ionization chamber array system (2D array) was used for dose measurement. Measurement sampling time of the 2D array was set to 50 ms, and a sensitivity correction that depended on gantry angle was applied. The dose difference on the central coronal plane between SSVMAT delivery and the original VMAT delivery was analyzed. The dose at the isocenter was also compared using the center chamber of the 2D array. Pass rate was calculated from the dose difference with a criterion of 1% for a region that delivered a dose higher than 10% of the maximum dose.

Results: Mean differences in doses at the isocenter between VMAT and SSVMAT were not significant (0.5 $\pm$ 0.5% for 10 s interval, 0.2 $\pm$ 0.3% for 15 s interval, 0.2 $\pm$ 0.2% for 20 s interval, 0.0 $\pm$ 0.1% for 30 s interval, and 0.0 $\pm$ 0.1% for 40 s interval, $p > 0.05$). Pass rates based on dose difference were 85 $\pm$ 17% for 10 s interval, 99.9 $\pm$ 0.2% for 15 s interval, 100 $\pm$ 0% for 20 s interval, 100 $\pm$ 0% for 30 s interval, and 100 $\pm$ 0% for 40 s interval. SSVMAT with the breath-hold interval of 10 s had a significantly reduced pass rate ($p = 0.017$).

Conclusions: In the present study, a practical irradiation method that can be used to divide VMAT delivery into feasible breath-hold intervals was developed. Analysis of dose verification revealed that SSVMAT deliveries with intervals of 15 s or longer provided accurate doses.

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The Dosimetric Effect of Tumor Size and Position in Prone Radiation Therapy of Breast Using a Novel Stereotactic Breast Irradiation Device

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Purpose/Objective(s): A dedicated stereotactic breast radiation therapy unit was developed to treat small breast tumors. Numerous reports in the literature have identified a strong correlation between radiation toxicity and dose-volume levels for the breast, target volume and proximity to critical structures such as skin and chest wall. Demonstrating the dosimetric capabilities of this novel treatment technique, this study reports the dose-volume characteristics with respect to varying size of breast tumors, tumor locations and proximity to critical structures.

Materials/Methods: The device consists of a hemi-spherical, prone irradiation unit housing radioactive Cobalt sources, a 3D maneuverable patient positioning system and a vacuum-assisted breast cup immobilization device with built-in stereotactic fiducial markers. In this study, CT images of a prone breast phantom were acquired while mounted on the dedicated stereotactic immobilization device and subsequently registered in the device treatment planning system. 24 hypothetical target volumes were generated corresponding to lesions of 1, 2 and 3 cm in maximum diameter and positioned in eight different locations within the breast volume (center of the breast, multiple locations at the base of the breast cup as well as apical, lateral and superiorly at 0.5 cm to skin surface). Tumor volumes were expanded 3 mm for localization uncertainty to create final PTV (2.1-24.4 cm^3). Dosimetric evaluations include literature based whole breast indices associated with cosmetic outcome, skin (defined as 0.5 cm strip) and plan quality indices such as dose homogeneity and conformity.

Results: Maximum dose in all plans were less than 120% of the prescription dose (107-120%) and was realized within the target volume (prescription dose was normalized to cover 95% of the PTV). Median dose homogeneity indices were less than 10% for all plans. Tumor proximity to skin was observed to correlate with larger dose variations across the target volume ($p < 0.01$). Dose conformity indices ranged from 1.7 to 3.3, 1.0 to 1.3, and 1.1 to 1.4 for 1-, 2- and 3-cm tumors respectively. Median volume of breast receiving 50% of the prescription dose (V50) was 7.8% (2.2-18.0%) whereas median V20 was 18.6% (6.1-40.0%). Maximum skin dose ranged between 71 to 102% when targets were located within 0.5 cm of the skin surface. In other cases, where the target was away from the skin (> 0.5 cm), skin dose was 9.0 to 71.0%.

Conclusions: In efforts to reduce tissue toxicity and promote better cosmesis in patients treated for early stage breast cancer, this study demonstrates the dosimetric ability of the device to deliver highly conformal and homogenous doses in a range of tumor sizes and locations.

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Advances in Whole Abdominal Irradiation: What Protons, VMAT, and IMRT Using Multicriteria Optimization Can Offer

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Purpose/Objective(s): The most commonly used technique for whole abdomen irradiation is an antero-posterior/postero-anterior (AP/PA) beam arrangement with liver and kidney blocking. Limitations include bone marrow toxicity which may impair or delay treatment, and underdosage to portions of the target volume (peritoneal cavity) due to liver and kidney shielding. The first aim of this study was to evaluate the potential of intensity-modulated radiation therapy (IMRT) and proton pencil-beam scanning (PBS) using multicriteria optimization (MCO) as well as volumetric modulated arc therapy (VMAT) to improve target coverage and sparing of organs at risk (OARs) compared to conventional AP/PA technique. The second aim was to discuss feasibility and availability of IMRT, VMAT and PBS in this indication.

Materials/Methods: IMRT, VMAT, PBS and new AP/PA plans were generated based on treatment planning CT scans of 10 patients previously treated with AP/PA technique. MCO was used for IMRT and PBS but was not available for VMAT. The planning target volume (PTV) included the entire peritoneal cavity, the liver capsule and the pelvic and para-aortic node regions. OARs were kidneys, liver, heart and bones. A total dose of 30 Gy was prescribed to the PTV in 20 fractions. Dose constraints were the same for all 4 treatment techniques and if all constraints could not be met, priority was given to the OARs over the target coverage. D95% (PTV) and equivalent uniform doses (EUDs) were analyzed. Paired t-tests were used for statistical comparison.

Results: All 4 techniques met the constraints for OARs whereas only IMRT and PBS plans met the constraints for target coverage. In terms of coverage, IMRT, PBS and VMAT plans were all significantly superior to AP/PA plans with average D95% of 29.1 Gy, 28.6 Gy, 25.1 Gy and 15.0 Gy, respectively. IMRT, VMAT and PBS achieved significantly better sparing of liver, heart and bones over AP/PA. The largest absolute dose difference was seen for bones, with average EUDs of 22.6 Gy for AP/PA versus 18.7 Gy (IMRT), 13.9 Gy (PBS) and 15.5 Gy (VMAT). Overall, PBS generated the best plans followed by IMRT and VMAT. Estimated average daily treatment time (beam on time only) was 5 min (AP/PA), 15 min (VMAT and PBS) and 40 min for IMRT, respectively.

Conclusions: IMRT, VMAT and PBS plans were all clearly superior to AP/PA plans in terms of both target volume coverage and sparing of OARs, especially bones. Overall, PBS generated the best plan quality, but given the high costs, it is unclear if the dosimetric advantages are enough to justify its use for this indication. IMRT or VMAT should be offered to GYN patient population instead of AP/PA, VMAT being a good