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Evaluation Of Interpolation Effect On Cumulative Dose Volume Histogram in Left-Sided Breast Cancer Radiotherapy

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Abstract: This work aims to studying the effect of interpolation in breast cancer radiotherapy, on values of doses to organs at risk (OARs); lung, heart, and contralateral breast in the dose volume histogram, and doses to the planning target volume (PTV) and the Clinical target volume (CTV). Thirty women patients with left sided breast cancer, were studied using the three-dimensional radiation treatment planning system 3D-RTPS prowess panther TPS model build number 4608 in planning process; two plans for each case (the first with interpolation and the second with manual contouring), then we compared dosimetrically between the two plans using the DVH. This study resulted in good dose coverage was achieved by the two plans. The 95% isodose covered (96.86±1.85), (97.22±1.90) of the volume of PTV for plans (1) and (2) respectively. Also, the HI was (0.115±0.04), (0.114±0.05), and the CI was (0.68±0.43), (0.68±0.43) for plans (1) and (2) respectively. It was found that, there is no difference between the dose effect of interpolation and manual contouring on the DVH.

Keywords: Breast cancer, interpolatation, manual contouring, dose volume histogram

1.Introduction

In women the breast cancer is considered one of the most common neoplasm types. The main reason of deaths in women is breast cancer. The process of treatment from breast cancer happened by many undetectable steps; surgery, chemotherapy, radiotherapy, and targeted therapy[1].The mastectomy or breast conserving surgery followed by the assistant radiotherapy is the most continuous methods of breast cancer treatment [2]. When using the adjutant radiotherapy after the breast conserving surgery, the result is better. The local recurrence and the risk of regional could be stopped. Also the overall survival of patients can be amended [2-4].Treatment planning system is comprehensive software system which has been developed to allow 3-dimensional planning of radiation therapy treatments using the extensive anatomical information made available by imaging modalities such as CT and MR. Biological structures of interest and tumor volumes are defined by outlines drawn on a sequence of m slices. Beam set-ups may then be determined in three dimensions by displaying the structure contours in a beam’s eye view, or in two dimensions using a single CT cut. The important of radiotherapy planning is to decrease and protect doses to the neighboring healthy tissues as probable. Also, in the same time to deliver the better treatment dose to the tumor. However, exemplary planning is always improbable to be coordinated with the restriction imposed by normal tissues. As they must treat the target volume in conformal manner and a homogeneous [4]. Radiotherapy requires the target area and the organs at risk to be contoured on the CT image of the patient [5]. During the delineation process of organs-at-risk (OAR) of the chest and abdomen, the doctor needs to contour at each CT image. The delineations of large and varied shapes are time-consuming and laborious, thus the interpolation is used by the radiation treatment planning system RTPS algorithm instead of manual contouring in each axial CT-cut [6]. This study aims to evaluate dosimetrically the interpolation algorithm compared to manual contouring.

2. Patients and Methods:

Sixty plans were created form thirty early-stage breast cancer women patients treated by 40 Gy in 15 fractions/ 3 weeks teletherapy. They received breast conserving surgery. They diagnosed all of them with left-sided breast cancer without supraclavicular or axillary lymph nodes, and had undergone breast conserving surgery. The patients were imaged using the computed tomography (Siemens Biograph Horizon PET/CT) simulation in supine position. We create two plans one with interpolation algorithm and the other with manual contouring in the delineation step of the planning process. The two plans were made using the three-dimensional radiation treatment planning system 3D-RTPS prowess panther TPS model Build Number 4608. From the dose-volume histograms we were able to get the dosimetric parameters used in our study to compare between interpolate and utilizing of manual contouring.

2.1. Breast volumes:

In our study, patients have different left breast volumes. There are three groups of the volume of the studied left breast; small breast volume (≤1500 cc), medium breast volume (1500 cc- 2000 cc) and large breast volume (> 2000 cc) [7]. There was no limitation of age for patients (Table 1).

Table 1: The percentage ratio of the number of patients to the three sizes for the Breast volumes (PTV):

PTV Volume	Percentage of patients' number
Small	100%
Medium	0 %
Large	0%

2.2. Treatment planning

All patients are treated with external beam radiotherapy with a prescribed dose of 4000 cGy in 266.66 cGy fractions for 5 days per week, after breast conserving surgery. The radiotherapy planning process is done using Prowess panther 3D planning system to achieve the therapeutic ratio. Two tangential (medial and lateral) 6 MV energy beams of a linear accelerator are used. Two types of plans in our study are designed (with interpolation contouring and manual contouring). The 95% of PTV volume in the two plans should be covered with the prescribed dose of 4000 cGy.

2.3. Analysis of dose difference (Dosimetric Evaluations):

In our study they compare between these two treatment planning plans. There are many parameters are to be evaluated. The conformity index (CI), homogeneity index (HI) and uniformity index (UI) were calculated using the following formula [8].

Conformity index (CI) = VRI / TV (1)

Where the CI was the ratio between VRI and TV. Where, VRI is the volume of the reference isodose and VT is the volume of the target [9,10].

Homogeneity index (HI) =(D2%-D98%)/D50%. (2)

Where The HI was is the ratio between Subtract of D2% and D98% to D50%. Where, D2%, D98% and D50% represent the doses delivered to 2%, 98% and 50% of PTV [11,12].

HI is one of the evaluating parameters, it indicates to the homogeneity of the dose distribution within the volume of the target.

Uniformity index (UI) = (D5% / D95%) (3)

Where the UI was calculated from the ratio between D5% and D95%, where, D5% and D95% represent the doses delivered to 5% and 95% of PTV [13].

3. Results and Discussion

Sixteen plans were generated for patients with left-sided breast cancer. All the patients were treated by receiving a dose of 40 Gy/15 fractions to the breast. There isn't limitation of our study. In our study they used interpolation or without interpolation.

3.1 Statistics:

The Statistical Package of Social Science (SPSS) program for Windows analyzed using data. The normality of data was first tested with one-sample Kolmogorov-Smirnov test.

Qualitative data were described using number and percent. Continuous variables were presented as mean ± SD (standard deviation) for normally distributed data. The following tests were used;

Student t test: Compare two quantitative variables (parametric).

ANOVA test: Compare more than two quantitative variables (parametric).

For all above mentioned statistical tests done, the threshold of significance is fixed at 5% level. The results was considered significant when p ≤ 0.05. The smaller the p-value obtained, the more significant are the resul**t.**

Table (2): Comparison between plan (1) and plan (2) regarding heart and left lung

Organ at Risk	Parameters	Plan (1)	Plan (2)	Test of significance	P value
Heart	D_{max}	91.70±31.57	92.37±32.04	t=0.045	0.965
	D_{min}	0.0±0.0	0.0±0.0	-	-
	D_{mean}	12.58±5.51	12.54±5.49	t=0.013	0.839
	D2	85.90±30.32	86.18±30.39	t=0.507	0.619
	V_5	19.19±3.85	20.44±5.01	t=1.017	0.322
	V_{10}	12.03±7.07	13.29±8.37	t=0.365	0.72
	V_{20}	11.33±3.63	13.25±5.31	t=0.140	0.89
	V_{30}	8.58±3.22	10.61±5.13	t=0.134	0.895
	V_{40}	12.76±3.57	14.49±5.16	t=0.577	0.571
Left Lung	D_{max}	107.82±6.42	108.28±6.16	t=0.163	0.872
	D_{min}	0.0±0.0	0.0±0.0	-	-
	D_{mean}	20.32±7.22	20.54±7.42	t=0.067	0.947
	D_2	102.94±7.01	103.29±6.93	t=0.112	0.912
	V_5	25.50±8.03	25.21±8.20	t=0.082	0.936
	V_{10}	21.71±7.19	21.06±7.26	t=0.202	0.842
	V_{20}	18.71±6.82	17.76±6.81	t=0.311	0.759
	V_{30}	16.09±6.31	15.09±6.26	t=0.359	0.724
	V_{40}	19.31±7.04	18.88±7.00	t=0.136	0.893
	V_{43}	19.30±6.81	18.85±7.15	t=0.144	0.887

Mean: the mean of percentages for doses at (D%) and for volumes at (V%) plan (1): shows the result by using manual contouring. Plan (2): shows the result by using interpolate.

Mean of percentage of D_{max} is higher for plan no.2 than plan no.1. The mean of percentage of D_{max} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of D_{mean} is higher for plan no.1 than plan no.2 ones. The mean of percentage of D_{mean} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of D_2 is higher for plan no.2 than plan no.1. The mean of percentage of D_2 shows no significant difference ($P > 0.05$) for plan (1) and plan (2).

Mean of percentage of V_5 is higher for plan no.2 than plan no.1. The mean of percentage of V_5 shows significant difference ($P < 0.05$) for plan no.2 compared to plan no.1.

The mean of percentage of V_{10} is higher for plan no.2 than plan no.1. The mean of percentage of V_{10} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of V_{20} is higher for plan no.2. than plan (1) no.1. The mean of percentage of V_{20} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of V_{30} is higher for plan no.2 than plan no.1. The mean of percentage of V_{30} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of V_{40} is higher for plan no.2 than plan (1) no.1. The mean of percentage of V_{40} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

In left lung:

Mean of percentage of D_{max} is higher for plan no.1 than plan no.2. The mean of percentage of D_{max} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2. Mean of percentage of D_{mean} is higher for plan no.2 than plan no.1. The mean of percentage of D_{mean} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2. The mean of percentage of D_2 is higher for plan no.1 than plan no.2 .The mean of percentage of D_2 shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of V_5 is higher for plan no.1 than plan no.2. The mean of percentage of V_5 shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of V_{10} is higher for plan no.1 than plan no.2. The mean of percentage of V_{10} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2Mean of percentage of V_{20} is higher for plan no.2 than plan no.1. The mean of percentage of V_{20} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of V_{30} is higher for plan no.1 than plan no.2. The mean of percentage of V_{30} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of V_{40} is higher for plan no.2 than plan no.1. The mean of percentage of V_{40} shows no significant difference ($P > 0.05$) for plan (1) and in plan (2).

Mean of percentage of V_{43} is higher for plan no.2 than plan no.1. The mean of percentage of V_{43} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Table (3): Comparison of CTV dose and volume between the two plans:

CTV	plan(1)	plan (2)	Test of significance	P value
D_{max}	112.96±4.45	112.94±4.46	t=0.01	0.992
D_{min}	85.29±5.32	86.05±5.14	t=0.325	0.749
D_{mean}	103.05±1.92	102.71±1.92	t=0.396	0.697
D_2	109.74±3.68	109.64±3.65	t=0.061	0.952
D_{50}	103.05±1.75	102.89±1.67	t=0.209	0.837
D_{95}	97.35±2.89	97.24±2.46	t=0.092	0.927
D_{98}	96.24±2.15	94.16±6.77	t=0.925	0.367
V_{10}	100±0.0	100±0.0	-	-
V_{20}	100±0.0	100±0.0	-	-
V_{30}	100±0.0	100±0.0	-	-
V_{40}	79.61±11.30	80.09±11.18	t=0.096	0.925
V_{95}	98.46±1.39	97.62±2.78	t=0.854	0.404
V_{43}	100±0.0	100±0.0	-	-

Mean of percentage of D_{max} is higher for plan no.1 than plan no.2. The mean of percentage of D_{max} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of D_{min} is higher for plan no.1 than plan no.2. The mean of percentage of D_{min} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of D_{mean} is higher for plan no.1 than plan no.2. The mean of percentage of D_{mean} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of D_2 is higher for plan no.1 than plan no.2. The mean of percentage of D_2 shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of D_{50} is higher for plan no.1 than plan no.2.The mean of percentage of D_{50} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of D_{95} is higher for plan no.1 than plan no.2. The mean of percentage of D_{95} shows significant difference ($P < 0.05$) for plan no.1 compared to plan no.2.

Mean of percentage of D_{98} is higher for plan no.1 than plan no.2. The mean of percentage of D_{98} shows no significant difference ($P > 0.05$) for plan no.1 and plan (2). no.2.

Mean of percentage of V_{40} is higher for plan no.2 than plan no.1. The mean of percentage of V_{40} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of V_{95} is higher for plan no.1 than plan no.2.The mean of percentage of V_{95} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

The table contains CI, HI, and UI of the target region in the two different plans. These two studied plans show no statistically significant difference ($P > 0.05$) in CI, HI, and UI of the target region

Mean of percentage of D_{max} is higher for plan no.1 than plan no.2.The mean of percentage of D_{max} shows no significant difference ($P > 0.05$) for plan no.1 and plan (2) no.2.

Mean of percentage of D_{min} is higher for plan no.1 than plan no.2.The mean of percentage of D_{min} shows no significant difference ($P > 0.05$) for plan no.1 and plan no.2.

Mean of percentage of D_{mean} is higher for plan no.1 than plan no.2. The mean of percentage of D_{mean} shows no significant difference (P > 0.05) for plan no.1 and plan no.2.

Mean of percentage of D_2 is higher for plan no.2 than plan no.1. The mean of percentage of D_2 shows no significant difference (P > 0.05) for plan no.1 and plan no.2.

Mean of percentage of D_{50} is higher for plan no.2 than plan no.1. The mean of percentage of D_{50} shows no significant difference (P > 0.05) for plan no.1 and plan no.2.

Mean of percentage of D_{95} is higher for plan no.1 than plan no.2. The mean of percentage of D_{95} shows significant difference (P < 0.05) for plan no.1 compared to plan no.2.

Mean of percentage of D_{98} is higher for plan no.2 than plan no.1. The mean of percentage of D_{98} shows no significant difference (P > 0.05) for plan no.1 and plan no.2.

Mean of percentage of V_{40} is higher for plan no.2 than plan no.1.The mean of percentage of V_{40} shows no significant difference (P > 0.05) for plan no.1 and plan no.2.

Table (4): Comparison of PTV dose and volume, CI, HI and UI between the two plans:

PTV	Plan (1)	Plan (2)	Test of significance	P value
D_{max}	113.26±4.28	113.36±4.23	t=0.053	0.959
D_{min}	60.49±15.80	60.10±11.91	t=0.062	0.951
D_{mean}	102.67±2.26	102.59±2.03	t=0.083	0.935
D_2	109.15±4.96	109.21±4.89	t=0.027	0.979
D_{50}	102.77±1.82	102.86 ±1.80	t=0.111	0.913
D_{95}	96.86±1.85	97.22±1.90	t=0.426	0.675
D_{98}	93.97±2.54	94.28±2.58	t=0.675	0.79
V_{10}	100.00±0.0	100.00±0.0	-	-
V_{20}	100.00±0.0	100.00±0.0	-	-
V_{25}	100.00±0.0	100.00±0.0	-	-
V_{30}	100.00±0.0	100.00±0.0	-	-
V_{40}	79.52±12.09	79.92±11.26	t=0.076	0.94
V_{95}	94.39±5.24	96.26±2.89	t=0.985	0.338
CI	0.68±0.43	0.68±0.43	t=0	1
HI	0.115±0.04	0.114±0.05	t=0.038	0.97
UI	1.05±0.02	1.04±0.01	t=0.857	0.403

Mean of percentage of V_{95} is higher for plan no.1 than plan no.2. The mean of percentage of V_{95} shows no significant difference (P > 0.05) for plan no.1 and plan no.2.

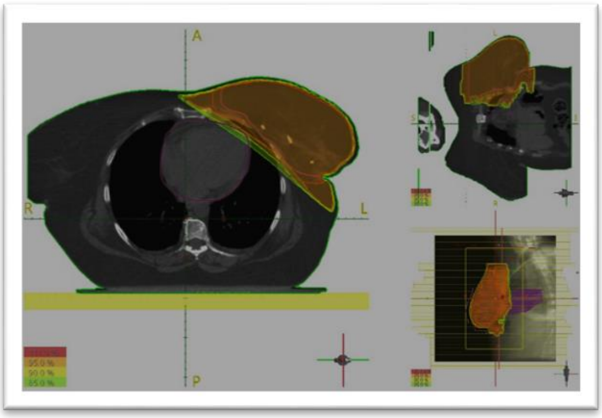

fig (1): The result of using interpolate.

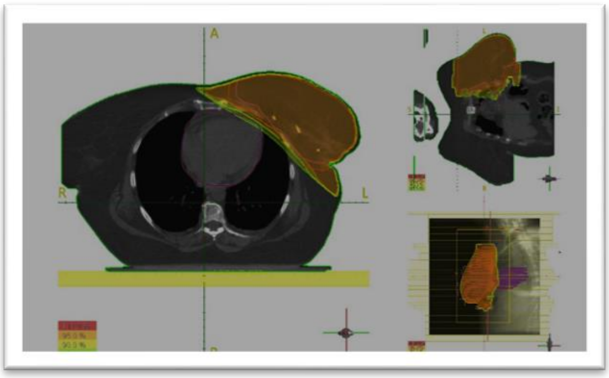

figure (1): The result of using manual contouring.

4. Discussion

Till nowadays, radiotherapy is known as an effective treatment after breast-conserving surgery for early breast cancer. The process of treatment from breast cancer used treatment planning system by computerized process. They used the dose volume histogram (DVH). There are many factors influence on dose volume histogram(DVH) such as interpolation (automation).

In literature, the expected benefits of using automatic tools are considered the reduction of the amount of time taken to draw the contours, and potentially also excessed reproducibility of the contours (i.e., decrease inter-observer variation) [14]. Contouring tools can be categorized as semi-automatic, fully automatic or fully manual based on the intended level of involvement of computation. and the radiation oncologist

In our study aimed to evaluate the influence of interpolation on dose volume histogram (DVH) during treatment planning system. Where the automation reduced the time of contouring task without effected on the dose of the target and organs at risk (OARs) such as the heart and left lung. During using the interpolation, there is no significant difference between using the automation where it isn't influence on the heart and left lung or without it.

5. Abbreviations:

PTV: Planning Target Volume; CTV: clinical Target Volume; OARs: Organs at Risk; HI: Homogeneity Index; CI: Conformity Index; MU: Monitor Unit; DVH: Dose Volume Histogram, LINAC: Linear Accelerator; CT: computed tomography; no.: Number

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