VNU Journal of Science, Mathematics - Physics 25 (2009) 179-184

Intercomparison on internal dose assessment for ^{131}I

Nguyen Van Hung[1,*], Bui Van Loat[2]

[1]*Nuclear Research Institute, 1 Nguyen Tu Luc, Dalat*
[2]*College of Science, VNU, 334 Nguyen Trai, Thanh Xuan, Ha Noi*

Received 4 June 2009

Abstract. The paper resented the results of assessing internal dose for ^{131}I by the direct method for Vietnamese objects that was issued in the Intercomparison Program of IAEA. The results on experimental measurements, calculating intake (I) of ^{131}I to thyroid by the specilizing system for measuring thyroid activity, and committed effective dose E(50) using the specializing code of LUDEP 2.0 were shown that the results carrying out at the Nuclear Research Institute ($I = 1.48.10^5$ Bq, E (50) = 2.32 mSv) were good and were in accordance with the those of the authors in other laboratories in the world.

Keywords: Occupational exposure, Intake, Thyroid dose, Committed effective dose, LUDEP 2.0.

1. Introduction

There have been several intercomparison exercises organized already at national and international levels for the assessment of occupational exposure due to intakes of radionuclides to the body. These intercomparison exercises revealed significant differences in approaches, methods and assumptions, and consequently in the results. Therefore, IAEA organized a new intercomparison exercise in cooperation with the IDEAS project under the 5th EU Framework Programme (EU Contract No. FIKR-CT2001-00160) and invited participating contries. Content of intercomparison exercises consists of assessing intakes of HTO, ^{137}Cs, ^{90}Sr, ^{60}Co, ^{131}I, enriched uranium, Pu and ^{241}Am. The results were received from 42 countries with 81 participants and 72 reports, in which there were 63 participants having the reports of ^{131}I. The laboratory code of No.50 located at the Nuclear Research Institute attended this intercomparison program also [1].

This new intercomparison exercise focused especially on the effect of the guidelines for harmonization of internal dosimetry. It also considered the followwing aspects: i) to provide possibilities for the participating laboratories to check the quality of their internal dose assessment methods in applying the recent ICRP recommendations (e.g. for the new respiratory tract model); ii) to compare different approaches in interretation of internal contamination monitoring data; iii) to quantify the differences in internal dose assesment based on the new guidelines or on other procedures, respectively; iv) to provide some figures for the influence of the input parameters on the monitoring results; and v) to provide a broad forum for information exchange [1].

IAEA organized a new intercomparison exercise in cooperation with the IDEAS project under the 5th EU Framework Programme (EU Contract No. FIKR-CT2001-00160) and invited participating

* Correcsponding author. E-mail: ngvhung@hcm.vnn.vn

contries. Several cases have been selected for this exercise with the aim of covering a wide range of practices in the nuclear fuel cyce and in medical applications. The cases were: i) acute intake of HTO; ii) acute inhalation of fission products ^{137}Cs and ^{90}Sr; iii) intake of ^{60}Co; iv) repeated intakes of ^{131}I; v) intake of enriched uranium; and vi) single intake of plutonium radionuclides and ^{241}Am [1].

Based on the equipment on measuring activity of ^{131}I in thyroid and the computer Program for Lung Dose Evaluation in version of 2.0 (LUDEP 2.0) that have had at the Nuclear Research Institute, the case on internal dose assessment of ^{131}I for the radiation workers working at the radioisotope production laboratory by direct method (in-vivo method) was done [2,3].

2. Experimental

2.1. Case description

In order to evaluate exactly internal radiation dose, case description had to be carried out in detail. In case of evaluating internal dose of ^{131}I for the radiation workers working at the radioisotope production laboratories, case description was follows:

2.1.1. The event

- Description of the working area (Chemical laboratory in a medical institution): The chemical laboratory (belongs to the Center for Research and Productin of Radioisotope, Nuclear Research Institute) has been used to produce radiopharmaceuticals of ^{131}I for thyroid diagnosis and therapy of patients in nuclear medicine of hospitals. It consists of hot cells and production boxes for preparing and handling ^{131}I [5].

- Characteristics of work (Preparing and handling radiopharmaceuticals of ^{131}I for therapeutic purposes): Radiopharmaceuticals of ^{131}I were produced by irradiating TeO_2 targets during 100 hrs. (from Monday morning to Friday afternoon in a week) at the "neutron trap" of Dalat nuclear reactor with thermal flux of 2.2×10^{13} n/cm^2/sec. After that, the irradiated products were handled in the hot cells and the boxes in order to become the radiopharmaceutical of ^{131}I [2].

- Reasons for monitoring; initiating event: During handling highly radioactive material (on Monday of next week), ^{131}I in type of elementary iodine was released in the air of the laboratory which causes internal exposure to the radiation workers through inhalation. Therefore on the following days, the workers were routinely monitored via direct measurements (in-vivo) for thyroid as well as via indirect ones (in-vitro) by urine analysis, but the in-vivo method was used here [2,3,4,5].

- Actions taken: Because a high level of ^{131}I activity was measured in the thyroid, the measurement was repeated on the following days.

2.1.2. Additional information

- Air monitoring: Measurements for radioactive concentration of ^{131}I in the air of the laboratory could be carried out by using the portable sampler for collection of iodine through activated charcoal filters. After that, radioactive activities on these filters were determined by the low background gamma spectrometer with HPGe detector. From that, radioactive concentration of ^{131}I would be determined [3].

- Chemical form: Elementary iodine
- Physical characteristics, particle size: Vapour
- Nose swab, bronchial slime or similar: None
- Non removable skin contamination: None
- Wound site activity: N.A.

- Any intervention used (blocking, chelating, etc.): None

2.1.3. Personal Data

Sex: Male

- Age: 50
- Weight: 54 kg

2.1.4. Monitoring data for organ activity

Applying direct technique by the specilizing system for measuring activity of ^{131}I in thyroid (the single-channel spectrometer coupled with NaI(Tl) detector and the thyroid calibration blocks) [2-5]. The measured thyroid activity of ^{131}I with time was shown in Table 1.

2.1.5. Intake and dose estimation

From the data in Table 1, values of intake (I) and committed effective dose E(50) for ^{131}I were detemined with the internal dose assessment code of LUDEP 2.0. The calculated results were as follows:

$$I = 1.48.10^5 \text{ Bq} \quad (1)$$

$$E(50) = 2.32 \text{ mSv} \quad (2)$$

Table 1. The measured thyroid activity of ^{131}I for the radiation worker

Week days (d)	Time after the first day of handling (d)	Thyroid activity of ^{131}I (Bq)	Comment
Monday of the first week	0		One day for handling
Tuesday	1	2.05E+03	1st day of measurement
Wednesday	2	1.91E+03	2nd day of measurement
Thursday	3	1.74E+03	3rd day of measurement
Saturday	5	1.44E+03	5th day of measurement
Monday of the second week	7	1.19E+03	7th day of measurement
Wednesday	9	9.89E+02	9th day of measurement
Thursday	10	8.20E+02	10th day of measurement
Saturday	12	6.19E+02	12th day of measurement
Tuesday of the third week	15	5.14E+02	15th day of measurement
Thursday	17	4.39E+02	17th day of measurement
Sunday	20	2.43E+02	20th day of measurement
Friday of the fourth week	25	1.54E+02	25th day of measurement

2.2. Discussion

2.2.1. Generation of data set

The data set was generated artificially assuming an acute intake of 40 kBq of ^{131}I on each day of the three day working period. Thus, these intakes during the three consecutive days (a total of 120 kBq) would give a committed effective dose of 2.40 mSv applying the appropriate dose coefficient of $2.0.10^{-8}$ Sv/Bq (ICRP-68 and ICRP-78) [1].

The predicted thyroid activities were generated with internal dose assessment code of IMBA. Uncertainties (i.e. scatter of data) were then included by assuming that the measuremnts follow a lognormal distribution with a geometric standard deviation (i.e. SF) of 1.2. From that, the best estimate of intake per day was 43.2 kBq (it meand that the total intake during the three day working period was 130 kBq). Thus, the committed effective dose could be calculated as $1.3.10^5 \times 2.0.10^{-8} = 2.6.10^{-3}$ Sv = 2.6 mSv [1].

2.2.2. Overall distribution of results

The statistical evaluation of the results, excluding outliers by IAEA and IDEAS was given in Table 2.

Table 2. Characteristic parameters of the statistical evaluation (excluding outliers) [1]

Parameters	Intake	E(50)
N	58	50
Geometric mean (GM)	160133 Bq	2.57 mSv
Geometric standard deviation (GSD)	1.39	1.07
Arithmetic mean (AM)	169659 Bq	2.58 mSv
Arithmetic standard deviation (ASD)	62153 Bq	0.17 mSv
Minimum	88000 Bq	2.2 mSv
Maximum	329000 Bq	3.0 mSv
Max/Min ratio	3.74	1.36
Outliers	5	13

The below figures shown frequency distributions and ratios of all individual results normalized to the geometric mean.

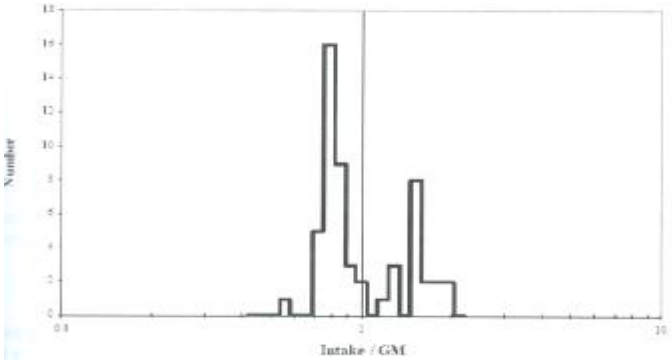

Fig. 1. Frequency distribution of results without outliers (N = 58). ^{131}I normalized to the geometric mean (GM = 160133 Bq, GSD = 1.36) [1].

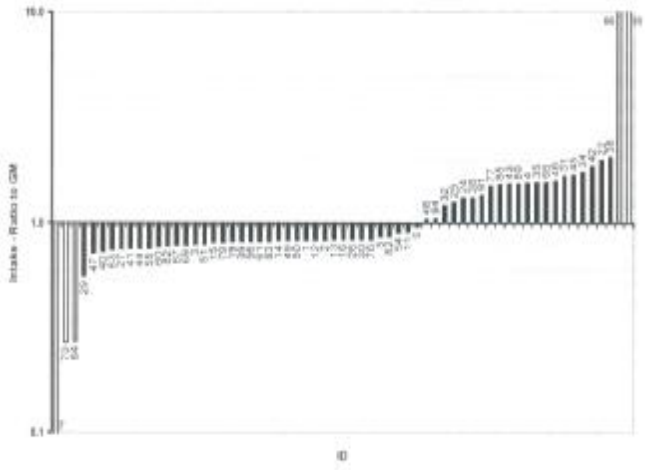

Fig. 2. Ratios of all individual results normalized to the geometric mean (GM = 160133 Bq, GSD = 1.36, N = 58). The outliers were indicated with blank columns [1].

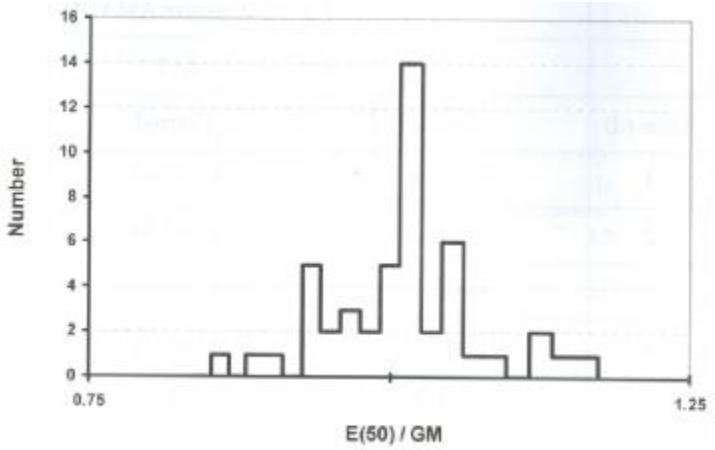

Fig. 3. Frequency distribution of results without outliers (N = 58). Values of committed effective dose due to ^{131}I normalized to the geometric mean (GM = 2.57 mSv, GSD = 1.07) [1].

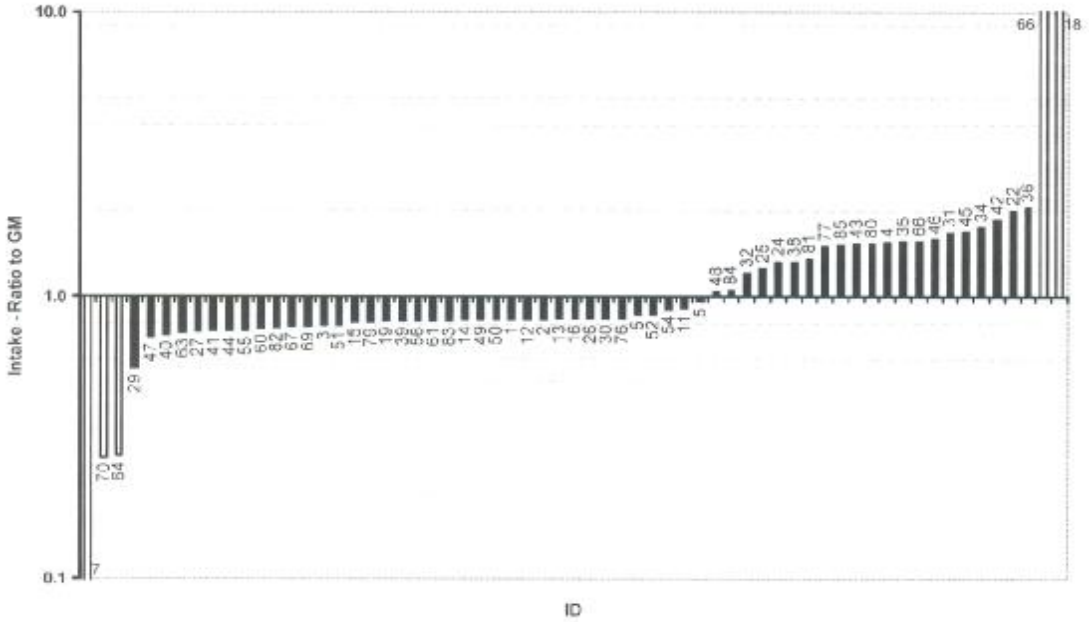

Fig. 4. Ratios of all individual results normalized to the geometric mean (GM = 2.57 mSv, GSD = 1.07, N = 50). The outliers were indicated with blank columns [1].

Laboratory code of Vietnam was 50. Thus the calculated values of intake and E(50) from the code of 50 were good and not belonged outliers.

2.2.3. Identification of outliers

Outliers were identified by the statistical criteria described in the Table 2. Total number of submitted results from the participants were 63 for intake and 63 for E(50), and number of identified outliers were 5 for intake and 13 for E(50).

2.2.4. Software used

Altogether 20 different internal dosimetry software were used by the participants. The most frequently used software code was IMBA, but other programmes were also used by more participants. Twelve participants used IMBA, six used LUDEP, four used MONDAL, whereas three participants used IMIE or AIDE, two indicated the use of IDEAS DV0102 and Mathematica - Excel, while one participant used other 13 codes. As many as 17 participants declared that they used no software but manual evaluation methods.

In the used software of LUDEP, intake retention fractions and dose coefficients were based "Human Respiratory Tract Model", "Gastrointestinal Tract Model", and "Systemic Biokinetic Model" in ICRP-66, ICRP-30, and ICRP-54, respectively [2-5].

3. Conclusion

The laboratory on internal radiation dosimetry of Nuclear Research Institte had attended the intercomparison on internal dose assessment for intake of ^{131}I through inhalation by the direct method (in-vivo method). The measured and calculated results of intake ($I = 1.48.10^5$ Bq) and committed effective dose ($E(50) = 2.32$ mSv) for ^{131}I were shown that they were good (with error of 10% in comparison with the reference values) and were in accordance with the results of other authors attending the research cooperation project. Thus, they were also issued in the specialized book namely as IAEA-TECDOC-1568 (Intercomparison Exercise on Internal Dose Assessment, Final report of a joint IAEA-IDEAS project, IAEA, Sept. 2007) [1]. This work is financially supported by Joint IAEA-IDEAS Project, IAEA-TECDOC-1568 and QG 09-06 Project.

References

[1] IAEA, *Intercomparison exercise on intenal dose assessment*, Final report of a joint IAEA-IDEAS project, IAEA-TECDOC-1568, September 2007.

[2] Nguyen Van Hung, *Research in internal dose dosimetry based on methods of whole-body measurement and Human urine analysis*, PhD thesis in physics (in Vietnamese), MOET, September 2003.

[3] Hoang Van Nguyen, Nguyen Van Hung et al., *Some researches in the field of radiation dosimetry*, Final report of the ministry's research project for 1998-1999 (in Vietnamese), MOST, March 2000.

[4] Nguyen Van Hung et al., *Internal radiation dosimetry for some of gamma emitting radionuclides by a chair-type whole-body counter using a scintillation detector*, Final report of the institute's research project for 2003 (in Vietnamese), VAEC, August 2005.

[5] Nguyen Van Hung et al., *Research in internal dosimetry for radiation workers for some of gamma emitting radionuclides by direct method with using a chair-type whole-body counter*, Final report of the institute's research project for 2002 (in Vietnamese), VAEC, March 2003.