

(Continued)

Nurses specialized in RO (n = 67)		Nurses in oncology, not specialized in RO (n = 288)		Responsibilities (for RO patients)
n	%	n	%	
38	56.7%	125	43.4%	Completing a history and physical
0	0%	24	8.3%	None of the above

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## 2967

### Variability and Factors Impact Irradiation Area of Regional Lymph Node in Low-Burden Breast Cancer Patients after Omitting Axillary Dissection: Experience from a High-Volume Center

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**Purpose/Objective(s):** Sentinel lymph node biopsy (SLNB) has been the standard treatment procedure for clinically node-negative (cN0) breast cancer (BC). Three randomize trials (Z0011, AMAROS and SENOMAC) have confirmed that patients with low-burden sentinel lymph node metastasis can be safely omitted axillary lymph node dissection who receive adjuvant radiotherapy. However, these published research papers have been insufficient to accurately assess the recurrence risk in this patient population, leading to variability in adjuvant radiotherapy volume across different studies. Therefore, the optimal adjuvant regional nodal irradiation (RNI) volume for early-stage BC with low-burden sentinel lymph node metastasis remains undetermined. Therefore, we performed present study to analyze and explore the factors that influence the decision of regional nodal irradiation in this patient population.

**Materials/Methods:** A retrospective single-institution review was performed in breast cancer patients eligible for enrollment from 2018 to 2024. Univariate and multivariate logistic regression analysis were used to analyze the clinicopathological factors influencing different radiotherapy decisions.

**Results:** Among 215 eligible patients, 190 (88.4%) received regional lymph node radiation: 83.7% to the clavicle, 66.5% to the internal mammary region, and 80% to the axillary region. Univariate analysis linked SLN positivity (>1), adjuvant chemotherapy, histologic grade III, and Ki-67 ≥14% to clavicle irradiation. Multivariate analysis identified SLN >1 (p=0.018) and histologic grade (p=0.042) as independent predictors. For axillary irradiation, Ki-67 ≥14% was the sole risk factor (ORadj 2.26, 95%CI: 1.00-5.13, p=0.05). Univariate analysis suggested tumor size, SLN positivity, adjuvant chemotherapy, PR status, triple-negative status, histologic grade, and Ki-67 as potential risks for internal mammary irradiation, but multivariate analysis found no independent predictors.

**Conclusion:** For early-stage BC with low-burden sentinel lymph node metastasis, the number of positive sentinel lymph nodes and histological grade were two important factors for radiation oncologists to decide the irradiation of clavicle lymph node region, while ki-67 index was the only risk factor for receiving axillary lymph node area irradiation. No significant factors could be found associated with inner mammary node irradiation, suggesting whether inner mammary node irradiation remained

controversial among this patients population, and further studies are clearly suggested to investigate this issue.

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## 2968

### Practice Patterns of Boost Administration after Whole Breast Irradiation in Early-Stage Invasive Breast Cancer and DCIS across a Statewide Quality Consortium

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**Purpose/Objective(s):** Tumor bed boost improves local control following whole breast radiotherapy (WBRT) for women with early-stage invasive cancer or ductal carcinoma in situ (DCIS) with high-risk features. Despite evidence-based indications for boost administration, there is significant practice variability. We sought to analyze practice patterns of boost dose administration across academic and community practices in the treatment of early-stage invasive cancer and DCIS to identify factors associated with boost utilization.

**Materials/Methods:** This analysis includes women who underwent WBRT with or without surgical bed boost for early-stage invasive cancer or DCIS, prospectively enrolled from August 2017 to June 2023 at 29 radiation oncology centers in a state-wide quality consortium. Of 11,176 patients evaluated, 10,550 had complete data available for inclusion in the analysis. Invasive cancer and DCIS were evaluated separately. Bivariable and multivariable associations between boost administration and patient/disease characteristics were evaluated. For comparison of boost rates with TROG 0701 publication, we limited inclusion to cases beginning RT two years before publication (9/1/20 – 8/31/22) to one year after publication (9/1/2022 – 7/1/2023).

**Results:** Of women with invasive breast cancer, 75.5% received a boost, while 66.9% of women with DCIS received a boost. The use of the boost varied widely across institutions, from 45.2% to 98.5% for invasive cancer and from 37.9% to 100% for DCIS. For patients with early-stage invasive cancer, younger age, black race, high tumor grade, close or positive surgical margins, negative hormonal receptor status, presence of nodal disease, chemotherapy administration, and treatment at an academic center were all associated with increased use of radiotherapy boost (p < 0.001 for all). The area under the curve (AUC) is 0.84. For patients with DCIS, younger age, higher tumor grade, close or positive margins, and treatment at an academic center were significantly associated with increased use of radiotherapy boost (p < 0.001). Race was also a significant factor associated with use of boost, with black patients more likely to receive a boost than other races with p = 0.0235. Hormone receptor status was not significantly associated with boost administration (p = 0.0757). The AUC is 0.79. Boost use increased from 63.9% before TROG 0701 publication to 70.9% after publication (p = 0.032).

**Conclusion:** Across a statewide quality consortium, patient and tumor factors corresponding to higher risk of tumor recurrence were associated with increased boost utilization. Race and treatment at academic institutions also had significant associations with boost use, highlighting the need for further investigation into practice pattern variability.

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## 2969

### Biological Difference of Proton and Photon Radiotherapy in Breast Cancer

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**Purpose/Objective(s):** Despite proton therapy has theoretical dosimetric advantages in breast cancer treatment, its radiobiological differentiation from photon therapy remains mechanistically undefined. This study employs a multi-omics approach to systematically compare DNA damage patterns and subsequent alterations at the transcriptional, proteomic, and metabolic levels between different radiation modalities in a murine orthotopic breast cancer models.

**Materials/Methods:** Optimal irradiation dose was determined both photon and proton irradiation in the MDA-MB-231 cell line using comet assays and DNA damage and repair markers ( $\gamma$ -H2AX, p-p53). Subsequently, the effects of proton irradiation versus photon irradiation on tumor progression were evaluated by tumor volume and survival time of 4T1 murine orthotopic breast cancer models. Finally, transcriptomic, proteomic, metabolomic, and phosphorylated proteomic alterations were analyzed 72 hours post-irradiation.

**Results:** Multi-omics analysis identified 2613 unique genes, 1458 proteins, 5104 phosphorylated peptides, and 325 metabolites specific to proton therapy, as well as 2967 unique genes, 779 proteins, 3837 phosphorylated peptides, and 140 metabolites specific to photon therapy. Enrichment analysis indicated that the "Calcium signaling pathway" was the most prominently upregulated pathway in the transcriptomic after photon irradiation, and this pathway was also associated with the proteomic and phosphoproteomic findings. In the photon irradiation group, both transcriptomic and proteomic profiles were enriched for in the "Drug metabolism - cytochrome P450" pathway. Notably, the "Central carbon metabolism in cancer" pathway was upregulated in the metabolism of proton, whereas it was downregulated in the metabolism of photon and phosphorylated proteomics.

**Conclusion:** Multi-omics results demonstrate that proton and photon radiotherapy exert unique biological effects in the treatment of breast cancer, and pathways associated with carbon metabolism may play a critical role in driving the different effect between proton and photon irradiation. These findings offer valuable insights for further research into identifying key targets in breast cancer proton radiotherapy, potentially guiding the development of more precise and effective radiotherapy strategies.

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## 2970

### Impact of Aerobic Exercise on Positioning Accuracy Guided by AccuTrack in Postoperative Breast Cancer Patients Undergoing Radiotherapy

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**Purpose/Objective(s):** Aerobic exercise may indirectly improve radiotherapy positioning accuracy by enhancing posture, muscle strength, and respiratory control. However, direct evidence is lacking. This study aims to investigate the impact of aerobic exercise on positioning accuracy using AccuTrack in postoperative breast cancer patients undergoing radiotherapy, providing insights for optimizing precision and rehabilitation strategies.

**Materials/Methods:** A randomized controlled trial enrolled breast cancer patients receiving IMRT on precision radiation medicine company devices from October 2024 to February 2025. Patients were randomized into Group A (routine care + customized aerobic exercise) and Group B (routine care only). Group A performed low-intensity aerobic exercises (e.g., brisk walking, rope skipping, cycling) three times weekly (30 minutes per session) starting 3 weeks post-surgery until radiotherapy completion, while Group B received only routine daily care without mandatory exercise. During treatment, patients' positioning was guided using China's domestically developed optical surface AccuTrack system, with weekly kilovoltage cone-beam computed tomography (CBCT) for spatial verification. Setup errors were measured in six directions (translational: X, Y, Z; rotational: Roll, Pitch, Rtn). Ipsilateral limb lymphedema was monitored, and patients' physical and mental states were assessed using the fatigue scale (Borg CR10) and anxiety scale (GAD-7). Assessments were conducted at the start of treatment, mid-treatment, and the final treatment session.

**Results:** Thirty patients (median age: 48 [32–65]; breast-conserving surgery: 12; radical mastectomy: 18; right-sided: 14; left-sided: 16) were included. Setup errors in Group A vs. Group B: X-axis (1.31±0.95 vs. 1.98±1.56 mm, P=0.002); Y-axis (1.61±1.24 vs. 2.24±1.36 mm, P=0.004); Z-axis (1.41±0.97 vs. 1.85±1.41 mm, P=0.026). No significant differences were observed in rotational errors: Roll (0.65±0.52° vs. 0.81±0.72°, P=0.161); Pitch (0.81±0.68° vs. 0.70±0.59°, P=0.338); Rtn (0.56±0.49° vs. 0.58±0.51°, P=0.71). Group A had significant improvements in fatigue (mean difference: 4.9 [95% CI: 2.3–7.5]) and anxiety (mean difference: 3.2 [95% CI: 1.1–5.3]) compared to Group B. Lymphedema incidence was similar (5% vs. 7.5%, P=0.65).

**Conclusion:** This prospective study is the first to demonstrate that aerobic exercise can effectively improve three-dimensional positioning accuracy in radiotherapy, alleviate fatigue, and reduce the incidence of anxiety. Due to the limited sample size, further validation with larger-scale studies is required.

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## 2971

### Survival Determinants and Toxicity of Second-Course Radiotherapy for Isolated Nodal Recurrence in Breast Cancer

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**Purpose/Objective(s):** Isolated nodal recurrence (INR) after localized breast cancer are rare, with an incidence of less than 1%. Curative management typically includes surgical resection, often with axillary lymph node dissection (ALND), followed by regional nodal radiotherapy. However, evidence-based guidelines remain limited due to the rarity of this clinical scenario. The aim of this study was to evaluate the survival determinants and the acute and long-term toxicities associated with second-course regional nodal irradiation as part of curative strategies for INR after localized breast cancer.

**Materials/Methods:** This retrospective study included 11 patients with localized breast cancer who developed ipsilateral, non-metastatic INR between 2003 and 2019. All patients were treated with curative intent, including regional nodal irradiation. Overall survival (OS), cancer-specific survival (CSS), metastasis-free survival (MFS), local control, and treatment toxicities were analyzed. Survival probabilities were calculated using the