Calculation of Thyroid Equivalent Dose Conversion Factor for Surface Contamination Monitor in Radiation Emergency Response

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1. Introduction

When a nuclear accident occurs, radioiodine typically are released into the environment, which cause the internal contamination of individuals. Once radio iodine is accumulated in the thyroid, it is difficult to excrete from the body. Therefore, rapid determination of internal thyroid contamination is essential for effective accident response and medical intervention.

In 2011 Fukushima Daiichi Nuclear Power Plant (FDNPP) accident, thyroid contamination monitoring was conducted, but not adequately performed. Therefore, several studies have been conducted on thyroid contamination monitoring in japan after the accident[1].

In South Korea's radiological emergency medical system, off-site radiation emergency medical clinics are set up in response to a nuclear accident, and radiation emergency medical personnel conduct the screenings for potentially contaminated individuals. They make a decision for radiological triage based on measured count rates which are set as the screening levels. To determine the screening level radiation instrument, it is necessary to calculated conversion factors that convert the response of radiation measurement instrument into thyroid dose. By pre-calculating the response-to-thyroid dose conversion factor, thyroid doses can be quickly identified, enabling prompt medical action.

The purpose of this study is to calculate the response-to-thyroid equivalent dose conversion factors for promptly determining internal thyroid contamination during nuclear power plant accidents. For the surface contamination monitor used in South Korea's radiological emergency medical system (RadEye B20-ER (Thermo Scientific)) to thyroid equivalent dose conversion factors were calculated.

2. Material and Methods

Commercial hand-held type radiation detection instrument (RadEye B20-ER, developed by ThermoFisher, USA), widely used in radiation emergency response, were utilized in this study. RadEye B20-ER has pancake GM tube and can measure 0 to 500 kcps contamination. Conversion factors were calculated to convert the response of RadEye B20-ER (cps) into thyroid equivalent dose (Sv). These factors were obtained through experiments using an ANSI neck phantom (ANSI/HPS N13.44- 2014) and a radioactive source fabricated by KRISS. Due to the short half-life of the radionuclide I-131(gamma with 364 keV(81.5%), …), which makes it challenging to conduct multiple experiments, Ba-133(gamma with 356 keV(62.05%), …), with a similar gamma energy spectrum but a much longer half-life, was used. The experiment was conducted using the geometry shown in Figure 1. The central axis of instrument was aligned with the center of the neck phantom, and a 0.5 cm gap was maintained between the instrument and the phantom to reflect measurement conditions. The source was placed inside the phantom, and after allowing the instruments a stabilization period of one minute, the response was recorded ten times at 10-second intervals.

Figure 1. Measurement geometry (Radeye B20-ER)

The thyroid equivalent dose conversion factor was calculated by considering the thyroid retention function and the thyroid equivalent dose conversion coefficient. The thyroid retention function was derived from parameters embedded in the MONDAL software (Ver. 3.01) of Japan's National Institute of Radiological Sciences (NIRS) [2]. The dose coefficient for the thyroid equivalent dose per unit intake was obtained from the ICRP Database (Ver. 3.0) [3].

3. Results

The results from measuring background radiation 10 times with the RadEye B20-ER 0.828 ± 0.112 cps (k = 2). With the source inserted into the thyroid phantom and measured at a distance of 0.5 cm, the result was 3.973 ± 0.215 cps (k = 2). Therefore, the net count was 3.145 ± 0.242 cps (k = 2).

Based on the measurement results, the equivalent dose conversion factors for the thyroid were calculated and are shown in Table 1. The conversion factors showed significant variation depending on the elapsed time from intake to measurement due to the short half-life of I-131 (8.04 days). Additionally, differences in conversion factors were observed based on the intake route and absorption type.

Table 1. Thyroid equivalent dose conversion factor for adult (Sv/cps)

Elapsed time after intake (day)	Absorption type			
	Inhalation			Ingestion
	Methyl iodide	Elemental iodine	Type F	
1	2.75E-03	2.72E-03	2.79E-03	2.72E-03
2	2.84E-03	2.79E-03	2.88E-03	2.80E-03
3	3.13E-03	3.07E-03	3.15E-03	3.06E-03
4	3.44E-03	3.36E-03	3.46E-03	3.36E-03
5	3.78E-03	3.71E-03	3.81E-03	3.69E-03
6	4.16E-03	4.07E-03	4.18E-03	4.06E-03
7	4.54E-03	4.48E-03	4.60E-03	4.46E-03
8	5.00E-03	4.90E-03	5.05E-03	4.90E-03
9	5.50E-03	5.41E-03	5.54E-03	5.40E-03
10	6.03E-03	5.93E-03	6.09E-03	5.92E-03
14	8.79E-03	8.62E-03	8.87E-03	8.62E-03
20	1.54E-02	1.51E-02	1.55E-02	1.51E-02
30	3.90E-02	3.84E-02	3.95E-02	3.83E-02

In radiation emergency medical clinic, it is difficult to determine the intake route and absorption type of the radioactive substance. If the absorption type varies, it may cause confusion in applying conversion factors. To account for this, the conversion factors for radiation emergency response can be based on a reasonable conservative assumption, and the conversion factor for Type F can be used as the representative factor. Even when assuming Type F for dose calculations, the dose would likely not be overestimated by more than 4% compared to other absorption types. In radiation emergency medical clinic, the elapsed time after intake should be estimated, and the corresponding equivalent dose conversion factor for Inhalation - Type F should be applied.

4. Conclusions

In this study, thyroid equivalent dose conversion factors were calculated to rapidly assess thyroid contamination during a nuclear power plant accident. By using the derived thyroid equivalent dose conversion factors, it is expected that thyroid equivalent dose levels can be quickly identified on the site, allowing for prompt medical intervention. Furthermore, the established screening levels help identify patients who are likely to exceed the 100 mSv thyroid equivalent dose threshold. However, since conservative assumptions were incorporated in setting the standards, more detailed dose assessment or classifications may be needed, and additional calculations should be performed when necessary.

This study is expected to strengthen the initial response and help reduce health risks from radioactive materials. By reflecting on these results and conducting further research, such as refining the dose assessment methodology and establishing criteria for different age groups, it is anticipated that a more robust accident response system can be developed.

REFERENCES

[1] Kurihara O., Kim E., Tani K., Ogawa M., Yajima K., Kowatari M. and Tatsuzaki H. Effective population monitoring for determination of the thyroidal radioiodine of the public following a nuclear accident in Japan. Eniviron. Adv. 8, 100206(2022).

[2] N. Ishigure, T. Nakano, M. Matsumoto and H. Enomoto, Database of Calculated Values of Retention and Excretion for Members of Radionuclides, Radiation Protection Dosimetry, Vol. 105, pp. 311–316, 2003.

[3] International Commission on Radiological Protection, ICRP Database of Dose Coefficients: Workers and Members of the Public, Version 3.0., Pergamon Press, Oxford, 2012.

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