

RESEARCH ARTICLE

Effects of Millimetric Shifts in Breast Cancer Radiotherapy on the Radiation Dose Distribution

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Abstract

Background: This study aimed to facilitate decision-making in cases of breast cancer radiotherapy shifts by simulating millimetric shifts and analyzing their effects on dose distribution. **Methods:** The study included 30 patients with left side breast cancer who were treated with three dimensional conformal radiotherapy (3D-CRT) in the Radiation Oncology Department in Hatay Public Hospital, between January 2013 and April 2015. A treatment plan shifting at three axes with six different measures was simulated. **Results:** The biggest difference in values was (+3mm shift) 476cGy, with a 7.7 % change for heart and 25.6% for spinal cord. The shifts in values respectively for CTV min, mean, max were -4.8%, 2.5%, 4%. The differences for lymphatic min, mean, max were 21.3%, 20.3%, -12.2%. **Conclusion:** The most important thing is not the treatment plan quality, but its practicality. The treatment plan must be practical and its practice must be controlled rigidly.

Keywords: Breast cancer - radiotherapy - millimetric shifts - radiation dose distribution

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Introduction

Patients with breast cancer has a long survival rate after treatment and this disease has become an ordinary one in Turkey and all over the world (Ferlay et al., 2010; Carter et al., 1989). Radiotherapy is an important part of the treatment procedure. Radiotherapy has two parts, namely planning and practice. Physicians and medical physicist work together during the planning part; the technicians play a big role during its practice. The most important part is the correction implementation of plan and practice (Wigg et al., 2001). The practice must be carried out precisely as it has been planned. It is commonly observed that the patients move intrafractions and do not lie down on the treatment table in the same position each day. Technicians control the shifts but cannot make the necessary corrections the plan by 1 or 2 millimeters. There is no significant data about the effects of these millimetric shifts. Correcting the position of all patients is virtually impossible because of time and workload concerns but if the shifts are not corrected the treatment could fail and this could cost the patient's life. Could we overlook some shifts or should we correct them all?

Materials and Methods

The study included 30 patients with left side breast cancer treated with three dimensional conformal radiotherapy (3D-CRT) in our department between January 2013 and April 2015. The ages of the patients

were between 35 and 66. All patients had similar treatment fields and contoured pattern like RTOG contouring atlases (Gentile et al., 2015). Every patient's treatment plan was 5000cGy in 25 fractions to breast or chest wall and lymphatic field. Every patient had lymphatic treatment field including supraclavicular fossa and axillar levels. Thirteen of them had breast conserving surgery (BCS) and boost radiotherapy. Boost dose given to BCS patients was 10Gy. Boost radiotherapy doses were not studied in the analysis. We designed the study by excluding the effects of boost radiotherapy because of the small field and long distance from organs at risk (OAR).

We designed the shifts in three axis same. Six different shifts were calculated by Medical Physicists and Eclipse Planning System was used. Every shift was planned

Table 1. ?? [PLEASE SUPPLY]

		Values
Age		35-66
Treatment Fields	Chest Wall	17
	Breast	13
Dose	Heart	442cGy (214-803)
	Lung	686cGy (476-798)
	Spinal	2014cGy (938-3463)
	Healthy Breast	360cGy (94-586)
	CTVmin	4263cGy (3857-4614)
	CTVmean	5076cGy (5026-5153)
	CTVmax	5392cGy (5289-5457)
	Lymph min	4564cGy (4487-4706)
Lymph mean	4990cGy (4901-5140)	
Lymph max	5281cGy (5118-5469)	

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Table 2. ?? [PLEASE SUPPLY]

	Original	1	-1	2	-2	3	-3
Heart	442%	7.2%	6.3%	7.5%	5.2%	7.7%	6.6%
Lung	686%	6.3%	8.5%	4.8%	8.6%	3.5%	11.1%
Spinal Cord	2014%	4.9%	1.7%	-1.9%	-0.5%	-9.5%	25.6%
Healthy Breast	360%	18.8%	18.1%	21.4%	17.5%	20.5%	16.9%

Table 3. ?? [PLEASE SUPPLY]

	Original	1	-1	2	-2	3	-3
CTVmin	4263	2%	1.5%	2.5%	-4.8%	2.6%	0.3%
CTVmean	5076	0.6%	0.5%	0.7%	0.3%	2.5%	0.7%
CTVmax	5392	3.6%	3.9%	3.9%	4%	2.7%	3.8%
Lym min	3678	16.4%	21.3%	14.3%	-2.3%	17.2%	8%
Lym mean	4290	18.9%	18.5%	20.3%	-4.3%	19.8%	16.9%
Lym max	5281	2.5%	2.2%	1.4%	-12.2%	5.7%	2.4%

Table 4. ?? [PLEASE SUPPLY]

	1	2	3	-1	-2	-3
Dose Change	8.1%	7.9%	9.2%	8.3%	6%	9.2%

as 1mm difference. +1 mm shifts at all axis from the originally planned isocenter, followed by +2mm and +3mm differences. The opposite direction shift as -1mm, -2mm and -3mm were also investigated. Finally, we have 7 different dose results and plans. We compared all results with the original plan and search for dose differences. SPSS 17.0 was used for variables and data analyses. Minimum, mean and maximum doses were analyzed for CTV & Lymphatic volumes. Mean doses for heart and lung, max doses for spinal cord (SC) and healthy breast (HB).

Results

Patient characteristics are summarized in Table 1. Median age of all patients was 52 years (range: 35-66 years). There was not any significant difference in demographic or dose distribution characteristics. The average dose of original plan for heart was 442cGy. The most different value was (+3mm shift) 476cGy and 7.7% change. The most different value for lung was (-3mm shift) 762cGy and 11.1% change from original dose (686cGy). Average dose of original plan for spinal cord was 2014cGy. 2530cGy and 25.6% change for -3mm shift. The shifts differences of OAR from original plan are summarized in Table 2. We analyzed minimum, mean and maximum dose values of CTV and lymphatics summarized in Table 3. The most different values respectively for CTV min, mean, max were -21.3%, 20.3%, -12.2%.

Discussion

We designed this study to make the decision making process easier in relation to intrafractional moves in order to decrease the workload of oncology departments (Wigg DR and Morgan GW, 2001). Heart volume dose changes were between 5.2%-7.7. There is no significant difference between consecutive shifts. This data is not helpful to

decide whether some of the shifts can be overlooked, but it shows a more important result. If heart dose was high in the treatment plan (Bentzen et al., 2010), utmost care is necessary because even a 1mm shift can change the dose more than 7%. But this change can occur if the shift is the same in every fraction of treatment. Just one fraction change was 0.03%.

There was no significant difference in other OAR and Treatment volumes between consecutive shifts. For lung, 3.5% - 11.1 difference, and for healthy breast 16.9% - 21.4. Most of the dose changes show us higher doses although analyses show that dose changes could be decreasing or increasing (Redpath AT and Muren LP 2006). Spinal cord dose changes -9.5% 25.6%, it is very variative. That would be about point dose analyses. But we do not know cold spot and hot spot in same place. At one fraction 1.03% change could occur. If the spinal cord maximum dose at treatment plan was 45Gy that would be 45.5Gy in one fractional shift. So, it can be said that, if the plan has risky doses for OAR, be more careful and inform your technicians.

Dose changes were higher for lymphatic volume than CTV (chest wall or breast). CTV dose change for 1mm shift is 2% and 13% for lymphatic volumes. When we turn back to planning software, we discovered that the volumes look similar to spheric design and inside the homogen tissues effect the dose change minimum. That could be the reason for huge change between CTV and lymphatic volume.

Analyzing the shifts we calculate the average of all volumes in consecutive shifts (Table 4). 6% for -2mm shift was the smallest change. There was a big difference between -2mm and -3mm shift, but that is not a useful data for practice.

When this study was designed a lot of possibilities that would change shifts and dose changes were also taken into account. We could simulate more patient data or other cancer data like prostate, pancreas etc. The most important thing was possible combinations. We designed same value for all axis like +1mm every dimension +2mm, and +3mm for every dimension, but this could be randomized like 0mm to one axis, 3mm for another and -1mm for last one. 342 different combinations are possible, but we chose to

simulate a few to guess the big picture.

In Conclusion, When we started this study, we planned to decrease the workload of technicians and have a clear conscience at the same time. The study showed that the most important thing is not your treatment plans quality, but its practicality. The treatment plan must be practical and its practice must be controlled rigidly.

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