UNIVERSITÀ DEGLI STUDI DI MILANO

SCUOLA DI SPECIALIZZAZIONE IN FISICA MEDICA

FACOLTÀ DI MEDICINA E CHIRURGIA

Dosimetric feasibility study of Total Body Irradiation treatment with Volumetric Modulated Arc Therapy technique

Relatore: Prof.ssa Cristina LENARDI
Correlatore: Dott. Angelo Filippo MONTI
Correlatore: Dott.ssa Cristina DE MATTIA
Controrelatore: Dott. Roberto PELLEGRINI
Controrelatore: Dott.ssa Anna Enrica FRANCIA

Tesi di Specializzazione di:
Denise Curto
Matr. S63341

Anno Accademico 2020/21

ABSTRACT

Introduction: Total Body Irradiation (TBI) is a radiotherapy treatment prescribed for patients with different form of leukaemia. It is part of conditioning regimen for hematopoietic stem cell transplantation and different techniques can be adopted to deliver TBI treatment. The conventional method consists of two static either lateral (LAT) or anterior-posterior/posterior-anterior (AP/PA) opposed photon beams, delivered with a linear accelerator (LINAC) at an extended source-surface distance, so as to cover the entire patient's body with the fields. Developments on linear accelerator and multi-leaf collimator allowed to introduce Volumetric Modulated Arc Therapy (VMAT) for TBI treatments. Different centres tried to implement this technique addressing various treatment aspects (CT simulation, planning, pre-treatment dosimetry, patient positioning and immobilization systems) and they verified its effectiveness and advantages. This thesis is a dosimetric feasibility study, which purpose is to implement VMAT-based TBI in Grande Ospedale Metropolitano (GOM) Niguarda, where TBI treatment with conventional method is currently performed.

Material & Methods: Feasibility of CT-simulation with Canon Aquilion Exceed LB CT, contouring and planning with MIM® 7.1.4 (MIM Software Inc.) and Monaco® 5.51.10 (Elekta AB, Sweden) Treatment Planning System (TPS), delivery with an Elekta LINAC equipped with Agility® (Elekta AB, Sweden) Multi Leaf Collimator (MLC) were investigated following different approaches found in literature. Dosimetric verifications of calculated and delivered doses were performed with Thermo Luminescent Dosimeters for point measurements and with the Delta^4 phantom+ (ScandiDos AB, Sweden) for 3D measurements. The human-like Alderson Rando phantom was used for the entire implementation, while two whole-body retrospective CT acquisitions of two patients undergoing conventional TBI were used for planning optimization. Treatment goals of VMAT-TBI plan were to cover almost 95% of PTV volume with 95% of prescription dose (12 Gy delivered in 6 fractions twice a day) and to reduce mean dose to lungs below 10 Gy.

Results: CT-simulation, contouring, planning and delivery of VMAT-TBI treatment were successfully performed. CT-simulation consisted of two CT-acquisitions with different orientations, one head-first supine (HFS) and the other feet-first supine (FFS). On the two CT-scans the PTV (the whole body reduced by 3 mm from the skin) and the OARs (lungs and, eventually, kidneys) were contoured, and subsequently, the planning was carried out on them. The VMAT-TBI treatment plan consisted of six overlapping fields with six different isocentres and maximum size of 40x40 cm^2. Three fields were planned on the HFS-CT, while the other three on the FFS-CT, resulting in two plans optimized thanks to Monaco "Bias Dose" tool. Dosimetry, carried out simulating the treatment on Alderson Rando with TLDs and then with Delta^4, verified that calculated dose by Monaco was comparable with delivered and measured dose. Average mean and maximum percentage differences between calculated and measured doses obtained from point measurements with TLDs were 2.3% and 10.4%. Gamma passing rate (3%/3 mm, global, 10% cut) of single beams dose distributions acquired with Delta^4 resulted always higher than 99%, while dose distributions in junction regions between adjacent fields resulted higher than 90%. VMAT-TBI simulated treatment plans of two patients fulfilled treatment goals of PTV coverage and OARs sparing: average PTV volume that receive almost 95% of prescription dose resulted 97.44%, while average mean dose to lungs was 9.89 Gy and mean dose to kidneys was 10.11 Gy.

Conclusions: This study confirms the feasibility of VMAT-based TBI in GOM Niguarda Hospital. Next step of the treatment implementation is to investigate more clinical oriented aspects, such as immobilization systems for patient's positioning and setup verifications.