Analysis of accidents in medical exposures

Accident in BSS

Any unintended event including
- operating errors
- equipment failures
- or other mishaps

the *consequences* or *potential consequences* of which are not negligible from the point of view of protection or safety

Possible Accident Scenarios

- A radioactive source may be misplaced, lost or stolen.
  - Loss or misplacement of a brachytherapy source in patient treatment
- A radioactive material may be dispersed.
  - Due to breakage of a vial containing a radioactive solution
  - Damage to a sealed source

Possible Accident Scenarios

- A radioactive source becomes unshielded.
  - Failure of shutter mechanism in cobalt units
  - Failure of drive mechanism in a remote afterloading system
  - Teletherapy source drawer failing out of the container
- In a nuclear medicine procedure mal administration of:
  - Radioisotope
  - Radiopharmaceutical
  - Activity

Radiological consequences

- Internal exposure
- External exposure

Potential to produce a significant collective dose

Aim of the lecture

- Analyze the accidents in medical exposure
- Suggest measures to prevent their recurrence.

Nuclear Medicine

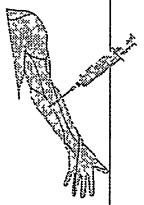
Misadministration

Mis-administration of radiopharmaceuticals

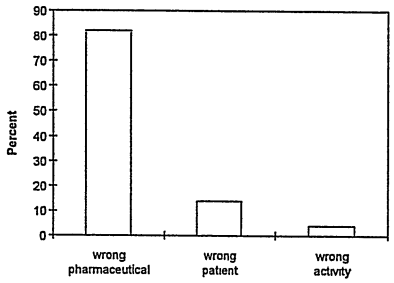
The administration of dose of radiopharmaceuticals that *fails to provide clinical or diagnostic information* for which it was administrated.

Misadministration

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



Misadministration



Data from USA

Accident scenario

- Mis-administration of radiopharmaceuticals to a wrong patient
- Administration of a wrong pharmaceutical to a patient or a pharmaceutical injected in a wrong route
- Radiopharmaceuticals given is of a wrong activity
- Administration of radio-pharmaceutical in pregnant female patient without confirming the pregnancy

...any of these situations can lead to an accidental condition.

Case 1
MISADMINISTRATION (wrong patient)

A therapy dose of 350 MBq of I-131 was given to the wrong patient (patient A instead of patient B).

Accident Scenario

- 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.

Accident Scenario

- 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.

Result

- 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.

Accident Analysis

- **Initiating event:**

  A patient responded to another patient's name being called

- **Contributing factor:**

  Hospital protocol for identification of patients was not followed

Case 2
MISADMINISTRATION (pregnant woman)

A 43y female patient was scheduled for a thyroid scan



Accident Scenario

- 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.

Result

- Later it appeared that the patient was pregnant at a very early stage and she had a miscarriage

Accident Analysis

- **Initiating event:**

  Examination of a pregnant woman

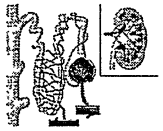
- **Contributing factor:**

  Communication failure
  Bad local rules

Case 3
MISADMINISTRATION (wrong route of administration)

A technologist scanned the nuclear medicine request form for a patient and noted that it involved Tc99m-DTPA.





Accident Scenario

- 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.

Accident Analysis

- **Initiating event:**

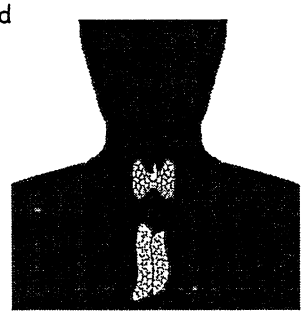
  Wrong route of administration

- **Contributing factor:**

  No careful reading of request form

Case 4
MISADMINISTRATION (Wrong activity)

A patient was to be administered 259 MBq I-131.



Accident Scenario

- The radiopharma-ceutical was in two 130 MBq capsules and was so indicated on the vial label.
- Previous doses at the hospital had been administered in the formof 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.

Result

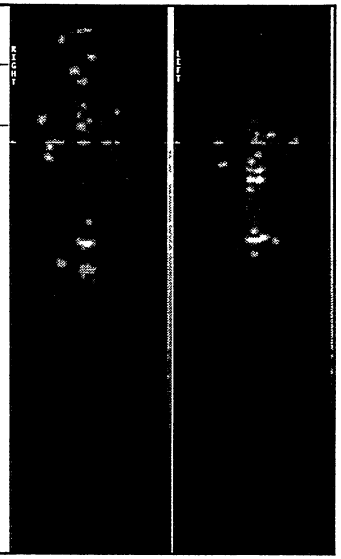
- The patient received only 50% of the prescribed activity.

Accident Analysis

- **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.

Case 5 MISADMINISTRATION (Wrong pharmaceutical)

A patient arrived at the department for a bone scan



Accident Scenario

- 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 radio-pharmaceutical used for brain and kidney imaging.

Accident Analysis

- **Initiating event:**
  Wrong radiopharmaceutical
- **Contributing factor:**
  Improper labeling of the radio-pharmaceutical (syringe)

Misadminstration - Counter Measures

Immediately use all available means to minimise any adverse effects

- Expeditious 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.
- Wse of blocking agents to diminish the absorbed dose to the thyroid gland, salivary glands and stomach.

Misadministration - Causes

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

Consequences of mis-administration

- non-justified exposure
- repetition of radioactive dose administration
- Increased radiation risks
- delayed diagnosis
- increase in cost
- increase in workload
- reduction in confidence

Accident analysis

First establish the cause by asking following questions?

- Was it due to communication problems or gaps?
- Did the busy environment at the hospital caused distraction?
- Is there written code of practice to be followed by doctors?
- If yes, Was it bypassed intentionally?
- If not, was it due to lack of proper training to the staff?
- Was it due to lack of clearly defined responsibilities?
- Was it due to absence of efficient quality assurance programme?

Result

In most cases the root causes can be:

- Non-adherence to the code of practice of first establishing identity of patient
- Communication gap between the nursing staff and the doctor
- Non-verification of the type and quantity of the radiopharmaceuticals
- And all these causes can also be the result of rush of work at the hospital.

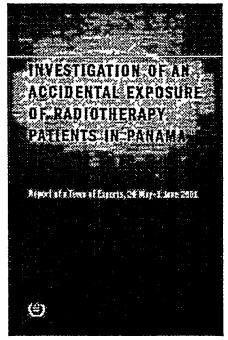
Recommendations to prevention mis-administration of radiopharmaceuticals

- Use transparent vial and syringe shields
- Tag and segregate the vials and syringes with proper labelling
- Write the amount of activity, name of the source and the patient on the vial or syringe containing dose
- Check the labels of vial or syringes before administration
- Measure the activity in radio-pharmaceutical and identify the source before administration
- Identify the name, number and case of the patient with his case file
- Ensure that the female patient is not pregnant

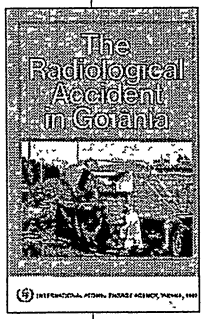
Radiotherapy

Accidents involving the exposure of patients

- Panama accident an example



Accidents involving sources from a radiotherapy department causing exposure of general public



- Includes also brachytherapy sources leaving the hospital

Case 1

Accident in external beam therapy equipment due to equipment design - error in accelerator control software.

Accident scenario

An operator of an accelerator wrongly selected X-ray mode and quickly changed to electron mode before the machine was able to complete the first request and it operated with hybrid instructions leading to overexposures of patients.

(to operate in X-ray mode;
the computer process for setting and verifying the machine parameters required about 20 seconds once X-ray mode was selected)

Accident analysis

Why the operator could quickly change from X-ray mode to electron mode?

- Whether the operator was unaware of the delay to be provided to switch the accelerator between the two modes?
- Was it due to lack of training or rush of work?
- Was it due to lack of improper operating instructions provided by the manufacture?
- Was such a feature built into the machine or not to cop up with the treatment environment at the hospitals?
- Even if such a quick switch over was done, why the operator could not get warning signal that an over exposure was in the offing?

Accident analysis

Why the operator could quickly change from X-ray mode to electron mode?

- Was it due to unavailable beam monitoring systems?
- Was it due to negligent approach of the operator?
- Was it due to failure of the monitoring equipments due to poor maintenance?
- Was it due to poor quality assurance programme being followed by the hospital?
- Was it due to change in the operator and lack of formal communication of proper operating instructions to the new operator?
- If yes, was it a failure on the part of the management for not providing proper written procedure or the operator was so over confident that he did not care to read the instructions before adopting such a course?

Accident analysis

Whether there was a well laid out emergency management plan to handle such a situation?

What precautionary measures can be suggested to avoid repetitions of such accident?

Result

- The analysis showed that the particular model of the accelerator was not tested for extreme conditions that one encounters in the hospitals neither at themanufacturer's place nor at the hospital.
- Probably such a requirement was notvisualised in advance.
- Thus lack of user-manufacturer interface prior to the design could result into such an accident.
- It is suggested that proper beam monitoring/exposure rate monitors with alarm facility should be used to provide warning of over exposure.

Case 2

Treatment data incorrectly written on patient treatment card.

Accident scenario

- Patient with larynx cancer
- Irradiation with a Cs-137 unit
- Medical physicists calculated the treatment time for SSD=40cm.
- The treatment distance written on the patient card was SSD=30cm.



Case 3

- Staff
  - Five radiation oncologists
  - Two medical physicists and one dosimetrist
  - Four radiotherapy technologists
- Two shifts from 6 am to 9 pm
- Two radiation oncologists (one in the morning and one in the evening) in Hospital Arosemena on a monthly rotation

Case 3

Workload

- 70 to 80 patients per day
- Multiple fields and beam shaping devices (shielding blocks and wedges)
- All fields every day
- SSD technique for multiple fields

Case 3

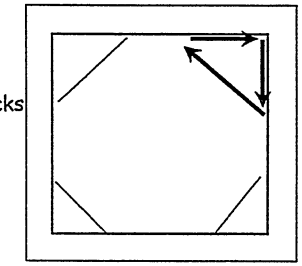
The Treatment Planning System

- 2 D planning
- Multidata RTP/2
- Version 11, installed in 1993
- Allows for
  - Brachytherapy
  - External beam
- Restriction to four blocks per field

Case 3

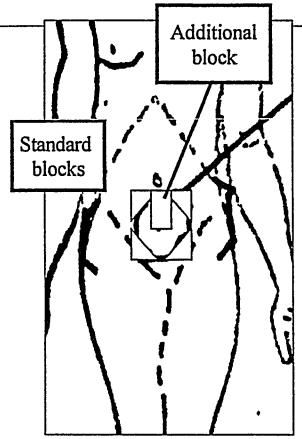
Treatment Planning Entering blocks separately

- Add 1 block
- Type transmission factor
- Digitize contour
- Repeat the procedure with other blocks



Case 3

- In April 2000 radiation oncologists expressed the demand to use a fifth (central) block
- A temporary solution was found to calculate only for the central block
- Ignoring the other four blocks in the calculation of the dose to specified point



Accident scenario

- In August 2000 one physicist came up with another solution: to enter several blocks at once.
- **BUT** the procedure was not written
- Another physicist entered the data in a similar but slightly different way
- Computer accepts input and calculates wrong treatment time by about + 100 %

Accident scenario

- The treatment time was approximately twice
  Example: similar treatment on another patients 0.6 min (one field) as compared with more than 1.2 min
- The computer printout provides distorted isodoses and the longer treatment time but the icon with the four blocks

The discovery of the accident

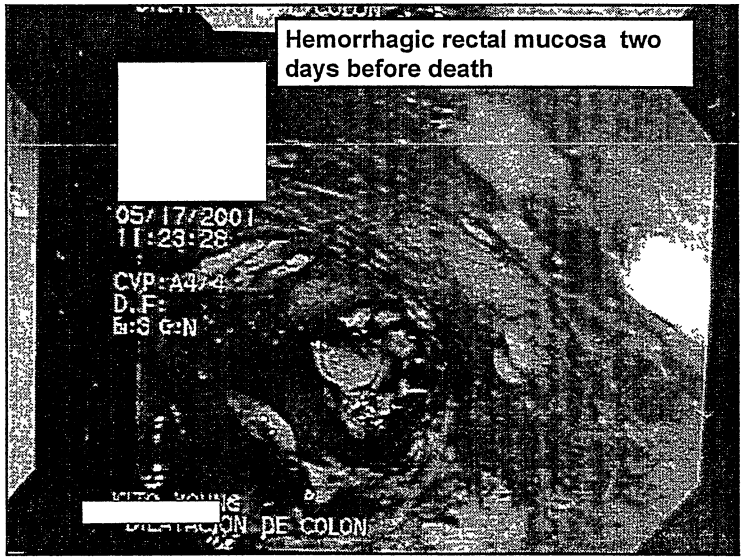
- In November 2000 a radiation oncologist started to observe diarrhea, which was unusually prolonged
- In December 2000 the effect was observed in other patients
- The physicists examined the charts but did not found any abnormality (the computer calculation was not questioned)

The discovery of the accident

- In March 2001 the isodoses and the treatment time were reexamined closer and found differences in isodose shape and different treatment times
- The treatment was simulated on a water phantom and measurement of doses were made which confirmed higher dose...
- Doses to patients were calculated manually

Results to Date (May 30, 2000)

- 8 Deaths of 28 patients
- 5 Radiation related
- 2 Unknown. Not enough data
- 1 Due to metastatic cancer
- 20 Surviving patients



Accident Analysis

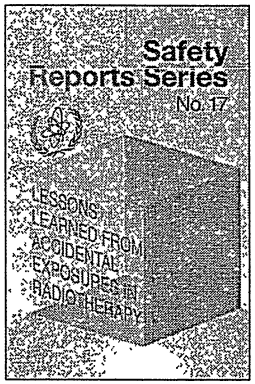
- The event was triggered by
  - The search for a way to overcome the limitation of the planning computer (four blocks only)
- Contributory factors
  - The computer presented the icon as if the block were correctly recognized
  - The procedure was not tested
  - The trick "worked" and was time saving
  - It was claimed that, in another TPS in Panama the same way of data entry works well

Accident Analysis

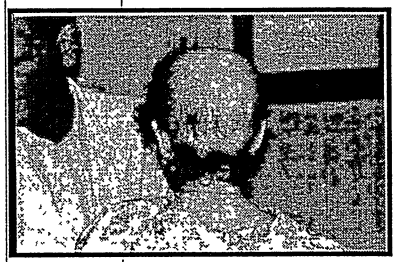
- Contributory factors (cont'd)
  - Procedure not properly documented
  - Treatment times were longer than usual but no one detected it
    - workload
    - limited interaction (radiation oncologists, medical physicists and radiotherapy technologists)
    - Computer calculations in general were not verified
  - Patient reactions were realized but the follow-up was insufficient

Not an isolated event

- More than 90 cases documented
- Affects brachytherapy and external beam radiotherapy
- Affects developed and developing countries



Consequences of accidents





External and internal...

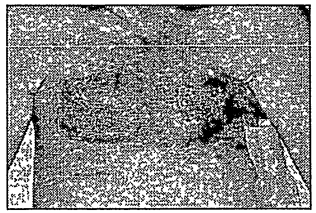
Actions after an accident in radiotherapy

- Investigation
- Report
- Actions to prevent a recurrence of the accident

... not necessarily closure of the radiotherapy facility

Radiotherapy can cure cancer

An uncontrolled cancer can look just like a deterministic radiation effect and can kill a patient in the same way



A treatment unit may treat hundreds of patients per year - even if only a fraction of them is cured this constitutes a significant contribution to public health

Radiotherapy can cure cancer

- Clearly, an accident
  - SHOULD be prevented
  - MUST be investigated and
  - a recurrence MUST be made impossible,
- however, if at all possible:

Radiotherapy should go on...

General Recommendations

General recommendation

To quickly mitigate the impact of an accident always keep in readiness a well laid out emergency management plan

- Emergency Response Committee (a team of experts)
- Each member of the team or committee is assigned specific responsibilities
- The Committee should discuss the problem periodically to avoid recurrence of accidents

General recommendation

An emergency in a department

- should be attended immediately
- reported to other staff members
- reported to head of the institution
- discussed to remove gaps

General recommendation

In addition

- There should be adequate number of trained staff available in the department to carry out the emergency plan
- The personnel/staff should be instructed to exercise care in respective areas to avoid situations that may lead to an accident
- All radiation monitoring, measuring instruments and safety devices should be routinely checked and kept in working condition
- A proper inventory of radioisotopes received, used, and in stock should be maintained.

Assessment and Monitoring after Accidents

- All reasonable steps shall be taken to assess exposure incurred by members of the public as a consequence of an accident
- the results of the assessmentshall be made public

Assessment and Monitoring after Accidents

The assessment

- shall be based on the best available information
- shall be promptly updated in the light of any information that would produce substantially more accurate result

Assessment and Monitoring after Accidents

Keep records of

- assessment
- their updates
- monitoring results of workers, the public and the environment

Observation

Type of Radiation Emergency

Sr.No.	Number of persons involved	Rad. Received by the Persons	Rad. Received by the public	Action taken

Emergency preparedness

- Consider what could happen
- Try to prevent it
- Prepare for the emergency situation
  - internal
    (overdose of patients, malfunction of equipment)
  - external
    (dose to general public where expertise or equipment in a radiotherapy department is required)

References

1. International Basic Safety Standards for protection against ionizing radiations and for the safety of radiation sources. Safety Series No. 115,IAEA, Vienna (1996).
2. Emergency planning and preparedness for accidents involving radioactive materials used in medicine, industry, research and teaching. Safety Series No, 91, IAEA, Vienna (1989).
3. Recommendations for the safe use and regulation of radiation sources in industry, medicine, research and teaching. Safety Series No, 102, IAEA,Vienna (1990).