Section: Miscellaneous

Original Research Article

DEEP INSPIRATION BREATH HOLD (DIBH) IN LEFT-SIDED BREAST CANCER RADIOTHERAPY: DOSIMETRIC AND CLINICAL OUTCOMES

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ABSTRACT

Background: Radiotherapy for left-sided breast cancer increases the risk of unintended cardiac irradiation, especially of the left anterior descending (LAD) artery, which can contribute to late ischemic heart disease. Deep Inspiration Breath Hold (DIBH) is a technique that increases thoracic volume, separating the heart from the chest wall during treatment and thereby reducing the cardiac dose compared to Free Breathing (FB). The objective is to quantify and compare the dosimetric differences between DIBH and FB during postoperative radiotherapy for left-sided breast cancer, focusing on the dose received by the heart, LAD, lungs, and planning target coverage. **Materials and Methods:** This prospective study included 40 women with early to locally advanced left-sided breast cancer who underwent CT simulation in both DIBH and FB positions. Organs-at-risk (OARs) and planning target volumes (PTVs) were contoured according to RTOG guidelines. The prescribed radiotherapy doses were 40.05Gy/15 fractions or 50Gy/25 fractions. Dosimetric parameters analysed included mean dose, maximal dose, and volume percentages for the heart, LAD, ipsilateral lung, and contralateral breast. Paired t-tests were used to assess statistical significance ($p<0.05$). **Result:** DIBH significantly reduced the mean heart dose (4.2Gy vs. 6.4Gy; $p<0.001$), LAD mean dose (12.1Gy vs. 16.9Gy; $p=0.010$), and heart V20% and V25%. Mean dose to the ipsilateral lung was also lower with DIBH (11.4Gy vs. 13.1Gy; $p=0.005$). Planning target volume (PTV) coverage (V90%) was improved with DIBH (93.5% vs. 91.6%; $p=0.027$). No statistically significant difference was found in contralateral breast dose. **Conclusion:** DIBH provides substantial sparing of cardiac and pulmonary structures without compromising target volume coverage in left-sided breast cancer radiotherapy. Its routine adoption may reduce the long-term risk of radiation-induced cardiac morbidity and improve survivorship.

INTRODUCTION

Breast cancer remains one of the most common malignancies among women worldwide, with an estimated global incidence of over 2.2 million new cases annually. Advances in early detection, surgery, and systemic therapies have improved outcomes, but radiotherapy is pivotal for locoregional control, especially in left-sided breast cancer.

Epidemiology and Risk

Left-sided breast radiotherapy poses unique challenges due to proximity of the heart—especially the LAD artery—to the radiation field. Long-term studies have established a link between cardiac radiation exposure and the risk of ischemic heart disease and morbidity.[1]

Cardiac Injury: Mechanisms and Clinical Implications

Radiation-induced heart disease (RIHD) spans coronary artery disease, pericarditis, valvular dysfunction, and heart failure. The risk increases with mean heart dose and is aggravated by adjuvant therapies and comorbidities. The LAD is particularly susceptible.

Historical Approaches and Evolution of DIBH

Strategies for cardiac sparing include prone positioning, partial breast irradiation, and technical advancements. DIBH is widely adopted. Deep inspiration expands thoracic volume, shifting the heart further from irradiated regions. Multiple studies underscore substantial reductions in heart and LAD dose.

Rationale and Objectives: Despite strong evidence DIBH adoption is inconsistent globally due to resource and logistical constraints.[2-9]

This study aims to:

- Quantitatively compare DIBH and FB for heart, LAD, lung, and target dosimetry.
- Evaluate target coverage.
- Assess workflow feasibility and recommend clinical protocols.

MATERIALS AND METHODS

Study Design and Ethics: Prospective, single-institution study with institutional review board approval. Written informed consent was obtained. Adherence to ICMJE and COPE guidelines.

Patient Population: Forty women (<70 years; mean 47.7) with left-sided invasive ductal carcinoma, from Jan 2022 to Apr 2024. Surgery included mastectomy or breast-conserving procedures. All required postoperative radiotherapy.

Inclusion Criteria

- KPS ≥80
- No prior chest irradiation
- Reliable DIBH performance

Exclusion Criteria

- COPD/asthma
- BMI >40
- Chest deformity
- Inability to comply with DIBH

Simulation and Coaching: Standardized physiotherapy and coaching (using systems like Varian RPM). Immobilization on breast boards with both arms up. FB and DIBH CT scans acquired.

Contouring and Planning

Organs-at-risk and targets contoured (RTOG and Duane et al. Atlas). Prescribed doses: 40.05Gy/15 or 50Gy/25 fractions. QUANTEC dose constraints used.

Plans generated in Eclipse or Monaco, normalized for PTV V90% >90%. Daily image guidance as indicated.

Dosimetric Endpoints

- Heart: mean dose, V20%, V25%, Dmax
- LAD: mean dose, V20%, Dmax
- Lungs: mean dose, V20%, Dmax, volume
- Contralateral breast: mean dose, V5%, V10%
- PTV: V90%, V95%

Statistical Analysis

Normality tested. Paired t-tests compared dosimetric data between DIBH and FB, $p<0.05$ significant. Subgroup analyses per surgical type.

RESULTS

Patient Characteristics

- Mean age: 47.7±9.2
- 42.5% Stage IIA; majority ER+ (67.5%)
- Surgery: 42.5% mastectomy, 27.5% BCS, rest axillary procedures
- Radiotherapy: 60% hypo fractionated

Dosimetric Comparison

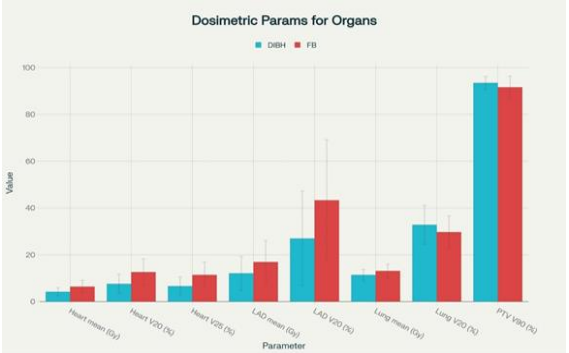
Table 1: Dosimetric parameters for heart, LAD, ipsilateral lung, and PTV

Parameter	DIBH	FB	p-value
Heart mean (Gy)	4.2±1.8	6.4±2.7	<0.001
Heart V20 (%)	7.6±4.1	12.6±5.6	<0.001
Heart V25 (%)	6.6±3.9	11.4±5.5	<0.001
LAD mean (Gy)	12.1±7.2	16.9±9.1	0.010
LAD V20 (%)	27.0±20.2	43.3±25.9	0.002
Lung mean (Gy)	11.4±2.3	13.1±2.9	0.005
Lung V20 (%)	32.8±8.3	29.7± 6.9	0.685
PTV V90 (%)	93.5±2.7	91.6±4.7	0.027

No significant difference in contralateral breast dose.

Subgroup and Toxicity Analysis

No significant heart/LAD dose differences by surgery type; lung dose varied with target volume. Acute toxicity similar across groups; no grade ≥2 cardiac toxicity.



DISCUSSION

Interpretation of Findings: DIBH results in significant mean heart and LAD dose reductions. Population studies correlate each 1Gy increase in heart dose with major cardiac event risk. LAD dose reduction is especially relevant.

Lung dose reduction matches published reports.

Mechanisms and Technical Implications

DIBH expands lung and shifts heart inferior/posterior, sparing OARs. Real-time monitoring enhances reproducibility 7–9.

Literature Comparison

Meta-analyses report 1.5-3Gy heart dose reduction. LAD sparing is consistent with Loap et al. Target coverage is unaltered.

Feasibility: Compliance in the study mirrors other cohorts. Real-world adoption depends on coaching/equipment.

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Limitations

Sample size, short follow-up, and exclusion of certain patients limits generalizability.

Recommendations

DIBH should be standard for left-sided breast/chest wall radiotherapy. Training and protocolization needed for best uptake.

CONCLUSION

DIBH is safe, feasible, and effective for cardiac sparing in left-sided breast cancer radiotherapy.[2,4,7–9] It does not compromise target coverage or increase risks to other organs.

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