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Original Research

Varied Head Position in Supraclavicular Nodal Irradiation using IMRT Technique and its Effect on Dysphagia in Breast Cancer Patients

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Introduction: Locally advanced breast cancer patients undergo a tri-modality therapy in which radiotherapy has a significant role. Toxicities associated with adjuvant radiotherapy are reduced to a minimum with the advancement of techniques, but the acute toxicities that occur during supraclavicular field radiation, like pharyngitis and esophagitis, need to be addressed. To reduce the severity of the dysphagia, variation in head position during radiation is also a commonly used and scarcely studied method. The purpose of the study is to compare the dose received by the Pharyngo-Esophageal Segment in the head-straight and head-turn positions and its correlation with dysphagia.

Methods: One hundred patients were randomized into head-straight or head-turn positions during immobilization. After the simulation scan, the targets and organs at risk were contoured in both groups according to the guidelines, and additionally, the Pharyngo-Esophageal Segment was contoured. Both groups received the same radiation dose to the supraclavicular field using the intensity modulated radiotherapy technique and were assessed for dysphagia.

Result: Fifty-three right-sided and 47 left-sided breast cancers were accrued with their age ranging from 30 to 82 years. The average Pharyngo-Esophageal Segment length, of mean dose, maximum dose, and dose of 2cc volume in head straight position group were 4.5 cm, 24 Gy, 40.4 Gy, and 25.9 Gy, respectively; whereas in head turn group the values were 5.5 cm, 30.3 Gy, 41.2 Gy, and 34.4 Gy, respectively. These parameters were significantly lower in the head straight position than head turn position, with the p-value being $p=0.005$, $p<0.001$, $p=0.04$, $p<0.001$, respectively.

Conclusion: The head straight immobilization can be considered during supraclavicular irradiation, as it significantly reduces dose to the Pharyngo-Esophageal Segment.

Introduction

Breast cancer is the most common cancer among females globally and in India. It accounts for 11.6% of all cancers and 6.9% of all cancer-related deaths globally [1]. Advancements in multi-modality treatment have led to better mortality rates and quality of life among survivors. Adjuvant radiotherapy in breast cancer reduces the risk of local/regional recurrence and improves overall survival [1] of patients as it addresses the primary postoperative area and regional nodes like the supraclavicular fossa nodes. Supraclavicular Fossa Radiotherapy (SCF RT) is said to reduce the nodal recurrence, and it has been suggested by ASCO guidelines to irradiate SCF even in 1-3

axillary LN-positive cases [2] Around 70-80 % of patients undergo SCF RT, and it leads to an acute and significant toxicity, dysphagia. This dysphagia is due to the Pharyngo-Esophageal Segment (PES) receiving an incidental radiation dose in SCF RT. Structures like the spinal cord and lungs are kept under dose constraints, but PES isn't given any constraints in multiple centres, and hence the incidental dose leads to pain, affecting diet, leading to dehydration, malnourishment, and also affecting the patient's quality of life.

The patients are immobilized with either the head turned (HT) to the opposite side or to keep the head straight (HS) during RT. In the conventional era, the HT to the opposite side was followed during SCF RT for clear visibility of the treatment field, to reduce the skin folds at the irradiation area, and it was believed to reduce the area of pharynx with in the field of irradiation. In this conformal era, multiple institutes continue to immobilize in HT position assuming that the dose to pharynx and esophagus is reduced. But in the study by Anbumani et al. it is shown that HS position has dosimetric advantage while treating SCF with 3DCRT technique.

This study was conducted to prospectively compare the variation of dose received by the PES in HS and HT positions, in Intensity Modulated Radiotherapy Technique (IMRT) and the association of dysphagia with dosimetric parameters.

Materials and Methods

The study design was approved by the institutional review board of our hospital (approval number: DRP/ FAC-NF1479/2025), and all study participants provided informed consent. Patients aged 18 years or above with histologically proven invasive breast cancer, who had undergone modified radical mastectomy or breast conservative surgery and axillary dissection with negative nodes and/or had pathologically positive axillary lymph nodes without supraclavicular or internal mammary node or distant metastases were included in the study. Recurrent cancer patients were excluded from the study. Patients were randomized in a 1:1 ratio to the head-straight (HS) or head-turn (HT) position using a simple randomization sequence generated in Microsoft Excel. Randomization was not stratified by side (right/left) or surgery type (MRM/BCS); however, post-randomization balance between groups was assessed for key baseline characteristics including age, tumor stage, nodal status, and surgical type. Chi-square tests were used for categorical variables and independent t-tests (or Mann–Whitney tests, as appropriate) for continuous variables to confirm comparability between groups. All patients were immobilized with a thoracic cast extending from the neck to the coastal margin, as shown in Figure 1, and a simulation computed tomography scan with 2.5mm slice thickness.

Figure 1. Immobilization of Patient Using Cast a-with Head Straight and b- with Head to Turned to Opposite Side.

The contouring of the primary and the regional nodes were done according to RTOG guidelines [3] and the PES was contoured 5mm above and below the supraclavicular PTV as per West et al. [4] and no dose constraints were given to PES. IMRT technique-based planning was done using Monte Carlo algorithm in Monaco treatment planning system, with the beam angles standardized in both the arms. During plan evaluation V40Gy >90-95% metrics was followed and, length of PES, incidental mean dose (Dmean), maximum dose (Dmax), and dose to 2 cc volume (D2cc) of PES were recorded. Patients were monitored at the first week during radiation, at the end of RT, and at the 2nd week follow-up post radiation completion, and the dysphagia was graded as per RTOG criteria [5] (Table 1).

Dysphagia	Grade 1	Grade 2	Grade 3	Grade 4
Pharynx & Esophagus	Mild dysphagia or	Moderate dysphagia or	Severe dysphagia or	Complete obstruction,

	odynophagia/ may require topical anesthetic or non-narcotic analgesics / may require soft diet	odynophagia / may require narcotic analgesics / may require puree or liquid diet	odynophagia with dehydration or weight loss > 15% from pretreatment baseline requiring NG feeding tube, IV fluids, or hyperalimentation	ulceration, perforation, fistula

Table 1. Radiation Therapy Oncology Group Grading for Dysphagia.

Sample estimation: To get 80% power and 95% confidence level in the result, considering the minimum difference in mean dose received by the PES between both the head-straight and head-turn groups as 0.65 Gy and based on the result obtained from Anbumani et al., where the average mean dose received with HS is 4.8 Gy and with HT is 6.5 Gy, it is estimated that 49 participants are required in each group.

Statistical Analysis

Statistical analysis was performed using SPSS (Version 29). Descriptive statistics of the grade of dysphagia was analyzed and summarized in terms of percentage. Correlations between dysphagia grade (ordinal variable) and dosimetric values were assessed using the Spearman rank correlation coefficient. To adjust for potential confounders such as age, receipt of neoadjuvant or adjuvant chemotherapy, and surgery type (MRM vs. BCS), a multivariable logistic regression was conducted with grade ≥ 2 dysphagia as the dependent variable. For continuous dosimetric parameters, Cohen's d was calculated to quantify the magnitude of between-group differences, interpreted as small (0.2–0.5), medium (0.5–0.8), or large (> 0.8). Given the multiple comparisons performed across dosimetric parameters (mean, maximum, and D2cc doses; PES length) and at different time points, Bonferroni correction was applied to control the family-wise error rate. Adjusted p-values were interpreted using the corrected significance threshold ($p < 0.05$ divided by the number of comparisons). When reporting results, both unadjusted and adjusted p-values are presented to allow transparency of inference. The Mann-Whitney test was used to compare the grade of dysphagia and dosimetric values between the head- straight (HS) and head-turn (HT) groups. To evaluate potential effect modification, interaction analyses were performed between head position and clinical subgroups (surgery type: MRM vs. BCS, and tumor laterality: right vs. left side). Interaction terms were tested using two-way ANOVA for continuous variables and logistic regression for categorical outcomes, with significance set at $p < 0.05$.

Results

One hundred patients were accrued and the median age was found to be 52 years (ranging from 30 to 82 years). The patient and tumor characteristics are summarized in Table 2.

Characteristics	HS group (%)	HT group (%)	Total
Age group (years)			
30-40	7 (14.56)	7 (13.44)	14
41-50	16 (33.28)	20 (38.4)	36
51-60	9 (18.72)	12 (23.04)	21
>60	16 (33.28)	13 (24.96)	29
Pathological stage			
Tumor stage			
T0	4 (8.32)	6 (11.52)	10
T1	13 (27.04)	10 (19.20)	23
T2	20 (41.60)	24 (46.08)	44

T3	6 (12.48)	8 (15.36)	14
T4	5 (10.40)	4 (7.68)	9
Node stage			
N0	12 (24.96)	12 (23.04)	24
N1	19 (39.52)	22 (42.24)	41
N2	13 (27.04)	11 (21.12)	24
N3	4 (8.32)	7 (13.44)	11
Hormone Status			
ER	37 (76.96)	34 (65.28)	71
PR	36 (74.88)	34 (65.28)	70
HER2NEU	11 (22.88)	12 (23.04)	23

Table 2. Patient and Tumor Characteristics of the Accrued Patients. No statistically significant baseline differences were observed between the head-straight (HS) and head-turn (HT) groups (all p > 0.05).

Baseline distributions of age, tumor stage, nodal stage, hormone receptor status, and type of surgery were comparable between the HS and HT groups, with no statistically significant differences observed (p > 0.05 for all variables), confirming adequate randomization balance. Fifty-three among them, were right-sided breast cancer and 47 were left-sided breast cancer. Fifty-eight patients received neoadjuvant chemotherapy, while the remaining 42 were given adjuvant chemotherapy. Modified radical mastectomy was done in 82 patients, and 18 patients had breast conservation surgery. On subgroup analysis, neither surgery type (MRM vs. BCS) nor tumor laterality (right vs. left) demonstrated significant differences in PES dosimetric parameters or dysphagia grades. Interaction tests confirmed that the effect of head position on mean dose, Dmax, and D2cc did not significantly vary by surgical type or side (p for interaction > 0.1 for all comparisons), indicating that the observed dosimetric benefit of the HS position was consistent across these subgroups.

The average PES length in the field of irradiation was 4.99 cm (range of 2.25 cm to 7 cm), with the average length in HS and HT being 4.9 cm and 5.36 cm, respectively. Dysphagia observed during the course of the study is as depicted in Graph 1. (FIGURE 2)

Figure 2. The Distribution of Dysphagia Grades Over the Course of Study.

Dysphagia grade showed a positive correlation with mean dose and D2cc of the Pharyngo-Esophageal Segment (PES) (r_s = 0.36, p = 0.01 for mean dose; r_s = 0.31, p = 0.03). After adjustment for age, type of surgery, and chemotherapy in multivariable logistic regression, mean dose remained independently associated with grade ≥ 2 dysphagia (adjusted OR 1.08 per Gy, 95 % CI 1.02–1.15, p = 0.01).

Despite this, the difference in grade 2 dysphagia incidence between HS and HT groups did not reach statistical significance (p= 0.93). The large dosimetric differences (mean dose Δ ≈ 6 Gy) corresponded to a Cohen's d= 0.78, indicating a moderate-to-large effect size. This suggests that the lack of significance for the clinical endpoint may reflect a Type II error due to limited sample size, as the study was powered primarily for dosimetric outcomes rather than toxicity events. Table 3 summarizes the dosimetric correlation with dysphagia.

Weeks	Grades of dysphagia	Mean dose (Gy)	Maximum dose (Gy)	D2cc (Gy)	Length of PES (cms)
First week of RT	0	26.3	39.4	29	5.01
	1	29.3	39.9	32	4.93
	2				
End of RT	0	28	40	30.5	5.7

	1	26.4	39.3	28.9	4.7
	2	27.4	39.7	30.4	5.1
Second week follow up post RT	0	25.8	39.2	28.8	5.1
	1	29.3	40.2	31.3	4.7

Table 3. Weekly Assessment of Grades of Dysphagia and its Correlation with Length and Dosimetric Data as Mean Dose, Maximum Dose, and D2cc of Pharyngo-Esophageal Segment (PES).

Forty-eight were accrued in HS arm and 52 in HT arm. The HS and HT comparative dosimetric parameters are as mentioned in Graph 2(FIGURE 3).

Figure 3. Dose Comparison between Head Straight (HS) Versus Head Turn (HT).

The average length of the PES was 4.5 cm. The average of mean dose, maximum dose, and D2cc in the HS group were 24 Gy, 40.4 Gy, and 25.9 Gy, respectively, whereas in the HT group they were 30.3 Gy, 41.2 Gy, and 34.4 Gy. The mean dose difference between HS and HT was 6.3 Gy (95% CI: 4.8–7.8 Gy), and the D2cc difference was 8.5 Gy (95% CI: 6.1–10.9 Gy), both remaining statistically significant after Bonferroni correction ($p < 0.001$). The difference in maximum dose (0.8 Gy, 95% CI: –0.3 to 1.9 Gy) was not significant after adjustment ($p = 0.06$). All analyses were performed using an intention-to-treat framework, as no participants were lost to follow-up or excluded after randomization. These findings suggest that the head-straight position has a notable favourable impact on all four measurements, with the strongest effect observed for the mean dose and D2cc.

After Bonferroni correction for multiple comparisons, the significance of the differences between HS and HT positions remained robust for mean dose and D2cc ($p < 0.001$ for both), whereas the difference in maximum dose approached but did not reach the adjusted threshold ($p = 0.06$), indicating that the key findings were not driven by false-positive results.

Among the right-sided breast cancers, the HS position yielded average Dmean, Dmax, and D2cc as 24.9 Gy, 40.3 Gy, and 27.2 Gy, respectively, which is lower than the dose parameters obtained in the HT position: 28.6 Gy, 41.2 Gy, and 33.0 Gy. Similar was the observation in left-sided breast cancers, with Dmean, Dmax, and D2cc being lower among HS (23.5 Gy, 40.6 Gy, and 24.6 Gy) in comparison to HT (32.3 Gy, 41.1 Gy, and 36.1 Gy). The absence of significant baseline imbalances between randomized groups strengthens the internal validity of the dosimetric and clinical comparisons.

Discussion

During the past five decades, there have been major advancements in radiotherapy, including technique, dose, and fractionation for breast cancer. Doses to target regions have become more uniform, and unwanted incidental irradiation of nearby organs has been reduced, limiting the side effects. During SCF RT, which is indicated in patients with clinical node-positive or pathologic node-positive disease or in those who received neoadjuvant systemic therapy or presence of extensive lymphovascular invasion or evidence of tumor emboli in the axillary soft tissue or extracapsular extension ≥ 2 mm; the post-cricoid and cervical esophagus are in proximity and receive a substantial radiation dose, as is evident by the dysphagia experienced by the patients. This is a very commonly encountered side effect in patients and needs emphasis on its preventive measures [6-8].

Multiple studies have analyzed the radiation-induced dysphagia in SCF-irradiated patients, and each of these studies have assessed different dosimetric parameters like V25 and V35, as in Wang et al. [9], and D98%, D95%, and D2%, as in Anbumani S et al. [10]. Three basic parameters are

analyzed here: mean, max, and D2cc dose, and it has shown that mean dose correlated significantly with 2nd- week post-RT dysphagia, and though the other parameters showed correlation, they were not of significant value.

The non-significant difference in grade 2 dysphagia between groups ($p = 0.93$) despite clear dosimetric separation (Cohen's $d \approx 0.8$) likely reflects a Type II error, as the study was powered for dosimetric rather than clinical endpoints. The regression analysis adjusting for age, surgery type, and chemotherapy confirmed that mean PES dose remained the dominant predictor of dysphagia, reinforcing the biological plausibility of the observed trend. Although the HS group demonstrated lower mean, maximum, and D2cc doses to the Pharyngo- Esophageal Segment (PES), this dosimetric advantage did not translate into a statistically significant reduction in clinically observed dysphagia. This may be attributed to the study being powered primarily for dosimetric rather than clinical endpoints. Importantly, when analyzed against previously published thresholds such as the 31 Gy mean dose criterion proposed by West et al. [4], a larger proportion of patients in the HS group had PES mean doses below this threshold compared to the HT group. This indicates that while overall dysphagia incidence was not significantly different, the HS position more consistently achieved dosimetric safety limits associated with reduced risk of esophagitis, suggesting potential clinical relevance in larger cohorts.

In a study by Radhakrishna et al.[11] on SCF RT it was concluded that right-sided SCF RT patients had a lower dose to the esophagus in comparison to the left side (D max 36.45 and 39.75Gy respectively). In another study by Bhaskaran et al.,[12] the incidence of grade 2 esophagitis, 11/20 (55%), was higher in left-sided breast cancer patients than in the right-sided, 9/20 (45%) [13]. Similarly, in our study, the right-sided breast cancers mean dose to PES was significantly 27.8 and for the left-sided it was 28.4 (p value = 0.036). For maximum dose and 2cc dose the difference was not significant with p value of 0.75 and 0.11, respectively. And there were no significant variations in grade of dysphagia among the right and left sided cancers in both head positions. These findings were further supported by non-significant interaction terms, suggesting that the influence of head position on PES dose and dysphagia was independent of surgical approach and tumour laterality. The cervical esophagus starts at the midline but then descends to the left of the midline through the neck and superior mediastinum and this attributes to the lower incidental dose in right sided breast cancer in comparison to the left sided cancers [14].

In this era of image guidance and highly conformal techniques, several institutes plan irradiation of breast cancer patients with the IMRT technique. Multiple studies address different aspects of RT in breast cancer using the IMRT technique, such as the study by Yaney et al. [14], where the authors state that in the patients irradiated using the IMRT technique, grade 2 dysphagia is increased, and hence they have recommended contouring of PES in such cases where a higher technique is being used. In our study all breast cancer patients received radiation using IMRT technique and as recommended, the PES was contoured in all and analysis was done between both the groups of head position.

A study by Anbumani S et al. [10] addresses the effect of head position on dysphagia in SCF RT patients, and they have concluded that HS is better than HT for reducing the dysphagia in the 3DCRT technique. This study using the IMRT technique has shown that the use of a higher conformal technique does not negate the benefit of the head-straight position in SCF RT. Additionally, the HS position is easier to maintain and reproduce than an HT position; and the dermatitis was also similar in both groups with only grade 1 dermatitis being observed at end of treatment in 60% of HT patients and 58% of HS patients. Future studies to concentrate on long term follow up of the patients and to study the errors in verification images in HS and HT groups.

In conclusion, when employing intensity-modulated radiotherapy for supraclavicular nodal irradiation in breast cancer, contouring the proximal esophagus (PES) and immobilizing patients with the head in a neutral, straight position are preferable, as this approach is associated with a significant reduction in the dose delivered to the PES. This positioning results in a higher

proportion of patients remaining below the 31 Gy mean dose threshold previously associated with a reduced risk of esophagitis, thereby supporting its continued use, pending validation in larger, adequately powered clinical studies.

Declaration of conflicts

The authors declare no conflict of interest.

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Originality Declaration for Figures

All figures included in this manuscript are original and have been created by the authors specifically for the purposes of this study. No previously published or copyrighted images have been used. The authors confirm that all graphical elements, illustrations, and visual materials were generated from the data obtained in the course of this research or designed uniquely for this manuscript.

Clinical trial registration

It is not a clinical trial. The institutional ID is DRP/ FAC-NF1479/2025

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