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Pre-Implementation of Total Body Irradiation Using Volumetric Modulated Arc Therapy: Full Body Anthropomorphic Phantom Development

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Abstract : Introduction: In combination with chemotherapy, Total Body Irradiation (TBI) is most used as part of the conditioning regimen prior to allogeneic hematopoietic stem cell transplantation. Conventional TBI techniques have a long application time but non-conformality of beam-application with the inability to individually spare organs at risk. Our institution's intention is to start using Volumetric Modulated Arc Therapy (VMAT) techniques to increase homogeneity of delivered radiation. As a first approach, a dosimetric plan was performed on a computed tomography (CT) scan of a Rando Alderson antropomorfic phantom (head and torso), using a set of six arcs distributed along the phantom. However, a full body anthropomorphic phantom is essential to carry out technique validation and implementation. Our aim is to define the physical and chemical characteristics and the ideal manufacturing procedure of upper and lower limbs to our anthropomorphic phantom, for later validate TBI using VMAT. Materials and Methods: To study the better fit between our phantom and limbs, a CT scan of Rando Alderson anthropomorphic phantom was acquired. CT was performed on GE Healthcare equipment (model Optima CT580 W), with slice thickness of 2.5 mm. This CT was also used to access the electronic density of soft tissue and bone through Hounsfield units (HU) analysis. Results: CT images were analyzed and measures were made for the ideal upper and lower limbs. Upper limbs should be build under the following measures: 43cm length and 7cm diameter (next to the shoulder section). Lower limbs should be build under the following measures: 79cm length and 16.5cm diameter (next to the thigh section). As expected, soft tissue and bone have very different electronic density. This is important to choose and analyze different materials to better represent soft tissue and bone characteristics. The approximate HU values of the soft tissue and for bone shall be 35HU and 250HU, respectively. Conclusion: At the moment, several compounds are being developed based on different types of resins and additives in order to be able to control and mimic the various constituent densities of the tissues. Concurrently, several manufacturing techniques are being explored to make it possible to produce the upper and lower limbs in a simple and non-expensive way, in order to finally carry out a systematic and appropriate study of the total body irradiation. This preliminary study was a good starting point to demonstrate the feasibility of TBI with VMAT.

Keywords : TBI, VMAT, anthropomorphic phantom, tissue equivalent materials
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