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

Potential and Accidental Medical Exposure in Nuclear Medicine



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OBJECTIVE

To be able to identify hazardous situations which can result in accidental exposure and to take the necessary corrective actions. Case studies on accidental exposures and lessons learned.



Content

- Potential exposure, safety assessment
- Accident prevention, lessons learned



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Potential Exposure Accidental Medical Exposure



Potential exposure.
Safety assessment

Potential exposure

Exposures that may or may not be delivered and to which a probability of occurrence can be assigned.

(BSS)

Safety culture

The assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance.

(BSS)

SAFETY ASSESSMENT

The licensee shall conduct a safety assessment applied to all stages of the design and operation of the nuclear medicine facility, and present the report to the Regulatory Authority if required. The safety assessment shall include, as appropriate, a systematic critical review of identification of possible events leading to accidental exposure (BSS IV.3–7).

SAFETY ASSESSMENT

A review of the aspects of design and operation of a source which are relevant to the protection of persons or the safety of the source, including the analysis of the provisions for safety and protection established in the design and operation of the source and the analysis of risks associated with normal conditions and accident situations .

SAFETY ASSESSMENT

Patient

- Request and scheduling
- Identification
- Information
- Administration of radiopharmaceutical
- Waiting
- Examination
- Leaving the department

SAFETY ASSESSMENT

Source/worker

- Ordering
- Transport
- Receipt and unpacking
- Storage
- Preparation and administration of radiopharmaceutical
- Radioactive waste

SAFETY ASSESSMENT

General public

- Transport
- Storage
- Handling of sources
- Radioactive waste
- Radioactive patient

SAFETY ASSESSMENT What can happen?

Patient

Procedure	Incident
•Request and scheduling	Wrong patient
•Identification	Wrong patient
•Information	Pregnancy, nursing
•Administration of radiopharmaceutical	Misadministration
•Waiting	Contamination
•Examination	Contamination Bad quality
•Leaving the department	Medical emergency Death of patient

SAFETY ASSESSMENT
What can happen?

Source/worker

Procedure	Incident
•Ordering	Unauthorized
•Transport	Transport accidents Loss of shipment
•Receipt and unpacking	Damage to package
•Storage	Loss of sources
•Preparation and administration of radiopharmaceutical	High dose to worker Contamination
•Radioactive waste	Loss of sources

SAFETY ASSESSMENT
What can happen?

General public

Procedure	Incident
•Transport	Transport accident
•Storage	Loss of sources
•Handling of sources	Spread of contamination
•Radioactive waste	Loss of sources Contamination
•Radioactive patient	Uncontrolled exposure and contamination

EMERGENCY PLANS

On the basis of events identified by the safety assessment, the licensee shall prepare emergency procedures (BSS V.2–6).
The procedures should be clear, concise and unambiguous and shall be posted visibly in places where their need is anticipated.

An emergency plan shall, as a minimum, list/describe:

- **predictable incidents and accidents** and **measures** to deal with them;
- the **persons responsible for taking actions**, with full contact details;

EMERGENCY PLANS (Cont'd)

- the **responsibilities** of individual personnel in emergency procedures
- **equipment and tools** necessary to carry out the emergency procedures;
- training and periodic rehearsal;
- **recording and reporting system**;
- **immediate measures** to avoid unnecessary radiation doses to patients, staff and public;
- **measures to prevent access** of persons to the affected area; and
- measures **to prevent spread of contamination.**

EMERGENCY!

LARGE AMOUNTS OF RADIOACTIVE SPILLS!

Immediate actions by any worker in the nuclear medicine department:

- **The RPO should immediately be informed and directly supervise the clean-up (CALL .....)**
- **All people not involved in the spill should leave the area immediately.**
- **Absorbent pads may be thrown over the spill to prevent further spread of contamination.**

EMERGENCY!

LARGE AMOUNTS OF RADIOACTIVE SPILLS! Cont'd

- **All people involved in the spill should be monitored for contaminationwhen leaving the room.**
- **If clothing is contaminated it should be removed and placed in a plastic bag labeled 'RADIOACTIVE'.**
- **If contamination of skin occurs, the area should immediately be washed.**
- **If contamination of eye occurs, flush with large quantities of water.**

EMERGENCY KIT

Should be kept readily available for use in an emergency. It may include the following:

- protective clothing e.g. overshoes, gloves
- decontamination materials for the affected areas including absorbent materials for wiping up spills,
- decontamination materials for persons
- warning notices,
- portable monitoring equipment
- bags for waste, tape, labels, pencils.



EMERGENCIES

All people in the nuclear medicine department shall be trained in handling emergencies.



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Potential Exposure
Accidental Medical Exposure

Accident prevention.
Lessons learned

Prevention of accidents and mitigation of their consequences

The licensee shall incorporate within the RPP (BSS IV.10–12):

- defence in depth measures to cope with identified events, and an evaluation of the reliability of the safety systems (including administrative and operational procedures, and equipment and facility design); and

- operational experience and lessons learned from accidents and errors. This information should be incorporated into the training, maintenance and QA programmes;

The licensee shall promptly inform the Regulatory Authority of all reportable events, and make suitable arrangements to limit the consequences of any accident or incident that does occur.

Accident

Any unintended event, including operating errors, equipment failures and other mishaps, whose consequences or potential consequences cannot be ignored from radiation and safety point of view and which can lead to potential exposure and subsequently to abnormal exposure conditions.

(BSS)

ACCIDENT EXAMPLE

A 87 y old patient was administered a therapy dose of I-131 (7.4 GBq) in the hope of relieving esophageal compression caused by metastatic thyroid carcinoma. About 34h after receiving the dose the patient had a cardiopulmonary arrest and expired. Attempts at resuscitation were made in the patient's room by 16 staff members. The efforts included insertion of a pacemaker. Contaminated blood and urine were spilled and no surveys of the clothing of those present were done. The highest personnel monitoring reading was 0 3 mGy for one of nurses. Even though the contamination was extensive, subsequent thyroid uptake measurements showed no uptakes by involved staff

Initiating event: Heart failure of patient shortly after iodine therapy
Contributing factor: Contingency procedures for emergency situations involving radionuclides were not available. Monitoring instruments and decontamination equipment were not available. No simulation exercises had been performed.

Lessons learned from accidental exposure

A safety culture should include collection of information on unusual events which led or might have led to incidents and accidents. This information provides material that can be used to prevent future accidents.

MEDICAL EMERGENCY

Contact the RPO for specific instructions.

Medical personnel should proceed with emergency care while attempting to take precautions against spread of contamination:
avoid direct contact with patient's mouth,
all members of the emergency team should wear impermeable protective gloves.

Medical personnel shall be informed and trained in how to deal with a radioactive patient



MEDICAL EMERGENY

Radiation protection considerations should not prevent or delay life-saving operations in the event surgery on the patient is required. The following precautions should be observed:

- Notify the operating room staff.
- Modify operating procedures under the supervision of RPO to minimize exposure and spread of contamination.
- Protective equipment may be used as long as efficiency and speed is not affected.
- Rotation of personnel may be necessary if the surgical procedure is lengthy. The RPO should monitor individual doses to members of the staff.

Accidental Medical Exposure

BSS II.29. Registrants and licensees shall promptly investigate any of the following incidents:

(a) any therapeutic treatment delivered to either the wrong patient or the wrong tissue, or using the wrong pharmaceutical, or with a dose or dose fractionation differing substantially from the values prescribed by the medical practitioner or which may lead to undue acute secondary effects;
(b) any diagnostic exposure substantially greater than intended or resulting in doses repeatedly and substantially exceeding the established guidance levels; and ....

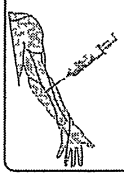
Accidental Medical Exposure

BSS II.30. Registrants and licensees shall, with respect to any investigation required under para. II.29:

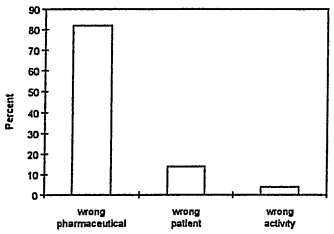
(a) calculate or estimate the doses received and their distribution within the patient;
(b) indicate the corrective measures required to prevent recurrence of such an incident;
(c) implement all the corrective measures that are under their own responsibility;
(d) submit to the Regulatory Authority, as soon as possible after the investigation or as otherwise specified by the Regulatory Authority, a written report which states the cause of the incident and includes the information specified in (a) to (c), as relevant, and any other information required by the Regulatory Authority; and
(e) inform the patient and his or her doctor about the incident

MISADMINISTRATION

- **wrong radiopharmaceutical**
- **wrong patient**
- **wrong route of administration**
- **wrong activity**
  - therapy >10% from prescribed activity
  - diagnosis > 50% from prescribed activity



MISADMINISTRATION IN NUCLEAR MEDICINE



Misadministration consequences

Non justified exposure
Increased radiation risks
Delayed diagnosis
Increased costs
Increased workload
Reduced confidence

MISADMINISTRATION (wrong patient)

A therapy dose of 350 MBq of I-131 was given to the wrong patient (patient A instead of patient B) Patient A was to receive 500 MBq Tc-99m for a bone scan. This dose was administered and the patient was seated in the waiting room. Patient B who was scheduled for an I-131 hyperthyroidism treatment arrived, completed an interview and was seated in the waiting room. The technologist prepared the activity of I-131 and called patient B However, patient A responded. The technologist explained the treatment, scheduled a follow-up appointment and administered the activity. The patient then questioned the technologist and it became evident that the wrong patient had been treated Patient A was immediately informed of the error and his stomach was pumped, retrieving about 1/3 of the activity. The patient was given perchlorate and Lugol's drops to release any I-131 trapped in the thyroid and to block further uptake. The misadministration resulted in an absorbed dose to the thyroid of patient A of about 8 Gy.

Initiating event: A patient responded to another patient's name being called
Contributing factor: Hospital protocol for identification of patients was not followed

MISADMINISTRATION COUNTER MEASURES

Immediately use all available means to minimise any adverse effects.

- Expedious removal of orally administered radiopharmaceuticals by emesis, gastric lavage, laxatives or enemas.
- Accelerated excretion of intravenously administered radiopharmaceuticals by hydration, diuresis etc.
- Removal of urine by catheterization from patients who cannot void spontaneously.
- When appropriate, use of blocking agents to diminish the absorbed dose to the thyroid gland, salivary glands and stomach.

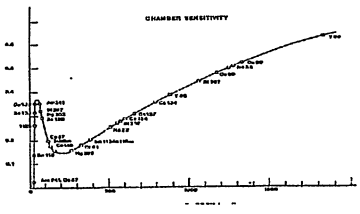
Misadministration (wrong activity)



A patient was to be administered 259 MBq I-131. The radiopharmaceutical was in two 130 MBq capsules and was so indicated on the vial label. Previous doses at the hospital had been administered in the form of one 259 MBq capsule. When the vial was inverted one of the two capsules fell out and the technologist assumed this was the entire dose. Much later the other capsule was detected The patient received only 50% of the prescribed activity.

Initiating event: One of two capsules remained stuck in the vial
Contributing factor: Absence of cross check of the vial label with respect to both activity and number of capsules. No measurement of the activity before treatment.

Activity meter





CRC-16W
Kem # 5130-3113

Correct settings?

Activity meter

Setting	Relative activity
Tc-99m	1.00
Co-57	1.19
In-111	2.35
Tl-201	1.76
Ga-67	1.12
I-123	2.19
I-131	1.43

Misadministration (wrong radiopharmaceutical)

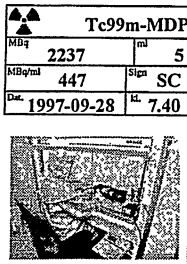
A technologist injected a patient with what he believed to be a radiopharmaceutical used for bone scan. Several hours later the patient was scanned. There was no evidence of bone uptake. Instead the patient appeared to have been injected with a radiopharmaceutical used for brain and kidney imaging



Initiating event: Wrong radiopharmaceutical
Contributing factor: Improper labeling of the radiopharmaceutical (syringe)

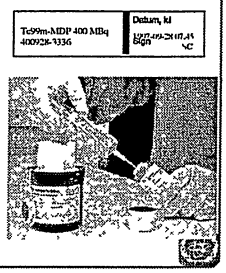
SAFE PREPARATION OF RADIOPHARMACEUTICALS

- Use a transparent vial shield
- Put the kit in the shield
- Add Tc99m and finish the preparation
- Measure the activity
- Write the label and put it on the vial shield
- Check the kit and the label on the vial shield. Same radiopharmaceutical?



SAFE DISPENSING OF RADIOPHARMACEUTICALS

Check the kit and the vial shield label
Correct radiopharmaceutical?
Dispense the requested volume
Measure the activity
Put a label on the syringe (activity, radiopharmaceutical, date and time)



SAFE INJECTION OF RADIOPHARMACEUTICALS

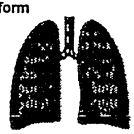
Patient name?
Patient identification number?
Pregnant?
Breastfeeding a baby?
Check the request form
Check the label of the syringe
Correct radiopharmaceutical for the requested examination?
Prescribed activity?
Inject!



Misadministration (wrong route of administration)

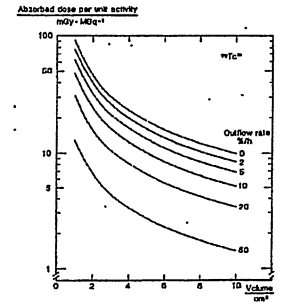
A technologist scanned the nuclear medicine request form for a patient and noted that it involved Tc99m-DTPA. The technologist draw a standard dose of the radiopharmaceutical and injected it before noting that the requested study required inhalation of the radiopharmaceutical in aerosol form.

Initiating event: Wrong route of administration
Contributing factor: No careful reading of the request form





Absorbed dose at injection site



Radionuclide	keV/disintegration
Tc-99m	12.7
In-111	31.8
I-131	180.8
Sr-89	1463
Y-90	2283



Misadministration (pregnant women)

A 43y female patient was scheduled for a thyroid scan. She called the department in the morning and told the technologist that she was trying to get pregnant but there was no evidence at the moment that she was. The technologist misunderstood the patient and she was persuaded to make the examination. Later it appeared that the patient was pregnant at a very early stage and she had a miscarriage

Initiating event: Examination of a pregnant woman.
Contributing factor: Communication failure. Not working local rules.

PREGNANCY (BSS)

Registrants and licencees 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.

IF YOU THINK THAT YOU MIGHT BE PREGNANT , NOTIFY STAFF BEFORE TREATMENT



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 chlonde	150	24
Y-90 colloid (arthntic joints)	400	0
Y-90 colloid (malignancy)	4000	1

MISADMINISTRATION

A nursing mother was given 180 MBq of I-131 that resulted in absorbed doses to her infant estimated as 300 Gy to the thyroid and 0.17 Gy to the whole body. The error was detected when the patient returned to the hospital for a whole body scan. The scan indicated an unusual high breast uptake of I131. The infant will require artificial thyroid hormone medication for life to ensure normal growth and development



Initiating event: A dose of I-131 was given to a nursing mother
Contributing factor: The technologist was distracted and forgot to ask a standard list of questions

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

IF YOU ARE BREAST-FEEDING, PLEASE NOTIFY THE STAFF



MISADMINISTRATION (causes)

- *Communication problems*
- *Busy environment, distraction*
- *Unknown local rules*
- *No training in emergency situations*
- *Not clearly defined responsibilities*
- *No efficient quality assurance*

How to avoid accidents and misadministrations

- Safety culture
- Safety assessment to define critical procedures and emergency situations
- Reporting system (When? Where? Why?)
- Education and training
  - initial
  - continuing

Investigation of accidental medical exposure

- Inform responsible nuclear medicine physician
- Inform patient and referring physician
- Calculate dose
- Indicate corrective measures
- Implement measures
- Submit report to RPC and Regulatory Authority

CONCLUSIONS

Misadministration of radiopharmaceuticals should not be characterized as random human errors The initiating event and the contributing factors can always be identified..

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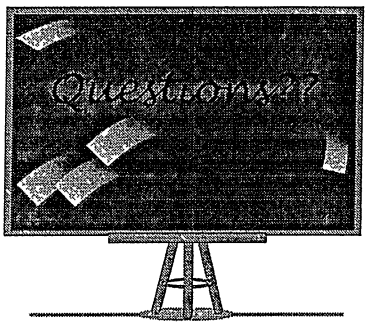
This information provides material that should be used to prevent future accidents.



DISCUSSION

A shipment of 10 GBq I-131 was left unattended in the department. It disappeared.

How to act!

DISCUSSION

What type of accidents could happen in the room for preparation of radiopharmaceuticals?

DISCUSSION

A patient containing 5 GBq I-131 has escaped from the isolation ward. How to act?

Where to Get More Information

- Other sessions
  - Part 4 Safety of sources. Design of facilities
  - Part 5. Occupational protection
  - Part 6 Medical exposure
  - Part 8 Radionuclide therapy
  - Part 10 Radioactive waste
  - Part 12 Protection of the public
- Further readings
  - IAEA publications