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Implementation of a Knowledge-Based Model for Gastrointestinal (GI) Site-Specific Photon Radiotherapy Planning

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INTRODUCTION

RapidPlan knowledge based planning (RP) is a treatment planning tool that provides models to be used as a baseline for developing IMRT or VMAT plans. RP can reduce variability in treatment planning by achieving greater consistency and quality of planning while reducing planning time.
We evaluated the efficiency and dosimetric impact of implementing a knowledge-based planning model for GI site-specific plans.
A GI specific model was trained for each site – Anal, Rectal, Pancreas and Liver SBRT- using RapidPlan to generate improved plan quality with a significantly reduced clinical planning time.

METHOD

Four sites were chosen to investigate the efficacy of knowledge-based planning (KBP) in radiotherapy for GI cancers: Anal, Rectal, Pancreas, and Liver SBRT. Varian's implementation of KBP, RapidPlan®, was used to develop and train models for each site. For each model, 70-92 prior clinical plans were chosen for training.

10 patients were selected and their clinical plans were excluded from the training plan dataset. For each of these patients, the appropriate site model was used to generate a KBP plan which was then compared to the prior clinical plan. The comparison was completed based on the dose evaluation metrics used to evaluate plans for clinical acceptability. For each site, these metrics can be seen in Figure 2. These metrics were chosen to indicate clinical acceptability of the KBP plans. Only a single iteration of optimization was used for the KBP based plans.

5 patients were selected to evaluate the planning efficiency of the KBP models for each site (for a total of 20 patients). Active Planning Time, defined here as the amount of time spent optimizing a plan excluding plan prep (contouring, beam arrangement, etc.) and plan evaluation, was used for planning efficiency comparison. KBP model planning was allowed one iteration of optimization and manual planning had no limit on optimization iterations.

ANAL
-89 Plans for model training
-1 Target: 4500 cGy PTV
-7 OARs: Bladder, Left Femoral Head, Right Femoral Head, Genetalia, Perineum, Small Bowel Loops, Small Bowel Bag

RECTUM
-92 Plans for model training
-1 Target: 4500 cGy PTV
-7 OARs: Bladder, Left Femoral Head, Right Femoral Head, Genetalia, Perineum, Small Bowel Loops, Small Bowel Bag

PANCREAS
-78 Plans for model training
-2 Targets: 4500 cGy PTV, 4500 cGy iCTV
-9 OARs: Large Bowel, Small Bowel, Duodenum, Left Kidney, Right Kidney, Liver, Spinal Cord, Stomach

LIVER SBRT
-70 Plans for model training
-3 Targets: 5000 cGy PTV, 5000 cGy CTV, 5000 cGy GTV
-13 OARs: Chest/Abdominal Wall, Duodenum, Esophagus, Gallbladder, Heart, Kidneys,

DOSIMETRIC COMPARISON

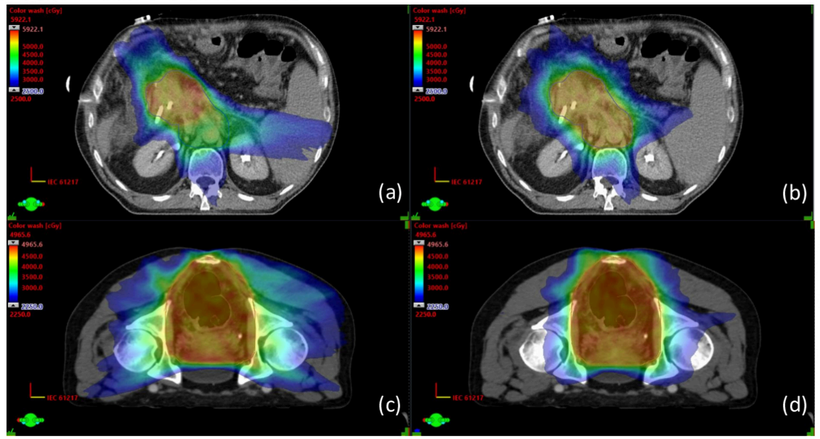

Figure 1. Dose distributions for a clinical plan (a) and model generated plan (b) for a pancreas case and a clinical plan (c) and a model generated plan (d) for a rectum case. For both the pancreas and rectum cases, as well as anal and liver sites, target coverage was compare between clinical and RapidPlan generated plans, but RapidPlan exhibited improved or comparable OAR sparing.

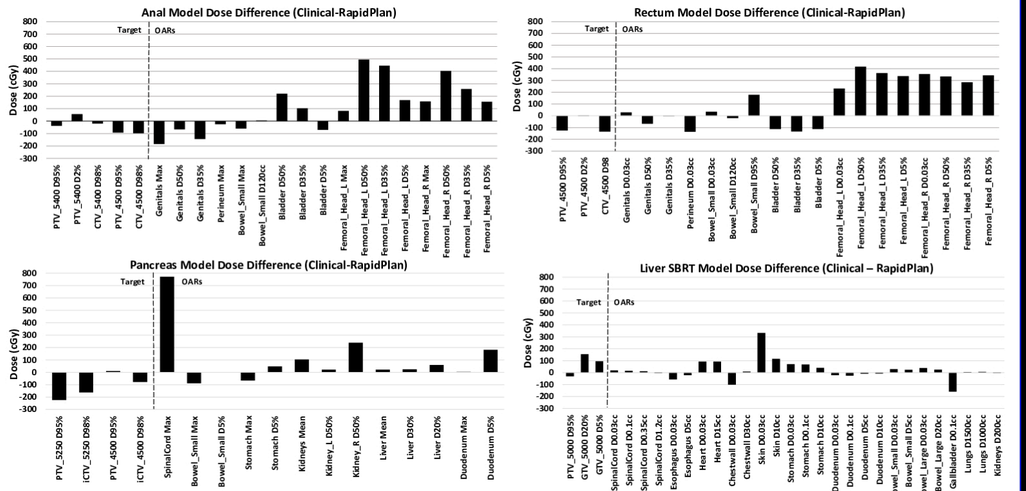

Figure 2. Average dose difference per metric between the clinically treated plan and the model generated plan. Positive differences indicate the clinical plans exhibit a greater dose for that metric and negative differences indicate the clinical plan has a lower dose for that metric (negative numbers signify improvement for the target coverage and positive numbers signify better OAR sparing in the RapidPlan model). Top Left: Anal Model, Top Right: Rectum Model, Bottom Left: Pancreas Model, Bottom Right: Liver Model.

CONCLUSIONS

The knowledge based planning models showed equivalent, and in many cases improved, plan quality but a key result of this model is the improved planning efficiency. Typically, GI sites require 2-5 iterations of optimization to achieve clinically acceptable plan quality. The knowledge-based model can achieve plans with a comparable plan quality to manual planning within a single iteration. On average, a single VMAT iteration using the knowledge-based model for GI sites will take 7-31 minutes of active planning time for a planner to create a full plan while 2-5 iterations of manual planning will take about 20-52 minutes, reducing the planner workload by about 50%, by achieving an acceptable plan within one iteration.
Combining the equivalent plan quality of the knowledge-based models with the significantly improved planning efficiency provides a benefit to clinical workflow and reduces the burden on clinical resources.

CONTACT INFORMATION

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PLANNING EFFICIENCY COMPARISON

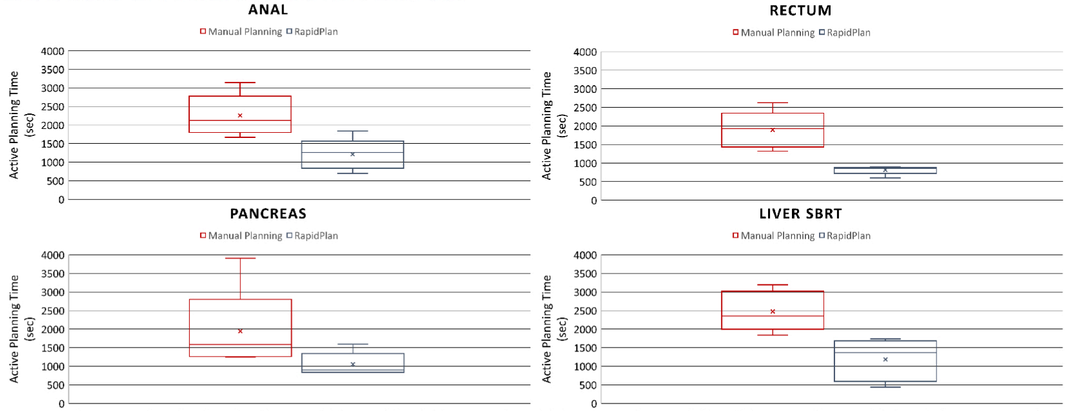

Figure 3. Active Planning Time (in seconds) for Anal (top left), Rectum (top right), Pancreas (bottom left) and Liver SBRT (bottom right). Red plots represent the average manual planning time and blue plots represent the average planning time for KBP model planning. For all sites, manual planning required 2-5 iterations of optimization to achieve a final clinically acceptable plan while the KBP models were able to achieve a clinically acceptable plan in a single iteration.