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The estimation of activity contents by RMC-II Phantom

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1. Introduction

In dose assessment of internal contamination, the characteristics of radionuclide, applied geometry mode of system, and measuring mode of dosimetry program should be considered thoroughly.

This study concentrated on the optimized measuring geometry mode and the change of final radioactive content estimated by different efficiency mode. Radionuclide I-131 has the target organs of thyroid [1]. So the activity measurement from inhalation time to deposition time is relatively difficult and non-accurate, also we could not easily determinate efficiency mode for the time period. Therefore we tried calculating and comparing theoretically the values of radioactive contents with appropriate efficiency mode and conventional geometry mode.

2. Methods and Results

2.1 Detecting the activity with the RMC-II phantom

Figure 1 is measured value, using the RMC-II phantom and source, (Exp_{Co60}) of ^{60}Co radiation source and certified value (Act_{Co60}) of source by using WBC (Canberra 2260 ACCUSCAN Bed Whole body counter). The ratio of above two values is displayed as the result y axis value (%).

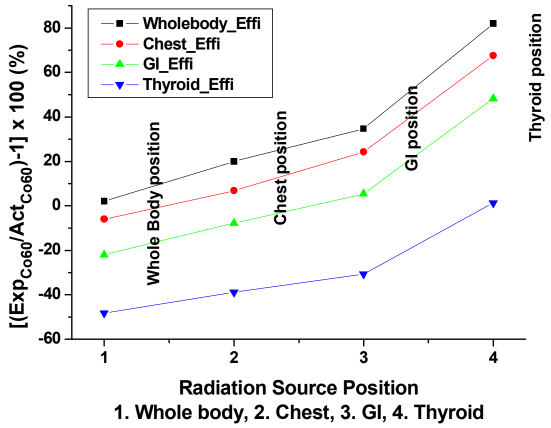


Figure 1. Results of using the one source position and one geometry position.

$$A_{cal} = (Act_{Co60} \times Eff_{\text{source position}}) / Eff_{\text{geometry of WBC measurement}} \quad (1)$$

*A_{cal} : measurement value, Eff : WBC Geometry Efficiency of ^{60}Co

Measurement value is proportioned to the efficiency of source position, but it is inversely proportioned to the geometry mode. So we did make formula (1) and calculate the detection value. We could acquire similar results by using known activity value from the below experiment (Figure2).

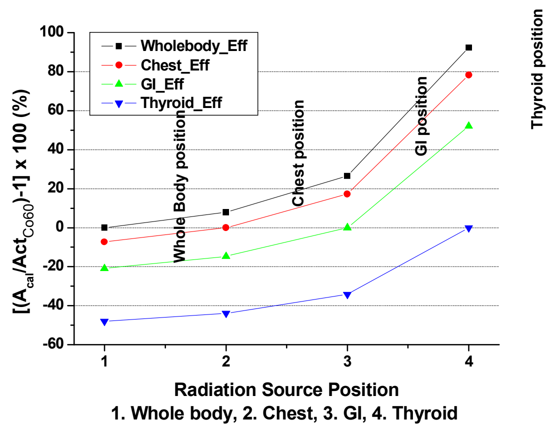
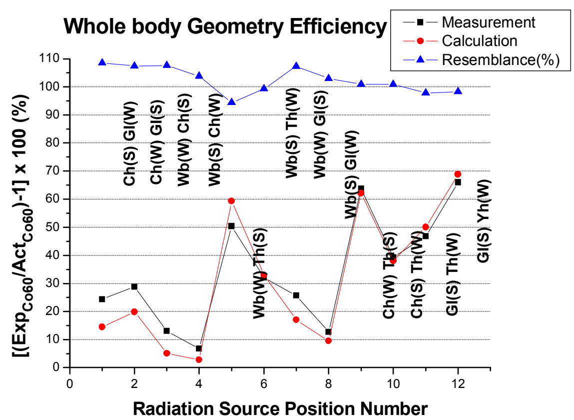


Figure 2. The results of using the two sources.

Considering above experiment results, measured values were acquired by combining two radioactive materials of different activities with 12 source allocation and each efficiencies. In case of applying Whole body geometry, the difference between measuring values and theoretical values was displayed in Figure 3. Thyroid, Chest, GI efficiency also shows the similar shapes.



(S: Strong source, W : Weak source)

Figure 3. the difference between measuring values and theoretical values (Similarity value : $Exp_{Co60}/Act_{Co60} \times 100$ (%)).

$A_{cal} = (Act_{Co60(S)} \times Eff_{S\ source\ position} + Act_{Co60(W)} \times Eff_{W\ source\ position}) / Eff_{geometry\ of\ WBC\ measurement}$ (2)

Above formula (2) can be applied in the case of using multiple radioactivity source like formula (3). So formula (3) is the general form of formula (2).

$$A_{cal} = [\sum(A_i \times Eff_{i\ source\ location})]/Eff_{geometry\ of\ WBC\ measurement} \quad (3)$$

2.2 Calculating activity contents of I-131 using IRF

Below Figure 4 plots the IRF (Intake Retention Fraction) table in case of inhaling I-131 (5 μm, Type F)[2].

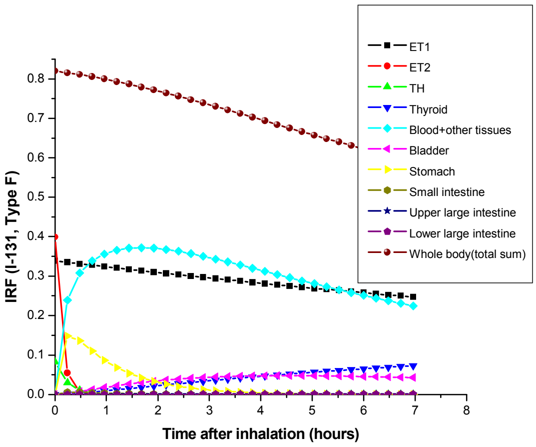


Figure 4. Change of retention fraction after inhaling I-131 IRF (5 μ m, Type F).

From the above plot, as we can see, the most of radioactive materials exist in Blood+other tissues, ET1, Thyroid, Bladder parts. For convenience of calculation, we assume that the values of retention fractions are radiation contents in human body, and the positions of radiation contents in IRF table can be simplified as geometry position of RMC-II phantom in Table 4, because efficiency of the ICRP-60 internal phantom cannot be used directly in calculation.

Table 4. Equivalent geometry efficiency

IRF tissue	expectative equivalent RMC-II geometry efficiency
ET1	I-131 thyroid efficiency
Thyroid	I-131 thyroid efficiency
Blood+other tissues	I-131 whole body efficiency
Bladder	I-131 GI efficiency

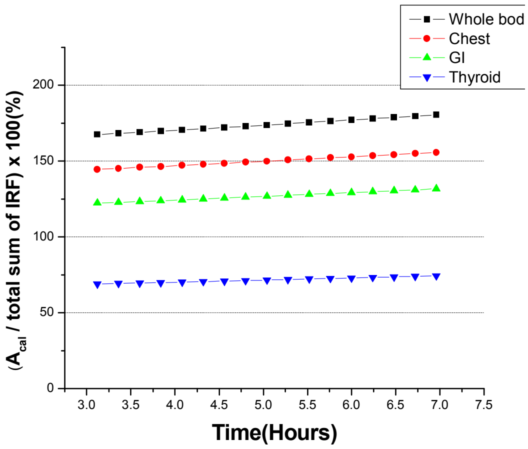


Figure 5. I-131 activity calculated measurement rate by geometry mode.

To estimate real contents of I-131, the activity in formula (3) were replaced by value of retention fraction table, therefore we assumed that total sum of retention fraction value was real contents activity in human body. So, if radiation worker inhaled radionuclide I-131 and being measured by WBC with whole body efficiency geometry mode, as we can see from Figure 5, the measured radioactive material contents might be almost twice of the real radioactive contents value in human body. In conclusion, if we want to approach to the real radioactive contents value, application of Thyroid or GI efficiency mode seems to be considered.

3. Conclusion

By use of RMC-II phantom, the relationship has been reviewed at this study between measured value of internal radiation quantity and analyzed theoretical value depending on various combination of different efficiency mode and source position in phantom.

But, the limit of used RMC-II phantom, as we reviewed in this study, is apparent in following the new ICRP recommendation. In the future, the development of new phantom for internal contamination should be considered to achieve more accurate dose estimation than now days.

REFERENCES

[1] ICRP, ICRP PUBLICATION 78: INDIVIDUAL MONITORING FOR INTERNAL EXPOSURE OF WORKERS, 1994

[2] 한전 전력연구원, 내부피폭 선량평가 코드(KIDAC) 섭취잔류분률 및 화학형 개정보고서, 2006