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Monitoring of iodine-125 and iodine-131 in thyroid of individuals in nuclear medicine centers of North West provinces of Iran

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ABSTRACT

Background: Due to volatility of radioactive iodine solutions, usually internal exposure would occur in personnel that are working in nuclear medicine centers. The activities in the thyroid of individuals who work in nuclear medicine centers of North West provinces of Iran were measured using NaI (Sodium Iodide) detectors. In every center, nearly 40 - 500 mCi of ^{131}I and 50 - 600 μCi of ^{125}I are used for diagnosis or treating patients, as well as monthly protein labeling.
Materials and Methods: A portable measurement instrument was made for this purpose. A collimator with thickness of 10 mm lead thickness of copper alloy with 2 mm was made to focus the detector on thyroid gland and to reduce the background. Two NaI (Tl) detectors one with lower thickness for ^{125}I and one with higher thickness for ^{131}I were used for measurement. The goal of these measurements was to determine the activity of radioiodines in the thyroid gland of individuals in medical centers, and to give some advice such as more care at their working place and increasing the power of their venting system for reducing radioiodines exposure. The detectors had been calibrated for ^{125}I and ^{131}I by a locally made ANSI/IAEA Plexiglass neck phantom (ANSI N44.3 1973).
Results: There were not any contamination and thyroid activities of ^{125}I in the thyroid glands of personnel. The activity of ^{131}I in the thyroid gland of individuals in all centers was lower than 0.4 kBq, and the activity of ^{131}I in one center was as high as 3.4 kBq. The background of every place was determined and subtracted from each measurement.
Conclusion: The results indicate that more measurements should have been carried out in all nuclear medicine centers to determine the activity of individuals' thyroid gland in Iran. In addition, the workers of those centers should try to reduce the intake and exposure to ^{131}I and ^{125}I using more care at their working place and more efficient ventilator. *Iran. J. Radiat. Res., 2004; 2 (3): 141-147*

Keywords: *Radioiodine, nuclear medicine centers, neck phantom, NaI (Tl) detectors, thyroid.*

INTRODUCTION

Iodine-131 (^{131}I) has been known as a radionuclide with potential adverse health effects following both occupational and environmental exposures (NCRP 1985, Zanzonico and Becker 2000, Astakhova *et al.* 1998). ^{131}I has a physical half life of 8 days, biological half life of 80 days, conceptually an effective half life of 7.3 days. With respect to occupational exposures to ^{131}I, there are two categories of workers who are potentially exposed to significant intake of this radionuclide in the course of their activity. The first groups are those working in laboratories producing ^{131}I- radiopharmaceuticals. About one TBq per month (40 Curies) of ^{131}I is usually handled in such laboratories. Although

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sophisticated facilities, including hot cells are required and applied for handling such levels of ^{131}I activity, the risk of personnel contamination resulting from containment failure or human errors always exists. Also, iodine-125 (^{125}I) production laboratory usually handle about three GBq per month (120 mCi) of ^{125}I (carrier free iodine in sodium hydroxide solution). ^{125}I is being widely used, as a tracer in radioimmunoassay studies. It is apparent that the workers, producing compounds labeled with significant amounts of activity of ^{125}I are liable to receive considerable intakes, because of the volatility of iodine element. The physical, biological, and as a result the effective half life of ^{125}I are 60, 80, and 34 days, respectively.

The second group of workers are those involved in treating patients with thyrotoxicosis or thyroid cancer and protein labeling in some nuclear medicine departments and laboratories. Such workers handle several GBq (millicuries) of ^{131}I for treating purposes (40-500 mCi) and several MBq of ^{125}I (50-600 μCi) each month. Solutions with high specific activities of ^{131}I are usually prepared and administered to patients. It is obvious that any incident during handling such source solutions can result in significant contamination of the laboratory and the personnel. The internal contamination of the workers to radioiodines mainly occurs through inhalation of airborne iodine, as an aerosol and iodine vapour. Monitoring internal ^{125}I and ^{131}I contamination of the workers is, therefore, of significance for radiation protection purposes. The individual monitoring techniques applied by the investigators include *in vivo* thyroid monitoring which is a direct method for thyroid activity monitoring of ^{125}I and ^{131}I gamma ray (Bordell *et al.* 1972, Johnson 1978, Kivinitty *et al.* 1984, Whiting *et al.* 1981) and *in vitro* bioassay of urine (Johnson 1978), or Saliva (Nishizawa *et al.* 1985). Among these, the *in vivo* thyroid monitoring is widely used, because it is the most reliable and accurate method of assessing individual contamination for iodine radioisotopes. According to recommendations of the ICRP (1998) such workers have been classified as those potentially exposed to significant internal exposure, and the implementation of routine individual monitoring program for them is necessary. This kind of monitoring, particularly for radioiodines, is more reliable and accurate than airborne and surface contamination monitoring for evaluating internal exposure of the personnel. The main reasons for inadequacy of workplace monitoring for radioiodines are the presence of radioiodines in the air in both particulate and gaseous forms, as well as the feasibility of intake through intact skin absorption. However, regular workplace monitoring in the above-mentioned laboratories and nuclear medicine centers is essential for continuous evaluation of the workplace air quality and the early detection of incidents.

Direct measurement of ^{131}I deposited in the thyroid is also applied widely, because it is the most reliable and accurate method of assessing radioiodine intake. For these measurements, various thyroid-counting instruments have been designed and applied (Nishizawa and Maekoshi 1990, Bartolini and Ribela 1988, Burns and Peggie 1980, Sumerling *et al.* 1983, Lambert 1981, Whiting *et al.* 1981, Zvonova and Shalatenko 1994, Krajewska and Krajewski 2000). The problems encountered in the application of this technique have also been reviewed (Kramer *et al.* 1993, Kramer and Meyerhof 1994 a and b, IAEA 1995).

This paper describes the programme and the results of thyroid monitoring of a group of individuals working with ^{125}I for protein labeling and ^{131}I-radiopharmaceutical for treating patients in nuclear medicine centers in the North West provinces of Iran.

MATERIALS AND METHODS

Workers and work conditions

The ^{125}I and ^{131}I-radiopharmaceutical are used for protein labeling and for treating patients (mainly in sodium iodide chemical form) in the laboratories and nuclear medicine centers. The amount of ^{125}I activity used at each laboratory was nearly 50 to 600 μCi per month (several MBq), and the amount of ^{131}I activity used at nuclear medicine centers was 40 to 500 mCi per month (several GBq).

The laboratories and nuclear medicine centers are usually equipped with fume hood which transfers the air to the outside through the hood. Also, they have a small lead shield which is used for protecting the workers against the radiations of ^{125}I and ^{131}I.

The services, provided by the National Radiation Protection Department (NRPD), consisted of routine and special individual monitoring. In addition, at some laboratories, continuous workplace monitoring for both air and surface contaminations, during and after the operations, have been carried out by health Physics officer at the laboratory.

Monitoring Programme

The workers of the laboratory and nuclear medicine centers have been monitored for thyroid activities to ^{125}I and ^{131}I by thyroid counter after working in the laboratories and nuclear medicine centers. The background of each place was determined by monitoring a person who was not involved in working with ^{125}I and ^{131}I. Based mainly on thyroid monitoring results, improvements were carried out in the facilities and procedures were introduced to reduce laboratories and nuclear medicine centers contamination. The results of monitoring were reported to the head of Radiation Protection Department and Inspection Section for more investigation on both air and surface contamination during and after operations.

Measurements and calculations

The ^{125}I and ^{131}I content in the thyroid of the workers has been measured using two different NaI (Tl) detectors. The first one was a thin window 50 mm diameter by 2 mm thick NaI (Tl) detector (Eberline Instrument Corp), and the second was a 50 mm diameter by 50 mm thick NaI (Tl) detector (Eberline Instrument Corp.). Each detector is interfaced to photomultiplier tube and can be adjusted to certain high voltage (430v for ^{125}I and 460v for ^{131}I) for better and higher counting rate. The detector incorporated a cylindrical lead collimator of 10 mm thickness (except at the mouth of the collimator), and extended 50 mm beyond the detector face. The interior surface of the collimator has been lined with 2 mm thick copper alloy sheet. Figure 1 shows the schematic of locally made lead collimator.

The detectors have been also calibrated for ^{125}I and ^{131}I measurement by a locally made ANSI/IAEA neck thyroid phantom (ANSI 1973). The phantom is a plexiglass cylinder of 127 mm diameter and 127 mm height which has a cylindrical hole for inserting a polyethylene

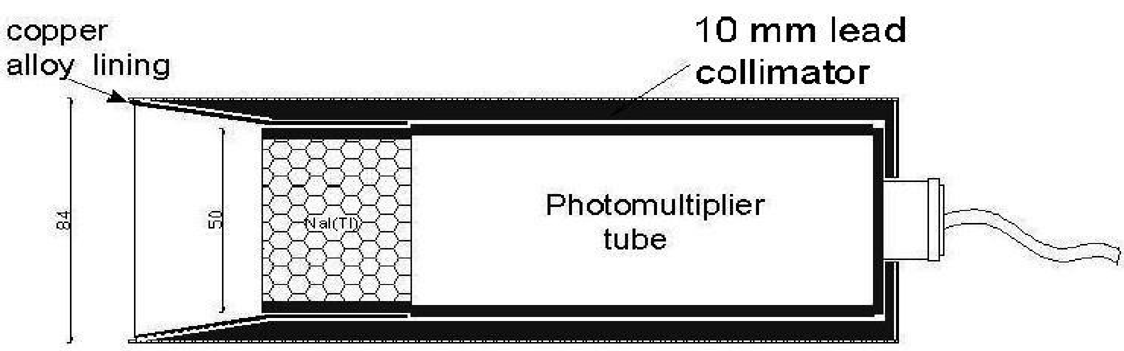

Figure 1. The locally made lead collimator with NaI (Tl) detector interfaced for measurement of ^{131}I activities in thyroid gland.

vessel of 30 ml volume as thyroid simulator. The depth of the vessel inside the phantom is 22 mm corresponding to average thyroid depth in the neck of an adult person. An investigation was also carried out to evaluate the variations of counting efficiency with thyroid depth in the neck. For this purpose a cylindrical vessel made of Plexiglas's with dimensions similar to ANSI phantom and filled with water was applied. The depth of the thyroid simulator in this phantom could have been changed from 19 to 34 mm in 5 mm intervals. The ^{125}I and ^{131}I counting efficiency of the currently used system, for an average thyroid depth of 22 mm and 50 mm counting distance, had been found to be 0.0174 and 0.0179 counts $s^{-1}Bq^{-1}$. The variations in counting efficiency for ± 3 mm changes in thyroid depth were found to be ± 6% for ^{131}I. The background count rate of the detector in 364 keV gamma-ray peak regions was found to be in the range of 6.5-7.9 counts s^{-1}. The minimum detectable activity (MDA) of ^{131}I, for 5 minutes counting time was calculated to be in the range of 46-50 Bq (1.35 nCi), with 95% confidence interval.

For determining ^{125}I and ^{131}I activity in the thyroid, each worker was counted once or twice, for 5 minutes. The background count rates of detectors in the energy of each iodine (30 keV for ^{125}I and 364 keV for ^{131}I) were different in each place. The backgrounds were determined, applied, and subtracted from each individual's thyroid activities.

RESULTS AND DISCUSSION

According to the monitoring, there were not any contamination and thyroid activities of ^{125}I in the thyroid of fourteen individuals who were working in the laboratories and nuclear medicine centers; however, there were considerable activities of ^{131}I activities in thyroids of 9 individuals; further were significant even in one nuclear medicine center, one of the workers had contaminations very close to the investigation level, and one of them had thyroid activity higher than investigation level. Investigation level is the value of a quantity such as effective dose, intake, or contamination per unit or volume above which an investigation should be conducted. There were sixteen measurements of activities for ^{131}I in thyroid of individuals' gland. In one nuclear medicine center there was no contamination on thyroid gland activity similar to the location of nuclear medicine center of B (in table 1), and the background activity was the same as place B (474.2 cpm).

In spite of the fact that nuclear medicine centers radiation workers worked with lower amount of radioisotope than those who worked in the production center, in one center they had more internal contamination to ^{131}I in their routine work (Alirezazadeh *et al.* 2003). There is no any internal contamination in nuclear medicine centers for radiation workers where there were considerable internal contaminations of ^{125}I for those who worked in productions laboratory (Alirezazadeh *et al.* 2004). The backgrounds for ^{125}I and ^{131}I, which were measured for those who were not involved in working with radioiodines, were within 20.4-56 and 407-474.2 cpm.

Table 1 shows the result of the measurements of ^{131}I activities in the thyroid of individuals using portable locally made instrument.

As it can be seen, by recommendation of ICRP on radiological protection, the contaminations of two individuals in one nuclear medicine center has been considerably higher than others; i.e., in one individual the rate was very close to the investigation level and in another person it was higher than investigation level (ICRP 1989, 1994, 1987, 1991). Suggestions and advices were introduced to decrease the inhalation of radioiodine such as the use of gloves and increasing the suction of their venting system. Also, the results indicated that the portable instrument with the locally made collimator is very efficient and the results are reliable. Moreover, all parts of instrument can be easily and quickly assembled and be ready for monitoring the activities in thyroid gland. In addition, the

Table 1. The activity of ^{131}I in thyroid gland using NaI (Tl) detector with locally made collimator.

NO.	Nuclear Medicine Center	Gross Count (cpm)	Background of N.M.C. (cpm)	Net Count (cpm)	Activity in Thyroid Gland (Bq)
1	A	467.1	440	27.1	30.8
2		596	440	156	177
3		659	440	219	249
4		--	440	---	---
5	B	759.7	474.2	285.5	324.2
6		788	474.2	313.8	356.3
7		--	474.2	--	--
8		--	474.2	--	--
9	C	2373.1	422.3	1950.8	2215.1*
10		3426.5	422.3	3004.2	3411.2*
11	D	--	407	--	--
12		--	407	--	--
13		--	407	--	--

* Investigation level of ^{131}I activity in thyroid gland is 2220 (Bq).

amounts of background activities of the instrument in different places and locations were similar.

CONCLUSION

The results indicated that the portable locally made collimator with NaI (Tl) is very efficient for quick measurement of activities in thyroid gland of individuals working with ^{125}I and ^{131}I at laboratory and nuclear medicine centers. In addition, more measurements should be carried out in all nuclear medicine centers of other provinces in Iran to determine the activity of individuals' thyroid glands. Also, more work on the instrument should be done to increase its efficiency and if possible to try to improve the mechanical shape for adjustment of detector to the thyroid glands of individuals in the future. In nuclear medicine centers with high air contaminations, more care and better equipments, such as a more efficient ventilator, should be used to reduce the inhalation and intake to ^{125}I and ^{131}I at their working place.

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