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Scientific Paper

Three dimensional conformal radiotherapy for synchronous bilateral breast irradiation using a mono iso-center technique

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Abstract

Objective: The purpose of this study is to demonstrate the synchronous bilateral breast irradiation radiotherapy technique using a single isocenter.

Materials and Methods: Six patients of synchronous bilateral breast were treated with single isocenter technique from February 2011 to June 2016. All the patients underwent a CT-simulation using appropriate positioning device. Target volumes and critical structures like heart, lung, esophagus, thyroid, etc., were delineated slice by slice in the CT data. An isocenter was placed above the sternum on the skin and both medial tangential and lateral tangential of the breast / chest wall were created using asymmetrical jaws to avoid the beam divergence through the lung and heart. The field weighting were adjusted manually to obtain a homogenous dose distribution. The planning objectives were to deliver uniform doses around the target and keep the doses to the organ at risk within the permissible limit. The beam energy of 6 MV or combination of 6 MV and 15 MV photons were used in the tangential fields according to the tangential separation. Boluses were used for all the mastectomy patients to increase the doses on the chest wall. In addition to that enhanced dynamic wedge and field in field technique were also used to obtain a homogenous distribution around the target volume and reduce the hot spots. The isocenter was just kept on the skin, such that the beam junctions will be overlapped only on the air just above the sternum. Acute toxicity during the treatment and late toxicity were recorded during the patient's follow-up.

Results: During the radiotherapy treatment follow-up there were no acute skin reactions in the field junctions, but one patient had grade 1 esophagitis and two patients had grade 2 skin reactions in the chest wall. With a median follow-up of 38.5 months (range: 8 - 49 months), no patients had a local recurrence, but one patients with triple negative disease had a distant metastases in brain and died after 28 months.

Conclusions: We were able to successfully treat the synchronous bilateral breast using single isocenter radiotherapy while keeping the lung and heart doses within the acceptable dose limits. During the treatment follow-up there were no symptoms of acute skin reactions in the field junction.

Key words: bilateral breast; synchronous bilateral breast; mono isocenter.

Introduction

Synchronous bilateral breast cancer (SBBC) incidence is uncommon; it accounts approximately 2% of the total breast cancer patient's population, routine use of contra-lateral breast screening has led to the increases in occurrence [1]. Still there are no clear guidelines in the diagnosis and management of synchronous bilateral breast cancer patients; radiotherapy has a clear indication in the loco-regional control. Radiotherapy treatment planning for bilateral breast is always controversial due to its large irregular geometry, issue of junction overlapping and a saving the organ at risk (OAR). A conventional tangential field with dual isocenter is clumsy and has a potential disadvantage of overlapping and missing the region of interest. Many author's had tried with Tomotherapy, Intensity modulated Radiotherapy (IMRT) and volumetric Modulated Arc Radiotherapy (VMAT) to overcome overlap problem and saving the OAR's [2-4].

Materials and Methods

Patient selection

From February 2011 to December 2015, 332 patients were treated with radiation for breast cancer in our center, which includes six patients (1.82%) with synchronous bilateral breast cancer patients were treated with the proposed single isocenter technique. Out of the six patients, three had bilateral breast conservation surgery; two had bilateral mastectomy done and one patient with right side mastectomy and left side breast conservation surgery. All the patients underwent axillary dissection during the surgery prior to the radiotherapy. The mean age of the SBBC patient was 50.5 yrs (range 35 to 63 yrs). Histopathology reveals out of six patients, three patients were diagnosed with invasive ductal carcinoma, two patients with ductal carcinoma in situ and one patient had papillary carcinoma. All the patients received adjuvant chemotherapy prior to radiotherapy. Patient demographic data is listed in the **Table 1**.

Table 1. Patient demographic data

Patient demographic data	Numbers
Sex	
Female	6
Age	
35 to 40	2
40 to 50	2
50 to 60	1
Above 60	1
Surgery	
Bilateral lumpectomy	3
Bilateral mastectomy	2
Right mastectomy & left lumpectomy	1
Histopathology	
Invasive ductal carcinoma (IDC)	3
Ductal carcinoma in situ (DCIS)	2
Papillary carcinoma	1
Right breast tumour status	
T1 (< 2cm)	2
T2 (2 to 5cm)	2
T3 (> 5 cm)	2
Left breast tumour status	
T1 (< 2cm)	2
T2 (2 to 5cm)	3
T3 (> 5 cm)	1
Right axillary nodal status	
Node negative	2
N1 (1 to 3 nodes +ve)	2
N2 (4 to 9 nodes +ve)	1
N3 (10 or more nodes -ve)	1
Left axillary nodal status	
Node negative	2
N1 (1 to 3 nodes +ve)	1
N2 (4 to 9 nodes +ve)	2
N3 (10 or more nodes -ve)	1

CT Simulation

All the patients underwent a Computed tomography (CT) simulation (GE Discovery 600 PET-CT) in supine position with arms above the head. A radio opaque brass wire was kept around the breast surface for the landmark identification. CT slices with 2.5 mm thickness were acquired using either 'T' grip wing board or MT-350 Breast board (M/S Civco, USA) as a positioning device depends upon the patient's body geometry. Wing board was preferred, if the patient chest was flat without slope on a flat surface, otherwise breast board with 10 to 30 degree angle was used to make an entire chest flat. The DICOM images from the CT control console were transferred to the treatment planning system. The images were imported in the Eclipse treatment planning system (M/S Varian Medical System, Palo Alto, USA).

Target and organ and risk delineation

All the critical structures like heart, lung, thyroid, esophagus, left anterior descending artery (LAD), left ventricle (LV), spinal cord, both lungs, etc., were delineated. Both the breasts were delineated for breast conservation surgery patients, and bilateral chest wall were delineated for the mastectomy patients as a clinical target volumes (CTV). An additional margin of 5mm isotropic margin was given around the CTV to generate planning target volume (PTV). CTV boost volume for the lumpectomy patients were delineated with the aid of surgical clips, cavity and other radiological and clinical information available for the patients. A PTV boost volume has been created by giving additional 5 mm isotropic margin around the CTV boost volume. **Figure 1** illustrates the target and OAR delineation in different planes.

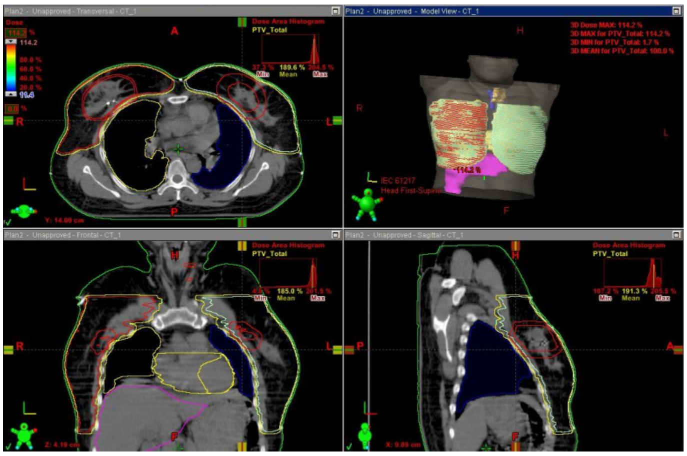

Figure 1. Target and OAR delineation of bilateral breast patient.

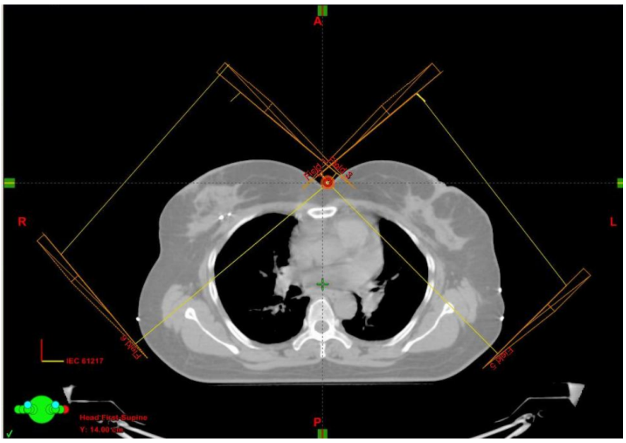

Figure 2. Isocenter placement of single isocenter bilateral breast technique.

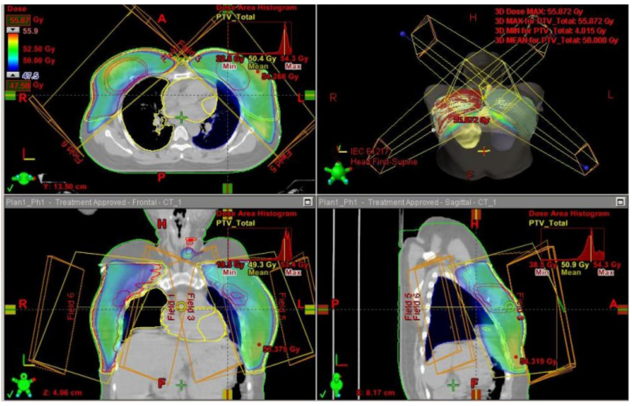

Figure 3. Dose distribution on the bilateral breast patient.

Treatment Planning

All the patients were planned with Eclipse treatment planning system with an intent dose of 50 Gy in 25 fractions for the whole breast / chest wall and followed by 15 Gy in 5 fraction boost only to the PTV boost volume for the breast conservation surgery patients. An isocenter was placed above the sternum on the skin and both medial tangential and lateral tangential of the breast / chest wall were created using asymmetrical jaws to avoid the beam divergence through the lung and heart (**Figure 2**).

The collimator was rotated to 90 degree to utilize the enhanced dynamic wedges (EDW) for compensating the breast tissues as well as to have a sharper penumbra using the lower jaws in the field junctions. As the isocenter was placed on the skin above the sternum both the tangential fields beam weighting were adjusted to obtain a homogenous dose distributions and a supraclavicular field using a gantry at zero degree was also added if needed using the asymmetrical jaws and the field weighting were adjusted as per the requirement. The beam energy of 6 MV or combination of 6 MV and 15 MV photons were used in the tangential fields according to the tangential separation and bolus were used for all the mastectomy patients to increase the doses on the chest wall. In addition to that EDW and field in field technique were also used to obtain a homogenous distribution around the target volume and reduce the hot spots. The isocenter was just kept on the skin, such that the beam junctions will be overlapped only on the air just above the sternum. **Figure 2** shows the beam placement of the bilateral breast radiotherapy using a single isocenter technique. The tangential and medial tangential fields were also collimated if necessary or shielded with MLC according to the PTV volume. The analytical anisotropic dose calculation algorithm (Version 11.0) was used for the dose calculation for all the patients. **Figure 3** illustrates the 95% dose distribution on the bilateral breast patient. All the patients were treated with Clinac 2100 DMX or True Beam Linear Accelerator (Varian Medical Systems, USA) both equipped with millennium-120 leaf MLC and On-Board Imager.

Plan quality and dosimetric data of the patients

ICRU 83 report [5] released in 2010 used different concepts of plan evaluation parameters to evaluate the plans; we used the ICRU 83 definition to determine the dose conformity. Dose conformity and homogeneity are independent specifications of the quality of the absorbed dose distribution. Dose conformity characterizes the degree to which the high dose region conforms to the target volume whereas dose homogeneity characterizes the uniformity of the absorbed dose within the target volume.

Homogeneity Index (HI)

$$Homogeneity\ Index = \frac{D_{2\%}-D_{98\%}}{D_{50\%}} \qquad \text{Eq. 1}$$

Where $D_{2\%}$, $D_{98\%}$ and $D_{50\%}$ represents the doses received by 2%, 98% and 50% volumes of the PTV. HI = 0 (zero) is ideal value.

Conformity Index (CI)

In 1993, Radiation Therapy Oncology Group recommended conformity index (CI) as a ratio of the reference isodose volume to the target volume.

$$CI_{RTOG} = \frac{V_{RI}}{TV} \qquad \text{Eq. 2}$$

Where, V_{RI} is a reference isodose volume, and TV is the target volume.

Mean and maximum doses were documented for the parallel and serial architecture structures. Additional parameters such as V_5 (volume receiving at least 5 Gy), V_{10}, V_{20} and V_{30} for lungs, thyroid, heart and esophagus were documented.

Patient follow-up

Patients were followed up every week during the treatment to document the acute toxicity and late toxicity was documented after four weeks of completion of the treatment. All the patients tolerated the treatment well without any grade three or four acute toxicity. During the treatment, 2 patients had grade 2 skin reactions and one patient had a grade one esophageal toxicity. The patients were followed up with every 3 months interval for the first year after completion of the treatment and from second year the patients were followed up with six month intervals. With a median follow-up of 38.5 months (range: 8 - 49 months), no patients had a local recurrence, but one patients with triple negative disease had a distant metastases in brain and died after 28 months. One patient lost to follow-up after two year of completion of treatment and the patient was disease free and asymptomatic at that period.

Results and Discussion

Patient's demographic data has been listed in the **Table 1**. PTV total structure was generated using Boolean operation i.e., PTV (Total) = PTV (Right Breast / Chest Wall) + PTV (Left Breast / Chest Wall) ± Supraclavicular fossa to determine the homogeneity and conformity index using the **Equation 1** and **2**. The mean homogeneity index and conformity index of all the patients were 0.089 (range 0.079 - 0.094) and 1.33 (range 1.28 - 1.39). The mean V_{20} for the total lung was 16.7% (range 15.3% to 18.9%), whereas the mean V_5, V_{10} and V_{30} were 36.6%, 27.6% and 10.7% respectively. The mean lung dose of both the lungs of all the patients was 15.7 Gy. Gokula *et al* [6] quoted in his meta-analysis report that extensive research works done to correlate the V_X (volume receiving 'x' dose) volume with the radiation pneumonitis using 3-dimensional conformal radiotherapy for breast cancers and found no clear threshold dose for symptomatic radiation pneumonitis. But the collected data showed 20% risk of radiation pneumonitis for a mean lung dose of 20 Gy, in our study the mean lung dose was well within this limit around 15.7 Gy. Lind *et al* [7] found that the mean lung dose got a significant correlation with the grade of radiation pneumonitis, the mean lung dose was 7.5 Gy, 13.5 Gy and 16.0 - 16.6 Gy for no, mild and moderate radiation pneumonitis respectively.

The mean heart dose was 4.7 Gy and the mean V_5, V_{10}, V_{20} and V_{30} were 24.9%, 20.7%, 16.75 and 11.58% for all the patients. Darby *et al* [8] done an extensive study on effect of radiation dose to subsequent risk of ischemic in 2168 women who underwent breast radiotherapy and found that the rates of major coronary events has a increase linear correlation with the mean dose to the heart by 7.4% per Gy with no apparent threshold. The increase in the coronary event observed within the first 5 years after radiotherapy and continued until the third decade. There were no acute and late pulmonary and cardiac toxicity was noted during the follow-up. Since the late effects of lung and cardiac toxicity arises after 5 to 15 years, hence further follow-up is required to certainly comments on the late toxicity.

There are many publications published with mono isocentric bilateral breast treatment using IMRT, VMAT and tomotherapy, but this is the first research paper of this kind (according to our knowledge) for the treatment of bilateral breast radiotherapy using a conventional 3 dimensional radiotherapy with a single isocenter technique. The concept of this technique is simple such that the mono-isocenter is placed just on the skin above the sternum region to avoid the junction of the both the bilateral tangential fields and forcing the beam junction happening in the air just above the skin. In our study all the patients under went daily image guidance technique using a paired-orthogonal imaging using an on-board imager, this will ensure that the geometry of the beams created in the treatment planning system were executed in the similar manner. The anterior images were matched with the carina to correct the lateral and superior-inferior direction and in the lateral images, sternum was used as a bony landmark for matching in the anterior-posterior direction with respect to the digitally reconstruct radiograph.

We also recommend to practice this technique with daily image guidance using an on board imager / portal imager for safe practice and to avoid any setup / human error, which may potential harm the patients.

During the patient simulation it is very important to keep the patient chest flat without any slope around the sternal region using a breast board with appropriate angle which will make your treatment planning easier.

Conclusions

We were able to successfully treat the synchronous bilateral breast using single isocenter radiotherapy while keeping the lung and heart doses within the acceptable dose limits. During the follow-up there were no acute skin reactions in the field junctions for all the patients, out of six patients, one patient had grade one esophagitis, two patients had grade two skin reactions in the chest wall and no other acute and late toxicities were documented.

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