CARO-COMP Joint Scientific Meeting
September 20-23, 2023 • Hôtel Le Centre Sheraton Montréal
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Static Couch Non-Coplanar Arc Selection for Lung SBRT Treatment Planning

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INNOVATION / IMPACT

- Novel methodology of combining OAR avoidance with 4π sampling is presented.
- Optimized arc selection has the potential to reduce OAR doses for lung SBRT while maintaining target conformity.

INTRODUCTION

- OAR sparing is possible for lung SBRT using non-coplanar optimization[1].
- Mean arc distance (MAD)[2] can be used to quantify arc separation and enforce 4π sampling in SRS/SRT.

METHODS AND MATERIALS

- The Möller-Trumbore ray-triangle intersection algorithm[3] was used to efficiently compute 4π cost associated with overlap between OARs and PTV in the beams-eye-view (BEV) **(Figure 1)**.
- A stochastic algorithm generated 100,000 random combinations of arc trajectories.
- Patient specific optimized arcs chosen by balancing percentiles along number lines of both 4π cost (OAR avoidance) and MAD (4π sampling) in tandem **(Figure 2)**.
- VMAT plans optimized retrospectively on a cohort of 18 lung SBRT patients for both clinical and patient specific arcs **(Figures 3 to 5)**.

RESULTS

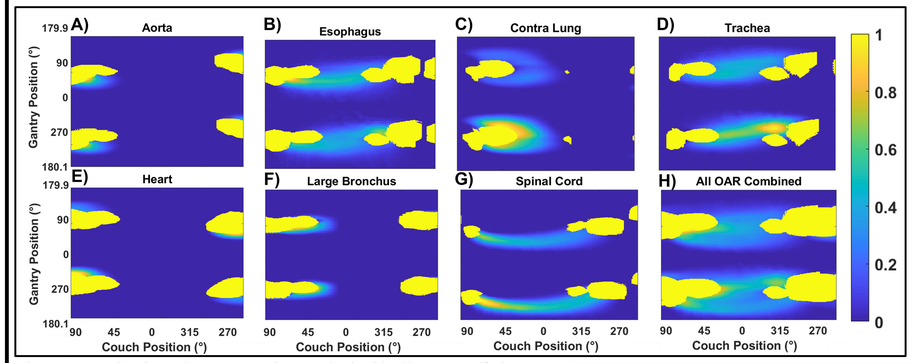

Figure 1: Construction of example 4π cost map using OARs (A-G) weighted by organ specific dose tolerance and summed to yield map in (H). Dark blue regions indicate low cost, while brighter regions indicate high cost. Brightest regions indicate raytracing through holes in the CT when arms were raised.

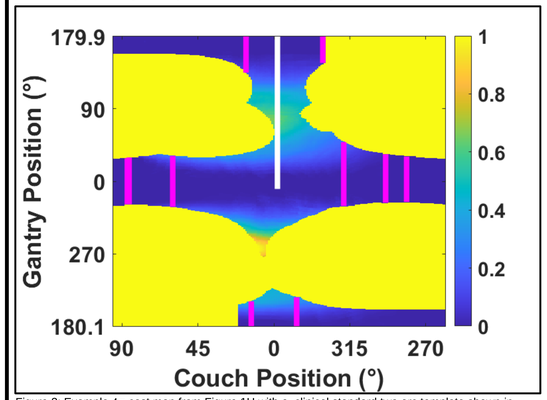

Figure 2: Example 4π cost map from Figure 1H with a clinical standard two arc template shown in white lines, and optimized patient specific arcs shown in magenta lines. A patient specific collision zone with 3 cm buffer was applied, denoted with the brightest yellow regions on the map.

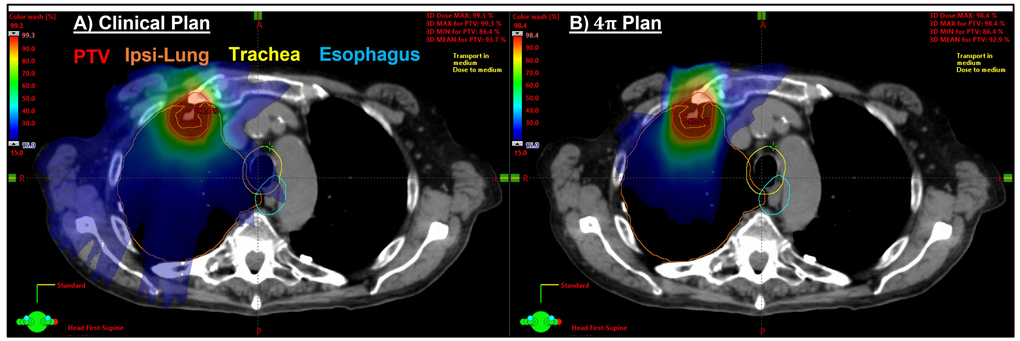

Figure 3. Example patient planned with clinical arc template (A) and 4π optimized arcs (B). The lower limit of the dose wash was set to 15%. Prescription dose was 48 Gy in 4 fractions for all cases.

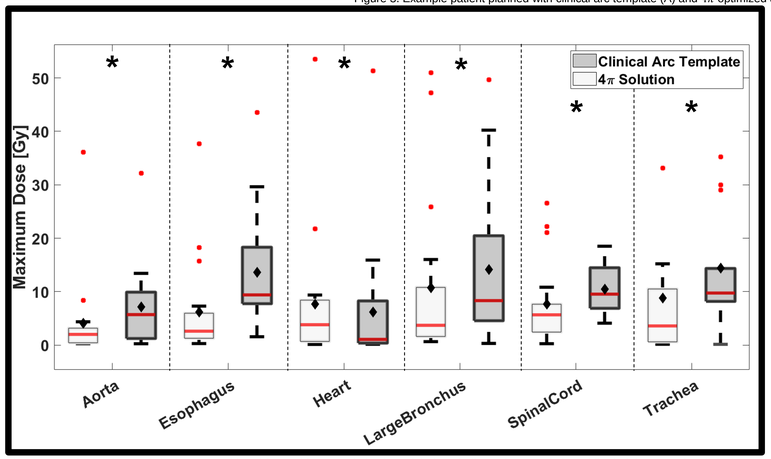

Figure 4: Maximum doses of six OARs considered for avoidance optimization. Light bars indicate the 4π solution while dark bars are the clinical arcs. Mean values are denoted with black diamonds and statistical significance is denoted with black stars.

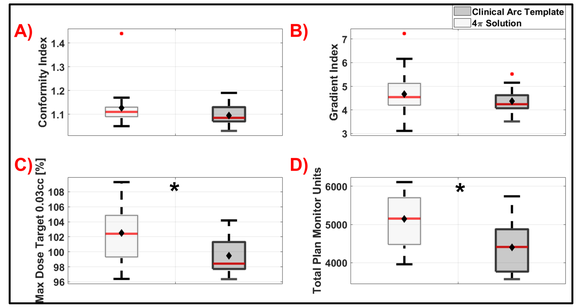

Figure 5: Plan quality metrics for target volumes of conformity index (A), gradient index (B), maximum dose inside the target (0.03 cc) (C), and total plan monitor units (D). Light bars indicate the 4π solution while dark bars are the clinical arcs. Mean values are denoted with black diamonds and statistical significance is denoted with black stars.

CONCLUSIONS

- Optimized non-coplanar arcs for lung SBRT reduced maximum doses to five of six OARs considered ($p < 0.05$).
- Balancing 4π cost with 4π sampling ensured target conformity remained clinically acceptable below a value of 1.2

REFERENCES

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2. **MacDonald *et al*.** Mean Arc Distance (MAD): a quantity to compare trajectory 4π sampling in single target cranial stereotactic radiotherapy. *Biomed Phys Eng Express* 2022. 8(5).
3. **Möller & Trumbore**. Fast, minimum storage ray/triangle intersection. In: *ACM SIGGRAPH 2005 Courses*. 2005: 7-es.

ACKNOWLEDGEMENTS

We gratefully acknowledge Dr. Robin Kelly for the creation of the ESAPI script used to extract RTOG metrics from the Eclipse TPS. JL also acknowledges the CIHR GSD-167032

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