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Original Research Paper

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DOSIMETRIC ANALYSIS OF INCIDENTAL AXILLARY NODE IRRADIATION IN CARCINOMA BREAST TREATED BY IMRT TECHNIQUE

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ABSTRACT **Introduction:** Radiotherapy plays a crucial role in the comprehensive treatment of breast cancer, aiding in the eradication of microscopic tumor foci post-surgery. However, the inclusion of axillary nodes in radiotherapy fields remains debated due to the risk of lymphedema. This study assesses the incidental dose received by axillary regions during radiotherapy. **Materials and Methods:** Eighteen post-Modified Radical Mastectomy (MRM) patients receiving adjuvant radiotherapy were retrospectively selected. Treatment fields were delineated following RTOG Breast Cancer Atlas guidelines. Clinical Target Volume (CTV) included the chest wall and Supraclavicular lymph nodes (SCF). Planning Target Volume (PTV) was created with a 5 mm margin. Treatment, delivered using 6 MV or 16 MV photons, consisted of 40 Gy over 15 fractions in 3 weeks. Mono-isocentric planning incorporated tangential and supraclavicular fields with subfields. Axillary lymph nodes (levels I, II, III) were delineated for dose evaluation using Dose-Volume Histograms (DVH). **Results:** PTV received 93.19% V95, 37.20 Gy D90, 38.47 Gy D95, 44.01 Gy Dmax, and 40.10 Gy Dmean. Axilla Level I, II, and III received 36.77 Gy, 36.31 Gy, and 16.60 Gy Dmean, respectively, with V90% of 75.11%, 60.10%, and 21.60% and V95% of 64.11%, 56.51%, and 19.16%. The combined mean dose for all axillary levels was 29.67 Gy. **Conclusion:** Axillary levels I and II receive substantial incidental radiation through IMRT, potentially aiding regional control. Prospective studies are needed to weigh risks and benefits, allowing for individualized approaches based on patient needs and clinical scenarios.

KEYWORDS : breast cancer, radiotherapy, axillary irradiation, lymphedema, IMRT, dose-volume histogram, adjuvant nodal irradiation, axillary nodes, regional recurrence

INTRODUCTION

Radiotherapy plays a vital role in the comprehensive treatment approach for breast cancer, aiding in the potential elimination of microscopic tumor foci post-surgery. Adjuvant nodal irradiation is typically recommended for patients with high-risk features. However, the administration of full axillary radiation following dissection carries an elevated risk of lymphedema, which can subsequently lead to a diminished quality of life. Consequently, the inclusion of axillary nodes in radiotherapy fields remains a long-standing and debated issue.1

The advantages of reducing regional recurrences with axillary nodal irradiation must be meticulously assessed against the risk of chronic lymphedema and its impact on the quality of life. Surgeons have increasingly shifted towards limited sentinel nodal dissection (2-3) due to concerns about this morbidity. Similarly, the idea of irradiating axillary nodes, even in high-risk cases, lacks universal endorsement among radiation oncologists. Moreover, it is important to consider that axillary nodes may inadvertently receive radiation from tangential chest-wall beams, with the dose contingent upon various factors like patient anatomy and the employed technique.

The following study was conducted to analyze the incidental dose received in the axillary region and to evaluate the potential benefit of incorporating radiotherapy into the axillary region.

MATERIAL AND METHODS:

Patient Selection:

Eighteen post Modifed Radical Mastectomy (MRM) patients who received adjuvant radiotherapy between December 2022 to September 2023 were retrospectively selected for this study.

Simulation and Delineation: The delineation of the treatment area was done according to the RTOG Breast Cancer Atlas. This means that the radiation therapy treatment fields were carefully planned based on established guidelines.Clinical Target Volume (CTV): During simulation, patients were positioned in a supine position on a breast board with their arms raised and externally rotated above their head. The CTV included the chest wall and Supra-clavicular lymph nodes (SCF) if they were indicated as part of the treatment plan. The CTV helps ensure that the radiation therapy targets the necessary areas. An additional margin of 5 mm was added to the CTV to create the Planning Target Volume (PTV). This margin is often added to account for any uncertainties in the treatment process.

Treatment Delivery:

The treatment was delivered using either 6 MV or 16 MV photons using the Eclipse treatment planning system version 17.01.

Dose:

The total dose delivered was 40 Gy (Gray) in 15 fractions. Each fraction delivered 2.6 Gy. This treatment schedule was administered over a period of 3 weeks, with treatment given 5 days a week.

Planning Technique:

The planning technique employed for this treatment was a mono-isocentric technique, incorporating a half-beam block at the intersection of the tangential fields and the supraclavicular field. Two open tangential fields were meticulously designed to ensure that the beam entry did not traverse through the opposite breast. The primary objective was to achieve a uniform dose distribution to the Planning Target Volume (PTV) while minimizing regions with excessive radiation exposure (hot spots). Subfields were manually crafted to enhance the radiation dose to areas not adequately covered by the dose wash. Multiple iterations of subfields were performed to attain the desired dose distribution. The number of subfields ranged from one to three tangential pairs, depending on the specific case requirements. The selection of either 6 MV or 10 MV photons for the subfields was determined based on the separation of the treatment fields. Finally, the plans were individually optimized using the Field in Field (FIF) technique, with adjustments made to the weighting of the beams as needed.

Delineation:
Axillary lymph nodes were delineated individually for levels I, II, and III in accordance with the guidelines provided by the Radiation Therapy Oncology Group (RTOG).4 This meticulous separation allowed for precise targeting of each level during treatment planning.

The radiation dose delivered to each of these lymph node levels was assessed. This evaluation was performed to determine the incidental dose received by each level during the course of treatment. To evaluate the radiation dose distribution, the Dose-Volume Histogram (DVH) was utilized. The DVH is a graphical representation that illustrates the percentage of tissue or structure receiving specific doses of radiation. It provides a comprehensive view of how radiation is distributed within the target area and surrounding tissues.

Variable	Parameters
PTV	V95,D90, D95, Dmax, Dmean
Axillary lymph nodes Level I,II,III	Dmean,V95, V90,

Statistical Analysis:
Software Used:
SPSS software was utilized to analyze the collected data.

Parameters Evaluated:
- Mean: The average value of the dataset.
- Median: The middle value of the dataset when it's sorted in ascending order.

RESULTS
Dosimetric Parameters of Planning Target volume (PTV), Axillary Lymph nodal mean doses

Table-1: Dose-Volume Histogram (DVH) for Planning Target Volume (PTV)

Variable	Mean
V95 (%)	93.19
D90 (Gy)	37.20
D95 (Gy)	38.47
Dmax (Gy)	44.01
Dmean (Gy)	40.10

In this table, the dose received by 90% of the PTV volume is 37.20 Gy, and the dose received by 95% of the PTV volume is 38.47 Gy. These values are presented alongside the corresponding percentage of PTV volume for each DVH curve.

Table 2: Volume dose parameters of Axillary Lymph Node Levels(I, II & III)

Variable	Axilla Level I	Axilla Level II	Axilla Level III
V90 (%)	75.11	60.10	21.60
V95 (%)	64.11	56.51	19.16
Dmean (Gy)	36.77	36.31	16.60

Axilla Level I ,II and III received a mean dose of 36.77Gy, 36.31 Gy and 16.60 Gy respectively with V90% 75.11%, 60.10% and 21.60% respectively and V95 64.11%, 56.51%, and 19.16% respectively. All three levels combined, reported a mean dose of 29.67 Gy.

DISCUSSION
The side effects related to radiation in breast cancer patients can vary, with one of the most prevalent being ipsilateral arm edema [5-9]. According to the After Mapping of the Axilla: Radiotherapy Or Surgery (AMAROS) study, clinical signs of lymphedema were observed in 15% of patients one year after receiving axillary radiation therapy without Axillary Lymph Node Dissection (ALND). These percentages decreased slightly to 14% at the three-year mark and further to 11% at the five-year point [8].

Disruption of the axillary lymphatic system due to breast cancer treatment can result in Breast Cancer-Related Lymphedema (BCRL), which has a detrimental impact on the quality of life of breast cancer patients [10-12]."Several studies have examined axillary coverage using conventional radiation techniques involving parallel-opposed tangential fields [13–16]. These studies generally concluded that the mean dose and the volume receiving more than 95% of the prescribed dose were insufficient. An alternative approach to enhance axillary coverage involves adjusting the cranial border of the radiation field to position it just below the humeral head [16]. However, it's crucial to weigh the potential benefits against the increased risk of lymphedema in the ipsilateral arm [17].

As an increasing number of breast cancer patients undergo treatment with Intensity-Modulated Radiation Therapy (IMRT), some articles have shed light on the incidental irradiation of the axillary region via IMRT, despite its apparent simplicity. Kataria et al conducted an analysis of incidental irradiation to the axilla using three different radiation techniques: intensity-modulated tangents, three-dimensional tangents (utilizing the Field-in-Field or FIF technique), and standard tangents. Their findings indicated that all three tangent approaches led to substantial incidental radiation doses in the lower axilla (Level I and II). However, conformal techniques demonstrated significantly lower incidental doses to the axilla when compared to the standard tangents [18].

Zhang et al contributed to this discussion by reporting on the dose coverage of the axilla in early breast cancer patients using simplified IMRT (s-IMRT) and Field-in-Field IMRT (FIF technique with two tangential fields). Their conclusion highlighted that the s-IMRT plan delivered a reduced dose to the axilla, prompting caution for centers employing the s-IMRT technique.[19]

Kataria et al,[18] and this study showed relatively similar mean dose the lower axilla area (level I and II). However, the values for the same parameters reported by Zhang et al[19] were too low compared to those of Kataria et al and this study. This difference might be due to differences in patient position, contouring extent of the axilla, field extent, and/or IMRT optimization.Because the irradiated dose outside the target volume can vary with the degree of IMRT optimization, the axillary dose can also vary. compared to doses in the Kataria et al study (level I: 39 Gy, level II: 35 Gy, level III: 25.5 Gy) and Zhang et al study (level I: 27.7 Gy, level II: 10.6 Gy, level III: 2.5 Gy) In our study mean Dose to axillary leves are 36.77, 36.31 band 16.60 for Level I, II & III respectively, The upper part of axilla (level III), this study showed a significantly lower dose with the IMRT plan. These differences could be due to the degree of IMRT optimization. Because the irradiated dose outside the target volume can vary with the degree of IMRT optimization, the axillary dose can also vary.

We have not yet taken into account the radiation dose administered to the axilla in the context of Intensity-Modulated Radiation Therapy (IMRT) for early-stage breast cancer. This comparison has not been made with cases of advanced disease where the axilla was intentionally included in the target volume. However, it's important to acknowledge that excluding the axilla from the radiation field carries the potential risk of missing an opportunity for regional control of hidden axillary metastasis. This is particularly significant for patients with limited positive sentinel lymph nodes who do not undergo completion Axillary Lymph Node Dissection (cALND). Therefore, a more individualized approach to radiation therapy tailored to the specific needs of each patient may be necessary.

CONCLUSION:

Axillary levels I and II received a substantial amount of incidental radiation through IMRT technique. This incidental radiation may potentially aid in controlling micro-metastases or isolated tumor cells within the axillary region. Conducting more prospective clinical studies to delve into this matter could provide valuable insights into the trade-offs between risks and benefits associated with axillary lymph node irradiation.The treating oncologist has the flexibility to make decisions regarding constraints on axillary radiation, particularly when lymphedema is a concern. Alternatively, the oncologist may choose to include the axilla as a radiation target, albeit with a prescription of a potentially lower dose compared to the breast tissue. The choice depends on the specific clinical situation and patient needs.

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