Investigating the Dosimetric Differences between Clinical Planning using Volumetric Modulated Arc Therapy and Auto-Planning in Patients with Cancer of the Prostate and Pelvic Lymph Nodes

A Lirani, B.Sc., CS Ha, M.D., T Eng, M.D., Z Shi, M.D., Ph.D., K Rasmussen, Ph.D., D Baacke, B.Sc., N Papanikolaou, Ph.D., AN Gutierrez, Ph.D., M.B.A

Department of Radiation Oncology, University of Texas Health Science Center San Antonio, San Antonio, TX 78229

Introduction

Volumetric modulated arc therapy (VMAT) is the most prominent technique used in irradiating cancer of the prostate and pelvic lymph nodes. VMAT planning requires a consistent, proficient, and time-consuming effort from the planner to obtain an optimal plan. With Auto-Planning, the experience of the planner becomes less of a factor because auto-plan adds its own structures, objectives, and weighting given a set of parameters and optimization goals in order to obtain an efficient plan. Time spent planning can also be significantly reduced with auto-plans. The objective of this study was to evaluate the auto-planning process and juxtapose the results with those of clinical plans conducted with VMAT.

Methods and Materials

- Twenty patients, who had previously been treated with 6 MV photon energy to the prostate and pelvic lymph nodes, were chosen.
- Patients were planned utilizing the Auto-Planning feature of Pinnacle^3 TPS Version 9.14.
- Auto-plans had the same prescription, number of beams, beam geometry, beam energy, and isocenter as the clinical plan. A single template was created and applied for all auto-plans.
- Auto-plans were subsequently modified with a maximum of three warm-starts to further enhance the plan. Each warm-start was optimized to 25 iterations.
- Plans were normalized such that 95% of the PTV received 100% of the prescription dose.
- Patients were evaluated for PTV and organ at risk (OAR) parameters for the rectum, bladder, sigmoid, small bowel, penile bulb, and the right and left femoral heads.
- Metrics used for comparison were D_{mean}, D_{2cc}, homogeneity (HI), prescription dose conformality (CN), dose falloff (R_{50}), and total monitor units (MUs) for the PTVs and D_{mean}, D_{2cc}, $V_{80\%}$, $V_{60\%}$, $V_{40\%}$, and $V_{20\%}$ for the OARs.
- Statistical differences were evaluated with a paired-sample Wilcoxon signed rank test with a significance level of 0.05.

Results

For the PTV, there were statistical differences in the CN, HI, and total monitor units. There were no statistical differences in mean dose, max dose to 2_{cc}, and dose falloff. Although not statistically significant, the R_{50} values of auto-plans were higher for 18 out of the 20 patients. In regards to the OARs, all structures except the penile bulb, had a statistically significant reduction in D_{mean}. The femoral heads showed an improvement in D_{2cc}. The rectum, bladder, sigmoid, and small bowel all showed statistically significant improvement in the $V_{40\%}$.

Conclusion

Auto-Planning can help the planner meet certain dose constraints that might be more difficult to achieve with regular VMAT plans. In examining the OARs, nearly all structures had less overall mean dose. Reducing dose to structures is critical when it comes to sparing OAR function and limiting the side effects of radiotherapy on patients. Auto-Planning can make treatment planning less laborious and time consuming, while providing comparable or significantly improved outcomes than VMAT plans done manually.

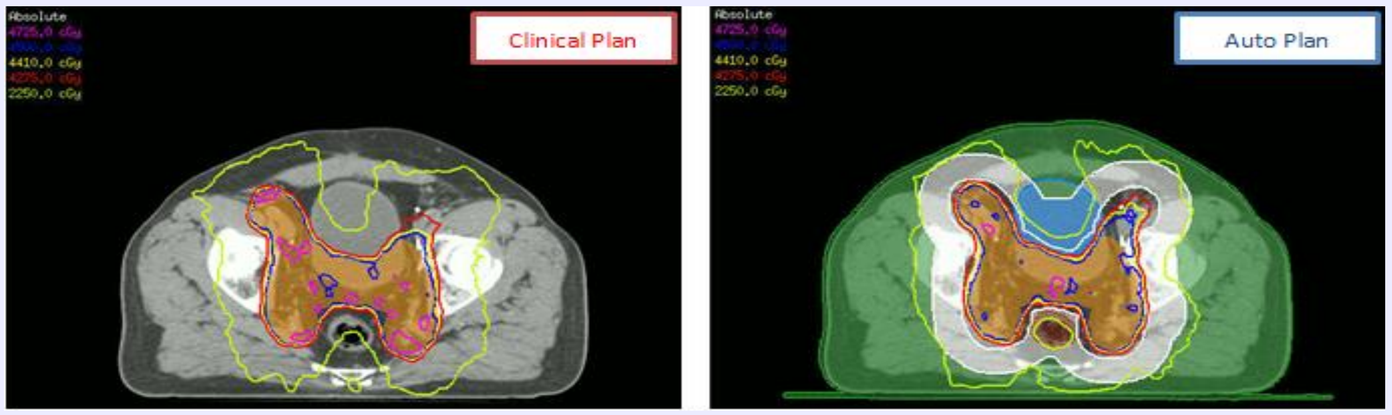

Figure 1: An axial slice of a sample patient treated with 6 MV photon energy to the prostate and pelvic lymph nodes. Both the clinical (*left*) and auto-plan (right) are shown along with respective isodose lines. Some of the structures created by auto-plan and used for optimization are also shown (light blue, green, white, brown).

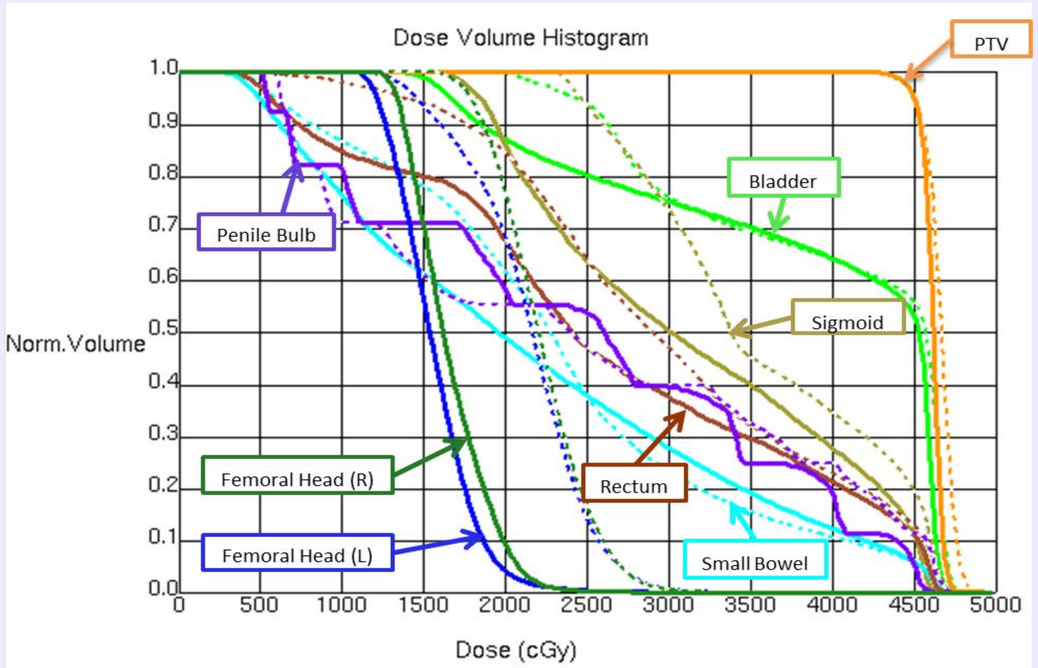

Figure 2: Cumulative, normalized DVH for a sample patient shows improved PTV uniformity and lower or comparable doses to the organs at risk for the auto-plan compared with the clinical plan.

Table 1: Median percent difference of PTV parameters for the clinical plan vs. auto-plan; Parameters with P<0.05 and thus statistically significant are in bold. A better conformality and homogeneity and less monitor units were observed with auto-plan compared to the clinical plan.

	D_{mean}	D_{2cc}	CN	HI	R_{50}	Total MUs
PTV	-0.8%	-1.6%	**-3.2%**	**-1.6%**	4.5%	**-9.2%**

Table 2: Median percent differences of OAR parameters for the clinical plan vs. auto-plan; All OARs with P<0.05 and thus statistically significant are in bold.

	D_{mean}	D_{2cc}	$V_{80\%}$	$V_{60\%}$	$V_{40\%}$	$V_{20\%}$
Rectum	**-8.7%**	0.3%	-6.7%	**-6.5%**	**-12.2%**	-3.0%
Bladder	**-11.8%**	-0.6%	-7.0%	-21.1%	**-13.1%**	**-3.5%**
Sigmoid	**-13.9%**	-0.5%	**-23.2%**	**-26.4%**	**-6.5%**	0.0%
Small Bowel	**-22.3%**	0.6%	14.3%	-20.3%	**-37.8%**	**-10.6%**
Penile Bulb	10.8%	0.4%	-2.4%	1.0%	5.7%	-1.2%
Femoral Head (R)	**-4.1%**	**-9.6%**	-	-95.1%	-29.3%	-4.7%
Femoral Head (L)	**-13.7%**	**-8.9%**	-	-77.7%	-45.7%	-0.1%