A Deterministic Dose Calculation Algorithm Using Convolution/superposition method for Treatment Planning System of Boron Neutron Capture Therapy

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Boron neutron capture therapy (BNCT) is a binary system of using a targeted radiotherapy method. After boron drug injection in patient body, boron-10 ( ) compounds are accumulated in the tumor cells [1]. While the healthy tissues have a three to four times lower boron concentration than tumor regions. Neutrons are irradiated at the tumor site that thermalized through the moderator of beam shaping assembly (BSA) and patient body. These thermal neutrons interact with the nuclei. The nuclei with a large absorption cross section for thermal neutron cause significant decrease of thermal neutron flux in tumor cells. As a result, high linear energy transfer (LET) alpha and lithium particles are produced and destroy the tumor cells selectively [2-3].

Unlike photon radiotherapy, the transport of epithermal neutrons involves radiation components having different relative biological effectiveness (RBE) which therefore need to be considered separately. There are four dose components in BNCT which are boron, nitrogen, fast neutron, and gamma doses. Boron dose generated from reaction, nitrogen dose from , fast neutron dose from reaction and gamma dose from , reactions and also by some contaminated gamma rays come from the BSA. An algorithm is required to calculate the influences of each dose component in BNCT for computerized treatment planning [4].

In Korea, the accelerator based BNCT treatment facility, A-BNCT is under construction. It requires a treatment planning system (TPS) for its clinical trial and actual patient treatment. Unfortunately, the uniform international dosimetry guidance for BNCT radiotherapy modalities is not exist at present. Only Monte Carlo (MC) based treatment planning system have been applied in clinical BNCT because of the complex and scatter-dominated nature of the thermal neutron transport [5]. However, dose calculation using the MC stochastic simulation methods are often very time consuming and require huge computing power, which has led to the development of the faster deterministic methods.

Convolution / superposition (CS) is a deterministic dose calculation method using MC simulation results. Usually applied in dose calculation for photon beam radiation therapy. Calculation speed is much faster using CS method than MC simulation. Furthermore, the result of MC methods is only slightly more accurate for photon beams than the CS calculation [6]. In this paper, the CS method is applied to BNCT dose calculation algorithm for each dose components. To do this, the concept of ‘TEGMA’ is suggested first in this paper. TEGAM is the abbreviation of ‘Total Energy Generated per unit Mass’. It functions similar to TERMA – Total Energy Released per unit Mass – utilized in CS methods for gamma dose calculation. The difference is that TEGMA indicates the energy generated by nuclear reaction. TEGMA convoluted with neutron energy deposition kernel for

calculating the neutron dose. After dose calculation using CS algorithm, the results are compared with MC simulation in terms of precision and speed.

References

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