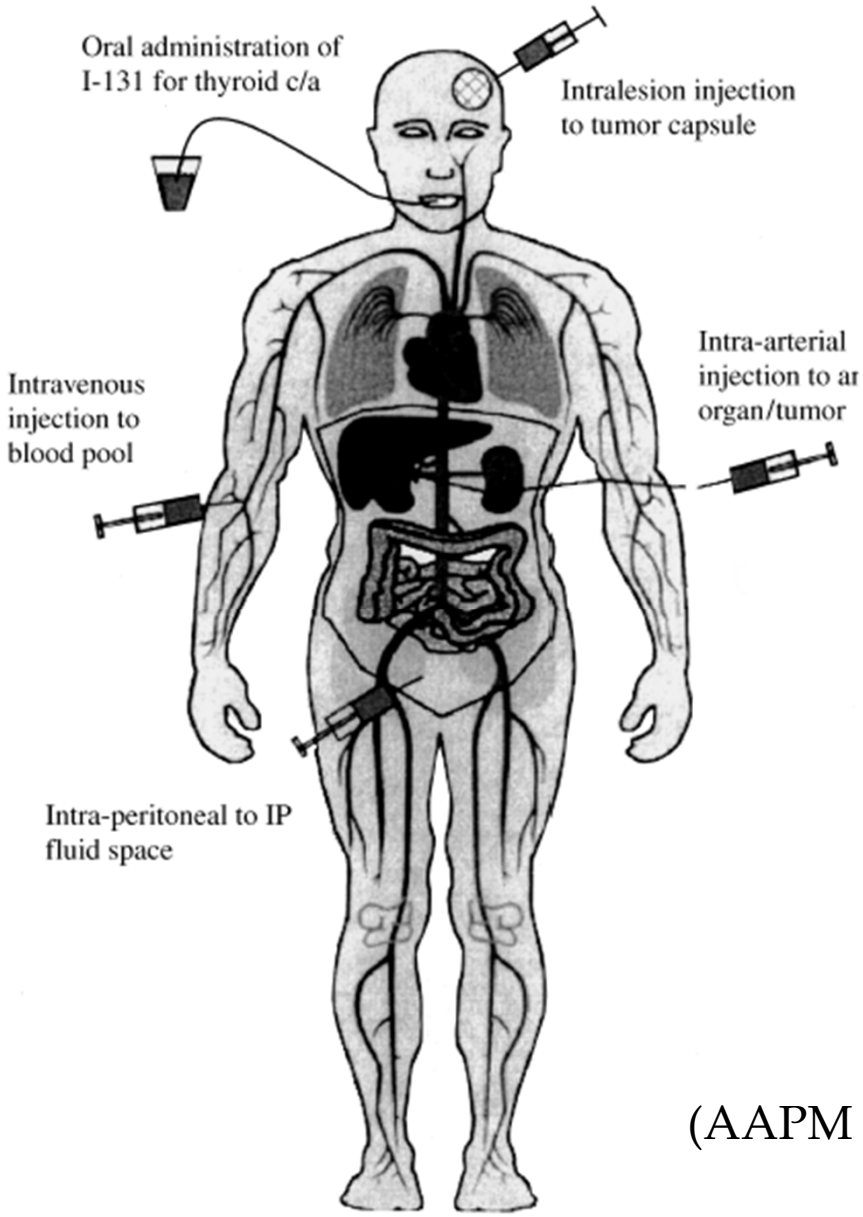
^{131}I-Iodide **5500** **> 80** **thyroid ablation**

^{131}I-MIBG **~ 660 MBq/kg** **pediatric neuroblastoma**

Routes of administration of radiopharmaceuticals to a therapy patient



(AAPM Report 71 (2001)

Annual Numbers of Therapies with Radiopharmaceuticals in all Health-care Levels

(As per UNSCEAR Report 2008)

Number of Patients per million population

Thyroid Malignancy:	1950.1
Hyperthyroidism:	4616.6
Polycythemia vera:	168.1
Bone Metastases:	316.5
Synovitis:	380.6
Others:	120.5
Total	**7552.4**

General Considerations
Dosimetry (BSS: Interim Edition)

"3.167. Registrants and licensees shall ensure that dosimetry of patients is performed and documented by or under the supervision of a medical physicist, using calibrated dosimeters and following internationally accepted or nationally accepted protocols, including dosimetry to determine the following:

- .....
- (c) For therapeutic medical exposures, absorbed doses to the tissues or organs **for individual patients**, as determined to be relevant by the radiological medical practitioner."

Need for action wrt patients

- Dose planning before therapy. No therapy without dose planning!
- Individual patient biokinetics
- Individual dose calculations
- Dose distributions within organs and tissues
- Same protocol for different hospitals and clinics for measurements of biokinetic data and for dosimetry
- A formalism for the addition of doses from nuclear medicine therapy, external radiation therapy and brachytherapy for patients receiving various treatments (Biologically Effective Dose, BED)

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**

Activity (MBq)=

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

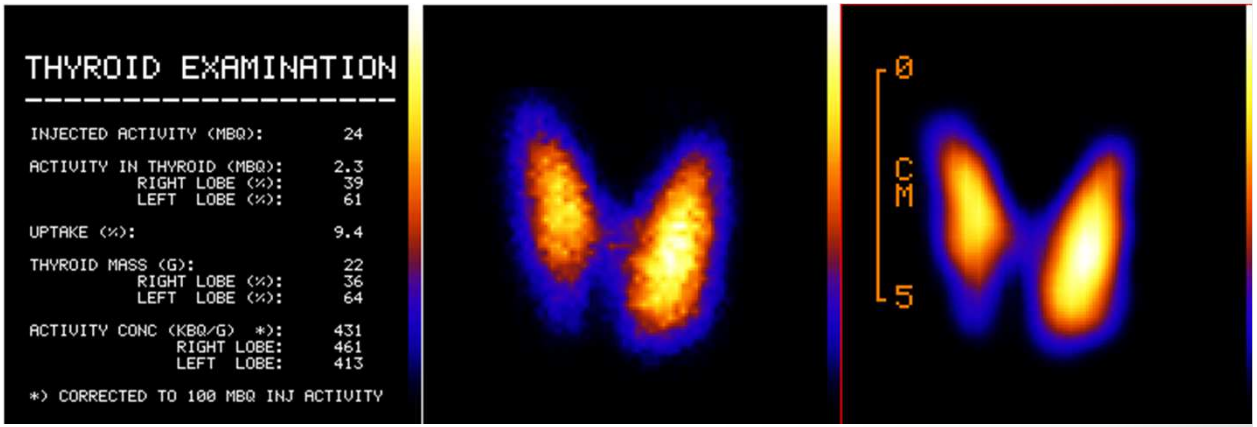
Berg GEB et al, J Nucl Med 1996; 37:228-232

Thyroid Cancer Therapy with Iodine-131

Acquisition of Paharmacokinetic Patient Data

Uptake Measurement

Gamma Camera Examination

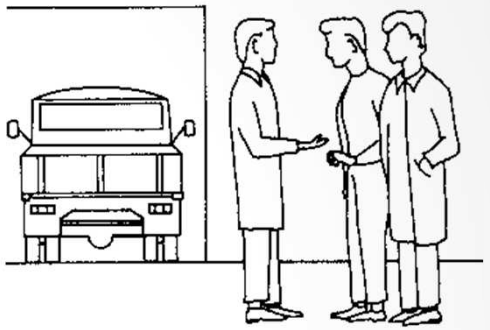


Used to determine the size of the organ

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
- The radioactive patient and dose constraints
- The hospitalized patient
  - •instructions to nursing staff
  - •personal monitoring
  - •discharge of the patient
  - •contamination survey
  - •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 un- authorized 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

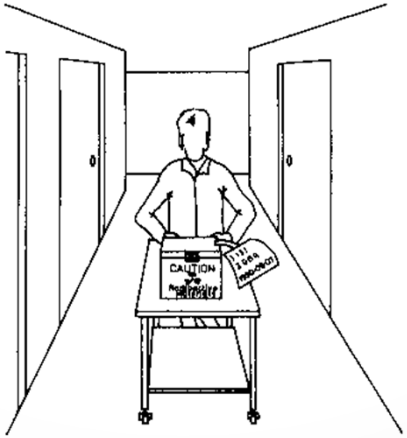
- Protective clothing
- Lead shields (bench top shield, vial shield, syringe shield)
- Keep the vial in the fume hood and on a tray with lips, lined with plastic backed absorbent pads.
- Handle the vial with forceps or similar long handled instruments.
- Cover the vial with lead after use.
- Check the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



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?
- Verbal and written **individual** instructions to the patient.

Need for action with regard to patients (II): Women of fertile ages (15-55 years)

1. Careful check of pregnancy

2. Careful check of breast feeding

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Foetal thyroid

Warning! Radioactive iodine. Especially therapy!

Radioiodine administered to a woman, after 10-13 wk post-conception → the fetal thyroid concentrates the iodine which crosses the placenta.

Doses to the fetal thyroid per activity administered to the mother (mGy/MBq) Watson EE, 1992				
Gestational Age (mo)	I-123	I-124	I-125	I-131
3	2.7	24	290	230
4	2.6	27	240	260
5	6.4	76	280	580
6	6.4	100	210	550
7	4.1	96	160	390
8	4.0	110	150	350
9	2.9	99	120	270

Treatment of thyroid cancer

3700 MBq at18 weeks

Recognised after 25 days

Foetus: Whole body dose: 700 mGy

Thyroid dose: 300 Gy

Berg G et al., Acta Oncol 47, 145-149, 2008

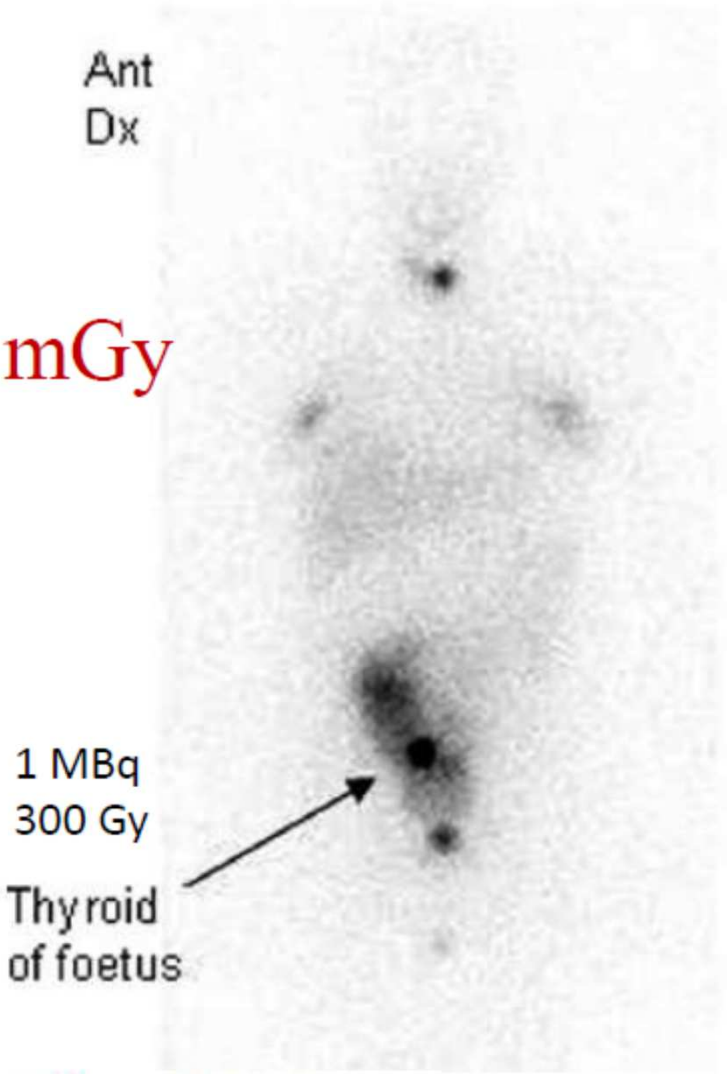


Figure 1. Gamma camera examination 6 days after administration of 3 700 MBq 131-I in Case 2. Note small uptake in the thyroid bed, uptake in mammary glands, and uptake in the fetal thyroid and fetal body/amniotic fluid.

Pregnancy (BSS: Interim Edition)

- "3.175. Registrants and licensees shall ensure that there are **procedures in place for ascertaining the pregnancy status** of a female patient of reproductive capacity before the performance of any radiological procedure that could result in a significant dose to the embryo or fetus, so that this information can be considered in the **justification** for the radiological procedure (para. 3.154 and 3.156) and in the **optimization of protection** and safety (para. 3.165)."

Radioiodine Therapy and Pregnancy

•As a rule, a pregnant woman should not be treated with a radioactive substance unless the therapy is required to save her life: in that extremely rare event, the potential absorbed dose and risk to the fetus should be estimated and conveyed to the patient and the referring physician. Considerations may include terminating the pregnancy.

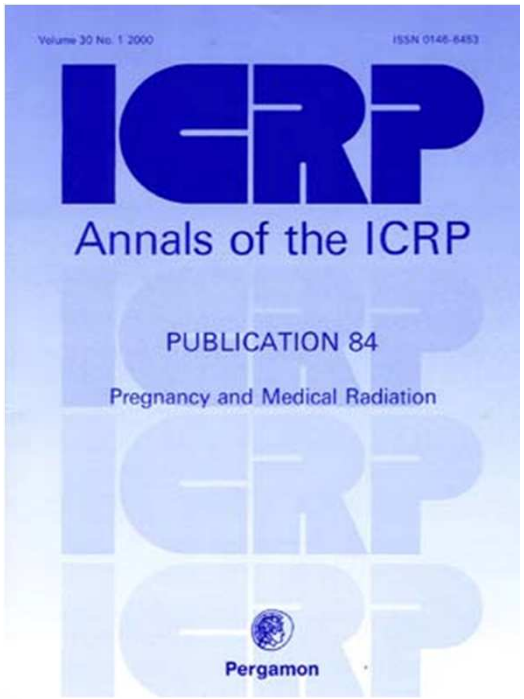
•Thyroid cancers are relatively unaggressive compared to most cancers. As a result both surgical and radioiodine treatment are often delayed until after pregnancy. In general, if any therapy is to be performed in pregnancy, it will be surgery during the 2nd or 3rd trimester.

Inadvertent Administration of Therapy Dose

- **Menstrual history is often not adequate to ensure that a patient is not pregnant. In most developed countries, it is common practice to obtain a pregnancy test prior to high-dose 131 I scanning or therapy for women of childbearing age unless there is a clear history of prior tubal ligation or hysterectomy precluding pregnancy.**
- **In spite of the above, it still happens that pregnant women are treated, either because of false histories or because the pregnancy is at such an early stage that the pregnancy test is not yet positive.**

Becoming Pregnant after Irradiation

ICRP has recommended that a woman not become pregnant until the potential fetal dose from remaining radionuclides is less than 1 mGy.



Pregnancy after Therapy

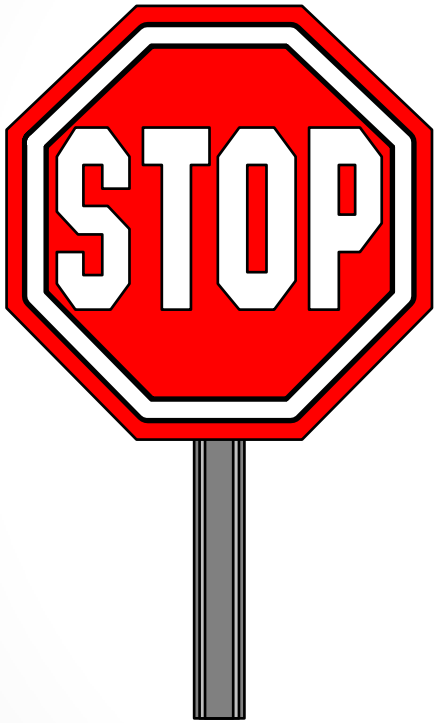
Radiopharmaceutical	All activities up to (MBq)	Avoid pregnancy (months)
Au-198 colloid	10000	2
I-131 iodide (thyroid ca)	5000	4
I-131 iodide (thyrotoxicosis)	800	4
I-131 MIBG	5000	4
P-32 phosphate	200	3
Sr-89 chloride	150	24
Y-90 colloid (arthritic joints)	400	0
Y-90 colloid (malignancy)	4000	1

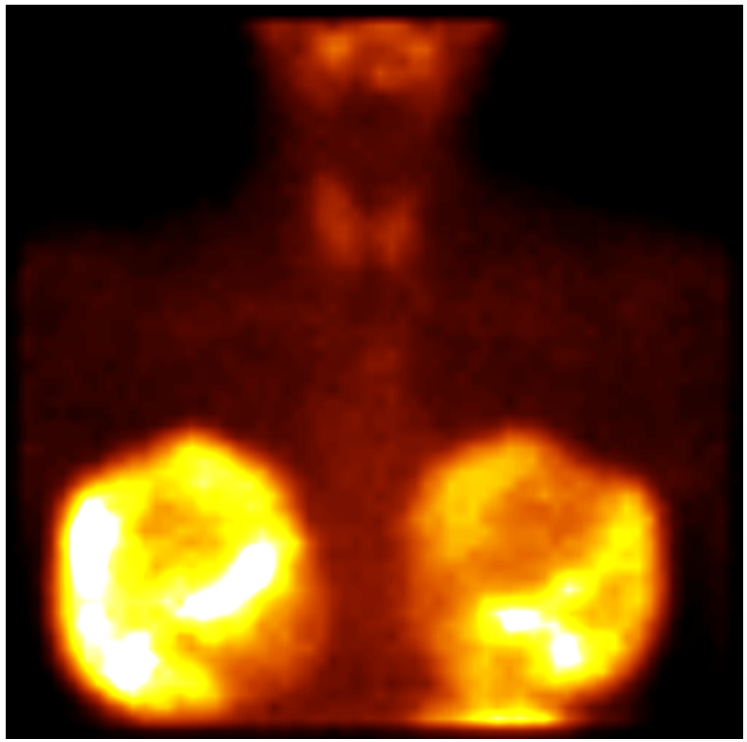
Breast Feeding (BSS: Interim Edition)

- "3.176. Registrants and licensees shall ensure that there are arrangements in place for establishing that a female patient is **not breast-feeding** before the performance of any radiological procedure involving the administration of a radiopharmaceutical that could result in a significant dose to an infant being breast-fed, so that this information can be considered in the j**ustification** for the radiological procedure (para. 3.154 and 3.156) and in the **optimization** of protection and safety (para. 3.165)."

Breast Feeding

Stabin MG and Breitz HB, 2000. *Breast Milk Excretion of Radiopharmaceuticals: Mechanisms, Findings and Radiation Dosimetry*. J Nucl Med; 41:863-873.





Uptake of pertechnetate in the breast of a lactating women scheduled for a thyroid scan. The activity in the breasts is about 50% of the administered. The thyroid has an uptake of 1-2%.

Administration of Therapy: Calibration of Sources (BSS)

"3.166. In accordance with para. 3.153(d) and (e), the medical physicist shall ensure that:

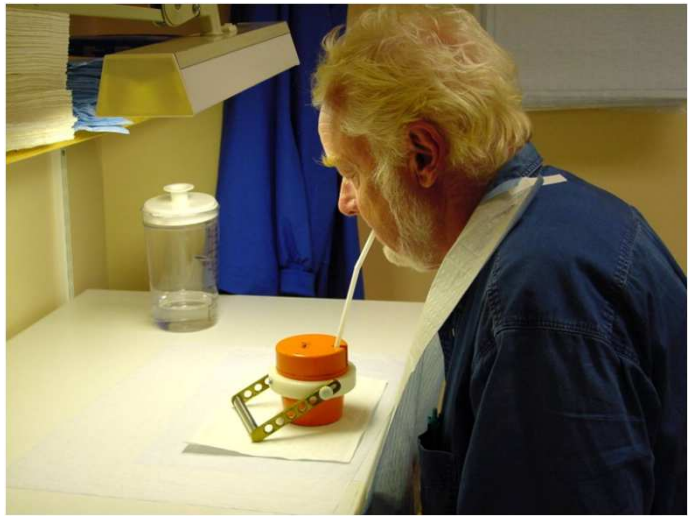
- (a) All sources giving rise to medical exposure are calibrated in terms of appropriate quantities using internationally accepted or nationally accepted protocols;

3.164. For therapeutic radiological procedures in which radiopharmaceuticals are administered, the radiological medical practitioner, in cooperation with the medical physicist and the medical radiation technologist, and if appropriate with the radiopharmacist or radiochemist, shall ensure that for each patient the appropriate radiopharmaceutical with the appropriate activity is selected and administered so that the radioactivity is primarily localized in the organ(s) of interest, while the radioactivity in the rest of the body is kept as low as reasonably achievable."

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.

Safe Administration

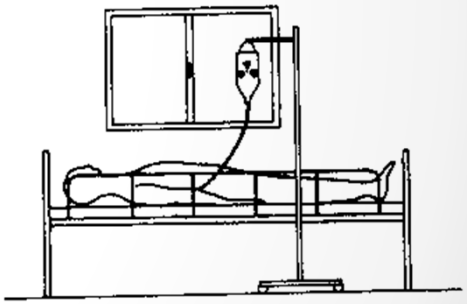


- I-131 administered in an oral solution (50 ml) should be sucked up through a straw from the shielded vial by the patient.
- The vial should be flushed with water several times.
- The patient should drink several glasses of water to clean the mouth.

Safe Administration

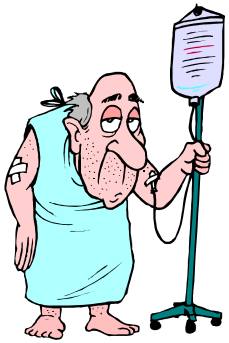
- **The prolonged infusion time and requirements for patient monitoring create a significant radiation hazard for staff.**
- **Local shielding will often be required to limit irradiation of the staff.**
- **Automatic methods of administration (e.g. a syringe pump) and remote patient monitoring devices should be used to minimise the time the staff need to spend in close proximity to the patient.**

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

Shall the Patient be Hospitalized?

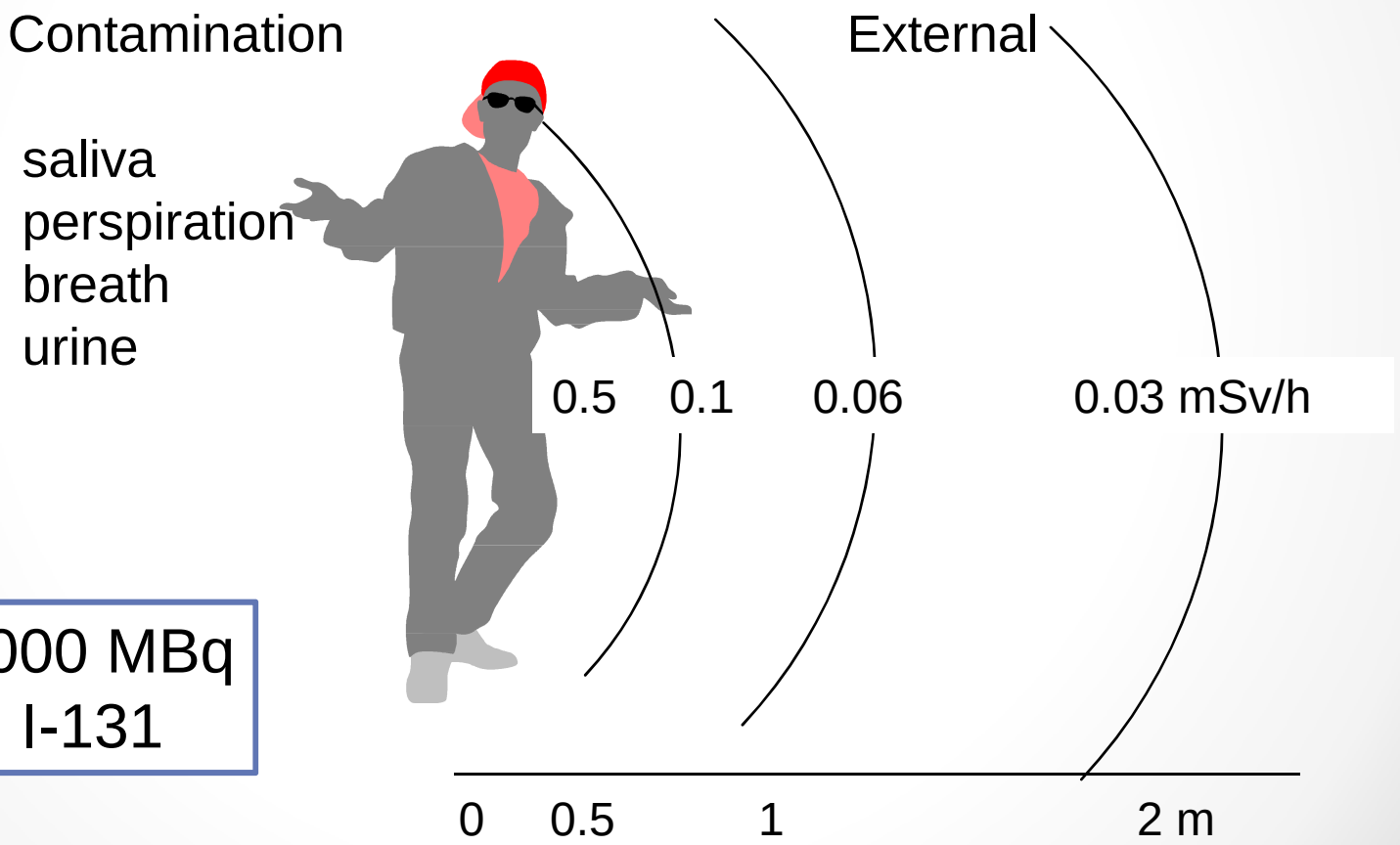


Can the patient leave?
Any restrictions?

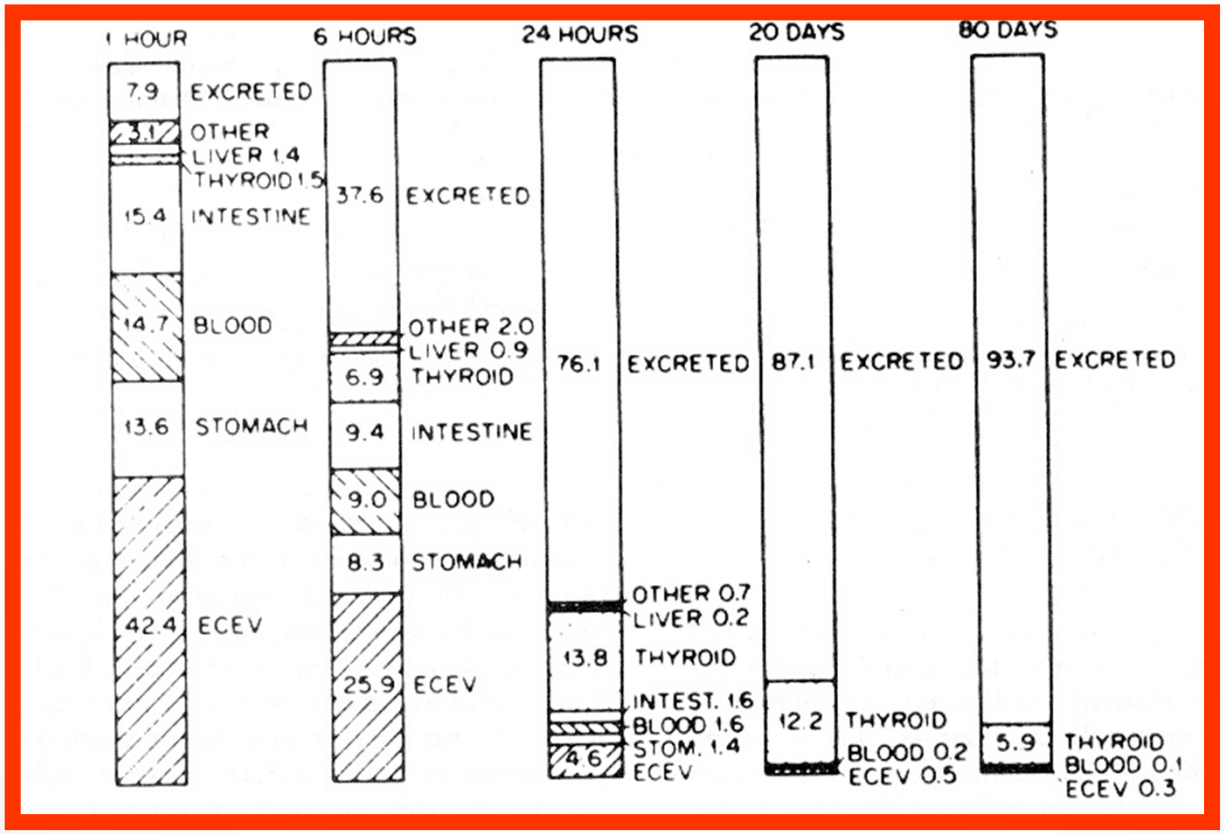
Dose Constraints (BSS: Interim Edition)

"3.172. Registrants and licensees shall ensure that relevant dose constraints (para. 3.148(a)(i)) are used in the optimization of protection and safety in any procedure in which an individual acts as a carer or comforter."

Exposures From Patient



Biodistribution of I-131



(MIRD)

Contamination

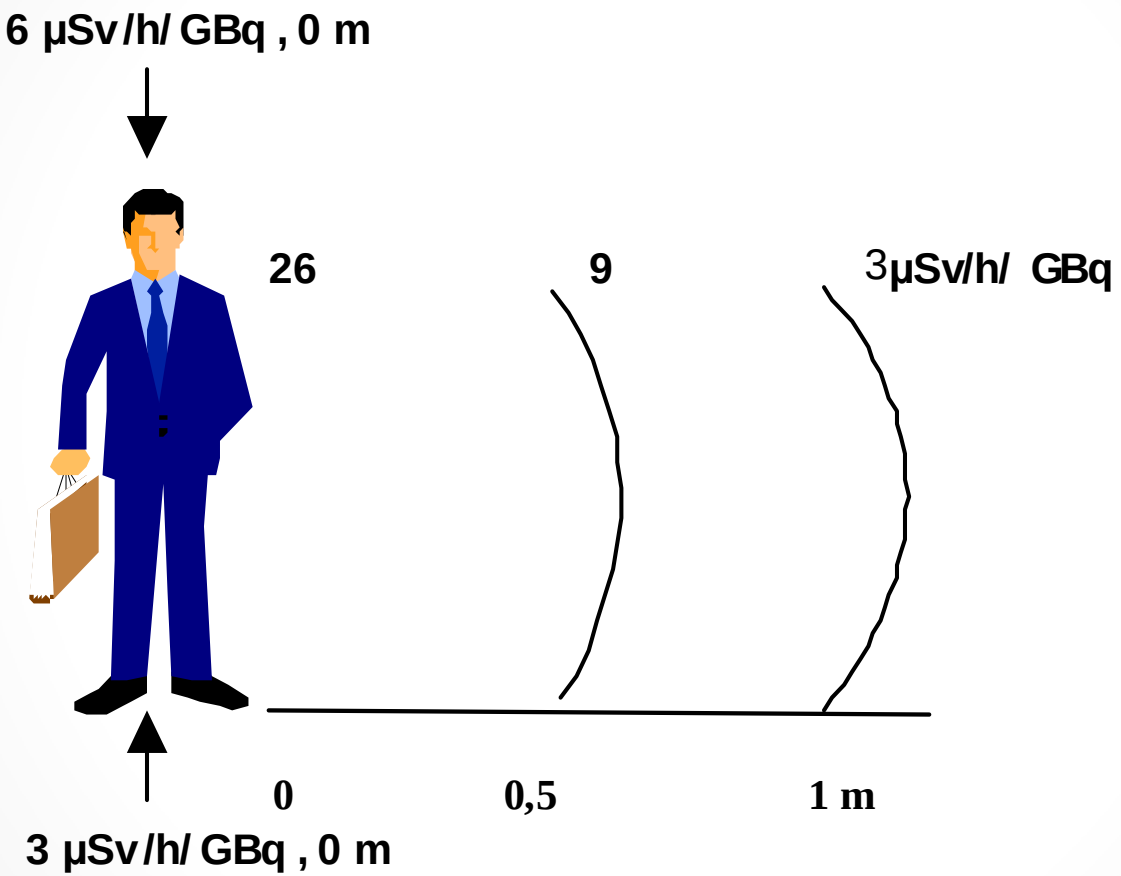
Administered activity: 1000 MBq I-131

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

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

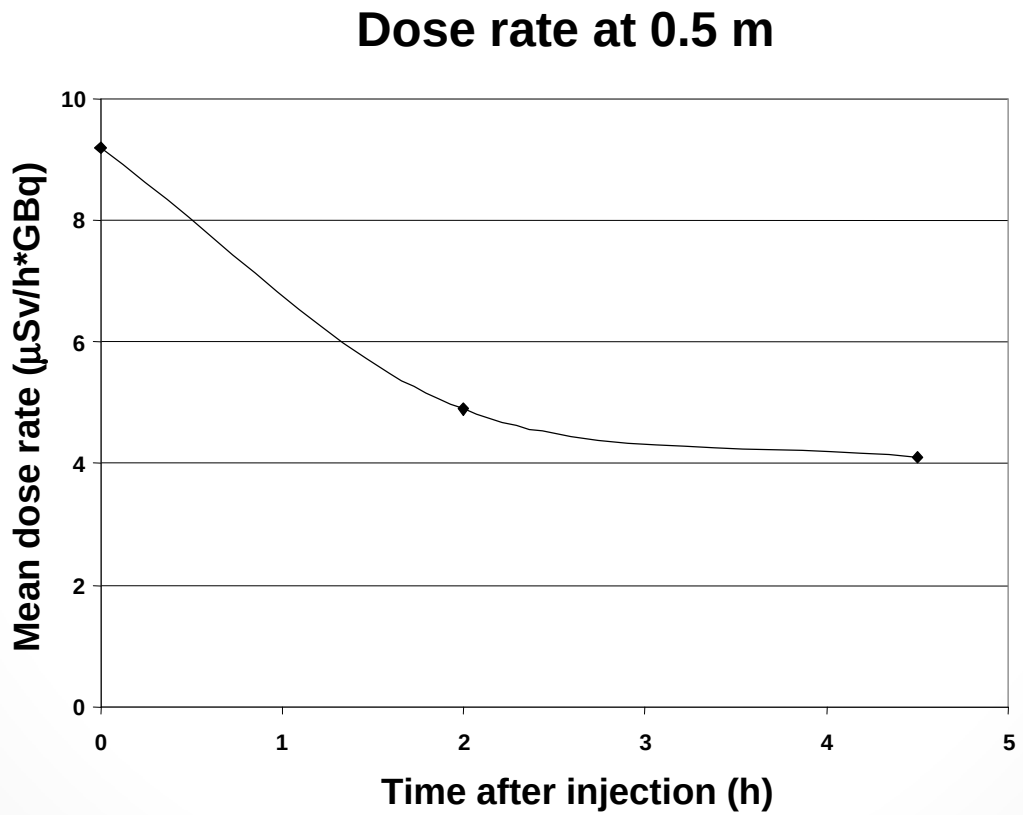
Exposures from Patient

Sm-153



Activity concentration in urine: 0.3 MBq/ml/GBq

External Exposure from Patient Sm-153



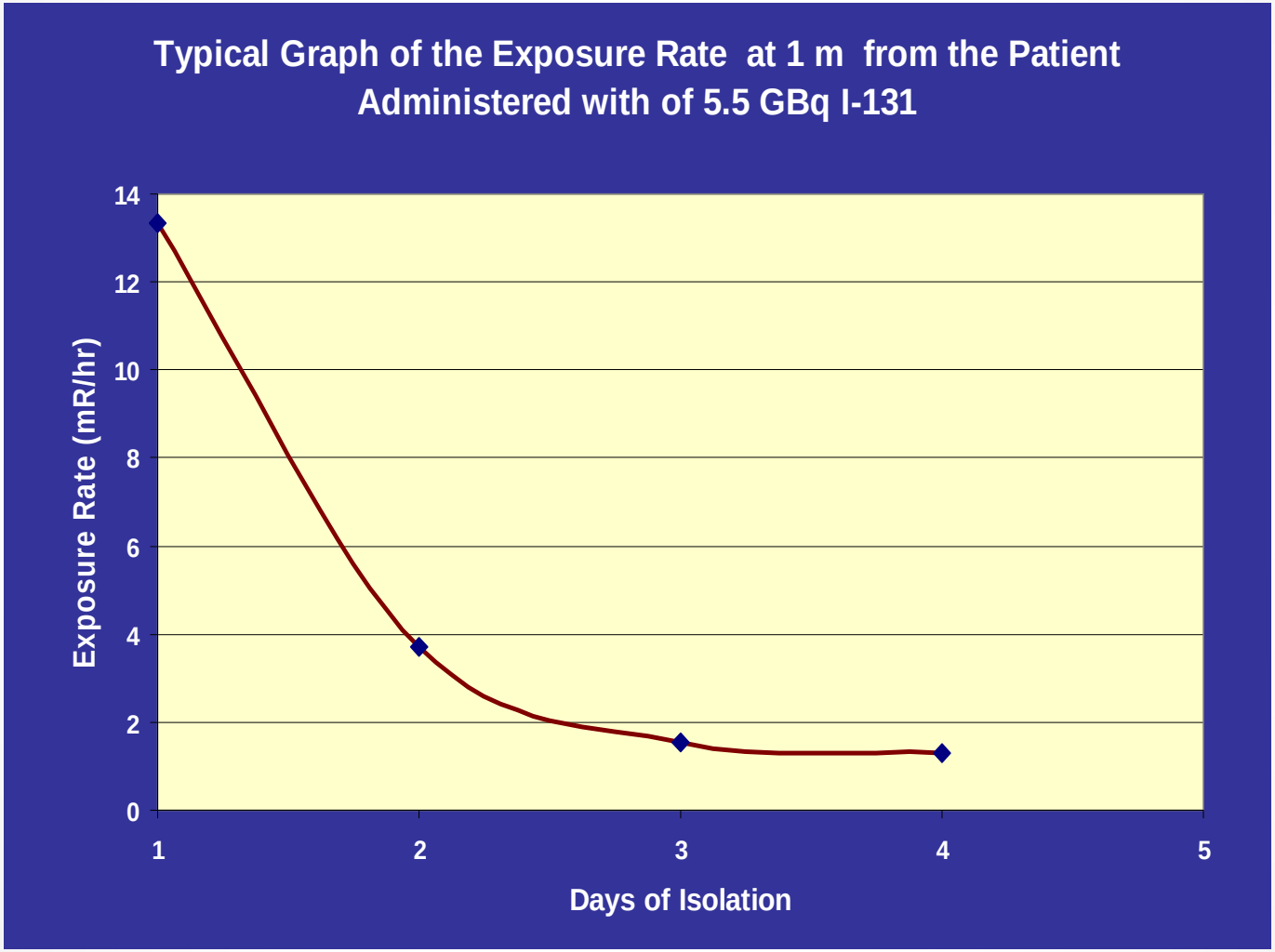
I-131 Therapy Patient

For hyperthyroidism treatment, 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

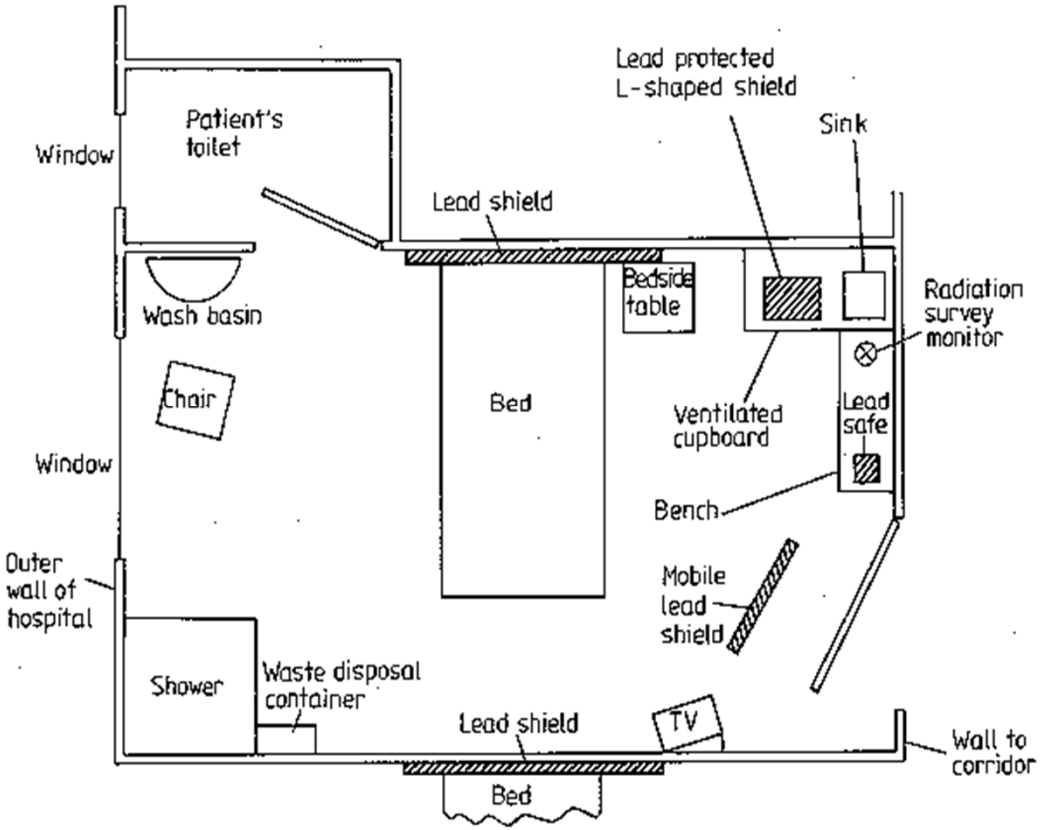


Abdalla Al-Haj

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 body fluid samples
- 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

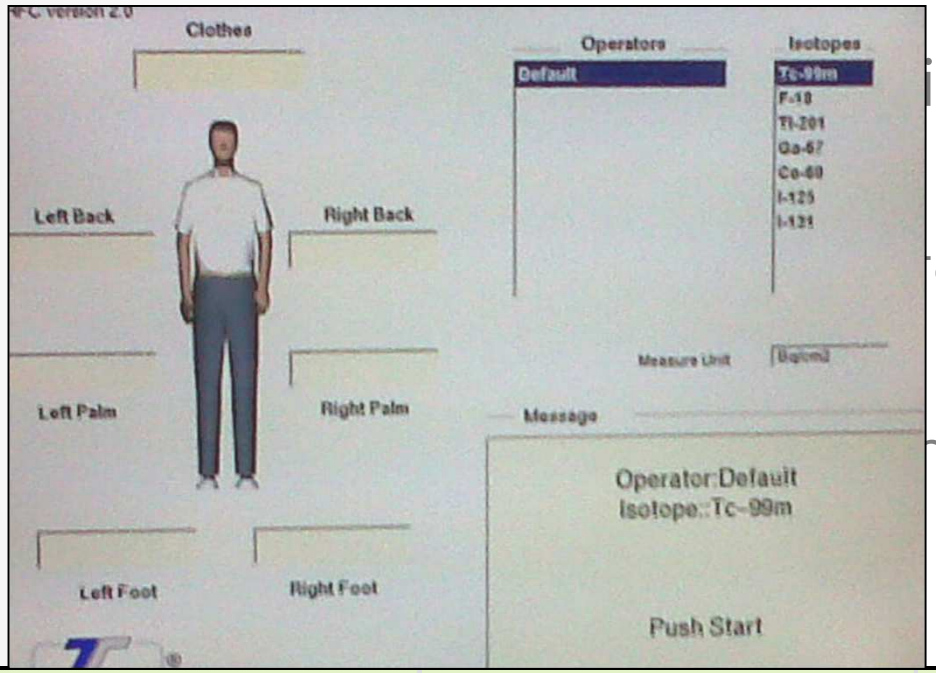
- Consistent with patient safety and good quality medical care, r**educe time** spent with patient by planning ahead and working efficiently.
- Work **as far** from patient as possible.
- Practice preventative measures **against contamination**.

  -wear impermeable protection gloves

  -wear shoe covers

  -wear a protective gown
- Remove **protection clothing** before leaving the room.
- At exit, check personal contamination with **hand-foot-clothing monitor**.

Monitoring of Staff Internal Contamination

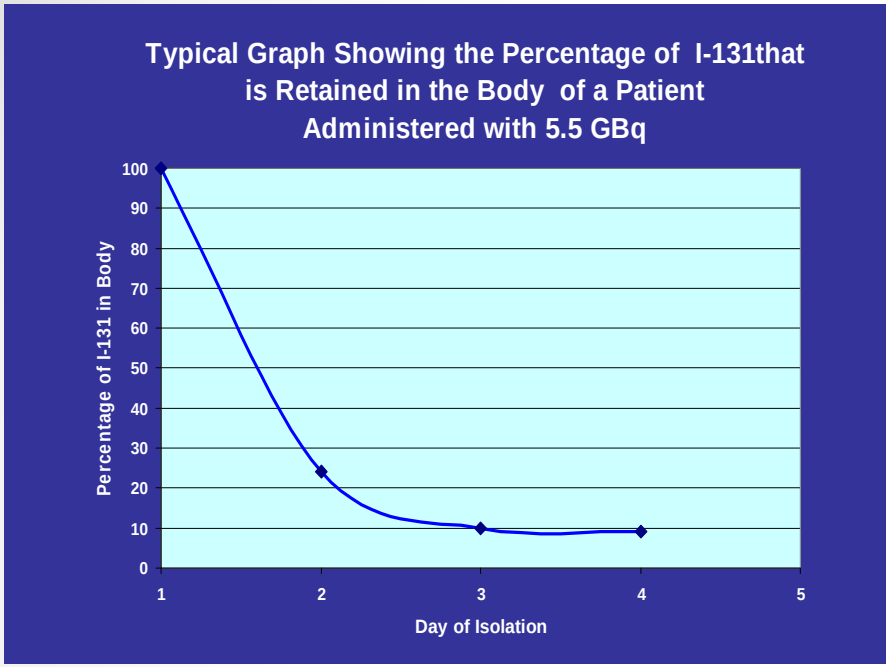


- ination
-
- opes
-
- nd alarms

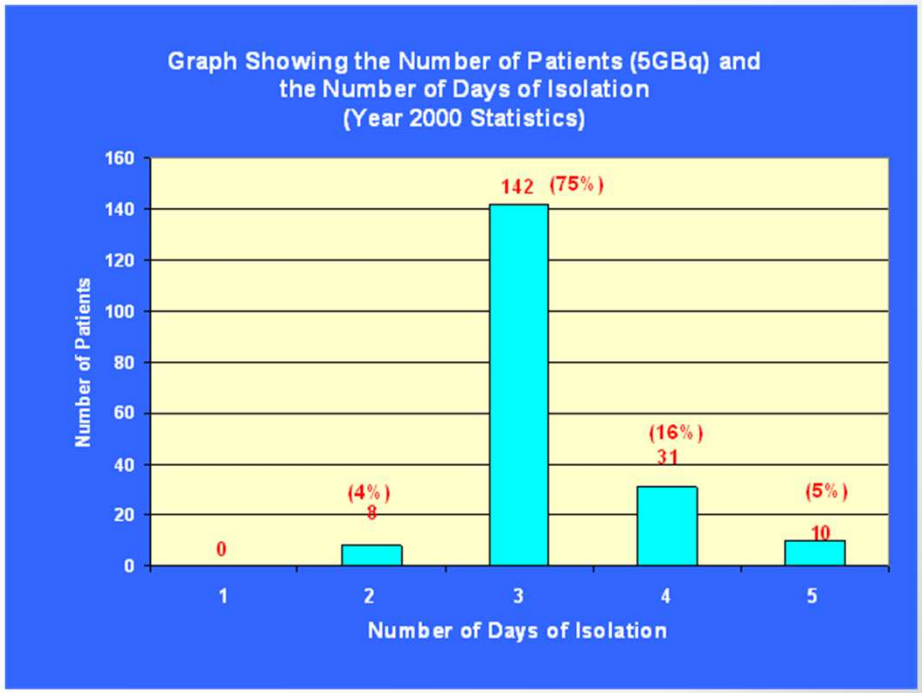
Background		Calibration		Threshold
		Bq/cm2/cps		
9 - 10 cps		0,74		100 cps

- Radiation Protection in Radionuclide Therapy

Discharge of Patient



Abdalla Al-Haj



Decontamination of a general use room

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.

Ready for a New Patient

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

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Contamination Monitoring

Furniture and telephone sets are surveyed.

I-131 Derived Limit: 3 Bq/cm^2

Areas suspected to be contaminated are surveyed.

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- Assay of removable contamination on potentially contaminated surfaces shall be performed at regular intervals and whenever contamination is suspected, using a **«wipe test».**
- Results shall be recorded and maintained for periods established by regulatory authorities.

Nursing Instructions for Handling Laboratory Specimens Taken from Patients Receiving Radionuclide Therapy

1. Any lab specimen taken from a patient receiving radionuclide therapy must first be labeled with the appropriate patient identification. In addition to that a radiation warning label must also be attached to the specimen container and to the lab requisition. A copy of the lab instructions must also be attached to the requisition. Finally, the specimen container must be placed in a zip-lock type plastic bag for transport to the laboratory. CALL THE RECEIVING LABORATORY TO ALERT THEM THAT A RADIOACTIVE SPECIMEN IS COMING. A RUNNER MUST TAKE THE SPECIMEN DIRECTLY TO THE LABORATORY.

2. Radiation warning labels, lab instructions, and zip-lock bags may be found in the LAB KIT placed in the patient's room by the technologist handling the therapy dose administration. THIS KIT MUST STAY IN THE PATIENT'S ROOM AT ALL TIMES!!!!

http://pbadupws.nrc.gov/docs/ML1101/ML110110130.pdf

Radioactive Waste

- **Solid waste.**
  Cover papers, gloves, empty vials and syringes.
  Items used by hospitalized patients after radionuclide therapy.

- **Liquid waste**.
  Patient excreta.

- **Gaseous waste**.
  Exhausted gas from treated patients

Radioactive Waste

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

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.
- Disposable cutlery and dishes should be used. If not, they 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.

Storage of radioactive waste

A room for interim storage of radioactive waste should be available. The room should be locked, properly marked and if necessary ventilated.

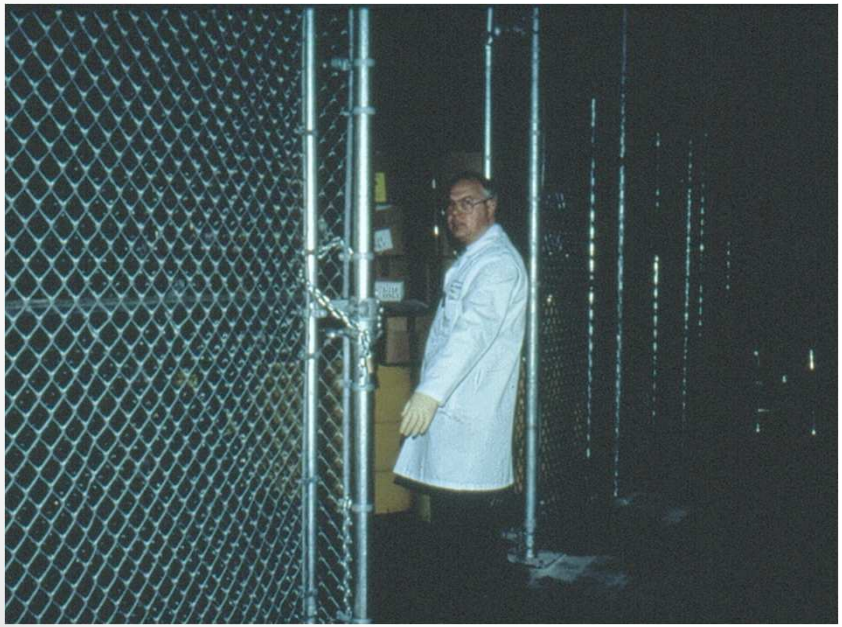
Each type of waste should be kept in separate containers properly labeled to supply information about the radionuclide, activity concentration etc. Flammable goods should be kept apart.

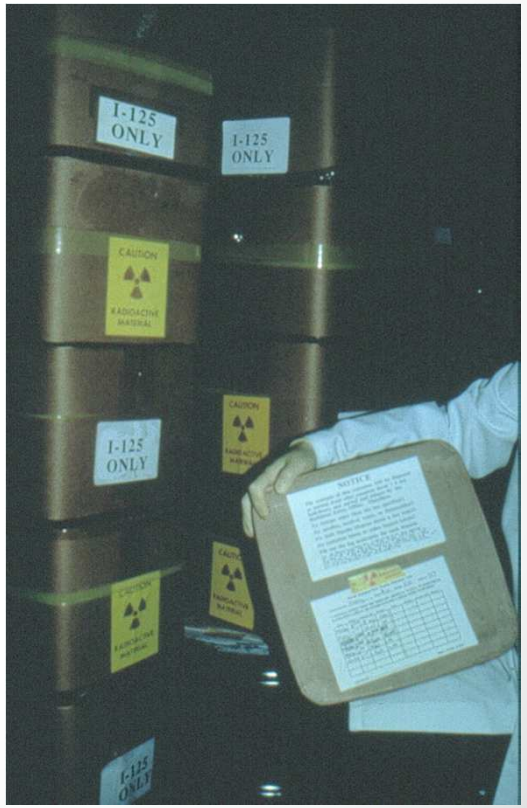
Records should be kept where the origin of the waste can identified.

Short-lived radionuclides such as I-131, Sm-153, Sr-89 etc. should, after segregation, be stored for decay during a period of time established locally by the RPO, taking into account all applicable national regulations.

Storage of radioactive waste

- Patient wastes generated from radionuclide therapies may need to be stored for decay for periods from 1 week to several months depending on the activity and radionuclide used.
- Wastes should be stored until a survey indicates that only background levels of activity are present.





PATIENT EXCRETA

Therapy patients

Different policies in different countries:

- Use separate toilets equipped with delay tanks or an active treatment system, or
- Allow the excreta to be released directly into the sewer system.

The Regulatory Authority should define the principles taking the environmental impact into consideration

I-131 LIQUID DISCHARGES in University Hospital in Udine (Italy)

- ~100 pts/year
- ~ 5.55 GBq/pt

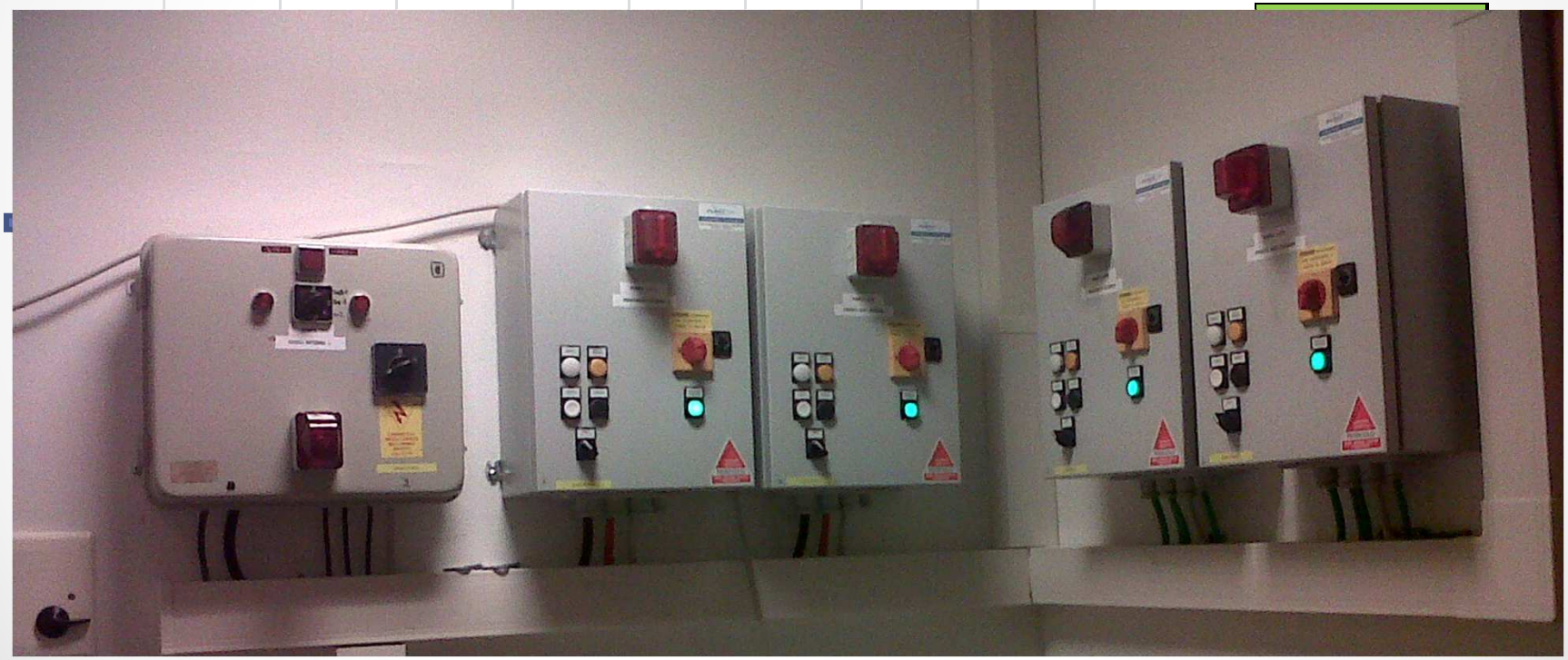
- Annual limit of discharge: 70 MBq (~ 0.01 % of administered activity)

- Limit for discharge into public sewage: 1 Bq/l

I-131 LIQUID DISCHARGE

Sewer system for decay storage
in University Hospital in Udine (Italy)

15 m3



Staff Monitoring: External monitoring

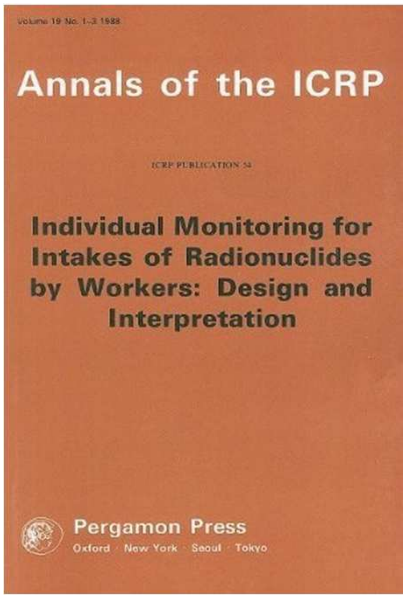
- Personal monitoring for external exposure shall be performed for all occupationally-exposed individuals, according to RSO classification.

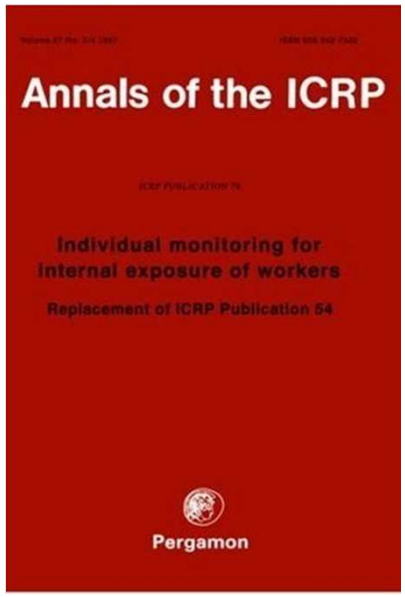
- Extremity dosimeters shall be worn when an individual's extremities are expected to be closer to the source than the body.

Monitoring of Staff Internal Contamination

- Bioassay is used to determine the activity present in an individual.
- The optimal type of bioassay procedure to use depends on:
  - Chemical and physical form of the radioactive material
  - Radiation emissions; Mode of intake
  - Biodistribution and half-lives in the body.
- By application of appropriate biological models, bioassay measurements are converted to body or organ activity burdens and, finally, to absorbed doses.
- Personnel who prepare or administer therapeutic amounts of radioiodine should be monitored due to the volatilization and inhalation of the radioiodine as a gas
- Thyroid burden should be measured with a thyroid uptake probe within 1-3 days after the administration.

Monitoring of Staff Internal Contamination





- Routine Monitoring and Special Monitoring after accidental contamination.
- Procedures for bioassay and estimates of doses should be a part of the institution's policy and procedure manual.

Monitoring of Staff Internal Contamination

Iodine-131 (half-life = 8.0 d)

Table A.6.15. Emissions

Radiation	Energy (MeV)	Intensity (%)	
β^-	0.19[a]	89	
γ		0.36	81

[a]Average energy

Table A.6.16. Measurement techniques

Method of measurement		Typical detection limit
γ-ray spectrometry *in vivo*	Thyroid	100 Bq
γ-ray spectrometry on biological samples	Urine	1 Bq l^{-1}

I-131 Special Monitoring

- Monitoring carried out in actual or suspected abnormal conditions.
- Necessary to know the time of possible intake.

Iodine-131 presents no detection problems. The urinary excretion rate decreases rapidly with time following intake and so thyroid monitoring is to be preferred unless the actual time of intake is known. Monitoring by urinary excretion would be required if thyroid uptake had been blocked.

ICRP 78 Table A.6.17. Special monitoring: predicted values (Bq per Bq intake) for inhalation of ^{131}I

	Type F		Vapour	
Time after intake (d)	Thyroid	Daily urinary excretion	Thyroid	Daily urinary excretion
1	1.2E–01	2.8E–01	2.3E–01	5.3E–01
2	1.2E–01	2.3E–02	2.2E–01	4.3E–02
3	1.1E–01	1.4E–03	2.0E–01	2.5E–03
4	9.9E–02	1.5E–04	1.9E–01	2.7E–04
5	9.0E–02	8.9E–05	1.7E–01	1.7E–04
6	8.2E–02	9.6E–05	1.5E–01	1.8E–04
7	7.4E–02	1.0E–04	1.4E–01	1.9E–04
8	6.8E–02	1.1E–04	1.3E–01	2.0E–04
9	6.2E–02	1.1E–04	1.2E–01	2.1E–04
10	5.6E–02	1.1E–04	1.1E–01	2.1E–04

I-131 Routine Monitoring

- Routine monitoring involves regular measurements on individual workers.
- It is only required in conditions of essentially continuous risk of contamination of the workplace as a result of normal operations.
- Necessary to assume a pattern of intake in order to interpret the measurements, usually at the mid-point of the monitoring interval.

ICRP 78 INDIVIDUAL MONITORING FOR INTERNAL EXPOSURE OF WORKERS

Table A.6.19. Routine monitoring: predicted values (Bq per Bq intake) for inhalation of ^{131}I

	Type F		Vapour	
Monitoring interval (d)	Thyroid	Daily urinary excretion	Thyroid	Daily urinary excretion
30	(3.5E–02)[a]	9.8E–05	(6.6E–02)	1.8E–04
14	7.4E–02	1.0E–04	1.4E–01	1.9E–04
7	9.9E–02	1.5E–04	1.9E–01	2.7E–04

[a]Values in brackets do not satisfy the requirements set out in Section 6

Emergencies

Safety Assessment Contingency Plan

A safety assessment will reveal the possible situations where emergency actions have to be taken:

- Loss or damage of radioactive material
- Spillage of radioactive material
- Fire
- Medical emergencies
- ...

A detailed contingency plan covering actions to be taken in any foreseeable accident should be available.

Cardiac or Respiratory Arrest

- Lifesaving efforts shall take precedence over consideration of radiation exposure received by medical personnel.
- These procedures may result in contamination of the hands, gloves and clothing of involved medical personnel.
- Decontamination of these personnel and of the location where the medical emergency has taken place should be undertaken by radiation safety staff once the medical emergency has been resolved.

NCRP Report n. 155

Emergency surgery

- Consideration of radiation exposure should not deter the surgery from proceeding.
- If possible, **consult the RSO**. If not possible, and the situation is life-threatening, the surgery should proceed and the necessary information should be conveyed to the surgical team a.s.a.p.
- Standard precautions always used in surgical settings will minimize the spread of radioactive contamination and the risk of internal contamination to OR personnel.
- Tools and other equipment from the surgery should be monitored and decontaminated as necessary, or stored for decay or reated as radioactive waste.

NCRP Report n. 155

Patient on Dialysis

- These pts will not clear radioactive materials as quickly as other pts, and the clearance will generally not take place until the patient undergoes a dialysis session.
- So the administered activity should be based on a trial administration, to observe the elimination rate.
- The largest amount of activity will usually be eliminated during the 1st dialysis session.
- Before, consult the RSO to assess the radiation exposures likely to be received by medical personnel.
- The materials, tubing, filters and waste containers used in the dialysis session should be checked and stored for decay.
- The volume of fluids used during dialysis should be sufficient to dilute the radioactive concentration below regulatory limits for sewer discharge.

NCRP Report n. 155

Death of Patient

In the event of death of a patient who has recently received a therapeutic dose of a radionuclide, care has to be taken to ensure that personnel receive as low a dose as possible at all stages prior to the burial or cremation.

Table 10: Maximum activities proposed for autopsy, embalming, burial or cremation of the body of a patient who has died during treatment with unsealed radioactive substances (IAEA 2007)

	Half life (days)	Indicative maximum activity administered (MBq)	Autopsy/ Embalming (MBq)	Burial (MBq)	Cremation (MBq)
^{32}P	14.3	200	100	2 000	30
^{89}Sr	50.7	200	50	2 000	20
^{90}Y	2.7	2 000	200	2 000	70
^{131}I	8.0	10 000	10	400	400

Note: Samarium-153, an alternative to strontium-89 for the palliation of malignant bone disease, is not included in Table 10 as the short half life of 1.95 days allows significant reduction in residual activity after a few days delay.

Death of Patient

Precautions that should be given are depending on the residual activity and the expert advice provided by the RPO and may involve the following:

- preparation for burial or cremation should be controlled by a competent person,
- relatives should be prevented from coming into close contact with the body,
- people should not be allowed to linger in the presence of the coffin,
- all personnel involved in handling the corpse should be instructed by the RPO and monitored if appropriate,
- all objects, clothes, documents etc that might have been in contact with the deceased must be tested for contamination,
- it may be expedient to wrap the cadaver in waterproof material immediately after death to prevent spread of contaminated body fluids,
- embalming of cadavers should, if possible, be avoided,
- autopsy of highly radioactive cadavers should be restricted to the absolute minimum

Thank you for listening !