Oncology
and Radiotherapy©
18(10) 2024: 001-007 • RESEARCH ARTICLE

Dosimetric comparison of Anisotropic Analytical Algorithm (AAA) and Acuros XB (AXB) using Volumetric Modulated Arc Therapy (VMAT) for oesophageal cancer

S. Sriram Prasath[1,2], Akib Ahamed[1], Kiran Joshi[1], Satyam Arora[1], A. Prasheedha[1], Aranya Sarkar[1], Smita Jagdish Kalita[1], B. Arun[1], Moses ArunSingh[1], Tapesh Bhattacharya[1], Indranil Mallick[1], P. Ramesh Babu[2]

[1] Department of Radiation Oncology, Tata Medical Centre, Kolkata, India
[2] Department of Physics, School of Advanced Sciences, Vellore Institute of Technology, Vellore, Tamil Nadu, India

ABSTRACT

Aim: To compare and analyse the dosimetric parameters between Anisotropic Analytical Algorithm (AAA) and Acuros XB (AXB) algorithm in Volumetric Modulated Arc Therapy (VMAT) plans for Oesophageal Cancer.

Materials and Methods: Total 30 patients who were treated between the year 2020 and 2024 in our institute taken for this retrospective study. All the patients underwent VMAT treatments with dual Arc using AAA calculation and these patients dose plans were calculated using AXB using the same optimization parameters. The prescription doses to the target were ranging between 41.4 Gy to 60 Gy. The dosimetric comparison between AAA and AXB was performed using Planning Target Volume (PTV) coverage, Conformity Index (CI), Homogeneity Index (HI) and organ at risk (OAR) doses such as spinal cord planning risk volume, dose received by total lung volume of 20 Gy, 10 Gy, and 5 Gy (V20, V10, V5) and mean dose to heart. The statistical analysis was done using paired sample t-test.

Results: The mean difference in CI and HI were 0.64 ($p<0.001$) and 0.10 ($p=0.10$ respectively. The mean dose differences between these 2 calculation algorithms were insignificant for Spinal cord PRV (MD=0.92 Gy, $p=0.62$), heart mean dose (0.27 Gy ($p=0.90$)) and total lung doses. The mean difference for total lung was 0.16 Gy ($p=0.81$), and in V20Gy, V10Gy V5Gy were 0.16% ($p=0.93$), 0.58% ($p= 0.81$), 1.19% ($p=0.74$) respectively

Conclusion: We observed from the results that the difference in HI, OAR doses were insignificant, but difference in the CI showed significant between AAA and AXB calculated VMAT plans. AAA overestimates the coverage in PTV when compared to AXB. This suggests that appropriate calculation algorithm to be chosen for sites having much heterogeneity in tissues surrounding the PTV.

Keywords: Anisotropic Analytical Algorithm (AAA), Acuros XB (AXB), Oesophageal Cancer (OC), Conformity Index (CI), Homogeneity Index (HI), Volumetric Modulated Arc Therapy (VMAT)

Address for correspondence:

P. Ramesh Babu

Department of Physics, School of Advanced Sciences, Vellore Institute of Technology, Vellore, Tamil Nadu, India

E-mail: prameshbabu@vit.ac.in

Word count: 3979 **Tables:** 05 **Figures:** 06 **References:** 27

Received: 18 October, 2024, Manuscript No. OAR-24-150369
Editor assigned: 21 October, 2024, Pre-QC No. OAR-24-150369(PQ)
Reviewed: 06 November, 2024, QC No. OAR-24-150369(Q)
Revised: 11 November, 2024, Manuscript No. OAR-24-150369(R)
Published: 18 November, 2024, Invoice No. J-150369

INTRODUCTION

Recent advancements in radiation therapy, particularly Volumetric Modulated Arc Therapy (VMAT) and Anisotropic Analytical Algorithm (AAA), have significantly improved the treatment of oesophageal cancer [1, 2]. VMAT enhanced precision and efficiency, optimizing dose delivery while protecting healthy tissue. The AAA further refined dose calculation through advanced modelling techniques. This comparative study, backed by patient data, offers insights into VMAT's optimization and the selection of suitable dose calculation algorithms, aiming to improve therapeutic outcomes for oesophageal cancer patients [3, 4].

The AAA algorithm, acclaimed for its accuracy and prevalent utilization in the planning of radiotherapy treatments, presents limitations due to its sole dependence on parameters of tissue density, consequently neglecting the essential aspect of elemental composition [5-7]. This affects its precision in areas with varying tissue densities and implanted materials with high atomic numbers. In contrast, Acuros XB (AXB) is an advanced algorithm that directly solves the linear Boltzmann transport equation, offering Monte Carlo-level accuracy more efficiently [8, 9]. AXB improves upon AAA by splitting dose calculation into two phases: simulating the radiation beam in the accelerator head and then computing the dose distribution in the patient. AXB's unique feature is its detailed consideration of the elemental composition of tissues, aligning voxel geometry with mass density and material composition from CT scans. This ensures high accuracy in diverse density environments. AXB primarily calculates dose-to-medium, but can convert it to dose-to-water, introducing some uncertainty. However, dose-to-medium remains preferred for treatment evaluation and outcome analysis, with ongoing research into the best clinical dose reporting methods [10, 11].

Numerous studies indicated that the Acuros XB (AXB) algorithm predicts dose distribution in low-density tissues more accurately than the Anisotropic Analytical Algorithm (AAA), which tends to overestimate [12-17]. Specifically, AXB showed lower mean doses in oesophageal cancer treatments involving Rapid Arc, affecting PTV, GTV, and OARs surrounded by low-density lung tissue. These results suggest AAA might over predict doses, influencing tumor control. Similar trends were observed in prostate and head and neck cancer treatments. This paper presented a detailed comparison of AAA and AXB in VMAT for oesophageal cancer, focusing on dosimetric differences that could

impact clinical decisions and treatment efficacy [18].

METHODS AND MATERIALS

Patient selection and VMAT planning

After receiving the approval from the Institutional Review Board (IRB), Helical CT scan Image data sets of 30 Oesophagus cancer patients were selected for this retrospective. Dosimetric study. VMAT plan mostly using dual arc optimization was done in the Eclipse TPS software (version15.1) (Varian Medical Systems, Palo Alto, USA). The VMAT planning was done for most of the patients using double arcs except one patient using tripe arc in depending upon the complexity of the PTV. The VMAT plans were generated using the MLC optimization algorithm called Photon Optimizer (PO).

Plan evaluation

The evaluation of VMAT plans was conducted to compare dosimetric outcomes between AAA and AXB calculations. This assessment utilized the institutional protocol's dose constraints, addressing both PTV coverage criteria and doses to Organs At Risk (OAR). In addition to the institutional protocol, the Conformity Index (CI), as proposed by Paddick et al., [19] and the Homogeneity Index (HI), as defined by ICRU83, were employed [20-23].

The Prescription doses were 41.4 Gy, 50 Gy, 50.4 Gy, 55 Gy and 60 Gy to 15 patients, 12 patients, 1 patient, 1 patient and 1 patient respectively. The volume of the PTV varied from maximum of 755.3 cc to minimum of 186.8 cc with SD of 137.26 cc. The doses to OAR such as Maximum dose to Spinal Cord PRV, total lung (V_{20Gy}, V_{10Gy}, V_{5Gy} were the relative volume of total lung receiving 20 Gy, 10 Gy, 5 Gy respectively), mean dose to total lung, mean dose to Heart, were also compared between the AAA and AXB calculated VMAT plans. Statistical analysis was done using 2 sample t-tests. The VMAT plans were generated following the institutional protocol for oesophagus dose constraints (Figure 1).

Fig. 1. Shows the comparison of AAA and AXB calculated VMAT plans for oesophageal cancer displaying the dose colour wash in AXB plans and AAA plans in Axial, Sagittal and Coronal views

The VMAT plans evaluation was done using the Conformity Index (Paddick, 2000) [19]. CI given in Equation (i) as

$$\text{Conformity Index (Paddick CI)} = \frac{TV_{PIV}^2}{TV \times PIV} \quad \text{(i)}$$

Where TV_{PIV} was the volume of target covered by prescription isodose, PIV was the prescription isodose in the total body; TV was the Target Volume and the Homogeneity Index (HI) from ICRU: Prescribing, Recording, and Reporting Photon-Beam Intensity-Modulated Radiation Therapy (IMRT). ICRU Report 83 (2010) [20].

Given in equation (ii) as

$$\text{Homogeneity Index (HI)} = \frac{(D2\% - D98\%)}{D50\%} \quad \text{(ii)}$$

Patient plan delivery quality assurance

The VMAT plans of patients were recalculated on the Cheese Phantom and the point dose measurement are done using the A1SL chamber of volume 0.053 cc (Figure 2). The points in a homogeneous dose distribution area were chosen for the point dose measurement. The Gamma Pass test was performed with 3% Dose Difference (DD) and 3 mm of Distance-To-Agreement (DTA), passing rate criteria (3%/3 mm) threshold (Figure 3). The Gamma analysis was done using portal dosimetry using amorphous silicon (a-Si 1200) MV detector panel (Varian Medical Systems, Palo Alto, USA).

Fig. 2. Shows the Point dose measurement setup using Cheese Phantom along with A1SL chamber in Linear Accelerator

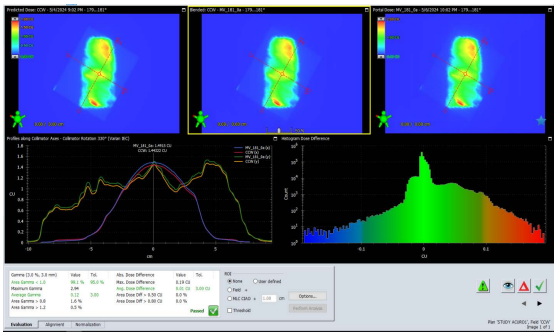

Fig. 3. Gamma analysis (3%/3mm pass criteria) using portal dosimetry

RESULTS

Table 1 compared radiation doses to OAR from VMAT plans using AAA and AXB, showing no significant differences. The Spinal cord maximum doses differed by -0.49 Gy (SD ± 0.58 Gy), with AAA and AXB averaging 34.56 Gy and 34.07 Gy (Figure 4), respectively (p=0.783). Spinal cord PRV maximum doses also showed negligible difference, with a mean of -0.92 Gy (Std ± 1.97 Gy) and average doses of 37.64 Gy for AAA and 36.72 Gy for AXB (p=0.620).

Tab. 1. Comparison of critical organs at risk dose statistics

	Mean Difference ± Std (Max, Min)	AAA Mean ± Std	AXB Mean ± Std	p-Value
Spinal cord Max	-0.49 ± 0.58 (1.56, -1.82) Gy	34.56 ± 6.82 Gy	34.07 ± 6.89 Gy	0.783
Spinal cord PRV Max	-0.92 ± 1.97 (0.29, -2.34) Gy	37.64 ± 7.19 Gy	36.72 ± 7.03 Gy	0.62
Total lung V20Gy	-0.16 ± 0.19 (0.2, -0.64) %	14.93 ± 7.15 %	14.77 ± 7.10 %	0.931
Total lung V10Gy	-0.58 ± 0.41 (0, -1.62) %	40.31 ± 9.89 %	39.72 ± 9.73 %	0.818
Total lung V5Gy	-1.19 ± 1.09 (-0.1, -5.1) %	56.91 ± 14.36 %	55.72 ± 13.74 %	0.745
Total lung Mean	-0.16 ± 0.07 (0.01, -0.27) Gy	10.08 ± 2.57 Gy	9.91 ± 2.53 Gy	0.806
Heart mean	-0.27 ± 0.17 (0, -0.54) Gy	13.73 ± 8.57 Gy	13.73 ± 8.41 Gy	0.904

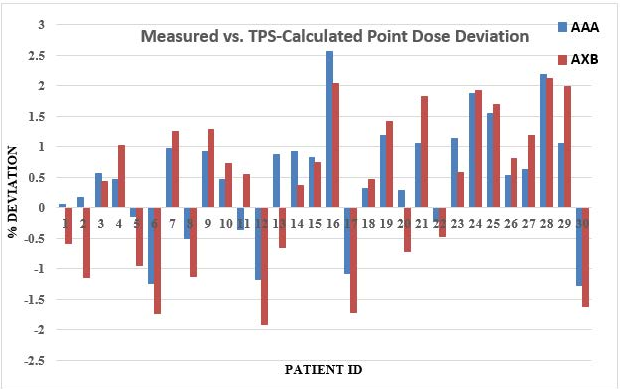

Fig. 4. Percentage deviation of measured dose with AAA and AXB calculated dose

When considering lung doses, the total lung V_{20Gy} showed a mean difference of -0.16% with a SD of ± 0.19%, and the p value of 0.931 indicated a non-significant difference between the mean doses of 14.93% for AAA and 14.77% for AXB. Similarly, the total lung V_{10Gy} and V_{5Gy} had mean differences of -0.58% and -1.19%, SD of ± 0.41% and ± 1.09%, and p-values of 0.818 and 0.745, respectively. These results suggested that the differences in lung doses at these volume thresholds were not statistically significant.

In conclusion, the average doses for the lungs and heart demonstrated marginal differences of -0.16 Gy and -0.27 Gy (Figure 5), respectively, accompanied by minimal (SD) of ± 0.07 Gy for the lungs and ± 0.17 Gy for the heart. The p values for both were above 0.8, indicating that the differences observed in the mean doses for both OARs between AAA and AXB were not statistically significant.

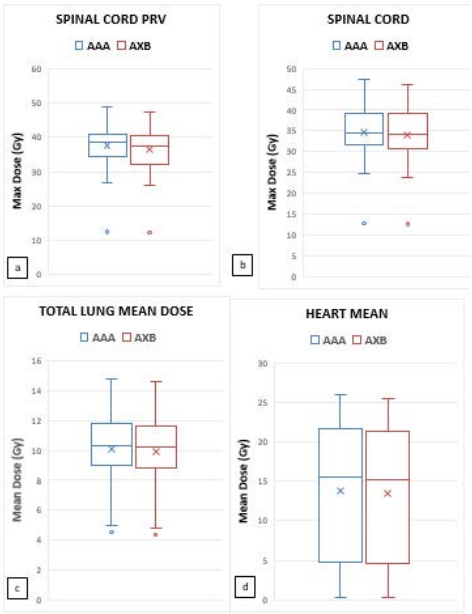

Fig. 5. Box plot for comparison of doses between AAA and AXB plans a) max dose to spinal cord PRV b) max dose to spinal cord c) total lung mean dose d) heart mean dose

The analysis of PTV dose statistics presented in table 2 revealed a comparison between 2 calculation algorithms, AAA and AXB. The mean dose values for D99% and Mean dose categories indicated a slightly higher dose delivery with the AAA compared to AXB, with mean differences of 0.42 Gy and 0.52 Gy, respectively. However, these differences were not statistically significant, as reflected by the p-values (0.75 and 0.71, respectively), which were much higher than the conventional threshold of 0.05 for statistical significance. Conversely, for D95%, Max, and Min dose categories, AXB showed marginally higher doses, but again, these differences were not statistically significant (p-values: 0.81, 0.76, and 0.96, respectively). The SDs associated with these measurements suggested a comparable level of variability between the 2 algorithms. Overall, the data suggested that both AAA and AXB delivered similar dose distributions to the PTV, with no significant differences observed in this comparison.

Tab. 2. Comparison of PTV dose statistics

PTV	AAA Mean ± Std Dose (Gy)	AXB Mean ± Std Dose (Gy)	Mean Difference [Mean ± Std (Max, Min)] (Gy)	p-Value
D99%	41.94 ± 5.11	41.52 ± 4.91	0.42 ± 0.66 (1, -0.03)	0.75
D95%	43.57 ± 6.9	43.95 ± 5.05	-0.38 ± 5.46 (0.96, -0.29)	0.81
Max	49.64 ± 5.89	50.10 ± 5.79	-0.46 ± 0.88 (-0.02,1.84)	0.76
Min	32.55 ± 7.44	32.65 ± 7.17	-0.11 ± 1.69 (1.99, -0.05)	0.96
Mean	46.64 ± 5.39	46.13 ± 5.32	0.52 ± 0.15 (0.78,0.0)	0.71

The data presented in table 3 compared the CI and HI of PTV coverage in VMAT plans calculated using 2 algorithms: AAA and AXB. For the CI, in VMAT plans calculated with AAA showed a mean of 0.64 and a SD of 0.14, with values ranging from a maximum of 0.83 to a minimum of 0.35. Conversely, AXB exhibited a lower mean of 0.41, a higher SD of 0.2, and a broader range of values, with the maximum at 0.82 and the minimum at 0.14. The p-value for the CI comparison was less than 0.001, indicating a statistically significant difference between the two algorithms.

Tab. 3. Comparison of conformity and homogeneity indices

	AAA [Mean ± Std (Max, Min)]	AXB [Mean ± Std (Max, Min)]	p-Value
CI	0.64 ± 0.14 (0.83, 0.35)	0.41 ± 0.2 (0.82, 0.14)	<0.001
HI	0.10 ± 0.03 (0.17, 0.06)	0.12 ± 0.03 (0.18, 0.07)	0.104

The results from table 4 indicated a comparison of point dose measurements between the measured dose and the TPS calculated dose. For the AAA algorithm, the point dose deviation was reported as 0.49% with a SD of 0.96%, and the range of deviation spanned from a maximum of 2.57% to a minimum of -1.27%. Conversely, the AXB algorithm showed a slightly lower mean point dose deviation of 0.33%, albeit with a higher SD of 1.27%, indicating a broader spread of values (Figure 6). The maximum

deviation observed for AXB was 2.12%, while the minimum was -1.92%.

Tab. 4. Comparison of point dose measurement

Point Dose Deviation (%) Measured Dose *vs.* TPS Calculated Dose [Mean ± Std (Max, Min)]		p-Value
AAA	AXB	
0.49 ± 0.96 (2.57, -1.27)	0.33 ± 1.27 (2.12, -1.92)	0.579

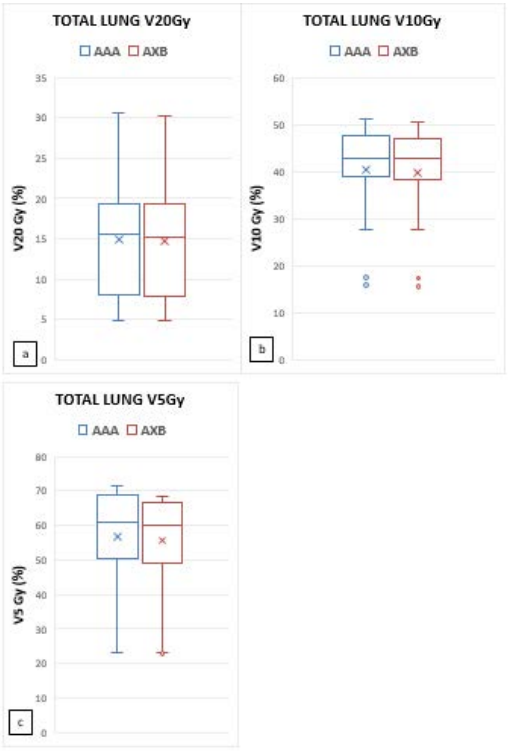

Fig. 6. Box plot for comparison of total lung doses between AAA and AXB plans a) total lung v20 Gy b) total lung v10 Gy c) total lung v5 Gy

The results from the gamma analysis using portal dosimetry, as presented in table 5, showed that both AAA and AXB have demonstrated high levels of agreement with the gamma criteria of 3%, 3 mm. The mean gamma pass rate for AAA was 98.6% with a SD of 0.85% (ranging from 96.7% to 99.8%), while AXB had a slightly higher mean of 98.8% and a SD of 0.82% (also ranging from 96.7% to 99.8%). The p-value, which was 0.292, indicated that the difference in performance between AAA and AXB was not statistically significant in this analysis.

Tab. 5. Comparison of gamma analysis using portal dosimetry

Point Dose Deviation (%) Measured Dose *vs.* TPS Calculated Dose [Mean ± Std (Max, Min)]		p-Value
AAA	AXB	
0.49 ± 0.96 (2.57, -1.27)	0.33 ± 1.27 (2.12, -1.92)	0.579

DISCUSSION

In a study by Rana and colleagues, the clinical dosimetric impacts of AAA and AXB were analysed through Rapid Arc plans for prostate cancer patients, confirming a slight variation in PTV D95% values (range 0.21%-0.67%) [15]. Similarly, Kan and the team observed that AXB calculations for PTV70 in nasopharyngeal carcinoma were lower than AAA's, with notable discrepancies in bone content doses [17].

Similarly, from our study, in the comparison of PTV dose statistics between AAA and AXB, the mean doses with SD s are listed, along with the mean differences, maximum and minimum values, and p values. For D99%, the mean dose is slightly higher for AAA than AXB, with a mean difference of 0.42 Gy. The maximum dose observed is higher for AXB by 0.46 Gy. Overall, the mean doses are comparable, with no significant differences indicated by the p values, suggesting similar dose distributions between the 2 methods.

Similarly, our study showed that in the comparison of PTV dose statistics between AAA and AXB, the mean doses with SDs were listed, along with the mean differences, maximum and minimum values, and p values. For D99%, the mean dose was slightly higher for AAA than for AXB, with a mean difference of 0.42 Gy. The maximum dose observed was higher for AXB by 0.46 Gy. Overall, the mean doses were comparable, with no significant differences indicated by the p values, suggesting similar dose distributions between the 2 algorithms.

Fogliata's research corroborates this, noting minimal differences in lung volume dose calculations between AXB and AAA [21-24]. From our study, the data presented on comparison of dose statistics for OARs using 2 different calculation algorithms, AAA and AXB, the mean differences in doses are minimal, with the largest observed in the total lung V5Gy at -1.19 ± 1.09%. The spinal cord maximum dose shows a slight reduction in the AXB mean compared to AAA, but this difference is not statistically significant, as indicated by the p values which are all well above 0.05.

Han's research found good agreement between AAA and AXB dose calculations with RPC lung phantom measurements, attributing the minor discrepancies to AXB's more accurate lung tissue heterogeneity modelling, a finding echoed by other studies and

highlighted by Robinson's demonstration of AAA's overestimation at heterogeneity interfaces [25-27]. In our study, overall, the results suggested comparable performance between the 2 algorithms in terms of OARs dose.

The p-value, which assesses the statistical significance of the difference between the 2 sets of point dose measurements, is 0.579. This suggested that there were no statistically significant differences in the deviations. The measured point dose agreement with the calculated point doses by AAA and AXB algorithms was consistent. Therefore, both algorithms demonstrated a similar level of accuracy in point dose measurement compared to the TPS-calculated dose.

The gamma analysis results showed a high level of consistency between the AAA and AXB dosimetry systems, with both meeting the gamma criteria effectively. The p value exceeded 0.05, which statistically indicated that the difference in their performance was not significant.

CONCLUSION

We observed from the results that the difference in HI, and OAR doses was insignificant, but the difference in the CI showed significance between AAA and AXB calculated VMAT plans. AAA overestimates the coverage in PTV when compared to AXB. This suggested that an appropriate calculation algorithm to be chosen for sites having much heterogeneity in tissues surrounding the PTV. This study could be further extended by performing in-vivo dosimetry in heterogeneous phantoms such as the Quasar Phantom and the thorax region in the Rando Phantom.

ACKNOWLEDGEMENTS

The author is grateful for the support from Clinician colleagues, Senior Consultants Dr Rimpa Achari, Dr. Sanjoy Chatterjee, Dr. Indranil Mallick, Dr. Santam Chakraborty and Dr. Tapesh Bhattacharya, and Associate Consultant Dr. Moses Arun Singh. Also, the author is grateful for the support from the Physics colleagues Mr. B. Arun, Ms. Anurupa Mahata, Mr. Samar Mandal, Ms. Smita Jagadish Kalita, Mr. Aranya Sarkar, Ms. A. Prasheedha, Mr. Satyam Arora, Mr. Kiran Joshi Mr. Bhakti Dev Nath and Catherine D' Souza. Also, the author is thankful for the help from the Physics Interns Mr. Jayesh Wakade, Ms. Anjali Hembram, Ms. S. Meenakshi, Ms. MD Janaganandhini, Ms. Pallavi Mondal, Ms. Aarthi Pandi, Ms. L. Vinothini, and Mr. C. Rajendran. The author is grateful for the help from the Imaging data scientist Mr. Sougata Maity.

FUNDING STATEMENT

- No Fund was received for this study
- If it was approved by any scientific Body/ if it is part of an approved student thesis-Yes, Approved by Institution Review Board, Protocol Waiver NO: EC/WV/TMC/23/23.

CONFLICT OF INTEREST

- Authors declare no conflict of interest.
- How the ethical issue was handled (name the ethical committee that approved the research). This project involves publicly available datasets. This study is not involved with any patients or any healthy volunteers. Approved by Institution Review Board, Protocol Waiver NO: EC/WV/TMC/23/23.

AUTHORS CONTRIBUTION

- Concept and data collection by S. Sriram Prasath, Guidance and supervision by P. Ramesh Babu; Manuscript evaluation and modification by S. Sriram Prasath and P. Ramesh Babu.
- Availability of data (if apply to your research) Data is available on request.

REFERENCES

1. International Commission on Radiation Units and Measurements. ICRU Report 83: Prescribing, Recording, and Reporting Photon-Beam Intensity-Modulated Radiation Therapy (IMRT). 2012;188:97-99.
2. Xin Z, Liu Q, Ai D, Chen K, Mariamidze E, et al. Radiotherapy for Advanced Esophageal Cancer: From Palliation to Curation. Curr Treat Options Oncol. 2023;24:1568-1579.
3. Holt A, Van Gestel D, Arends MP,. Multi-institutional comparison of volumetric modulated arc therapy vs. intensity-modulated radiation therapy for head-and-neck cancer: a planning study. Radiat Oncol. 2013;8:26.
4. Fogliata A, Nicolini G, Clivio A, Vanetti E, Cozzi L. On the dosimetric impact of inhomogeneity management in the Acuros XB algorithm for breast treatment. Radiat Oncol. 2011;6:103.
5. Sievinen J, Ulmer W, Kaissl W. AAA Photon Dose Calculation Model in Eclipse (Whitepaper). Varian Medical System; 2005;118:2894.
6. Krishna GS, Srinivas V, Reddy PY. Clinical implications of Eclipse analytical anisotropic algorithm and Acuros XB algorithm for the treatment of lung cancer. J Med Phys. 2016;41:219-223.
7. Van Esch A,. Testing of the analytical anisotropic algorithm for photon dose calculation. Med Phys. 2006;33:4130-4148.
8. Padmanaban S, Warren S, Walsh A, Partridge M, Hawkins MA. Comparison of Acuros (AXB) and Anisotropic Analytical Algorithm (AAA) for dose calculation in treatment of oesophageal cancer: effects on modelling tumour control probability. Radiat Oncol. 2014;9:286.
9. Fogliata A, Nicolini G, Clivio A, Vanetti E, Cozzi L. Dosimetric evaluation of Acuros XB advanced dose calculation algorithm in heterogeneous media. Radiat Oncol. 2011;6:82.
10. Sarin B, Bindhu B, Raghu Kumar P, Sumeesh S, Saju B. Dosimetric accuracy of Acuros® XB and AAA algorithms for stereotactic body radiotherapy (SBRT) lung treatments: evaluation with PRIMO Monte Carlo code. J Radiother Pract. 2023;22:65.
11. Hoffmann L, Alber M, Söhn M, Elstrøm UV. Validation of the Acuros XB dose calculation algorithm versus Monte Carlo for clinical treatment plans. Med Phys. 2018;45:3909-3915.
12. Yan C, Combine AG, Bednarz G, Lalonde RJ, Hu B, et al. Clinical implementation and evaluation of the Acuros dose calculation algorithm. J Appl Clin Med Phys. 2017;18:195-209.
13. Bufacchi A, Caspiani O, Rambaldi G,. Clinical implication in the use of the AAA algorithm versus the AXB in nasopharyngeal carcinomas by comparison of TCP and NTCP values. Radiat Oncol. 2020;15:150.
14. Mbewe J, Shiba S. Halcyon™ Acuros XB vs AAA: A RapidArc Planning Comparison for Head & Neck Cancers. Int J Med Phys Clin Eng Radiat Oncol. 2022;11:189-199.
15. Rana S, Rogers K, Pokharel S, Lee T, Reed D, et al. Acuros XB Algorithm vs. Anisotropic Analytical Algorithm: A Dosimetric Study Using Heterogeneous Phantom and Computed Tomography (CT) Data Sets of Esophageal Cancer Patients. J Cancer Ther. 2013;4:138-144.
16. Onizuka R, Araki F, Ohno T,. Accuracy of dose calculation algorithms for virtual heterogeneous phantoms and intensity-modulated radiation therapy in the head and neck. Radiol Phys Technol. 2016;9:77-87.
17. Kan MW, Leung LH, Yu PK. Dosimetric impact of using the Acuros XB algorithm for intensity modulated radiation therapy and RapidArc planning in nasopharyngeal carcinomas. Int J Radiat Oncol Biol Phys. 2013;85:73-80.
18. Srivastava RP, Basta K, De Gersem W, De Wagter C. A comparative analysis of Acuros XB and the analytical anisotropic algorithm for volumetric modulation arc therapy. Rep Pract Oncol Radiother. 2021;26:481-488.
19. Paddick I. A simple scoring ratio to index the conformity of radiosurgical treatment plans. Technical Note. J Neurosurg. 2000;93:219-222.
20. International Commission on Radiation Units and Measurements. ICRU Report 83: Prescribing recording and reporting photon beam intensity modulated radiation therapy (IMRT). Oxf Univ Press. 2012;188:97-99.
21. Teoh M, Clark CH, Wood K, Whitaker S, Nisbet A. Volumetric modulated arc therapy: a review of current literature and clinical use in practice. Br J Radiol. 2011;84:967-996.
22. Kathirvel M, Subramanian S, Clivio A, Arun G, Fogliata A, et al. Critical appraisal of the accuracy of Acuros-XB and Anisotropic Analytical Algorithm compared to measurement and calculations with the compass system in the delivery of RapidArc clinical plans. Radiat Oncol. 2013;8:140.
23. Fogliata A, Nicolini G, Clivio A, Vanetti E, Cozzi L. Critical appraisal of Acuros XB and Anisotropic Analytical Algorithm dose calculation in advanced non-small-cell lung cancer treatments. Int J Radiat Oncol Biol Phys. 2012;83:1587-1595.
24. Han T, Followill D, Mikell J,. Dosimetric impact of Acuros XB deterministic radiation transport algorithm for heterogeneous dose calculation in lung cancer. Med Phys. 2013;40:051710.
25. Robinson D. Inhomogeneity correction and the analytic anisotropic algorithm. J Appl Clin Med Phys. 2008;9:112-122.
26. Liu HW, Nugent Z, Clayton R,. Clinical impact of using the deterministic patient dose calculation algorithm Acuros XB for lung stereotactic body radiation therapy. Acta Oncol. 2014;53:324-329.
27. Prasath SS, Ramesh Babu P. Dosimetric comparison between Acuros XB (AXB) and Anisotropic Analytical Algorithm (AAA) in volumetric modulated arc therapy. Asian Pac J Cancer Prev. 2023;24:1677-1685.