A Quantitative Analysis of Dose Distributions of Two Tangential Whole Breast Irradiation Techniques

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Abstract: We compared DVHs (dose volume histograms) of two tangential irradiation techniques for whole breast RT (radiotherapy): CT (computed tomography) based 2D (two dimensional) technique with wedge filters and 3D CRT (three dimensional conformal radiotherapy) with segmented fields. These two modalities are commonly used in external beam radiotherapy of breast cancer in Clinical Center Nis, Clinic of Oncology, Serbia. Therapy plans that employed two techniques were generated for eighteen patients. Dosimetric outcomes of each technique were investigated. The maximum dose of breast CTV was significantly reduced from 55.83 Gy for 2D to 54.1 Gy for 3D CRT. Also, the maximum dose of lung tissue decreased from 51.81 Gy for 2D to 49.61 Gy for 3D. The dose conformity and uniformity were much better with 3D CRT segmented field technique.

Key words: Breast cancer, conformal technique, virtual simulation, tangential fields, segmented fields.

1. Introduction

Breast cancer is the most common malignancy in women. Whole breast radiotherapy after breast conserving surgery is regarded as the standard treatment for early stage breast cancer [1]. Breast cancer patients make 30% of all RT (radiotherapy) patients in the clinic. We have started to use 3D CRT (three dimensional conformal radiotherapy) since 2009. The most of breast cancer patients are treated routinely with this technique. Three dimensional approach in CT simulation allows VSim (virtual therapy simulation) of breast cancer patients that is more time effective. The standard technique in RT of breast cancer is two opposing tangential photon beams [1-3]. We performed a quantitative evaluation of the dose distribution using two tangential beams modalities of whole breast irradiation: virtual simulation of beams with physical wedges and conformal fields with segments.

2. Materials and Methods

Eighteen patients were included in this study

ranging from 35-63 years of age. All the patients had left side breast cancer in early stage and were node negative. There were thirteen patients with pathologic stage I and five patients with stage II. Tumor size was less than 2 cm in seventeen patients and only one patient had tumor size more than 2 cm. Breast-conserving surgery has been performed on all of them, and external beam whole breast irradiation after.

Patients are immobilized in the supine position with Extended Wing Board (Civco Medical Solution, USA). Both arms of the patient are raised above patient's head. Clinical borders of breast tissue are marked with wire. The breast is marked with radio-opaque markers that are visible on CT in the medial, lateral, superior, and inferior directions. CT acquisition was performed from the neck to the abdomen with multislice CT scan dedicated for radiotherapy (Siemens Sensation Open with Coherence Dosimetrist software, Siemens, Germany). Radiation oncologist delineates breast CTV (clinical target volume) and OARs (organs at risk) according to the RTOG (Radiation Therapy Oncology Group) recommendations [4]. Radiation oncologist defines tangential beams using 3D patient

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data. TPS (treatment planning system) (XiO, version 4.40, CMS) was used to generate 2D and 3D plans for all patients. For 2D plans, dose distribution of two tangential high energy 6 MV beams was improved with physical wedges (15°, 30°, 45°, 60°). Conformal plans with segmented fields (Fig. 1) are based on fundamental tangential technique. Segmented fields are copies of high energy 6 MV beams which are made by blocking 110% isodose with the help of MLC (multi-leaf collimator). We usually use one segment per beam. Calculated number of accelerator monitor units is about twelve. Approved plans are digitally transferred to Oncor Impression (Siemens, Germany) linear accelerator.

The treatment dose for each patient was 50 Gy in 25 fractions. The dose was prescribed according to the ICRU (International Commission on Radiation Units and Measurements) Reports 50 and 62 recommendations [5]. The dose width is preferably to be between 95% and 107% isodose lines. The target

coverage and sparing of organs at risk were evaluated from cumulative DVHs for both plans. For breast CTV, we recorded and compared maximum and mean doses, volumes of breast tissue in percent receiving at least 95% (V95) and 100% (V100) of the prescribed dose. Dose volume reporting was followed with D50, D95, D98 and D2, which represent the doses to the 50%, 95%, 98% and 2% of the target volume, respectively. Radiation dose HI (homogeneity index) and CI (conformity index) were calculated [5]. While, for OARs we investigated maximum and mean doses and volumes of lung receiving more than 20 Gy (V20).

3. Results

Eighteen radiotherapy patients with left side breast cancer were treated and DVH parameters (Fig. 2) were compared for standard tangential CT based technique and for 3D CRT with segmented fields. Number of patients was not significant for analysis of

Fig. 1 Conformal technique with segmented fields.

Fig. 2 Dose volume histograms for segmented fields 3D (solid) and 2D (dashed) techniques for whole breast irradiation.

Table 1 Dose-volume values for breast CTV.

CTV	3D CRT	2.5D	<i>p</i>
Dmax (Gy)	54.1 ± 0.55	55.83 ± 1.11	< 0.001
Dmean (Gy)	50.94 ± 0.47	50.93 ± 0.82	NS
V100 (%)	75 ± 10.4	80 ± 9.6	NS
V95 (%)	97 ± 1.4	94.5 ± 2.9	< 0.05
D98 (Gy)	47.07 ± 0.75	40.09 ± 9.76	< 0.05
D50 (Gy)	51.22 ± 0.55	51.38 ± 0.68	NS
D95 (Gy)	48.26 ± 0.55	47.26 ± 2.32	NS
CI	0.97 ± 0.01	0.95 ± 0.03	< 0.05
HI	12.04 ± 1.68	28.15 ± 19	< 0.05

uncertainty. Comparison of mean values of dose and volume parameters for breast tissue and OARs was made using student *t* test. Results are represented as mean values and SD (standard deviation).

For breast CTV (Table 1), there were not any significant difference of D50, D95 and mean doses when comparing 2D with 3D CRT. Both modalities of irradiation give acceptable dose distribution inside the target volume. Also, we found that V100 value was 75% of the target volume for 3D CRT while for virtual therapy simulation it was 80% (NS). Values outlined for V95 volumes were increased from 95% to 97% in favor of 3D CRT and accordingly the dose

conformity index ($p < 0.05$). The maximum dose of breast CTV was significantly reduced (from 55.83 ± 1.11 for 2D to 54.1 ± 0.55 for 3D CRT). Moving from 2D to 3D the dose homogeneity index was decreased from 28.15 ± 19 to 12.04 ± 1.68. Regarding dose changes inside the target volume, 2D plans do not fulfil the ICRU quality criteria (HI should be less than 15) [2, 5].

For organ at risk (Table 2), the maximum dose for lung tissue was significantly reduced (51.81 ± 2.43 for 2D and 49.61 ± 1.84 for 3D). Deviations of mean values of other dose and volume parameters were not significant.

Table 2 Dose-volume values for OAR.

OAR	3D CRT	2D	p
LUNG			
Dmax (Gy)	49.61 ± 1.84	51.81 ± 2.43	< 0.001
Dmean (Gy)	5.38 ± 1.86	5.55 ± 1.23	NS
V20 (%)	9.78 ± 4.15	9.89 ± 2.86	NS
HEART			
Dmax (Gy)	39.54 ± 11.14	40.06 ± 14.31	NS
Dmean (Gy)	1.94 ± 1.52	1.87 ± 1.16	NS
CONTRALATERAL BREAST			
Dmax (Gy)	1.83 ± 0.71	2.14 ± 0.42	NS

4. Discussion

Probability of curative intent in radiotherapy has been increased with patients treated with 3D CRT [1-3]. The most of RT departments use nowadays standard three dimensional conformal technique because of homogenous and tailored dose distribution inside the target volume while sparing healthy tissue. The most of the patients in our clinic are treated routinely with conformal technique, other with virtual therapy simulation. We compared two techniques in order to establish quality improvement. Virtual therapy simulation used 3D anatomical patient data [1, 2] and, based on this procedure, dose volume parameters Dmean, D50, D95 and V100 for 2D and 3D therapy planning were comparable for breast CTV. The dose distribution was acceptable for both plans. Our analysis of dose changes inside the breast glandular tissue is expected and consistent with many papers showing improvement of dose uniformity when using segmented field technique instead of standard 3D CRT in breast cancer radiotherapy [2, 4]. The values V95, CI and Dmax for lung tissue were also consistent with the literature data [2, 4].

Standard three dimensional conformal technique in radiotherapy is necessary modality in treating patients. Based on 3D approach in radiation therapy simulation, conformal tangential technique with segmented fields is superior to standard tangential technique with wedge filters in terms of dose uniformity for whole breast radiotherapy.

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