

# EFFECT OF CHANGE IN THE NECK POSITION ON DOSIMETRIC PARAMETERS OF THE OESOPHAGUS IN BREAST CANCER PATIENTS UNDERGOING SUPRACLAVICULAR IRRADIATION



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## ABSTRACT

### *Background*

A limited number of publications examine approaches to decreasing esophageal dose and acute esophagitis during breast cancer radiotherapy (RT).

### *Objectives*

This study aimed to analyze the effect of the two different neck positions when the neck turned to the contralateral side or straight on dosimetric parameters such as mean dose ( $D_{\text{mean}}$ ), maximum dose ( $D_{\text{max}}$ ), and volume of esophagus receiving doses ( $V_x$ ), in breast patients (BC) who require supraclavicular irradiation.

### *Materials and Methods*

Of all patients undergoing chest wall and supraclavicular regional node irradiation with a dose of 40Gy in 15 fractions, 25 patients were simulated with their necks straight (NS) group, whereas 25 patients with tilted neck position (NT) group.  $D_{\text{mean}}$ ,  $D_{\text{max}}$ ,  $V_5$ ,  $V_{10}$ ,  $V_{15}$ , and  $V_{20}$  were calculated and converted to EQD2 (Equivalent dose in 2 Gy fractions).

### *Results*

$D_{\text{mean}}$ ,  $V_5$ ,  $V_{10}$ ,  $V_{15}$ , and  $V_{20}$  were significantly lower in (straight neck position) SN group patients when compared to the (tilted neck position) TN group ( $P$  values  $<0.05$ ).  $D_{\text{max}}$  was slightly higher in the SN group than the NT group ( $p=0.083$ ). When the laterality of breast cancer was evaluated in the two groups, all dosimetric parameters ( $D_{\text{max}}$ ,  $D_{\text{mean}}$ ,  $V_5$ ,  $V_{10}$ ,  $V_{15}$ , and  $V_{20}$ ) were higher in left-sided breast cancer as compared in right-sided breast cancer for SN and NT groups ( $P$  values  $<0.05$ ).

### *Conclusion*

We found that the positioning of a straight neck resulted in considerable oesophageal sparing. Therefore, esophagitis may be reduced, which substantially impacts the quality of life of BC survivors.

**Keywords:** *Oesophagus, dosimetric parameters, breast cancers, neck position, supraclavicular irradiation.*

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## INTRODUCTION

Radiotherapy (RT) is an essential part of the treatment of breast cancer. It includes irradiating the chest wall after a mastectomy or conserved breast and regional nodes (RN) <sup>(1,2)</sup>. In addition, radiotherapy can reduce the breast cancer mortality risk for women who have had breast-conserving surgery or mastectomy for node-positive disease <sup>(3)</sup>. However, the positive effects of radiotherapy must be assessed against its possible risks. Diseases of the heart, lungs, and esophagus have been identified through randomized trials as the primary causes for which breast cancer radiotherapy may cause mortality <sup>(4)</sup>.

The esophagus is a radiosensitive structure, and it is constituted of rapidly proliferating squamous epithelium and traverses the full length of the mediastinum longitudinally. Consequently, the esophagus may receive a clinically substantial radiation dose and become inflamed during radiotherapy to the supraclavicular lymph node (SCL) region <sup>(5)</sup>. The proximity of the esophagus to various radiation fields that are used to treat supraclavicular lymph nodes during breast cancer (BC) RT might result in BC patients experiencing acute esophagus toxicity <sup>(6)</sup>.

The risk of esophagitis has been demonstrated to increase with the dose that the oesophagus receives, either as a dose delivered or as a function of the esophagus's volume <sup>(7-9)</sup>. A multivariate analysis of mean dose ( $D_{\text{mean}}$ ) revealed a better association with esophageal toxicity. In addition, Dankers R et al. (2015) reported that the mean dose was a good predictor of esophageal toxicity <sup>(10)</sup>.

More research has been conducted on esophagitis in lung and head and neck radiotherapy <sup>(7-9)</sup>, and very few related to breast cancer. Previous studies of acute esophagus toxicity in breast cancer patients have documented increased esophagus toxicity, possibly related to the dose received by the esophagus. During the planning process, esophageal toxicity can be reduced to a minimum by maintaining the mean radiation dose to the esophagus at less than 31Gy <sup>(6)</sup>. Another study by Wang Q et al. (2017) reported that the dosimetric parameters such as mean dose ( $D_{\text{mean}}$ ) and volume of esophagus receiving doses correlated with acute esophagitis <sup>(11)</sup>.

During treatment simulation and planning, the head and neck can be positioned to the contralateral side of the affected breast or straight to reduce the risk of acute

esophagitis and decrease the overlapping volume of the esophagus with the planning target volume.

Therefore, this study aimed to analyze the effect of the two different neck positions when the neck turned to the contralateral side or straight on dosimetric parameters such as mean dose ( $D_{\text{mean}}$ ), maximum dose ( $D_{\text{max}}$ ), and volume of oesophagus receiving doses, in breast cancer patients during supraclavicular irradiation treating with three-dimensional conformal radiotherapy (3DCRT).

## MATERIALS AND METHODS

### Treatment Plan Selection

The study was carried out retrospectively by assessing the radiation treatment plans of 50 patients (25 patients with straight neck positions and 25 patients with tilted neck positions who were treated with 3-dimensional conformal radiotherapy (3DCRT) for BC at Zhinawa cancer center in Sulaimani City, Kurdistan region-Iraq, and Tohid hospital, radiotherapy department, Sanandaj city, Iran. This study comprised breast conservation and post-mastectomy patients with indications for chest wall and supraclavicular regional node irradiation. Patients who received RT to the chest wall alone were excluded. Data were collected between October 2021 and June 2022.

### Treatment planning and radiotherapy

All patients receiving radiotherapy for breast cancer were simulated and planned according to departmental procedures. Twenty-five (25) patients were simulated with their necks straight (15 right-sided and 10 left-sided breast cancer), whereas 25 patients with tilted neck positions (15 right-sided and 10 left-sided breast cancer).

The SN (straight neck position) group included patients whose treatment was planned with the neck position with the head straight, while the TN (tilted neck position) group consisted of patients whose necks were turned to the opposite side of the affected breast. Based on the laterality of the breast cancer, each group was further separated into two subgroups: right SN, right TN, left SN, and left TN.

All patients received a radiation dose of 40Gy in 15 fractions (2.67 Gray per fraction). CMS XIO was used to generate the patients' three-dimensional conformal radiotherapy (3D-CRT) treatment plans. The Radiation Therapy Oncology Group (RTOG) breast contouring atlas was followed for the delineation of the clinical

target volume (CTV) and planning target volume (PTV). All 3DCRT plans used 6MV or 10MV photon beams to the chest wall alone or the whole breast in those patients who underwent lumpectomy and 6MV or 10MV photon beams to the supraclavicular fossa (SCF), all delivered by the Elekta Synergy® linac (Elekta et al.). A hypo-fractionated dose of 40Gy in 15 fractions was prescribed to plan target volume (PTV) for both chest wall and supraclavicular field irradiation. The esophageal volume was contoured from the caudal edge of the cricoid cartilage.

From the dose-volume histogram, the mean dose ( $D_{mean}$ ), maximum dose ( $D_{max}$ ), and volume of esophagus receiving 5 Gy ( $V_5$ ), 10 Gy ( $V_{10}$ ), 15 Gy ( $V_{15}$ ), 20 Gy ( $V_{20}$ ) were calculated and converted to EQD2 (Equivalent dose in 2 Gy fractions).

**Statistical analysis**

Data were analyzed using (SPSS version. 21). The dosimetric comparison between the two groups (NS and NT) was performed using a paired sample t-test, and a non-parametric test was performed to compare doses from right-sided breast to left-sided breast. P values of <.05 were considered significant.

**RESULTS**

There were 50 patients included in the study with a median age of 47.5 (range 33 to 68) years. Demographic data are shown in Table 1.

Table 2 showed that the  $D_{mean}$ ,  $V_5$ ,  $V_{10}$ ,  $V_{15}$ , and  $V_{20}$  were significantly lower in SN group patients compared to TN group P values <0.05.  $D_{mean}$  was  $10.48 \pm 5.13$ Gy

and  $11.48 \pm 6.12$  in the SN and NT groups, respectively ( $p=0.025$ ) (Figure 1).  $D_{max}$  was slightly higher in the NS group than the NT group ( $39.18 \pm 5.17$  in the NS group and  $38.82 \pm 7.03$  in NT); however, this difference was not statistically significant ( $P= 0.083$ ).

When the laterality of breast cancer was evaluated, and the two groups were further divided into patients with right and left-sided breast tumours, a statistically significant difference was seen between the groups for all dosimetric parameters ( $D_{max}$ ,  $D_{mean}$ ,  $V_5$ ,  $V_{10}$ ,  $V_{15}$ , and  $V_{20}$ ) P values <0.05.

The mean oesophagus dose among patients with left- and right-sided breast cancer was  $13.65 \pm 2.10$  and  $7.50 \pm 2.05$  in the NS group, ( $P= 0.002$ ), and ( $D_{mean}$ ) was  $14.45 \pm 2.174$ Gy versus  $8.60 \pm 2.15$ Gy for left- and right-sided breast cancer, respectively in NT group ( $p= 0.002$ ). The maximum dose for left and right breast was  $40.55 \pm 3.11$ Gy and  $38.22 \pm 3.19$  in the NS group ( $P= 0.021$ ), and  $D_{max}$  was  $39.98 \pm 3.11$ Gy versus  $37.68 \pm 3.19$  Gy for left- and right-sided breast cancer, respectively in NT group ( $P= 0.024$ ) (Table 3).

For the right-sided breast, the mean dose was higher in the NT group when compared to the NS group. However,  $D_{max}$  was slightly higher in the NS group than in the NT group (Figure 2). For left-sided breast, the mean dose was higher in the NT group when compared to the NS group, while  $D_{max}$  was slightly higher in the NS group as compared to the NT group (Figure 3).

**Table 1. Baseline Patient characteristics.**

| Characteristic                      |               |
|-------------------------------------|---------------|
| No. of patients                     | 50            |
| Sex                                 | Female        |
| Age                                 | 47.5 (33-68)  |
| Type of cancer                      | Breast cancer |
| <b>Laterality of treatment area</b> |               |
| Right                               | 30            |
| Left                                | 20            |
| <b>Marital status</b>               |               |
| Single                              | 11            |
| Married                             | 39            |
| <b>Stage of disease</b>             |               |
| Stage II                            | 33            |
| Stage III                           | 17            |

Table 2. Comparison of dosimetric parameters the mean dose ( $D_{mean}$ ), maximum dose ( $D_{max}$ ), and volume of oesophagus receiving 5 Gy ( $V_5$ ), 10 Gy ( $V_{10}$ ), 15 Gy ( $V_{15}$ ), 20 Gy ( $V_{20}$ ) of the SN (straight neck position) group and TN (tilted neck position), data are represented as (mean±SD).

| Dosimetric parameters                        | NS group      | NT group      | P-value |
|--|---------------|---------------|---------|
|  | Mean± SD      | Mean± SD      |         |
| Mean dose ( $D_{mean}$ ) Gy                  | 10.48 ± 5.13  | 11.48 ± 6.12  | 0.025   |
| Maximum dose ( $D_{max}$ ) Gy                | 39.18 ± 5.17  | 38.82 ± 7.03  | 0.083   |
| Volume receives a dose of 15 Gy ( $V_5$ )    | 38.15±11.17   | 43.15±11.16   | 0.019   |
| Volume receives a dose of 10 Gy ( $V_{10}$ ) | 29.83 ± 15.19 | 38.83 ± 12.13 | 0.002   |
| Volume receives a dose of 15 Gy ( $V_{15}$ ) | 25.23±9.45    | 30.73 ± 11.09 | 0.008   |
| Volume receives a dose of 20 Gy ( $V_{20}$ ) | 19.32 ± 10.01 | 24.26 ± 9.01  | 0.014   |

SD: standard deviation

Table 3. Comparison of the mean dose (Dmean), maximum dose (Dmax), and volume of oesophagus receiving 5 Gy (V5), 10 Gy (V10), 15 Gy (V15), 20 Gy (V20) of the SN (straight neck position) group and TN (tilted neck position) for right and left breast cancer, data are represented as (mean±SD).

| Dosimetric parameters                        | NS group      |               | p-value | NT group      |               | p-value |
|--|---------------|---------------|---------|---------------|---------------|---------|
|  | Mean± SD (RT) | Mean± SD (LT) |         | Mean± SD (RT) | Mean± SD (LT) |         |
| Mean dose ( $D_{mean}$ ) Gy                  | 7.50±2.05     | 13.65 ± 2.10  | 0.002   | 8.60±2.15     | 14.45 ±2.17   | 0.002   |
| Maximum dose ( $D_{max}$ ) Gy                | 38.22 ± 3.19  | 40.55 ±3.11   | 0.021   | 37.68±3.19    | 39.98 ±3.11   | 0.024   |
| Volume receives a dose of 5 Gy ( $V_5$ )     | 27.69±11.17   | 48.58±3.51    | 0.001   | 30.15±4.81    | 56.17±5.16    | 0.001   |
| Volume receives a dose of 10 Gy ( $V_{10}$ ) | 19.42 ± 5.01  | 40.18 ± 6.12  | 0.002   | 26.77±4.19    | 50.82 ± 4.10  | 0.001   |
| Volume receives a dose of 15 Gy ( $V_{15}$ ) | 15.73±4.15    | 34.79±4.15    | 0.004   | 18.60±3.10    | 42.88±2.91    | 0.002   |
| Volume receives a dose of 20 Gy ( $V_{20}$ ) | 11.87 ± 4.36  | 26.78 ± 4.05  | 0.002   | 14.28±6.81    | 34.20 ± 5.01  | 0.005   |

(RT): Right-sided breast, (LT): Left-sided breast

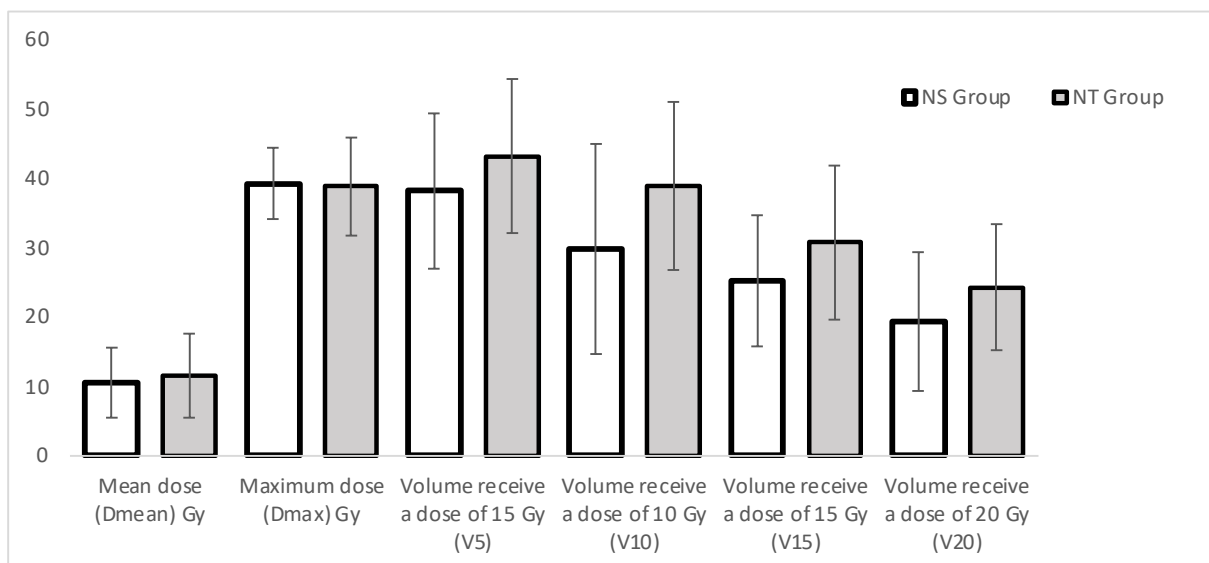
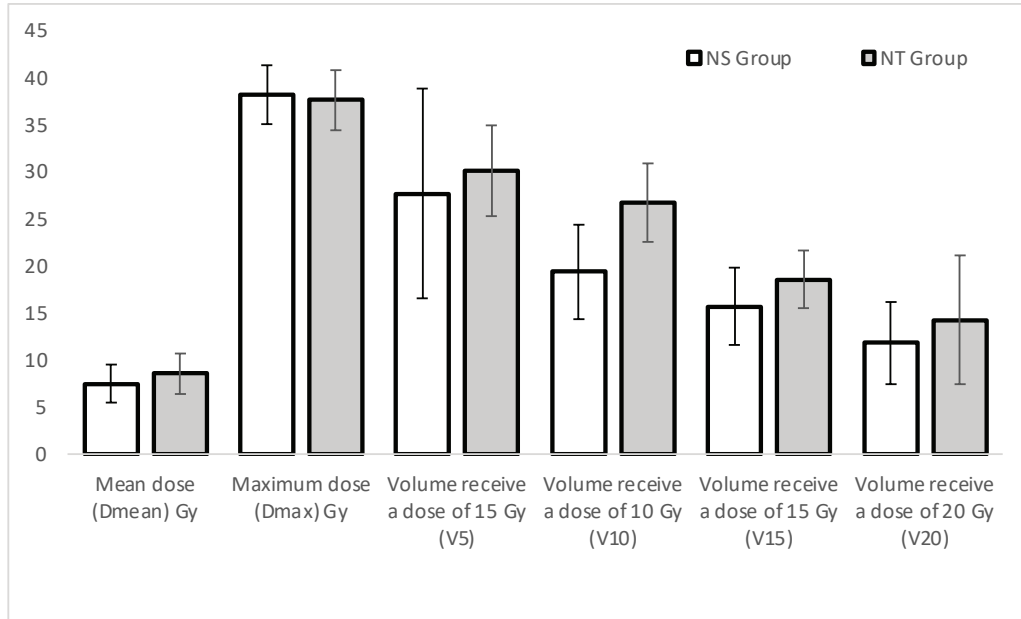
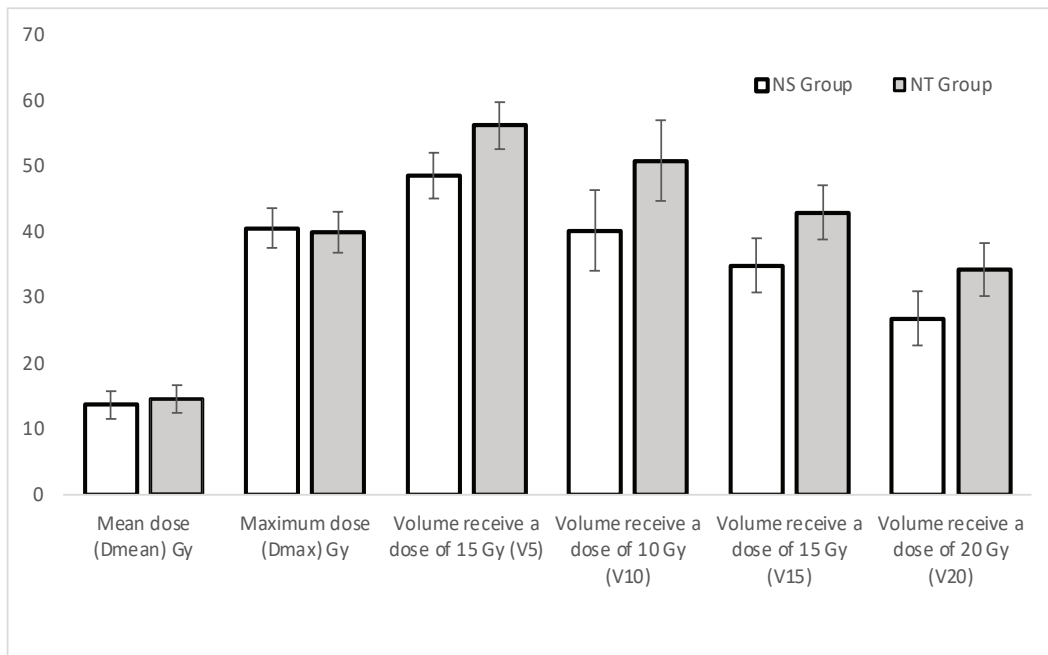


Figure 1. Comparison of dosimetric parameters of the SN (straight neck position) group and TN (tilted neck position) with a standard deviation.

*Effect of Change in the Neck Position on Dosimetric Parameters...*



**Figure 2. Comparison of dosimetric parameters of the SN (straight neck position) group and TN (tilted neck position) for right-sided breast cancer with a standard deviation.**



**Figure 3. Comparison of dosimetric parameters of the SN (straight neck position) group and TN (tilted neck position) for left-sided breast cancer with a standard deviation.**

## DISCUSSION

The present study was designed to compare the dosimetric parameters of using two different neck positions to spare the oesophagus from higher radiation doses and to reduce the volume of irradiated oesophagus exposed during breast radiotherapy. We found that the positioning of a straight neck achieved significant oesophagus sparing.

The oesophagus is an organ that is at risk during radiotherapy for breast cancer, and tolerance doses for the oesophagus need to be taken into account. West K et al. (2020) found that twenty-four patients (31%) reported that they had esophagitis of grade 2. Patients who received a mean oesophageal dose of more than 31 Gy were more likely to experience grade 2 esophagitis than those who received a dose of less than 31 Gy in a single-arm prospective observational study of 77 patients followed up for twice-weekly monitoring for the period of radiotherapy or until oesophageal side effects cleared. Patients received a total dose of 50 Gy in 25 fractions. The neck was turned away from the ipsilateral side (6). However, the findings of the  $D_{\text{mean}}$  oesophagus were higher than our result. The higher dose in their study may be due to the result of establishing a set of limitations for target volumes and organs at risk (OAR) in IMRT planning.

In addition, the difference in contouring guidelines followed may also contribute to the increased value, in the observation of Wang Q (2017), in 200 cases, the neck was turned to the contralateral, while 1.5% (3 cases) had a diagnosis of acute radiation esophagitis. Our results showed a higher  $D_{\text{mean}}$ ,  $11.48 \pm 6.12$ , for patients whose neck was turned to the contralateral. A reasonable explanation could be radiation delivery techniques (3DCRT vs. IMRT) and OAR. Our analysis was retrospective, and there was no new planning following oesophageal contouring. The mean oesophageal dose could have been lower if the plans had been modified to reduce the oesophageal dose (12).

Concerning the neck in a straight position, a retrospective study included treatment plans generated with and without oesophagus delineation for 44 patients who were treated with 3DCRT; they compared dose volumetric parameters of the oesophagus in radiation treatment of the breast with and without oesophagus delineation.  $D_{\text{mean}}$  was  $14.11 \pm 4.24$  Gy in the without oesophagus delineation group. A higher mean dose and  $V_{15}$  in their study may be due to the contouring

oesophagus at risk as they delineated the oesophagus from the room caudal border of the cricoid cartilage to the lower border of supraclavicular PTV (13).

The risk of esophagitis in breast cancer patients after supraclavicular RT depends on the volume of the oesophagus receiving a dose; an increase in the volume of oesophagus volume irradiated correlated with an increased incidence of esophagitis, according to Yaney A et al., (2021) those patients who received oesophageal mean dose,  $V_{10}$  and  $V_{20}$  more than 11 Gy, 30%, and 15%, respectively; were more likely to develop esophagitis grade 2 than those who did not. In addition, the head-neck position was not mentioned. However, the  $D_{\text{mean}}$  was almost identical to our study (14).

The findings of this retrospective study may be verified by conducting additional prospective trials applying random allocation of patients.

In conclusion, esophagitis resulting from radiotherapy has an impact on the quality of life of breast cancer survivors. Esophagitis depends on the mean dose received by the oesophagus. Appropriate positioning of the neck during breast cancer radiotherapy can reduce the mean dose received by the oesophagus. Our results indicated that positioning of a straight neck is preferable in breast cancer patients undergoing supraclavicular irradiation to decrease the mean dose to the oesophagus, and thus, this reduction may result in the most significant predicted reduction in the occurrence of acute esophagitis in breast cancer patients.

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