# Dosimetric Impact of calculation grid size for spine SBRT plans using Acuros XB Algorithm

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## INTRODUCTION

Stereotactic body radiation therapy (SBRT) and stereotactic radiosurgery (SRS) are becoming more commonly used as a means of treatment for various sites in radiation therapy. High doses are administered for SBRT and SRS cases which is why it is important to have the most accurate representation of dose. Geometric and tissue heterogeneity uncertainties are two areas that can cause dose calculation errors. It is necessary to use methods such as intensity modulated radiation therapy (IMRT) and volumetric modulated radiation therapy (VMAT) to provide the most conformal treatment. Both IMRT and VMAT provide very sharp dose drop offs from the target volume, which introduces a dose gradient that can have an added effect to the dose error uncertainties. It is important to have the most accurate dose representation in thoracic SBRT plans because of higher dose gradient near critical structures such as spinal cord and presence of tissue heterogeneity.

## AIM

We investigated dosimetric effects associated with changing grid sizes for thoracic spine SBRT plans using IMRT and VMAT techniques utilizing Acuros-XB calculation algorithm.

## METHOD

Fifteen patients treated with SBRT for thoracic-spine were selected. 5 patients were planned with IMRT and 10 with VMAT. VMAT plans consisted of 2-3 full arcs while IMRT plans consisted of 8-12 static fields. All clinical plans were calculated using the Anisotropic-Analytical-Algorithm(AAA) and were then recalculated using Acuros-XB(AXB) using grid sizes of 2.5mm,1.5mm, and 1mm using Eclipse TPS. It is important to note that the MU, dose rate, and MLC sequence were identical for every plan. The plans were then evaluated based on the target coverage receiving 90% of the prescription dose, 95% of the PTV Various Dosimetric parameters such as V90, D95, Dmax, Dmin, Dmean and Conformality-Index(CI) for PTV and maximum, mean and Dv% dose-parameters for OARs were compared.

## RESULTS

| Treatment Site | Prescription | Technique | Number of Fields or Arcs | Collimator angles | Fusion rods |
|---|---|---|---|---|---|
| T7-8 | 27 Gy-3 fx | VMAT | 3 Arcs (181-179) | 30-80-90 | Yes |
| T7-9 | 40 Gy-5 fx | VMAT | 3 Arcs (181-179) | 345-15-90 | Yes |
| T4-6 | 30 Gy-5 fx | VMAT | 3 Arcs 181-179 | 345-15-90 | No |
| T3-6 | 27 Gy-3 fx | VMAT | 3 Arcs 181-179 | 90-80-5 | Yes |
| T8 | 30 Gy-5 fx | VMAT | 3 Arcs 181-179 | 330-30-90 | No |
| T8 | 27 Gy-3 fx | VMAT | 3 Arcs 190-170 | 330-30-90 | No |
| T5-7 | 30 Gy-5 fx | VMAT | 3 Arcs 181-179 | 330-30-85 | No |
| T1-2 | 25 Gy-5 fx | VMAT | 3 Arcs 181-179 | 345-15-85 | No |
| T1 | 25 Gy-5 fx | IMRT | 12 fields | 0 | No |
| T8 | 24 Gy-2 fx | VMAT | 2 Arcs 181-179 | 330-30 | No |
| T3-4 | 30 Gy-5 fx | VMAT | 2 Arcs 181-179 | 330-30 | Yes |
| T4-5 | 24 Gy-3 fx | IMRT | 9 fields | 0 | No |
| T11 | 24 Gy-3 fx | IMRT | 8 fields | 0 | No |
| T6 | 25 Gy-5 fx | IMRT | 11 fields | 0 | Yes |
| T12 | 24 Gy-3 fx | IMRT | 9 fields | 0 | no |

***Table 1***. Summary of the fifteen SBRT spine cases including the dose prescription, technique (VMAT or IMRT), number of arcs or fields, collimator angles, and if the patient presented with fusion rods.

| Comparison of Dosimetric Parameters | Avg. Deviation 2.5 vs 1.5 | Max Deviation 2.5 vs 1.5 | Avg. Deviation 2.5 vs 1 | Max Deviation 2.5 vs 1 | Avg. Deviation 1.5 vs 1 | Max Deviation 1.5 vs 1 |
|---|---|---|---|---|---|---|
| PTV 90% IDL | 0.44% | -1.21% | 0.55% | | | |
| PTV95 | 0.64% | -2.30% | 0.80% | 1.89% | 0.18% | 0.81% |
| PTV Max | 2.14% | -7.50% | 3.27% | - | - | - |
| PTV Min | 2.91% | 8.40% | 1.15% | 2.80% | 0.25% | 0.90% |
| PTV Mean | 0.45% | 1.30% | 0.46% | - | - | - |
| Conformality Index | 0.05 | -0.16 | 0.06 | 9.20% | 1.11% | 2.60% |
| | | | | 4.70% | 0.45% | 1.30% |
| | | | | 1.50% | 0.18% | 0.40% |
| | | | | 0.19 | 0.02 | 0.17 |
| Cord Max | 2.89% | 7.0% | | | | |
| Cord Min | 0.40% | 2.40% | 4.30% | 9.50% | 1.57% | 3.70% |
| Cord Mean | 1.34% | 3.70% | | | | |
| Cord V10 | 1.72% | 11.70% | 0.60% | 3.80% | 0.20% | 1.50% |
| | | | 1.60% | 4.20% | 0.20% | 0.60% |
| | | | 1.92% | 13.84% | 0.43% | 2.14% |
| Heart Max | 0.70% | -1.90% | | -2.5% | | - |
| Heart Min | 0.08% | 0.60% | 0.90% | 1.0% | 0.30% | 1.10% |
| Heart Mean | 0.14% | 0.30% | | 0.3% | | |
| Heart V15cc | 0.56% | -6.96% | 0.15% | | 0.06% | 0.40% |
| | | | | 0.42% | | |
| | | | 0.15% | | 0.01% | 0.10% |
| | | | 0.22% | | 0.90% | 6.62% |
| Esophagus Max | 2.06% | -4.50% | | | | |
| Esophagus Min | 0.19% | 1.30% | 2.70% | 5.30% | 0.98% | 3.70% |
| Esophagus Mean | 0.65% | 2.10% | | | | - |
| Esophagus V5cc | 0.76% | 3.25% | 0.20% | 1.40% | 0.04% | 0.20% |
| | | | 0.70% | 2.40% | 0.08% | 0.30% |
| | | | 0.83% | 3.90% | 0.22% | 1.32% |

***Table 2***. *Evaluation of the* dosimetric parameters such as target coverage, maximum doses, minimum doses, mean doses, V10, V5cc, V15cc, and conformality index (CI) were evaluated for the planning target volume (PTV), spinal cord, heart, and esophagus for all fifteen spine SBRT cases.

| Comparison of Calculation time | 2.5 mm vs 1.5 mm | 2.5 mm vs 1 mm | 1.5 mm vs 1 mm |
|---|---|---|---|
| Average deviation | 132 seconds | 563 seconds | 442 seconds |
| Maximum Deviation | 300 seconds | | |
| Statistical Analysis | < 0.01 | 1175 seconds | 875 seconds |
| | | < 0.01 | < 0.01 |

***Table 3***. Evaluation of the calculation time (seconds) differences associated with varying grid sizes between 2.5 mm, 1.5 mm, and 1 mm sizes.

| Statistical Analysis of Dosimetric Parameters | 2.5 mm vs 1.5 mm | 2.5 mm vs 1 mm | 1.5 mm vs 1 mm |
|---|---|---|---|
| PTV 90% IDL | 0.36 | 0.39 | 0.65 |
| PTV95 | 0.19 | 0.23 | 0.63 |
| PTV Max | < 0.01 | < 0.01 | < 0.01 |
| PTV Min | < 0.01 | 0.02 | 0.05 |
| PTV Mean | 0.53 | 0.61 | < 0.01 |
| Conformality Index | 0.20 | 0.20 | 0.70 |
| Cord Max | < 0.01 | < 0.01 | < 0.01 |
| Cord Min | 0.29 | 0.24 | 0.46 |
| Cord Mean | < 0.01 | < 0.01 | < 0.01 |
| Cord V10 | 0.04 | 0.05 | 0.11 |
| Heart Max | 0.18 | 0.02 | 0.14 |
| Heart Min | 0.27 | 0.26 | 0.25 |
| Heart Mean | < 0.01 | < 0.01 | 0.35 |
| Heart V15cc | 0.45 | 0.43 | 0.37 |
| Esophagus Max | 0.46 | 0.79 | 0.49 |
| Esophagus Min | 0.24 | 0.28 | 1.0 |
| Esophagus Mean | 0.02 | 0.04 | 0.60 |
| Esophagus V5cc | 0.07 | 0.09 | 0.42 |

***Table 4***. Statistical analysis results of all dosimetric parameters associated with target coverage, maximum doses, minimum doses, mean doses, V10, V5cc, V15cc, and conformality index when comparing grids sizes of 2.5 mm, 1.5mm, and 1 mm for the fifteen SBRT spine cases.

All values from this study were evaluated using the Eclipse treatment planning system DVH. On average the PTV95 coverage changed by 0.72% when comparing the 1.5 and 1 mm grid size to the 2.5 mm. The maximum deviation was -2.8% when comparing the 2.5 mm to the 1mm grid size. The percentage volume of the PTV receiving 90% of the prescription was found to all change < 1% for all grid sizes and the maximum deviation was 1.89 when comparing 2.5 mm to 1mm grid sizes. The average maximum dose deviation to the PTV was 2.14% and 3.27% when comparing the 2.5 mm grid size to the 1.5 mm and 1 mm respectively. The greatest maximum dose deviation for the PTV was -9.6%. The average minimum dose deviation to the PTV was 3.32% and 2.91% when comparing the 2.5 mm grid size to the 1.5 mm and 1 mm. The greatest minimum dose deviation recorded was 10.2% when comparing a 2.5 mm grid size to a 1.5 mm. The average and maximum mean dose deviations for the PTV were all < 1%. The average conformality index varied < 0.1 for all grid sizes and the biggest deviation was -0.19 when comparing a 2.5 mm grid size to 1 mm. On average the spinal cord maximum dose deviated by 2.89% and 4.3% when comparing a 2.5 mm grid size to 1.5 mm and 1mm grid sizes. The greatest maximum dose deviations were 7% (2.5 vs 1.5) and 9.5% (2.5 vs 1). All the cord minimum dose averages were < 1%, but the greatest deviation was 3.8% (2.5 vs 1). The cord average mean difference was 1.6% and a maximum difference of 4.2% (2.5 vs 1). The V10 averages varied by 1.72% (2.5 vs 1.5) and 1.92% (2.5 vs 1). The V10 significantly changed with a maximum deviation of 11.7% (2.5 vs 1.5) and 13.84% (2.5 vs 1). The heart average maximum deviation was < 1% and the greatest maximum dose deviation was -2.5% (2.5 vs 1). All the average and maximum deviations for the minimum, mean, V5cc doses of the heart were ≤ 1%. One specific case had a significant V15cc deviation of -6.96% (2.5 vs 1.5). The esophagus average maximum dose deviation was 2.1% and 2.7% when comparing 2.5 mm grid sizes to 1.5 and 1 mm grid sizes. The greatest maximum dose deviations were -4.5% (2.5 vs 1.5) and 5.3% (2.5 vs 1). The average minimum dose deviations were <1 % and the greatest minimum difference for the esophagus was 1.4% (2.5 vs 1). The average deviations for the mean and V5cc were all < 1% for the esophagus. The greatest mean deviation was 2.4% (2.5 vs 1) and the greatest V15cc deviation was 3.9% (2.5 vs 1). Calculation time was the last component evaluated. The average time difference was 132 seconds for 2.5 vs 1.5 mm grid sizes, 563 seconds (2.5 vs 1), and 442 seconds (1.5 vs 1). The maximum deviations were 300 seconds (2.5 vs 1.5), 1175 seconds (2.5 vs 1) and 875 seconds (1.5 vs 1).

## CONCLUSIONS

1mm grid-size resulted in the greatest increase in PTV coverage and the greatest decrease in dose to organs at risk. Without the use of a GPU-calculation based server, 1mm grid-size seems practically unacceptable due to its significantly increased calculation time. The 1.5mm calculation grid-size proved to have comparable results to the 1mm grid-size with much shorter calculation times.The 1.5mm provides better PTV coverage as well as OAR sparing compared to the 2.5 mm grid-size. We recommend using 1.5mm grid-size to best compromise between dose accuracy and calculation time for thoracic-Spine SBRT plans using Acuros-XB .

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