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Evaluation of Radiation Dosimetric Parameters and its Association with Acute Skin Toxicity in Whole Breast Radiation

Jahnabi Das[1], Gunaseelan K[2], Saravanan K[3], Chandramouli R[4]

[1]MD Radiation Oncology, Senior Resident, JIPMER, Puducherry, India
jahnabids[at]gmail.com

[2]MD Radiation Oncology, HOD of Radiation Oncology, JIPMER, Puducherry, India
gunapgi[at]gmail.com

[3]Assistant Professor of Medical Physics and Radiation Safety Officer, JIPMER, Puducherry, India
bvksaravanan[at]gmail.com

[4]MD Radiation Oncology, Senior Resident, JIPMER Puducherry, India
chandramouliramalingam92[at]gmail.com

Abstract: ***Purpose:*** ***This study was designed to evaluate the radiation dosimetric parameters and its association with acute skin toxicity following whole breast radiation using conformal radiotherapy in early breast cancer.*** ***Methods and materials:*** ***Computed tomography scan images of 50 early breast tumour patients who had undergone breast conservation surgery were selected for this study. Contouring of skin was done as a structure with 5mm thickness from the surface of the body to the anterior margin of the breast planning target volume (PTV). Constraints to the skin were given, without compromising the dose to the PTV (Planning Target Volume). Dose delivered was 50 Gy/25# to the whole breast with tumour bed boost of 12 Gy/6#. Assessment of reactions of the skin was done for each patient weekly by using the Common Terminology Criteria for Adverse Events (CTCAE), version 4.03. All patients in this study were followed up weekly by clinical examination during RT and post RT every month until 3 months. During follow- up the worst grade of skin toxicity was recorded. Correlation between dosimetric parameters of skin and PTV with a grade of skin toxicity was done using the Spearman method.*** ***Results:*** ***Mean dose received by the skin was 36.3±7.6 Gy. Maximum dose received by the skin was 65.6±2.92. There was no significant correlation between the skin constraints and PTV parameters given with the highest grade of skin toxicity. During RT, 54% had grade 1 skin reaction, 32% had grade 2 skin reaction and 14% had grade 3 skin reaction. Grade 2 and 3 skin toxicities peaked at 1 or 2 weeks after RT despite stratification of RT techniques(3DCRT/IMRT/RapidArc)*** ***Conclusion:*** ***Taking skin as an organ at risk, and limiting the dose to the skin, by contouring the irradiated part of the skin without disturbing the PTV coverage, showed no significant association with skin toxicity but the rate of grade 3 and 4 skin toxicities were reduced. Thus that there is no statistical significance in giving constraints to the skin during planning. To give statistically significant data, the study has to be further continued with more samples. Follow up assessment done monthly for 3 months after completion of radiation had higher proportions of grade 1 skin reaction with no other complications like pain and swelling at the site of radiation. As there are no standard guidelines of skin contouring of breast, evaluation of dosimeters parameters with skin toxicity can be done if the whole skin is contoured.***

Keywords: Radiotherapy, skin reaction, skin toxicity, quality of life

1. Introduction

GLOBOCAN 2018 showed that breast cancer is the commonest cancer as well as the leading cause of cancer-related deaths in Indian women. It contributes significantly to the cancer burden in our country, that has to be treated to reduce the mortality and the economic loss to the country. (1) Whole breast radiation is the standard of care after breast conservation surgery as it proved a significant benefit in loco-regional control irrespective of the response to neoadjuvant chemotherapy. Skin is relatively radiosensitive and exhibits varying degrees of damage depending on the dose of radiation it receives. The proximity of skin to the target volume makes it more prone to higher radiation exposure. Studies have shown that the conventional radiotherapy techniques using photons of high energy and two wedged tangential fields result in side effects which may be acute or chronic. Effects like fibrosis and skin desquamation are appreciated even after using modern treatment techniques and fractionation schemes. The most common complications include skin erythema, breast oedema, and breast fibrosis after external beam radiotherapy. (2)This present study is designed to prospectively evaluate radiation dosimetric parameters and its association with acute skin toxicity following whole breast radiotherapy.

2. Methods and Materials

It is a prospective observational study conducted from 2017-2019 at a tertiary cancer care centre in South India. Biopsy proven carcinoma breast patients who underwent breast conservation surgery and planned for adjuvant whole-breast irradiation were included in the study. Patients received adjuvant RT using either a standard wedge missing tissue compensation technique or breast IMRT or RAPIDARC. The primary endpoint was to evaluate the radiation dosimetric parameters of radiation for the patients undergoing radiotherapy to the whole breast. The secondary objective was to identify the association of dosimetric parameters with acute skin toxicity among the patients undergoing whole breast radiotherapy. The sample size was

calculated as per the number of patients visiting the outpatient department of Radiation Oncology in a tertiary care centre. Preoperative CT scan was also advised to delineate the tumour. The patient underwent postoperative CT(Somatom Spirit-Siemens), with the necessary immobilisation devices. The medial and lateral field borders were marked to define the field length using radiopaque markers placed clinically by the physician. The planning target volume (PTV) was contoured as per RTOG (Radiation Therapy Oncology Group) breast cancer atlas for radiation therapy planning consensus definitions.(3) The involved breast with supraclavicular fossa, axilla level 1, 2 and 3 were included in Clinical target volume (CTV-50). The lumpectomy cavity was included in CTV-12. The axilla level – I & II were irradiated only if there was an extranodal extension or inadequate axillary lymph node clearance (less than 10 lymph nodes isolated in the post-op histopathology specimen)

Contouring and planning:

Contouring of target volume and OARs were done as per the RTOG guidelines. Contouring of skin was done as a structure with 5mm thickness from the surface of the body**.** As per department protocol, the skin was not included in the target volume. GTV (Gross tumour clips) - clips were contoured to delineate the tumour bed. An anisotropic margin (1cm superoinferiorly & 0.5cm diagonally) from the GTV- clips to CTV-12 was given. PTV-12 and PTV -50 were given 0.5 cm margins from CTV-12 and CTV-50 respectively. The CTV-50 was cropped out from the skin, excluded the ribs and lungs and included the breast tissue anterior to pectoralis major muscle. CTV-12 included the lumpectomy cavity with surgical clips as well as the seroma volume. In external beam radiotherapy, dose prescription used was whole breast plus nodal RT-50Gy/25 fractions (2Gy/fraction) with 3Dimensional Conformal Radiotherapy (3DCRT), Intensity Modulated Radiotherapy (IMRT) or Rapid Arc (RA) technique. Tumour bed boost(12Gy/6 fractions), was given with Rapid Arc technique/ 3DCRT. Dose-volume parameters were obtained from the Dose Volume Histogram of Treatment Planning System (Eclipse V-10) using the Analytical Anisotropic Algorithm (AAA algorithm) present in our department. After dose optimization dose to the organs at risk (OAR) (heart, ipsilateral and contralateral lung, skin, contralateral breast and surrounding ipsilateral breast tissue) were measured.. The treatment was delivered using Varian Clinac IX with 6 MV photon energy. The plan that achieved the best PTV coverage and sparing of OAR was chosen for the treatment. All patients were treated with a continuous course of radiation, 2 Gy per fraction, once a day, 5 days a week from Monday to Friday to a total dose of 62 Gy in 31 fractions. Dosimetric data was collected from the TPS. Clinical data were collected on the first day of irradiation, then weekly during their treatment, at first month and third month after completion of the treatment course. Before the start of radiation, the patients were counselled regarding the skincare and made aware of the possible toxicities she might encounter during radiation treatment or in the early post-treatment period. During each consultation, patients were examined for acute toxicities of skin.

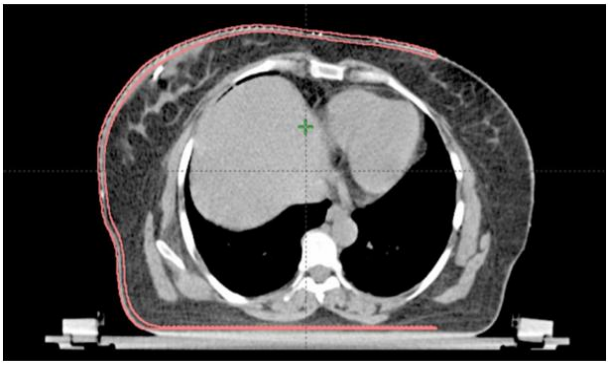

Figure 1: Contouring of the skin

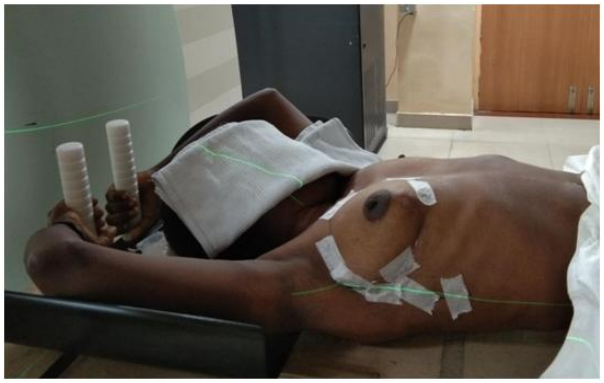

Figure 2: Patient positioned on the wing board in supine treatment position with the head tilted towards the opposite side; arms above the head; ipsilateral arms marked with wire

Table 1: Grade of skin reactions

Acute Skin toxicity (RTOG)	Definition
Grade 1	Follicular, faint or dull erythema/epilation/dry desquamation / decreased sweating
Grade 2	Tender or bright erythema, patchy moist desquamation/moderate oedema
Grade 3	Confluent moist desquamation (excluding areas of skin folds) / pitting oedema
Grade 4	Ulceration, haemorrhage or necrosis

Table 2: Dose constraints to the organ at risks (OARs)

Organ	Parameter	Dose constraints
Skin	V40	<88%
	V45	<83%
	V50	<58%
	Mean	<47 Gy
B/L Lung	V20	<30%
	Mean	<15 Gy
Contralateral breast	Mean	<4Gy
	V10	<5%
Heart	Mean	<5 Gy
	V25	<10%
Spinal cord	Dmax	<46 Gy
Thyroid	Dmean	<26 Gy
Liver	Dmean	< 26 Gy

Table 3: Dose Volume constraints to the target volumes

Lumpectomy PTV description	Goal	Volume /Dose constraint
Lumpectomy PTV maximum dose	Per protocol	Dose does not exceed 115% of the boost dose.
	Variation acceptable	Does Not exceed 120% of the boost dose
Conformity index (Ratio of volume covered by 95% prescription isodose/volume of the lumpectomy PTV)	Per protocol	0.95 to 2.0
	Variation acceptable	Not less than 0.9 and not more than 3

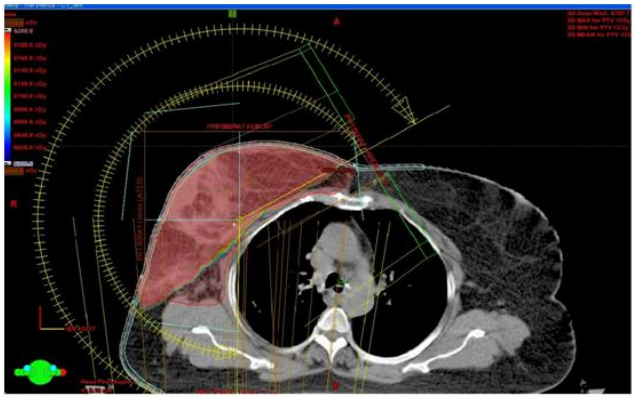

Figure 3: Dose distribution of 100% colour wash for PTV in a Rapid Arc plan

Figure 4: Dose colour wash of 95% prescribed dose

Figure 5: Cumulative dose histogram of 95% PTV coverage (prescribed dose 62 Gy/31#)

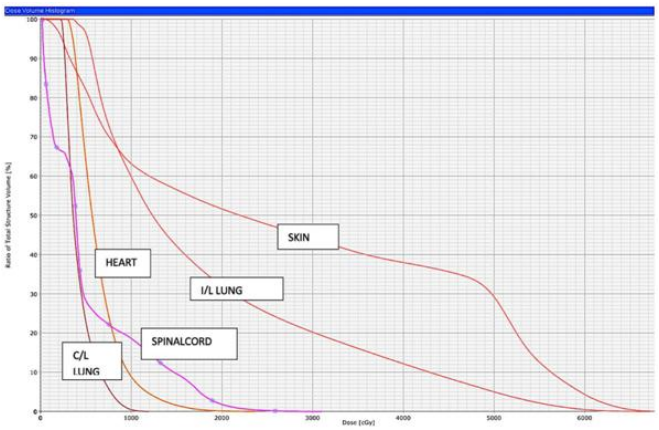

Figure 6: Dose volume histogram of skin, heart, spinal cord, ipsilateral lung, contralateral lung

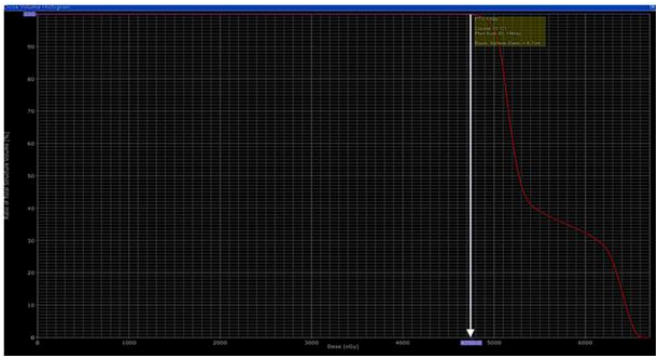

Figure 7: Cumulative dose histogram of 95% ptv coverage of prescribed dose (50 Gy/25#)

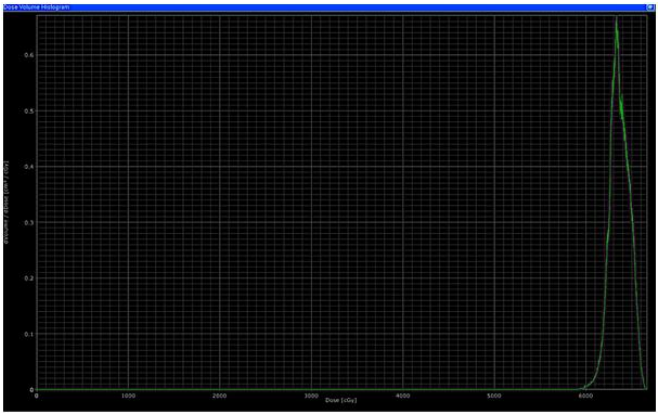

Figure 8: Differential graph of PTV. 100% of PTV covers 100% of the prescribed dose.

3. Statistical Analysis

Data analysis was done using SPSS version 20. We used the Kolmogorov-Smirnov test to assess normality of the different variables. The continuous data which were normally distributed were expressed as mean with a standard deviation. The continuous data which were not normally distributed were expressed as median with interquartile range. The distribution of categorical variables such as skin toxicity, site of the tumour, clinical characteristics etc. will be expressed as frequency and percentage. The proportion of skin toxicity with the above mentioned categorical variable will be carried out by using a chi-square test or Fischer's exact test. The comparison of a continuous variable in relation to skin toxicity will be carried out by using a one-way analysis of variance or Kruskal Wallis test. Spearman's

correlation was used to find an association between the dose received by the OAR and the grade of toxicities. All the statistical analysis were carried out at 5% level of significance and a p-value of less than 0.05 considered as significant.

4. Results

A total of 50 patients were included in the study from the period, April 2017 to April 2019**.** Th**e** mean age was 50 years. 36% were perimenopausal and 64% postmenopausal. 52% of the patients were started within 3 months after surgery and 12% of the patients were started after 6 months. 20% of the patients received neoadjuvant chemotherapy while 80% of the patients received adjuvant chemotherapy.

Table 4: Patient characteristics: Patient, tumour and treatment-related parameters:

Category	n(%)
Age	N=50
20-34	2(4%)
35-54	31(62%)
55-69	17(34%)
BMI	
18.5-24.9	46%
25-29.9	36%
>30	18%
Laterality	
Left	24(48%)
Right	26(52%)
T-stage	
1	10%
2	68%
3	22%
The time gap between BCS and adjuvant RT	
<3months	26(52%)
3-6 months	18(36%)
>6months	6(12%)
Duration of RT(weeks)	6.28±0.73
Distribution of modality of RT	
PHASE I	
3DCRT	2(4%)
RAPID ARC	41(82%)
IMRT	7(14%)
PHASE II	
RAPID ARC	44(88%)
3DCRT	6(12%)
ENERGY LEVEL	
6MV	50(100%)
Treatment gap	6(12%)
Present	7(14%)
Skin reaction	1(2%)
Low compliance	44(88%)
Absent	
Systemic therapy	
Timing of Chemotherapy	
Adjuvant	40(80%)
Neoadjuvant	10(20%)
Anti hormonal therapy	
No antihormonal therapy	9(18%)
Tamoxifen only	18(36%)
Tamoxifen+Transtuzumab	2(4%)
Letrozole only	13(26%)
Letrozole+Transtuzumab	3(6%)
Only Transtuzumab	5(10%)

Table 5: Radiation dosimetric parameters

Dmax	114%(109-116)
Dmean(Gy)	65.02± 1.69
D98(Gy)	59.60±3.90
D2(Gy)	68.35±2.2
Dmax(Gy)	69.93±2.34
Dmedian(Gy)	65.21±1.76
D90(Gy)	62.38±1.66
D95(Gy)	61.39±2
V90(Gy)	100(99-100)
V100(Gy)	94.3(86.5-97.1)
CI(phase 1)	0.91±0.1
CI(phase 2)	1.17±0.37
HI	0.13±0.06
TV-V110% (in%)	10.6(0.02-23.9)
PTV-V107% (in%)	25.6±23.2

Table 6: Dose received by the OARs

Classification	Category	Mean(SD/Median(range)
Ipsilateral Breast	Dmean(Gy)	57.23±3.35
Contralateral Breast	Dmean(Gy)	5.16±1.18
	V10(%)	11.26±5.44
Ipsilateral Lung	V20(%)	34.08±6.45
	V30(%)	18.03±5.23
contralateral Lung	V5(%)	52.38±20.82
Total Lung Mean	Dmean(Gy)	12.35±2.09
Heart	V30(%)	9.5(0-11)
	V25(%)	9.8(0-11.6)
	MEAN(Gy)	9.1(5-10.5)
	MeanR(Gy)	6.1±2.2
	Mean L (Gy)	10.3±1.5
Spinal cord	Dmax(Gy)	36.60±5.72
Thyroid	Dmean(Gy)	33.59±5.11
liver	Dmean(Gy)	7.42±5.45
Tumour bed volume(cc3)		186±96.7

Table 7: Dose received by the skin

Classification	Category	Mean(SD)
Skin	V40	49.71±16.53
	V45	43.06±18.44
	V50	32.4±18.99
	Mean(Gy)	36.3±7.6
	Dmax(Gy)	65.68±2.92

Table 8: Correlation between skin dosimetric parameters with grades of skin toxicity during RT using the Spearman method (n=50;the level of significance p<0.05)

Skin dose parameters	The highest grade of skin toxicity during RT	
	P-value	R- value
V40	0.6	0.06
V45	0.8	0.02
V50	0.8	0.02
Dmax	0.3	0.1
Dmean	0.7	0.04

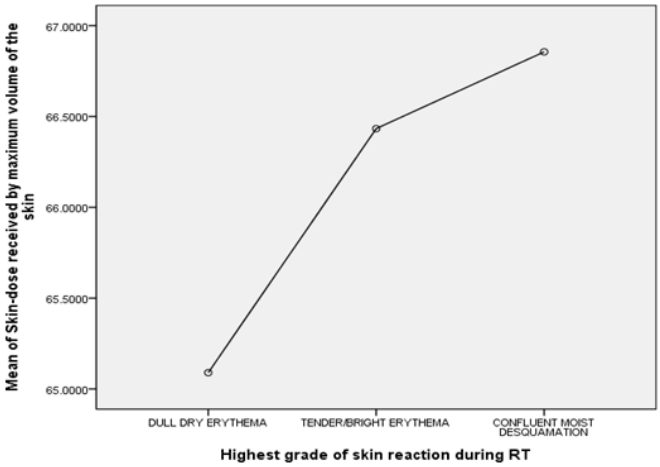

Figure 9: Increase in skin Dmax showed an increase trend in skin reaction but no statistical significance (p=0.1)

There is no correlation between skin dosimetric parameters and grade of skin toxicity during radiation. But the increase in Dmax of the skin had shown an increasing trend in the skin reaction

Table 9: Correlation between dosimetric parameters of PTV and grade of skin toxicity during radiation using the Spearman method (n=50; the level of significance p<0.05)

Parameters	Grade of skin toxicity during radiation	
	P value	R value
V100	0.1	0.2
TV-V110	0.7	0.03
V107	0.5	0.08
PTV Dmax	0.8	0.04
CI(Phase I)	0.7	0.05
CI(Phase II)	0.4	0.1
HI	0.2	0.17
D2	0.5	0.1

There is no significant correlation between PTV parameters and skin toxicity during radiation.

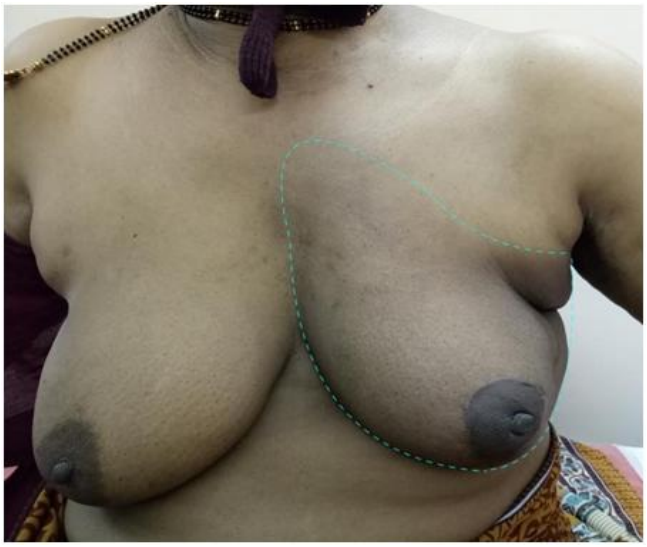

Figure 10: Grade 1 skin reaction (highest grade of skin toxicity) of the left breast during the course of radiation.

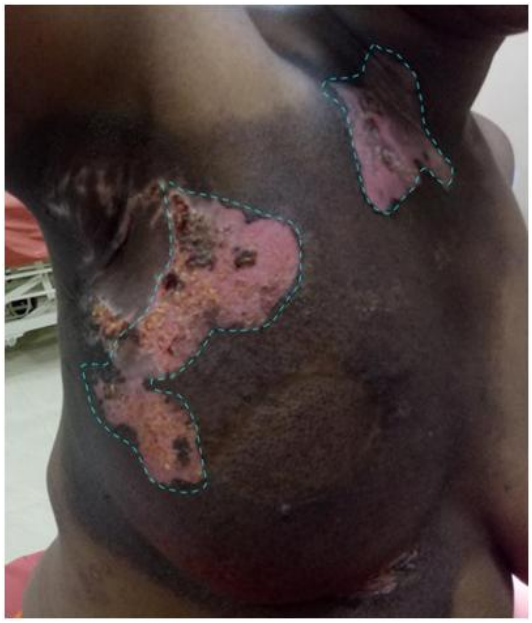

Figure 11: Grade 3 skin reaction on the healing phase during radiation

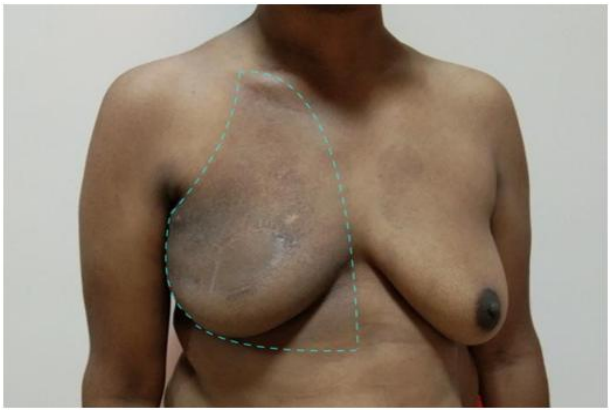

Figure 12: Grade 1 skin reaction of the same patient during 3rd month follow up

5. Discussion

In this study, the skin was considered as an organ at risk (OAR) and skin constraints were given to limit the dose to the skin during whole breast radiation after BCS. This study was conducted in a tertiary Regional Cancer Centre which offers free service. The mean age group of the patients enrolled in our study was 50 years.63% of the patients' age group is in the 35-54 years age group. This is according to the National Cancer Registry Programme where the incidence rate in India had begun to rise in the early thirties and peak at ages 50-64 years. [4]

Only 10% of our patients were diagnosed at stage I of the disease. Rest of the patients were from Stage II/III. Desai et al, in his analysis of the cancer control programmes in India, noted that illiteracy and socio-economic backwardness hamper the early detection of cancer in India. Health education programmes along with infrastructure generation for cancer care should reduce cancer morbidity and mortality.[5]

Conventional dose fractionation was used i.e. 50 Gy in 25

fractions followed by 12 Gy in 6 fractions. The mean duration of the radiation course was 6 weeks. In this study around 86% of the patients had completed whole breast radiation in 6 weeks without any treatment gap. Around 14% of the patients had completed RT beyond 6 weeks. The delay in the completion of radiation was mainly due to the skin reactions during the time of radiation. In this study, patients had started to develop Grade 1 skin reaction i.e. mild erythema, with dry desquamation approximately around 10-14 days after initiation of treatment. The dose threshold is around 10 Gy- 12 Gy.

In our study, we had noted the highest grade of skin reaction during radiation followed by monthly follow up for 3 months.54% of the patients during RT had the highest grade 1 skin reaction, 32% had grade 2 skin reactions and 14% had grade 3 skin reaction. Patients had received treatment by 3DCRT/IMRT/RA in phase I and only by RA and 3DCRT in phase II. According to Tiefenbacher et al after BCS, patients were treated with 3D-CRT (50 Gy whole breast photon radiotherapy followed by 16 Gy boost to the tumour bed with electrons). They had noted the skin toxicity after completion of the 50 Gy course. Out of 211 patients, the number of patients who had no erythema was 28.9%, 62.2% of patients showed Grade 1 and 8.5% had grade 2 skin reactions. None of the patients had grade ¾ erythema. In their study, a significant trend was observed for large breast volumes (p=0.004), as well as the large tumour size (p=0.009). In another study done by Chen et al, 90 patients underwent chest wall irradiation and 68 patients received whole breast radiation. The incidence of moist desquamation was around 19% of the patients who received whole breast irradiation with 3DCRT. They used the prescription dose of 50.4 Gy. (6)

The PTV coverage was given priority in our study. The median value of $V_{100\%}$ was 94.3%, Dmedian was 65.21 Gy, Dmean was 65.02 Gy. In a study done by Chen et al, V100% was 95%, Dmedian was 53 Gy, and Dmean was 52.5 Gy. In their study, they had used adjuvant 3DCRT with a dose prescription of 50.4 Gy in 28 fractions.

In our study, the median PTV-$V_{107\%}$ was 25.86% and median TV- $V_{110\%}$10.68%. There was no significant correlation between grades of skin toxicity and PTV-V107 and TV-V110. In a study done by Chen et al, they found no significant association between the incidence of acute skin toxicity and PTV-V107%. The median PTV-V107% was 28.6% in their study.[7] But the median value of TV-V110% was 5.13% in the study which acted as a predictive power on the incidence of radiation dermatitis. The study had two groups prophylactic skincare group and therapeutic skincare group where the incidence of moist desquamation was higher in the therapeutic skincare group.

In our study, the mean (SD) Homogeneity index was 0.13(0.06) and the mean (SD) Conformity Index for phase I (50 Gy in 25 fractions) was 0.91(0.1) while for phase II (12 Gy in 6 fractions) was 1.2(0.4). There was no significant correlation between conformity and homogeneity index with a grade of skin toxicity. In the study done by Deve et al, they had compared Homogeneity index and conformity index in whole breast radiotherapy with and without segmental fields with conventional doses of radiation. The technique with segmental fields allowed more homogeneity distribution when compared to standard two tangential field techniques. The HI value of segmental technique was 1.08±0.01 and for conformity index was 1.38±0.02.[8]

Logically, by improving the homogeneity and conformity index, there will be better local control and reduction of complications by the radiation treatment, but so far there are no studies to confirm that by improving the homogeneity and conformity indices there is a better clinical response or better local control compared with plans with inferior homogeneity index.

In our study, V_{90} and V_{95} though showed a correlation with skin toxicity, but there is no statistical significance.

RADIATION DERMATITIS: In our study, skin contouring was done as a 5mm strip extending from the patient's body surface. 5mm thickness of the skin was chosen to include the epidermis/dermis/hypodermis which was similar to the study conducted by Elantholi P Saibishkumar. In our study, constraints to the skin were given, without compromising the dose to the PTV.

In the study done by Saibishkumar et al, they had compared IMRT plans done for both skin-sparing and non-skin sparing technique delivered by helical tomotherapy(HT) by giving skin constraints to the skin-sparing technique and no constraints to the non-skin sparing technique in patients with early breast cancer. They had used the dose-volume histogram(DVH) to look for the constraints achieved by the planning target volume, skin and organs at risk (OAR). The study concluded that the skin-sparing approach had significantly reduced the dose received by the skin compared to non-skin-sparing approach without compromising the PTV coverage. The skin parameters of our study were much lower than the study done by Saibishkumar et al. This difference can be explained by the following points:

1. The method of contouring
2. The technique used for radiation planning. In both the studies, the skin was contoured as a 5mm strip extending from the patient's body surface. But the skin was included within the PTV in our study while in the study done by Saibishkumar et al the posterior extent of the skin was the anterior surface of the PTV. They had used IMRT as a planning technique. Whereas, in our study, Rapid arc was used as a planning technique in most of the cases. To maintain the uniformity of the contouring, we contoured the skin 1-2 cms from the midline extending posteriorly as there are no specific guidelines for contouring skin during whole breast radiation. Moreover, the study done by Saibishkumar et al was a planning study and the results of clinical application of skin parameters and its association with skin toxicity were not commented.

HEART: For left-sided disease, the mean heart dose(SD) was 10.3 Gy(1.5). For the right-sided disease, the heart dose was 6 Gy(2). A systematic review done from 2014 to 2017 based on heart dose during whole breast radiotherapy, showed that for left- sided disease, mean dose received by the heart was 3.6 Gy and for the right-sided disease, the heart dose was 1.9 Gy. In our study, it was higher by around

6 Gy. Unlike the free-breathing technique and supine position used in our study, deep inspiratory breath-hold technique as well as set up the position of the patient either prone or lateral decubitus had significantly reduced the heart dose. [9]

LUNG: The mean lung dose (where bilateral lungs were considered a single organ) in our study was 12.4± 2.1. Mean (SD) value of V20 of the ipsilateral lung is 34.1% (6.5) and V30 of the ipsilateral lung is 18%(5). The contralateral lung mean (SD) value of V5 is 52.4% (20). In a study done by Aznar et al, the average mean lung dose was 11.7 Gy which was almost similar to our study.(10) Various studies have concluded that the mean lung dose correlated with the extent of irradiation. The addition of axilla/supraclavicular fossa irradiation increased it to 11.2 Gy (SD 0.6) and inclusion of the internal mammary chain (IMC) further increased it to 14.0 Gy (SE 0.8). The average value of V20 of the ipsilateral lung was 13.9% and V5 of the ipsilateral lung was 39.5%.(10) Another study done by Alexendra et al commented on V30 of the ipsilateral lung dose as 10%where they used conventional radiation dose to whole breast (50 Gy/25 fractions).(11)These values were much lower than our study as our first priority was PTV coverage.

CONTRALATERAL BREAST: The mean (SD) dose of contralateral breast Dmean was 5.2Gy (1.2) and V10 was 11.3%(5.4) which was within the normal limits of RTOG constraints. In the study done by Supakalin et al. the VMAT mean dose (SD) of contralateral breast dose was 4.98 Gy (0.6) which was similar to our study. (12)

6. Strengths of the Study

1) This is one of the very few studies available in the literature where the evaluation of radiation dosimetric parameters and its association with skin toxicity in whole breast radiotherapy is done.
2) Throughout the study, there was involvement of the same Radiation Oncologists and Medical physicist from the start of recruitment of patients, simulation, contouring, planning, initiation of treatment and weekly and monthly assessment of skin toxicity of the patients so that there is less interobserver variation.
3) 3.Skin toxicity was graded into grade 1, grade 2, grade 3, and grade 4 as per RTOG and grade 2 and 3 were clubbed as high grade and grade 1 as a low grade as per the guidance from the previous studies.
4) Photographs were taken from the institute's DSLR camera to ensure that they are of high quality.

7. Limitations of the Study

1) Since this was a single institutional study, it was prone to institutional bias in the selection of patients and conduct of the study.
2) Though we could appreciate an increase in grade of skin reactions with an increase in the skin dose (mean dose of the skin), there was no statistical significance because of small sample size
3) There is less proportion of grade 3 skin reactions and no grade 4 skin reaction. Therapeutic interventions were done to avoid dropouts in the study.

8. Conclusion

The study on "evaluation of radiation dosimetric parameters and its association with acute skin toxicity", we estimated the skin dose by giving special constraints during planning. We had delivered a dose of 50 Gy in 25 fractions followed by 12 Gy in 6 fractions to the boost volume using 6 MV photon energy. Taking skin as an organ at risk, and limiting the dose to the skin, by contouring the irradiated part of the skin without disturbing the PTV coverage, showed no significant association with skin toxicity but the rate of grade 3 and 4 skin toxicities were reduced. Hence, we came to the conclusion that there is no statistical significance in giving constraints to the skin during planning. In order to give statistically significant data, the study has to be further continued with more number of sample. Follow up assessment done monthly for 3 months after completion of radiation had higher proportions of grade 1 skin reaction with no other complications like pain and swelling at the site of radiation. As there are no standard guidelines of skin contouring of breast, evaluation of dosimeters parameters with skin toxicity can be done if whole skin is contoured. A longer follow up period is required to comment about late skin toxicity and the local control rates. Based on the technique (3DCRT/IMRT/RA) beam entry and exit points have to be taken into account while contouring the skin.

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Author Profile

Dr. Jahnabi Das, [MBBS (AMC, Dibrugarh, Assam), MD (Radiation Oncology), JIPMER]. She can be contacted at Email: jahnabids@gmail.com

Academic Involvement

a) CMEs

- Recent advances and updates in colorectal cancer
- Neuroendocrine tumors
- Updates in Prostate cancer
- Palliative care
- Head and neck oncology 2019, JIPMER

b) Conferences and workshops

- 1st AROI-ICRO INTAS radiobiology teaching course on clinical radiobiology for radiation oncologists
- Master class on Molecular Oncology 2019,JIPMER
- 2nd Indian Cancer Congress, 2017 (Bengaluru)
- INDO-UK ONCOLOGY SUMMIT, DECEMBER 2017
- 9th AROI-ICRO Clinical Radiobiology Teaching course(South zone)
- Training on Good Clinical Practices, 2019 JIPMER

c) Workshops in Palliative Care

- Certificate course in Essentials of Palliative Care (CCEPC November 2017)
- POSTER PRESENTATION (ESTRO meets Asia, Singapore, December 2018 and JIPMER 4th research 2019)
- Dosimetric parameters and acute skin toxicity association in whole breast radiotherapy

Dr. Gunaseelan K (M.B.B.S, M.D) is Additional Professor, Department of Radiation Oncology, Regional CancerCentre, JIPMER. He can be contacted at Email: gunapgi@gmail.com

a) Projects undertaken in the last 5 years (brief title, funding source, amount, status)

- Clinical outcomes and the determinants of survival in cervical cancer patients in a tertiary health care hospital in South India NCDIR, ICMR (ON –GOING)
- Clinical outcomes and its association with patterns of care and socio-demographic and clinical factors in patients with Head and Neck cancer in a tertiary health care hospital in South India. NCDIR, ICMR (ON –GOING)
- Clinical outcomes and the determinants of survival among breast cancer patients in a tertiary health care hospital in South India NCDIR, ICMR (ON –GOING)
  Amount - Rs 1,53,45,573

b) Relevant research training/experience in the area

- Actively involved in Undergraduate & post graduate teaching programs, Tumorboard meeting; Treatment Planning Discussions; Maintaining Cancer Registry; Conducting Palliative Care Clinic. Extra-mural grants from ICMR & JDF, Texas, USA for Cancer registry & palliative care staffs support, respectively.
- 42 publications including 18 in indexed journal. 22 Oral presentations and 6 Poster presentation at National Conference. Delivered 16 lectures in the CME's and Conferences.
- Have completed 8 and 3 ongoing for guide ship program for MD Radiation Oncology
- Total PG Teaching & Research Experience: 14 Years
- Have received extramural research grant for Rs 1,53,45,573 from, NCDIR Bengaluru - Pattern of Care survival studies (POCSS) for head, cervix & breast cancer as principal investigator for conducting and co-coordinating for National Cancer Registry Program (NCDIR), ICMR under Ministry of health & family welfare, India.

c) Relevant publications

(All publications in the last five years and other publications relevant to the current study; Vancouver format)

1) Gunaseelan K, Patro DK, Lal A, P K, D B, N V. Efficacy of Extracorporeal Irradiation in Primary Malignant Bone Tumours: A Tertiary Cancer Centre Experience. Asian Pac J Cancer Care 2019; 4:53–7. https://doi.org/10.31557/apjcc.2019.4.2.53-57
2) Rapole PS, Gunaseelan K, Kandasamy S, Prabhu S, Kumar R, Vivekanandam S. Dosimetric Comparison and Feasibility of Simultaneous Integrated Boost (SIB) in Treatment of Malignant Gliomas Using Intensity Modulated Radiotherapy (IMRT) or Volumetric Modulated Arc Therapy (VMAT). Asian Pac J Cancer Prev 2018;19. (corresponding author) https://doi.org/10.22034/APJCP.2018.19.9.2499.
3) Gunaseelan K, Sagar RP, Joy A, Vedasoundaram P. Assessment of Psychological Distress and its Effect on Quality of Life and Social Functioning in Cancer Patients. Indian J Palliat Care 2018; 24:72-7. http://www.jpalliativecare.com/text.asp?2018/24/1/72/223206
4) Dr. Kannan P, Dr. Gunaseelan K, Dr. Srinivas BH, Dr. Vivekanandam S. A RARE PRESENTATION of CERVICAL CANCER WITH UMBILICAL NODULE: A CASE REPORT. Ind J App Med Res 2016: 4; 233-234 (corresponding author) DOI : 10.36106/ijar
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8) Sivaraman Ganesan1 , Sivanesan Sivagnanaganesan1 , Mahalakshmy Thulasingam2 *, Gunaseelan Karunanithi3 , Kalaiarasi R1 , Surya Ravichandran1 , Sunil Kumar Saxena1 ,

KarthikeyanRamasamy Diagnostic Delay for Head and Neck Cancer in South India: A Mixed-Methods Study Asian Pac J Cancer Prev, 21 (6), 1673-1678 DOI:10.31557/APJCP.2020.21.6.1673
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Saravanan. K is Assistant Professor (Medical Physics) from Jan 2010 to till date. He can be reached at Department of Radiation Oncology, RCC, JIPMER, Puducherry-605006. He is qualified as Ph. D. (Medical Physics) Ph. D. (Medical Physics) Ph. D. (Medical Physics)

Publications in journals indexed in Index Medicus/Medline, PMC, SCI, Excerpta Medica, Scopus, IndMed (do not include abstracts in conference proceedings)†

No.-Details (Vancouver style), and DOI if available-Impact Factor-Citations

1) **Saravanan K**, Reddy KS, VivekanandanN, Parthasarathy V, Gunaseelan K. Inter-fraction variation in interstitial HDR Brachytherapy. Journal of Radiotherapy in Practice 14 (2), 143. (2015) http://dx.doi.org/10.1017/S1460396915000047-0.18-3
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Dr. Chandramouli R, MBBS (JIPMER), MD Radiation Oncology (JIPMER). He can be reached at chandramouliramalingam92@gmail.com.

Field of Interest

- Paediatric Radiation Oncology
- Paediatric Palliative care
- Head and Neck malignancies
- Gynaecological malignancies
- Brachytherapy
- Breast cancer
- Palliative care

Career Objective

Seeking a good position in a Tertiary care GovernmentRadiation Oncology department, where I canactively participate in patient care, academics and research activities.

Work Experience

- Internship in 2014 in JIPMER
- Junior Resident in the Department of Radiation Oncology, RCC JIPMER (3 years;2016-18)
- Senior Resident in Department of Radiotherapy, AIIMS BHUBANESWAR (7.5 months, 14th March 2019 – 31st October 2019)
- Senior Resident in Department of Radiation Oncology, RCC JIPMER (1 year; 7th November 2019- till date)
- Total experience as Senior Resident in Department of Radiation Oncology- RCC – 1 Year and 7.5 months.
- Consulted, opined and treated around 2655 cases, out of which, respective count of cases were 1000 telemedicine cases, 550 OPD follow-up cases,75 radiotherapy planning cases and 25 brachytherapy cases, 100 new cases with decision on oncological management, 175 day-care cases, 400 palliative care cases, 250 inpatient cases, 80 referrals from other department case in this one year as SR in JIPMER.
- Trained in Fire safety precautions and procedures.

Academic Achievements -

- Passed in First Class Distinction in 10th Standard, 12th Standard, MBBS and MD Final examinations.
- Secured school first in 10th standard public examinations.
- Participated and won in various quizzes in School period.
- Passed Rashtrabasha- Praveen examination on Hindi language.
- Participated and won in various quizzes in MBBS and MD period.
- Passed Part Aand Part B of Certificate Coursein Essentialsof Palliative Care (CCEPC), certified by IAPC (Indian Association of Palliative Care).
- Passed Medical statistics, Chemotherapy and Physics papers in FRCR exam Part 1.