A Review of Daily Cone Beam Computed Tomography (CBCT) Scans to Analyze Dose Variation due to Daily Rectal Variation and Distension in Post-prostatectomy Radiation

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Introduction

In the post-prostatectomy setting, radiation toxicity and dose is limited by the surrounding organs at risk: the rectum and the bladder. Rectal toxicity is a known and often common complication of prostatic fossa radiation, including symptoms such as diarrhea, rectal urgency or tenesmus, and less commonly, bleeding, ulceration, incontinence or rectovesical fistula. Image-guided radiotherapy (IGRT) has made it possible to make the necessary shifts in patient position to accurately target the proper internal anatomy. Oftentimes, treatment day planned treatment volume (PTV) and Organs at Risk (OAR) contours differ from those seen during simulation prompting investigational efforts at Adaptive Radiation Treatment Planning, which involves substantial effort and resources (1,2). Rectal distension caused by fecal matter or rectal gas, which is identifiable on daily CBCT, can push the anterior rectal wall into the treatment volume, thus over-dosing the rectum and under-dosing the PTV.

Rectal distension displaces the prostatic fossa and thus the PTV, in turn increasing the rectal dose while simultaneously reducing the effectiveness of treatment (3). We examined the V50, V60 and V70 points. Certain rectal dose constraints are associated with minimizing radiation-induced injury as delineated in QUANTEC; 2010 (4). Previous investigators have reported that V50 of the rectum is correlated with rectal toxicity after post-prostatectomy radiation to conventional doses (66-70 Gy), and coincidentally they reported rectal dose are often higher than expected during treatment planning due to motion and distension. (5,6).

We present a novel approach that has been successfully implemented into clinical practice at OHSU by using daily IGRT to reproduce the simulation position of the PTV.

Methods

From July 2011 to December 2012, 86 post-prostatectomy prostate cancer patients with presumed localized disease were treated at OHSU with adjuvant/salvage radiation to 70 Gy in 35 fractions with RapidArc IMRT.

Prior to simulation an enema was done to minimize rectal distension for treatment planning. Daily CBCT was utilized and the patient was positioned using the most apical surgical clips. If the visualized rectal volume overlapped the PTV by 1 cm or more in any axial plane, treatment was held and the patient was asked to empty their bowel and drink water to maintain bladder filling. The patient was then re-imaged with CBCT to verify appropriate rectal positioning relative to the PTV. Occasionally patients were required to undergo repeated rounds of bowel emptying and CBCT.

In this study, pre-evacuation and post-evacuation CBCTs were co-registered with rigid registration, using bony anatomy and the most apical surgical clips, to the primary plan; each rectum was contoured over the same cranio-caudal dimensions as the primary treatment plan. Fusion to the planning CT allowed the treatment plan to be simulated on the pre and post-evacuation rectal contours.

Results

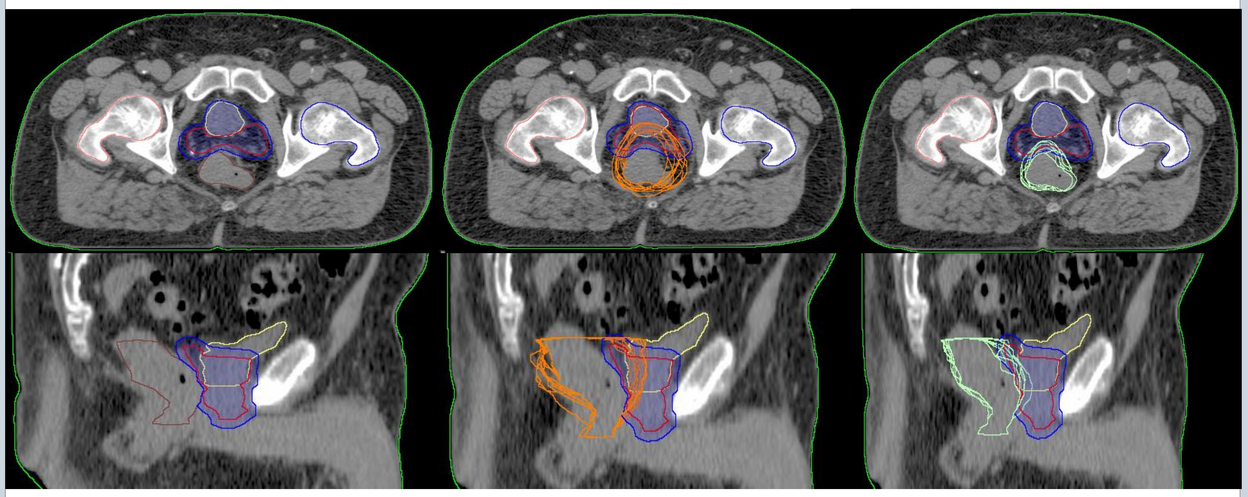

Figure 1. Sample patient with axial and sagittal views of the simulation, with each intervention demonstrated with the associated contours for pre-evacuation CBCT (orange rectum) and the post-evacuation CBCT (green rectum)

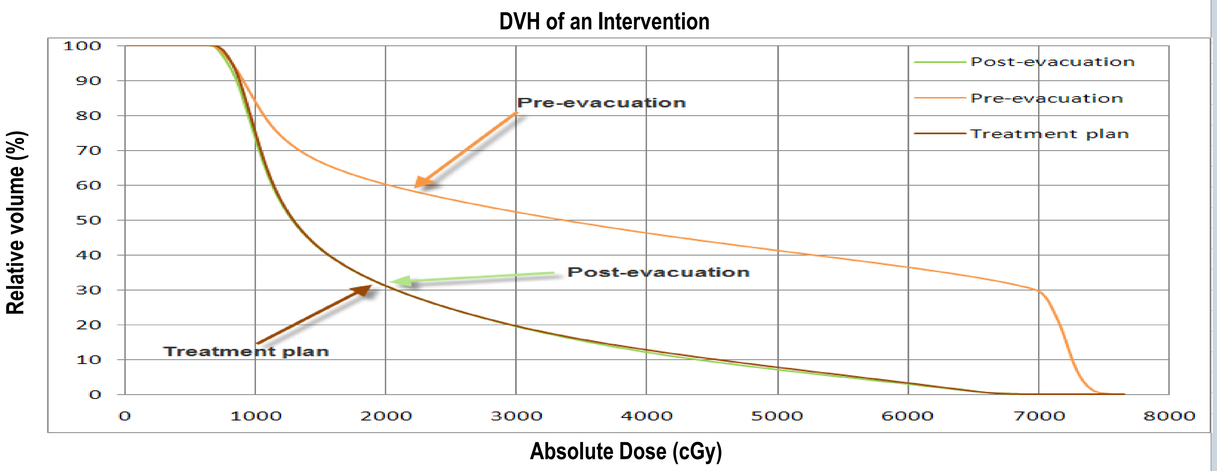

Figure 2. DVH from the same sample patient pictured above, this data is taken from a single intervention – note the relationship of the post-evacuation and treatment plan

	Treatment Plan	Pre evacuation	Post evacuation
V70:	0.2 % (0-0.94)	24.0 % (10.49 - 33.83)	4.0 % (0 - 22.55)
V60	7.2 % (2.27 - 14.05)	34.4 % (20.62 - 45.97)	12.4 % (1.55-29.34)
V50	16.2 % (7.75 - 29.06)	42.0 % (25.10-56.08)	21.0 % (5.05 - 44.04)
Rectal volume(cc)	36.2 (18.6 - 58)	76.9 (24.1 -170.7)	46.3 (17.9 - 92.4)

Table 1. Mean DVH results of the five patients reviewed involving every episode in which they were asked to evacuate there rectum

Methods

A total of five patients that required at least 4 interventions were identified and reviewed, a composite mean V50, V60 and V70 and rectal volume was calculated on the pre and post-evacuation contours, using all the data obtained on these five patients.

Results

Twenty-nine of the 86 treated patients underwent at least one intervention of rectal voiding during their course of treatment. For each patient, this occurred a mean of 2.9 (8.3%) times. The five patients reviewed in this study had four or more interventions (mean of 7 interventions; range 4-12), with results indicated in Table 1.

Sample imaging from a daily intervention done for a single patient is seen in Figure 1. A DVH (Figure 2) was created to represent a full course of treatment to the pre-evacuation and post-evacuation volumes from a single intervention. Notice the relative similarities of the post-evacuation rectal volume DVH with the treatment plan rectal volume. This is an exaggerated perspective to visualize the effectiveness of a daily intervention, as a controlled comparison with this method of daily intervention would be considerably challenging.

The patients were often embarrassed or at least apologetic about disrupting their normal routine and the therapists' schedules. Once patients were asked to step down from the treatment table to void rectal contents they often noted and verbalized their efforts to void prior to their treatment appointments to avoid future interruptions

Conclusions

•Rectal emptying when rectal distension is noted on daily CBCT prior to radiation treatment is a simple intervention that is easily implemented.

•This practice reduces dose to the rectum and potentially reduces clinically relevant rectal toxicity.

•This practice may also negate the need for adaptive radiation in this setting, as the post-evacuation rectal volumes are comparable to those seen during initial simulation.

References

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