Réseau de cancérologie Rossy | Rossy Cancer Network

Rectal toxicity prediction using average-delivered DVHs determined from daily CBCT imaging for hypo-fractionated radiotherapy of the prostate

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INTRODUCTION

Rectal toxicity is a potential side effect of radiotherapy (RT) of the prostate that can affect a significant proportion of patients, with symptoms that may lead to decreased quality of life. In order to reduce the occurrence of rectal toxicity, it is necessary to understand the relationship between the dose delivered to the rectum and the symptoms that are experienced.

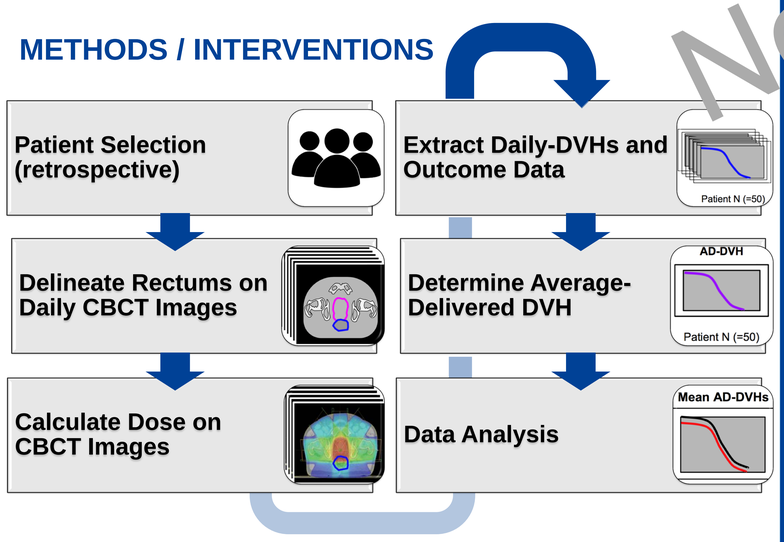
In practice, the dose-volume histogram (DVH), which summarizes the 3D dose distribution in a 2D format, is used to guide radiotherapy planning. However, we have not observed a clear relationship between DVH parameters and toxicity. We believe that this may be due to the difference between the planned dose and delivered dose caused by motion of organs (i.e. the prostate, bladder and rectum) between radiotherapy fractions.

In this retrospective study we are examining if rectal DVHs calculated using daily cone-beam CT (CBCT) images correlate better with reported rectal toxicities than those calculated using planning CT images.

OBJECTIVES

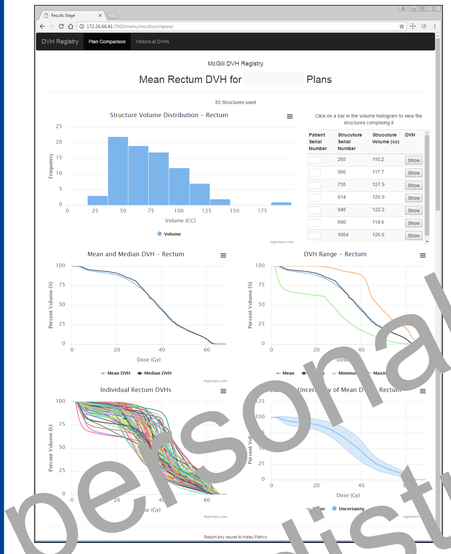
1. Examine the difference between planned-DVH and average-delivered-DVH to the rectum at the end of RT of the prostate, delivered with daily CBCT imaging guided setup,
2. Determine the level of correlation between the DVHs of the rectum (planned and average-delivered) and various acute and late toxicity endpoints (e.g. frequency or severity of diarrhea and proctitis), and
3. Develop and put in place a comprehensive dose-volume-outcome analysis infrastructure for RT at the MUHC and the JGH that will be made available to clinicians and for other future RT studies at both centres.

METHODS / INTERVENTIONS



RESULTS

Development of DVH Analysis Infrastructure



We have developed a DVH registry software that may be used to:

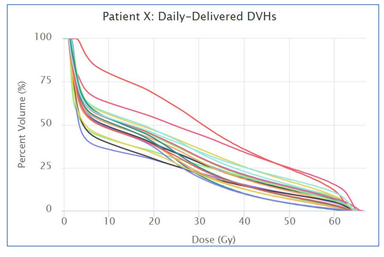
- Upload new data
- Select specific cohorts from the registry
- Analyze and display cohort data
- Compare new data to historical cohorts in the database

Example screenshot of the DVH Registry results page for a patient cohort of rectum DVHs.

Difference between Planned and Delivered DVHs

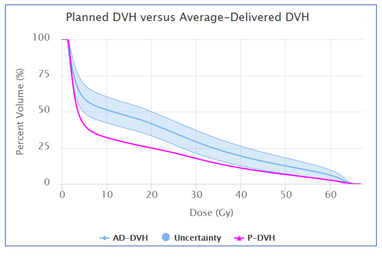
To date, nine patient datasets have undergone full DVH analysis. Daily-Delivered DVHs representing the dose distribution in the rectum of each fraction were observed to change over the course of treatment. In addition, the Average-Delivered DVHs (which estimate the total delivered dose distribution) of some patients were found to be significantly different from the Planning-DVHs.

The DVHs of a representative patient are presented below as an example.



Individual daily-delivered DVHs varied for patient X over the course of treatment. This behaviour was found to be typical of all patients analyzed thus far.

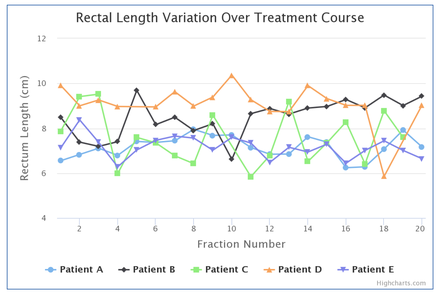
The average-delivered DVH for patient X differs from his planned DVH, particularly in the low dose region where the difference is significant. This shows that, due to organ motion, this patient received more low dose radiation to the rectum than planned.



Examination of Anatomical Changes over Treatment Course

We used the length of the rectum (defined as the distance from the lowest level of the ischial tuberosity to the recto-sigmoid flexure as projected on the z-axis of the patient's CBCT scan) as a surrogate to quantify rectum changes over the course of treatment.

*Rectal length was found to vary over the course of treatment in all patients. Some, such as **Patient A** displayed only minor changes, whereas other patients had a much wider range of rectal lengths and changed more erratically, as seen for **Patient C.***



PATIENT IMPACT

At the current stage of the project we have:

- Developed a software infrastructure to quantify and evaluate anatomical changes and their consequences during treatment
- Confirmed that the volume of the rectum changes over the course of treatment
- Observed that rectal anatomical changes result in a delivered dose that differs from the planned dose

We anticipate at the conclusion of this project to have:

- Finalized our software into an informatics tool for physicians to clinically evaluate patient treatment plans
- Better understanding of the dose actually delivered to patients
- The tools and infrastructure required to improve prediction of the likelihood and severity of rectal toxicity in our prostate cancer patients.

CONCLUSION

We have developed a software infrastructure for the purpose of comparing the radiation dose planned and delivered to prostate cancer patients during RT. Using this software we have evaluated nine patients and confirmed that the rectal anatomy changes over the course of treatment and that the rectal dose distribution varies as a consequence. Carrying on in our research, our next steps are to incorporate patient outcome data to investigate if these variations correlate to the frequency and severity of rectal toxicity.

TRANSLATION ACROSS THE RCN

The dose-volume-outcome analysis infrastructure that we have developed is available to clinicians at the MUHC and the JGH. Although this project is specific to prostate cancer, our analysis tool is designed to be applicable to all cancer types and with multiple applications in mind, including the ability for dosimetrists to compare their plans to historical populations.