Measurement of the internal organs' absorption and extracorporeal excretion of radioactive iodine fit to the characteristics of Koreans

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1. Introduction

Radiation dosimetry will prove helpful to active approaches, such as limiting the amount of radiation exposure, which can be called the negative effect of radiation on the body, or using radiation to treat diseases.[1-4] Defective nuclear fuel at a nuclear power plant or ^{131}I used for oral thyroid gland examination and treatment of cancer may cause internal exposure during the replacement of nuclear fuel, or maintenance. Also, it is reported that, clinically, ^{131}I has the negative function of increasing the radiation exposure of the other organs as well as the positive function related to thyroid gland diagnosis and cancer treatment. Estimation of internal exposure to ^{131}I must take the physical properties of ^{131}I and the physiological properties of individuals into account. The extracorporeal excretion rate of radionuclides and the proportion remaining in the body may vary depending on the physiological properties of the Oriental and Occidental people. The existing physiological properties are data originating from Westerners, so if the data are applied to Koreans, differences in dietary life and physiological properties may lead to underestimation or overestimation of internal exposure. Therefore, this study aims at measuring the radionuclide absorption and excretion rates in human organs to establish the physiological radionuclide metabolism fit to Koreans and the Oriental people whose physique is similar to that of Koreans.

2. Methods and Results

With adult males in their late 20's and early 30's in the experiment group, radioactive iodine 100uCi was administered orally, and the internal organs' absorption and extracorporeal excretion rate were measured. The thyroid gland uptake and urinary excretion rate estimation method is described in 2-1 and 2-2.

2.1 Thyroid gland absorption estimation methodology [5]

$$Uptake\ \ rate(\%) = \frac{A-B}{C-D}\times 100 \qquad (1)$$

where is A; neck coefficient
B; background radiation (type B filter)
C; standard source coefficient
D; background radiation (type B filter)

2.2 Urinary Excretion rate estimation method [5]

$$Urinary\ \ Excretion\ \ rate(\%) = \frac{\frac{E}{55}\times(F-G)}{\frac{1000}{55}\times(H-G)}\times 100 \qquad (2)$$

where is E; 24-hour amount of urination
F; urinary radiation of the specimen
G; comparison urinary radiation
H; standard solution radiation

2.3 Analysis of differences in uptake and urinary excretion rate by time

This study administered 100uCi ^{131}I orally to Korean adult males to measure the thyroid gland uptake and urinary excretion rate of radioactive iodine fit to the physiological characteristics of Koreans. After a certain number of hours afterwards (2, 4, 6, and 24 hours) radiation in the thyroid gland, the liver, the stomach, the small intestine, the kidney, and urine were measured, and on this basis the internal organs' uptake and urinary excretion rate were estimated.

[Table 1] uptake and excretion rate by time

time / Organ	2 hours	4 hours	6 hours	24 hours	F-value (p value)	Post-hoc comparison
	M (SD)	M (SD)	M (SD)	M (SD)		
thyroid gland	6.60 (1.96)	10.51 (3.26)	13.69 (5.48)	19.45 (4.75)	31.68 (.000)	(1,3)(1,4) (2,4)(3,4)
liver	2.49 (.63)	1.92 (.72)	1.69 (.97)	.34 (.46)	28.66 (.000)	(1,3)(1,4) (2,4)(3,4)
stomach	6.02 (2.08)	4.82 (1.77)	4.64 (2.81)	.33 (.12)	29.06 (.000)	(1,4) (2,4)(3,4)
small intestine	2.75 (1.82)	2.01 (1.53)	2.11 (2.54)	.28 (.13)	6.64 (.001)	(1,4) (2,4)(3,4)
right kidney	1.87 (.39)	1.38 (.30)	1.2 6(.50)	.21 (.06)	78.14 (.000)	(1,2)(1,3) (1,4)(2,4) (3,4)
left kidney	3.48 (1.03)	2.55 (.85)	2.58 (1.66)	.25 (.09)	29.94 (.000)	(1,4) (2,4)(3,4)
urinary excretion	19.39 5.36)	16.27 (2.81)	9.92 2.97)	72.66 (10.80)	373.56 (.000)	(1,3)(1,4) (2,3)(2,4) (3,4)

Time-based analysis of differences between different organs after oral administration of ^{131}I revealed, first, that the thyroid gland showed an average of 19.45% uptake 24 hours later, and the uptake rate tended to increase over time (2 hours later: 6.50%, 4 hours later: 10.51%, 6 hours later: 13.69%, 24 hours later: 19.45%). In addition, at the 0.05 significance level, the differences were statistically different. To see what difference there is between different times, Duncan test was conducted at the 0.05 significance level. The result showed that there was a significant difference between 2 hours later and 6 hours later, between 2 hours later and 24 hours later, between 4 hours later and 6 hours later, and between 4 hours later and 24 hours later respectively. However, organs other than the thyroid gland showed the highest uptake rate 2 hours after the administration of radioactive iodine, and the uptake rate tended to decrease afterwards. The differences were significant at α=0.05

As for urinary excretion rates, the excretion rate 24 hours later was 72.66%, similar to the value presented by ICRP-54. In addition, the urinary excretion rates reached the peak 2 hours after the administration of radioactive iodine, and declined afterwards. The urinary excretion rates showed statistically significant differences as the thyroid gland uptake rates did ($p < .05$). These results deviate from the argument reported at ICRP-53 that 'absorbed radioactive iodine begins to be excreted in the urine approximately 6 to 8 hours later,' which is thought to be attributed to the physiological differences between Westerners and Koreans.

3. Conclusion

As part of the experiment to estimate the absorbed dose of the radionuclide fit to the characteristics of Koreans, this study selected ^{131}I and measured the internal organs' uptake rate and excretion rate. As for the experimental methodology, ^{131}I were administered to adult males orally, and the radioactivity of thyroid gland, the liver, the stomach, the small intestine, the kidneys and the urine was measured after the lapse of 2, 4, 6 and 24 hours, and calculated the internal organs' uptake and urinary excretion rate. The organs showed the maximum uptake and urinary excretion rate 2 hours after the administration of ^{131}I, and then began to decrease afterwards, but the thyroid gland showed 19.45% uptake on the average 24 hours later. Except the thyroid gland the exposure dose was the highest in the stomach, followed by left kidney, the liver, the small intestine, and the right kidney in that order. In addition, the change in the thyroid gland absorption 24 hours after the administration of radioactive iodine showed a result different than the existing ICRP-54 data evaluated at 30% concentration. Accordingly, it is necessary to minimize errors of the existing 3-compartment model presented by ICRP for quantitative estimation of absorbed dose of iodine (^{131}I) by refraining from the use of the 3-compartment model and setting up a compartment for each organ, and estimate internal absorbed dose in a way fit to the characteristics of Koreans and Asians similar to Koreans.

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REFERENCES

[1] Robert Lovinger, Thomas F. Budinger, MIRD Primer for Absorbed Dose Caluculations, Society of Nuclear Medicine (1991).

[2] Jeffry A et al, MIRD Pamphlet No 16 . J Nucl Med. 1999;40:37S-61S

[3]Howell R.W. Wessels BW, Loevinger R, et al The MIRD perspective 1999. J Nucl Med. 1999;40:3S-10

[4] M.G. Stabin, M Tagesson, S.R. Thomas, M. Ljungberg, S.E. Strand. Radiation dosimetry in nuclear medicine. Applied Radiation and Isotopes 50(1999)73-87.

[5]Chang-Soon Koh. Nuclear Medicine. Seoul: Korea Medical Book Publisher, (1997).