

A Spatially Fractionated GRID RT Case Study: Dosimetric Comparison Between 3D Grid and VMAT Lattice

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INTRODUCTION

- Our Institution has been delivering the 3D spatially fractionated GRID radiotherapy (SFGRT) technique since 2003, first starting with Cerrobend, followed by MLC-based fields in late 2005 to the present. A 1fx high dose of 12-15Gy GRID is followed by EBRT standard fractionation.
- We have seen dramatic clinical outcomes for patients with superficial bulky disease, but are seeking to deposit a higher dose deeper into the tumor using Lattice technique.

PURPOSE/OBJECTIVES

- Unlike EBRT, the goal is not to treat the entire tumor with uniform dose. Instead, SFGRT creates high dose and low dose regions called “peaks and valleys” (Figure 1) using 1cm-diameter holes/vertices.
- The “peak” stimulates tumor necrosis.
- Although the “valley” region is not directly hit, the bystander effect shows those nearby cells are still affected in both protective and damaging ways. (Figure 2)

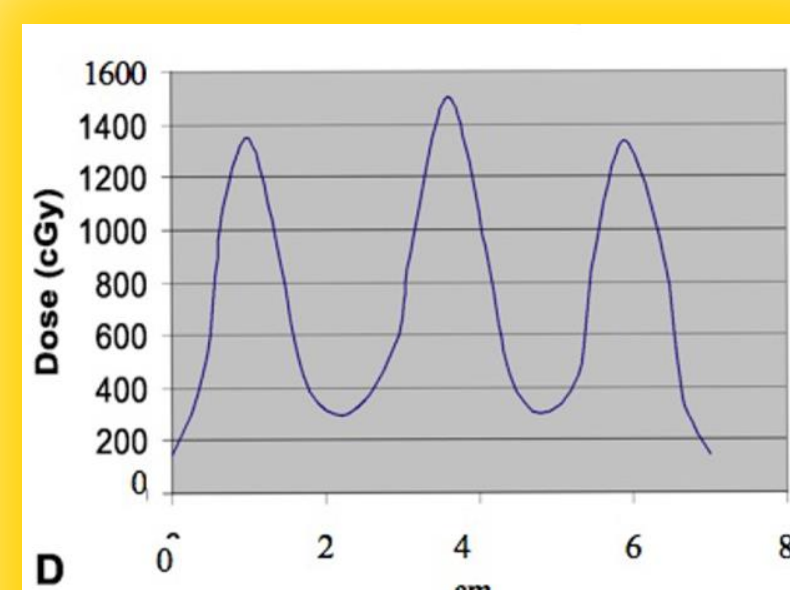


Figure 1. “Peaks” of high dose and “valleys” of low dose (Figure 2)

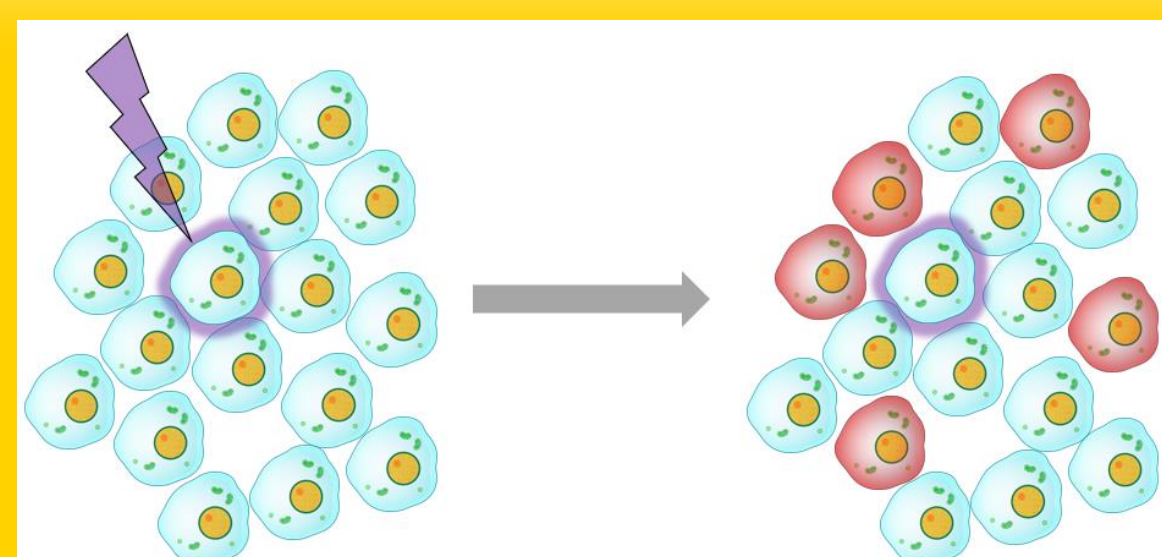


Figure 2. Bystander effect . Some cells produce growth factors and inhibit toxic factors, while others generate reactive oxygen.

METHODS & MATERIALS

- A left lung patient was retrospectively selected for comparative 3D versus Lattice planning using RayStation TPS (Version 8A).
- “GTV_GRID” or “GTV LA” volume can commonly be adjusted from GTV target in size/shape. In our case, this volume was cropped away from the heart. (Figure 3)

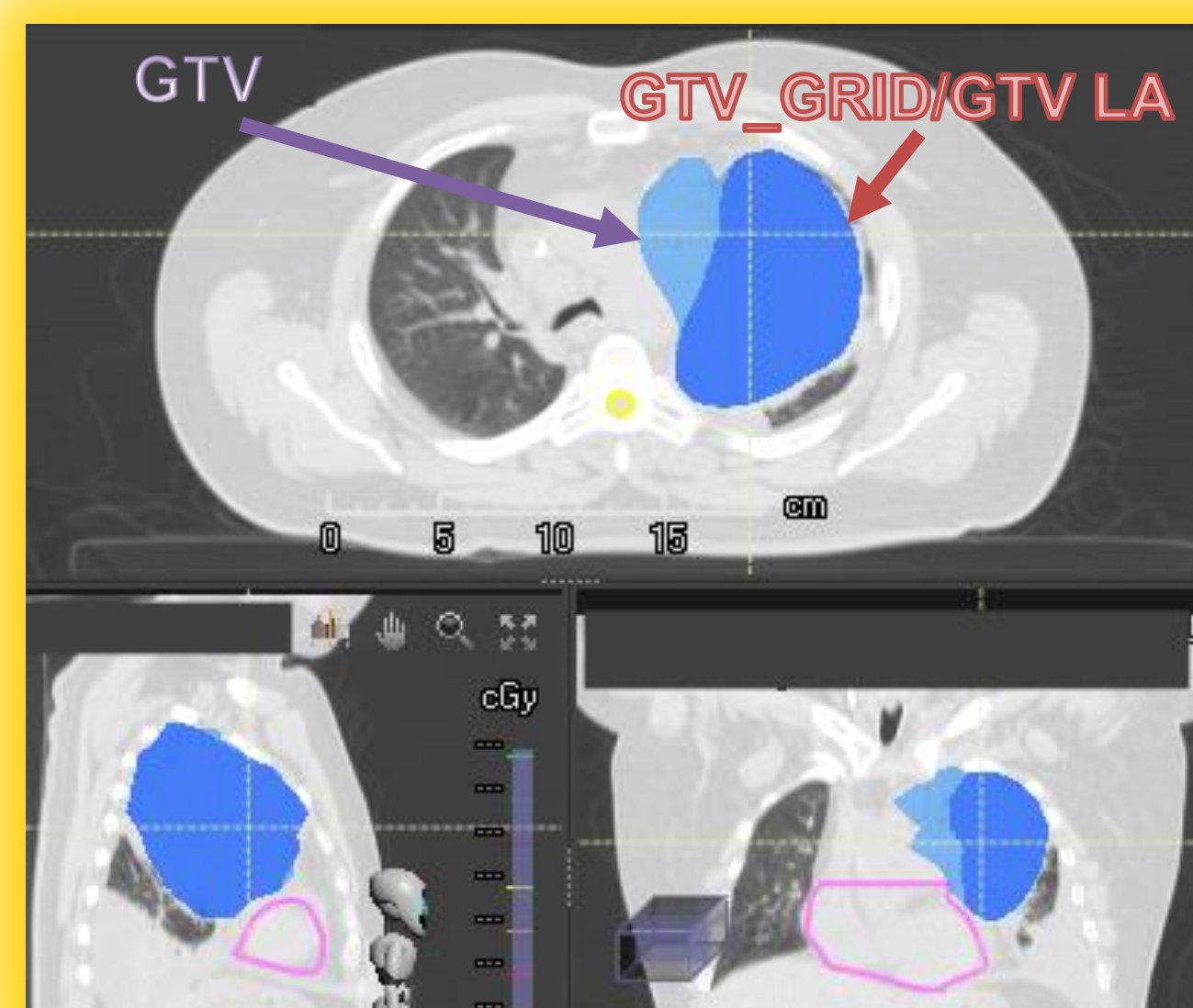


Figure 3. GTV versus GRID volume

****Please note: Our departmental target nomenclature differs per technique, but it is the same volume for this case**

- For the 3D grid plan, the angles of beam, collimator and couch (Figure 4) were chosen to avoid entrance thru and exit into organs-at-risk (OARs). 18X energy beam was set to 100 SSD and the isocenter point was converted into a Point of Interest (POI) for use in the script.

METHODS & MATERIALS (continued)

- The in-house script created strips with 1cm holes utilizing MLCs. The beams-eye view (BEV) was used to manually close jaws/MLCs over OARs or peripheral edges (Figure 5). Monitor units (MUs) were calculated with 12Gy dose, by plugging measured output factors and inverse square values into a formula. Dose was calculated in using those MUs with a 2mm x 2mm grid size.



Figure 4. 12 degree gantry, 323 degree collimator and 34 degree couch kick

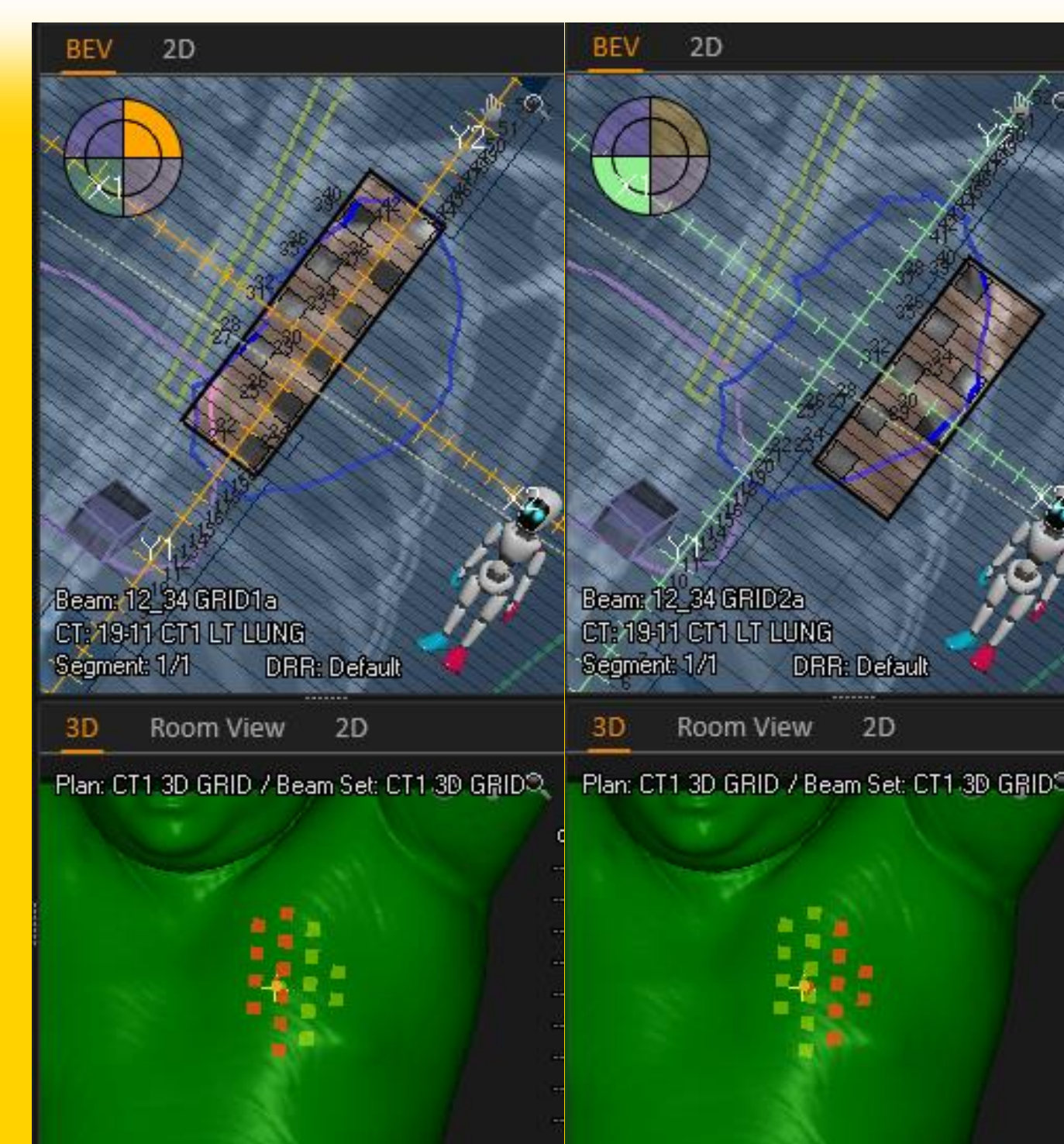
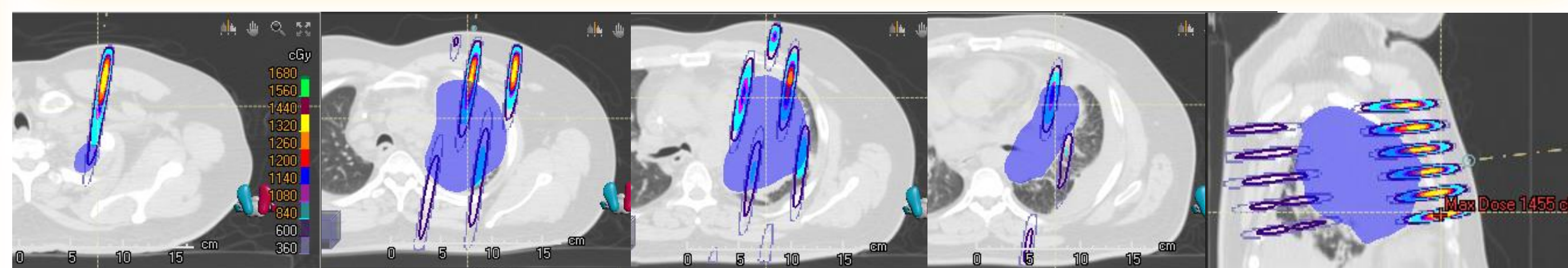


Figure 5. BEV w/ collimator optimized to target



- For the Lattice VMAT plan, the MD first created a volume contracted 0.5cm from the GTV LA in order help prevent creation of spheres near the edge of the target. An in-house script was then used to generate the 1cm-diameter vertices (center-to-center distance of approx 3.5cm apart) – shown in Figure 6. The vertices were then 3-Dimensionally rotated and evaluated for manual editing. Partial vertices were removed at MD discretion. A 1.0cm peripheral ring of the GRID LA called “GTVperiphery” volume was also created and used to increase the 3Gy dose to the target (Figure 7). The dosimetrist created ring-type planning structures to assist in pushing dose fall-off of vertices during optimization. Planning was also done in RayStation, with the 12Gy dose prescribed (Average dose) to the “LATTICE” ROI . A 2mm x 2mm dose grid was maintained. Due to the offset of the tumor location and the high amount of MUs , 6 ipsilateral partial arcs were chosen. The collimator was rotated off 0 for each beam (30, 340, 350, 10, 20 and 30) to allow more conformality between the vertices with the goal to increase the peak to valley ratio. MU limit of 1450 per beam was set as a parameter during optimization.



Figure 6. Vertices

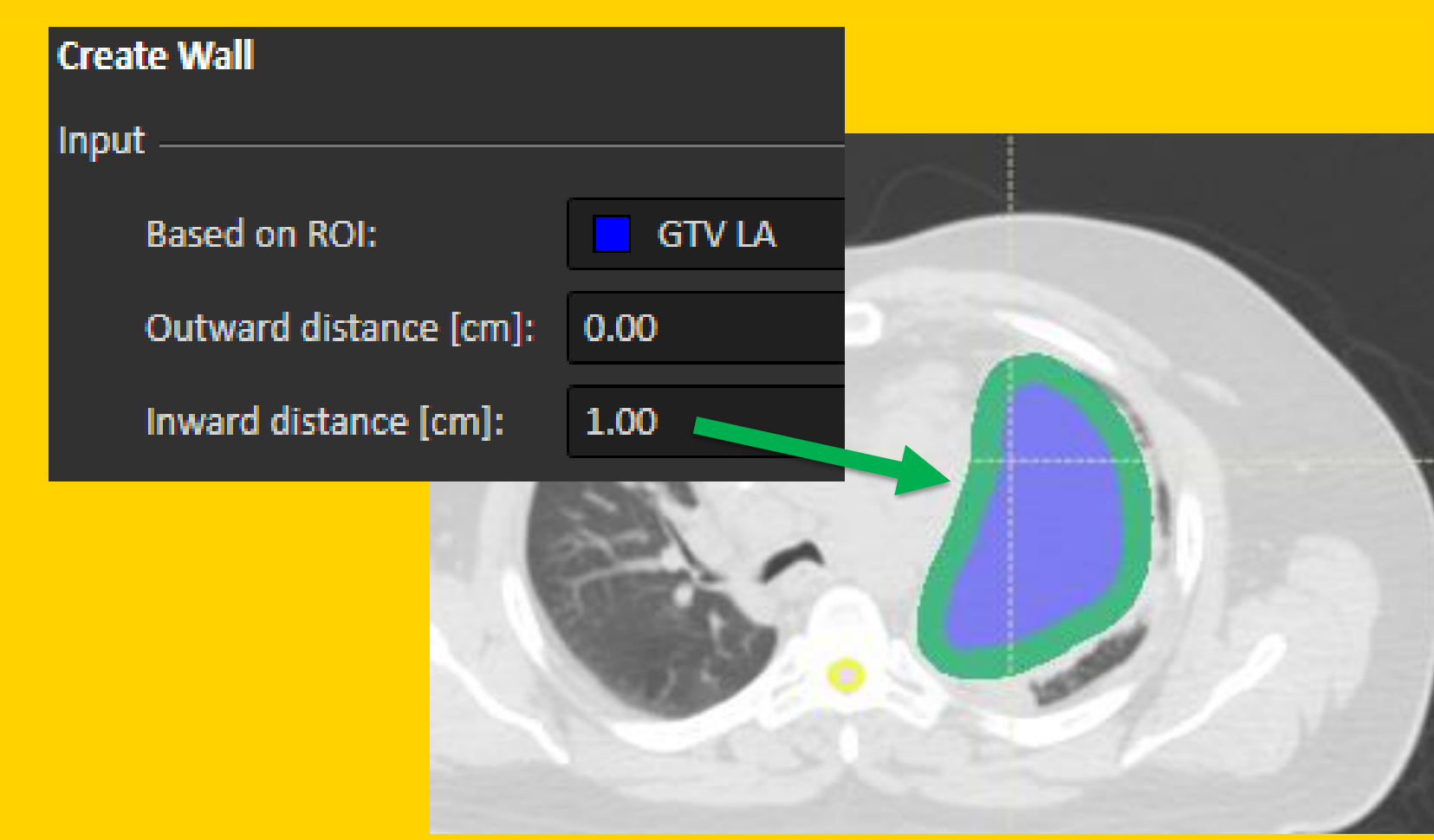
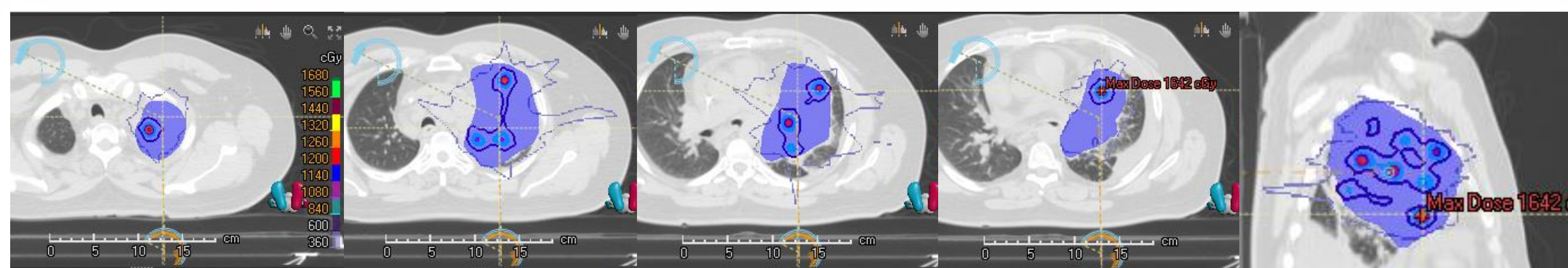
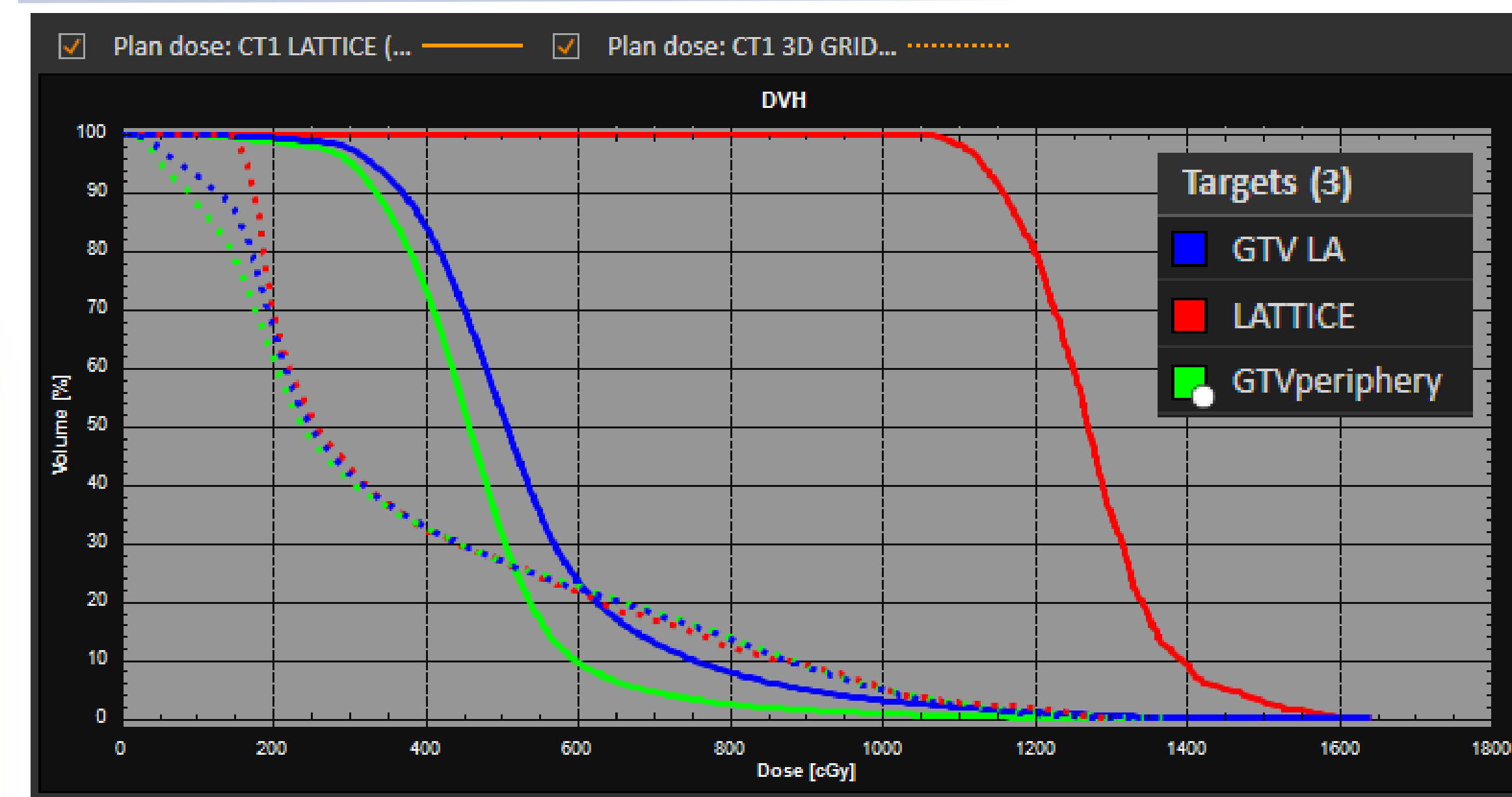


Figure 7. “GTVperiphery”



RESULTS



	LATTICE	3D
Number of Vertices/Holes	13	12**
Max Hotspot %	136.8%	121.3%
GTVperiphery V3Gy	95.3%	40.8%
Volume receiving 95% Rx (in cc)		
GTV LA	9.2	8.8
Ant Half of GTV LA	5.0	8.8
Post Half of GTV LA	4.2	0.0
Normal Tissue (Ext-GTV LA)	0.0	37.5
Organs at Risk		
SpinalCord Max Dose (cGy)	51	1
Heart Max Dose (cGy)	471	89
Esophagus Max Dose (cGy)	260	10
Total Lung Mean Dose (cGy)	83	26

** Total 3D holes = 17, but only 12 hit target with 95% isodose

DISCUSSION & CONCLUSIONS

- The percentage of the GTVperiphery volume receiving 3Gy in the Lattice plan was significantly higher and shows more of the target can receive a standard hypofractionated dose than with the 3D.
- It was hypothesized the volume receiving 95% of Rx (1140cGy) within GTV LA target would be higher with the Lattice plan, but it was surprisingly similar to the 3D, 9.2cc and 8.8cc respectively.
 - A POI was auto-placed inside the GTV LA to determine where to split the target into anterior and posterior parts. As seen by the results, no volume [95% Rx] of the 3D plan reached the posterior portion.
 - Favorably, no volume [95% Rx] of the Lattice plan was in the normal tissue compared to the 3D.
- Overall, OAR doses were minimal. In cases where a suitable 3D angle cannot avoid OARs, there could be a benefit using the Lattice technique. This would need to be studied further.
- Scripting allows easy modulation of distance between peaks and peak to valley ratio, but the optimal distance is still being evaluated.
- With the widespread availability of scripting and familiarity of VMAT planning, Lattice has the ability to be easily implemented in large hospital and community-based centers.

REFERENCES

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