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Effective Half Life of Iodine for Five Thyroidectomy Patients Using an *in vivo* Gamma Camera Approach

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Biological half life/Effective half life/Thyroidectomy/Thyroid/Ablation/Iodine.

The effective half-life of radioactive iodine for (near) thyroidectomy patients was evaluated using an *in vivo* gamma camera approach. Five patients with post administered iodine for remnant ablation of thyroid were thoroughly scanned *in vivo* for one to four weeks. Derived data were analyzed in a *MATLAB* program to revise the ICRP recommended effective half-life and, thus, to offer a more reliable dose predication protocol from a health physics viewpoint. A quantitative index, AT (Agreement), was also introduced to specify the deviation between the actual measurement and the results fitted in *MATLAB* for each patient. The ATs were evaluated as 1.52 ± 1.54 and 14.05 ± 11.01 for the thyroid compartment and the remainder, re-spectively, indicating a slight discrepancy between the computed and practical results for the remainder. The actual effective half-life of iodine in the thyroid or the body fluid compartment shifted from 7.3d or 0.24d to only 0.61 ± 0.50d or 0.49 ± 0.23d, respectively. Additionally, the integrated T_{eff} for the remainder (both body fluid and whole body compartments) was still about 5.8d, since the body fluid and the whole body compartment was inseparable in real whole body scanning. The branching ratio from body fluid compartment to the thyroid and the excretion compartment also changed from 30% and 70% to 11.6 ± 14.0% and 88.4 ± 14.6%, respectively. The thyroid was the dominant compartment for a healthy person in the traditional biokinetic model. However, this dominant compartment was shifted to both thyroid and body fluid, based on analyses of the data following thyroidectomy, for the patients herein.

INTRODUCTION

This work presents the evaluation of the effective half-life of iodine for (near) total thyroidectomy using an *in vivo* gamma camera approach. Iodine-131 has been extensively adopted to treat thyroid cancer. After initial treatment (near-total or total thyroidectomy), most patients are treated with ^{131}I for ablation of the residual thyroid gland.[1–4] However, estimates of cumulative absorbed doses for patients and people around these patients remain controversial, since the effective half-life of iodine differs dramatically between thyroidectomy patients and non-patients.[5–7] The ICRP-30 report in 1978 gave the established criteria for the iodine biokinetic model with all related information for a healthy person,[8] but no attempt was made to evaluate the iodine effective half-life for thyroidectomy patients until the last two decades, despite the fact that the obtained data remain very disparate.[5,6,9–11] The evaluation of the iodine effective half-life for patients following remnant ablation of thyroid must be reconsidered from various perspectives, since the most dominant gland, thyroid, for (near) total thyroidectomy patients is the remnant gland of interest. Furthermore, The specific evaluation is essential from the viewpoint of dose prediction and cancer risk assessment. Researchers have also noted the disagreement between theoretical suggestions and real evaluations of thyroidectomy patients. Some simplified biokinetic models with two compartments have been adopted based on whole body counting for patients with only a single NaI detector. Yet, the unsuitable assumption in the simplified model may also cause error in the interpretation of the evaluated data. Since a single NaI detector as employed in earlier works can detect only the gross radioactive gamma ray in each patient, despite the presence of various organs, it is ineffective for evaluating precisely the iodine effective half-life of each compartment in humans. At least two or three model-based time-dependent data must be initially input to determine the complexity of simultaneous differential equations of iodine biokinetic model. In contrast, the use of a gamma camera to

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survey patients' absorption of radio pharmaceutical products meets the criteria for evaluating the iodine biokinetic model. The precise setting for region of interest (ROI) and gamma ray counts acquiring system of gamma camera easily determines the time-dependent gross counts in any particular ROI by making *in vivo* measurement of various patients. The revised T_{eff} of ^{131}I is determined from many *in vivo* measurements made for thyroid carcinoma patients. Five patients underwent one to four weeks of whole body scanning using a gamma camera following surgical ablation of the thyroid. Derived data thus obtained were analyzed and normalized as the input data to fit a *MATLAB* program. Revised T_{eff} of ^{131}I differed significantly from those obtained using an ICRP-30 and agreed partially with the empirical findings of other works.

MATERIALS AND METHODS

Biokinetic model of iodine

According to the ICRP-30 report, a typical human body can be divided into five major compartments in the biokinetic model of iodine: (1) stomach, (2) body fluid, (3) thyroid, (4) whole body, and (5) excretion, respectively as clearly illustrated in Fig. 1. Additionally, the simultaneous differential equations for obtaining the time-dependent correlation for each compartment are also indicated in Eq. 1 ~ 4.

$$\frac{dq_1}{dt} = -(\lambda_R + \lambda_{12})\, q_1 \tag{1}$$

$$\frac{dq_2}{dt} = \lambda_{12}\, q_1 - (\lambda_R + \lambda_{25} + \lambda_{23})\, q_2 + \lambda_{42}\, q_4 \tag{2}$$

$$\frac{dq_3}{dt} = \lambda_{23}\, q_2 - (\lambda_R + \lambda_{34})\, q_3 \tag{3}$$

$$\frac{dq_4}{dt} = \lambda_{34}\, q_3 - (\lambda_R + \lambda_{42} + \lambda_{45})\, q_4 \tag{4}$$

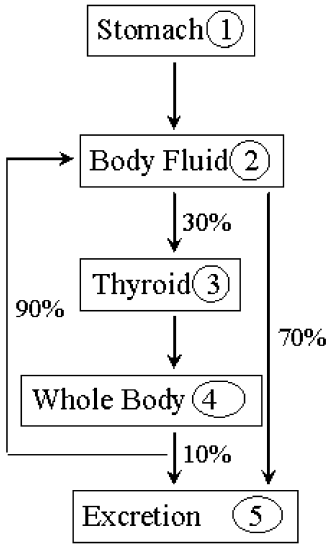


Fig. 1. Biokinetic model of Iodine for a standard healthy man. The model was recommended from ICRP-30.

The q_i and λ_i is defined as the time-dependent quantity of ^{131}I in each compartment and the decay constant between each compartment, respectively. Since the biological half-lives of iodine recommended by ICRP-30 for the stomach, body fluid, thyroid and whole body are 0.029d, 0.25d, 80d and 12d, respectively, the corresponding decay constants for each variable can be calculated [cf. Table 1]. Additionally, the time-dependent quantity of iodine in each compartment [cf. Fig. 2] and the initial time is defined as the time when a ^{131}I dose is administered to patient. The results can be calculated and plotted using an self-developed *MATLAB*

Table 1. The coefficients of variables for simultaneous differential equations as adopted in this work. The calculation results are theoretical estimations of the time-dependent quantity of iodine in various compartments for a typical body. Additionally, the decay constant for physical half life of ^{131}I is indicated as λ_R and the decay half-life is 8.02d.

λ	coeff.	derivation
λ_R	0.0862 d^{-1}	ln2 / 8.02
λ_{12}	24 d^{-1}	ln2 / 0.029
λ_{23}	0.832 d^{-1}	0.3 × ln2 / 0.25
λ_{25}	1.940 d^{-1}	0.7 × ln2 / 0.25
λ_{34}	0.0087 d^{-1}	ln2 / 80
λ_{42}	0.052 d^{-1}	0.9 × ln2 / 12
λ_{45}	0.0052 d^{-1}	0.1 × ln2 / 12

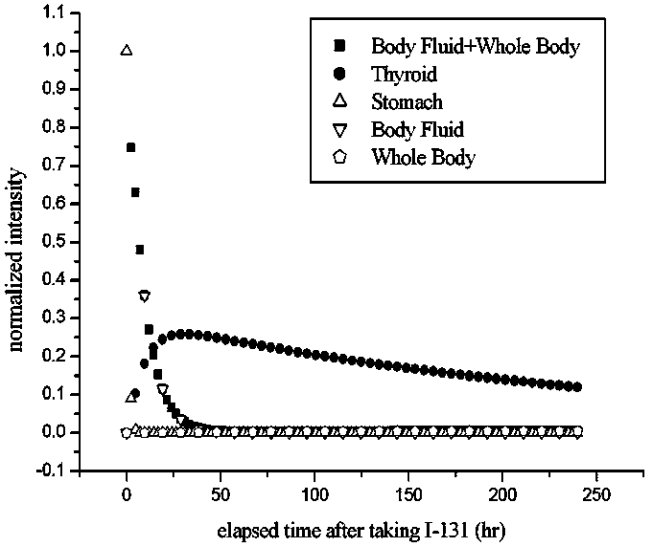


Fig. 2. The theoretical estimation for time-dependent quantities of iodine in various compartments of the biokinetic model. The solid dots represent either the sum of body fluid and whole body or the thyroid gland. The acquired data from either body fluid or whole body cannot be split in real measurement, whereas the thyroid gland is easily identified during data collecting.

Table 2. Patients' characteristics. Five patients underwent whole body scanning for further analysis of iodine biokinetic model.

subject no.	gender	age	weight (kg)	syndrome	status of remnant
1	female	46	62	palillary thyroid cancer	complete ablation
2	female	37	58	palillary thyroid cancer	minimal residual
3	female	37	55	palillary thyroid cancer	complete ablation
4	female	38	41	palillary thyroid cancer	minimal residual
5	male	35	84	palillary thyroid cancer	complete ablation

program. The *MATLAB* program was designed to solve and plot the time-dependent simultaneous differential equations (1)~(4). The thyroid compartment dominates the time-dependent function (Fig. 2). Since the thyroid gland accumulates most of the iodine nuclides, the number of residual nuclides in other compartments declines rapidly over the first 50 hours (~2 days). Furthermore, the derived effective half-life T_{eff} of iodine (~7.5d) is consistent with the theoretical definition, and equals the inversion of the sum of the inversion of the physical and the biological half-lives. However, the definition of the coefficients in Table 1 are inappropriate for all (near) total thyroidectomy patients since the dominant gland, the thyroid, is only the remnant gland in reality. Additionally, the thyroid cannot contain sufficient iodine for a long enough holding time since only about 1~5% of the thyroid remains following surgical resection. The biokinetic model of iodine for thyroidectomy patients must be reconsidered to determine the actual metabolic mechanism.

Patients' characteristics

Five patients (4F/1M) aged 37~46 years underwent consecutive one to four weeks whole body scanning by gamma camera after post surgical administration of ^{131}I for ablation of residual thyroid. Table 2 lists patients' characteristics. In addition, all five patients were accomplished the iodine clearance measurement before the practical scanning to suppress the interfering of evaluated data herein.

Experimental setup

Gamma Camera

The adopted gamma camera (SIEMENS E-CAM) was located at Chung-Shan Medical University Hospital (CSMUH). The gamma camera's two NaI $48 \times 33 \times 0.5$ cm^3 plate detectors were positioned 5 cm above and 6 cm below the patient's body during scanning. Each plate was connected to 2"-diameter 59 Photo Multiplier Tube (PMT) for data recording. Ideally, the 2 detectors can capture ~70% of the emitted gamma ray. Each patient scanned was given 1.11 GBq (30 mCi) ^{131}I capsule for thyroid gland remnant ablation. The ^{131}I capsule was carrier free with a radionuclide purity exceeding 99.9% and radiochemical purity exceeding 95.0%. All radio pharmaceutical capsules were fabricated by Syncor Int., Corp. The coefficient of variance (%CV) between capsules from the same fabricated batch was less than 1.0% confirmed by spot checks.[12] Thus, the position-sensitive gamma ray emitted from the ^{131}I dose administration for patient can, then, be analyzed and plotted.

Table 3. The time schedule for, and measured data from, whole body scanning of patient subject 1 in first week. The last column presents data for the thigh area and simulates the pure background for the NaI counting system. The net counts of the ROI (either the remainder or the thyroid) was simply determined by subtracting the count in the thigh region plus that in the thyroid areas or that in the thigh area only from the total counts in the actual whole body.

counting No.	elapsed time (hrs)	whole body	thyroid	thigh
1	0.05	21504618	355224	101133
2	0.25	19894586	434947	219306
3	0.50	22896468	754599	308951
4	0.75	23417836	834463	298034
5	1.00	23645836	944563	316862
6	2.00	21987448	1014885	311113
7	3.00	18901178	1124704	260065
8	4.00	18997956	1329043	245960
9	5.00	19006712	1297005	242498
10	6.00	16861720	1247396	204844
11	7.00	16178016	1334864	191212
12	8.00	14884935	1222750	175766
13	32.00	7810032	1080369	70999
14	56.00	3709699	949135	17926
15	80.00	2100217	673606	7377
16	104.00	1639266	540182	4627
17	128.00	1477639	429230	5457

Whole Body Scanning of Patients

Each patient was treated with 1.11 GBq ^{131}I once weekly for four consecutive weeks, for complete ablation of the residual thyroid gland. This treatment suppressed the rapid response of ultra high absorbed dose in normal organs. The post treatment ^{131}I was typically given six weeks after the thyroidectomy operation. However, thyroid medication was discontinued during that sixth week to reduce the complexity of any side effect. Care was taken to ensure that drugs that were administrated one week before scanning contained no iodine or radiographic contrast agents. Table 3 presents the measured data and scanning schedule for the first subject in the first week. The schedules for other patients (subjects 2~5) were similar with minor manipulations and represented individual deviations. The final column in Table 3 shows data from the ROI area of the thigh. This specific area simulated the pure background of the NaI counting system. Additionally, the body fluid and whole body compartments were treated as one and re-defined as "remainder" in the empirical evaluation since those were not separable by *in vivo* measuring. Therefore, the net counts of the ROI (either the remainder or the thyroid) was simply determined by subtracting the count in the thigh region plus that in the thyroid areas or that in the thigh area only from the total counts in the actual whole body.

RESULTS

Data of each patient are analyzed and normalized as initial input data to fit the optimal solution for Eqs. 1~4. Furthermore, to distinguish between the result fitted from *MATLAB* and the practical data in each subject, a value, Agreement (AT), is used. The agreement, AT is defined as

$$AT = \sqrt{\frac{\sum_{i=1}^{n}\left[Y_i(raw\ data) - Y_i(MATLAB)\right]^2}{N}} \times 100\% \tag{5}$$

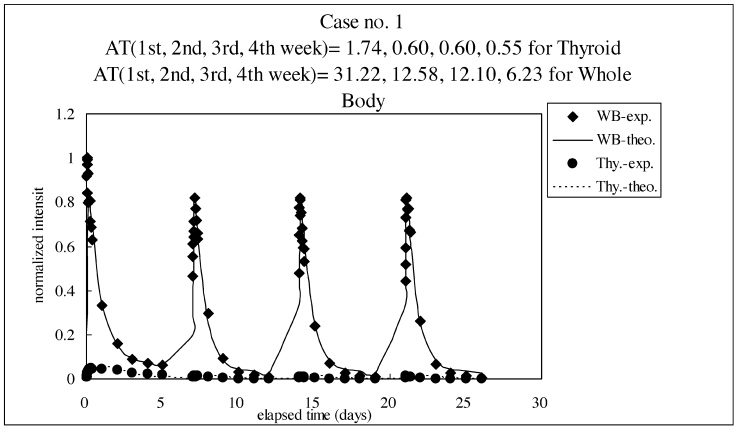
where Y_n (*raw data*) and Y_n (*MATLAB*) represent the normalized raw data from the practical evaluation of each subject at the n_{th} data acquisition and that result computed from *MATLAB*, respectively. The value of N is defined to be between 11 and 17, which corresponding to the different arrangements of counting schedule for each subject herein. An AT value of zero reveals perfect agreement between analytical and empirical results. Generally, an AT value lower than 5.00 can be treated as an excellent consistency between

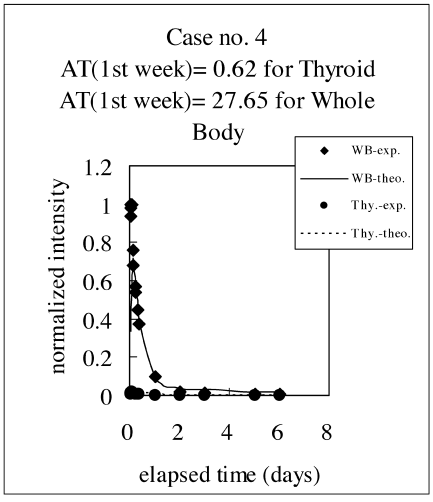
Table 4. The evaluated results for 5 subjects in this work. The theoretical data quoted from ICRP-30 report is also listed in the first row for comparing.

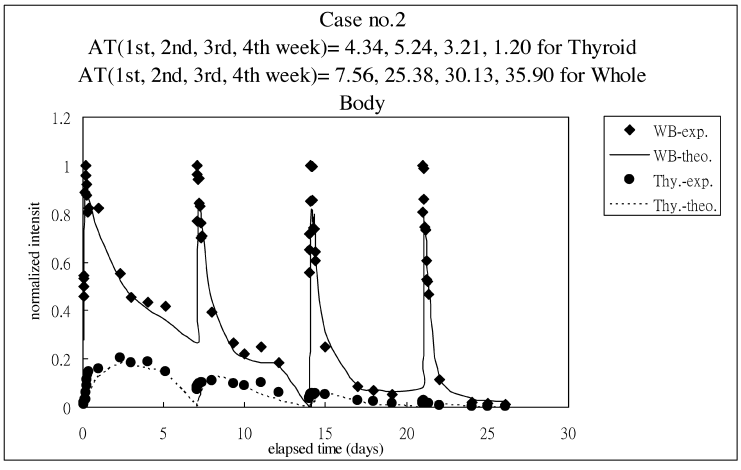
case No.	week	$T_{1/2}$(thy.) (d)	$T_{1/2}$(BF) (d)	$I_{thy.}$ (%)	$I_{exc.}$ (%)	$AT_{thy.}$	AT_{BF}
ICRP-30		80	0.25	30	70		
1	1	1.10	0.65	12.5	87.5	1.74	31.22
	2	0.50	0.50	5.0	95.0	0.60	12.58
	3	0.50	0.50	5.0	95.0	0.60	12.10
	4	0.50	0.50	5.0	95.0	0.55	6.23
2	1	1.70	1.20	55.0	45.0	4.34	7.56
	2	1.25	0.80	32.5	67.5	5.24	25.38
	3	1.10	0.55	12.5	87.5	3.21	30.13
	4	0.50	0.30	5.0	95.0	1.20	35.90
3	1	0.15	0.40	5.0	95.0	0.53	8.93
	2	0.15	0.40	5.0	95.0	0.22	2.07
	3	0.15	0.40	5.0	95.0	0.10	3.64
	4	0.15	0.40	5.0	95.0	0.70	7.56
4	1	0.25	0.25	5.0	95.0	0.62	27.65
5	1	1.25	0.50	5.0	95.0	1.74	5.79
Average		0.66 ± 0.50	0.52 ± 0.23	11.4 ± 14.6	88.4 ± 14.6	1.52 ± 1.54	14.05 ± 11.01

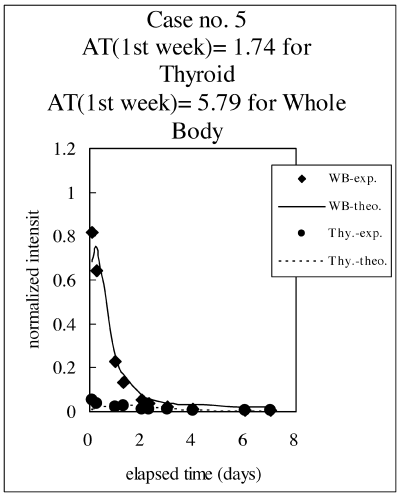
The BF implis the compartment of body fluid and the $I_{thy.}$, $I_{exc.}$ represents the branching ratio from body fluid to thyroid and to excretion, respectively in the biokinetic model.

computational and practical data, whereas the AT fallen within 10.00–15.00 may still offer reliable confidence in a certain level.[13,14] Table 4 presents the evaluated data for five subjects during one to four weeks of whole body scanning. As shown in Table 4, the $T_{1/2}(thy.)$ and $T_{1/2}(BF)$ are shifted from 80d and 0.25d to 0.66 ± 0.50d and 0.52 ± 0.23d, respectively. Yet, the branching ratio from the body fluid compartment to either the thyroid compartment ($I_{thy.}$) or the









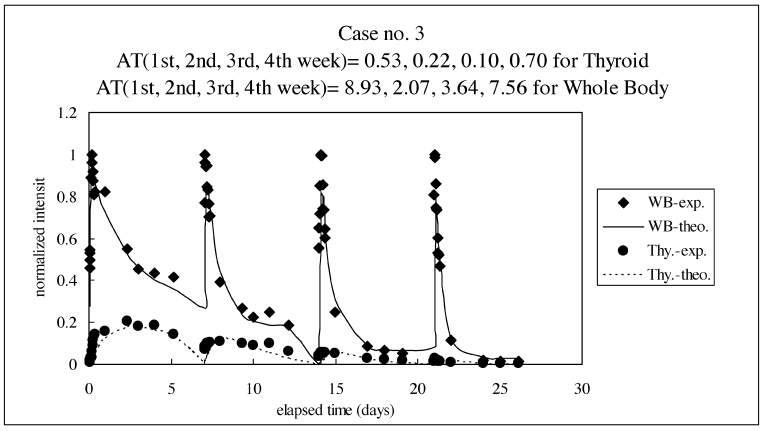


Fig. 3. The time-dependent intensity of either whole body plus body fluid compartments or thyroid compartment from the optimized results of revised biokinetic model of iodine. The various data from *in vivo* scanning of 5 patients are also included.

excretion compartment ($I_{exc.}$) is changed from 30%, 70% to 11.4 ± 14.6%, 88.4 ± 14.6%, respectively. A shorter biological half-life (80d→0.66d) and a smaller body fluid to remnant thyroid gland branching ratio (30%→11.4%) also reveal the rapid excretion of the iodine nuclides in the metabolic mechanism in thyroidectomy patients. Information is also provided to elucidate the trend in values for all subjects. Subject 1 had a larger remnant thyroid gland in the first week post-administration, and therefore a longer holding time for iodine nuclides inside the thyroid gland was expected; then the holding time was reduced rapidly to a level that was maintained for the following three weeks. Subject 2 had a moderate reaction to the administered iodine nuclides, so the biological half-life of iodine in the thyroid fell from 1.7d, 1.25d, 1.10d to 0.5d in the fourth week. The biological half-life of iodine in the thyroid gland in all four weeks in subject 3 was similar, being about 0.15d, which was also the lowest value of any subjects. Apparently, the thyroid gland in subject 3 barely functioned even during the initial period post-administration of iodine. Moreover, the characteristics of patients supported the evaluated results according to their status of remnant thyroid gland [cf. Table 2]. Subjects 1, 3 underwent complete ablation of thyroid gland while the subject 2 was given the minimal residual. Additionally, many of the given iodine nuclides were excluded in the initial period post-administrated, since most $I_{exc.}$ was as high as 95% with an average $I_{exc.}$ of 88.4% [cf. Table 4]. The lower $I_{exc.}$ was mostly associated with subject 2 since she still had a few remnant thyroid glands among all five subjects. Specifically, for subject 2, the $I_{exc.}$ was increased from 45%, 67.5%, 87.5% to eventually 95.0%, corresponding to the 1st, 2nd, 3rd and 4th weeks post-administration of ^{131}I, since the remnant thyroid gland degraded slowly. The mean corresponding ATs for the thyroid compartment and the remainder are 1.52 ± 1.54 or 14.05 ± 11.01. The lower AT of the thyroid compartment is associated with stronger agreement with the *MATLAB*-computed results than the remainder. An AT of only 1.52 ± 1.54, as determined by evaluation of the thyroid compartment is entirely consistent with the actual data, while the higher AT (14.05 ± 11.01) still reveals acceptable consistency for the remainder. Figure 3 displays the results computed using *MATLAB* coupled with practical data for various subjects work to clarify further the evaluation of either the thyroid compartment or the remainder. As clearly shown in Fig. 3, the consistency between each evaluated curve and practical data for various subjects reveals not only the accuracy but also the different characteristics reflecting to real status of remant thyroid glands.

DISCUSSION

Original and Revised Biokinetic Model of Iodine

Defining the biological half-life of iodine in the thyroid compartment without considering the contributions of other compartments in the biokinetic model remains controversial. The thyroid compartment dominates the biokinetic model of iodine for healthy people. Both the body fluid and the thyroid are the dominant compartments in the revised biokinetic model for (near) total thyroidectomy patients, based on the analytical results. Furthermore, by precisely comparing the original and revised iodine biokinetic models [cf. Figs. 2, 5], the biological half-life of iodine in the thyroid of a healthy person can be evaluated directly using the time-dependent curve, while the time-dependent curve for thyroidectomy patients degrades rapidly because iodine's short biological half-life in the remnant thyroid gland. Alternatively, withholding iodine from the body fluid compartment for thyroidectomy patients rapidly increase the percentage of iodine nuclides in subsequent *in vivo* scanning. The T_{eff} of iodine in the thyroid of a healthy person is 7.3d [$(1/8.02 + 1/80)^{-1} = 7.3$] (the physical and biological half life of ^{131}I is 8.02d and 80d, respectively) and is dominated by the thyroid compartment only. The T_{eff} of iodine in the thyroid compartment for thyroidectomy patients, however, is reduced to about only 0.61d [$(1/8.02 + 1/0.66)^{-1} = 0.61$] (the physical and biological half life of ^{131}I is 8.02d and 0.66d, respectively) and the retention of iodine is shared with the body fluid compartment, since the $I_{exc.}$ (branching ratio from body fluid compartment to excretion) approaches 90% and, thus, also dominates the biokinetic model [cf. Table 4]. The fact that different compartments dominate the iodine biokinetic model requires the different analysis of dose evaluation and for release criteria for patients based on public hygiene considerations. Furthermore, the standard dose prediction protocol on the basis of Medical Internal Radiation Dose (MIRD) calculational result[15] is also inappropriate for the thyroidectomy patients, since the rapid retention of radionuclide ^{131}I may induce comparatively high dose in the primary period after the post administration of iodine.

In a further examination of the theoretical biokinetic model, since 90% of the given ^{131}I in the whole body (compartment 4) feeds back to the body fluid (compartment 2) and only 30% of the given ^{131}I in the body fluid flows directly into the thyroid (compartment 3) [cf. Fig. 1], the cross-links between compartments makes obtaining solutions to Eqs 1~4 extremely difficult. Just a minor change in the biological half-life of iodine in the thyroid compartment significantly influences the outcomes for all compartments in the biokinetic model. Moreover, the contribution of the stomach (compartment 1) to all compartments is negligible in this calculation since the biological half-life of iodine in the stomach is as short as 0.029 day (~40 min). The scanned gamma camera counts from the stomach yield no applicable data 2 hours after the administration of I-131, since nearly 90% of the total iodine nuclides is transferred to other compartments. Therefore, analysis of the calculated result for biokinetic model remains in either the remainder or the thyroid compartment only. Figures 4 and 5 plot the time-

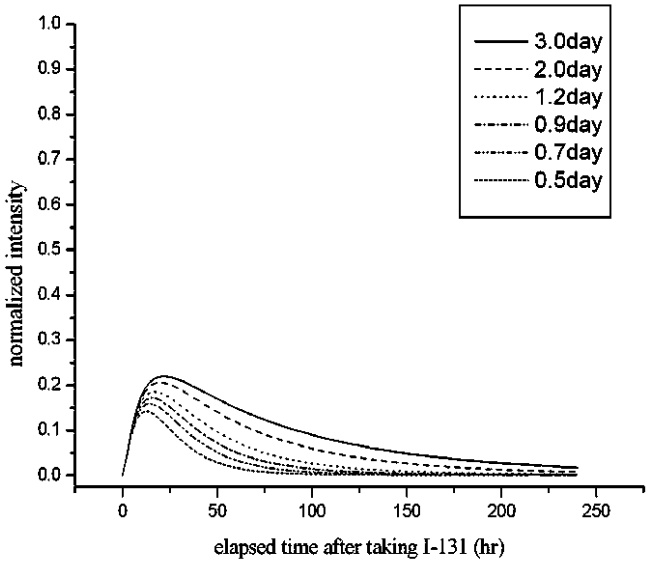


Fig. 4. The relative intensity of iodine inside the thyroid compartment versus elapsed time after taking I-131 under various assumptions of thyroid biological half life.

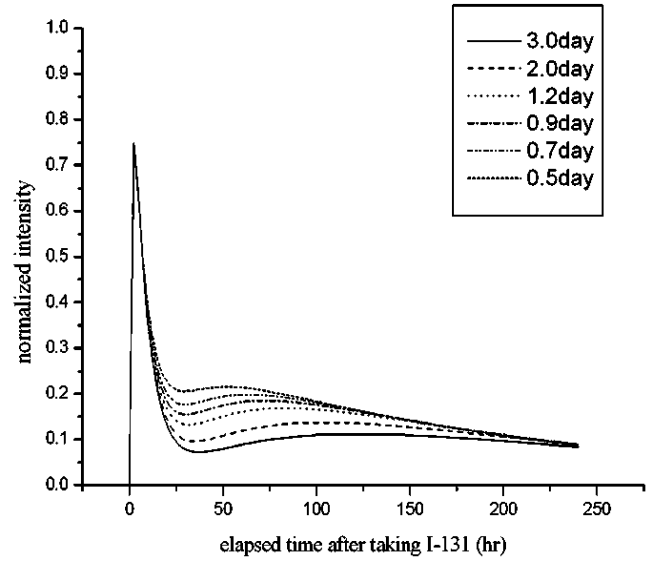


Fig. 5. The relative intensity of iodine inside both the whole body and the body fluid compartments versus elapsed time after taking I-131 under various assumptions of thyroid biological half life.

dependent intensities of thyroid and remainder in general, respectively after iodine was administered. The different biological half-lives of iodine in the thyroid can cause marked percentage changes in the retention of iodine in both the thyroid compartment and the remainder [cf. Figs. 4, 5]. As clearly shown, the intensity of iodine in the thyroid is maximal around $0.8d$~$1.2d$ after dose administration and implied less than ~24% for all doses with various parameter setting.

Effective Half-Life of Iodine in Thyroid and Body Fluid Compartments

The U.S. Nuclear Regulatory Commission (NRC) guidance document (U.S. NRC 1997b) recommends an effective half-life of ^{131}I in the thyroid compartment of 0.33d and in remaining compartments of more than 7d.[16] Additionally, some researchers have noted changes in the effective half-life of iodine in the human body for (near) total thyroidectomy patients.[5–7,17–21] Specifically, Dr. Erdi identified three different T_{eff} of iodine in the thyroid, 0.58d, 1.42d and 1.80d, for three thyroidectomy patients using PET imaging, whereas, the T_{eff} of iodine in the bodies of the patients were in fact 0.4d to 6.0d.[7] In contrast, the evaluated T_{eff} for the thyroid and the body fluid compartments are 0.61d [$(1/8.02+1/0.66)^{-1}$ = 0.61] and 0.49d [$(1/8.02 + 1/0.52)^{-1}$ = 0.49], respectively herein and the theoretical effective half life for the body fluid compartment is 0.24d [$(1/8.02+1/0.25)^{-1}$ = 0.24] [cf. Table 1]. The difference of T_{eff} between the results in the different works may follow from the various definitions of specific compartments that were adopted in the model computation. For instance, Dr. North measured the scanned gamma ray of 268 patients at a distance of 1 meter by an NaI detector at three specific times 0.04d, 0.5d and 1.8d after iodine was administered. Accordingly, the evaluated T_{eff} of iodine (0.58d) was derived from the gross patient counts, which approximately equaled the sum of the whole body, body fluid and thyroid compartment counts herein [cf. Fig. 1]. Therefore, the T_{eff} for iodine that was reported by Dr. North may not represent that in either the thyroid or the body fluid compartment, as defined in the biokinetic model, even though, the T_{eff} determined for iodine in the thyroid still approached to a similar value herein (0.61d), differing markedly from the results of the analyses of over 250 cases.[6] Dr. Kramer employed two groups of NaI detectors to scan thyroid glands and the whole body within the first week following the iodine doses was administered. They found that the biological half-lives of iodine were 1.0d and 18.4d, respectively over the short and long terms. These values were obtained using a two compartment retention model and averaged over nine athyreotic subjects.[5] Based on Figs 4 (for the thyroid compartment), and 5 (for the remainder, comprising body fluid and whole body compartments), the evaluated results for thyroid obtained herein must be verified with reference to other reports since the definition of the thyroid gland is direct and straightforward, while the definition of whole body is not. The whole body compartment plus the body fluid compartment is the remainder in the five compartment biokinetic model as used in this computation, whereas the whole body is either an independent compartment or combined together with the thyroid gland in some simplified two-compartment biokinetic models for other works. Furthermore, since the biological half-life of iodine in the whole body compartment is still 12 days in this specific five compartment biokinetic model computation, the

integrated T_{eff} of the remainder (both body fluid and whole body compartments) [cf. Fig. 5] remains about 5.8d. The value (5.8d) agrees well with that obtained by Dr. Erdi (0.4d~6.0d)[7] and the recommendations of the NRC (~7d).[16] The value (5.8d) is obtained on the assumption that T_{bio} of the thyroid compartment is 0.6d with the other parameters held for a standard man as given in Table 1. Some of the computed data from which T_{eff} (5.8d as aforementioned) was determined, were interpolated between elapsed time of 50h to 240h as plotted in Fig. 5, since the thyroid remnant retains iodine in transient equilibrium with the whole body and the body fluid in early stage according to the biokinetic model.

CONCLUSION

The effective half-life of iodine in either the thyroid or the body fluid compartment for (near) total thyroidectomy patients was determined using *in vivo* gamma camera approach. The revised values were initially obtained from the computations made using the iodine biokinetic model in each subject and averaged over all five subjects. In contrast, the T_{eff} of iodine in the thyroid compartment was changed from the original 7.3d to the revised 0.61d, while the T_{eff} of iodine in the body fluid compartment increased from 0.24d to 0.49d. Furthermore, the $I_{thy.}$ and $I_{exc.}$ was changed from the original 30% and 70% to the revised 11.4% and 88.4%, respectively for real *in vivo* measurement. The difference between the results of the original and the revised iodine biokinetic model were used the quantified AT to imply the biological half-life of iodine in the thyroid and the remainder. The integrated T_{eff} of the remainder (both body fluid and whole body compartments) remained about 5.8d, since the body fluid and whole body compartment were inseparable in real whole body scanning. The diffferent effective half life of radioiodine nuclides for thyroidectomy patients needed to be further cared in evaluating the effective dose from medical physics veiwpoint.

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