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*abstract*

## **Ultrasound-Based Bladder Volume Monitoring in Pelvic Radiotherapy: A Path to Safer and More Efficient Treatment**

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*abstract*

## Ultrasound-Based Bladder Volume Monitoring in Pelvic Radiotherapy: A Path to Safer and More Efficient Treatment

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**Introduction:** Accurate pelvic radiotherapy depends on consistent bladder filling to ensure precise tumor targeting and minimize radiation exposure to surrounding organs. Variations in bladder volume can lead to target displacement, suboptimal dose distribution, and increased toxicity. The full bladder protocol is commonly used in external beam radiation therapy (EBRT) to improve treatment reproducibility and protect radiosensitive organs. Ultrasound assessment provides a non-invasive, real-time method to verify bladder volume before treatment, supporting protocol adherence, treatment accuracy, and patient safety.

This study investigates the impact of ultrasound (US)-guided bladder volume (BV) assessment on radiotherapy (RTH) planning and delivery for pelvic cancer patients. The goal was to evaluate whether US-based BV monitoring improves treatment reproducibility, reduces radiation exposure, and enhances patient comfort.

**Methodology:** Twenty-five patients undergoing radical pelvic RTH were randomly selected before

(pre-US) with a total of 548 fractions and after (post-US) with a total of 424 fractions for the introduction of US assessment for bladder filling between 2024 and 2025. Ages ranged from 30–85 years (pre-US: 30–72; post-US: 34–85). Patients were instructed to fill their bladder to 200–300 mL, verified by US before CT simulation. Real-time BV (rBV) was assessed via US before each session, with adjustments to maintain volumes within  $\pm 20\%$  of planning BV (pBV). For diabetic or urinary dysfunction patients, US enabled controlled filling to 100–150 mL. Data on the number of CT and CBCT scans, dose-length product (DLP)(CT and CBCT), and treatment time were collected and compared between groups.

**Results:** US-guided BV assessment reduced the number of CT scans (2 vs 1), CT DLP (1027 vs 485 mGy·cm), CBCT scans (2 vs 1), CBCT DLP (473 vs 299 mGy·cm), and treatment time (23.0 vs 16.2 min). Controlled filling in diabetic/urinary dysfunction patients prevented overdistension and improved reproducibility and comfort. Planning with bladder volumes above 300 mL was difficult to reproduce, with older patients (>70 years) more likely to present

with low bladder volumes. Maintaining pBV within 200–300 mL improved patient comfort and reproducibility.

**Conclusion:** US-based rBV assessment before CT and daily CBCT significantly improved bladder volume reproducibility, reduced radiation exposure, and enhanced patient experience. Implementing US-guided bladder scanning improves treatment quality by reducing irradiated bladder volume and patient waiting time.

**Conflict of interests:** The authors declare no conflict of interests.

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