RADIATION RISK OF PERSONNEL DURING THERAPEUTIC USE OF IODINE-131

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1. Introduction

The therapy of benign and malign thyroid disease with ^{131}I is a common therapeutic procedure in Nuclear Medicine. For the therapy of thyroid cancer activities of 3.7 - 7.4 GBq of ^{131}I are administered.

For this purpose, several radiation protection procedures according to international and national regulations have been established. Therefore, from the aspect of radiation protection, the handling of ^{131}I is the most important procedure in Nuclear Medicine.

There are three sources of possible radiation exposure in connection with radioiodine therapy:

1) External radiation exposure has to be considered. The dose rate of 3.7 GBq in a distance of 1 m is about 0.2 mSv/h.
2) Considering that about 70% of the administered activity is excreted by urine, stool and sweat, external contamination might lead to radiation exposure.
3) The third source of radiation exposure is inhalation of gaseous ^{131}I. Due to this aspect, primarily the air of the patient rooms must be considered as a source of possible incorporation.

In addition to the international and national safety regulations, internal controls have to be established to take care of corresponding radiation protection procedures. External radiation exposure measurement is done by TLD (or film) badges. Internal radiation measurement is done by whole body counting or measurement of thyroid uptake.

2. Material and methods

External dosimetry

External dosimetry is made by TLD badges. The evaluation is performed by the "Prüfanstalt für Radiologie und Elektromedizin" in Vienna. Reports are created monthly and controlled by the radiation protection officer.

Whole body counter

The Whole Body Counter (Canberra ACCUSCAN) is build in shadow shield-geometry with 10 cm strong steel slabs. Two detector-systems are available for radiation detection: A NaI-scintillation-detector with a crystal size of 12.5 x 7.5 x 50 cm (5 x 3 x 20 inches) is mostly used for quantitative evaluation because of its higher efficiency. In addition, a co-axial Germanium-detector with 30% relative efficiency is mainly used for the radionuclide-identification because of its higher energy-resolution.

Routine acquisition is done quarterly by a technologist, and reports are automatically generated by a DEC- MicroVAX 3300 system using Canberra's ABACOS-plus for VMS software. The system provides a minimal detectable activity (MDA) of about 90 Bq ^{131}I in a 70-kg bottle phantom.

Aerosol monitoring

Aerosol monitoring is performed by an Iodine monitor (BERTHOLD BAI 9123-1). A sodium iodine crystal of 5 cm thickness and 5 cm in diameter is shielded by 5 cm lead. 5 mm in front of the detector

an activated carbon filter of 0.5 mm thickness and 5 cm in diameter is placed (Schleicher & Schüll No. 509).

The readout of the detector is made by digital electronics (BERTHOLD MultiLogger LB 5310).

3. Results

30 persons, employed at our department have access to the therapy unit and are therefore checked for Iodine inhalation. Split up into different occupational categories there were: 7 Physicians, 5 Technologists, 8 Nurses, 3 Cleaning Personnel and 6 Physicists/Engineers.

Fig. 1. Results of external dosimetry ***(see text)***

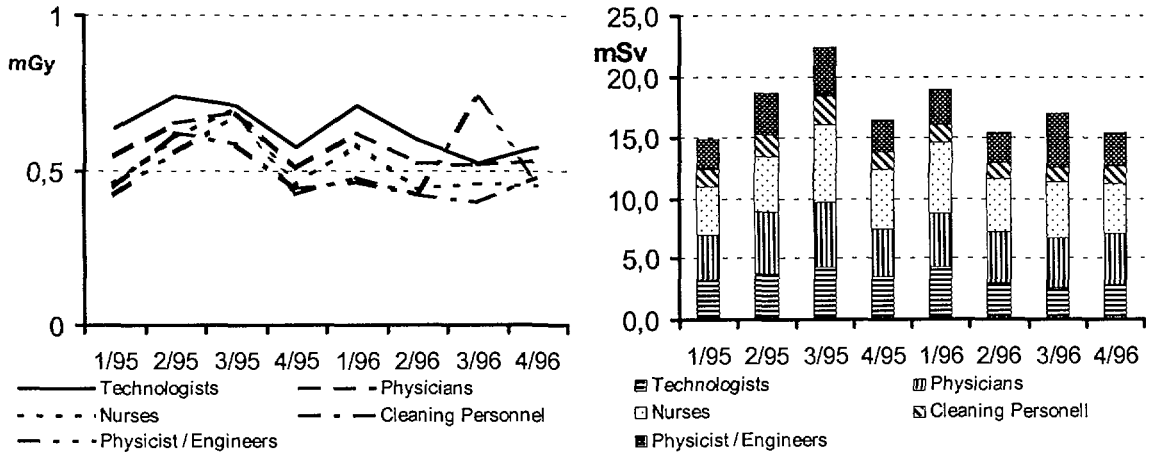

Fig. 2. ^{131}I results of whole body counting ***(see text)***

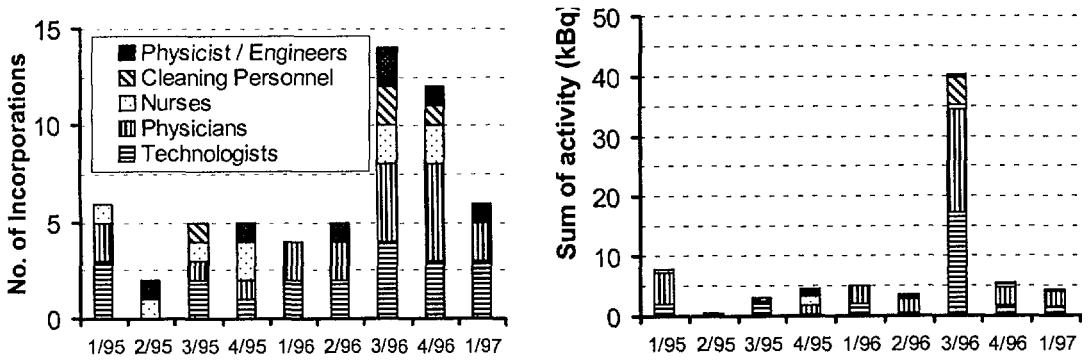

Figure 1 shows the results of external dosimetry. On the left hand, mean values of quarterly received occupational doses are shown. The graph on the right hand shows the sum of effective doses per quarter (to be compared with figure 2). Reported mean doses are between 2 and 3 mGy/a. Even during the year 1996 no changes in doses can be seen.

Figure 2 shows the results of incorporation control with our whole body counter. From the time period 1/95 to 2/96 5 persons usually showed ^{131}I incorporations. Detected activities were low: a total of 0.5 kBq to 7 kBq was measured during this period. In the second half of the year 1996 an increase of incorporations can easily be seen: 14 persons showed measurable I-131 Incorporations. The sum of the reported activity at that period exceeded 40 kBq.

Tab. 1. Results of wipe tests

Location	activity	
Lead shielding, outside	1,8	kBq
Lead shielding, inside	11,4	kBq
Lead shielding, bottom	11,1	kBq
Glass bottle, outside	3,1	kBq
Seal of glass bottle	33,5	kBq
Capsule (outside)	141,6	kBq

Wipe tests were carried out, to detect the source of internal contamination. The outer containment of the capsules (lead shielding) showed measurable contamination with ^{131}I (see Table 1). The result of the wipe test of the capsule surface gave evidence that ^{131}I in gaseous form was emitted to the air.

Fig. 3. Air activity concentrations related to the opening of the containment seal

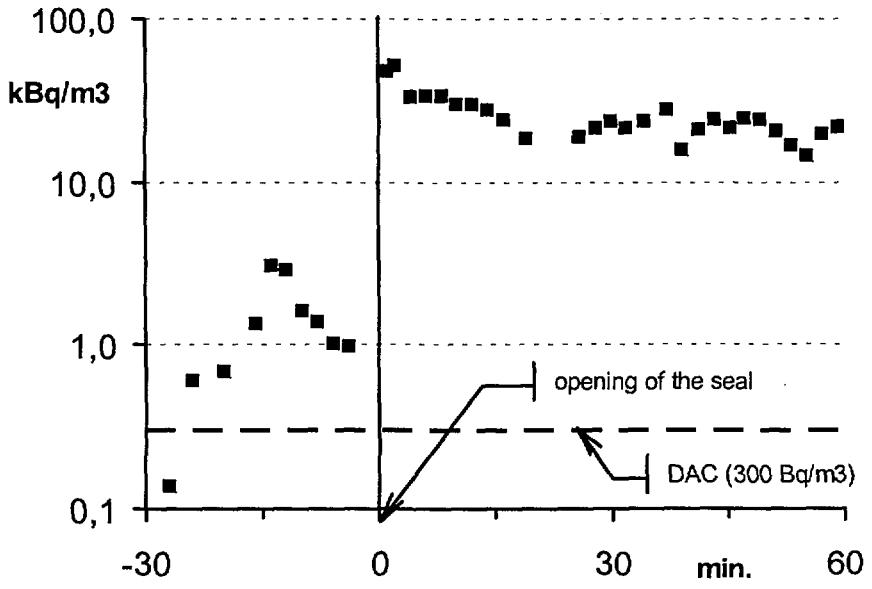

Figure 3 shows the results of measurements of activity concentrations in air. Time axis is calculated in relation to the opening of the seal (glass containment). After this moment the activity concentration increased to 60 kBq/m^3 and remained nearly unchanged for the next 60 hours (not seen in figure 3).

4. Discussion

Of the various types of radiation exposure for the personnel of a Nuclear Medicine department effective dose caused by external exposure is usually low (2.8 mSv/a). Considering the fact, that natural radiation exposure is included in the measurements, the values range within a few mSv/a. This radiation dose is caused mainly by the manipulation of radioisotopes and by exposure from patients after administration of radiopharmaceuticals.

The group of persons which has usually the highest radiation burden in a Nuclear Medicine department is the group of Technologists because of regularly eluting of the Mo-99/Tc-99m generators and labeling of radiopharmaceuticals.

The group of persons which has the second highest radiation exposure dose is the group of medical doctors due to the injection of radiopharmaceuticals and regular administration of therapeutic doses of radioisotopes.

Radiation burden due to incorporation of radionuclides on the other hand is a very rare case in our experience. Measurements of radionuclides incorporation reveal activities of not more than 1 kBq per person. Considering an „annual limit of intake" (ALI) of 1 MBq for ^{131}I (ICRP 30) this is less than 1% of ALI, and no further examinations had to be done so far.

Therefore, it was a remarkable event, when an amount of 15 kBq of ^{131}I was found in a medical doctor in the 3rd quarter of 1996. Taking into account the higher efficiency of the thyroid geometry - routine spectra are evaluated with whole body efficiency calibration - this value has to be multiplied by a factor of 2.

In search for possible causes of this incorporation, working procedures were controlled. It could soon be detected, that the incorporation was caused by a leakage of gaseous ^{131}I from the capsules containing the therapeutic doses of radioiodine.

The incorporation was a consequence of the inhalation of ^{131}I during administration of the therapeutic dose. The procedure usually was done by a person once a week in turn and lasted 15 min. A wipe test carried out at the outer surface of the capsule revealed activities, which were in the range usually used for diagnostic purposes.

Opening of the lead-shielded glass-containment with exhaustion minimized the amount of activity incorporation by the individual person, but not the number of persons showing internal contamination's.

^{131}I but not the number of internal contamination itself. Because of our complaints and similar observations, made by an other Nuclear Medicine institution, the manufacturer stopped the production of this therapeutic device.

Federal regulations prescribe control measurement for incorporation once a year. Because incorporation control of all persons is done quarterly in our department, the problem could be detected within the first 2 months. Regular monitoring for internal contamination is therefore recommended by us to detect changes in inhalation risk doing routine procedures.

5. References

[1] ICRP Publication 54: Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation, Pergamon Press, Oxford (1988)

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[3] IAEA Safety series No. 114: Direct Methods for Measuring Radionuclides in the Human Body, International Atomic Energy Agency, Vienna, (1996)

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