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Development of the Discrimination Programs between the Internal and External Radioactive Contamination of Workers Using a Whole Body Counter

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1. Introduction

A whole body counter (WBC) is used to identify and measure the radioactivity in the body of human beings in a nuclear power plant (NPP). In domestic NPPs, several whole body counters are in operation to monitor the internal radioactive contamination of workers. All workers take a whole body counting after radiation works if there is high possibility of radioactive contamination or the radioactivity is detected by portal monitoring. It is, however, found that the external contamination is occasionally estimated as the internal radioactive contamination. In this case, the worker is recommended to take showers for the decontamination of skin and take a whole body counting again. Although the detected radioactivity is reduced remarkably after several decontaminations, confirmed as the external contamination, it is determined finally as an internal contamination if the radioactivity is still detected in the body of worker. The amount of detected radioactivity can be much higher than that of the expected for this mistaken contamination since the radioisotopes attached to skin come to be close to the detectors of WBC. Finally, this makes not only the misjudgment of the external contamination as the internal contamination, but also the excessively conservative estimation of radioactive contamination.

In this study, several experiments were carried out to set up the discrimination program between the internal and external radioactive contamination using the humanoid phantom and a whole body counter. After the analysis of experimental results, we found that the use of front and backside counts could be applied to the discrimination of the external contamination and the ratio of detected radioactivities between front and backside counts was more than about factor 2 for the external contamination.

2. Method & Materials

In this study, the back and forth counting using a WBC was used to differentiate the external contamination from the internal contamination. It is assumed that the difference of detected radioactivities between front and backside counts is higher than that of the internal contamination if the radionuclides are attached on the surface of skin [1]. In addition, the body of worker shields the radiation from the source to the detector when the worker turns around in a WBC. On the contrary, in the case of internal contamination, there is no significant change of distance between the body of worker and the detectors. Furthermore, the radiation shielding is not matter since the radiation source is located at the inside of the body; thus, the difference between front and backside counts is not distinguishable.

The humanoid phantom of typical Korean male, developed by the Radiation Health Research Institute (RHRI) of Korea Hydro & Nuclear Power Corporation (KHNP) for radiation protection purpose, was used for front and backside counts. This phantom satisfies the reference Korean physical model (Height: 170.9cm, Weight: 68.1kg, etc.) and is sliced into 2cm sections to facilitate dose mapping. First, the number tags of 1 to 14 for front and 15 to 28 for backside of the phantom surface were attached to position the radioactive source.

The WBC utilized for the experiments is Canberra's Fastscan (Model 2250), which is used at most domestic NPPs. The counting was accomplished under four WBC geometries which are whole body, thyroid, lung, and gastro-intestine and the counting time was 3 minutes. A mixture source of Cs-137 and Co-60, manufactured by North American Scientific Inc., was used for the experiments of external contamination and two point sources of Cs-137 and Co-60, manufactured by Korea Research Institute of Standards and Science (KRISS), were used for the experiments of internal and external contamination since those sources are the most important and common internal dose contributors for PWR reactors.

3. Experiments & Results

Three categories of experiments were conducted. The first one was the front and backside count to test for the external contamination and the second one was for the internal contamination. Third one was the back and forth counting for the simultaneous contamination of both internal and external body. The experiments which were performed in this study were listed below:

1. Experiments on the external contamination
   A. Front and backside contamination
   B. Flank contamination
   C. Simultaneous contamination of front and backside
2. Experiments on the internal contamination
3. Experiments on the simultaneous contamination of both internal and external body
   A. Front and backside contamination
   B. Flank contamination

Three experiments were conducted for the external contaminations. The first one is the experiment of front and backside contaminations that the external radioactive contamination happens on either front or backside of workers. In this experiment, a mixture source of Cs-137 and Co-60 were attached to either front or backside of phantom surface and then the back and forth counting was carried out while the phantom turned around in a WBC. The experimental results indicated that the average ratios of front and backside counts were 8.8 for Co-60 and 14.2 for Cs-137 for the attachment of a mixture source to front side of the phantom. For the position of a source on backside of the phantom, similar results were also obtained; the average ratios of front and backside counts were 7.0 for Co-60 and 11.4 for Cs-137. The second one is the experiment of flank contamination assuming that the external radioactive contamination happens on both sides of worker flank. In this experiment, two point sources of Cs-137 and Co-60 were attached to the phantom flank: Cs-137 for left flank and Co-60 for right flank and then the back and forth counting was carried out while the phantom turned around in a WBC. As a result, it was found that there was no distinguishable difference between the back and forth counts. The experimental results showed that the average ratios of front and backside counts were 1.2 for both Co-60 and Cs-137. The third experiment intended for the case of simultaneous contamination of front and backside of workers. In this experiment, four point sources of Cs-137 and Co-60 were attached to both front and backside of phantom surface. In the first case, two point sources of Cs-137 and Co-60 were fixed on the backside of phantom and other two point sources of Cs-137 and Co-60 were positioned on the front side of phantom in order of number tags. For the second case, two point sources of Cs-137 and Co-60 were fixed on the front side of phantom and other two point sources of Cs-137 and Co-60 were positioned on the backside of phantom in order of number tags. The experimental results demonstrated that the average ratios of front and backside counts were 0.6 for Co-60 and 1.5 for Cs-137 for the first case and 0.9 for Co-60 and 2.0 for Cs-137 for the second case.

For the case of internal radioactive contamination, the experiment that radiation sources were located at the inside of phantom was conducted. In this experiment, two point sources of Cs-137 and Co-60 were put on the phantom slice and then the back and forth counting was carried out while the phantom turned around in a WBC. As a result, it was found that the average ratios of front and backside counts were 1.4 for Co-60 and 1.5 for Cs-137; thus, there was no big difference between front and backside counts.

The third category of experiment intended for the case of simultaneous contamination of both internal and external body. In this category, two experiments were carried out; the first one is the experiments of front and backside contamination. In this experiment, four point sources of Cs-137 and Co-60 were used; two sources of Cs-137 and Co-60 were put on the inside of phantom and other two sources were attached to either front or backside of phantom surface and then the back and forth counting was carried out while the phantom turned around in a WBC. The experimental results indicated that the average ratios of front and backside counts were 2.7 for Co-60 and 2.0 for Cs-137 for the attachment of external sources to front side of the phantom. For the position of sources on backside of the phantom, the average ratios of front and backside counts were 3.1 for Co-60 and 2.4 for Cs-137. The second one is the experiment of simultaneous contamination of both internal body and flank. Similar to previous experiments, two point sources of Cs-137 and Co-60 were located at the inside of phantom and other two sources were attached to the phantom flank. As a result, it was found that there was no conspicuous difference between front and backside counts; the average ratios of front and backside counts were 0.9 for Co-60 and 0.9 for Cs-137.

4. Conclusion

It is important to estimate the exact internal exposure dose for radiation workers since most workers in NPPs think that the internal contamination is more dangerous than the external contamination or external exposure. In this study, several experiments of back and forth counting using a WBC and the humanoid phantom were performed to set up the discrimination program between the internal and external radioactive contamination. As a result, it was found that the use of front and backside counts could be applied to distinguish between the internal and external radioactive contamination. It was also recognized that the ratio of detected radioactivities between front and backside counts was more than about factor 2 for the external contamination. It is, however, necessary to further steps to discriminate the external contamination from the internal contamination for the ratio of less than factor 2. In this case, several re-counts at regular intervals are demanded within a fixed period of time. Finally, it is determined whether the internal contamination is or not after the inter-comparison between re-counting results and the intake retention function (IRF) graphs of corresponding nuclides.

5. Acknowledgement

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REFERENCES

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