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Comparing Dosimetric Outcomes of Static IMRT and VMAT in Accelerated Partial Breast Irradiation for Medially Located Tumor Beds

Introduction

Breast cancer is the most commonly diagnosed cancer in women worldwide. Advances in early detection have led to more early-stage diagnoses, increasing the demand for treatments that minimize side effects while maintaining disease control.

Accelerated Partial Breast Irradiation (APBI) targets only the tumor bed, reducing radiation exposure to healthy tissues compared to whole-breast irradiation. This makes it an attractive option for eligible patients.

Left-sided, medially located tumors pose a particular challenge due to their proximity to the heart and lungs. This study compares static Intensity-Modulated Radiation Therapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT) to evaluate target coverage and organ-at-risk sparing.

Methods

Patient Selection
Ten patients with left-sided, medially located breast tumors in the inner quadrant were retrospectively selected. All met standard eligibility criteria for Accelerated Partial Breast Irradiation (APBI).

Treatment Planning
Each patient had two treatment plans generated using the Pinnacle planning system: one with static IMRT and one with VMAT. All plans used identical contouring guidelines, target volume definitions, and dose constraints.

Dosimetric Evaluation
Dose-volume histogram (DVH) data were collected for the heart, lungs, LAD, right breast, and left breast-PTV volumes. Metrics included mean doses, volume-based thresholds (e.g., V3Gy, V6Gy), and PTV coverage (100%, 95%).

Statistical Analysis
A non-parametric sign test was used to compare paired IMRT and VMAT results for each patient across all metrics. This test evaluated the directionality of difference without assuming a normal distribution. Significance was defined as $p < 0.05$.

Results

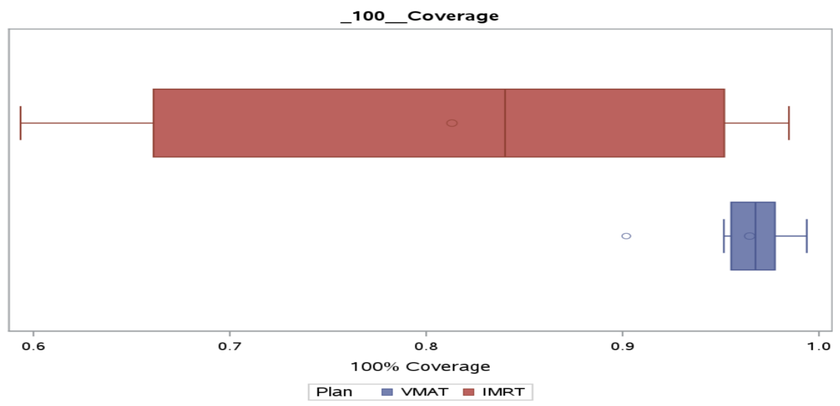

Fig. 1. Sign test comparison of 100% PTV Coverage – Static IMRT vs VMAT. VMAT provided significantly higher full-target coverage than IMRT ($p = 0.0215$) Box and whisker plot, boxes display lower 25% of data, mid 50% and upper 75% of data.

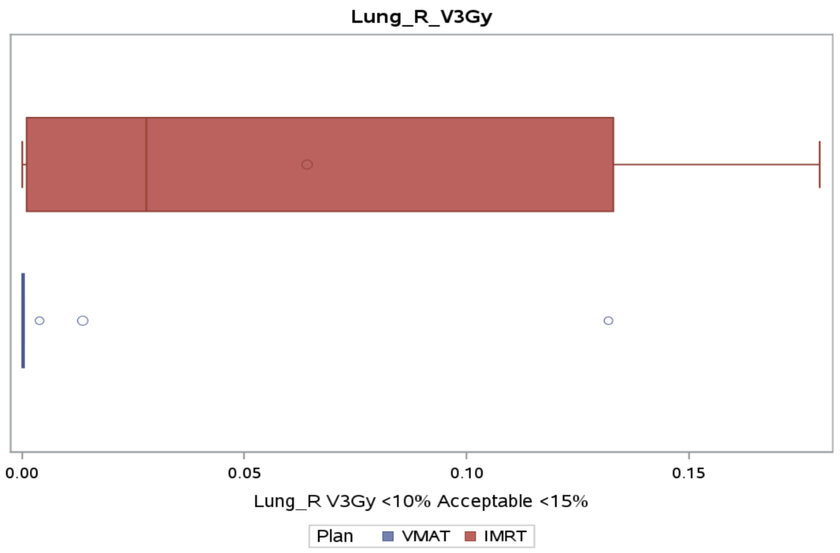

Fig. 2. Sign test comparison of Contralateral Lung V3Gy – Static IMRT vs VMAT. VMAT significantly lowered radiation to the right lung at the 3 Gy threshold ($p = 0.0391$) Box and whisker plot, boxes display lower 25% of data, mid 50% and upper 75% of data.

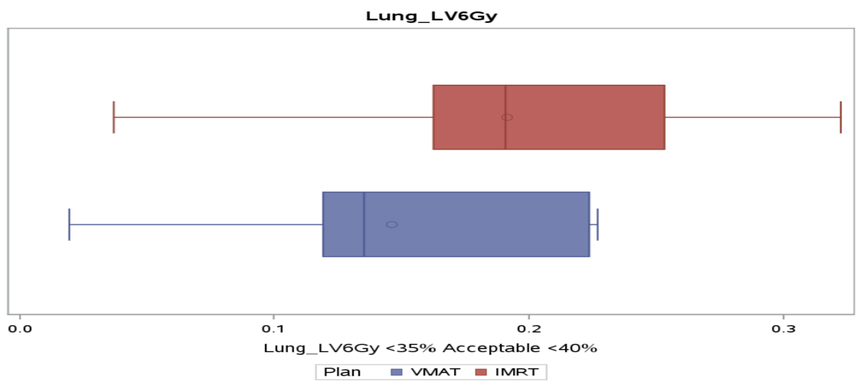

Fig. 3. Sign test comparison of Ipsilateral Lung V6Gy – Static IMRT vs VMAT. VMAT significantly reduced low-dose lung exposure compared to IMRT ($p = 0.0215$). Box and whisker plot, boxes display lower 25% of data, mid 50% and upper 75% of data.

Conclusion

The results of this study show that VMAT offers significant dosimetric advantages over static IMRT in APBI for medially located, left-sided breast tumors, particularly in improving 100% PTV coverage and reducing low-dose lung exposure.

VMAT significantly reduced ipsilateral lung V6Gy and contralateral lung V3Gy while also demonstrating a trend toward lower heart doses. These findings suggest that VMAT may be the preferred planning technique in these anatomically challenging cases, offering better organ-at-risk sparing without compromising target coverage.

Limitations

The primary limitation of this study is its small sample size of ten patients, which may limit the generalizability of the results. Additionally, the use of different treatment planners for plan creation could introduce variability in the results.

Only static IMRT and VMAT were compared, excluding other potential APBI techniques that may offer similar or better outcomes.

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