Comparison of AAA and Acuros XB for Small Field Lung SBRT

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2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

INTRODUCTION

Accurate dose calculation in small radiation fields within low density lung tissue remains challenging due to lateral electronic disequilibrium and tissue heterogeneity. This study compared the performance of the Analytical Anisotropic Algorithm (AAA) and Acuros XB (AXB) implemented in the Eclipse treatment planning system (version 16.1) for small-field lung dosimetry. The objectives were to (1) evaluate small-field output factors (FOFs) calculated with AAA and AXB using Monte Carlo (MC) simulations as reference and (2) quantify dosimetric differences for small lung stereotactic body radiation therapy (SBRT) as a function of target size and lung density

METHOD

Field output factors (FOFs) from 0.5×0.5 cm² to 10×10 cm² were computed in a lung phantom at 10 cm depth (2.5 cm solid water and 7.5 cm cork) using a 6 MV TrueBeam beam commissioned with a minimum field size of 2×2 cm², and compared against EGSnrc Monte Carlo simulations. Six SBRT plans were created for spherical targets of 1.5 cm and 2.0 cm in diameter with overridden lung densities of 0.2, 0.3, and 0.5 g/cm³. Plans were calculated independently using AAA and AXB with identical beam geometries, SBRT prescription and constraints. Dose–volume histograms (DVHs), target dose coverage, maximum dose, and MU/Gy were compared

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RESULTS

Small-field output factors (FOFs) comparisons

- FOFs of field sizes ranged from 0.5×0.5cm² to 10×10cm² were calculated in a lung phantom defined for SAD= 100cm at 10cm depth (2.5cm solid-water and 7.5cm cork slabs) for TrueBeam 6MV with beam data commissioned with the smallest field size of 2x2cm²; Fig.1 (a) shows FOFs plotted from 5×5 mm² to 50x50 mm² calculated with AAA, AXB and MC algorithms; Fig.1 (b) shows the difference of FOFs calculated with both AAA and AXB compared to EGSnrc MC simulations.
- For field sizes below 3×3 cm², AAA consistently underestimated FOFs relative to MC, with discrepancies reaching approximately 9% for the smallest fields, reflecting its limitations in modeling lateral electronic disequilibrium and low-density heterogeneities. In contrast, AXB demonstrated substantially improved agreement with MC across the small field range, with differences within ±5% for most fields and near zero deviation for fields ≥1.2×1.2 cm². However, AXB tended to overestimate output for the smallest fields, particularly at 0.5×0.5 cm².

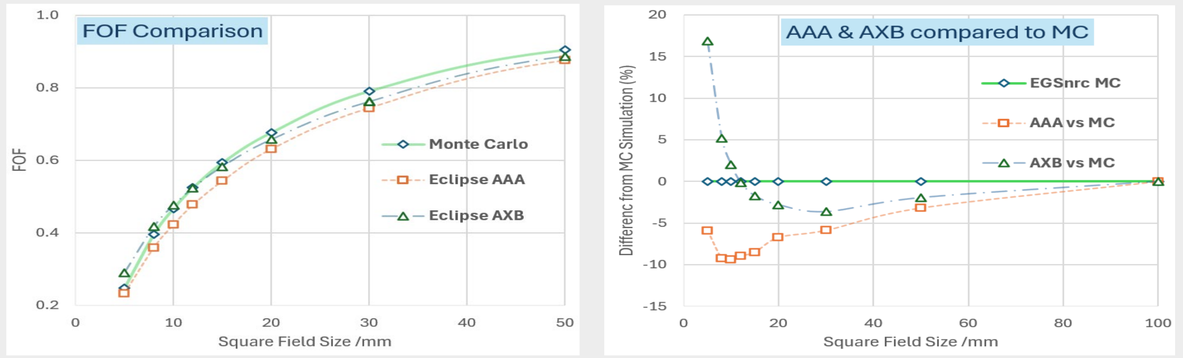

Fig. 1 FOF comparison between AAA & AXB: (a) FOFs from 5×5 mm² to 50x50 mm² (b) Difference of AAA & AXB to MC

SBRT plan dosimetric parameters

- Figure 2 demonstrated dose calculation accuracy for small lung SBRT targets is strongly dependent on both target size and lung density, with systematic differences observed between the AAA and AXB.
- AXB predicted consistently lower target dose coverage and steeper DVH fall-off compared to AAA. For the 1.5 cm target, DVHs showed pronounced algorithm related differences, particularly at lower lung densities (ρ = 0.2 and 0.3 g/cm³), where AAA systematically predicted higher dose coverage than AXB in the high dose region. These differences were reduced but remained noticeable for the 2.0 cm target, indicating improved lateral electronic equilibrium for larger lesions but persistent sensitivity to tissue heterogeneity. Increasing lung density resulted in narrower DVH separation between the algorithms for both target sizes. MU/Gy increased with decreasing lung density for both algorithms, reflecting reduced photon scatter and electronic equilibrium in low density media. AXB consistently required higher MU/Gy than AAA for the same prescription, particularly for the smaller target, highlighting AAA's tendency to overestimate dose deposition in lung equivalent tissues.

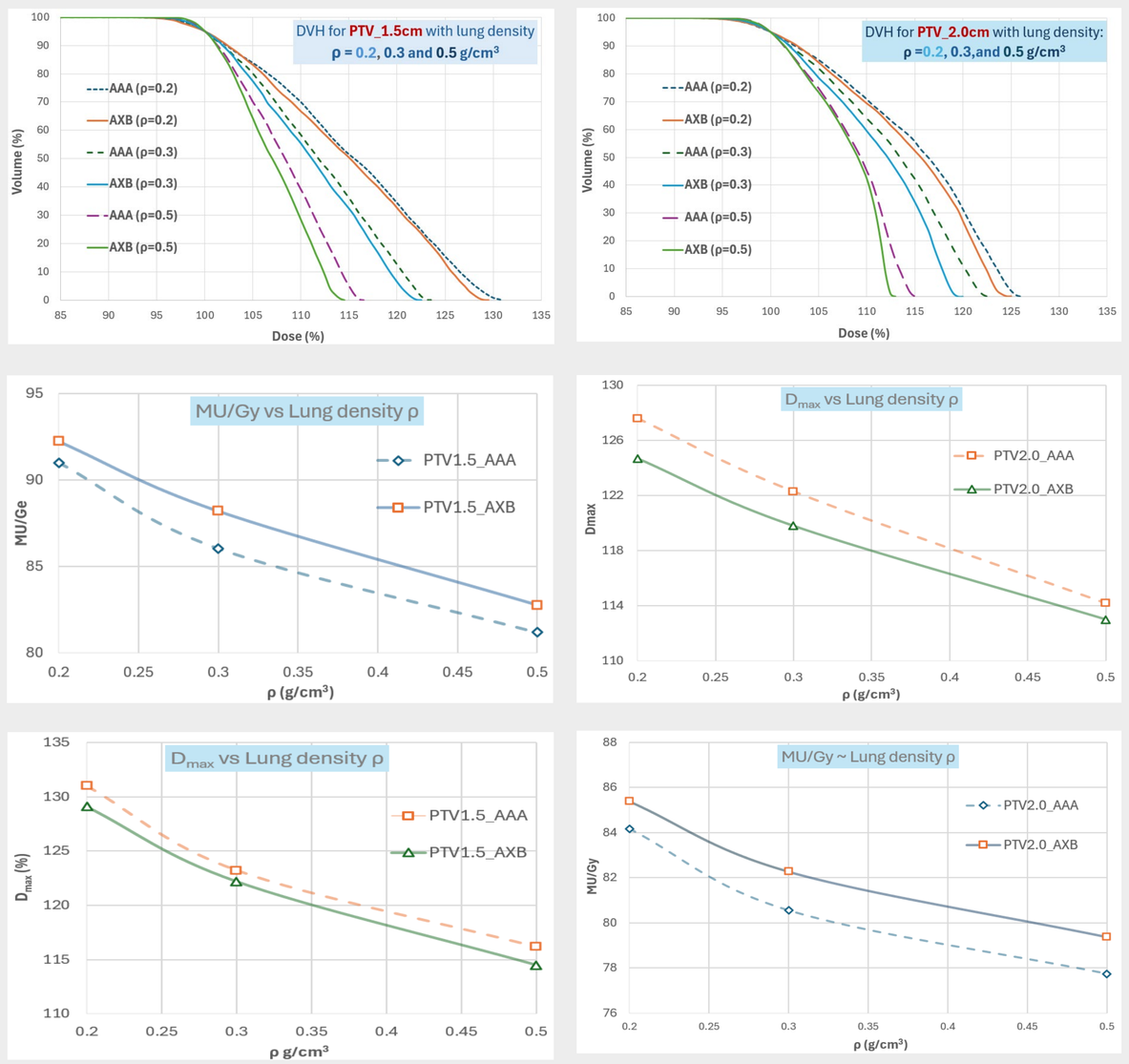

Fig. 2 Comparisons of DVHs, maximum dose and MU/Gy for SBRT plans with the same prescription for PTV_1.5cm (left) and PTV_2.0cm (right) with 0.2, 0.3 and 0.5 g/cm² lung densities created with AAA and AXB calculations

CONCLUSIONS

AAA overestimates target dose and underestimates MU for small-field lung SBRT, particularly in low-density lung, due to its limited modeling of electron disequilibrium. AXB provides closer agreement with MC and more accurate dose predictions for highly heterogeneous small-field conditions and should be preferred for small-field lung SBRT planning.

REFERENCES

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