Contralateral Breast Exposure to Radiation; Does Linear Accelerator Gives any Advantage Over Cobalt Unit?

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ABSTRACT

Introduction: With better understanding of tumor behavior, availability of better chemotherapeutic agents, radiotherapy equipment, techniques and development of oncosurgery, the survival in carcinoma breast has significantly improved. Longer survival has lead to increased incidence of late side effects of treatment. As breast cancer is the commonest malignancy among women, the late effects in this disease are a matter of concern. One of late effect of treatment is malignancy of contralateral breast (CLB).

Material and Methods: In this study, we compare dose to CLB during irradiation of diseased breast on cobalt and linear accelerator (LA). Measurement of CLB was done in 50 patients undergoing radiotherapy for carcinoma breast following surgery; 25 on cobalt teletherapy machine and 25 on LA unit. Standardized and precalibratedCaSO4: DyThermoluminescent discs (TLD) were used for the dose measurement.

Results: For all patients, the total dose to the CLB was more with Cobalt unit- 168.29cGy (3.36%) than with LA 120.77cGy (2.41%)($p<0.001$). At gantry angle more than 50 degree, the dose received was more for both cobalt and LA units ($p=0.199$ for cobalt and $p=0.682$ for LA).

Conclusion: With the advancement of techniques like three dimensional conformal radiotherapy and Intensity Modulated Radiotherapy with linear accelerator, we can reduce the CLB dose as compared to conventional cobalt teletherapy.

Keywords: Cobalt, Linear Accelerator, Contralateral Breast, Thermoluminescent Disc

INTRODUCTION

Breast cancer is the most common malignancy among the women worldwide. Radiotherapy plays an important role in the management of carcinoma breast. Radiotherapy is a double edged sword in the treatment of cancer because its use in treatment of cancer is well known; however, it may also cause second malignancy. The minimum dose of ionizing radiation causing second malignancy cannot be defined because it is a stochastic effect, a minimal dose may cause cancer; however, intensity of second malignancy increases with increase in radiation dose. During the course of irradiation to the chest wall, some dose, which may range from few cGy to Gy, is also delivered to the contralateral breast (CLB) due to scattered radiation. Breast is highly radiosensitive tissue so, radiation induced malignancy is a major concern, especially in women of younger age.[1,2] Dose received by CLB during the course of treatment depends upon various factors; energy of incident photons, gantry angle at which dose was delivered, half beam block, radiotherapy technique and type of beam used (photon/electron). Several studies had proved the role of ionizing radiation in causing the second malignancy to CLB after the radiation given to affected breast after a long follow up. Half beam is routinely used in the treatment of breast cancer to reduce the dose to lungs. Studies have shown that the dose to CLB was maximum with half beam with custom block or breast cone and least with half beam with symmetrical jaws.[3] Dose received by CLB also depends upon the angle of the gantry at which radiation dose was delivered. If gantry angle is more than 50 degree, the scattered dose to CLB was increased.[4] In this study, we compare the dose received by CLB with cobalt and linear accelerator (LA) machine during the course of treatment of diseased breast.

MATERIAL AND METHODS

This study was done at Acharya Tulsi Regional Cancer Treatment and Research Centre, Bikaner, Rajasthan, India. Patients selection was based on inclusion and exclusion criteria. Before including the patients in the study a written informed consent was taken from them and ethical approval was taken from the institutional ethical board. Measurement of CLB was done in 50 patients (sample size calculation was done by t-test method) undergoing radiotherapy for cancer breast; 25 on cobalt teletherapy machine (Theratron 780 C and E, Canada) and 25 with LA (Varian, Palo Alto, USA) following modified radical mastectomy (MRM). Standardized and precalibrated CaSO4: Dy TLDs (9mm×13mm) were used for the dose measurement. The chips were placed on the surface of CLB; one at the level of the nipple and other two on either side of nipple along midline 3 cm away from nipple. Skin tattooing was done to demarcate the exact position at the first sitting and this was used subsequently to replicate the position. After exposure, the chips were removed and new set of three chips was placed to measure next exposure. The TLDs were stored in a radiation free room and the readings were taken after 24 hours and within seven days of exposure. The readings were taken with the help of NUCLEONIX TL10091 TLD reader. After one set of readings the chips were annealed by heating (400°C) and then were used for next set of exposure. Dose measurement was

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performed three times in a patient; first week, third week and fifth week. Total 50 Gy was delivered in 25 fractions, 2 Gy per fraction, 5 fractions in a week for five weeks on both the units. On cobalt teletherapy, supraclavicular field (SCL) field was treated daily while medial tangential (MT) and lateral tangential (LT) fields were treated on alternate day. On LA, all the three fields were treated daily. On cobalt unit, SSD technique was used while on LA isocentric technique (SAD) was used. Randomization was done based on computer generated program.

STATISTICAL ANALYSIS

The mean dose received by CLB on both the units was compared (Table 1). Also, the total dose received by CLB, was calculated by multiplication of mean dose to number of fractions (mean dose× no. of fractions). The percentage of radiation dose received by CLB with respect to the prescribed dose to diseased breast (Total dose× 100 / prescribed dose to diseased breast) was calculated and compared. The data was also stratified based on gantry angle at which EBRT was delivered (≤50 degree and > 50 degree).The statistical software SPSS version 20.0 was used for the data analysis.

RESULTS

In our study, 70% (35/50) of patients were < 50 years old. Out of 50 patients, 54% had right sided breast cancer. The mean dose of radiation received by the CLB was stratified according to age (table 2). In the age group 31-40 years, the total dose received with cobalt unit was 196.437 cGy (3.93%) while with LA, the total dose received in this age group was 112.687cGy (2.42%)(p<0.007). In the age group 41-60 years, the total dose received by CLB was less with LA but statistically not significant. Dose to the CLB was more with LA 118.0cGy (2.36%) than cobalt unit 97.875cGy

Patient Wise Dose Measurement On Cobalt Unit								Patient Wise Dose Measurement On Linac						
S. no.	Age	Gan-try Angle	Dose(cGy) MT	LT	SCL	Total dose	%	Age	Gan-try Angle	Dose(cGy) MT	LT	SCL	Total dose	%
1	31	52	6.88	1.22	1.46	239	4.78	31	55	3.01	0.73	0.85	114.75	2.29
2	31	45	5.66	0.47	0.94	176.75	3.54	38	50	3.81	0.84	1.07	143	2.86
3	35	50	3.44	1.15	1.02	140.25	2.81	40	49	2.87	0.95	0.91	118.25	2.36
4	35	52	4.78	0.54	1.56	167	3.34	40	47	1.99	0.49	0.51	74.75	1.49
5	35	59	7.01	2.48	1.72	280.25	5.61	41	61	3.15	0.86	1.12	128.25	2.57
6	38	48	3.36	1.83	1.87	176.5	3.53	42	53	2.46	1.12	1.14	118	2.36
7	40	56	5.17	1.35	1.19	192.75	3.86	44	52	2.97	1.25	0.58	120	2.4
8	40	47	5.36	1.28	1.32	199	3.98	44	50	3.14	0.73	0.81	117	2.34
9	45	60	6.93	1.01	1.59	238.5	4.76	45	52	1.83	0.43	0.64	72.5	1.45
10	45	58	7.25	1.35	3.05	291.25	5.82	46	42	2.61	1.14	1.67	135.5	2.71
11	45	45	3.23	0.45	1.55	130.75	2.62	46	59	3.3	0.66	0.69	116.25	2.32
12	45	48	2.01	0.51	0.65	79.25	1.59	46	56	3.01	0.88	1.01	122.5	2.45
13	48	46	2.56	0.78	1.14	112	2.24	48	52	2.63	1.12	0.73	112	2.24
14	50	57	3.81	1.22	1.08	152.75	3.06	48	48	3.11	0.91	0.82	121	2.42
15	50	59	1.55	0.42	0.46	60.75	1.22	50	60	2.84	0.98	0.91	118.25	2.36
16	50	49	6.61	0.24	2.14	224.75	4.49	50	53	4.43	1.35	1.01	169.75	3.39
17	50	60	4.14	2.63	1.21	199.5	3.99	53	45	2.52	1.13	0.93	114.5	2.29
18	50	56	3.76	0.62	1.48	146.5	2.93	54	46	2.99	1.13	1.05	129.5	2.58
19	50	45	2.72	0.59	0.77	102	2.04	54	62	3.15	0.8	0.79	118.5	2.37
20	55	45	3.64	0.99	1.08	142.75	2.85	56	51	2.89	0.93	0.92	118.5	2.37
21	55	55	6.86	1.57	1.44	246.75	4.93	58	50	2.56	0.99	1.22	119.25	2.38
22	60	56	2.17	1.9	2.99	176.5	3.53	58	53	3.15	1.25	1.27	141.75	2.83
23	60	65	2.89	1.48	1.07	136	2.72	60	51	3.69	0.87	1.02	139.5	2.79
24	64	56	2.24	2.04	0.81	127.25	2.55	65	45	2.35	1.34	1.13	120.5	2.41
25	70	50	1.52	0.85	0.37	68.5	1.37	67	48	2.92	0.86	0.84	115.5	2.31

MT: Medial tangential, LT: Lateral Tangential, SCF: Supraclavicular Field, %: Percentage

Table-1: Dose Received By Contralateral Breast in Each Patient on Cobalt and LA Units.

Characteristics		Radiation dose (cGy) Cobalt Total	Mean	S.D.	Linear Accelerator Total	Mean	S.D.	T Value	P Value
Age in years	31-40	63.06	7.882	±1.74	18.03	4.507	±1.12	3.468	<0.006
	41-50	69.51	6.319	±2.88	58.04	4.836	±0.86	1.636	0.129
	51-60	28.08	7.02	±2.02	35.25	5.035	±0.44	1.931	0.144
	>60	7.83	3.915	±1.66	9.44	4.72	±0.14	-0.683	0.565
All Patients		168.48	6.739	±2.48	120.76	4.830	±0.76	3.666	<0.001

Table-2: Mean Dose of Radiation Received by the Contralateral Breast According to Age.

Characteristics		Mean Percentage %				T Value	P value
		Cobalt	S.D.	Linear Accelerator	S.D.		
Age in years	31-40	4.09	0.945	2.22	0.606	3.566	0.005
	41-50	3.25	1.481	2.67	0.538	1.224	0.244
	51-60	3.49	1.341	2.47	0.128	1.516	0.226
	>60	1.73	0.876	2.37	0.049	-1.039	0.408
All Patients		3.44	1.354	2.52	0.459	3.205	0.003

Table-3: Percentage of dose received by contralateral nipple

Beam	Percentage of Dose Received by Contralateral breast		
	≤2.37	>2.38≤2.86	>2.86≤5.86
Cobalt Unit	05	05	15
Linear Accelerator Unit	13	12	00

Table-4: Results Stratification; Percentage of Dose Received by Contralateral breast

(1.96%) in patients with age more than 60 years (p=0.569). This was an unusual finding and may be due to small size of sample (n=4). For all the patients, the total dose to the CLB was more with Cobalt unit 168.29cGy (3.36%) than with LA 120.77cGy (2.41%)(p<0.001). The dose to CLB also compared in relation to gantry angle at which EBRT was delivered. At gantry angle more than 50 degree, the dose received was more for both cobalt and LA units (p=0.199 for cobalt and p=0.682 for LA).

In present study, the measured average contralateral nipple dose on cobalt unit was 171.88cGy (55.5-303.80cGy) which accounts 3.47% (1.11%-6.07%) of the prescribed dose (Table 3). The measured average contralateral nipple dose on LA unit was 125.74cGy (78.75-180.00cGy) which accounts 2.51% (1.57%-3.60%) of prescribed dose.

To better understand the implication of this result, the resultant CLB dose is divided into three different ranges: i) less than or equal to 2.37%, ii) 2.37-2.86% and iii) above 2.86% (Table 4). As per the results in our study, the LA is safer in terms of CLB dose, all the 25 patients receiving CLB dose values below 2.86%. Higher dose was delivered from telecobalt machine having 15 patients received doses more than 2.86%.

DISCUSSION

Breast cancer is the second most common cancer in the world and by far, the commonest cancer among women with an estimated 1.67 million new cases diagnosed in 2012 (25% of all cancer).[5] Multimodality treatment of breast carcinoma has resulted in longer survival. Radiotherapy for breast carcinoma inevitably results in radiation dose to the CLB. Several past studies have quantified this risk. Boice et al showed that CLB cancer risk does increase with radiation especially in young women.[6] In our study also 70% of the patients were below 50 years. Thus the need for measuring CLB dose becomes an important issue.

Most of previous studies were phantom based studies but the present study is a clinical study conducted directly on breast cancer patients undergoing radiotherapy. Muller et al showed that the skin dose measured at 5cm away from the medial border of the treatment field will be equivalent to the overall total scattered dose received by the contralateral breast.[4] In our study, three TLD were placed, one on nipple and other on either side of nipple at a distance of 3cm along the midline.

Tercilla et al compared isocentric (SAD) and SSD techniques with respect to CLB dose; he found that SSD technique gave lesser contribution compared to SAD technique.[7] In our study, the dose contribution to CLB was found to be high in SSD technique compared to SAD technique (3.36% versus 2.41%) because in the present study SSD technique was used only for Cobalt teletherapy unit while all patients on LA were treated with SAD technique. The wedges were not used as use of wedge is reported to increase CLB dose.[8] The MT field gantry angle that is used to deliver the photon beam is found to be around 50 degrees. So,a comparison was made between less than or equal to 50° and more than 50° gantry angle. Muller et al demonstrated that higher the gantry angle closer will be the beam to surface and hence higher will be the dose.[4] In our study, it was found that gantry angle >50° has contributed more doses to the CLB on both the units (table 3).

Chougule showed that the mean contralateral nipple dose was 152.5-254.75 cGy which accounts 3.05-6.05% for a dose of 50 Gy in 25 fractions for post mastectomy breast cancer treated on cobalt unit.[9] In the present study, the contralateral nipple dose was 171.88cGy (55.5-303.80cGy) which accounts 3.47% (1.11%-6.07%) of the prescribed dose on cobalt unit.

In a study conducted at All India Institute of Medical Science, New Delhi, India, intensity modulated radiotherapy-(IMRT) and Enhanced Dynamic Wedge (EDW) were utilized for comparison of CLB dose.[10] EDW reduces CLB dose compared to physical wedge. The IMRT technique provides good dose uniformity and reduces the dose to the CLB significantly. The dose to CLB can be reduced by reducing the medial gantry angle. In our study dose to CLB was more when gantry angle was greater than 50°, thus we can reduce the dose to CLB by reducing the gantry angle.

At University of Pittsburg in 2006, an on-patient study was conducted to determine the dose received by the CLB during breast irradiation using IMRT compared with conventional tangential field techniques.[11] Paired TLDs were placed on patient's contralateral breast, 4 and 8 cm from the center of the medial border of the tangential field. After single exposure, the TLDs were changed. Primary breast radiation with tangential IMRT technique significantly reduces the dose to the CLB compare to tangential field techniques.

CONCLUSION

It is evident that radiation induced carcinogenesis is a significant issue in the current context of longer survival of treated patients of breast cancer. Further, with the advanced techniques, we can reduce the CLB dose as compared to conventional cobalt teletherapy.

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