Impact of Ultrasound-Guided Bladder Filling on Efficiency and Dosimetry in Adaptive SBRT for Gynecologic Cancers: An Analysis of HERA Trial Patients

Rachel Wolff, MS, CMD[1], Rojine Ariani, MD, MS[1], Dishane Luximon, PhD[1], John Charters, PhD[1], Puja Venkat, MD[1]

[1]Department of Radiation Oncology, University of California, Los Angeles, Los Angeles, CA, USA

Purpose

Daily anatomical variation in bladder volume creates significant dosimetric uncertainty and optimization complexity, often necessitating prolonged on-table re-optimization during pelvic adaptive radiotherapy. This study investigates whether standardized ultrasound-guided bladder filling protocols improve the quality-efficiency index of adjuvant adaptive SBRT (30 Gy in 5 fractions) for gynecologic cancers. We evaluated patients treated on the HERA trial (NCT06538337) across two sites within a single institution: one employing a standardized bladder-filling ultrasound (US) protocol prior to each treatment and one utilizing standard non-protocol filling.

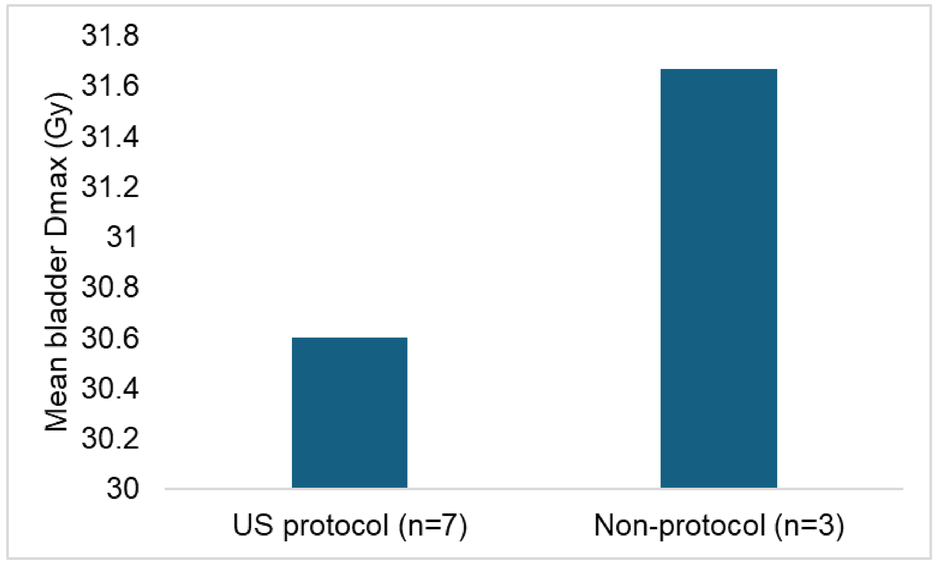

Figure 1 Mean bladder Dmax (Gy) for the ultrasound protocol and non-protocol cohorts.

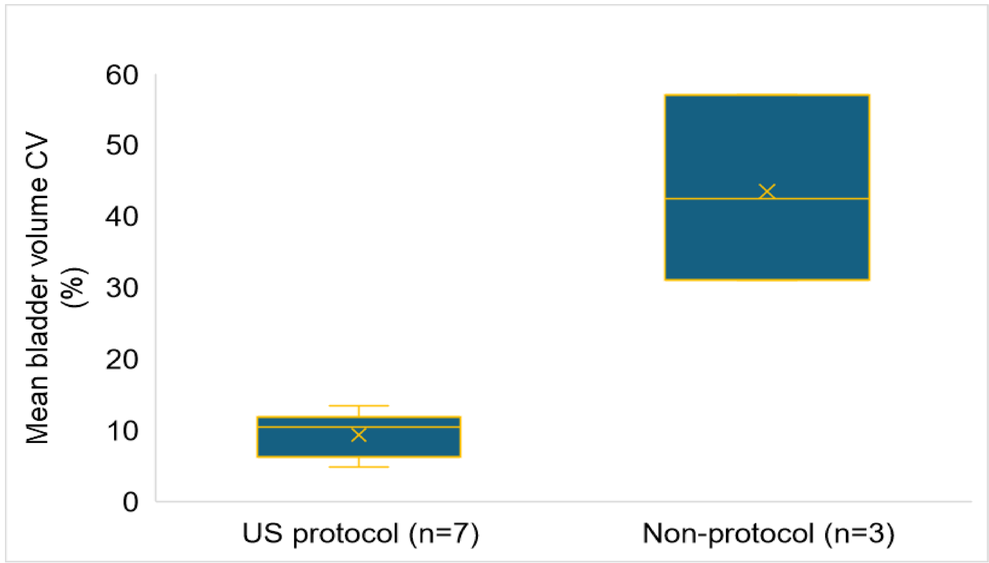

Figure 4 Comparison of mean bladder volume consistency for the ultrasound protocol and non-protocol cohorts, where boxes represent interquartile range, 'X' marks the mean, and horizontal lines indicate the median. *Abbreviations: CV = coefficient of variation.*

Materials/Methods

Dosimetric and operational data from patients (50 fractions) undergoing adaptive pelvic SBRT for gynecologic malignancies on the HERA trial were analyzed. Patients were cohort-stratified by treatment site: the US protocol site (n=7) and the non-protocol site (n=3). Key metrics included bladder volumetric consistency (coefficient of variation, CV), total on-table duration (including setup, image acquisition, adaptive planning, and treatment delivery), and bladder OAR sparing (Dmax and V30Gy, with goal Dmax≤32 Gy and V30Gy≤20%). Pearson correlation and linear regression analyses were performed to evaluate the relationship between bladder volumetric consistency and on-table duration.

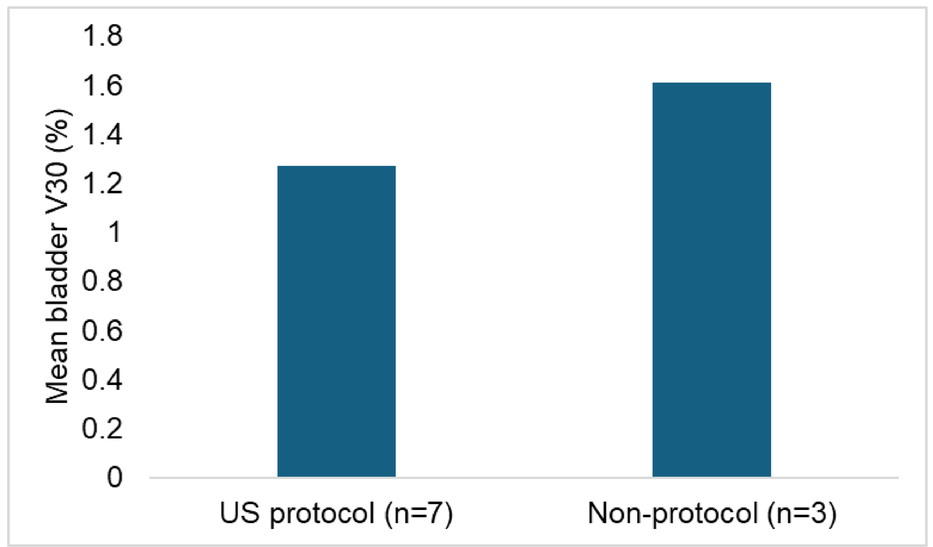

Figure 2 Mean bladder V30Gy (%) for the ultrasound protocol and non-protocol cohorts.

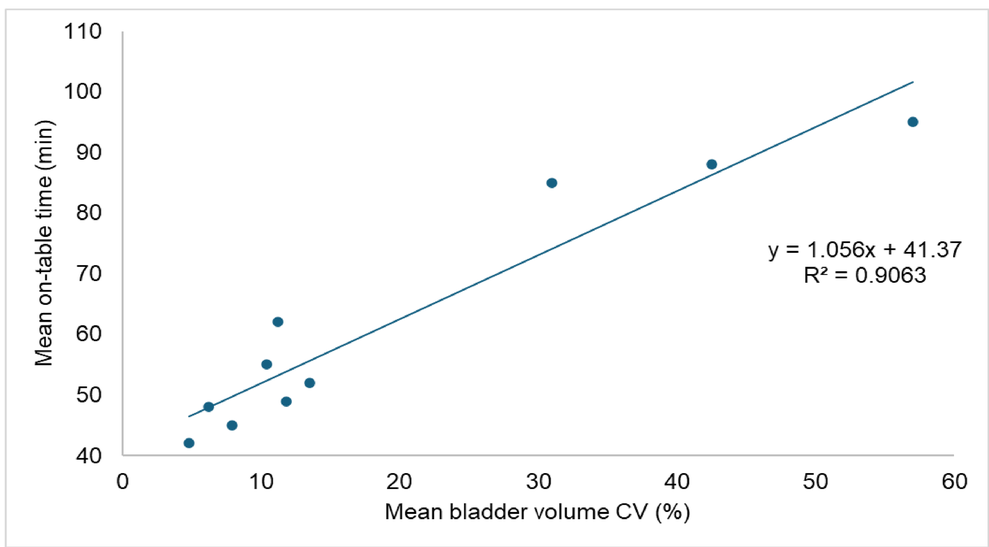

Figure 5 Correlation between mean bladder volumetric consistency and total patient on-table time (including setup, image acquisition, adaptive planning, and treatment delivery). *Abbreviations: CV = coefficient of variation.*

Results

The US protocol cohort demonstrated significantly higher bladder stability compared to the non-protocol cohort (CV 9.4% ± 3.2% vs 43.5% ± 13.0%, p=0.06). This site-specific bladder consistency translated into a reduction in mean on-table time (50.4 ± 6.7 vs 89.3 ± 5.1 minutes, p<0.001). A strong positive correlation was identified between bladder volume variability and treatment duration (r = 0.95, R2 = 0.906, p<0.001).

Dosimetrically, the US protocol cohort achieved a significantly lower mean bladder Dmax (30.60 ± 0.46 Gy vs. 31.67 ± 0.51 Gy, p<0.02). Mean bladder V30Gy was 1.27 ± 1.46% at the US-protocol site compared to 1.61 ± 0.25% at the non-protocol site (p=0.57). The non-protocol site required a 39 minute longer mean on-table duration (89 min vs 50 min, p<0.001) to achieve this sparing, while still incurring a 1.07 Gy higher Dmax than the US-protocol site.

Metric (mean ± SD)	Ultrasound protocol (n=7)	Non-protocol (n=3)	p-value
Bladder volume CV (%)	9.4 ± 3.2	43.5 ± 13	0.06
Treatment time (min)	50.4 ± 6.7	89.3 ± 5.1	<0.001
Bladder Dmax (Gy)	30.60 ± 0.46	31.67 ± 0.51	<0.02
Bladder V30 (%)	1.27 ± 1.46	1.61 ± 0.25	0.57

Table 1 Summary metrics for the ultrasound protocol and non-protocol cohorts. *Abbreviations: CV = coefficient of variation; SD = standard deviation.*

Conclusion

Within the HERA trial framework, increased bladder volumetric erraticism directly correlates to operational delays and imposes a significant "operational tax" on adaptive workflow for gynecological cancers. This inconsistency also negatively impacts patient experience by contributing to prolonged on-table time which could increase the risk of patient discomfort and intra-fraction motion. Consistent bladder volumes across fractions substantially reduces optimization complexity, allowing for higher dosimetric fidelity and may boost patient throughput. These findings suggest that the extended on-table times are a necessary compensation to reach baseline safety thresholds when bladder volume is variable across fractions, highlighting the utility of standardized bladder filling protocols for sustainable clinical implementation of adaptive SBRT in gynecological cancers.

Contact Information

Rachel Wolff, MS, CMD
rawolff@mednet.ucla.edu