CHARACTERISTICS AND INCORPORATION MONITORING RESULTS WITH A WHOLE BODY COUNTER

S. MAKRA[1], A. ANDRÁSI[2], É. BELEZNAY[2], G. REISCHL[1], ZS. KARIKA[1], M. FÜZY[1], GY. TARJÁN[1], I. SINKOVICS[1]

[1]National Institute for Oncology
1121 Budapest, Ráth György u. 7-9

[2]Central Research Institute for Physics
1525 Budapest, P.O.Box 49

The National Institute for Oncology's old whole body counter was reconstructed with the following main characteristics; detector: 15 cm dia x 10 cm sodium iodine single crystal, standard chair geometry, in a 20 cm thick iron shield. The detector signals are fed to a 1024 channel analyser. Spectra can be stored on magnetic and/or punched tapes. Punched tape data are used for off-line spectrum unfolding when needed.

On line data processing and plotting are planned by using a personal computer.

The ^{99m}Tc and ^{131}I incorporation of 16 persons working at the Isotope Department were monitored for a 6 month period to assess the effects of different working conditions. The doses received by assistants were found to be the highest but in no case exceeded the dose limit.

Introduction

The old whole body counter of the National Institute for Oncology was built in 1966 and used for routine control measurements for more than 15 years. Reconstruction was decided on a few years ago and it seemed advantageous to realize a standard tilted chair geometry with an NaI/Tl/ scintillation detector in order to take into account the planned aims of the counter.

The considerable increase in the use of radio-pharmaceuticals in diagnostic routines and clinical therapy justifies the utilization of a whole body counter to estimate, with an appropriate monitoring program, the internal burden of personnel resulting from the weekly handling of radioisotopes of 30-40 GBq ^{99m}Tc and 20-30 GBq ^{131}I.

Reconstruction and calibration

The basic structure of the old whole body counter /IAEA reference no. HY 1.1/ was not changed during this reconstruction [1]. The floor and the walls of the monitoring room are of old iron /thickness of 20 cm/ lined with 3 mm lead of low activity and 0.8 mm electrolytic copper to reduce the background in the low energy region. The internal dimensions are length 180 cm, width 62 cm, height 100 cm. The tilted chair geometry was slightly modified to render it similar in parameters to those in the Central Research Institute for Physics /IAEA reference no. HY 2.1/.

The old plastic detector was replaced by a low-background NaI/Tl/ crystal detector 15.2 cm in diameter and 10.2 cm thickness /Nuclear Enterprises, England/. The signals of the detector are processed by a 1024 channel analyser /Type EMG 1024, Hungary/. Spectra can be stored on magnetic and/or punched paper tapes. The punched tape is used for computer-evaluation. On-line data processing and plotting are planned by using a personal computer.

The integral background counting rate in the 0.1 - 2.0 MeV energy interval is 8.0 ± 0.5 cps.

For quantitative spectrum evaluation, calibration was performed by using a homogeneously filled BOMAB-type phantom /weight 70 kg/ as well as a Presswood phantom with point sources [2]. The calibration data are presented in Table I. The calibration data have been proved by intercomparison with those obtained by the whole body counter HY 2.1 of the Central Research Institute for Physics /KFKI/, Budapest using the same measuring geometry [1].

Monitoring program

The body burden of the personnel in the Oncology Institute's Isotope Department is due to both external and internal radiation. The latter is mainly from ^{99m}Tc and ^{131}I incorporation.

Incorporation is affected by several factors principally relating to local conditions /ventilation rate, face mask, training level of an assistant, etc./. The assistants handling radioiodine at therapy level are subject to the highest incorporation risk; somewhat lower but still significant incorporation is expected from handling of the technetium isotope. Radioactive aerosols exhaled by the patients are also a source of incorporation for personnel working at the scintillation cameras and at the bedside.

In order to obtain data for internal exposure which are directly comparable with intake limits or dose equivalent limits recommended by the ICRP [3], regular monitoring is required.

During a half year period 16 people were monitored for ^{131}I and ^{99m}Tc incorporation. Distribution of the 118 measurements is the following: 5 assistants and 4 physicians: 97 measurements; 5 nurses, 1 secretary and 1 technician: 21 measurements.

The half lives of the radionuclides in question determine the frequency of monitoring: every other day or preferably daily measurements for technetium, and one measurement per week for iodine determination. However, owing to administrative and organization problems this monitoring schedule could not be followed. Instead selected individuals were monitored more frequently for a period of 3-4 weeks /in one period one or two assistants and one physician/. Obviously when the monitored individuals were changed, personal factors /working style, etc./ would also change.

Results and discussion

Because of the high efficiency of the counter a measuring time of 200 or 400 s was generally sufficient. In case of very low incorporation values the measurement time was extended to 2000 seconds. Typical spectra are presented in Figs 1 and 2.

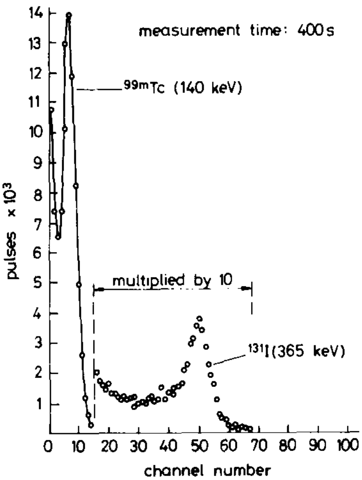

Fig. 1. Spectrum of assistant "A", measured after two hours of handling of 6 GBq ^{131}I and 2.5 GBq ^{99m}Tc

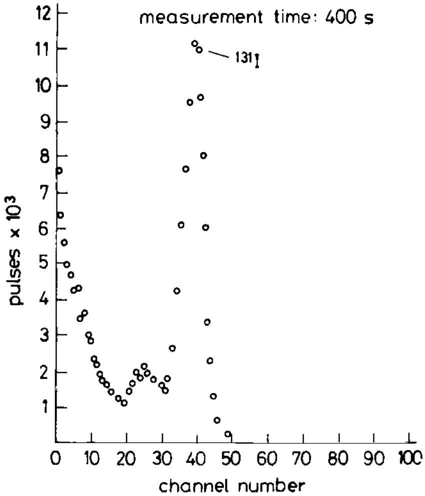

Fig. 2. Spectrum of assistant "B", measured after three hours of handling of 5 GBq ^{131}I and 3 GBq ^{99m}Tc

Average incorporation levels were determined by following the time variation of the incorporation for a specific time. Typical monitoring periods ranged from 3 to 4 weeks, covering typically 15-20 technetium and 3-6 iodine exposures, respectively. Average dose equivalent values were calculated for one month periods, and were expressed as a percentage of the "monthly dose equivalent limit" /1/12-th part of the dose equivalent limit/.

Typical results are presented in Fig. 3 and Table II. The results show that the internal doses received by the assistants working in the isotope laboratory are the highest, but even in these cases the values are well below the dose equivalent limit.

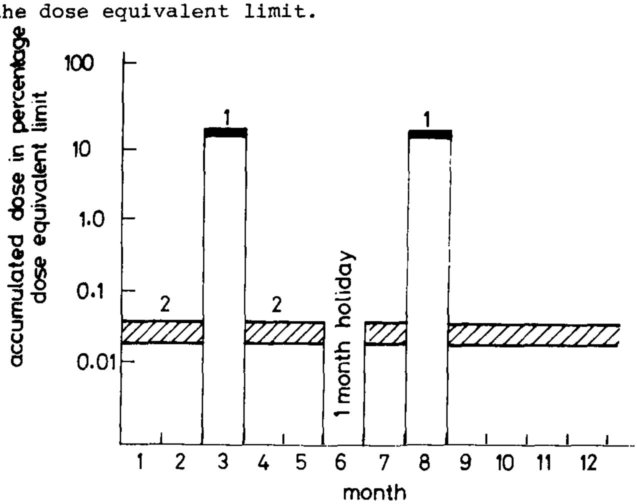

Fig. 3. Dose originating from ^{131}I when working in the isotope laboratory /1/ or at the scintillation cameras /2/

Table I

Full energy peak detection efficiency and minimum detectable activity /MDA/ for different isotopes

Isotope	E_{gamma} [keV]	Energy band [keV]	Full energy peak efficiency [cps/kBq]	[cps/gamma-kBq]	MDA* [Bq]
^{99m}Tc	140/87.7%/	95- 190	3.45	3.93	25
^{203}Hg	279/81.5%/	200- 350	3.25	3.98	30
^{51}Cr	320/9.8%/	238- 364	0.27	2.73	340
^{131}I	365/81.2%/	290- 450	2.75 /whole body/	3.38	33
			5.11 /thyroid/	6.30	18
^{137}Cs	622/85.1%/	530- 770	2.11	2.48	40
^{54}Mn	835/100%/	700-1000	1.93	1.93	35
^{65}Zn	1115/50.7%/	950-1300	0.77	1.68	77
^{22}Na	1275/99.9%/	1225-1425	1.77	1.77	25
^{60}Co	1173/100%/ 1333/100%/	1060-1425	4.16	2.08	15
^{40}K	1460/10.7%/	1300-1600	0.183	1.70	270

*in calculation of MDA a measuring time of 2000 s was assumed

Table II

Dose received due to ^{99m}Tc and ^{131}I in per cent related to the dose equivalent limit

Working conditions		Isotope	Dose per cent
assistant	- working in the isotope laboratory	^{99m}Tc	0.5-2 %
		^{131}I	10 - 20 %
	- working at the scintillation cameras	^{99m}Tc	0.01-0.1 %
		^{131}I	0.02-0.05 %
physician	- working in the isotope laboratory	^{99m}Tc	0.1 -0.2 %
		^{131}I	1 - 4 %
	- working at the scintillation cameras	^{99m}Tc	0.01-0.05 %
		^{131}I	0.01-0.04 %

References

1. Directory of Whole Body Radioactivity Monitors, IAEA, Vienna, 1970.
2. A. Andrási and É. Beleznay: International Intercomparison of Whole Body Counters, Report KFKI-1979-95, 1979.
3. Limits for Intakes of Radionuclides by Workers, ICRP Publication 30, Part 1 and Supplement, Pergamon Press, Oxford, 1979.