PhD Thesis title: 'Aperture Modulated Total body irradiation'

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ABSTRACT:

Total body irradiation (TBI) is typically used to suppress the immune system of cancer patients undergoing stem cell transplantation. Due to internal inhomogeneities, body contour variations and the large target size, achieving dose uniformity of the order of ±10% of the prescribed dose, as recommended, is challenging during TBI. A nonhomogeneous dose distribution might lead to TBI failure, either due to under-dosage of the bone marrow or over-dosage of the critical organs. We propose a novel, aperture modulated, translating bed TBI technique (AM-TBI) for improving dose uniformity within the patient. Two optimized fluence maps (AP and PA) were generated using the irregular electronic compensator algorithm in Eclipse™. Based on the optimized fluences multiple beam apertures using the multileaf collimator (MLC) were created along the superior-inferior axis of an anthropomorphic Rando® phantom. For the purpose of dose delivery to the Rando®, these individual MLC files were combined into a single dynamic MLC file (one each for AP and PA irradiation). For the dose distribution calculation, beam apertures were imported into Eclipse™. During irradiation, the phantom was translated on a moving bed under a stationary radiation beam with 0° gantry angle.

Dose calculations in Eclipse™ with aperture modulated TBI show better dose uniformity (±6%) than traditional fixed open beam translating bed TBI (±10%) in 3-dimensions. In-phantom measurements have demonstrated an agreement with calculation of better than ±3%.

We further identify, characterize, and correct for sources of error inherent in the AM-TBI technique to develop a clinically viable aperture modulated TBI technique. Instead of calculating optimized fluences in Eclipse™, radiological depths were calculated along divergent ray lines through transverse CT slices of the Rando® phantom. Based on these radiological depths, beam apertures were designed. The calculated beam apertures were further modified to correct for scatter contribution. Dose homogeneity in 3-dimensions was better than ±4% of the prescribed dose with this new TBI technique compared to ±6% with the Eclipse™ based technique.

Both the aperture modulated translating bed TBI techniques produce more uniform dose distributions in 3-dimensions compared to the fixed open beam translating bed TBI. However the aperture modulation TBI technique based on radiological depth is clinically feasible and computationally simple compared to the Eclipse™ fluence based technique.

References to author publications that relate specifically to the dissertation:

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3. ***Validation of the Eclipse AAA algorithm at extended SSD,***
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5. ***A Novel Translational Total Body Irradiation Technique,***
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