2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

The impact of bladder filling on patient setup and patient time in the treatment room during proton therapy of prostate cancer patients

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ABSTRACT

Purpose: The bladder is kept full during prostate proton therapy to push the small and large intestines out of the radiation field and maintain a consistent position for the bladder and nearby pelvic organs. However, it is a challenge to keep a regular bladder volume throughout the course of radiation, which may slow down treatment processes. This study aims to determine how bladder volume affects patient set-up, number of imaging episodes, and treatment durations.

Methods: In this retrospective analysis, data from 25 prostate cancer patients were analyzed. For each patient, a random five sessions of treatment were considered. For each session, the bladder volume, couch shifts, time in the treatment room, and number of KV and CBCT images were recorded. The net 3D Cartesian shift and percent volume difference from the planning volume were calculated for each treatment. Per-patient and pooled analysis was performed.

Results:
The distribution of bladder volume difference at treatment is skewed towards underfilling (mean = 10.2, median = -3.03). Further, a negative correlation (r=-0.48) was found between the per-patient averaged volume differences and the planning volume.

There is an expected correlation between the number of KV and CBCT images taken during patient setup and the treatment time (r=0.47). However, expected relationships between high volume differences and cartesian shift or treatment time are not readily apparent (r=0.14, r=0.06). Analysis is limited by outliers and corresponding factors, such as wait times for the shared beam facility across multiple rooms.

Conclusion: Current results show that patients may be presenting at simulation with bladder volumes inconsistent with those at treatments. Pooled correlations support that the relationship between bladder filling and patient setup is complex and warrants further investigation.

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INTRODUCTION

- Proton therapy has emerged as a highly effective treatment for prostate cancer but requires strong setup reproducibility [1].
- One of the primary challenges in achieving setup reproducibility during proton therapy for prostate cancer patients is maintaining a consistent bladder filling across treatments.
- The bladder is kept full to push OARs out of the radiation field and maintain a consistent position of nearby pelvic organs [2].
- When a patient arrives for treatment, CBCT is performed to align anatomy with the planning CT.
- If bladder volume is significantly different, the patient must intake fluids and CBCT will be repeated. This will increase radiation dose, increase IGRT imaging and patient time in the treatment room, and cost resources.

METHODS AND MATERIALS

- Following IRB approval, data from 25 randomly selected prostate cancer patients who were treated with PBS proton therapy in 2025 were collected and analyzed.
- 5 random treatment sessions were considered (N=125). Bladder volume, couch shifts, IGRT imaging time, time in the treatment room, and number of KV and CBCT images were recorded.

RESULTS

- Patients with low and high bladder volumes at simulation correlated with opposite bladder fillings (r= -0.48) during treatment days.
- Patient time in the treatment room is moderately correlated (r = 0.47) with the number of imaging episodes taken.
- There is no significant correlation (r = 0.14) between the % bladder volume difference between planning CT (pCT) and CBCT and cartesian shifts between pCT and CBCT.
- There is no significant correlation (r = 0.06) between the % bladder volume difference between planning CT (pCT) and CBCT and patient time in the treatment room.
- The bladder volume difference plays a significant role in the IGRT imaging time (p=0.035).

DISCUSSION

- Current results show that patients may be presenting at simulation with bladder volumes inconsistent with those at treatments.
- There is an expected correlation between the number of KV and CBCT images taken during patient setup and the treatment time, however, expected relationships between volume differences and cartesian shift or treatment time are not readily apparent.
- This analysis is limited by outliers and confounding factors, such as wait times for the shared beam facility across multiple rooms.

CONCLUSIONS

- Bladder filling protocols are an essential component of prostate proton therapy. By identifying optimal bladder volume (BV) and its impact on treatment efficiency and accuracy, this work aims to help proton therapy centers reduce patient time spent in the treatment room for higher throughput, minimize patient exposure to unnecessary radiation by avoiding too many X-ray images, and promote accurate delivery of the radiation dose to tumors while sparing the surrounding healthy tissue.

- The results of this study indicate that the relationship between bladder filling and patient setup is complex and warrants further investigation.

REFERENCES

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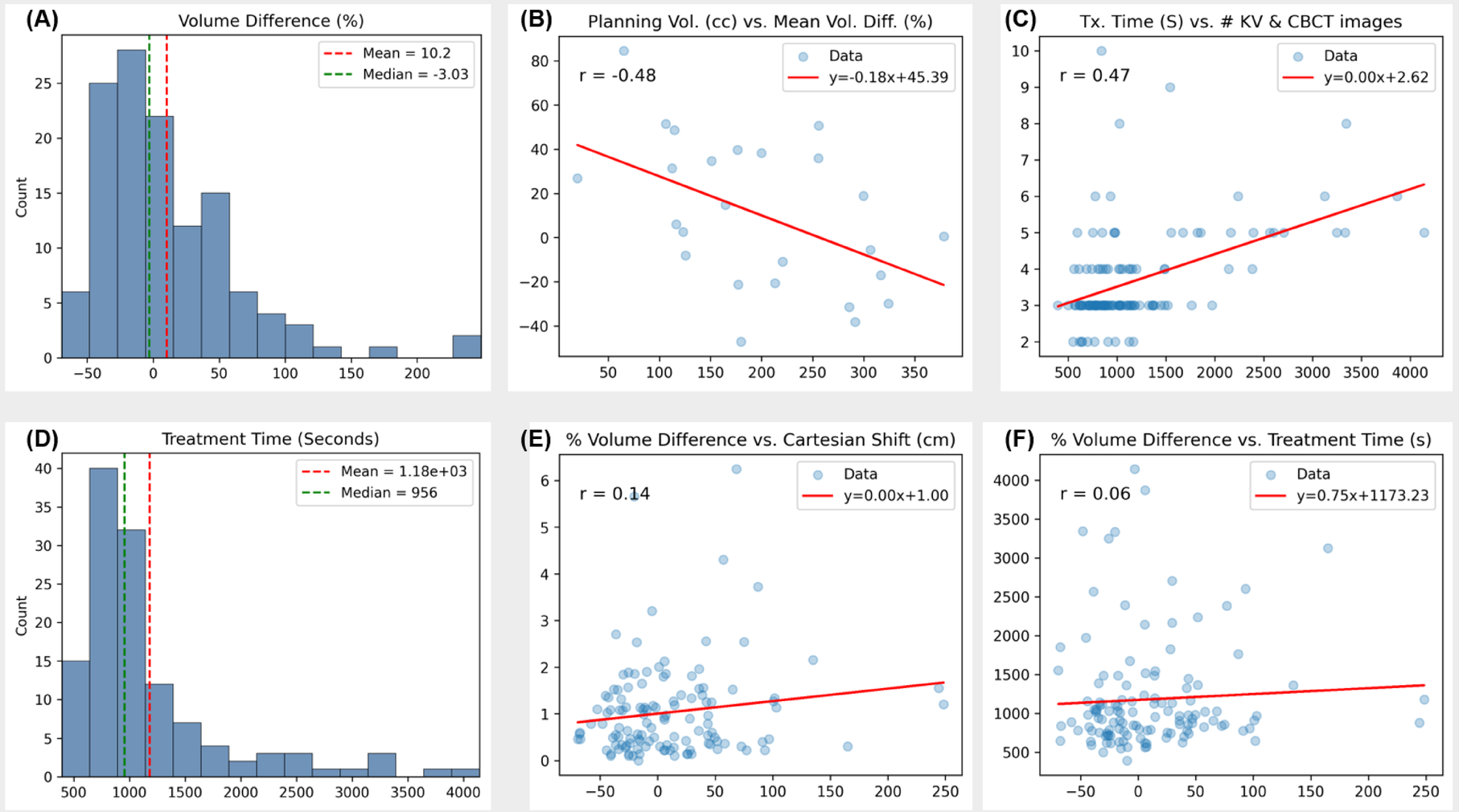

Figure 1. A) Distribution of % volume difference treatment from the planning BV, B) Planning CT BV vs. per patient average of % BV difference, C) Patient time (seconds) in the treatment room vs number of imaging episodes (kV+CBCT), D) Distribution of patient time (seconds) in the treatment room, E) Percentage BV difference between planning CT and CBCT vs. net cartesian shift (Longitudinal, Vertical, Lateral), F) Percentage BV difference vs. patient time (seconds) in the treatment room..