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# Dosimetric Comparison of AAA and Acuros Xb Algorithm In VMAT Total Body Irradiation

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## ABSTRACT

**Purpose:**
To compare dosimetric differences and calculation efficiency between the Anisotropic Analytical Algorithm (AAA) and Acuros XB for volumetric modulated arc therapy (VMAT)-based total body irradiation (TBI).
**Methods:**
Four previously treated VMAT TBI patients were retrospectively analyzed. Original plans, consisting of three isocenters with eight upper-body VMAT fields and two lower-extremity 3D parallel-opposed fields, were calculated with AAA (6 MV, 1200 cGy in 8 fractions) and recalculated with Acuros XB using identical beam geometry and monitor units. Target coverage, organ-at-risk (OAR) doses, and calculation time were compared.
**Results:**
Average calculation time was 313 s for AAA and 187 s for Acuros XB. AAA yielded higher V100% target coverage (4.8%–10.4%), whereas Acuros XB reduced maximum target dose by up to 3.2%. Acuros XB also predicted lower doses to the lungs (2.8%–3.5%), oral cavity (0.023%–3.3%), and lenses (0.613%–3.1%), while kidney and bowel dose differences were within 2%. Acuros XB demonstrated greater dose heterogeneity, with cold spots near bony anatomy.
**Conclusions:**
Compared with AAA, Acuros XB predicted lower target coverage, improved OAR sparing, and shorter calculation time, underscoring the importance of accurate tissue heterogeneity modeling in VMAT TBI planning.

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## INTRODUCTION

**AAA and AXB are the two most commonly used radiotherapy dose calculation algorithms.** AAA uses a convolution–superposition approach and performs well in homogeneous tissues, while AXB explicitly models photon and electron transport, providing greater accuracy in heterogeneous regions.

**Compared with AAA, AXB generally predicts slightly lower target and organ-at-risk doses**, with the largest differences occurring in highly heterogeneous treatment sites.

**VMAT-based total body irradiation (VMAT-TBI) offers significant advantages over conventional TBI**, using CT-based inverse planning and multi-isocenter delivery to improve target coverage and dose homogeneity while reducing doses to critical organs and treatment-related toxicities.

**Despite the established benefits of VMAT-TBI, the impact of dose calculation algorithm selection has not been systematically evaluated.** The large treatment volumes, multiple isocenters, and extensive tissue heterogeneity of VMAT-TBI may amplify differences between AAA and AXB.

**This study aims to compare AAA and AXB in VMAT-TBI planning** to assess their effects on target coverage, organ-at-risk doses, and overall treatment planning performance.

## METHODS AND MATERIALS

Seven previously treated patients undergoing VMAT TBI were retrospectively analyzed. Each patient received a three-isocenter VMAT plan consisting of eight upper-body VMAT fields and two conventional 3D parallel-opposed fields for the lower extremities.

All plans were calculated using AAA with 6 MV photon beams, prescribing a total dose of 1200 cGy delivered in 8 fractions.

For direct dosimetric comparison, each plan was recomputed using Acuros XB while preserving identical beam geometry and monitor units.

Dose calculation time was manually recorded for both algorithms.

Plan evaluation included target coverage specifically V100%, D1cc.

Dose homogeneity within the PTV was quantified using the homogeneity index (HI), defined as

$$HI = \frac{(D_2 - D_{98})}{D_{50}}$$

Dose to organs at risk (OARs) including Lungs, Kidneys, Bowel, Oral Cavity, and Lenses were compared

## RESULTS

The average dose computation time across all patients was 313 s and 187 s for AAA and Acuros XB, respectively.

Higher V100% target coverage was observed in AAA plans compared with Acuros XB for all four patients, with differences ranging from 4.8% -10.4%. Meanwhile reduced maximum target was observed in Acuros XB where the largest difference was 3.2%.

For organs at risk, Acuros XB demonstrated lower doses to the bilateral lungs (mean dose differences: 2.8% to 3.5%), oral cavity (D0.03cc differences: 0.023% to 3.3%), and lenses (D0.03cc differences: 0.613%–3.1%) compared with AAA.

Dose differences for the kidneys and bowel were within 2%. Noticeable heterogeneity in the isodose distribution was observed in Acuros XB plans, with pronounced cold spots near bony anatomy.

Across all patients, Acuros XB demonstrated lower HI values compared to AAA. AAA HI values ranged from 0.248 to 0.327, whereas Acuros XB ranged from 0.238 to 0.294. The largest reduction in HI was observed in Patient 4, where HI decreased from 0.327 with AAA to 0.294 with Acuros XB.

Overall, the results suggest that Acuros XB yields slightly more homogeneous dose distributions compared to AAA under identical planning conditions.

**Table 1. AAA vs Acuros OARs comparison across four patients**

| Patient | Algorithms | Lung mean dose (%) | Kidney mean dose (%) | Bowel $D_{0.03cc}$ (%) | Oral Cavity $D_{0.03cc}$ (%) | Lenses $D_{0.03cc}$ (%) |
|---|---|---|---|---|---|---|
| 1 | AAA | 62.12 | 74.08 | 110.04 | 108.11 | 91.39 |
| | Acuros XB | 59.28 | 72.55 | 108.96 | 105.65 | 89.06 |
| 2 | AAA | 58.19 | 67.60 | 112.32 | 107.35 | 89.74 |
| | Acuros XB | 55.00 | 66.21 | 112.40 | 104.41 | 86.68 |
| 3 | AAA | 62.53 | 74.71 | 111.00 | 112.24 | 88.62 |
| | Acuros XB | 59.00 | 73.63 | 110.78 | 109.83 | 87.38 |
| 4 | AAA | 57.93 | 67.46 | 113.23 | 111.44 | 86.65 |
| | Acuros XB | 54.79 | 65.84 | 111.32 | 108.15 | 85.14 |
| 5 | AAA | 54.71 | 74.71 | 111.00 | 112.24 | 88.62 |
| | Acuros XB | 51.60 | 73.63 | 110.78 | 109.83 | 87.38 |
| 6 | AAA | 55.00 | 71.86 | 112.13 | 108.54 | 88.12 |
| | Acuros XB | 52.00 | 69.53 | 110.60 | 109.61 | 86.75 |
| 7 | AAA | 58.22 | 72.60 | 112.77 | 108.46 | 89.69 |
| | Acuros XB | 55.95 | 71.33 | 112.61 | 107.54 | 88.86 |

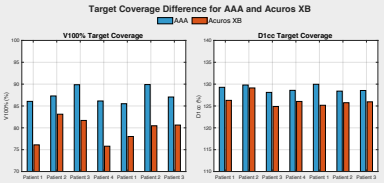


**Chart 1.** AAA vs Acuros XB Target coverage comparison for V100% and $D_{1cc}$

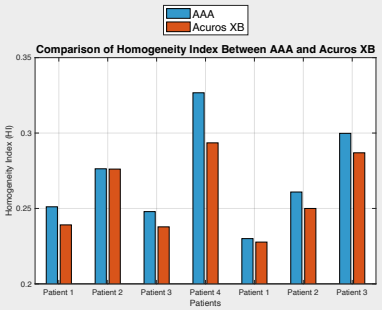


**Chart 2.** AAA vs Acuros XB dose homogeneity Index (HI) comparison

## DISCUSSION

This study demonstrates that dose calculation algorithm selection can significantly influence dosimetric evaluation in VMAT-based TBI. Despite identical beam geometry and monitor units, Acuros XB predicted lower target coverage and lower doses to several organs at risk, reflecting its more accurate modeling of tissue heterogeneity.

The higher target coverage reported by AAA likely represents dose overestimation in heterogeneous anatomy rather than improved plan quality, potentially masking clinically relevant cold spots, particularly near bone. More accurate OAR dose estimates with Acuros XB, especially for the lungs, may also improve toxicity assessment.

In addition to dosimetric differences, Acuros XB reduced calculation time, offering a practical advantage for the computational demands of VMAT TBI planning.

This study is limited by its small sample size and the use of recalculated rather than reoptimized Acuros XB plans.

## CONCLUSIONS

Dosimetric differences were observed between VMAT TBI plans calculated using AAA and Acuros XB. Acuros XB resulted in reduced target coverage but improved OAR sparing compared with AAA, while also demonstrating shorter dose computation time. These findings highlight the impact of tissue heterogeneity modeling and the importance of algorithm selection in VMAT TBI planning.

## REFERENCES

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