A Fundamental Study on Energy Decomposition and Current-mode SPECT for B-10 Concentration Estimation in Boron Neutron Capture Therapy

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Introduction

It has been nearly 70 years since the world's first Boron Neutron Capture Therapy (BNCT) was performed, but there are still some issues to be solved. One is the imaging of B-10 distribution during the treatment. Drug containing B-10, such as BPA, is distributed not only to tumor cells but also to normal cells. Therefore, positron emission tomography (PET) using F-18-BPA is employed to evaluate the B-10 concentration ratio for tumor to normal tissue (T/N) or tumor to blood (T/B). Referring to these ratios, the entry to BNCT is decided. However, there is no evidence that these ratios for F-18-BPA are the same with the ones for BPA and the drug administration method is different between BNCT and PET. Therefore, various methods for evaluating B-10 distribution during BNCT have been studied. We are studying on energy decomposition current-mode SPECT for B-10 concentration estimation in BNCT. At first, we performed a fundamental study on the feasibility for the position estimation of tumor region using our SPECT technique.

Materials and Methods

In this study, a special detector named as "transXend detector" is used [1]. This detector measures prompt gamma ray emitted from a patient during BNCT as a current value, and gamma-ray energy data is obtained by analysis. Two detectors were opposed to each other across a water-filled head phantom, and simulation was performed using PHITS for the position estimation of tumor region by the simultaneous current-mode measurement using two detectors [2]. The incident neutron beam axis passing through the phantom center is set to y-axis, and the axis perpendicular to the beam axis and passing through the phantom center is set to x-axis. First, the current measurement by

two detectors on both sides of the phantom was simulated, where a 478 keV isotropic source placed on the x-axis was moved. Next, the simple geometry under BNCT for the irradiation by the epi-thermal neutron irradiation mode at Heavy Water Neutron Irradiation Facility of Kyoto University Reactor (KUR-HWNIF) was simulated [3]. A spherical B-10 containing region of 4 cm in diameter was set as a tumor region. The B-10 concentration was 50 ppm, and the center of the tumor region was placed at 5-cm depth from the phantom surface on the y-axis.

Results

From the simulation for moving the 478 keV isotropic source on the x-axis, it was found that the position of the tumor region on the x-axis could be estimated almost accurately. From the simulation for simple BNCT geometry, the possibility of position estimation of the tumor region on the y-axis was confirmed.

Conclusion

From the fundamental study, it was confirmed that the possibility of position estimation of tumor region by simultaneous current-mode measurement using two transXend detectors opposite to each other. We have a plan to simulate more realistic BNCT conditions, in which boron is distributed in the whole of the phantom.

References

[1] I. Kanno, et al., Nucl.Sci. and Technol., 45, 1165 (2008).
[2] T. Sato, et al., Nucl. Sci. and Technol., 55, 684 (2018).
[3] Y. Sakurai and T. Kobayashi, Nucl. Instr. Eth. A, 453, 569 (2009).