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# Dosimetric comparison of prone versus supine hypofractionated partial breast irradiation via external beam radiotherapy in early breast cancer

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SUMMARY

Objectives: To analyze the dosimetry of PTV and OARs-heart and lungs in prone versus supine hypofractionated partial breast irradiation.

Methods and Materials: Between October 2014 and December 2016, 23 histologically proven early breast cancer patients were enrolled on the study.

All patients underwent breast conservation surgery followed by Adjuvant radiotherapy. A CTV of 1.5 cm was generated from the cavity followed by 0.5 mm PTV margins. 3DCRT or IMRT plans were generated in both the positions. Patient was treated in supine position to a dose of 40 Gy delivered in 15 fractions at 2.67 Gy per fraction, 1 fraction per day over 5 fractions per week. Dose constraints were applied to the OARs of ipsilateral lung V30 <10%, V20<20%, V30<10% and the heart V20<5%, V10<10% and Dmean <5Gy.

The PTV Dosimetric parameters were PTV D90, PTV V95 and PTV Dmax. Lung Dosimetric parameters were mean ipsilateral lung V30, V20 and V10 and Heart Dosimetric parameters were V20, V10 and mean heart dose.

Results: The PTV D90 was 37.91 Gy in supine position and 38.03 Gy in prone position. The PTV Dmax was 106.22 Gy in supine position and 105.87 Gy in prone position. The PTV V95 was 91.73% in supine and 93.77% in prone position.

The mean ipsilateral lung V30 was 6.69% in supine and 2.47% in prone position and was statistically significant (p=0.002). The mean ipsilateral lung V20 was 11.05% in supine and 4.87% in prone position and was statistically significant (p=<0.001). The mean ipsilateral lung V10 was 17.82% in supine and 7.97% in prone position and was statistically significant (p=<0.001). The mean ipsilateral lung dose was 6.37 Gy in supine position and 3.10 Gy in prone position which was also statistically significant (p=<0.001).

The Heart V20 was 1.28% in supine position and 1.53% in prone position. The Heart V10 was 3.99% in supine position and 3.19% in prone position. The mean heart dose was 1.86 Gy in supine position and 1.48 Gy in prone position. None of these parameters were statistically significant.

Conclusion: Prone position in breast irradiation had better dosimetry with ipsilateral lung. Although the cardiac dose was reduced by prone position compared to supine position, DVH parameters were not statistically significant.

Key words: breast, partial, hypofractionated, prone, supine, PTV, lung, heart

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## INTRODUCTION

Breast Conservation Therapy (BCT) is an accepted mode of treatment in most patients with stage I and II breast cancer. Multiple retrospective studies and prospective randomized trials have established the long-term equivalence of this treatment approach compared to mastectomy in terms of disease-free and overall survival [1, 2]. The major advantages of BCT are superior cosmetic results and reduced psychological and emotional trauma compared to mastectomy. Despite the obvious cosmetic and potential emotional advantages of BCT, only 10%-40% of patients who are candidates for breast conservation receive it [3]. This may be due to logistic problems associated with BCT related to the protracted course of External Beam Radiotherapy (EBRT) delivered to the whole breast. Standard therapy after tumor excision includes 5 (25 fractions) weeks of external beam RT to the whole breast (45 Gy-50 Gy) followed by boost to the tumor bed with an additional 5 to 10 fractions (1 fraction/day) of (EBRT).

Among patients who did not receive EBRT, majority of recurrences occurred in the tumor bed [2, 4-7]. In addition, the rate of development of new cancers in remote areas of the breast (unrelated to the index lesion) was similar whether or not Whole Breast Irradiation (WBI) was administered. EBRT after tumor excision exerts its maximal effect upon reducing breast cancer recurrence at tumor bed. Hypofractionated regimens improve the therapeutic index in slow-growing tumors with low $\alpha/\beta$ ratios, such as breast cancer [8]. In phase III studies, adverse effects and therapeutic efficiency of hypofractionated RT were found similar to the conventional fractionation models [9, 10]. The prone position has been shown to improve the dose homogeneity throughout the breast volume. Improved dose homogeneity and decreased skin dose from prone positioning may also prove to be advantageous for hypofractionated breast regimens, where larger doses per fraction are delivered [11]. A prone setup with hypofractionated partial breast irradiation reduces inclusion of heart and lung in the radiation field and reduces the late effects of RT. This study was done to analyze the dosimetry of PTV and OARs-heart and lungs in prone versus supine hypofractionated partial breast irradiation.

## MATERIALS AND METHODS

### Eligibility criteria

This study was was approved by the institutional scientific review board and ethical committee. A written informed consent was obtained from all the patients before their enrollment. The inclusion criteria were Histologically proven invasive ductal carcinoma, unifocal tumor, pathological tumor ≤ 3 cm, margins negative, Node negative, age ≥ 18 years, Karnofsky performance status of more than or equal to 70.

### Patient positioning and simulation procedure

Post Breast Conservation Surgery (BCS) patients underwent CT simulation in supine and prone position using supine (R611-5SDCF Breast board ® Klarity) and prone breast boards as shown in Figure 1 respectively. During supine CT simulation, the flat board was elevated to 12° and hip rest was kept at 0 cm. Arm rest was kept in position E and H. During prone simulation, patient was positioned prone over the prone breast board with nose and lips placed at the opening for easy breathing. The treatment breast was left to hang in the gutter while the opposite breast pulled and placed away using the breast rest. The CT scan was done from the mandible till Lower border of L1 to include the entire lung with slice thickness of 3 mm. Intravenous contrast (IOPROMIDE) was administered to all patients before the CT scan at a Dose-1-2 cc/kg body weight. These images were then transferred to treatment planning system.

**Fig. 1.** Prone breast board

### Volume of interest

The lumpectomy cavity was outlined based its on clear visualization on CT or with the help of surgical clips. The Clinical Target Volume (CTV) was defined by uniformly expanding the excision cavity volume by 1.5 cm, with limiting to 5 mm from the skin surface and Chest wall. The Planning Target Volume (PTV) was defined as a uniform 5 mm expansion of the CTV.

### Treatment planning

Three-dimensional treatment plans were generated using Eclipse (®Varian Medical Systems, USA) treatment-planning system. Non-coplanar medial and lateral tangential beams were used to cover the supine and prone PTV as shown in Figure 2. Multiple fields in fields were used and weights of the individual fields were optimized to maximize dose uniformity in the PTV. Forward IMRT was allowed with not more than 5 beams.

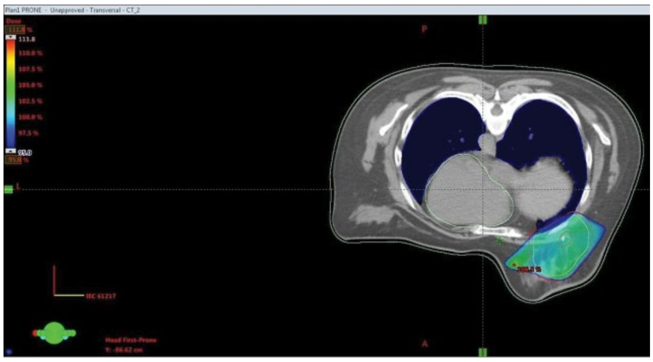

**Fig. 2.** Dose color wash showing 95% target volume coverage in prone position

A total dose of 40 Gy in 15 fractions at 2.67 Gy per fraction with five fractions delivered over a week for 3 weeks was prescribed for the PTV. Dose constraints were given to the Organ at Risk (OAR) namely, the ipsilateral lung V30 <10%, V20<20%, V30<10% and the heart V20<5%, V10<10% and D mean <5 Gy. Irrespective of the simulation position of the patient all patients were treated in supine position as immobilized during treatment CT simulation. Kilovoltage X-rays were taken using on-board Electronic Portal Imaging Device (EPID) in AP and Lateral position and matched with the fixed bony landmarks on the Digitally reconstructed Radiograph and then treated. Patients were planned for adjuvant chemotherapy either before or after RT followed by hormonal or targeted therapy in hormone positive or Her-2 positive patients respectively.

### Data collection and statistical analysis

Descriptive and inferential statistical analysis was carried out in the study. Statistical analysis was done using the SPSS v22.0 program for windows (SPSS Inc, Chicago, IL, USA). The Dosimetric data were obtained from the Dose Volume Histogram (DVH) generated to evaluate the supine and prone plans. Dosimetric coverage of PTV and OARs were analyzed and compared. The minimum dose received by the 90% of the PTV (D90), the volume of the PTV receiving 95% of the prescription dose (V95), the maximum dose in PTV (Dmax) were recorded. Volume of ipsilateral lung receiving 10 Gy (V10), 20 Gy (V20) and 30 Gy (V30) and ipsilateral lung mean dose were recorded. Volume of Heart receiving 5 Gy (V5) and 10 Gy (V10) and mean heart dose were recorded. Student t test (two tailed, independent) was used to find the significance of Dosimetric parameters of PTV, lung and heart. Chi-square test was used to find the significance of Dosimetric parameters of PTV, lung and heart between prone and supine groups. A p-value<0.05 was considered as statistically significant.

## RESULT

A total of 23 patients were recruited for the study between OCT 2014 till Dec 2016. All patients underwent Breast conservation surgery, of which 22 underwent lumpectomy and one quadrantectomy. Of 23 patients, 21 underwent Axillary Lymph Node Dissection (ALND) and 2 underwent Sentinel Lymph Node Biopsy (SLNB). All the patients received adjuvant chemotherapy of 3 cycles of Cyclophospamide,

**Tab. 1.** Dosimetric data of target and non-target volumes

| Volume | Dosimetric parameters | Supine/Prone Supine | Prone | P value |
|---|---|---|---|---|
| | PTV D90 (Gy) | 37.91 ± 1.07 | 38.03 ± 1.37 | 0.792 |
| PTV | PTV Dmax (Gy) | 106.22 ± 1.48 | 105.87 ± 1.17 | 0.313 |
| | PTV V95 (%) | 91.73 ± 3.93 | 93.77 ± 3.93 | 0.108 |
| | V30 (%) | 6.69 ± 6.15 | 2.45 ± 2.02 | 0.002 |
| | V20 (%) | 11.05 ± 6.82 | 4.87 ± 3.03 | <0.001 |
| Ipsilateral lung | V10 (%) | 17.82 ± 8.21 | 7.97 ± 4.34 | <0.001 |
| | $D_{mean}$ (Gy) | 6.37 ± 2.58 | 3.10 ± 1.75 | <0.001 |
| | V20 (Gy) | 1.28 ± 2.95 | 1.53 ± 2.16 | 0.716 |
| | V10 (Gy) | 3.99 ± 9.00 | 3.19 ± 3.61 | 0.636 |
| Heart | $D_{mean}$ (Gy) | 1.86 ± 2.07 | 1.48 ± 1.39 | 0.320 |

Epirubicin and 5-Flurouracil (CEF) regimen followed by 3 cycles of Docetaxel. Eleven patients were Hormone receptor positive and 10 of them received adjuvant hormonal therapy. Two treatment plans were generated for each patient-one for supine position and another for prone. Table 1 show the dosimetric data for target and OARs.

### Target volume dosimetry

The PTV dosimetric parameters were assessed using PTV D90, PTV V95 and PTV Dmax The mean PTV D90 was 37.91 ± 1.07 Gy in supine position and 38.03 ± 1.37 Gy in prone position (p=0.792). The mean PTV Dmax was 106.22 ± 1.48 Gy in supine position and 105.87 ± 1.17 Gy in prone position (p=0.313). The mean PTV V95 was 91.73 ± 3.93% in supine and 93.77 ± 3.67% in prone position (p=0.108). Neither of the parameters were statistically significant.

### Lung dosimetry

OAR's Prone positioning of the patient significantly spared the lung from radiation. Lung being parallel organ, volumetric dose constraints were used. The mean ipsilateral lung V30 was 6.69 ± 6.15% in supine and 2.47 ± 2.02% in prone position and was statistically significant (p=0.002). The mean ipsilateral lung V20 was 11.05 ± 6.82% in supine and 4.87 ± 3.03% in prone position and was statistically significant (p=<0.001).

The mean ipsilateral lung V10 was 17.82 ± 8.21% in supine and 7.97 ± 4.34% in prone position and was statistically significant (p=<0.001). The mean ipsilateral lung dose was 6.37 ± 2.58 Gy in supine position and 3.10 ± 1.75 Gy in prone position and was also noted to be statistically significant (p=<0.001).

### Cardiac dosimetry

Cardiac sparing was not significant between prone and supine position.

The Heart V20 was 1.28 ± 2.95% in supine position and 1.53 ± 2.16% in prone position (p=0.716). The Heart V10 was 3.99 ± 9.00% in supine position and 3.19 ± 3.61% in prone position (p=0.636). The mean heart dose was 1.86 ± 2.07 Gy in supine position and 1.48 ± 1.39 Gy in prone position (p=0.320). None of the parameters were statistically significant.

## DISCUSSION

Breast radiotherapy is complicated due to uneven contour of the breast and close proximity of it to lung and heart. Various methods have been tried to reduce dose to heart and lung viz., Conformal radiotherapy, respiratory gating techniques, Prone positioned radiotherapy, surface mould brachytherapy and others. Prone positioned radiotherapy is an easy method of sparing the OARs, without the need of much technicality. An indigenous or commercial prone breast board is however required.

During prone positioning of the patient, the breast hangs down due to gravity, thereby moving away from the chest wall, resulting in reduced radiation exposure to lungs. Breast irradiation in this position will reduce dose to lungs. AM Kirby et al. [11] compared non-target tissue dosimetry in prone versus supine positioning for whole and partial- breast radiotherapy. The ipsilateral lung mean dose was 1.2 Gy (0.3-1.4) in supine Partial Breast Irradiation (PBI) versus 0.4 Gy (0.2-0.8) in prone PBI (p<0.001). KL Griem et al. [12] compared V10 and V20 of ipsilateral lung during WBI. V20 was 266.64 cc (SD 121.54 cc) in supine vs 75.23 cc (SD 44.86 cc) in prone (p<0.0001).

In prone position the target volume swings away from heart and chest wall in left sided breast cancer, seemingly reducing the dose to the heart. However, heart too falls forward in the mediastinum towards the chest wall. AM Kirby et al. [11], showed that in the study population of 30 patients prone position improved the heart and LAD dose in 7 of them and worsened in 19. Heart Dmean was 0.3 Gy (0.3-0.5) in supine versus 0.4Gy (0.3-0.6) (p=0.09). Impact of CTV volume was assessed in this study which showed CTV ≤ 1000 cc cardiac dose increased significantly with prone position.

The target volume is usually a spherical structure edited with OAR restrictions. However, post lumpectomy when the seroma is drained an empty cavity remains which is filled by adjacent breast tissue changing the simple spherical volume. Further when a patient is positioned supine owing to the curvature of the chest wall the breast falls back on it and the volume flattens out. Hence the target volume separation along the plane tangential to chest wall increase attributing to the target dose inhomogeneities. This problem gets accentuated in pendulous breasts. In prone position the breast hangs down due to the gravitational effect thereby causing in a decrease in target volume separation translating into decreased dose inhomogenity. However, this doesn't significantly improve the dose coverage in the target volume as shown in the current study. J Buijsen et al. [13] showed Dmean PTV was 49.8 ± 0.8 Gy in supine and 48.2 ± 1.2 Gy in prone position (p=0.02).

Our study used same patient to generate both supine and prone position plan thus each patient was their own control. A dedicated prone breast board was used to have a reproducible patient position. Supine breast board with elevation also inherently reduced the dose to the lung.

This study had few drawbacks. ITV was not incorporated owing to the respiration. The sample size was small to draw inferences. Prone position was uncomfortable for most of the patient during simulation and hence will be difficult to reproduce during treatment. Patient comfortability and difficulty reproducing it are important hurdles in prone breast RT.

## CONCLUSION

Supine position Radiotherapy is the most commonly used treatment position. Prone position Radiotherapy has shown to reduce the dose to the lung, however the dosimetric benefit of prone radiotherapy translating to a clinical benefit of significance needs to be further evaluated.

## DECLARATIONS

The authors state that they have no conflict of interest.

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