Evaluation of internal exposure effect in consideration of internal activation during boron neutron capture therapy

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Abstract The internal exposure due to the activation during BNCT was estimated by a Monte Carlo code "PHITS" with a computational phantom "MRKPs" and a risk calculation software "DCAL". The committed effective dose due to the internal exposure was almost 2.5 μSv and smaller than the external exposure of almost 180 mGy-eq.

Keywords: BNCT, Monte Carlo simulation, dose evaluation, activation, computational phantom

1. Introduction It is expected that boron neutron capture therapy (BNCT) using accelerator-based systems in hospitals will become widespread in near future. From the viewpoint of radiation protection and quality assurance for BNCT systems, it is important to estimate the exposure dose of the patient's normal tissue. Particularly, thermal and epithermal neutrons are incident to the patient, so that components constituting the body are possibly activated. Previous studies reported that the ^{24}Na and ^{38}Cl produced by activation were main components for the internal exposure[1],[2]. In order to evaluate the exposure dose more accurately, the effect of internal exposure for the neutron activation in the body was evaluated.

2. Material and Methods Simulations were performed for the typical BNCT studies for brain and head-and-neck tumors at a reactor-based BNCT system settled in Kyoto University Reactor (KUR). It was assumed that the concentrations of boron-10 in the normal tissues and blood were 25 ppm, the value of compound biological effectiveness (CBE) was 1.35 for normal tissue, and the irradiation time was 1 hour. First, the external exposure dose during BNCT was evaluated using a Monte Carlo code "PHITS[3]" with a computational phantom "MRKPs[4]". Second, the distribution of the neutron-induced radioactivity in the body was simulated by PHITS. Third, the dose equivalent and the effective dose for the internal exposure by neutron activation are estimated by a dose and risk calculation software "DCAL[5]".

3. Results For a case of the head-and-neck tumors, the equivalent dose due to the external exposure was estimated to almost 180 mGy-eq on the average for the whole body including the target volume. The committed effective dose due to the internal exposure was almost 2.5 μSv.

4. Conclusion The effect of the internal exposure due to the activation in BNCT on normal tissues was evaluated to be five orders smaller than the external exposure. Therefore, it is not essential to consider about the internal exposure for the daily treatment planning and QA/QC.

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