Assessment of a Knowledge-Based RapidPlan Model for Craniospinal Irradiation (CSI)

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INTRODUCTION

Since the introduction of commercially available knowledge-based planning systems, KBP has been applied to numerical parts of body. However, KBP involving extensive target volumes, such as craniospinal irradiation (CSI), which involves a high number of organs at risk (OARs), have not been reported in literature. In this project, we built a KBP model to use for CSI target volume using RapidPlan™. We then tested the robustness the model and planning system.

AIM

1. To develop a knowledge-based planning (KBP) model to automate treatment planning for craniospinal irradiation
2. To evaluate clinical-suitability and robustness by comparison KBP with a traditionally developed clinical plan (CP).

METHOD

Twenty Volumetric Modulated Arc Therapy (VMAT) CSI previously delivered plans were used to build a RapidPlan™ model in Aria v15.6. In each plan, segmented organs at risk (OAR) included esophagus, lungs, kidneys, heart, thyroid and bowel. Once the model was created, a KBP was created for an additional CSI patient case outside the training set. Optimization of the KBP was limited to the six OARs listed above with RapidPlan™ generated constraints and priorities. The dosimetric parameters of KBP was then compared with the clinical plan (CP) generated with the normal optimization in RapidArc™.

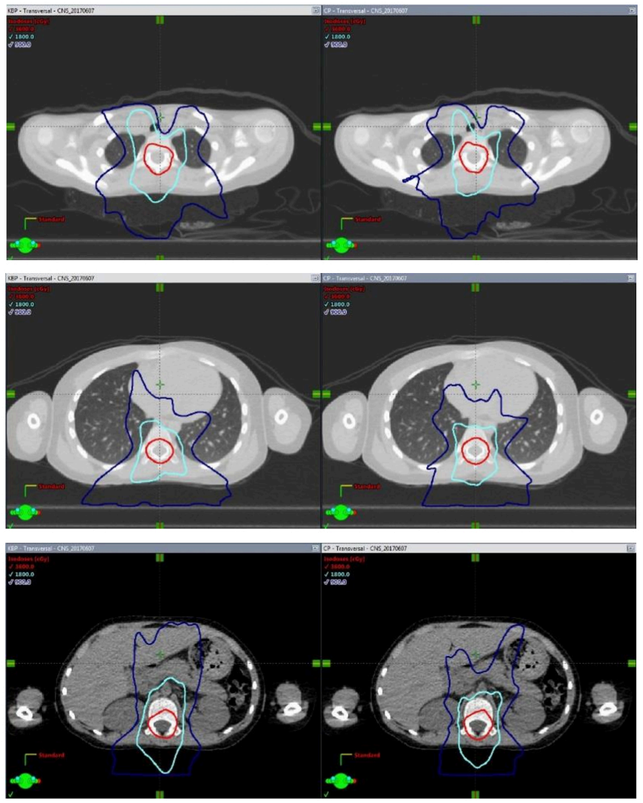
RESULTS

The major dosimetric parameters including PTV D98%, D95%, heterogeneity index (e.g. (D2%-D98%)/Rx), mean dose to major organs (including esophagus, lungs, kidneys, heart, thyroid and bowel, stomach, bronchial tree, liver), total MU, conformity indices at 100%, 50% and 25% prescription dose level are listed in the table below. Isodose distribution lines at different levels of body are shown for both KBP and CP for the dose level of 100%, 50% and 25% of prescription.

	$D_{98\%}$	$D_{95\%}$	Heterogeneity Index	Total MU
KBP	97.40%	99.60%	9.70%	345
CP	97.80%	99.70%	11.30%	471

Mean Doses			
	Esophagus	**Lungs**	**Kidneys**
KBP	1079 cGy	761 cGy	535 cGy
CP	1331 cGy	728 cGy	513 cGy
	Heart	**Thyroid**	**Bowel**
KBP	708 cGy	768 cGy	735 cGy
CP	721 cGy	845 cGy	639 cGy
	Stomach	**Bronchial Tree**	**Liver**
KBP	682 cGy	1502 cGy	593 cGy
CP	738 cGy	1261 cGy	562 cGy

Conformity Indices			
	100% CI	**50% CI**	**25% CI**
KBP	1.25	3.6	6.05
CP	1.27	3.46	5.72



The isodose distribution lines of 100% (Red), 50% (Cyan), 25% (Blue) at upper chest, middle chest and lumber spine of the test patient for both KBP (left side images) and CP (right side images)

CONCLUSIONS

1. Dosimetry of the KBP and CP is very similar in all aspects that we have evaluated. This demonstrates the capacity of KBP to generate clinically deliverable plans for large PTVs including CSI.
2. The KBP plan has MU that is over 25% lower than the CP, which demonstrates less modulation in the plan and more efficient in MU delivery. The reduction of MU can significantly cut the delivery time, which can potentially reduce the intrafraction movement uncertainty.
3. For the organs that are not the optimization list of the model (stomach, bronchial tree and liver), KBP was still able to get very similar results to CP. This demonstrates the robustness of KBP method.
4. The model built in this project can be used to train the new dosimetrists/physicists for the treatment planning of CSI plans, as this kind of plan is much more extensive than regular VMAT plan. KBP can show an acceptable solution and guide us to improved dosimetry. It can also help achieving more consistent results among a group of planners. This feature is especially helpful in big institution.

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