



# Integrating Noncoplanar Oblique Beam Arrangements with Knowledge-Based Planning for Reduced Immune Cell Radiation Dose

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## INTRODUCTION

**Purpose:** To investigate the role of a cardiac-sparing RapidPlan model and patient-specific beam geometry on plan quality to reduce the effective dose to immune cells (EDIC) for non-small cell lung cancer (NSCLC) patients.

**RapidPlan:** A type of knowledge-based planning that aids the generation of high-quality treatment plans from data-driven treatment planning algorithms. The model utilized in this study prioritized minimizing dose to cardiac structures.

**EDIC:** Effective dose to immune cells.

- Reduction in EDIC influences treatment outcomes.

## EQUATION

$$EDIC = B_1\% \times MLD + B_2\% \times MHD + [B_3\% + B_4\% \times k_1 \times (n/45)^{k_2}] \times ITDV / (61.8 \times 10^3)$$

B represents the four main blood-containing organs (lung, heart, great vessels, and vessels/capillaries in all other organs).  $B_1\% = 0.12$ ,  $B_2\% = 0.08$ ,  $B_3\% = 0.45$ ,  $B_4\% = 0.35$ . Dose effectiveness factor for small vessels and total body volume estimation is represented by  $k_1 = 0.85$  and  $n$  is the number of fractions. MLD = Mean Lung Dose, MDH = Mean Heart Dose, ITDV = Integral Total Dose Volume.

## METHODS

- 16 previously treated non-small cell lung cancer patients from 2013 – 2021 were replanned. Each case was prescribed 60 Gy in 30 fractions.
- All plans were calculated on a Varian Edge using 6X-FFF and a 1400 MU/min dose rate.
- Acuros (Version 16.1.0) was used for the final dose calculation.

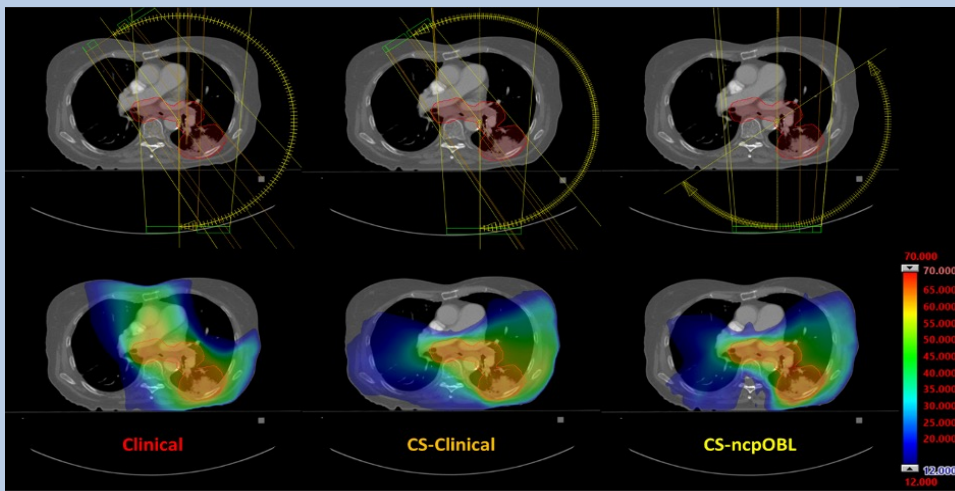
**Model Creation:** Cohort of 77 stage III NSCLC patients.

- Structures include target volumes, OARs, and 15 cardiac substructures.

**Field Geometry:** Two plans were generated using the same cardiac sparing model. The first plan utilized the clinical treatment plan field geometry and the second plan used a noncoplanar oblique field geometry.

- Noncoplanar oblique arc arrangements used partial arcs crossing midline posteriorly to avoid critical structures and to limit beam path lengths to the target.
- Plans were run without user interaction.
- Convergence mode enabled.
- All plans were normalized such that the prescription dose covers 95% of the target volume.
- Statistical analysis was performed using Wilcoxon signed-ranked tests with the Bonferroni correction.

- Clinical** = original, clinically treated plan.
- CS-Clinical** = cardiac-sparing RapidPlan model with the clinical treatment plan field geometry.
- CS-npOBL** = cardiac-sparing RapidPlan model with a patient-specific noncoplanar oblique field geometry.



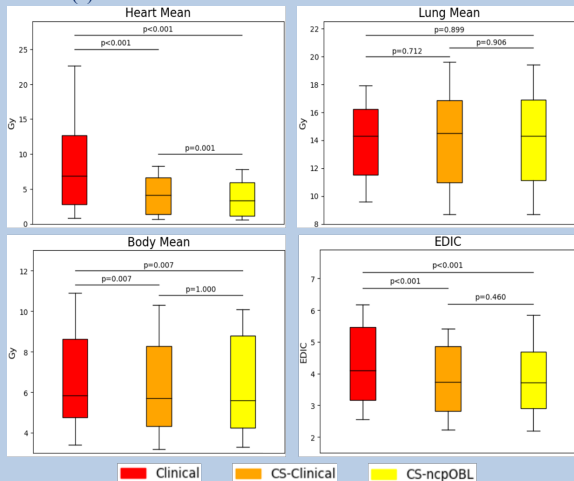
Field geometry and dose distribution comparison for a representative case.

Plan	Heart Mean(Gy)	Lung Mean (Gy)	Body Mean (Gy)	EDIC
Clinical	8.50 ± 6.91	13.92 ± 2.75	6.55 ± 2.39	4.27 ± 1.27
CS-Clinical	4.09 ± 2.73	13.97 ± 3.46	6.18 ± 2.39	3.81 ± 1.10
CS-npOBL	3.70 ± 2.50	14.00 ± 3.50	6.19 ± 2.40	3.79 ± 1.10

Heart mean, lung mean, body mean, and EDIC were analyzed for three plans.

	Clinical/CS-Clinical	Clinical/CS-npOBL	CS-Clinical/CS-npOBL
Heart Mean	<0.001*	<0.001*	0.001*
Lung Mean	0.712	0.899	0.906
Body Mean	0.007*	0.007*	1
EDIC	<0.001*	<0.001*	0.460

Results of the Wilcoxon signed-rank test (threshold=0.01) for EDIC, heart mean, lung mean, and body mean. Significant results are indicated by an asterisk (\*).



Box plots of the metrics analyzed for the three plans.

## RESULTS

- Significant reductions in mean heart dose ( $p < 0.001$ ) and mean body dose ( $p = 0.007$ ) were observed for plans utilizing the cardiac-sparing RapidPlan model.
  - No significant change in lung dose was seen between the three techniques.
- EDIC was significantly reduced using the RapidPlan model compared to the clinical plan ( $p < 0.001$ ).
- Further reduction in mean heart dose was observed using a patient specific, noncoplanar oblique beam arrangement ( $p = 0.001$ ).
- All plans met all clinical goals.

## CONCLUSIONS

Utilizing a site-specific KBP model proved to be beneficial in producing high-quality treatment plans. The influence of beam geometry emerged as a critical factor during treatment planning, emphasizing the importance of designing patient-specific treatment fields to enhance plan quality.

## REFERENCES

