

Development of a RapidPlan model for Pancreas SBRT: evaluating ring-based versus dose-specific optimization approaches for OAR sparing

Background

The planning process for pancreatic cancers can be difficult because of its anatomical proximity with multiple organs at risk (OAR). Rapidplan (RP) is a knowledge-based planning system that aims to improve plan quality, efficiency and consistency. By further exploring the use of ring structures and overlap structures with specific isodose lines, plan quality can be further enhanced. This study then compares the dosimetric outcomes and OAR sparing achieved using the incorporation of ring structures versus using dose specific optimization structures in the framework of RP for pancreatic stereotactic body radiotherapy (SBRT).

Purpose

The purpose of this study is to evaluate whether further utilization of ring structures or dose-specific overlap structures on opt of a RapidPlan model, designed for pancreatic SBRT with a single dose planning target volume (PTV) can enhance organ-at-risk sparing in these types of cases. Given the anatomical complexity of the pancreas and its proximity to critical organs, we aim to determine which optimization strategy yields better dosimetric outcomes within the RP framework. The findings may influence future model refinement and improve the consistency and quality of treatment planning for pancreatic cancer

Materials and Methods

A knowledge-based planning model was developed using 44 prior cases treated with Volumetric Modulated Arc Therapy (VMAT) to train a dose estimation system within RapidPlan. To evaluate the model's performance, 30 validation cases were subsequently planned using this approach. Dosimetric comparisons were then conducted, assessing the use of ring structures versus dose-specific optimization structures at the 33Gy, 20Gy, and 15Gy isodose levels. Given their anatomical proximity to the PTV, doses to the small and large bowels, duodenum, and stomach were specifically analyzed.

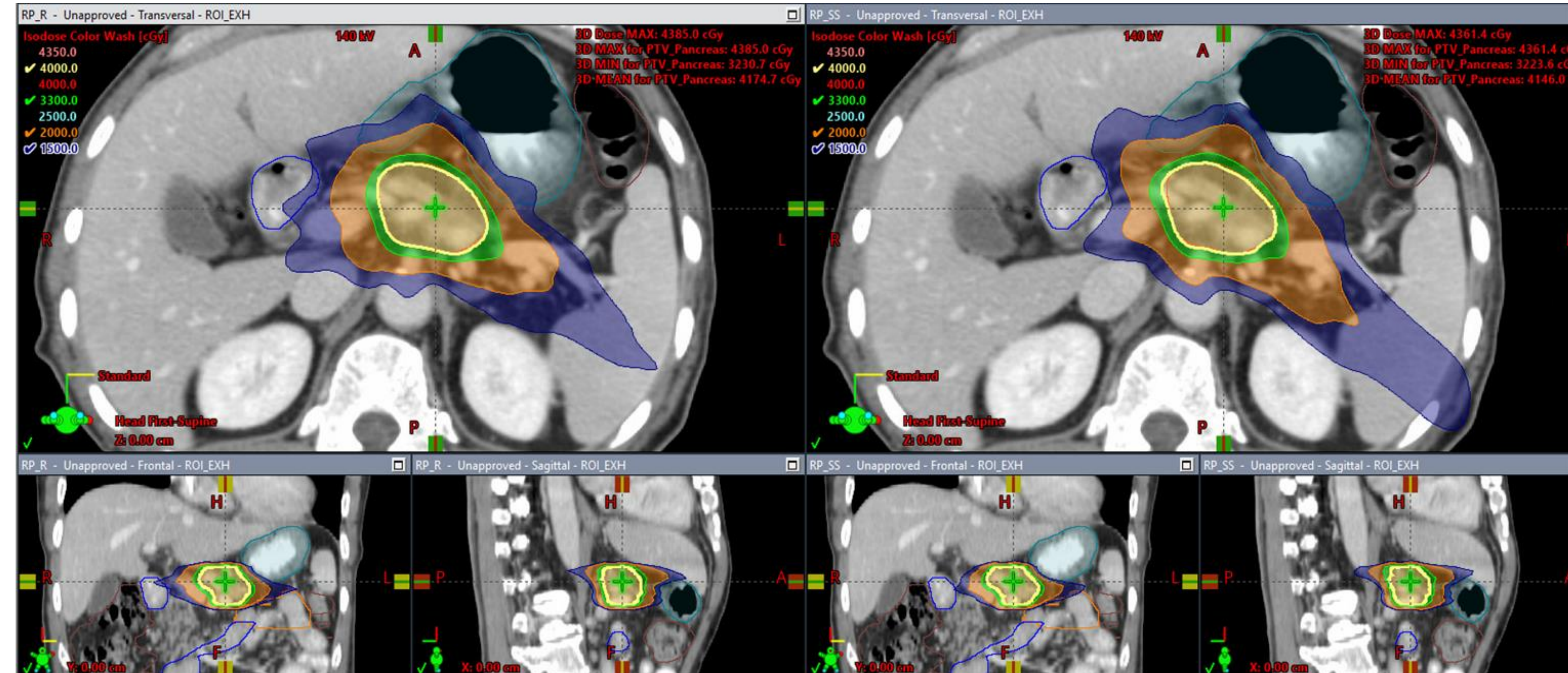


Figure 1: Comparison of dose distribution for the 15Gy, 20Gy and 33Gy in isodose wash for a pancreatic patient's RP with rings on the left and RP with special structures (SS) on the right. The RP with the rings has enhanced conformity, containing the 15Gy bleed. However, the RP with the SS spares the duodenum better.

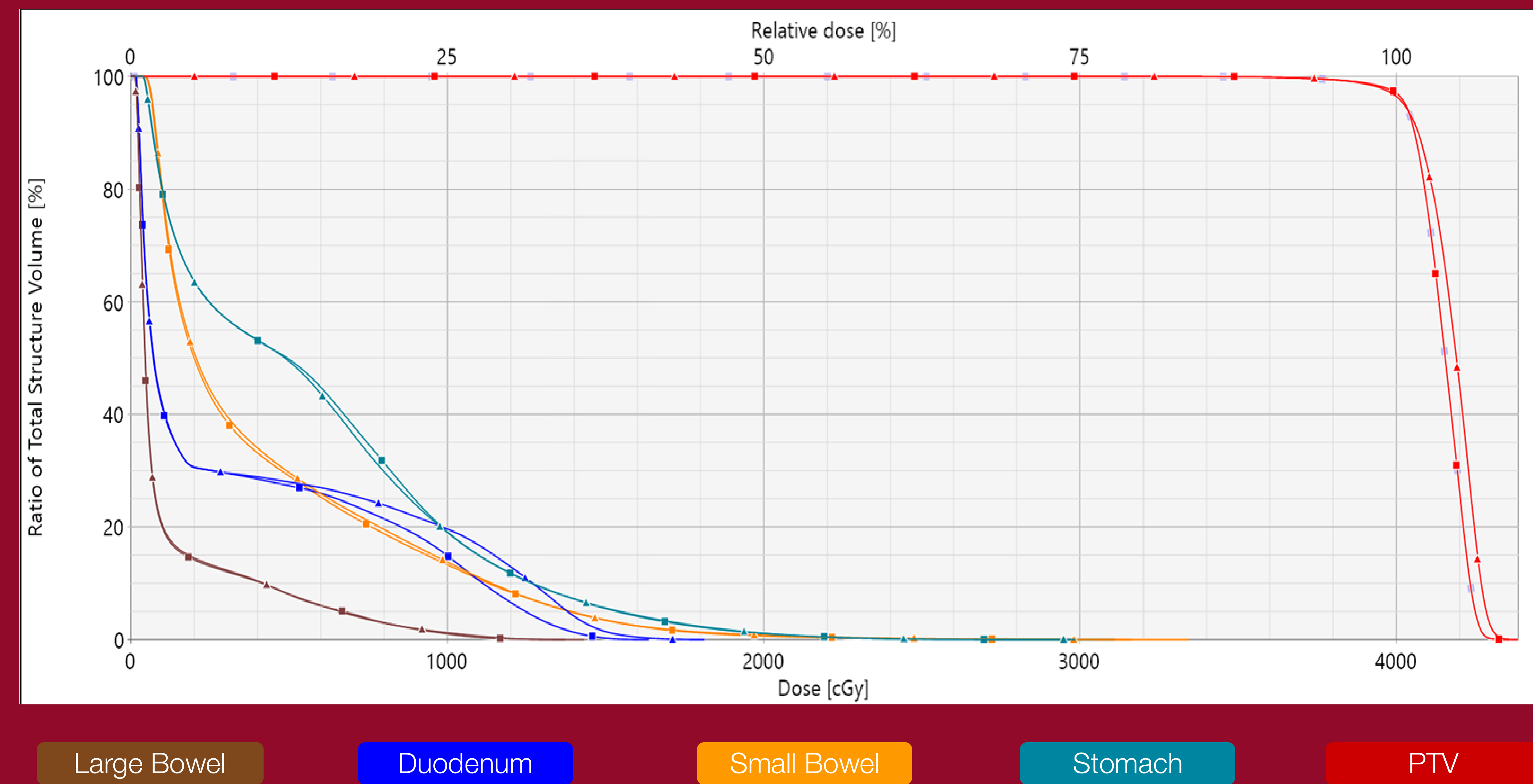


Figure 2: A Dose Volume Histogram (DVH) comparing the two plans, where the RP with rings is in squares and the RP with SS are in triangles. The RP with SS has improved sparing of all OARs in the anatomical proximity with the pancreas; small bowel, large bowel, duodenum and stomach

Plan		■ RP_R	▲ RP_SS
Total Dose		4000.0 cGy	4000.0 cGy
Clinical Goal Summary		0 1 4	0 1 4
● Duodenum	P1 V 1500 cGy < 9.00 cm ³	0.789 cm ³	0.144 cm ³
● SmallBowel	P1 V 2000 cGy < 3.00 cm ³	0.513 cm ³	0.419 cm ³
	P1 V 1500 cGy < 9.00 cm ³	2.251 cm ³	2.288 cm ³
● Stomach	P1 V 2000 cGy < 3.00 cm ³	2.670 cm ³	2.515 cm ³
	P1 V 1500 cGy < 9.00 cm ³	13.245 cm ³	13.033 cm ³

Figure 3: Clinical goal comparison for OARs receiving 15Gy and 20Gy. On the left shows OARs on the plan created with RapidPlan and ring structures receiving more 15Gy and 20Gy compared to the RapidPlan with specific dose overlap structures.

Results

The use of RP produced comparable dose distributions to the clinical plan with no significant differences in sparing of the OARs. However, introducing dose specific structures helped further reduce the volumes of the critical organs receiving 33Gy, 20Gy and 15Gy. Compared to RP alone, the dose specific structures reduced the 33Gy, 20Gy and 15Gy isodose levels on average by 8.4 % (p < 0.05). Using ring structures helped improve the conformity of the dose distribution, but did not significantly help reduce dose to the OARs compared to using RP alone.

Conclusion

RP for pancreatic SBRT helps improve the plan quality in conjunction with either rings or dose specific structures with the former improving plan conformity and the latter improving OAR sparing.

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