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Original article

Dosimetric Evaluation of Three-Dimensional Conformal Radiation Therapy Breast Cancer Treatment Plans

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ABSTRACT

Breast cancer is one of the most common cancers affecting women worldwide. Radiotherapy plays a pivotal role in breast cancer management. This study aims to conduct a comprehensive dosimetric analysis of breast cancer patients undergoing radiotherapy. In this study, 28 breast cancer patients were analyzed for various dosimetric parameters, including D98%, D95%, D50%, D5%, and D2%, as well as maximum, minimum, and mean doses within the PTV. PTV volume coverage was assessed at 95%, 93%, and 91% of the prescribed dose, with hot spot dose volumes at 115%, 110%, 108%, and 105%. Doses to organs at risk (OARs) were also evaluated. Dosimetric indices—uniformity index (UI), conformity index (CI), and homogeneity index (HI)—were calculated to assess treatment quality. Right-sided patients received higher doses at D98% and D95%, with smaller differences at D50%, D5%, and D2%. Left-sided patients had higher mean maximum and mean doses within the PTV, while right-sided patients had higher minimum doses. Left-sided chest wall-only patients showed higher hot spot volumes at 110% and 105%, though all patients had minimal volumes at 115%. Ipsilateral lung V20 was below 35% for all, with higher values in the chest wall and supraclavicular treatments. The mean heart dose was higher for left-sided treatments but stayed below cardiac toxicity limits. UI was slightly better in right-sided "Breast & SC" plans, and CI was higher in right-sided patients, while HI was higher in right-sided "Breast & SC" than left-sided "Breast Only." The study highlights differences in dose distribution between left and right-sided patients, with right-sided cases receiving higher doses at key points and left-sided cases showing larger PTV volumes and greater heart exposure. Dosimetric indices suggest treatment refinement may be needed, particularly for left-sided cases, to improve outcomes and reduce toxicity.

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INTRODUCTION

Breast cancer is the most prevalent malignancy among women globally and remains a significant public health challenge. Mortality rates in developed countries have markedly decreased since the 1990s due to advancements in screening, early detection, and the integration of multimodal treatment approaches, including surgery, systemic therapies, and radiotherapy [1]. Radiotherapy plays a vital role in breast cancer management, contributing to improved local control and overall survival rates [2].

Within radiotherapy departments, breast cancer patients represent a substantial proportion of cases. Treatment strategies are tailored to the disease stage and metastatic spread, typically involving surgical interventions such as lumpectomy or

mastectomy, followed by chemotherapy, hormone therapy, and radiotherapy. Standard radiotherapy protocols for breast cancer often utilize tangential fields to deliver 40 Gy in 15 fractions to the planning target volume (PTV) of the chest wall or breast, with additional fields for the supraclavicular region receiving the same dose.
Recent studies have focused on the dosimetric evaluation of various radiotherapy techniques to enhance target coverage and minimize toxicity to surrounding organs at risk (OARs). For example, a comprehensive dosimetric analysis of 623 patients demonstrated the effectiveness of the deep inspiration breath-hold (DIBH) technique in significantly reducing cardiac dose compared to free-breathing methods, with no notable differences in lung dose between the techniques [3]. Similarly, a review of six radiation therapy techniques, including intensity-modulated radiotherapy (IMRT), prone positioning, and partial breast irradiation, emphasized their dosimetric potential but highlighted the need for long-term follow-up to assess late cardiac and pulmonary toxicities [4]. Additionally, a study on three-dimensional conformal radiotherapy (3DCRT) revealed excellent target coverage but noted hot spots within the PTV and excessive lung dose in some cases, underscoring the importance of refining treatment plans to reduce toxicity [5].
These findings collectively support the hypothesis that advanced radiotherapy techniques can enhance treatment quality by improving dose conformity and homogeneity while reducing toxicity to critical structures such as the heart, lungs, and contralateral breast. The aim of this study was to perform a comprehensive dosimetric analysis of breast cancer patients undergoing 3DCRT, focusing on key parameters such as conformity index (CI), homogeneity index (HI), and uniformity index (UI). Additionally, the study evaluates radiation doses planning target volume and OARs to identify potential disparities between treatment techniques and provide insights for optimizing radiotherapy protocols.

METHODS

Study Design

This study is a retrospective dosimetric analysis conducted at the Radiotherapy Department of Tripoli University Hospital. The objective was to evaluate the treatment quality and dosimetric outcomes of three-dimensional conformal radiation therapy (3DCRT) for breast cancer patients treated between 2022 and 2023. The analysis focused on target volume coverage, dose uniformity, conformity, and homogeneity, as well as radiation exposure to organs at risk (OARs). A total of 28 patients were included in this study, stratified based on the type of surgery they underwent (breast conservation surgery or mastectomy) and the extent of the planning target volume (PTV) evaluated during imaging. Dosimetric parameters were compared for left-sided and right-sided breast cancer cases. The study adhered to institutional guidelines and ethical standards for retrospective data analysis, ensuring the anonymity and confidentiality of patient information.

CT images

All patients underwent CT simulation using the GE LightSpeed CT simulator. Images were acquired with a slice thickness of 5 mm, with patients positioned supine on a breast board with their arms resting on armrest paddles. Breast boundaries were delineated using clinical palpation and marked with radiopaque markers for imaging. Anatomical landmarks included:

- **Upper border**: Lower margin of the clavicular head,
- **Medial border**: Mid-axillary line,
- **Lower border**: 2 cm below the inferior breast fold.

Target and organ at risk delineation:

The CT scan data were transferred to the CMS XIO 4.70 treatment planning system, where contouring was performed by radiation oncologists. Contouring included the gross tumor volume (GTV), clinical target volume (CTV), planning target volume PTV, PTV evaluated, and organs at risk (OAR) such as the right and left lungs, heart, contralateral breast, and spinal cord, The CTV, PTV, and Organs at Risk (OARs) were generated following the Radiation Therapy Oncology Group (RTOG) 0319 protocol [6].

Treatment Planning Details and Dose Prescription

All patients were planned to receive a dose of 40Gy delivered in 15 fractions, with some patients receiving a boost dose of 9Gy over 3 fractions or 10Gy over 3 or 5 fractions. In 54% of cases, an alternative bolus of 0.5cm thickness was utilized. Treatment planning was conducted on the CMS XIO 4.70 treatment planning system using the ELEKTA Synergy platform linear accelerator photon beam. The treatment strategies were as follows: a) Patients with involvement of both the breast and supraclavicular region were treated with a mono-isocenter approach. A dose of 40Gy over 15 fractions was prescribed, delivered through two tangential 6MV photon fields for the chest wall PTV or breast PTV

(PTV eval.). Additionally, a dose of 40Gy over 15 fractions was administered using two parallel opposed fields, with a gantry angle of 10-15 degrees for the anterior field and utilizing 6MV photon beam, and 10MV photon beam for the posterior field in most cases, for the supraclavicular PTV. b) Patients without involvement of the supraclavicular region were treated with the isocenter positioned at the center of the chest wall or breast PTV (PTV eval.). The prescribed dose of 40Gy over 15 fractions was delivered through two tangential 6MV photon fields targeting the PTV evaluated. c) Patients with an extended PTV eval. received treatment with a mono-isocenter approach positioned at the first third of the PTV evaluated. The lower portion of the PTV evaluated received a dose of 40 Gy over 15 fractions through two tangential 6MV photon fields, while the upper portion of the PTV eval. and the supraclavicular PTV were treated using two parallel opposed fields, with a gantry angle of 10-15 degrees for the anterior field utilizing 6MV photon beam, and 10MV photon beam for the posterior field in most cases.

The weighting point of tangential fields was optimized at various sites around the center of the PTV eval. in most cases, the weighting dose was optimized for each field to ensure adequate coverage of the PTV evaluated (volume covered with 95% of the prescribed dose equal to or greater than 95% of the PTV evaluated volume) and to limit the maximum dose (hot spot) where are the volume 105% of the prescribed dose is less than or equal to 15% of the PTV eval. volume, using the field-in-field technique. Dose constraints for OARs were applied: the mean dose to the heart was limited to ≤5 Gy, the volume of the lungs receiving 20Gy was kept below 35%, the maximum dose to the contralateral breast was limited to <3Gy, and the maximum dose to the spinal cord was limited to <45Gy.

The dosimetric data were calculated and compared for each case using the following definitions:

Uniformity index (UI): Defined as the ratio between the minimum dose reaching 5% of the PTV volume (D5%) and the minimum dose reaching 95% of the PTV volume (D95%).

$$UI = D5\% / D95\%$$

Conformity index (CI) following RTOG (ICRU62): Defined as the ratio between the volume covered by the reference isodose volume (95%) (TVRI) and the target volume PTV evaluated (TV).

$$CI = TVRI / TV$$

Homogeneity index (HI):

defined as the ratio between the dose reaching 95% of the PTV volume (D95%) and the dose reaching 5% of the PTV volume (D5%).

$$HI = D(95\%) / D(5\%)$$

RESULTS

The total number of patients performed in this research is 28 patients (13 left side breast (46.4%) and 15 right side breast (53.6%)), the age of the patients is 49±9.8 y, all patients are female except one patient is male.

patients were categorized into two groups as left side breast and right-side breast, the cushion left-side breast patients 7 patients (53.8%) had chest wall PTV and SC PTV, one patient (7.7%) had chest wall PTV only, two patients (15.4%) had breast PTV with SC PTV and three (23.1%) had breast PTV only the right side breast patients are 10 patients (66.7%) had chest wall PTV and SC PTV, one patient (6.7%) had chest wall PTV only, one patient (6.7%) had breast PTV with SC PTV and three (20%) had breast PTV only.

Table 1 shows the dosimetric analysis focused on several parameters, including the mean dose values at different percentages of the planning target volume (PTV) evaluation volume, namely D98%, D95%, D50%, D5%, and D2% were examined for each patient group.

As illustrated in table 1, there are notable disparities in dose distribution between the left and right-sided breast cancer patients. Specifically, for both D98% and D95%, the right-sided breast patients consistently received higher doses compared to their left-sided counterparts across all subgroups categorized by target volume delineation. This discrepancy suggests potential asymmetries in treatment planning and delivery, which could influence treatment efficacy and toxicity outcomes.

Furthermore, the analysis of dose parameters at different percentiles (D50%, D5%, and D2%) provides insights into the distribution of radiation within the target volume. While the differences between left and right-sided breast patients are less pronounced for these parameters, variations in dose delivery may still impact treatment outcomes, such as tumor control and normal tissue toxicity.

Table 1. The mean dose (cGy) and standard deviation of % PTV eval. volume (D98%, D95%, D50%, D5% and D2%)

Treatment volume		No. of Pt.	Dose (cGy) of % volume of PTV eval.[2]				
			D98%[1]	D95%[1]	D50%[1]	D5%[1]	D2%[1]
Rt. side	CW& SC	10	3807±40	3874±39	4113±77	4312±104	4358±107
	CW only	1	3730	3810	4090	4470	4520
	Breast &SC	1	3920	3950	4100	4240	4260
	Breast only	3	3807±50	3890±36	4177±95	4383±103	4433±100
Lt. side	CW&SC	7	3764±41.2	3854±31	4137±41.9	4356±63	4399±76.9
	CW only	1	3690	3940	4350	4500	4540
	Breast &SC	2	3780±28.3	3870	4135±63.6	4355±21.2	4400±14.1
	Breast only	3	3720±26.5	3840±20	4077±15.3	4287±98.7	4327±115.9

[1] *The mean dose in cGy of 98%,95%,50%,5%,2% of the volume of PTV Eval,* [2] *the evaluation planning target volume*

Table 2 illustrates the mean of max dose, min. dose and mean dose within PTV, the table shows the mean of max. dose and mean dose in left-sided breast patients are greater than for right breast patients for either chest wall PTV or breast PTV, furthermore, the minimum dose within PTV for right breast side patients is greater than left side breast patients.

Table 2. The mean value of max. dose, min dose, and mean dose within the PTV eval. volume

Treatment volume		No. of Pt.	Max dose (cGy)	Mean dose (cGy)	Min dose (cGy)
Rt. side	CW& SC	10	4517±118	4102±65	1949±643
	CW only	1	4602	4107	831
	Breast &SC	1	4344	4102	2591
	Breast only	3	4566±94	4159±52	1602±497
Lt. side	CW&SC	7	4584±85	4112±37.4	1642±401
	CW only	1	4650	4291	1093
	Breast &SC	2	4556±32.5	4124±43.1	1094±462.4
	Breast only	3	4435±136.6	4057±11.9	1827±1366.1

Table 3 shows the difference in the mean value of PTV eval. volume, % volume of PTV eval. coverage by 95%, 93%, and 91% of the dose, For the two groups of patients, where PTV eval. The volume for the mastectomy for lt. side patients (626.8-822.07cc) is greater than the Rt. side patients (426.5-718.2 cc). And the coverage of PTV eval. 95% of the dose is good for all patients where it is greater than 96% of the PTV volume except for chest wall case for rt side breast, on the other hand, the PTV volume coverage by 93% and 91% of the dose is greater than 97% of the volume for all the patients. indicating excellent dose conformity across different treatment regions and patient groups.

Table 3. The mean value of PTV eval. volume, % volume of PTV eval. coverage by 95%, 93% and 91% of dose and the

Treatment volume		No. of pt.	PTV eval. Volume (cc)	% of PTV eval volume cover by (cGy)		
				95% of dose	93% of dose	91% of dose
RT.side	CW& SC	10	718.2±217	97.9±1.07	99.2±0.48	99.5±0.32
	CW only	1	426.5	95.6	97.8	98.1
	Breast &SC	1	1313.5	99.6	99.8	99.7
	Breast only	3	1697.2±421	98.1±1.09	98.6±0.34	99.3±0.14
Lt. side	CW&SC	7	822.1±158.4	96.41	97.8±1.6	98.4±1.07
	CW only	1	626.8	97.17	98.26	97.84
	Breast &SC	2	1355.9±649	97.8±0.26	98.7±0.33	98.8±0.17
	Breast only	3	1499.7±942.3	96.6±0.5	97.8±0.33	98.5±0.24

Table 4 shows the hot spot volume receiving 115% of the prescribed dose is minimal across all patients, demonstrating effective avoidance of excessive high-dose regions. The hot spot volume receiving 110% of the prescribed dose is generally small; however, it is notably higher for left-sided chest wall-only (CW-only) patients at 31.2%. This group also shows a significantly high hot spot volume at the 105% dose level, reaching 79%. In comparison, other patient categories have hot spot volumes ranging from 10.6% to 43.45% at the 105% dose level. It is important to note that these hot spot volumes should ideally be kept below 15% to minimize the risk of radiation-induced damage to surrounding healthy tissues.

Table 4. The volume of hot spot dose (115%,110%,108%,105%) within PTV eval.

Treatment volume		No. of pt.	Volume of Hot spot (cc)		
			115% of dose	110% of dose	105% of dose
RT. side	CW& SC	10	0.00125	3.98±6.8	23.9±18.8
	CW only	1	0	9.06	27.49
	Breast &SC	1	0	0	17.9
	Breast only	3	0	6.02±6.02	43.5±25
Lt. side	CW&SC	7	0.045±0.11	3.2±2.5	30.7±12.7
	CW only	1	0.3	31.23	79.29
	Breast &SC	2	0	2.03±0.61	31.95±14.4
	Breast only	3	0	1.6±2.7	10.6±9.14

Table 5 illustrates the mean value dose of OAR such as the % volume of ipsilateral lung received 20Gy, mean dose of heart, and max. dose of contralateral breast for each type of patient, the V20 parameter is a critical indicator of radiation-induced pulmonary toxicity risk. Table 4 shows that the percentage volume of the ipsilateral lung receiving 20Gy across all treatment types is below 35%, with values ranging from 19.6% to 32.1%. The highest V20 values are observed in CW&SC patients for both the right and left sides, reflecting the increased lung exposure when the supraclavicular region is included. These findings highlight the importance of carefully planning treatments involving the supraclavicular region to minimize lung dose and potential toxicity.
The mean dose to the heart is crucial for assessing the risk of cardiac toxicity The highest mean heart dose for right-sided treatments is observed in breast-only patients (351.7cGy), while the lowest is in breast & SC patients (58cGy). For left-sided treatments, the mean heart doses are higher due to the heart's anatomical position relative to the left chest wall. The highest dose is seen in CW&SC patients (530.3 cGy), and the lowest in breast-only patients (378.3 cGy). All these values are below the critical threshold of 600 cGy, suggesting an acceptable risk for cardiac toxicity.
The maximum dose to the contralateral breast is a key measure for minimizing the risk of radiation-induced secondary malignancies The highest maximum dose to the contralateral breast for right-sided treatments is seen in breast-only patients (1175.3 cGy), while for left-sided patients, the highest is in CW only patients (687 cGy). The large variability in these values, especially in breast-only treatments, underscores the need for stringent planning and dose constraints to protect the contralateral breast.

Table 5. The dose of OAR (% volume ipsilateral lung received 20CGy, Mean dose Heart, and Max. dose contralateral breast)

Treatment volume		% Volume ipsilateral lung received 20CGy	Mean dose Heart	Max. dose contralateral breast
RT. side	CW& SC	31.5±3.6	78±14.9	499±615.4
	CW only	23.9	128	279
	Breast &SC	32.8	58	436
	Breast only	24.1±0.8	351.7±340	1175.3±1773
Lt. side	CW&SC	32.1±4.4	530.3±134.7	545.1±907.5
	CW only	21	502	687
	Breast &SC	28.2±8.3	438±70.7	687±671.8
	Breast only	19.6±5.4	378.3±226.2	251.6±126.3

Table 6 demonstrates the dosimetric data (uniformity index UI, Conformity index CI, and Homogeneity index HI) calculated and compared for each type of breast cancer case treated. The table below reveals that the lowest UI value is 1.073 for Right. Side breast patients treated with breast and super clave, while the highest value is 1.173 for patients treated with chest wall only. On the other hand, for left-side breast patients, the lowest UI value is 1.116 for patients treated with breast only, and the highest value is for patients treated with chest wall only 1.142. The uniformity index is slightly better for the "Breast & SC" plan on the right side (1.073) and the "Breast only" plan on the left side (1.116) For the conformity index the table shows that for the right side (0.955-0.996) is better than for left side (0.964-0.978), The conformity index is highest for the "Breast & SC" plan on the right side (0.996) and "CW only" plan on the left side (0.972). the homogeneity index has a higher value for the right-side breast for patients treated with breast and SC of 0.932 a lower value of 0.888 for patients treated with breast only and for left side breast the higher value of 0.896 for patients treated with breast only and a lower value 0.876 for patients treated chest wall only.

Table 6. Demonstrates the dosimetric data (uniformity index UI, Conformity index CI, and Homogeneity index HI)

Treatment volume		Uniformity index UI	Conformity index CI	Homogeneity index HI
RT. side	**CW& SC**	1.113	0.982	0.899
	CW only	1.173	0.955	0.852
	Breast &SC	1.073	0.996	0.932
	Breast only	1.127	0.981	0.888
Lt. side	**CW&SC**	1.130	0.964	0.885
	CW only	1.142	0.972	0.876
	Breast &SC	1.125	0.978	0.889
	Breast only	1.116	0.965	0.896

DISCUSSION

The dosimetric analysis of the current study highlights notable differences in dose distribution and treatment outcomes between left- and right-sided breast cancer radiotherapy plans, providing insights into optimizing treatment quality.

Dose Distribution in Planning Target Volume (PTV): The study found that right-sided patients generally received higher doses at D98% and D95% compared to left-sided patients, indicating variations in target volume coverage. These findings align with prior studies that emphasize the influence of anatomical asymmetries and treatment setup on dose distribution [3]. Conversely, left-sided patients exhibited higher mean and maximum doses within the PTV, suggesting the need for improved hotspot management, particularly in left-sided cases. This aligns with the observation that left-sided treatments are inherently more challenging due to proximity to critical structures like the heart.

Dose Constraints and Organs at Risk: the mean heart dose for left-sided treatments was higher than for right-sided cases, as expected due to the anatomical position of the heart. Despite this, the doses remained within acceptable toxicity thresholds (≤5 Gy), consistent with previous reports that demonstrated the effectiveness of modern radiotherapy techniques, including the deep inspiration breath-hold (DIBH) method, in reducing cardiac exposure [3]. For the lungs, ipsilateral V20 values were generally below 35%, but treatments involving the supraclavicular region showed slightly elevated doses, emphasizing the need for careful planning in such cases to minimize pulmonary toxicity.

The analysis of dosimetric indices demonstrated good overall treatment quality. The conformity index (CI) was higher for right-sided patients, reflecting better dose conformality in these cases, likely due to less cardiac interference. Meanwhile, uniformity index (UI) and homogeneity index (HI) values were comparable across groups, indicating consistent dose uniformity and homogeneity within the PTV. These metrics corroborate prior findings suggesting that 3D conformal radiation therapy (3DCRT) provides acceptable dosimetric outcomes but could benefit from further refinement, such as integrating field-in-field techniques or advanced planning methods like IMRT [4,5].

Impact of Extended PTV and Hotspot Management: or cases involving extended PTV, the study highlighted increased challenges in achieving uniform dose distribution. Hotspot volumes (e.g., receiving 105% or 110% of the prescribed dose) were more prominent in left-sided chest wall-only treatments, raising concerns about potential tissue toxicity. The use of a bolus in more than half of the cases likely contributed to the observed variations in hotspot management. Future studies should explore alternative bolus thicknesses or advanced planning strategies, such as mixed photon-electron beams, to mitigate these effects [5].

While the study provides valuable insights, its relatively small sample size (28 patients) limits the generalizability of the findings. Moreover, the retrospective design precludes direct comparisons of clinical outcomes, such as recurrence rates or late toxicity. Future research should focus on larger, multicentric cohorts to validate these dosimetric findings and investigate their correlation with long-term clinical outcomes. Additionally, incorporating advanced techniques like DIBH, proton therapy, or hybrid plans could further improve dosimetric parameters and reduce toxicity, particularly for left-sided cases.

CONCLUSION

this study involving 28 breast cancer patients (13 left-sided and 15 right-sided) with a mean age of 49 years, predominantly female, reveals significant findings in dosimetric analysis. The results indicate notable disparities in dose distribution between left and right-sided breast cancer patients. Specifically, right-sided patients consistently received higher doses for D98% and D95% compared to left-sided patients, suggesting potential asymmetries in treatment planning and delivery. The analysis of dose parameters at different percentiles (D50%, D5%, and D2%) shows less pronounced differences but still highlights variations that could impact treatment outcomes, such as tumor control and normal tissue toxicity. Additionally, the mean maximum and mean doses were higher in left-sided breast patients, while the minimum dose was greater in right-sided patients. Overall, these findings underscore the importance of tailored treatment planning to address the observed asymmetries and optimize treatment efficacy and safety for breast cancer patients.

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Conflict of interest. Nil

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التقييم الجرعي لخطط علاج سرطان الثدي باستخدام العلاج الإشعاعي المطابق ثلاثي الأبعاد

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المستخلص
سرطان الثدي هو أحد أكثر أنواع السرطان شيوعًا التي تصيب النساء في جميع أنحاء العالم. يلعب العلاج الإشعاعي دورًا محوريًا في إدارة سرطان الثدي. تهدف هذه الدراسة إلى إجراء تحليل شامل للجرعات لمرضى سرطان الثدي الذين يخضعون للعلاج الإشعاعي. في هذه الدراسة، تم تحليل 28 مريضة بسرطان الثدي من أجل معايير قياس الجرعات المختلفة، بما في ذلك D98٪ و D95٪ و D50٪ و D5٪ و D2٪ ، بالإضافة إلى الحد الأقصى والحد الأدنى والجرعات المتوسطة ضمن .PTV تم تقييم تغطية حجم PTV بنسبة 95٪ و 93٪ و 91٪ من الجرعة الموصوفة، مع أحجام جرعات النقاط الساخنة بنسبة 115٪ و 110٪ و 108٪ و 105٪. كما تم تقييم الجرعات للأعضاء المعرضة للخطر (OARs).تم حساب مؤشرات الجرعات - مؤشر التوحيد (UI) ومؤشر المطابقة (CI) ومؤشر التجانس - (HI) لتقييم جودة العلاج. تلقى المرضى من الجانب الأيمن جرعات أعلى عند D98٪ وD95٪ ، مع اختلافات أصغر عند D50٪ و D5٪و .D2٪ كان لدى المرضى من الجانب الأيسر متوسط أعلى للجرعات القصوى والمتوسطة داخلPTV ، بينما كان لدى المرضى من الجانب الأيمن جرعات دنيا أعلى. أظهر مرضى جدار الصدر الأيسر فقط أحجام نقاط ساخنة أعلى عند 110٪ و 105٪، على الرغم من أن جميع المرضى كان لديهم أحجام دنيا عند 115٪. كان V20 في الرئة من نفس الجانب أقل من 35٪ للجميع، مع قيم أعلى في جدار الصدر والعلاجات فوق الترقوة. كان متوسط جرعة القلب أعلى للعلاجات من الجانب الأيسر ولكنها ظلت أقل من حدود السمية القلبية. كان مستوى مقاومة الأنسولين أفضل قليلاً في خطط "الثدي والحمل تحت الجلد" على الجانب الأيمن، وكان مؤشر كتلة الجسم أعلى لدى المرضى على الجانب الأيمن، بينما كان مؤشر كتلة الجسم أعلى لدى المرضى على الجانب الأيمن "الثدي والحمل تحت الجلد" مقارنة بالمريضين على الجانب الأيسر "الثدي فقط". تسلط الدراسة الضوء على الاختلافات في توزيع الجرعة بين المرضى على الجانب الأيسر والأيمن، حيث تلقت الحالات على الجانب الأيمن جرعات أعلى في نقاط رئيسية وأظهرت الحالات على الجانب الأيسر أحجام PTV أكبر وتعرضًا أكبر للقلب. تشير مؤشرات الجرعات إلى أن تحسين العلاج قد يكون ضروريًا، وخاصة بالنسبة للحالات على الجانب الأيسر، لتحسين النتائج وتقليل السمية.

الكلمات المفتاحية. سرطان الثدي، PTV، استئصال الورم، استئصال الثدي، مؤشر التجانس، مؤشر المطابقة، الأعضاء المعرضة للخطر، المجالات المماسية.