Feasibility of satisfying new dose volume constraints of bladder and rectum during treatment planning of prostate CyberKnife SBRT

Panayiotis Mavroidis[1], Nicholas Casteloes[1], Eric Schreiber[1], Michael Lawrence[1], Heidi Urquidi[2], Ronald Chen[3], Shiva K. Das[1], Michael Repka[1]

[1]Department of Radiation Oncology, University of North Carolina at Chapel Hill, NC; [2]Department of Radiation Oncology, University of Colorado Anschutz, Aurora, CO; [3]Department of Radiation Oncology, University of Kansas Cancer Center, Kansas City, KS

Purpose

To examine whether new recently reported dose volume constraints of bladder and rectum can be satisfied in prostate CyberKnife SBRTs without sacrificing target coverage. Also, to use a normal tissue complication (NTCP) model to determine the expected outcome in the clinical and re-optimized treatment plans.

Materials and Methods

74 consecutive patients, who underwent prostate CyberKnife SBRT receiving 36-38 Gy in 4 fractions were used to determine dose volume constraints for bladder and rectum. 5 of those patients whose treatment plans significantly violated those constraints were selected for re-optimization. For bladder, V10 < 80% and V20 < 30% were used and for rectum, V12 < 80% and V8 < 90%. The NTCP model parameters for frequency (TD50=21.8Gy, m=0.25 and n=1.0) and rectal urgency (TD50=21.5Gy, m=0.36 and n=1.0) were used to estimate the clinical outcome for the different plans.

Table 1. Summary of the dose-volume constraints that showed statistical significance for the urinary symptoms: u1, u3, u5, u7 and nocturia; and the rectal symptoms: r4 and r7 at 12 months post-RT, based on the PCSI scoring system. The values of those metrics for bladder and rectum from the clinical and re-optimized plans are presented.

Parameters	$V_{D(Gy)}$ (%)	Odds Ratio	Clinical plan	Re-optimized plan
PCSI scores		**Urinary symptoms**		
u1	$V_{20} < 35$	9.0 (1.3-61.6)	45.8 (37.9-72.0)	24.4 (22.3-25.2)
u3	$V_{10} < 80$	4.6 (1.1-19.1)	93.7 (90.0-99.4)	60.6 (50.5-78.9)
u5	$V_{20} < 30$	3.9 (1.1-14.0)	45.8 (37.9-72.0)	24.4 (22.3-25.2)
u7	$V_{10} < 80$	5.4 (1.3-21.9)	93.7 (90.0-99.4)	60.6 (50.5-78.9)
nocturia	$V_{10} < 80$	5.9 (1.1-30.9)	93.7 (90.0-99.4)	60.6 (50.5-78.9)
PCSI scores		**Rectal symptoms**		
r4	$V_{12} < 80$	7.7 (1.0-57.7)	83.8 (77.6-95.7)	45.1 (31.9-58.9)
r7	$V_8 < 90$	4.3 (1.2-14.8)	97.6 (92.8-99.9)	65.8 (49.3-82.0)

Results

The values of bladder V10 and V20 of the clinical plans were 93.7% (90.0-99.4) and 45.8% (37.9-72.0), whereas those of rectum V12 and V8 were 83.8% (77.6-95.7) and 97.6% (92.8-99.9), respectively. The corresponding values of the re-optimized plans were 60.6% (50.5-78.9) and 24.4% (22.3-25.2) for bladder and 45.1% (31.9-58.9) and 65.8% (49.3-82.0) for rectum, respectively.

The NTCP values of bladder for the symptom of frequency were 40.8% (29.9-66.8) for the clinical plans and 10.4% (4.9-19.1) for the re-optimized plans. Similarly, the NTCP values of rectum for the symptom of urgency were 30.3% (24.5-38.4) for the clinical plans and 13.9% (7.3-21.0) for the re-optimized plans.

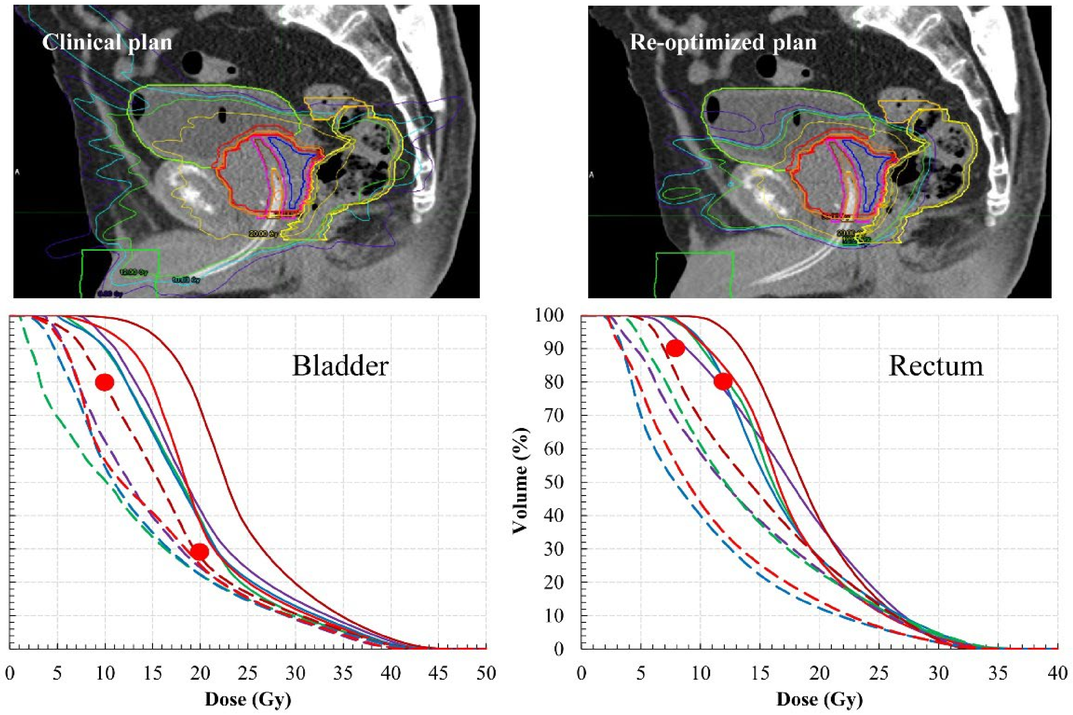

Figure 1. Upper: Sagittal view of one of the patients demonstrating the clinical and re-optimized plans. Lower: DVHs of bladder (left) and Rectum (right) of the 5 evaluated patients. The solid lines represent the clinical plans, whereas the dashed lines represent the re-optimized plans. The red solid dots point out the locations of the dose volume constraints of the urinary and rectal symptoms, respectively.

Conclusions

The new dose volume constraints could be satisfied in all the cases examined without affecting target coverage. The NTCP analysis indicated a significant reduction in the risk for urinary and rectal symptoms, respectively. These dose volume constraints were found to be feasible, and they may help in reducing the rates of urinary and rectal complications in patients receiving prostate SBRT.

Contact person: panayiotis_mavroidis@med.unc.edu