



Evaluating the efficacy of breast cancer treatments using PET-CT Imaging

Muntaser S. Ahmad ¹, Qais Hjouj ², Majed Alshareef ³ Miral Asfour ³ Ashraf Squeer ³

Mohammad Qwasmeh ³ Mohammad Hjouj ⁴

¹ Faculty of Allied Medical Health, Palestine Ahliya University and Department of Nuclear medicine, Al-Ahli Hospital (Palestine).

✉ wmuntaser@gmail.com

² Faculty of Medicine, Al-Quds University (Palestine).

✉ qais@gmail.com

³ Faculty of College of Pharmacy & Medical Science, Hebron University (Palestine).

✉ 21810344@students.hebron.edu

⁴ Faculty of Health Professions, Al-Quds University (Palestine).

✉ mhjouj@staff.alquds.edu

Received:03/02/2023

Accepted:11/03/2023

Published: 01/04/2023

Abstract:

Positron emission tomography-computed tomography (PET-CT) scans are used to detect and stage cancer and can be used to evaluate the effectiveness of treatments used for patients with different types of cancer. The current study aims to evaluate the effectiveness of treatments provided to breast cancer patients and the effect of treatment on the right and left breasts separately. A sample of (84) female left and right breast cancer patients were treated with radiation therapy and/or chemotherapy. The efficacy of the treatments was evaluated on 18 follow-up patients among the original sample who already underwent a PET-CT scan before starting their treatment. Treatment efficacy was evaluated by measuring the standard uptake value (SUV) of cancer lesions in patients before and after treatment. Results showed that 32.1% of the diagnosed lesions did not change their SUV values, 39.3% were treated, 27.4% were new lesions do not present in the original PET-CT scan, and 1.2% for lesions that increased the value of the SUV. Moreover, the results also showed that left breast cancer was more responsive to treatment than right breast cancer, while chemotherapy was more effective than radiation therapy. In summary, the efficacy of chemotherapy and/or radiotherapy for both right and left breast cancer patients was evaluated using PET-CT technology. Only one-third of the cancerous lesions were treated using the treatment methods described in this study. The research is unique in that it is the first in Palestine to investigate the feasibility and efficacy of the treatment delivered to breast cancer patients.

Keywords: PET-CT; Breast Cancer; Chemotherapy; Radiation therapy.

تقييم فعالية علاجات سرطان الثدي باستخدام التصوير المقطعي بالإصدار البوزيتروني

منتصر أحمد¹✉، قيس حجوج²، ماجد الشريف³، ميرال عصفور³، أشرف صقر³، محمد قواسمة³، محمد حجوج⁴

¹ كلية الصحة الطبية المساندة، جامعة فلسطين الأهلية وقسم الطب النووي، المستشفى الأهلي (فلسطين).

✉ wmuntaser@gmail.com

² كلية الطب، جامعة القدس (فلسطين)

✉ qais@gmail.com

³ كلية الصيدلة والعلوم الطبية، جامعة الخليل (فلسطين)

✉ 21810344@students.hebron.edu

⁴ كلية المهن الصحية، جامعة القدس (فلسطين).

✉ mhjouj@staff.alquds.edu

تاريخ النشر: 01/04/2023

تاريخ القبول: 11/03/2023

تاريخ الاستلام: 03/02/2023

ملخص:

تُستخدم فحوصات التصوير المقطعي بالإصدار البوزيتروني - التصوير المقطعي المحوسب (PET-CT) للكشف عن السرطان ومرحلته، ويمكن استخدامها لتقييم فعالية العلاجات المستخدمة للمرضى المصابين بأنواع مختلفة من السرطان. تهدف الدراسة الحالية إلى تقييم فعالية العلاجات المُقدّمة لمرضى سرطان الثدي، وتأثير العلاج على الثديين الأيمن والأيسر بشكل منفصل. أُجريت الدراسة على عينة مُكوّنة من (84) أنثى من مرضى سرطان الثدي الأيمن والأيسر، واللواتي قُدّم لهنّ العلاج الإشعاعي و/ أو العلاج الكيميائي، وتم تقييم فعالية العلاجات على (18) مريضة تم عمل متابعة لهنّ من بين العينة الأصلية اللواتي خضعن بالفعل لفحص (PET-CT) قبل بدء العلاج، كما تم تقييم فعالية العلاج عن طريق قياس قيمة الامتصاص القياسية (SUV) لآفات السرطان في المرضى قبل وبعد العلاج. أظهرت النتائج أن (32.1%) من الآفات التي تم تشخيصها لم تُغيّر قيم الامتصاص القياسية (SUV)، و(39.3%) تم علاجها، و(27.4%) كانت آفات جديدة غير موجودة في فحص (PET-CT) الأصلي، و(1.2%) للآفات التي زادت من قيم الامتصاص القياسية (SUV). علاوةً على ذلك، أظهرت النتائج أن سرطان الثدي الأيسر كان أكثر استجابة للعلاج من سرطان الثدي الأيمن، بينما كان العلاج الكيميائي أكثر فعالية من العلاج الإشعاعي. باختصار، تم تقييم فعالية العلاج الكيميائي و/ أو العلاج الإشعاعي لكل من مرضى سرطان الثدي الأيمن والأيسر باستخدام تقنية PET-CT. تم علاج ثلث الآفات السرطانية فقط باستخدام طرق العلاج الموصوفة في هذه الدراسة.

الكلمات المفتاحية: العلاج الكيميائي، سرطان الثدي، العلاج الإشعاعي، التصوير المقطعي بالإصدار البوزيتروني - التصوير المقطعي المحوسب.

1. Introduction:

Breast cancer is considered the most common type of cancer affecting women's lifestyles in the world and causing death. Most of cases, the cancerous tissue lining on the milk ducts and lobules are called ductal and lobular carcinomas, respectively. Several techniques are used to diagnose breast cancer including mammography (Ahmad et al., 2020a), ultrasound (Oglat et al., 2020; Oglat et al., 2018a; Oglat et al., 2018b), computed tomography (CT) (Al-Tell, 2019; Kmail et al., 2022; Ahmad et al., 2019; Ahmad et al., 2021a), Magnetic resonance imaging (MRI) (Ahmad et al., 2020b; Ahmad et al., 2022; Mohammad et al., 2020; Ahmad et al., 2020c), Positron Emission Tomography (PET)scan, and others. Breast Cancer cannot be definitively diagnosed unless a biopsy sample from the affected tissue is taken, through which the type and grade of the disease can be identified (Lubejko et al., 2019; Ban et al., 2021; Ahmad et al., 2019; Ahmad et al., 2022).

There are five phases of breast cancer, each with a different size and location of the malignant tissues. As Stage 0 is the initial stage its distinguished by a non-invasive stage of cancer, in which the cancer cells are localized in the same part of the breast and have not spread to nearby cells. Stage 1 cancer is an aggressive and microscopic invasion. This stage is divided into two categories: 1A, which is defined as a tumor with a diameter of less than 2 cm in size with no lymph nodes involvement, and 1B, which is defined as a tumor with a diameter of more than 2 cm and lymph nodes involvement in the same region of the breast. Stage 2 similarly has two parts, 2A, which describes the presence of axillary lymph nodes or sentinel lymph nodes but no malignancy within the breast tissue itself, and tumour with a diameter size of 2-5 cm, and 2B, which describes a tumor greater than 5 cm without axillary lymph nodes. Stage 3 is divided into two parts. 3A breast tissue tumor with 4-9sentienal or axillary lymph nodes is present, 3B more than 9 lymph nodes with breast tissue ulcers. Stage 4 is the final stage and it includes metastasis from the breast tissue to other organs such as the lungs, liver, and bone(Ahmad et al., 2021b; Makhamrah et al., 2019).

Depending on the type and stage of the illness, people with breast cancer can choose from a variety of treatments. Among these are resection surgery, in which the surgeon eliminates breast cancerous tissue, whether it be a mastectomy, in which all breast tissue is removed, or surgery with breast preservation, in which a portion of the normal tissue surrounding the affected area is removed. Adjuvant Chemotherapy which is sometimes administered before surgery in order to shrink the tumor, is another form of chemotherapy that is employed to kill any leftover cells following surgery. Chemotherapy might involve hormonal or biological therapy. Finally, breast cancer can be combined with radiation therapy. It is usually done after surgery and chemotherapy, and the number of sessions is dependent upon the patient's condition (Waks & Winer, 2019a; Makhamrah et al., 2023; Ahmad et al., 2021c; Ahmad et al., 2020d).

Although structural imaging modalities provide a tool for diagnostic purposes, such as computed tomography, magnetic resonance imaging and ultrasonography. PET-CT is a hybrid imaging modality that provides structural and functional information for breast cancer diagnosis, staging and treatment (Paydary et al., 2019; Ahmad et al., 2020a), and it is known that this method based on injecting a radioactive material into the patient body and detecting its distribution in biological tissues to form tomographic images. The objectives of the current study were to determine the justification rate for PET-CT procedures, the use of PET-CT to assess breast cancer response to different treatments, and to evaluate the effect and response on both the right and left breast individually.

2. Materials and Methods:

2.1 Study design

A retrospective study was performed to assess response to breast cancer after appropriate treatment types that had been provided. Information about the diagnostic and treatment procedures for patients during the period from 2021 to 2022 was collected from the Nuclear Medicine archive, Department at Al-Ahli Hospital - Hebron, Palestine.

2.2 Study population and data collection:

The sample consisted of 84 patients with a history of breast cancer, either in the right or left breast, where the sex of all patients was female. The number of women with left breast cancer was 38 and the number with right breast cancer was 46. All ages were included. However, patients who had only one PET-CT procedure without follow-up, who had not had chemotherapy or radiotherapy, patients who did not have a PET-CT report, were excluded.

2.3 Data Collection:

Whole-body PET-CT scans were performed in 3D mode using a dedicated in-line PET-CT scanner. All patients were instructed to fast for more than 6 hours prior to examination. Data were acquired 45-minutes after intravenous injection of approximately 5 MBq/kg body weight of FDG (up to 550 MBq). The scan Field of view from the vertex to the mid thigh was obtained using the following parameters: kVp: 120, mAs: 250, Field of view: 1500 mm, scan width: 2.00mm, scan time: 19 seconds, length: 936mm. All patients didn't receive intravenous iodinated contrast. On completion of CT, PET-CT scans of the same area were acquired for 1.5 min/bed position, with 11-13 bed positions per pat. All patients were imaged using a device manufactured by: Philips medical system (Cleveland), Inc. - 595 Miner Road - Cleveland, Ohio 44143 - USA. The archives of the Nuclear Medicine Department at Al-Ahli Hospital were also used to collect previous reports. Ethical approval was obtained from the relevant departments of Al-Ahli Hospital. Data on breast cancer patients were collected in 2021-2022 including: patient age, clinical history, reports, SUV volumes, chemotherapy sessions, radiotherapy sessions, and tumor size and location.

2.4 Data Analysis:

SPSS software version 23 was used to analysis of the data where: Chi-Square Tests used to find the Relationship between Radiotherapy and Chemotherapy and to find the Significant differences between SUV's values. ANOVA test was used to find the statistically significant differences between breast cancer and the extent of treatment provided, and the effect of radiotherapy and Chemotherapy sessions on both SUV pre and post-treatment.

3. Results

Demographic data for all patient

A total of 84 females' patient's data was collected, 54.8% had right breast cancer. where 79.8% of the participants were over 40 years old. Most patients 67.5% did not underwent any radiotherapy session. while 48.8% of the participants, did not underwent any chemotherapy session. However only 3.6% underwent more than 20 chemotherapy sessions. To evaluate the response to both radiotherapy and chemotherapy only 18 patients participated in these evaluations because they had follow-up sessions. Table 1 summarizes the demographic data of all participants who underwent follow-up PET-CT sessions.

Table (1): Distribution demographic data in the sample.

Patients underwent first PET-CT		Patients who underwent a follow-up PET-CT scan	
		N (%)	N (%)
Patient History	Rt Breast Ca	46 (54.8%)	9 (5.0%)
	Lt Breast Ca	38 (45.2%)	9 (5.0%)
Age group	20-40 years	17 (20.2%)	3 (16.7%)
	>40 years	67 (79.8%)	15 (8.3%)
Radiotherapy Sessions	no session	57 (67.9%)	15 (8.3%)
	< 10 sessions	4 (4.8%)	-
	between 10-20 sessions	15 (17.9%)	3 (16.7%)
	> 20 sessions	8 (9.5%)	-
Chemotherapy Sessions	no session	41 (48.8%)	7 (38.9%)
	< 10 sessions	33 (39.3%)	1 (5.6%)
	between 10-20 sessions	7 (8.3%)	6 (33.3%)
	> 20 sessions	3 (3.6%)	4 (22.2%)

Assessment of treatment

The Chi Square test was used to find the difference between radiotherapy and chemotherapy with respect to patients' history after the first and second follow-up PET-CT scans. Table 2 shows that there is no difference between radiotherapy and chemotherapy after the first follow-up examination because they are greater than 0.05, which was a p-value of 0.141 and a p-value of 0.193, respectively. This means that the both types of treatment of breast cancer does not have any differences.

Table (2): Relationship between Radiotherapy and Chemotherapy Sessions and patients history after first and second PET-CT scan.

Radiotherapy Sessions	Value	df	P-value
Pearson Chi-Square	5.46 ^a	3	0.14
Likelihood Ratio	5.44	3	0.14
N of Valid Cases	84		
a. 6 cells (75.0%) have expected count less than 5. The minimum expected count is .33.			
Chemotherapy Sessions	Value	df	P-value
Pearson Chi-Square	3.29 ^a	2	0.19
Likelihood Ratio	3.07	2	0.21
N of Valid Cases	84		
a. 4 cells (66.7%) have expected count less than 5. The minimum expected count is 1.33.			

Assessment SUV values**Distributions of SUV values in sample**

SUVs, measured to find the hypermetabolic rate, then each SUV is averaged and categorized into 3 categories: mild, moderate and hypermetabolic. The SUV values were as follows: mild absorption <2.48, moderate absorption 2.48–4.96, and hyper- absorption >4.96. Table 3 shows the SUV's classification through the 18 patients according to lesions number. According to SUV, 56% of lesions did not show any uptake value while 17.9% demonstrated hyper metabolic lesion. According to SUV₁, 21.4% of right (RT) breast lesion and 45.2% of left (LT) breast lesions did not demonstrate any uptake value, while 3.6% presented a hyper metabolic rate in RT breast lesions, and 10.7% have a hyper metabolic in LT breast lesions. According to SUV₂, 38.1% of lesions in RT breast cancer

patients and 65.5% of lesions in LT breast cancer patients did not show any uptake while 4.8% demonstrated hyper uptake in RT breast lesions but no hyper uptake in LT breast lesions.

Table (3): The SUV's classification through the 18 patients according to lesions number.

		N (%)
SUV	no uptake	47(56.0%)
	Poor uptake <2.48	4 (4.8%)
	Mild uptake 2.48- 4.96	18 (21.4%)
	Hyper uptake> 4.96	15 (17.9%)
	Total	84
		history of patient
		Rt Breast Ca Lt Breast Ca
SUV ₁	no uptake	18 (21.4%) 38 (45.2%)
	Poor uptake <2.48	1 (1.2%) 3 (3.6%)
	Mild uptake 2.48- 4.96	6 (7.1%) 6 (7.1%)
	Hyper uptake> 4.96	3 (3.6%) 9 (10.7%)
SUV ₂	no uptake	23 (38.1%) 55 (65.5%)
	Poor uptake <2.48	0 1 (1.2%)
	Mild uptake 2.48- 4.96	1 (1.2%) 0
	Hyper uptake> 4.96	4 (4.8%) 0
Total		28 56

SUV: first SUV; SUV₁: after first follow up; SUV₂: after second follow up

To find the Significant differences between SUV's using Chi-Square Tests. Table 4 shows there are no difference between SUV₁ and SUV₂ because the P-value are more than 0.05 which was p-value 0.565 and 0.012, respectively.

Table (4): Significant differences between SUV's using Chi-Square Tests.

SUV ₁	Value	Df	P-value
Pearson Chi-Square	2.03 ^a	3	0.56
Likelihood Ratio	1.97	3	0.57
N of Valid Cases	84		
SUV ₂	Value	Df	P-value
Pearson Chi-Square	11.01 ^a	3	0.01
Likelihood Ratio	12.32	3	0.01
N of Valid Cases	84		

SUV categories in sample

In Table 5, SUVs were classified out of 84 lesions and distributed into five classes (no changes, small changes, intermediate changes, large changes, and recurrent carcinoma with increasing value), where no changes means that there were no differences between SUV₁ and SUV lesion values. Small changes means that the difference between SUV₁ and SUV values was less than 33% of the original SUV value; Intermediate changes means that the difference between SUV₁ and SUV values was between 33-66% of the original SUV value; Significant changes means that the difference between SUV₁ and SUV values greater than 66% of the original SUV value; Recurrent cancer means that the lesion was not found in the original image SUV = 0 while the SUV₁ value is present after the first follow-up; Increasing the value means that the same pest is in the original and the first follow-up images while the value of the SUV has increased. Post the first treatment sessions, no change occurred on 32.1%. The percentage of treatment response includes both small changes 39.3% and large changes 27.4%, were new lesions that were not present in the original PET-CT scan, and 1.2% lesions

in which the value of the SUV increased. That means, the response rate to treatment was only 39.3% after providing the first treatments sessions. Lesions distribution among patients underwent the second treatment sessions, 66.7% of the lesions did not change, 28.6% of the lesions were treated, and 2.4% of both the recurring lesions in which the SUV value increased.

Table (5): SUV's categories through the 84 lesions.

		N (%)
SUV ₁ category	no changing	27 (32.1%)
	small changing	3 (3.6%)
	Large changing	30 (35.7%)
	Recurrent Ca	23 (27.4%)
	Increasing value	1 (1.2%)
	Total	84
SUV ₂ category	no changing	56 (66.7%)
	small changing	2 (2.4%)
	Large changing	22 (26.2%)
	Recurrent Ca	2 (2.4%)
	Increasing value	2 (2.4%)
	Total	84

SUV₁ category: Differences between SUV₁ and SUV, SUV₂ category: Differences between SUV₂ and SUV₁

Treatment effect on Patient history

Response of breast cancer patients

SUV's of the 84 lesions, categories in 5 (no changes, small changes, large changes, recurrent Cancer, and Increasing size). As shown in Table 6 the differences between Right and Left breast cancer in SUV₁ category. In SUV₁ RT breast cancer ,6.0% represented a recurrent cancer while the total treated lesions 13.1% (small and large changes). However, for LT breast cancer, 36.9% represented a recurrent cancer while the total treated lesions was 20.2%.

Table (6): Differences between Right and Left breast cancer in SUV₁ category after providing first sessions of treatment.

		history of patient		
		Rt Breast Ca	Lt Breast Ca	Total
SUV ₁ category	no changing	10 (11.9%)	8 (9.5%)	18
	small changing	1 (1.2%)	1 (1.2%)	2
	Large changing	10 (11.9%)	16 (19.1%)	26
	Recurrent Ca	5 (5.9%)	31 (36.9%)	36
	Increasing Size	2 (2.4%)	0	2
Total		28	56	84

The differences type of cancer and treatment

ANOVA test was conducted to find the differences between SUV₁ category, radiotherapy, chemotherapy in right and left breast cancer. Table 7 shows that there is Significant differences between SUV category with p-value was 0.013. However, both treatment types radiotherapy and chemotherapy show no difference between right and left cancer where the p-value was 0.217 and 0.835, respectively.

Table (7): Significant differences between right and left breast cancer respect treatments.

		Sum Squares	of Df	Mean Square	F	P-value
SUV ₁ category	Between Groups	15.48	1	15.48	6.52	0.013
	Within Groups	194.66	82	2.37		
	Total	210.14	83			
Radiotherapy Sessions	Between Groups	0.214	1	0.21	1.54	0.21
	Within Groups	11.35	82	0.13		
	Total	11.57	83			
Chemotherapy Sessions	Between Groups	0.006	1	0.006	.04	0.83
	Within Groups	11.23	82	0.13		
	Total	11.23	83			

The effect of radiotherapy on both SUV and SUV₁

As shown in Table 8, patients underwent 10-20 sessions had improved between SUV and SUV₁ values. Where LT Breast Cancer the SUV was 3 improved to SUV₁ 0. However, the RT breast cancer patient values showed no improvement but on the contrary worsened in SUV 0.5 value reaching to 2.5. LT breast cancer the SUV was 0.927 and it improved into SUV₁ 0.76. However, RT breast cancer patient values showed a little improvement in SUV 1.15, reaching to 0.65.

Table (8): Distribution the effect Radiotherapy Sessions on both SUV and SUV₁.

Radiotherapy Sessions	history of patient		SUV	SUV ₁
no session	Rt Breast Ca	N (%)	1.15	0.65
		N	26	26
		SD	1.19	1.06
	Lt Breast Ca	Mean	0.93	0.76
		N	55	55
		SD	1.25	1.19
between 10-20 sessions	Rt Breast Ca	Mean	0.5	2.50
		N	2	2
		SD	0.71	0.71
	Lt Breast Ca	Mean	3.00	0.00
		N	1	1
		SD	.	.
Total	Rt Breast Ca	Mean	1.11	0.79
		N	28	28
		SD	1.17	1.13
	Lt Breast Ca	Mean	0.96	0.75
		N	56	56
		SD	1.26	1.18

The effect of Chemotherapy on both SUV and SUV₁

As shown in Table 9, patients who underwent 10-20 sessions improved in SUV and SUV₁ values. LT breast cancer patients, SUV 3 was improved to SUV₁ 0.0. Conversely, RT breast cancer patient SUV values showed a regression from SUV 0 to 3. Patients did not undergo any session, where LT breast cancer, improved from SUV 0.94 to SUV₁ 0.81. However, breast cancer patients' RT values showed an improvement from SUV 1.15 to 0.65. Patients underwent less than 10 sessions were

improved SUV to SUV₁. Where LT breast cancer was SUV 0.67 improved to SUV₁ 0.00. Whereas, RT breast cancer patient's SUV values worsened from 1.00 to 2.00.

Table (9): The effect of chemotherapy to RT and LT breast cancer on both SUV and SUV₁

Chemotherapy Sessions	history of patient		SUV	SUV ₁
no session	Rt Breast Ca	Mean	1.15	0.65
		N	26	26
		SD	1.19	1.06
	Lt Breast Ca	Mean	0.94	0.81
		N	52	52
		SD	1.26	1.21
< 10 sessions	Rt Breast Ca	Mean	1.00	2.00
		N	1	1
		SD	.	.
	Lt Breast Ca	Mean	0.67	0.00
		N	3	3
		SD	1.15	0.00
between 10-20 sessions	Rt Breast Ca	Mean	0.00	3.00
		N	1	1
		SD	.	.
	Lt Breast Ca	Mean	3.00	0.00
		N	1	1
		SD	.	.
Total	Rt Breast Ca	Mean	1.11	0.79
		N	28	28
		SD	1.17	1.13
	Lt Breast Ca	Mean	0.96	0.75
		N	56	56
		SD	1.26	1.18
	Total	Mean	1.01	0.76
		N	84	84
		SD	1.23	1.16

4. Discussion

The current study examines the justification for PET-CT scanning procedures for breast cancer patients. Moreover, as different treatments are offered to breast cancer patients, the study also aims to assess the therapeutic response of breast cancer by PET-CT scan. The current study included 84 female patients with a history of breast cancer, whether the cancer was located on the right or left side. The study focused on the number of cancerous lesions in all patients. 79.8%, of patients were over 40 years old. Breast cancer is closely related to the age of the patient, due to age is one of the impact factors that increase the spread of breast cancer. This came due to the menopause period, which is usually over 40 years old, and thus the patient's hormonal disorders increase, and among the hormones are milk hormones, progesterone and others, and from here the increase in the incidence of women over 40 years can be explained (Schoemaker et al., 2018).

The distribution of treatment sessions for both radiotherapy and chemotherapy are usually through one cycle, each cycle contains 10 treatment sessions over a period of 21 days. This system is followed by the American Cancer Society (Ban et al., 2021). The values of the SUVs were divided

into three sections to evaluate the efficacy of the treatment on the cancerous lesions. The sections were mild uptake <2.48 , second moderate uptake $2.48-4.96$, third Hyper uptake > 4.96 . These values are similar to previous studies, where the value of the number 2 was adopted as a reference point (Bohnert et al., 2018; Brownlee et al., 2018).

Among the patients, the treatment rate for right Breast Cancer patients after receiving the first treatment sessions was 13.1%, while the treatment rate for left Breast Cancer patients reached 20.2%. This indicates that patients with Left Breast Cancer are more responsive than Right Breast Cancer patients, and this is due to the fact that the percentage of tissue concentration on the left side is more than the right (Han et al., 2020; Hennessey et al., 2014). On the other hand, the blood flow from the heart to the left side is higher than the blood flow from the right side. Thus, when receiving treatment such as chemotherapy, the movement is faster and at the same time more focused on the left side. This theory should be studied in the future through the work of studies focusing on this idea.

According to the significant differences between the SUV categories in both types of breast cancer support the result obtained that the treatments provided to patients had a greater effect on the left side than on the right side. While the effect of chemotherapy and radiotherapy on both sides does not affect the method of treatment and this is normal because of the presence of the same tissues on both sides.

Because the efficacy of the radiotherapy treatment offered on the left breast cancer compared to the right side, the effect was apparent on the values of SUV, where LT Breast Cancer the SUV was 3 and it improved into $SUV_1 0$, while the SUV values were not in favor of the right side as it increased from 0.5 to 2.5 and this supports the result we obtained previously. For the chemotherapy treatment, the SUV of LT breast cancer changes from 3 to 0.00, while in the RT breast cancer patient the SUV values reaching to 0 instead of 3.00. This gives the impression that chemotherapy for breast cancer patients has a more positive effect than radiation therapy. The reason for this is that the breast tissue has a high radiation tissue factor, but on the contrary, it may be the reason for increasing the spread of cancer instead of treating it (Hudson et al., 2020).

With the results obtained, there are shortcomings in the current study, which includes knowing the type of breast cancer, and tumor classification to know the disease most responding to treatment than others. Therefore, it can be used to conduct another study that includes these shortcomings.

5. Conclusion

The aim of this research is to know the effectiveness of the PET-CT device in evaluating the treatment of breast cancer. The study demonstrated that PET-CT technology is highly effective in evaluating the response of breast cancer to the given treatment. There are no significant differences between the two treatment values (chemotherapy or radiotherapy) in both breast cancers. However, chemotherapy has affected more than radiotherapy in treating breast cancer. Moreover, the results showed that left breast cancer is more responsive to treatment than right breast cancer.

References:

- Ahmad, M. S., & Arab, A. (2022). Ability of MRI Diagnostic Value to Detect the Evidence of Physiotherapy Outcome Measurements in Dealing with Calf Muscles Tearing. *Journal of Medical – Clinical Research & Reviews*, 6(10), 6–11. <https://doi.org/10.33425/2639-944X.1292>
- Ahmad, M. S., Makhamrah, O., & Hjouj, M. (2021a). Multimodal Imaging of Hepatocellular Carcinoma Using Dynamic Liver Phantom. *Intechopen, tourism*, 13. <https://doi.org/10.1016/j.radphyschem.2021.109632>
- Ahmad, M. S., Makhamrah, O., Suardi, N., Shukri, A., Ashikin Nik Ab Razak, N. N., Oglat, A. A., & Mohammad, H. (2021b). Hepatocellular carcinoma liver dynamic phantom for MRI. *MR Imaging of the Internal Auditory Canal and Inner Ear at 3T: Comparison between 3D Driven Equilibrium and 3D Balanced Fast Field Echo Sequences*, 188, 109632. <https://doi.org/10.1016/j.radphyschem.2021.109632>
- Ahmad, M. S., Makhamrah, O., Suardi, N., Shukri, A., Suardi, N., Noor, Nik Nik, A., & Hjouj, M. (2021c). Agarose and Wax Tissue-Mimicking Phantom for Dynamic Magnetic Resonance Imaging of the Liver. *Journal of Medical - Clinical Research & Reviews*, 5(11), 1-11. <https://doi.org/10.33425/2639-944X.1250>
- Ahmad, M. S., Rjoub, B., Abuelsamen, A., & Mohammad, H. (2022). Evaluation of Advanced Medical Imaging Services at Government Hospitals-West Bank. *Journal of Medical - Clinical Research & Reviews*, 6(7), 1–7. <https://doi.org/10.33425/2639-944X.1280>
- Ahmad, M. S., Suardi, N., Shukri, A., Mohammad, H., Oglat, A. A., Abu, B. M., Mohamed, A. M. H., & Makhamrah, O. (2019). Current Status Regarding Tumour Progression, Surveillance, Diagnosis, Staging, and Treatment Of HCC A Literature Review. *Journal of Gastroenterology and Hepatology Research*, 8(2), 2841–2852.
- Ahmad, M. S., Suardi, N., Shukri, A., Nik Ab Razak, N. N. A., Oglat, A. A., Makhamrah, O., & Mohammad, H. (2020a). Dynamic Hepatocellular Carcinoma Model Within a Liver Phantom for Multimodality Imaging. *European Journal of Radiology Open*, 7, 100257. <https://doi.org/10.1016/j.ejro.2020.100257>
- Ahmad, M., Shareef, M., Wattad, M., Alabdullah, N., D. Abushkadim, M., & A. Oglat, A. (2020b). Evaluation of Exposure Index Values for Conventional Radiology Examinations: Retrospective Study in Governmental Hospitals at West Bank, Palestine. *Atlas Journal of Biology*, 724–729. <https://doi.org/10.5147/ajb.vi.219>
- Ahmad, M., Suardi, N., Shukri, A., Mohammad, H., Oglat, A., Alarab, A., & Makhamrah, O. (2020c). Chemical characteristics, motivation and strategies in choice of materials used as liver phantom: A literature review. *Journal of Medical Ultrasound*, 28(1), 115–117. https://doi.org/10.4103/JMU.JMU_4_19
- Ahmad, M., Suardi, N., Shukri, A., Noor Ashikin Nik Ab Razak, N., A. Oglat, A., Makhamrah, O., & Mohammad, H. (2020d). A Recent Short Review in Non-Invasive Magnetic Resonance Imaging on Assessment of HCC Stages: MRI Findings and Pathological Diagnosis. *Journal of Gastroenterology and Hepatology Research*, 9(2), 3113–3123. <https://doi.org/10.17554/j.issn.2224-3992.2020.09.881>
- Al-Tell, A. (2019). Justification of Urgent Brain CT Examinations at Medium Size Hospital, Jerusalem. *Atlas Journal of Biology*, 655–660. <https://doi.org/10.5147/ajb.v0i0.213>

- Avril, S., Muzic, R. F., Plecha, D., Traughber, B. J., Vinayak, S., & Avril, N. (2016). 18 F-FDG PET/CT for Monitoring of Treatment Response in Breast Cancer. *Journal of Nuclear Medicine*, 57(Supplement 1), 34S-39S. <https://doi.org/10.2967/jnumed.115.157875>
- Ban, C. C., Khalaf, M. A., Ramli, M., Ahmed, N. M., Ahmad, M. S., Ahmed Ali, A. M., Dawood, E. T., & Ameri, F. (2021). Modern heavyweight concrete shielding: Principles, industrial applications and future challenges; review. *Journal of Building Engineering*, 39(December 2020), 102290. <https://doi.org/10.1016/j.jobbe.2021.102290>
- Bohnert, A. S. B., Guy, G. P., & Losby, J. L. (2018). Opioid Prescribing in the United States Before and After the Centers for Disease Control and Prevention's 2016 Opioid Guideline. *Annals of Internal Medicine*, 169(6), 367. <https://doi.org/10.7326/M18-1243>
- Brownlee, Z., Garg, R., Listo, M., Zavitsanos, P., Wazer, D. E., & Huber, K. E. (2018). Late complications of radiation therapy for breast cancer: evolution in techniques and risk over time. *Gland Surgery*, 7(4), 371–378. <https://doi.org/10.21037/gs.2018.01.05>
- Han, S., & Choi, J. Y. (2020). Prognostic value of 18F-FDG PET and PET/CT for assessment of treatment response to neoadjuvant chemotherapy in breast cancer: a systematic review and meta-analysis. *Breast Cancer Research*, 22(1), 1–15. <https://doi.org/10.1186/s13058-020-01350-2>
- Hennessey, S., Huszti, E., Gunasekura, A., Salleh, A., Martin, L., Minkin, S., Chavez, S., & Boyd, N. F. (2014). Bilateral symmetry of breast tissue composition by magnetic resonance in young women and adults. *Cancer Causes & Control*, 25(4), 491–497. <https://doi.org/10.1007/s10552-014-0351-0>
- Hudson, S. M., Wilkinson, L. S., Denholm, R., De Stavola, B. L., & Dos-Santos-Silva, I. (2020). Ethnic and age differences in right-left breast asymmetry in a large population-based screening population. *The British Journal of Radiology*, 93(1105), 20190328. <https://doi.org/10.1259/bjr.20190328>
- Kmail, M., S. Ahmad, M., & Hjouj, M. (2022). Evaluating the Accuracy of 128-Section Multi-Detector Computed Tomography (MDCT) in Detecting Coronary Artery Stenosis. *Proceedings of the 2022 5th International Conference on Digital Medicine and Image Processing*, 58–62. <https://doi.org/10.1145/3576938.3576948>
- Knudsen, K. E., Wiatrek, D. E., Greenwald, J., McComb, K., & Sharpe, K. (2022). The American Cancer Society and patient navigation: Past and future perspectives. *Cancer*, 128(S13), 2673–2677. <https://doi.org/10.1002/cncr.34206>
- Lubejko, B. G., & Wilson, B. J. (2019). *Oncology nursing: Scope and standards of practice*. Oncology Nursing Society.
- Makhamrah, O., Ahmad, M. S., & Hjouj, M. (2019). Evaluation of Liver Phantom for Testing of the Detectability Multimodal for Hepatocellular Carcinoma. *Proceedings of the 2019 2nd International Conference on Digital Medicine and Image Processing*, 17–21. <https://doi.org/10.1145/3379299.3379307>
- Makhamrah, O., Ahmad, M. S., Doufish, D., & Mohammad, H. (2023). Internal Auditory Canal (IAC) and Cerebellopontine Angle (CPA): Comparison between T2-weighted SPACE and 3D-CISS sequences at 1.5T. *Radiation Physics and Chemistry*, 206, 110797. <https://doi.org/10.1016/j.radphyschem.2023.110797>
- Mohammad, M., Ms, A., Mudalal, M., Bakry, A., & Arzeqat, T. (2020). The Radioactive Iodine (I-131) Efficiency for the Treatment of Well-Differentiated Thyroid Cancer. *HSA Journal of Nuclear Medicine, Radiology & Radiation Therapy*, 5(25), 5–10.

<https://doi.org/10.24966/NMRR-7419/100025>

- Muntaser S Ahmad, Zeyadeh, S. L., Odah, R., & Oglat, A. (2019). Occupational Radiation Dose for Medical Workers at Al-Ahli Hospital in West Bank-Palestine. *Journal of Nuclearmedicine, Radiology & Radiation Therapy*, 5(17), 1259–1266.
<https://doi.org/10.1016/j.jtusci.2017.01.003>
- Oglat, A. A., Alshipli, M., Sayah, M. A., & Ahmad, M. S. (2020). Artifacts in Diagnostic Ultrasonography. *Journal for Vascular Ultrasound*, 44(4), 212–219.
<https://doi.org/10.1177/1544316720923937>
- Oglat, A., Matjafri, M., Suardi, N., Oqlat, M., Abdelrahman, M., Oqlat, A., Farhat, O., Alkhateb, B., Abdalrheem, R., Ahmad, M., & Abujazar, M. M. (2018a). Chemical items used for preparing tissue-mimicking material of wall-less flow phantom for doppler ultrasound imaging. *Journal of Medical Ultrasound*, 26(3), 123-127. https://doi.org/10.4103/JMU.JMU_13_17
- Oglat, A., Matjafri, M., Suardi, N., Oqlat, M., Abdelrahman, M., Oqlat, A., Farhat, O., Alkhateb, B., Abdalrheem, R., Ahmad, M., & Abujazar, M. M. (2018b). Chemical items used for preparing tissue-mimicking material of wall-less flow phantom for doppler ultrasound imaging. *Journal of Medical Ultrasound*, 26(3), 123. https://doi.org/10.4103/JMU.JMU_13_17
- Paydary, K., Seraj, S. M., Zadeh, M. Z., Emamzadehfard, S., Shamchi, S. P., Gholami, S., Werner, T. J., & Alavi, A. (2019). The Evolving Role of FDG-PET/CT in the Diagnosis, Staging, and Treatment of Breast Cancer. *Molecular Imaging and Biology*, 21(1), 1–10.
<https://doi.org/10.1007/s11307-018-1181-3>
- Schoemaker, M. J., Nichols, H. B., Wright, L. B., Brook, M. N., Jones, M. E., O'Brien, K. M., Adami, H.-O., Baglietto, L., Bernstein, L., Bertrand, K. A., Boutron-Ruault, M.-C., Braaten, T., Chen, Y., Connor, A. E., Dorronsoro, M., Dossus, L., Eliassen, A. H., Giles, G. G., Hankinson, S. E., ... Swerdlow, A. J. (2018). Association of Body Mass Index and Age With Subsequent Breast Cancer Risk in Premenopausal Women. *JAMA Oncology*, 4(11), e181771.
<https://doi.org/10.1001/jamaoncol.2018.1771>
- Waks, A. G., & Winer, E. P. (2019a). Breast Cancer Treatment. *JAMA*, 321(3), 316.
<https://doi.org/10.1001/jama.2018.20751>
- Waks, A. G., & Winer, E. P. (2019b). Breast Cancer Treatment. *JAMA*, 321(3), 288.
<https://doi.org/10.1001/jama.2018.19323>
- Wang, L. (2017). Early Diagnosis of Breast Cancer. *Sensors*, 17(7), 1572.
<https://doi.org/10.3390/s17071572>