

Dose-LET Volume Histogram Markers of Genitourinary Toxicity In Proton Prostate SBRT

Duncan Bohannon, Sagar Patel, Scott McGinnis, Nicholas Bader, Ahmal Zafar, Zachary Diamond, Xiaofeng Yang, and Jun Zhou

Department of Radiation Oncology, Emory University, Atlanta GA

INTRODUCTION

Genitourinary (GU) toxicity is common following proton prostate SBRT. Steep **dose gradients and elevated linear energy transfer (LET)** near the end of the proton range are possible causes

Recently, **bladder neck (trigone)** dosimetry has shown a stronger association with GU toxicity than the bladder [1-2]

This study investigates what **bladder and trigone dose and LET thresholds** are strong predictors of **GU quality of life (QoL) decline** using **dose-LET volume histograms (DLVHs)**

METHODS

Cohort of **43 patients** treated with proton SBRT (5x36.25 Gy RBE) with bilateral opposed and two oblique beams

Patients experienced GU QoL decline if their **International Prostate Symptom Score (IPSS)** scores increased by one standard deviation from their baseline within one year of treatment

Bladder and trigone DLVHs were calculated for all patients, and relative volumes were compared at thresholds from 10.0–40.0 Gy and 0.0–3.0 keV/μm. Strong predictors of were identified with the **independent Mann-Whitney U Test**

The predictive power of DLVH thresholds was assessed with **univariate logistic regression**. Once trained, an **optimal separation threshold** was determined from the Youden index (maximizes false positive rate + true positive rate)

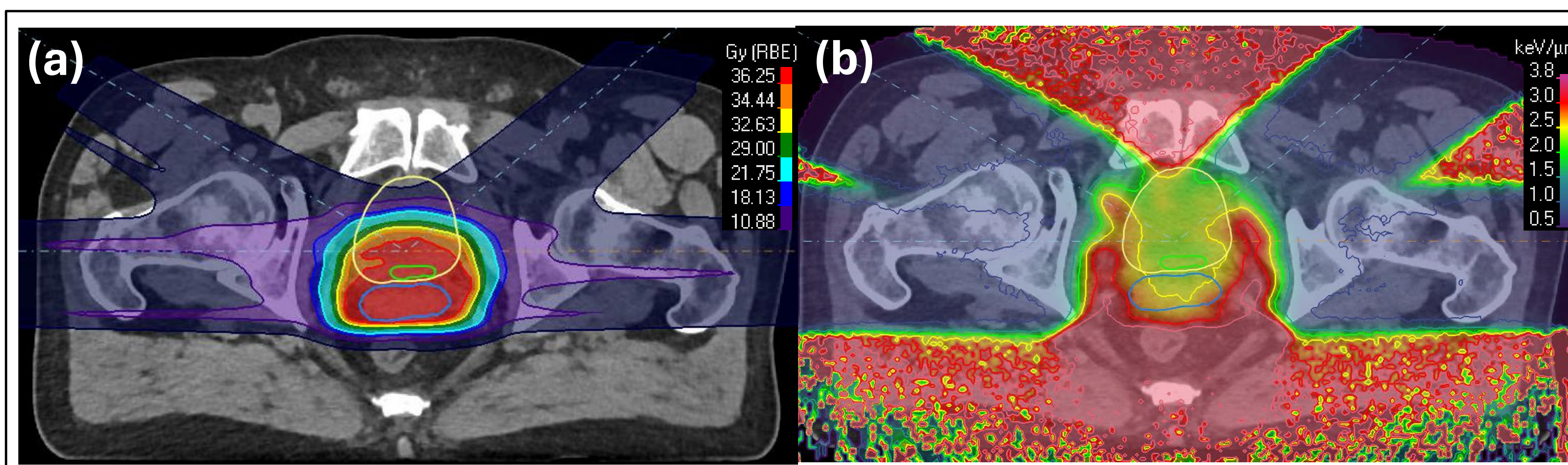


Figure 1: Example prostate SBRT patient's (a) Isodose and (b) LET distribution. Prostate is contoured in blue, trigone in green, and bladder in yellow

LOGISTIC REGRESSION RESULTS

V(36.70 Gy, 2.2 keV/μm) was the most significant trigone threshold ($p = .011$)

Logistic regression achieved:

- Area under curve (AUC) = 0.74
- Odds ratio (OR) = 855.32
- 95% OR confidence interval (CI) = $[1.76, 4.16 \cdot 10^5]$

V(36.70 Gy, 2.2 keV/μm) > 47.7% was the optimal separation threshold

Logistic regression with this threshold achieved:

- AUC = 0.74
- OR = 5.40
- 95% OR CI = $[1.35, 21.64]$

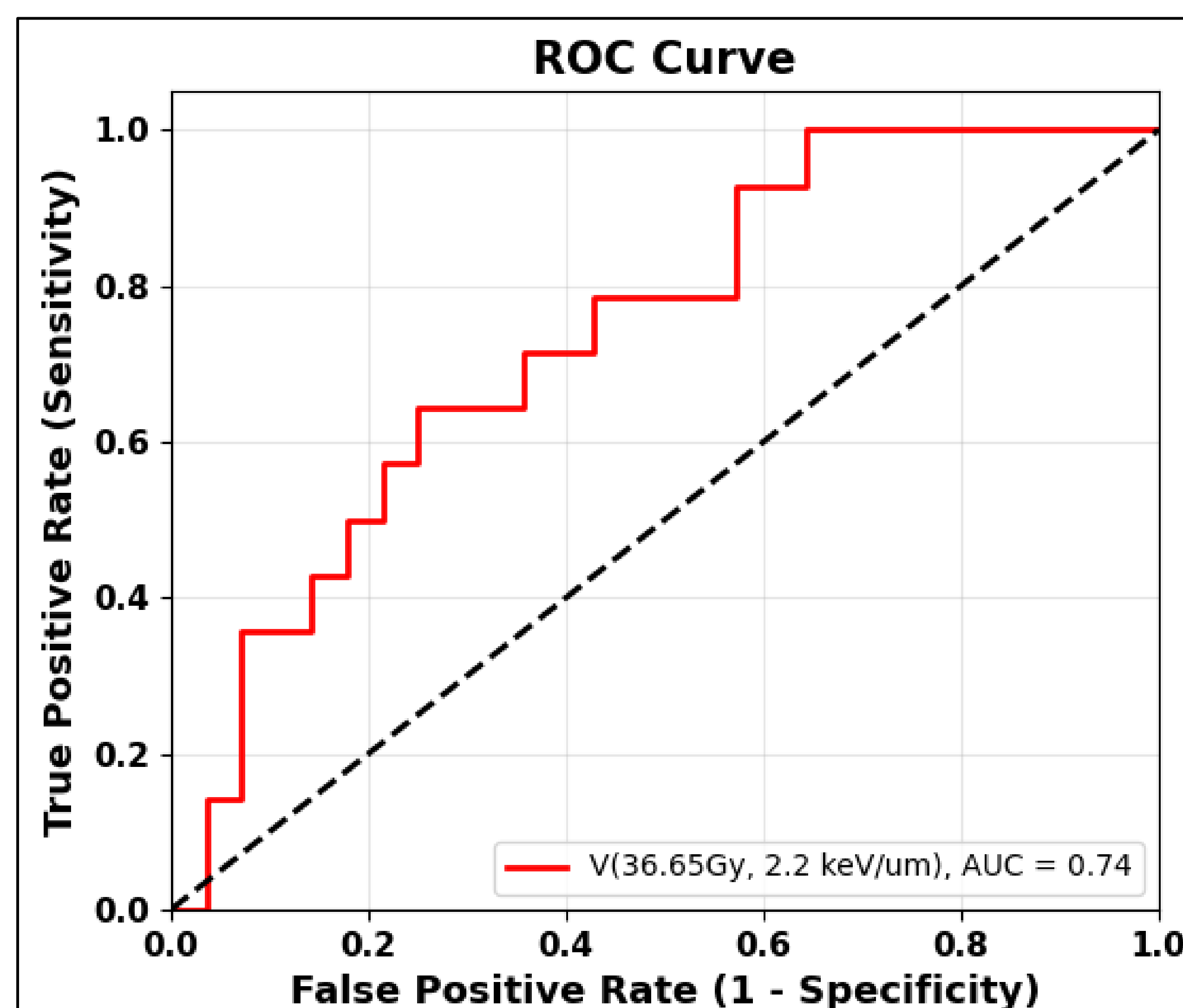


Figure 3: Logistic regression ROC curve

BLADDER/TRIGONE DLVH RESULTS

14 patients experienced GU QoL decline. No bladder DLVH thresholds were associated with GU QoL decline. Significant trigone DLVH thresholds were found at **doses near the prescription** and a broad range of LET values

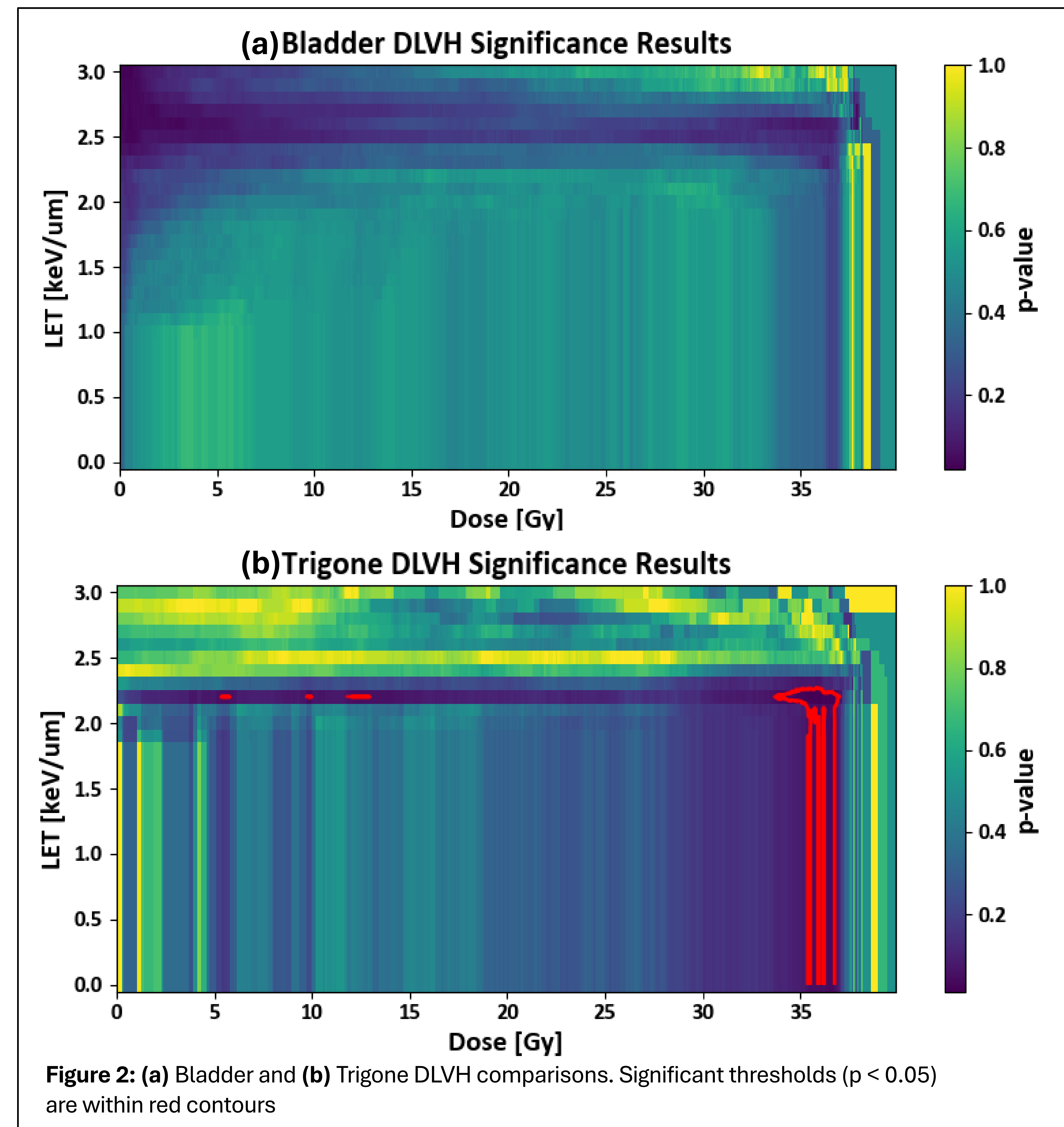


Figure 2: (a) Bladder and (b) Trigone DLVH comparisons. Significant thresholds ($p < 0.05$) are within red contours

CONCLUSIONS

This study found that high trigone dose was a strong predictor of GU QoL, while bladder dose wasn't

GU QoL decline has **minimal dependence on LET**

Our results imply that **trigone dose should be considered during planning** to reduce toxicity

REFERENCES

- [1] Ghadjar P, et al. Impact of dose to the bladder trigone on long-term urinary function after high-dose intensity modulated radiation therapy for localized prostate cancer. Int J Radiat Oncol Biol Phys. 2014 Feb 1;88(2):339-44. doi: 10.1016/j.ijrobp.2013.10.042. PMID: 24411606; PMCID: PMC4581453.
- [2] Henderson DR, et al. An Investigation of Dosimetric Correlates of Acute Toxicity in Prostate Stereotactic Body Radiotherapy: Dose to Urinary Trigone is Associated with Acute Urinary Toxicity. Clin Oncol (R Coll Radiol). 2018 Sep;30(9):539-547. doi: 10.1016/j.clon.2018.05.001. Epub 2018 May 25. PMID: 29807801.

CONTACT INFORMATION

- ✉ dhbohan@emory.edu
- ✉ jun.zhou@emory.edu