Cureus

Clinical Significance of Transitioning from an Anisotropic Analytical Algorithm to a Linear Boltzman Transport Equation Algorithm for Stereotactic Lung Treatments

Open Access
Abstract
Published 04/02/2023

Remy Manigold [1] , Garrett Baltz [1] , Steven Kirsner [1]

1. Radiation Oncology, Scripps Clinic, San Diego, USA

Corresponding author: Remy Manigold, manigold.remy@scrippshealth.org

Categories: Medical Physics, Radiation Oncology
Keywords: lung sbrt, acuros xb, anisotropic analytical algorithm, radiotherapy treatment planning

How to cite this abstract
Manigold R, Baltz G, Kirsner S (April 02, 2023) Clinical Significance of Transitioning from an Anisotropic Analytical Algorithm to a Linear Boltzman Transport Equation Algorithm for Stereotactic Lung Treatments. Cureus 15(4): a953

Abstract

Objectives:

Currently, based on Imaging and Radiation Oncology Core (IROC) Houston data, most clinics are using convolution/superposition class dose algorithms for treatment planning, such as the Anisotropic Analytical Algorithm (AAA). Current fractionation schemes and organ at risk (OAR) constraints are based upon dosimetric data calculated with such algorithms. Treatment planning systems are now implementing more advanced dose algorithms, such as Acuros XB (AXB), which numerically solves the linear Boltzmann transport equation to achieve comparable accuracy to Monte Carlo methods. The purpose of this study was to determine if there were any statistical or clinical differences in target and OAR dosimetry metrics for lung stereotactic body radiotherapy (SBRT) plans, when switching from AAA to AXB for treatment planning.

Methods:

45 patients were chosen retrospectively from our database that had received lung SBRT treatment (resulting in 50 total targets treated) between the years of 2014-2022. Patients were treated using volumetric modulated arc therapy (VMAT) plans with a prescribed dose of 50 Gy to the planning target volume (PTV) and 60 Gy to the internal target volume (ITV) or gross tumor volume (GTV) in 4-5 fractions. Treatment plans were initially optimized and calculated using either AAA (versions 11.0.31 to 15.6.05) or AXB (version 15.6.05). All patients were treated on a TrueBeam with High Definition MultiLeaf Collimators (HDMLC). For the comparison, a AAA plan, an AXB dose to water (D2W) plan, and an AXB dose to medium (D2M) were created by changing the dose calculation algorithm of the final clinical plan and recalculating with the same monitor units (MU). For all plans, the minimum, mean, and maximum dose to the target were recorded. In addition, D90%, D95%, and D98% for the PTV and ITV/GTV were recorded. The Ipsilateral lung V20(Gy) and mean dose, spinal canal max and mean dose, chest wall V30(Gy) and max dose, esophagus max dose, heart max dose, and great vessels max dose were recorded for OAR metrics. The Mann-Whitney U test with a significance value of $p< 0.05$ was used to determine statistical significance between AXB D2M and AXB D2W metrics, as well as AXB D2M and AAA metrics. The Mann-Whitney test was used due to the comparison data not being normally distributed as determined by the Shapiro-Wilk test. Clinical significance was also investigated for the metrics chosen to evaluate.

Results:

Comparisons of AXB D2M and AXB D2W plans demonstrated no statistical difference between any of the target or OAR metrics (p-values between 0.19-0.99). Due to this, comparisons of target and OAR metrics were only analyzed for AXB D2M vs AAA. AXB D2M and AAA comparisons show only differences in target maximum, ITV mean, and ITV D90% were statistically significant. On average the maximum dose to the target was 1.8% greater for AXB D2M compared to AAA, the mean dose to the ITV was 0.8% greater for AXB D2M compared to AAA, and the ITV D90 was 0.3% greater for AXB D2M when compared to AAA. For the rest of the target metrics on average, the PTV minimum was 3% lower for AXB D2M compared to AAA, PTV mean was 0.8% lower for AXB D2M compared to AAA, PTV D95 was 1.8% lower for AXB D2M compared to AAA, PTV D90 was 1.6% lower for AXB D2M compared to AAA, PTV D98 was 2% lower for AXB D2M compared to AAA, ITV minimum was 1.1% lower for AXB D2M compared to AAA, ITV D95 was 0.1% lower for AXB D2M compared to AAA, and ITV D98 was 0.2% lower for AXB D2M compared to AAA. For the OAR metrics on average, there was no difference in ipsilateral lung V20 for AXB D2M compared to AAA, ipsilateral mean lung dose was less than 1 cGy lower for AXB D2M compared to AAA, cord max dose was 25.5 cGy lower for AXB D2M compared to AAA, cord mean dose was 6.6 cGy lower for AXB D2M compared to AAA, chest wall V30 was 0.3 cc lower for AXB D2M compared to AAA, chest wall max dose was 94.4 cGy higher for AXB D2M

compared to AAA, esophagus max dose was 2.1 cGy lower for AXB D2M compared to AAA, heart max dose was 9.9 cGy higher for AXB D2M compared to AAA, and great vessels max dose was 8.2 cGy higher for AXB D2M compared to AAA.

Conclusion(s):

No statistical difference was observed in target or OAR metrics between D2W and D2M for AXB. In comparing AAA and AXB D2W, three target related metrics demonstrated statistical differences. Examination of the actual dose differences indicate that although there were statistical differences in these metrics, the difference in dose is within the accepted uncertainty of the calculation of the dose to these structures. Therefore, there are no true clinical differences of the dose calculated between the two algorithms. Based on these results, we conclude no adjustment to target dose prescription or OAR constraints is necessary when switching from AAA to AXB D2M generated treatment plans.