Réseau de cancérologie Rossy
Rossy Cancer Network

The impact of rectal filling on rectal dose during hypofractionated radiotherapy of the prostate

Haley Patrick MSc, Kelly Agnew BSc, Luis Souhami MD, Fabio Cury MD, Sergio Faria MD, Tamim Niazi MDCM, John Kildea PhD

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INTRODUCTION

Prostate cancer has one of the highest survival rates of all cancers[1]. 58% of patients receive radiotherapy as part of their treatment course[2], but as many as 50% of them experience negative side effects to the rectum that decrease their quality of life[3].

Understanding the relationship between radiation doses to the rectum and the severity of toxicities induced in it is crucial in the endeavour to improve radiotherapy outcomes.

OBJECTIVE

Our objective was to quantify the changes in rectal volume and gas levels over the course of radiotherapy in order to determine the strength of the relationship, if any, with the daily variations in rectal dose.

Doing so also allows us to assess the potential merits of a low gas diet regimen for patients.

METHODS / INTERVENTIONS

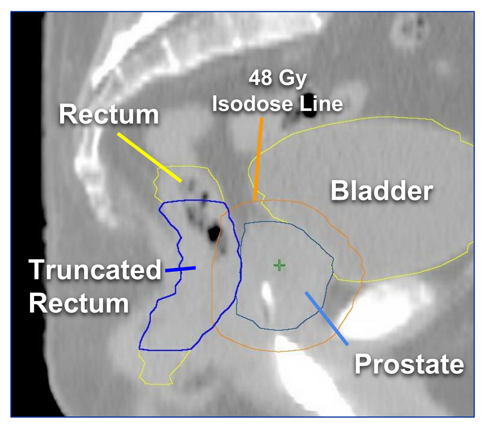


Figure 1. Notable structures and pelvic anatomy

The rectum was delineated on the planning CT and daily CBCT images of 16 moderate-risk prostate cancer patients who were treated with 60 Gy in 20 fractions. In addition to the rectum, a second rectum structure was defined as the normal rectum truncated to the superior and inferior boundaries of the 48 Gy isodose line.

Images, contours, and dosimetric data for all structures were exported from the treatment planning system. The volume of rectal gas on each day of treatment for each patient was quantified by calculating the number of gaseous voxels in each rectum structure using a custom analysis script. The script makes use of hounsfield unit data to differentiate between materials in the image.

Extracted dosimetric parameters were plotted as a function of volumetric parameters to determine level of correlation using linear least-squares regression. Significant correlations were defined as having $R^2 > 0.6$.

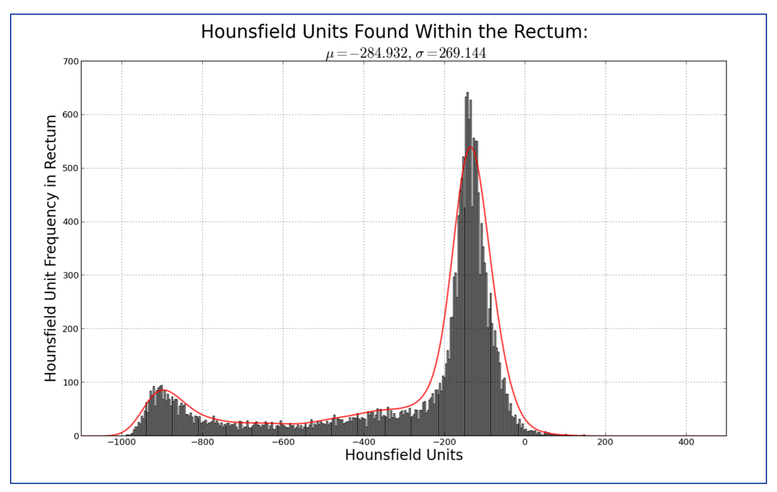


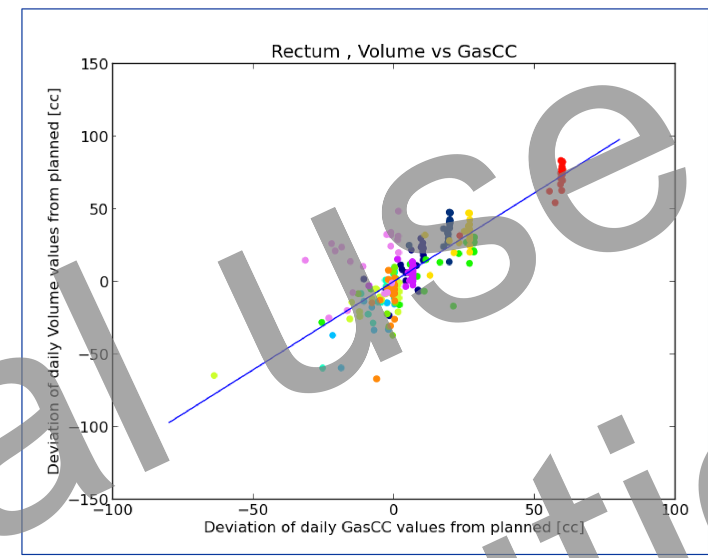
Figure 2. Distribution of Hounsfield Unit values in the rectum for a single treatment fraction

RESULTS

Changes in rectal volume are correlated with changes in rectal gas

The difference between planning and daily treatment volumes were plotted as a function of the difference between daily and planned gas volumes. Significant positive correlation between differences in gas and total volume were found for the full rectum structure (R^2 = 0.729, Figure 3), and the truncated rectum structure at the level of the prostate (R^2 = 0.696).

Figure 3 (right): Correlation between differences in planned and daily volumes of the rectum and differences in planned and daily rectal gas volumes. Each patient is represented by a different colour.



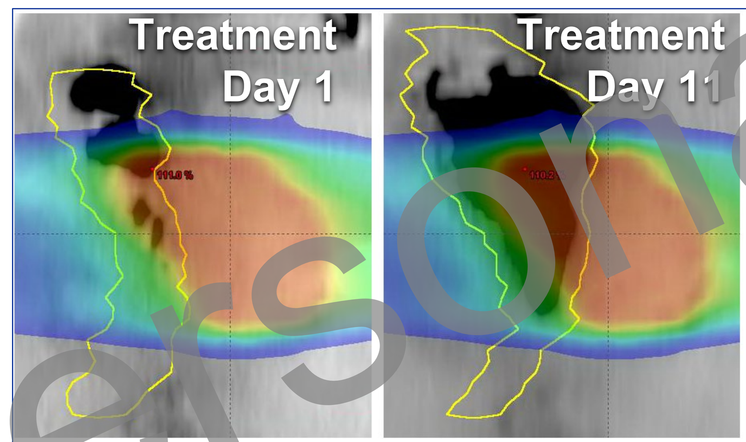
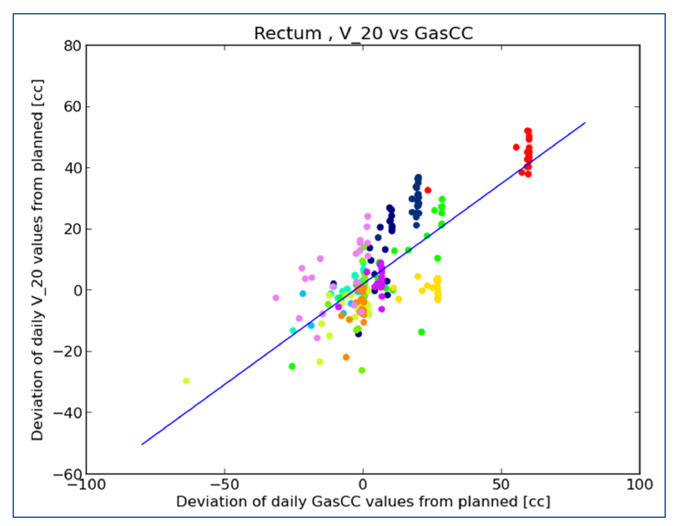


Figure 4 (left): Increase in rectal gas midway through treatment increases the portion of the rectum exposed to high radiation dose.

Changes in rectum dose are correlated with the differences between individual daily volumes and the volume at the time of planning

The level of correlation between daily fluctuations in the volume of the rectum receiving specific isodose levels and gas/total volume variations was investigated for both the full and truncated rectum structures. The strongest correlations were found to exist at lower isodose levels (Figures 5, 6), whereas correlations at higher isodose levels were not found to be significant. The total volume of the truncated rectum was found to be the strongest predictor of daily dose changes

Figure 5 (right): Differences in the planned and daily volumes of the complete rectum exposed to 20 Gy or more as a function of the differences in rectal gas volumes. R^2 was 0.615.



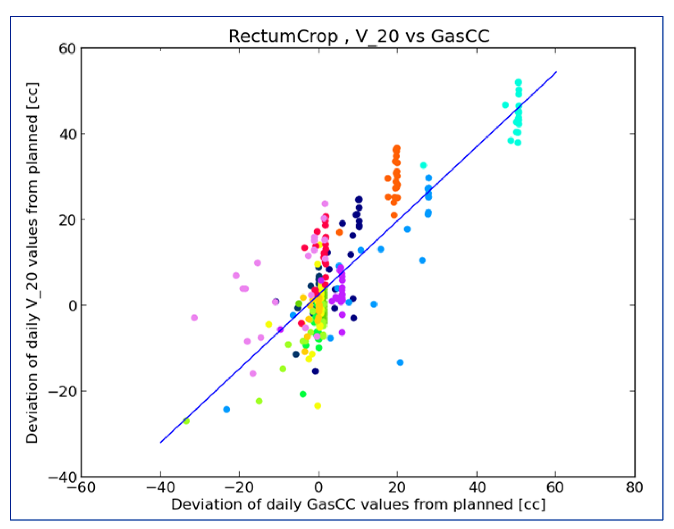


Figure 6 (left): Differences in the planned and daily volumes of the truncated rectum exposed to 20 Gy or more as a function of the differences in rectal gas volumes. R^2 was observed to increase to 0.723.

PATIENT IMPACT

Our current results suggest that regulating the degree of rectal filling over the course of treatment could reduce fluctuations in daily rectal dose. Given the strong correlation between rectal volume and gas content, management of gas levels alone may be sufficient.

Management of gas through diet may reduce the rates and severity of rectal side effects caused by overexposure of the organ during prostate cancer radiotherapy. In addition, dietary intervention is likely to be less invasive for patients than other methods to control rectal volume, such as the use of laxatives or enemas.

CONCLUSION

Variations in daily rectal volumes were found to be correlated with variations in rectal gas volumes over the course of treatment. When rectum exposure at multiple isodose levels was investigated, the portion of exposed rectum was found to be correlated to rectal gas at lower isodose levels, but not at the higher ones that are used as dosimetric constraints.

Correlation to changes in rectal dose improved when using the total rectal volume, suggesting changes in fecal matter levels also impact dose. Improvement was also observed when using the truncated rectum structure. This was understandable, as changes in positioning at the level of the prostate would be expected to have a greater impact on dose.

TRANSLATION ACROSS THE RCN

Patients across all hospitals in the Rossy Cancer Network may benefit by participating in the randomized trial we aim to conduct in the near future. In addition to access to a dietitian over the course of treatment, they will be able to actively participate in research through self-reporting and detailed follow-up appointments, with the potential to reduce their risk of developing radiation toxicities should they successfully follow their diet plans.

REFERENCES

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