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Boron Neutron Capture Therapy for Breast Cancer in Pregnancy: A Simulative Dosimetry Estimation Study

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Cancer complicates approximately 1 per 1000 pregnancies and causes one-third of maternal deaths. Pregnancy affects the treatment procedure and causes lots of limits in prescribing radiotherapies considering the fetus receiving dose. Especially in the case of breast cancer which is a common cancer in women, radiotherapy is hardly prescribed in the first and second trimester of pregnancy. Instead, surgery is usually suggested especially for the locally advanced tumors. In these situations, neutron capture therapy can be mentioned as a possible treatment: considered as a targeted therapy, avoid the high fetal dose and also conserve the breast.
In this study, dose assessment is performed by MCNPX 2.6.0 using new developed pregnant phantoms in Ferdowsi University of Mashhad based on magnetic resonance (MR) images tied to the International Commission on Radiological Protection (ICRP) reference voxel phantom. The phantom is developed for two cases of 3 and 6 month pregnant. The neutron beam source is extracted from the both thermal and epithermal output of In-Hospital Neutron Irradiator (IHNI) of Beijing, China. The neutron beam with the 6 cm radius is employed to the treated volume (breast) in five different orientations. No shielding is considered in the abdominal area.

Six different locations, each with four different tumor sizes, in the breasts of both 3 and 6 month pregnant phantoms (totally 24 situations) are considered as tumor volumes. In each breast, one case is assumed to be deep-seated and two others are near-surface. Each tumor volume is irradiated in five orientations: straight to the breast (anterior-posterior) and the other four items with 45 degree rotation in right, left, up and down of the right breast. RBE-weighted absorbed dose values are estimated for thermal and epithermal beams of IHNI. The optimum multi-beam irradiation for each tumor volume is obtained based on: total dose to fetus and its sensitive organs, tumor to normal tissue dose ratio, and dose uniformity in tumor volume. Based on these calculations, we conclude that BNCT can be applied to breast cancer in the pregnant women.

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Experimental trial of measuring spatial distribution of neutrons and gamma rays in BNCT using multi imaging plate system.

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Abstract
In accomplishing the quality assurance and quality control for neutron capture therapy, handy detection system for the distributions of neutrons and gamma rays is one of the potential and essential options. This study tries to use the imaging plate for this purpose. Previously, the configuration of the converter to enhance and separate the neutron and gamma ray components was investigated using Monte Carlo calculations with the code PHITS. This paper describes the experimental verification of this method.

The converter configuration utilized was determined referring to the previous proposal by the simulation using PHITS calculation. From upstream of the neutron and gamma ray beam, the converter consisted of 6 mm thick carbon for gamma rays, 2 mm thick epoxy with 6.85 wt % ^{10}B for thermal neutrons, and 4 mm thick epoxy with 6.85 wt % for epithermal neutrons. Each layer had the imaging plate in its center, e.g. at 3 mm depth for carbon, etc. Detecting fast neutrons was not tried in this study because the sensitivity to the fast neutrons was very low, e.g. a few % of the total for the configurations previously investigated. The imaging plate used was "BAS-TR" by Fuji Film Corporation, Japan. The irradiation was performed with the standard epithermal neutron irradiation mode at heavy water neutron irradiation facility at Kyoto University Research Reactor Institute. The fluence of each beam component was determined by solving the equations about the imaging plate signal and their sensitivities for components. Here, the sensitivities were determined with the PHITS calculation in advance.

As a result, plausible fluence distributions of epithermal neutrons and gamma rays were obtained. However, obtained results for thermal neutrons were negative values and were not appropriate. This may be due to low contribution of thermal neutron component to the energy deposition of the imaging plate in PHITS calculation, at most 8 %. However, this study demonstrates the validity of the multi imaging plate system in measuring the fluence distributions of certain components, and suggests that optimizing the enhancer configuration according to the neutron/photon field will improve the performance. Further attempts to improve the equations and resultant distributions will also be presented.

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On the Importance of a Dedicated Beam Monitoring System for BNCT Facilities

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The beam monitoring system is indispensable to BNCT facilities to achieve an accurate patient dose delivery. The beam monitoring of a reactor-based BNCT (RB-BNCT) facility can be implemented through the instrumentation and control system of the reactor provided that the spatial distribution of neutron flux in the reactor core remains constant during the reactor operation. However, due to the fuel depletion, poison production, control blade movement etc., which depend in a complicated manner on the neutron flux, some extend of variation may occur in the spatial distribution of the neutron flux in the reactor core. Consequently, there may be a variation in the neutron beam extracted from certain part of