JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING

# Using In-vivo EPID Measurements to Improve Bowel Toxicity Modeling

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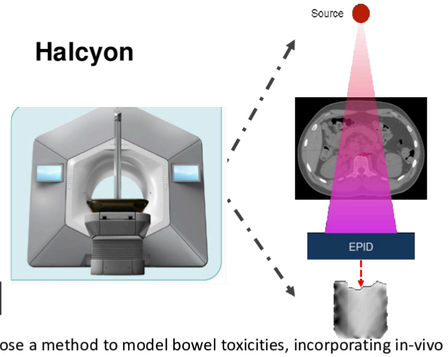
RETHINKING MEDICAL PHYSICS

## INTRODUCTION

- For gastrointestinal treatments, excess dose to the bowel can result in acute toxicities. Clinically significant acute GI toxicity occurs in approximately one third of patients (1, 2), adversely impacting quality of life (3) .
- Current estimates of bowel toxicity is based on pre-treatment dose volume histogram data. However, the actual dose the bowel receives can depend on intrafraction variations such as patient anatomy changes.
- Varian Halcyon collects in-vivo EPID images for every fraction of treatment.




## AIM

- We propose a method to model bowel toxicities, incorporating in-vivo patient information using transit EPID images.

## METHOD

- For 63 patients analyzed, who were treated to the lower thorax, abdomen or pelvis on the Varian Halcyon. 20 patients presented with toxicities.

### DVH Approach

- For each treatment plan, the absolute volume DVH of the bowel was exported and analyzed.
- For the dose-volume-response the logistic model was used

$$P = \frac{1}{1+\exp\left[-4\gamma_{50}\left(\frac{V}{V_{50}}\right)-1\right]}$$

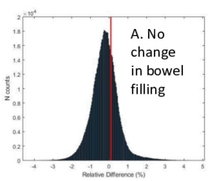
- V50 is the volume corresponding to 50% incidence of complications, and $\boldsymbol{\gamma}50$ is the normalized slope of the volume response curve.
- A maximum likelihood fit was used for best values. Likelihood ratio was used to establish if correlation is statistically significant

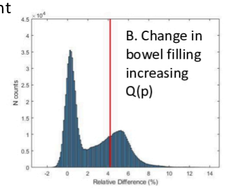
## METHOD

### In-vivo EPID Approach

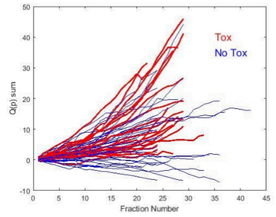
- For each fraction of treatment in vivo EPID images were collected and compared to the images collected on the first fraction of treatment.
- Using the reference image, the high dose low gradient region of the images were selected.
- For each fraction of treatment the distribution of relative pixel values was used to make a quantile function Q(p). The quantile function returns the threshold value, x which can identify changes in the pixel distribution caused by changes in patient anatomy.

Distribution of relative pixel differences between 2 fractions of treatment




The threshold x for which p=0.7 was calculated for each fraction of treatment and summed over the course of treatment. And is plotted for each patient, highlighting patients with and without toxicity.



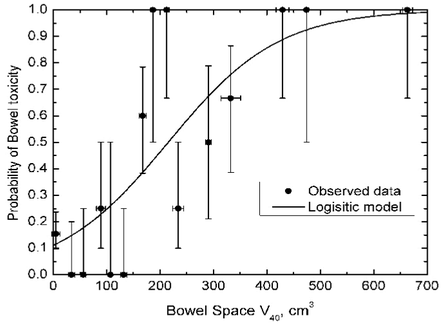

- To model the the toxicity response to the sum of Q(p) a logistic model was used

$$P = \frac{1}{1+\exp\left[-4\gamma_{50}\left(\frac{Q}{Q_{50}}\right)-1\right]}$$

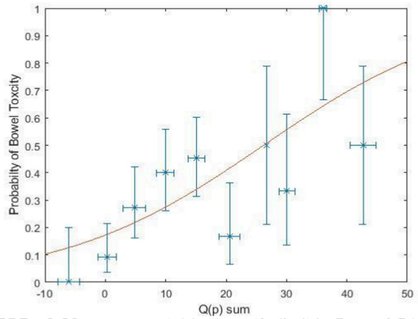
- Q50 is the sum of Q(p) corresponding to 50% incidence of complications, and $\boldsymbol{\gamma}50$ is the normalized slope of the response curve
- Similar to the dose-volume model, a maximum likelihood fit was used for best values and a likelihood ratio to establish if correlation is statistically significant.

## RESULTS

- The incidence of toxicity versus the volume of 40 Gy was fitted with a logistic function, which was superior to an average model ($p < 0.0001$) and agrees with previously published models (4).
- For NTCP=0.20 as acceptable, a safe limit is 71.8 cc, and negative predictive value of 29/33=87.8%.




- The incidence of toxicity versus the sum of Q(p) measured from in-vivo EPID images was fitted with the logistic model. The logistic model was superior to an average model ($p = 0.008$).




Setting NTCP =0.20 , as acceptable the safe limit is Sum of Q(p) = 4.0 and negative predictive value 18/20 = 90%.

## CONCLUSIONS

- This study supports the hypothesis that reducing bowel irradiation can result in lower acute GI toxicity.
- Additionally this study supports that in-vivo patient changes over the course of treatment can model acute GI toxicity.

## REFERENCES

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4. Simpson DR, Song WY, Moiseenko V, et al. Normal tissue complication probability analysis of acute gastrointestinal toxicity in cervical cancer patients undergoing intensity modulated radiation therapy and concurrent cisplatin. *Int J Radiat Oncol Biol Phys.* 2012;83(1):e81-e86. doi:10.1016/j.ijrobp.2011.12.012

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