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ABSTRACT

We describe here the standardization of a technique for the estimation of ^{125}I in the thyroid gland of laboratory workers involved with ^{125}I labelling techniques. It is based on a comparison with a standard curve obtained by placing in a thyroid neck phantom various calibrated standard sources of ^{125}I. The thyroid monitoring technique set up in our laboratory has demonstrated to be highly sensitive, precise and accurate. Its sensitivity was calculated around 0,8 - 1,7 nCi. The precision of our measurements was avaliated in a range of 1.35 - 310.5 nCi and the coefficient of variation obtained varied from 2,2% to 26,3%. The accuracy of our "in vivo" measurements was checked by analyzing the influence of the shape and the size of the thyroid in the neck phantom. The reproducibility of intra and inter day counting and the detector stability was studied using the same calibrated source (428,3 nCi at day "o") during 186 days. Thirty workers exposed to ^{125}I in their routine work and ten workers completely unexposed to radioisotopes, had their thyroid monitored utilizing the same counting schedule used for the standard curve. The thyroid burden was them calculated by comparison with the previous standard curve determined. It was shown that more than 80% of the first population had a significant thyroid contamination while no significant counting above background was ever detected in the second population. The annual thyroid doses were calculated using the MIRD specifications, assuming that the thyroid activity remains constant during one year. All the monitored workers were below the Maximum Permitted Annual Thyroid Dose. ^{125}I effective half-lives could also be calculated in the case of five workers and presented an average value in good agreement with the most recent literature data. Considering that only in São Paulo area about 50-70 people work directly with

^{125}I protein labelling and in view of our data, we are convinced that it is extremely important to set up a regular controland scrutiny policy, which is not yet available. We are convinced that the aim must undoubtedly be towards zero contamination for all workers. We thank the support received from the IAEA (4299/RB) and CNEN (Brazil).

UM MÉTODO DE MEDIDA DA TIREÓIDE PARA MONITORAR TRABALHADORES EXPOSTOS A ^{125}I

RESUMO

Nós descrevemos aqui a padronização de uma técnica para estimar o ^{125}I na glândula tireóide de trabalhadores envolvidos em técnicas de marcação com ^{125}I. Está baseada na comparação com a curva padrão obtida colocando num fantom de tireóide várias fontes padrão de ^{125}I. A técnica de monitoração da tireóide estabelecida em nosso laboratório mostrou ser altamente sensivel, precisa e exata. Sua sensibilidade foi calculada entre 0,8 a 1,7 nCi. A precisão de nossas medidas foi valiada num intervalo de 1,35 a 310,5 nCi e o coeficiente de variação obtido variou de 2,2% a 26,3%. A exatidão de nossas medidas "in vivo" foi verificada analisando a influência da forma e do tamanho da tireóide no fanton de pescoço. A reprodutibilidade das contagem intra e inter-dias e a estabilidade do detector foram estudadas usando-se uma mesma fonte calibrada (428,3 nCi no dia zero) durante 186 dias. Trinta trabalhadores expostos a ^{125}I no seu trabalho rotineiro e 10 trabalhadores não expostos a radioisótopos tiveram suas tireóides monitoradas utilizando-se o mesmo esquema usado para a curva padrão. A atividade na tireóide foi então calculada por comparação com a curva padrão previamente determinada. Foi mostrado que mais de 80% da primeira população apresentou uma contaminação significativa na tireóide enquanto nenhuma contagem significativa superior à radiação de fundo foi detectada na segunda população. As doses anuais da tireóide foram calculadas usando as especificações do MIRD, assumindo que a atividade na tireóide permaneceu constante durante um ano. Todos os trabalhadores monitorados estavam abaixo da dose máxima anual permitida para a tireóide. A meia vida efetiva do ^{125}I pode ser

também calculada no caso de 5 trabalhadores e apresentou um valor mé - dio em boa concordância com os dados mais recentes da literatura. Considerando que apenas na área de São Paulo cerca de 50 a 70 pessoas trabalham diretamente com marcação de proteínas com ^{125}I e em vista dos nossos dados nós estamos convencidos que é extremamente importante estabelecer um controle regular o que não é feito rotineiramente. Nós estamos convencidos que o objetivo indiscutivelmente é obter contaminação zero para todos os trabalhadores.

INTRODUCTION

The increasing use of ^{125}I for protein labelling has created the need for keeping radiation dosage to the workers exposed to this radioisotope as low as possible and, consequently, requires a greater availability of systems capable of measuring the thyroid burden (1, 2). This is particulary true for Latin American countries where a detector suitable for this type of measurement is seldom available.

We calculated that, in the São Paulo area, about 50 - 70 persons work directly with ^{125}I protein labelling and may be 10 or 20 times more use these radioiodinated products in research or clinical assay laboratories. We found it extremely important, therefore, to set up a control and scritiny policy which was not yet available. Adapting for this purpose an old detector we performed our measurements via an indirect technique based on a standard curve made by placing various cali - brated sources in a thyroid neck phantom.

Particular emphasis has been given to the methodological aspects, accuracy, precision and sensitivity as well as detector efficiency and stability. When possible the ^{125}I effective half-lives (T_{eff}) have been calculated in order to compare them to the expected value derived from the biological half-life (T_{biol}) of 138 days (3) and to several other , sometimes conflicting, literature data (4-9).

MATERIALS AND METHODS

A two channel measuring system with two scintillation counters , model Nucleopan 2K (Siemens) was adapted to our purposes (Fig. 1). Only one 5x5 cm collimated NaI (Tl) crystal detector was used, allowing thyroid measurements at a distance of 17.0 cm, the hole of the colli - mator having a diameter of 7.0 cm. In order to calibrate the system for ^{125}I with enough efficiency, some modifications were introduced in the adjustment of the high - voltage supply and in the linear amplifier unit.

Six standard sources, covering approximately the range 5 -500nCi were prepared in 1 ɸ x 7 cm polyethylene test tubes, diluting Na ^{125} I (Amersham, UK) in 1.o ml NaOH 0.1 M and adding 1 mg NaI carrier. After exact calibration in a well-type gamma counter (Gamma 4000, Beckman, USA) via the coincidence method described by Horrocks (10), they were placed in a Leucite neck phantom (1.7 cm absorption path) (Fig. 2)so as to plot a calibration curve (Fig. 3).

The sensitivity calculation was based on a t-test (one-sided, p = 0.05) carried out by comparison of n = 3 ten minutes countings of the zero point (background) and of the lowest source showing a significant difference from zero.

Each worker, who was subjected to ^{125}I contamination risk (n=30) and a control group not working with radioactivity (n=10) was monitored at least once every calender quarter. The annual thyroid doses were calculated using the MIRD pamphlet nº 11 (11) assuming that the thyroid activity remained constant during a year. The new Maximum Permissible Thyroid Burden was calculated as described by Bordell (6). Such calculation provided a value of 1.85 µCi for the MPTB.

Some of the workers with a higher thyroid burden who could remain for a certain period without working with ^{125}I, were used for the calculation of the T_{eff}.

RESULTS

In Fig. 3 an example of a standard curve which was made with seven 1 ml sources is presented. On this same curve five 30 ml sources (simulated thyroid) are also plotted, showing that this change in counting geometry does not significantly alter the detector efficiency.

The results of repeated countings and efficiency calculations carried out with the same standard source over a six month period are presented in Table 1.

An estimate of the precision of measurements was performed. Seven sources (1.35; 3.80; 11.0; 22.4; 78.1; 157.4 and 310.5 nCi) have been considered, carrying out 10 ten-minute measurements for each one of them. The coefficient of variation ranged from 2.2 to 26.3%.

Table 2 displays the results of the ^{125}I thyroidal measurements, together with the calculated annual doses of the 40 São Paulo laboratory workers considered in this study.

The semilogarithmic plot of thyroidal retention against time, with the calculated T_{eff} value for the worker with the highest contamination is presented in Fig.4. The average T_{eff} for 5 workers was calculated as 39.0 ± 0.6 days, which results in a biological half life of 111.4 days.

DISCUSSION

The thyroid monitoring technique set up in our laboratory has demonstrated to be highly sensitive, precise and accurate. Its sensitivity, calculated around 0.8 - 1.7 nCi, is at least as good as that presented by the two-probe coincidence technique described by Burns (1). This is also substantiated by the remarkably higher precision obtained in measurement of the lowest source (1.35 nCi).

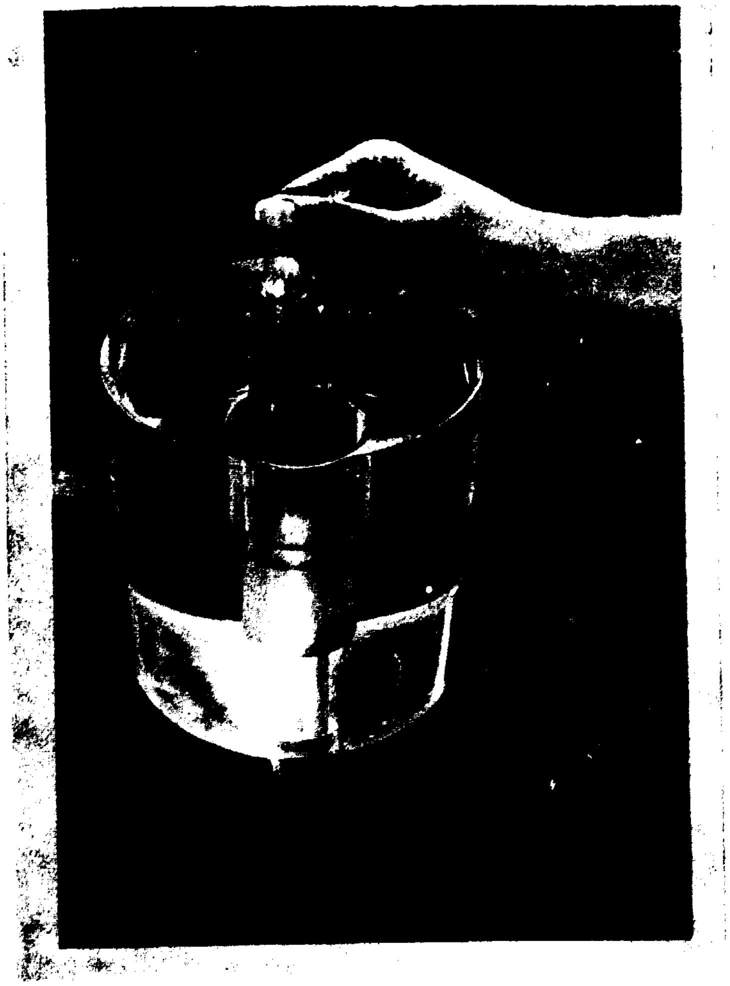
Even the change in geometry, from 1 ml to the approximate thyroid shape and volume, did not produce any significant departure from the original curve, at least up to about 500 nCi. This basically confirms the accuracy of our in-vivo measurements.

The stability in efficiency of our detector has also proved to be quite good and the introduction of an efficiency correction factor could decrease the small fluctuations sometimes occurring.

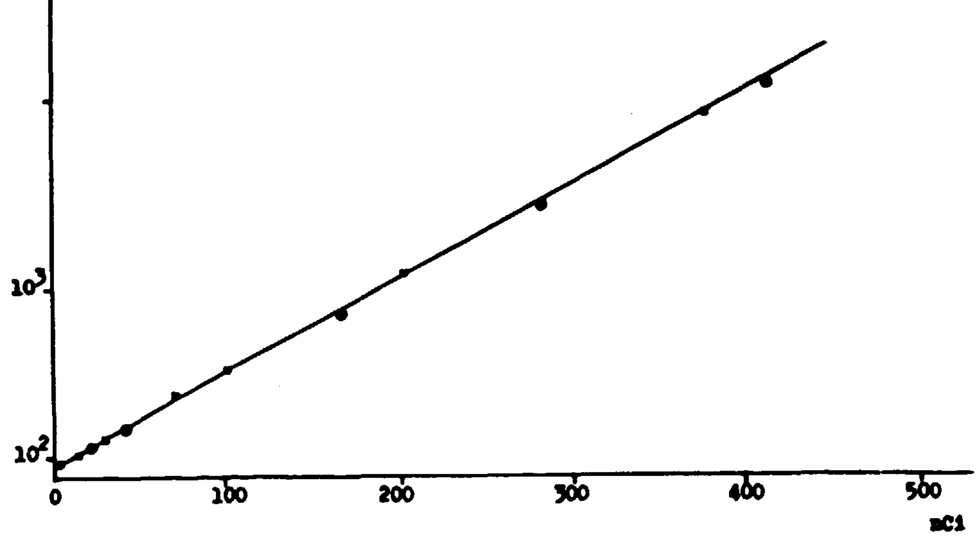
The thyroidal measurements were carried out basically among two types of populations: workers involved with ^{125}I labelling techniques and workers completely unexposed to radioisotopes. It was shown that more than 80% of the first population have a significant thyroid contamination, while no significant counting above background was ever detected in the second population.

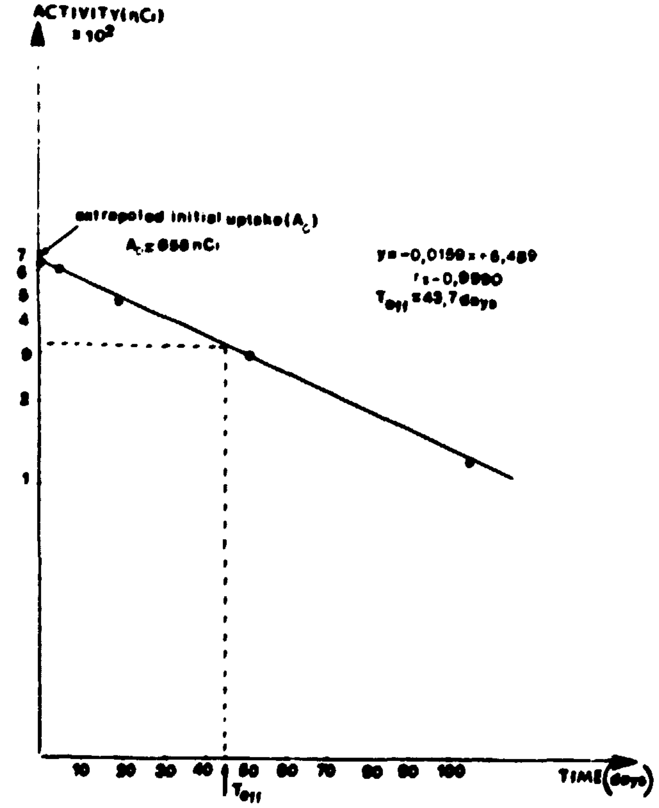
All the contaminated workers were well below the MPTB and the Maximum Permitted Annual Thyroid Dose, but we alerted the four persons whose burden was above 100 nCi, especially considering that there ex - ists controversey regarding the defined annual limit on intake (ALI) for ^{125}I (12). Besides these official considerations we are convinced that the aim must undoubtedly be towards zero contamination for all workers.

The effective half-lives of ^{125}I which could be calculated for 5 workers, presented an average value very close to the expected (3)and in good agreement with the most recent literature data.



STD. CURVE Nº	CORR. COEFF.	SLOPE (cpm/nCi)	INTERCEPT (cpm)	SENSITIVITY (nCi)
1	0.99990	5.601	32.52	0.80
2	0.99989	5.348	30.68	1.42
3	0.99993	4.788	39.01	1.69





LEGENDS

Fig. 1 Two-channel measuring system (Nucleopan 2K - Siemens), with two scintillation counters, adapted to ^{125}I thyroidal measurements.

Fig. 2 Leucite nech phantom utilized to set up the calibration curve.

Fig. 3 Example of a calibration curve obtained in the Leucite neck phantom (1.7 cm absorption path). The data reported above correspond to three different calibrations carried out over the period of a year.

—— x —— 1 ml sources in polyethylene tubes;
equation: Y = 4.788X + 39.01 (r = 0.99993)

—— ● —— simulated thyroid sources (30 ml in two 2.5 cm diameter plastic containers);
equation: Y = 4.848X + 29.44 (r = 0.99983)

Fig. 4 Elimination of ^{125}I activity from the thyroid of the employee with the highest burden and calculation of the corresponding effective half-life (T_{eff}).

Table 1. Determination of between-day counting reproducibility and detector stability using the same calibrated source (428.3 nCi at day "0")

Day	Nominal activity (dpm)	Measured activity (dpm)	Counting efficiency (%)
0	950,826	2433	0.256
4	907,897	2400	0.264
10	847,110	2032	0.240
25	712,358	1792	0.252
42	585,362	1453	0.248
45	565,426	1296	0.229
53	515,522	1304	0.253
74	404,492	1048	0.259
85	356,231	912	0.256
183	114,856	265	0.231
186	110,944	273	0.246
		$\bar{x}$ =	0.249
		SD =	±0.011
		CV =	4.52 %

Table 2. Thyroidal measurements and dose values

Employee	Maximum measured thyroid burden (nCi)	Annual dose (rem)
1	4.0	0.11
2	7.3	0.20
3	5.3	0.14
4	4.6	0.12
5	n.s.	
6	n.s.	
7	n.s.	
8	11.9	0.32
9	3.4	0.09
10	n.s.	
11	1.8	0.05
12	1.7	0.05
13	n.s.	
14	204.3	5.54
15	323.8	8.77
16	30.1	0.82
17	7.8	0.21
18	1.7	0.05
19	2.3	0.06
20	3.1	0.08
21	4.8	0.13
22	3.3	0.09
23	2.7	0.07
24	23.0	0.62
25	15.3	0.41
26	17.5	0.47
27	33.6	0.91
28	111.9	3.03
29	649.9	17.61
30	14.2	0.38
Control Group n = 10	n.s.	

n.s. (not significant) when $\angle$ 1.7 nCi

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