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Bilateral implant reconstruction does not affect the quality of postmastectomy radiation therapy

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ABSTRACT

To determine if the presence of bilateral implants, in addition to other anatomic and treatment-related variables, affects coverage of the target volume and dose to the heart and lung in patients receiving postmastectomy radiation therapy (PMRT). A total of 197 consecutive women with breast cancer underwent mastectomy and immediate tissue expander (TE) placement, with or without exchange for a permanent implant (PI) before radiation therapy at our center. PMRT was delivered with 2 tangential beams + supraclavicular lymph node field (50 Gy). Patients were grouped by implant number: 51% unilateral (100) and 49% bilateral (97). The planning target volume (PTV) (defined as implant + chest wall + nodes), heart, and ipsilateral lung were contoured and the following parameters were abstracted from dose-volume histogram (DVH) data: PTV $D_{95\%} > 98\%$, Lung $V_{20}Gy > 30\%$, and Heart $V_{25}Gy > 5\%$. Univariate (UVA) and multivariate analyses (MVA) were performed to determine the association of variables with these parameters. The 2 groups were well balanced for implant type and volume, internal mammary node (IMN) treatment, and laterality. In the entire cohort, 90% had PTV $D_{95\%} > 98\%$, indicating excellent coverage of the chest wall. Of the patients, 27% had high lung doses ($V_{20}Gy > 30\%$) and 16% had high heart doses ($V_{25}Gy > 5\%$). No significant factors were associated with suboptimal PTV coverage. On MVA, IMN treatment was found to be highly associated with high lung and heart doses (both $p < 0.0001$), but implant number was not ($p = 0.54$). In patients with bilateral implants, IMN treatment was the only predictor of dose to the contralateral implant ($p = 0.001$). In conclusion, bilateral implants do not compromise coverage of the target volume or increase lung and heart dose in patients receiving PMRT. The most important predictor of high lung and heart doses in patients with implant-based reconstruction, whether unilateral or bilateral, is treatment of the IMNs. Refinement of radiation techniques in reconstructed patients who require comprehensive nodal irradiation is warranted.

Introduction

Maximizing survival and quality of life are complementary goals in the treatment of breast cancer. Postmastectomy radiation therapy (PMRT) and breast reconstruction are 2 modalities used to achieve these goals. By providing local control, PMRT improves disease-free survival in node-positive breast cancer.[1] Breast reconstruction enhances cosmesis and contributes significantly to patients' quality of life.[2] Opinions regarding the optimal integration of these modalities vary. Some have suggested that immediate reconstruction hinders radiation treatment planning, whereas others disagree.[3–5] Despite the ongoing controversy, immediate reconstruction with a 2-stage tissue expander (TE)/permanent implant (PI) continues to be a popular option chosen by many patients.

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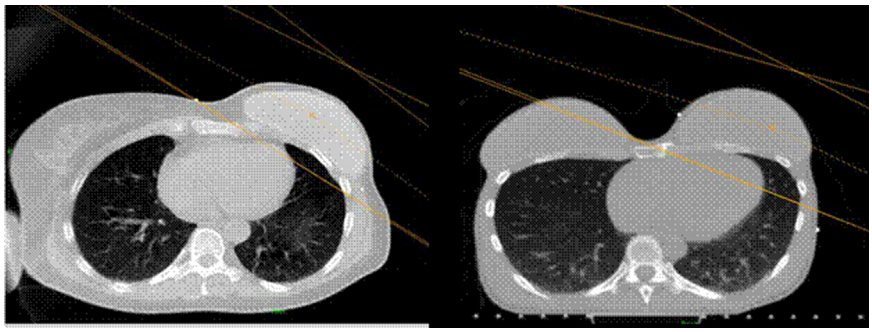

Fig. 1. Tangential beams in example patients with (A) unilateral and (B) bilateral implants. (Color version of figure is available online.)

Over recent years, our department has treated a high volume of patients with bilateral implant reconstructions. Subsequently, the question of whether the presence of bilateral implants hinders radiation treatment planning in these patients has been raised. Precise geometric placement of the tangent beams is particularly critical to minimize dose to normal organs and the contralateral side without compromising the ipsilateral target volume coverage (Fig. 1).

Our objectives were to quantify the effect of implant number (unilateral *vs* bilateral) and other implant and treatment factors on target volume coverage, and heart and lung dose in patients with breast cancer who underwent immediate reconstruction and PMRT. In addition, the dose delivered to the contralateral implant was quantified in patients with bilateral implants.

Methods and Materials

The study design was approved by the institutional review board at Memorial Sloan-Kettering (MSKCC).

Patients

From 2004 to 2009, 974 patients with Stage II–III breast cancer underwent mastectomy and immediate TE placement at our institution. Of these, 307 received PMRT in our department. After excluding patients with a history of chest wall irradiation (5), receipt of nonstandard PMRT techniques (30), removal of the implant before PMRT (15), and inaccessible treatment plans (60), 197 patients constituted the study cohort.

One hundred patients had unilateral and 97 bilateral breast prostheses (TEs or PIs). Of the 197 patients, 159 (80.7%) underwent exchange of the TE for PI(s) before PMRT according to an institutional algorithm[6]; whereas 38 (19.3%) patients underwent irradiation of the TE and had the exchange for a PI performed after PMRT. Of the 38 patients, 12 had unilateral TEs and 26 had bilateral TEs. All TEs were filled to the maximum planned volume before radiation therapy. Among the 159 patients who received PMRT to the PI, 80 had unilateral and 79 had bilateral implants.

Target delineation

Delineation of the target structures are shown in Fig. 2. The ipsilateral lung was defined using the automated tracking gradient contour function for lung parenchyma in the MSKCC Top Module Treatment Planning System. The heart was defined as the cardiac silhouette starting inferior to the aortic arch and extending down to the inferior left ventricle. The contralateral implant was defined as the contralateral prosthesis and overlying skin.

The planning target volume (PTV_{CW}) consisted of the chest wall, implant, overlying skin, level I–II axillary lymph nodes, and internal mammary nodes (IMNs) when applicable. The supraclavicular lymph nodes and level III nodes were not included in the PTV, as they were encompassed by a separate anterior oblique beam and would be unaffected by implant number. A uniform 3-mm margin to account for respiratory motion and setup error was included within the PTV. The chest wall and axillary lymph nodes were contoured using consensus guidelines.[7] IMNs were treated as per individual physician's discretion. When targeted, the IMNs were contoured within the first 4 intercostal spaces. In these cases, the chest wall and nodal target was termed PTV_{CW+IMN}. The dosimetric effects of supraclavicular fields were included in the dose-volume histograms (DVH).

Radiation treatment

All patients received ipsilateral PMRT to a total dose of 50 to 50.4 Gy delivered in 25 to 28 fractions. A 0.5- or 1.0-cm bolus over the chest wall was used on a daily basis. No patients received a chest wall boost.

Radiation treatment was delivered using 2 tangential photon beams covering the chest wall, the implant and lower axillary nodes were matched to an anterior oblique field encompassing the supraclavicular fossa. The tangential fields were either planned with wedges (6%) or simplified intensity-modulated radiation therapy (94%) technique.[8] Treatment planning was performed using the MSKCC treatment planning system,[9–13] which has been previously described. Tissue inhomogeneity corrections were applied to all dose calculations. 6 or 15-MV photons were utilized, depending on the medial-lateral separation of the patient. Patients with TEs received 15-MV photons to minimize attenuation from the metal port.[14] When the IMNs were targeted, either wide tangential photons or anterior oblique electron fields matched to shallow tangents were used. Treatment plans were selected by the treating physician based on the optimal combination of coverage and avoidance of excessive dose to normal tissue as seen on planning CT scans or DVHs or both. There were no formal dosimetric guidelines.

Dosimetric data

DVH data were generated for each patient. The volume of ipsilateral lung receiving $\leq$ 20 Gy (Lung V_{20}) and the percentage of the prescription dose delivered to $\geq$ 95% of the PTV ($PTV_{CW}D_{95}$ or $PTV_{CW+IMN}D_{95}$) was analyzed in all patients. In bilateral implant patients, the D_{max} and its location within the contralateral implant volume was identified on the treatment plan.

Statistical analysis

Differences in clinical, anatomic, and dosimetric characteristics between groups were assessed using the Pearson χ^2 test, Fisher exact test, or t-test. Univariate analysis (UVA) was performed to test the association of variables on each of the dosimetric end points. Multivariate analysis (MVA) was performed on the main variable of interest, implant number (unilateral *vs* bilateral), in addition to any other variables that were significant ($p < 0.05$) on UVA.

Structure	Dosimetric Endpoint
PTV_{CW} $PTV_{CW+IMN*}$	D95
Ipsilateral Lung	V20
Heart	V25
Contralateral Implant	Dmax

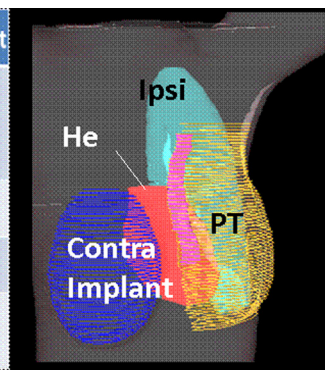

Fig. 2. Contoured structures and their respective dosimetric end points. (Color version of figure is available online.)