UNIVERSITY OF MIAMI
MILLER SCHOOL of MEDICINE

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

# Pre-Treatment Ultrasound for Bladder Volume Verification In Prostate Radiotherapy: Effects on Workflow and Dosimetric Endpoints

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## ABSTRACT

Purpose: Consistent bladder filling during prostate RT can improve the accuracy of treatment delivery. The use of a dedicated Ultrasound (US) scanner to assess the bladder volume prior to setting the patient on the treatment table can aid in reduced treatment times and more consistent treatment delivery. In this retrospective study, we have evaluated the benefits of utilizing a dedicated bladder US scanner for improving the clinical workflow and dosimetric endpoints for prostate RT.

Methods: 60 patients all treated with VMAT, were divided into three groups of 20: Prostate only (P) (70.2 Gy to PTV, 26Fx), Prostate with Lymph Nodes (P+LN) (80Gy, 40 Fx + 6 Gy Boost to GTV) and Prostate Bed with Lymph Nodes (PB+LN) (68 Gy to PTV + 52.7 Gy to LNs, 34 Fx). In each group, 10 patients were control patients and 10 were treated with pre-treatment US bladder volume evaluation using BladderScan (BS) Prime Plus (Verathon Inc. Bothell, WA, USA). Total number of repeated CBCTs due to unacceptable bladder volume were recorded. The bladder volume at the time of treatment was measured at all fractions for 10 patients in the P group ( five control and 5 US) using the CBCT image. Doses to the bladder and PTV were also estimated for the first three fractions of all patients by overlaying the treatment plan and recalculating the dose on the CBCT.

Results: None of the patients in the US group had any repeated CBCTs while for the control patients repeated scans were needed for some fractions P: 2±1.87 scans, P+LN: 5.5±4.42 scans, and PB+LN: 2.5±2.32 scans. Deviations of bladder volume at the time of treatment from the simulation images across the P group were significantly less for the US group compared to the control group (8.5±12.3% vs. -12.4±25.1%, P = <0.001). Mean D35% to the bladder across all patients was lower for the US group (10.1±6.8 Gy vs. 12.5±6.1 Gy) although it was not statistically significant (P = 0.24)

Conclusion: The use of pre-treatment US can reduce the time on the treatment table, the number of CBCTs and subsequently, imaging dose. It can also result in a more consistent patient setup during treatment. The use of this imaging modality can be beneficial for patients treated for prostate cancer, and other patients treated at the clinic by freeing up Linac time, and the overall clinical workflow.

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## INTRODUCTION

Consistent bladder filling during prostate radiation therapy will improve the accuracy of treatment delivery [1]; however, maintaining the required bladder volume throughout the course or treatment is one of the most difficult aspects of prostate treatment for both the patient and clinicians.

Bladder volume fluctuates frequently, and with limited feedback options. Usually, only the patient's self-report is available prior to daily treatment.

While there have been reports on the use of ultrasound (US) for assessment of the bladder volume during prostate RT [2], to the best of our knowledge currently there is an absence of a comprehensive study with uniform treatment parameters and common treatment sites, to evaluate the benefits of utilizing a modern dedicated bladder US scanner for prostate RT, which was the initiative for this study.

The results of our work can lead to utilizing the pre-treatment US for all patients who need consistent bladder volume for treatment, which can reduce unnecessary CBCT imaging dose and time on the treatment table, and improve the overall clinical workflow.

## METHODS AND MATERIALS

Sixty patients treated with Volumetric Modulated Arc Therapy (VMAT) were retrospectively analyzed across three distinct cohorts (n=20 each):

- Prostate only (P) (70.2Gy/26 Fx)
- Prostate with Lymph Nodes (P+LN) (80Gy/40 Fx+6Gy boost)
- Prostate Bed with Lymph Nodes (PB+LN) (68Gy PTV/52.7 Gy LN/34 Fx).

Within each group, 10 patients received pre-treatment US evaluation using the BladderScan Prime Plus (Verathon Inc.)(Figure 1), while 10 served as the control group.

The primary endpoint was the frequency of repeated Cone Beam CT (CBCT) scans due to unacceptable bladder filling. For ten patients in the P group (five control + five US), bladder volumes were measured across all fractions via CBCT.

Dosimetric impact was assessed by overlaying treatment plans on CBCT images to recalculate doses to the bladder and PTV for the first three fractions of every patient.

**Figure 1.** The Verathon BladderScan(BS) Prime Plus Ultrasound scanner used in this study for the pre-treatment assessment of the bladder volume.

## RESULTS

In Figure 2, the histogram of the number of extra CBCTs that were taken for all 30 control patients in each of the three groups (P, P+LN, and PN+LN) are shown.
The P+LN control group showed substantially more frequent repeated CBCT scans (5.5±4.42) compared to the P (2±1.87) or the PB+LN (2.5±2.32 scans) control groups. None of the patients in the US group had any extra CBCT scans.

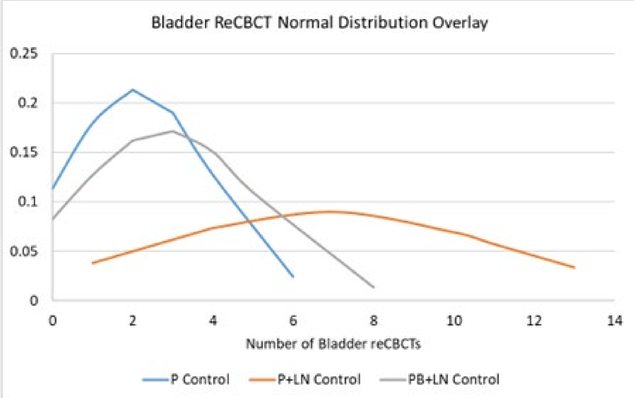


**Figure 2.** Histogram of the number of extra CBCTs required for maintaining consistent bladder volume for the control patients in the three patient groups. Patients treated for Prostate Bed and Lymph Nodes (P+LN) had the highest number of extra CBCTs.

Figure 3 depicts the relative change of the bladder volumes across all 34 fractions with respect to the volume at the time of simulation for ten individual patients in the P group (Five controls and five from the US cohort).
The combined bladder volume changes across all fractions and all five patients are also plotted in this figure.
Deviations of bladder volume at the time of treatment from the simulation images across the P group were significantly less for the US group compared to the control group (8.5±12.3% vs. -12.4±25.1%, P = <0.001).

Mean D35% to the bladder across all patients was lower for the US group (10.1±6.8 Gy vs. 12.5±6.1 Gy) although it was not statistically significant (P = 0.24)

Overall, the US cohort had more consistent bladder volumes which are slightly higher than the volume in the planning CT, which can also be seen in the group plots.

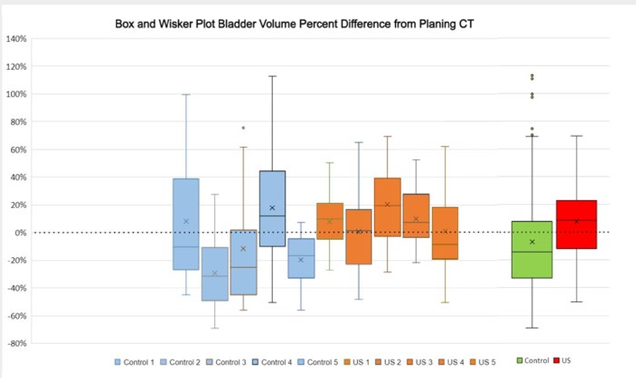


**Figure 3.** Percent change of bladder volumes based on the treatment CBCT images for ten patients (Prostate only) across all treatment fractions with respect to the bladder volume at simulation. (Blue: Control patients; Orange: US patients; Green: combined control cohort; Red: Combined US cohort.

## DISCUSSION

In this work, we studied the effects of using a pre-treatment bladder US scan for verification of the bladder volume prior to treatment of the prostate, prostate bed, and prostate bed and lymph nodes.

One major benefit of using the US scan is reducing the number of repeated CBCT verification images prior to the treatment of the patients. In our patient cohort, the number of the repeated scans was practically zero. In addition to reducing the imaging dose to the patients, this can also reduce the overall patient treatment time. Since the US scan is performed outside the treatment room, this can also reduce the time that the patient spends on the treatment couch which can lead to more efficient use of the machine time for treating other patients.

Also, as shown in the P group, the use of pre-treatment US scans can lead to more consistent bladder volumes throughout the course of treatment for these patients, compared to cases where the bladder volume verification was done only with the CBCT. Although the dosimetric benefit of using the US for bladder volume verification was not statistically significant, it still showed a reduction in the dose to the bladder. For the assessment of the change of the bladder volume across all fractions and its dosimetric impact, we only used a subset of the P group. As a continuation of this work, we will expand this study to include all subjects in all three groups. Also, as limitation of this study, we did not consider the effects of rectal volume which can be included in future studies.

## CONCLUSIONS

The use of pre-treatment US can reduce the time on the treatment table, the number of CBCTs and subsequently, imaging dose. It can also result in a more consistent patient setup during treatment. The use of this imaging modality can be beneficial for patients treated for prostate cancer, and other patients treated at the clinic by freeing up Linac time, and the overall clinical workflow.

## REFERENCES

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