OCCUPATIONAL RADIATION EXPOSURE IN NUCLEAR MEDICINE[+)]

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The use of radioactive material in nuclear medicine is associated with radiation exposure of patients, staff and part of the population. The radiation protection regulations of the Federal Republic of Germany guarantee the protection of the individual as well as the general public from damage caused by the radiation from radionuclides. Accordingly, the user is required to ensure that the radiation exposure of the persons involved be kept as low as is reasonably achievable. A compromise is often necessary in order to fulfil this requirement, when taking into account the different nuclear medical application of radionuclides in therapy, diagnostic procedures and research. The knowledge of the extent of radiation exposure and its main sources is certainly necessary in order a reasonable reducation.

In a large hospital (University Hospital, Homburg (Saar), 2ooo beds) the use of radionuclides was determined with the aim of a balance of the radionuclide flow through the clinic and the resulting radiation exposure for the persons involved.

Methods

Determination of external occupational exposure: this is based on the result of individual monitoring by film dosimeters. In addition on this the dose values were taken from ionization chambers worn as monitors and the result of dose measurements obtained with a portable scintillation dosimeter at the place of work.

Internal exposure: this was calculated for staff after the results of internal contamination monitoring using the MIRD concept(1) (2).

Area survey of environment and place of work: we analysed wipe tests taken from surfaces, and air and sewage samples with regard to γ-rays. Samples also containing ß emitting nuclides were examined in a low level liquid scintillation counter.

Results: Table 1, 2, 3 and 4

Surface contamination in working areas was seen in a high percentage. It results from radioiodines ^{51}Cr, ^{59}Fe, ^{99m}Tc, ^{113m}In and ^{198}Au (3).

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Radio-nuclide	Acquired x1o^{1o}Bq/a	Decay %	Westeair %	Sewage %	Refuse %
^{123}J D	14	65	o.o3	2o	15
^{124}J D	o.o67	5o	o.o4	35	15
^{125}J D	o.16	3	2	5o	45
^{131}J T	115	9o	o.o5	9	o.2
^{131}J D	3	3o	o.o3	6o	1o
^{75}Se	o.1	27	1.o	69	3
^{198}Au	o.16	6o	-	38	2
^{51}Cr	1.9	3o	-	68	2
^{59}Fe	o.1	2o	-	78	2
^{99}Mo	93	99.99	-	-	o.oo1
^{99m}Tc	19o	65	-	3o	5
^{32}P	o.o19	9o	-	8	2
^{89}Sr	o.o3	25	-	73	2
^{14}C	o.o1	o	?	65	35
^{113}Sn	o.16	99.99	-	-	o.oo1
^{113m}In	15	9o	-	8	2
^{3}H	o.o56	o	o.5	55	44.5

Tab. 1: Balance of acquisition and disposal of radioactive material at the University hospital Homburg (Saar)
?: Loss by evaporation established, but quantitative results at present not available

Discussion

Most of the aquired activity (3.7 x 1o^{12}Bq) is lost by physical decay or leaves the hospital with sewage (Tab. 1). Little is seen in refuse and air.

Occupation radiation exposure results mainly from physical decay inside the hospital and from radioactivity in the air which leads to incorporation of radioisotopes from iodine and tritium (Tab. 2). ^{99m}Tc, ^{59}Fe, ^{58}Co and ^{22}Na were not really incorporated but found on skin and clothes.

The application on the patient himself leads to an internal irradiation of the organism, the distribution of which is almost homogenous and partly more inhomogenous. The information supplied by giving the mean dose is not very helpful, as, among other things, the frequency of any particular method of examination would have to be taken into account. The external radiation orginating from other patients after application of the radio pharmaceutical is in comparison to the internal negligibly low.

Number of persons	percentage with detectable incorporation	Incorporated nuclide	Interval (Bq)	Activity Average value (Bq)	processed activity ($x10^8$Bq/a)
36o	15	^{131}J	4o-185ooo	3ooo	33
	1	^{123}J	4o-148ooo	15oo	3.7
	4	^{99m}Tc	4o-148ooo	185oo	11o
	2	^{59}Fe, ^{58}Co, ^{22}Na	4o- 148oo	11oo	o.oo4
4o	95	^{125}J	4o- 185oo	3ooo	o.15
447	7o	^{3}H	4o- 185oo	66oo	o.o2

Tab. 2: Results of the incorporation monitoring

Place	Nuclide	Average value (mBq/cm^3)	Interval (mBq/cm^3)	Percentage of workplaces with a detectable contamination with this nuclide
Lab 1	^{51}Cr	63o	4 - 63oo	48 %
	^{59}Fe	1o	- +	4 %
	^{99m}Tc	12o	1 - 37ooo	36 %
	^{113m}In	125	1.5- 37o	12 %
	^{123}J	65	o.7-1184ooo	56 %
	^{124}J	33	5 - 1oo	24 %
	^{125}J	115	o.7- 4o	32 %
	^{131}J	3oo	o.4- 48oo	76 %
	^{198}Au	6	-	4 %
Lab 2	^{125}J	78	o.7- 66o	94 %
Lab 3	^{51}Cr	5	4.8- 6	1oo %
	^{59}Fe	2	o.7- .3	75 %
	^{125}J	9	-	25 %

Tab. 3: Surface contamination at different working places
+: Single values

The external exposure of the staff originates from radionuclide sources (storage containers, injections) in the laboratory and examination rooms, as well as the activity applied to the patient. In the area of diagnostic an average dose value of o.8 to 1.2 mGy/a. Intracavitary therapy with ^{226}Ra has to be considered separately. A small group of coworkers are immediately engaged with the posing and removal of the socalled ^{226}Ra needle. These persons receive in the Homburg Hospital the highest occupational radiation exposure of about 12 mGy/a; in individual cases the dose limit of 5o mGy/a is reached.

Group of persons	Type of exposure	Type of dose determination	Average Dose ($x10^{-5}$Gy/a)	Interval Dose ($x10^{-5}$Gy/a)
Patient	internal	MIRD Concept	-	0.7 - 100000
	external	Scintillation dosimeter	3	1 - 10
Staff	internal	Whole body counter and MIRD	2	n.n.x - 500
	external	Film badge D	80	n.n. - 1500
	external	Film badge T (^{226}Ra)	1000	n.n. - 5000
	external	Scintillation dosimeter D	140	n.n. - 1500
	external	Contamination of room surfaces	0.006	n.n. - 6
Parts of the population	internal	General calculation basis BMI 1979	-	$5x10^{-6}$ - 50

n.n.x: not detectable D: diagnostic T: therapy

Tab. 4: Radiation exposure by the use of radioactive isotopes in nuclear medicine

In comparison, the external irradiation by contamined room surface contributes little to the total burden (Tab. 3), especially if one considers that the given values have to be assumed to be maximum values.

Finally, parts of the population can be included in the circle of persons exposed to radiation through nuclear medical use of radioisotopes, in addition to the naturally radiation background. The "General Basis for Calculation of the Bundesminister for Internal Affairs for the Radiation Exposure through Radioactive Drainage in Waste Air or in Survace Waters" supply rules to assess the expected radiation exposure of individuals in the most unfavourable cases.

This leads to an overestimation of the real exposure. The maximum value of the internal presented must therefore be considered as the maximum possible radiation dose. This is below the permitted limit for parts of the population.

References

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