Original Article
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Evaluation of the Histopathological Features of Early-stage Invasive Ductal Breast Carcinoma by ^{18}Fluoride-fluorodeoxyglucose Positron Emission Tomography/Computed Tomography

^{18}Flor-florodeoksiglukoz Pozitron Emisyon Tomografi/Bilgisayarlı Tomografi ile Erken Evre İnvaziv Duktal Meme Karsinomunun Histopatolojik Özelliklerinin Değerlendirilmesi

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Abstract

Objectives: This study investigates the relationship between ^{18}fluoride-fluorodeoxyglucose (^{18}F-FDG) positron emission tomography/computed tomography (PET/CT) parameters and histopathological features in patients with early-stage invasive ductal breast carcinoma (IDBC).

Methods: Patients with early-stage IDBC who underwent ^{18}F-FDG PET/CT scan for staging were included in this retrospective study. The status of estrogen receptor (ER), progesterone receptor (PR), and human epidermal growth factor receptor-2, Ki-67 proliferative index, and grades of tumors were recorded. The conventional metabolic parameters [maximum standard uptake value (SUV_{max}) and average standard uptake value] and volume-based parameters [metabolic tumor volume (MTV) and total lesion glycolysis] of the primary tumor were obtained from the ^{18}F-FDG PET/CT images. The associations and correlations between the ^{18}F-FDG PET/CT parameters and histopathological features were assessed.

Results: One hundred forty-three patients were included. ^{18}F-FDG PET/CT parameters, other than MTV, were significantly associated with the ER and PR status and Ki-67 index, while T-staging was significantly associated with all ^{18}F-FDG PET/CT parameters. In the axillary lymph node (ALN) involvement, no significant difference was found in the ^{18}F-FDG PET/CT parameters. In terms of the pathological stage, a significant difference was found in all ^{18}F-FDG PET/CT parameters. ^{18}F-FDG PET/CT parameters, other than MTV, were significantly higher in non-luminal breast tumors than luminal tumors and in high-grade tumors than low-grade ones. Triple-negative tumors had the highest ^{18}F-FDG PET/CT parameter, but the difference was insignificant for MTV. The SUV_{max} had the strongest correlation with Ki-67 proliferative index.

Conclusion: Tumors with aggressive histopathological features had higher ^{18}F-FDG PET/CT parameter values. This study suggests that ^{18}F-FDG PET/CT may provide prognostic information in patients with early-stage IDBC.

Keywords: Breast cancer, metabolic tumor volume, total lesion glycolysis, ^{18}fluoride-fluorodeoxyglucose, positron emission tomography/computed tomography

Öz

Amaç: Bu çalışmada, erken evre invaziv duktal meme karsinomunun histopatolojik özellikleri ile ^{18}florür-florodeoksiglukoz (^{18}F-FDG) pozitron emisyon tomografi/bilgisayarlı tomografi (PET/BT) parametreleri arasındaki ilişki incelenmiştir.

Yöntem: Bu retrospektif çalışmaya evreleme için ^{18}F-FDG PET/BT taraması yapılan erken evre invaziv duktal meme karsinomlu hastalar dahil edildi. Primer tümörün östrojen reseptör (ER), progesteron reseptör (PR) durumları ile insan epidermal büyüme faktörü reseptörü-2 ekspresyon durumu, Ki-67 proliferasyon indeksi ve histolojik dereceleri kaydedildi. Primer tümörün geleneksel metabolik parametreleri [maksimum standart alım değeri

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(SUV_{maks}), ortalama standart alım değeri] ve hacim bazlı parametreler [metabolik tümör hacmi (MTV) ve toplam lezyon glikoliz] ^{18}F-FDG PET/BT görüntülerinden elde edildi. ^{18}F-FDG PET/BT parametreleri ile histopatolojik özellikler arasındaki ilişki ve korelasyon değerlendirildi.

Bulgular: Çalışmaya toplam 143 hasta dahil edildi. MTV dışındaki ^{18}F-FDG PET/BT parametreleri, ER-PR durumu ve Ki-67 indeksi grubu ile anlamlı şekilde farklıydı. Öte yandan, T-evreleme ile tüm ^{18}F-FDG PET/BT parametreleri arasında ileri düzeyde farklılık bulundu. Aksiller lenf nodu tutulumu durumunda ^{18}F-FDG PET/BT parametreleri arasında anlamlı bir fark bulunmadı. Patolojik evre açısından tüm ^{18}F-FDG PET/BT parametrelerinde anlamlı farklılık vardı. MTV dışındaki ^{18}F-FDG PET/BT parametreleri non-luminal tümörlerinde luminal tümörlere göre ve yüksek grade tümörlerde düşük grade tümörlere göre anlamlı olarak daha yüksekti. Üçlü negatif tümörler en yüksek ^{18}F-FDG PET/BT parametrelerine sahipti, ancak MTV için fark anlamlı değildi. Ki-67 proliferasyon indeksi ile en güçlü korelasyon SUV_{maks} değerinde görüldü.

Sonuç: Agresif histopatolojik özellikleri olan tümörlerin ^{18}F-FDG PET/BT parametreleri daha yüksekti. Bu sonuçlar, ^{18}F-FDG PET/BT'nin erken evre invaziv duktal meme karsinomunda prognostik bilgi sağlayabileceğini düşündürmektedir.

Anahtar kelimeler: Meme kanseri, metabolik tümör hacmi, toplam lezyon glikolizi, ^{18}florür-florodeoksiglukoz, pozitron emisyon tomografisi/bilgisayarlı tomografi

Introduction

Breast cancer (BC) is the most widely diagnosed form of cancer and the second cause of cancer-related death in women (1). The most common pathological subtype is invasive ductal breast carcinoma (IDBC), which is associated with different prognostic behaviors concerning molecular subtypes (2). The size and grade of tumors, hormonal receptor status, human epidermal growth factor receptor-2 (HER-2) expression, Ki-67 proliferative index, axillary lymph node (ALN) involvement, and distant metastasis are important for the prognosis and treatment of IDBC (3,4).

^{18}Fluoride-fluorodeoxyglucose (^{18}F-FDG) positron emission tomography/computed tomography (PET/CT) has been widely used for the staging, restaging, assessment of treatment response, and prediction of prognosis in BC (5). Several studies have previously evaluated the relationship between the maximum standard uptake value (SUV_{max}) and clinicopathological factors in BC (6,7,8,9,10,11), while the metabolic tumor volume (MTV) or total lesion glycolysis (TLG), called volume-based PET parameters, shows the total tumor burden and tumor metabolism. The prognostic value of these parameters was significantly associated with BC subtypes and prognosis in many studies (12,13,14,15,16,17).

This study aimed to evaluate the relationship between the ^{18}F-FDG PET/CT parameters [SUV_{max}, average standard uptake value (SUV_{avg}), MTV, and TLG] and histopathological features (pathologic T size, pathological stage, ALN involvement, hormone receptor expressions, HER-2 receptor expression, Ki-67 proliferative index, and molecular subtypes) in IDBC.

Materials and Methods

The Local Ethics Committee of KTO Karatay University Faculty of Medicine approved this study under the decision number: 2020/10. Written informed consent was obtained from all patients. The data of patients with histopathologically documented and surgically excised IDBC, who underwent a preoperative ^{18}F-FDG PET/CT between July 2013 and December 2019, were analyzed. Patients with the following features were excluded from the study: Multifocal or multicentric tumors; bilateral breast tumors; chest wall, surrounding muscle, or skin tissue involvement; distant metastasis; missing clinical data; those with a history of any therapeutic intervention before surgery (e.g., chemotherapy, radiotherapy, and hormone therapy). Moreover, in this study, the largest diameter of the evaluated lesions required to be larger than 10 mm to decrease the partial volume effect.

Imaging and Analysis of ^{18}F-FDG PET/CT

Before the ^{18}F-FDG injection, the patients were fasted for at least six hours to ensure that the blood glucose levels were below 150 mg/dL. The scan was performed 60 min after the intravenous injection. The region of interest (ROI) around the primary tumor was drawn by manual adjustment to exclude structures showing physiological ^{18}F-FDG uptake around the tumor. The tumor was completely covered in three planes. SUV_{max} was obtained by manually drawing the ROI from the slice with the highest uptake of ^{18}F-FDG in the primary tumor. MTV was obtained using a 42% threshold of SUV_{max}. TLG was calculated by multiplying SUV_{avg} by MTV.

Histopathological Analysis and Molecular Subtypes

Patients included in this study underwent surgery or ALN dissection. The pathological data of the tumors, such as size, grade, pathological stage, and other prognostic parameters, were obtained from the records. The tumor has been graded according to the Bloom-Richardson grading system updated by Elston and Ellis (18). The pathological prognostic staging was performed according to the eighth edition of

the American Joint Committee on Cancer's Staging Manual (19). The status of the estrogen receptor (ER), progesterone receptor (PR), and HER-2 expression and the Ki-67 proliferative index were evaluated immunohistochemically. The fluorescence *in situ* hybridization method was used to confirm the presence of HER-2 expression, when the scores were 2+ (20). The molecular subtypes of the ER, PR, and HER-2 expression status were determined. The proliferative index was considered high when the Ki-67 was ≥14% and low when it was <14%. The subjects were classified according to the molecular subtypes as recommended in the 12th International Breast Conference (2). The molecular subtypes were divided into two groups: Luminal (luminal A, luminal B HER-2-negative, and luminal B HER-2-positive subtypes) and non-luminal [HER-2-positive and triple-negative (TN) subtypes].

Statistical Analysis

The statistical analyses were performed using IBM SPSS Statistics for Windows (ver. 21, IBM Corp., Armonk, NY). The normality of the distribution of the continuous data was evaluated. The continuous data were expressed as medians or mean ± standard deviations, where appropriate. The categorical data were shown as frequencies and percentages. For comparing continuous data, non-parametric tests were used. The relationship between the continuous data was evaluated using a Spearman correlation test. A p value less than 0.05 was considered statistically significant.

Results

One hundred forty-three female patients with IDBC and a mean age of 52.43±11.79 years (range: 29-81 years) were included. Table 1 shows the characteristics of the patients. Table 2 shows the relationship between the histopathological features and ^{18}F-FDG PET/CT parameters.

Fifty-nine (41.3%) tumors were stage T1c, and 84 (58.7%) tumors were stage T2. The median values of all ^{18}F-FDG PET/CT parameters were higher in the T2 group than the T1c group (p<0.001 for all comparisons).

All ^{18}F-FDG PET/CT parameters were almost similar across ALN states. The SUV_{max}, SUV_{avg}, and TLG were higher in high-grade tumors (p<0.001 for all comparisons). Moreover, high-grade tumors had higher MTV, but the difference was insignificant.

The SUV_{max}, TLG, and SUV_{avg} were higher in hormone-receptor-negative tumors compared with the positive ones. The MTV was also higher in hormone-receptor-negative tumors compared with the positive ones, but the differences were insignificant. HER-2-positive tumors had higher SUV_{avg} and SUV_{max} than the negative ones (p=0.046 and p=0.04, respectively). The TLG and MTV were higher in HER-2-positive tumors compared with the negative ones, but the differences were insignificant.

Figure 1 shows the transaxial slice of PET/CT images of a patient with IDBC (histologic grade 3; ER-positive, PR-positive, and HER-2-positive).

Luminal A was found in 33 patients (23.1%); luminal B HER-2-negative, 61 patients (42.7%); luminal B HER-

Table 1. Patients' characteristics

Characteristics	n
Number of patients	143
Age, mean	52.43±11.79
Pathological tumor stage	
T1c	59 (41.3%)
T2	84 (58.7%)
Grade of tumor	
I	17 (11.9%)
II	77 (53.8%)
III	49 (34.3%)
Axillary lymph node status	
Positive	78 (54.5%)
Negative	65 (45.5%)
ER status	
Positive	122 (85.3%)
Negative	21 (14.7%)
PR status	
Positive	114 (79.7%)
Negative	29 (20.3%)
HER-2 status	
Positive	38 (26.6%)
Negative	105 (73.4%)
Ki-67 index	
≥14	101 (70.6%)
<14	42 (29.4%)
Molecular subtypes	
Luminal A	33 (23.1%)
Luminal B HER-2-negative	61 (42.7%)
Luminal B HER-2-positive	28 (19.6%)
HER-2-positive	10 (7.0%)
TN	11 (7.7%)
Pathological N (pN)	
N0	65 (45.5%)
Nmi	3 (2.1%)
N1	54 (37.7%)
N2	13 (9.1%)
N3	8 (5.6%)
Pathological stage	
I	34 (23.7%)
II	88 (61.6%)
III	21 (14.7%)

ER: Estrogen receptor, PR: Progesterone receptor, HER-2: Human epidermal growth factor receptor-2; Nmi: Nodal micrometastasis, TN: Triple-negative

2-positive, 28 patients (19.6%); HER-2-positive, 10 patients (7.0%); TN, 11 patients (7.7%). The SUV_{max}, SUV_{avg}, and TLG were different among the five molecular subtypes (p<0.001, p<0.001, and p=0.010, respectively).

Table 2. Associations between the histopathological features and ^{18}F-FDG PET/CT parameters

	SUV_{max} median	SUV_{avg} median	MTV median	TLG median
Pathological tumor stage				
T1c	6.02	3.87	1.59	5.77
T2	10.58	6.52	3.48	22.15
p value	<0.001	<0.001	<0.001	<0.001
Axillary lymph node status				
Positive	7.99	5.00	2.72	12.04
Negative	8.17	4.94	2.06	10.81
p value	0.913	0.955	0.627	0.504
Pathological stage				
I	6.45	4.13	1.44	6.05
II	9.13	5.92	2.95	18.46
III	9.13	5.62	3.11	17.18
p value	0.013	0.028	<0.001	<0.001
Grade of tumor				
I	5.98	3.72	1.95	6.25
II	6.78	4.34	2.41	10.34
III	13.02	8.07	2.87	20.06
p value	<0.001	<0.001	0.294	<0.001
ER status				
Positive	6.88	4.47	2.24	10.15
Negative	17.07	10.55	3.75	28.84
p value	<0.001	<0.001	0.269	0.001
PR status				
Positive	6.88	4.47	2.28	10.67
Negative	13.02	8.07	2.87	18.31
p value	0.001	0.001	0.819	0.049
HER-2 status				
Positive	11.55	7.05	2.49	12.04
Negative	7.11	4.57	2.41	10.53
p value	0.04	0.046	0.773	0.340
Ki-67 index				
≥14	10.4	6.36	2.75	15.27
<14	6.05	3.66	2.06	6.83
p value	<0.001	<0.001	0.410	0.002
Molecular subtypes				
Luminal A	6.36	3.83	2.25	6.89
Luminal B HER-2-negative	7.05	4.54	2.32	11.95
Luminal B HER-2-positive	11.04	6.32	2.09	11.57
HER-2-positive	13.19	8.16	3.05	18.78
TN	21.29	13.24	5.22	50.21
p value	<0.001	<0.001	0.855	0.010
Molecular group				
Luminal	6.89	4.47	3.75	10.16
Non-luminal	17.07	10.55	3.75	28.85
p value	<0.001	<0.001	0.269	0.001

SUV_{max}: Maximum standard uptake value, SUV_{avg}: Average standard uptake value, MTV: Metabolic tumor volume, TLG: Total lesion glycolysis, ER: Estrogen receptor, PR: Progesterone receptor, HER-2: Human epidermal growth factor receptor-2, TN: Triple-negative

Although MTV varied among the molecular subtypes, the difference was insignificant. All ^{18}F-FDG PET/CT parameters were the highest in TN groups in terms of the molecular subtypes. In the post-hoc analysis, the luminal A group had a significantly lower SUV_{max} (p=0.026 and p<0.001, respectively) and SUV_{avg} (p=0.016 and p<0.001, respectively) than the HER-2-positive and TN groups. The luminal B HER-2-negative group had a significantly lower SUV_{max} (p=0.006) and SUV_{avg} (p=0.007) than the TN group. TLG was significantly lower in the luminal A group compared with the TN group (p=0.015).

Among the ^{18}F-FDG PET/CT parameters, TLG had the strongest correlation with the tumor's diameter (r=0.679; p<0.001). Moreover, SUV_{avg} had a modest correlation with Ki-67 (r=0.472; p<0.001). The group with Ki-67 ≥14% had a significantly higher SUV_{avg}, SUV_{max}, and TLG compared with that with Ki-67 <14% (p<0.001, p<0.001, and p=0.002, respectively). The MTV was higher in the group with Ki-67 ≥14% compared with that with Ki-67 <14%, but the difference was statistically insignificant.

There was a difference in the volumetric parameters (MTV and TLG) in the pathological stage (p<0.001 for both comparisons). Other PET parameters also varied significantly (SUV_{max} and SUV_{avg}; p=0.013 and p=0.028, respectively). In the post-hoc analysis, stage-I and stage-II tumors showed differences in terms of SUV_{max} (p=0.01), SUV_{avg} (p=0.026), MTV (p<0.001), and TLG (p<0.001), and stage-I and stage-III tumors showed differences in terms of MTV (p=0.008) and TLG (p=0.001).

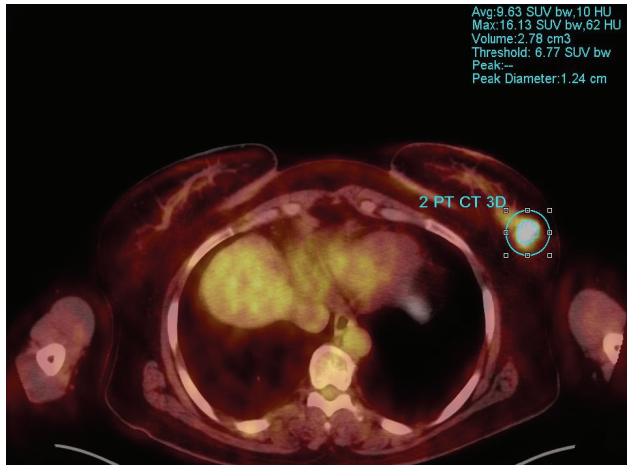

Figure 1. A 55-year-old patient with invasive ductal breast carcinoma (histologic grade 3; ER-positive, 90%; PR-positive, 40%; HER-2-positive). Intense ^{18}F-FDG uptake was seen in the primary tumor (SUV_{max}: 16.13, SUV_{avg}: 9.63, MTV: 2.78, and TLG: 26.73)
ER: Estrogen receptor, PR: Progesterone receptor, HER-2: Human epidermal growth factor receptor-2, ^{18}F-FDG: ^{18}Fluoride-fluorodeoxyglucose, MTV: Metabolic tumor volume, TLG: Total lesion glycolysis, SUV_{max}: Maximum standardized uptake value, SUV_{avg}: Average standard uptake value

Table 3 shows the comparison of the area-under-the-curve (AUC) values of ^{18}F-FDG PET/CT parameters for the histopathological. The AUC values were similar in all tested features except for MTV. Of note, the AUC of SUV_{avg} was the largest for ER and PR status, Ki-67 index, and molecular group. Considering the HER-2 status, TLG had the largest AUC.

Discussion

IDBC is a heterogeneous group of tumors (21). Several studies have reported a correlation between the parameters of ^{18}F-FDG PET/CT and the histopathological features of BC (12,22,23,24). However, most of them evaluated different histological subtypes of BC and reported highly variable results. This study showed that tumors with aggressive histopathological features are associated with high ^{18}F-FDG PET/CT parameters in IDBC.

Table 3. Comparison of the AUC values of the ^{18}F-FDG PET/CT parameters for predicting prognostic factors

	AUC	95% confidence interval	p value
ER negativity			
SUV_{max}	0.795	0.72-0.86	<0.001
SUV_{avg}	0.799	0.72-0.86	<0.001
MTV	0.576	0.49-0.66	0.386
TLG	0.724	0.64-0.80	<0.001
PR negativity			
SUV_{max}	0.701	0.62-0.77	<0.001
SUV_{avg}	0.703	0.62-0.78	<0.001
MTV	0.514	0.43-0.60	0.849
TLG	0.619	0.53-0.70	0.054
HER-2 positivity			
SUVmax	0.612	0.58-0.69	0.041
SUVavg	0.610	0.52-0.69	0.046
MTV	0.484	0.40-0.60	0.779
TLG	0.619	0.47-0.64	0.347
High Ki-67 index			
SUV_{max}	0.702	0.62-0.78	<0.001
SUV_{avg}	0.710	0.63-0.79	<0.001
MTV	0.544	0.46-0.63	0.391
TLG	0.669	0.58-0.74	<0.001
Non-luminal group			
SUV_{max}	0.780	0.72-0.86	<0.001
SUV_{avg}	0.799	0.72-0.86	<0.001
MTV	0.576	0.49-0.68	0.386
TLG	0.724	0.64-0.80	<0.001

AUC: Area-under-the-curve, ER: Estrogen receptor, PR: Progesterone receptor, SUV_{max}: Maximum standard uptake value, SUV_{avg}: Average standard uptake value, MTV: Metabolic tumor volume, TLG: Total lesion glycolysis

An independent prognostic factor for BC is the tumor's size. Moreover, poor histopathological differentiation and larger tumor size are related to an increased metastasis risk in BC (25). While some studies reported the correlation between the tumor's size and ^{18}F-FDG PET/CT parameters (9,23,26,27,28), others did not report such an association (8,10,29). In this study, the T-stage groups were associated with all ^{18}F-FDG PET/CT parameters. Our patient population was predominantly composed of individuals with pathological T2-stage tumors, and there were no T3 tumors in this series.

Studies showed that the negative ER status was associated with higher ^{18}F-FDG PET/CT parameters (12,24,26). In line with these studies, we found significantly higher ^{18}F-FDG PET/CT parameters in ER-negative patients than ER-positive patients, but the difference was statistically insignificant for MTV. According to the studies by Kajáry et al. (12) and Groheux et al. (24), a negative PR status was associated with higher SUV_{max}, MTV, and TLG. Conversely, according to the study by Kaida et al. (23), there was no association between PR status and any volumetric parameters (MTV and TLG). In the present study, there was a significant association between the ER or PR status and the ^{18}F-FDG PET/CT parameters, except for MTV. Some studies (12,30) have reported significant associations between HER-2 status and ^{18}F-FDG PET/CT parameters, but others did not report such an association (24,29). All ^{18}F-FDG PET/CT parameters were higher in HER-2-positive tumors than the negative ones, but significant associations were observed only for SUV_{max} and SUV_{avg} in the present study. A higher histological grade is associated with aggressive behavior (24). Several studies have demonstrated a significant relationship between the histological grade and ^{18}F-FDG PET/CT parameters (9,10,12,26,31,32,33). Similarly, in the present study, there was a significant association between tumor's grade and all ^{18}F-FDG PET/CT parameters, except for MTV. Several studies have demonstrated a positive correlation between the Ki-67 index levels and ^{18}F-FDG PET/CT parameters (9,26,29,32). Similarly, in our study, a positive correlation was observed between the Ki-67 levels and SUV_{max}, SUV_{avg}, and TLG. When the patients were grouped for their Ki-67 levels, the higher-level group had a significantly higher SUV_{max}, SUV_{avg}, and TLG. Our results showed that, among the ^{18}F-FDG PET/CT parameters, SUV_{max} had the strongest correlation with Ki-67.

Studies have reported that molecular subtypes are associated with a variable prognosis, for example, the worst for TN and HER-2-positive and the best for luminal A (12,26,34). Concerning the molecular subtypes, Kajáry et al. (12), Groheux et al. (24), and Önner et al. (26) reported significant associations with SUV_{max}, SUV_{avg}, and TLG. Similarly, in our study, there was a significant relationship between the molecular subtypes and ^{18}F-FDG PET/CT parameters, except for MTV. In the luminal A subtype, cellular proliferation genes are expressed at low levels. Conversely, the *HER-2* gene promotes both cancer growth and progression, and the rates of recurrence and mortality are higher in the HER-2-positive subtype (35). TN BC is the most aggressive subtype and is associated with a worse prognosis (36). In this study, the lowest SUV_{max}, SUV_{avg}, and TLG were observed in the luminal A group, while the highest was in the TN group. In this line, Önner et al. (26) and Kajáry et al. (12) observed the lowest SUV_{max}, SUV_{avg}, MTV, and TLG in the luminal A group and the highest SUV_{max}, MTV, and TLG in the TN group. In this study, SUV_{max}, SUV_{avg}, and TLG were significantly higher in the non-luminal group. Regarding MTV, the median values of MTV were similar in both groups. Similarly, previous studies reported that ^{18}F-FDG parameters were significantly higher in the non-luminal groups (12,24,26).

We performed receiver operating characteristic analyses to find which ^{18}F-FDG PET/CT parameters reflected the pathological features better. The AUC values of SUV_{max}, SUV_{avg}, and TLG were high in all pathological variables (ER, PR, and HER-2 status, Ki-67 index, and molecular subtypes). The largest AUC value was seen for SUV_{avg} in terms of the ER and PR status, Ki-67 index, and molecular groups and for TLG in terms of the HER-2 status. This was incompatible with some recent studies (12,23). We think that these differences are due to different SUV_{max} threshold values used in MTV calculation. Kaida et al. (23) used a threshold of 50% of peak SUV within the lesions for calculating MTV and reported that TLG reflected the tumor metabolism with histopathological features better than SUV_{max} or MTV. However, in another study using 2.5 as the SUV_{max} threshold value in MTV calculation, a high AUC value could not be achieved with MTV. There is a lack of consensus on methods for calculating the volumetric parameters in the literature (12,23,24,26,37,38). In solid tumors such as BC, some authors recommend using 42% of tumor SUV_{max} as a threshold to represent the glycolytic activity (37,38). So, we used 42% as the threshold for the present study.

Study Limitations

The limitations of this study include being retrospective and having low patients in the groups. Moreover, we cannot predict the findings of this study in patients with advanced IDBC.

Conclusion

The findings of this study showed that tumors with aggressive histopathological features are associated with high ^{18}F-FDG PET/CT parameters, and therefore, ^{18}F-FDG PET/CT imaging can be used as an aid in predicting the prognosis in early-stage IDBC.

Ethics

Ethics Committee Approval: The Local Ethics Committee of KTO Karatay University Faculty of Medicine approved this study under the decision number: 2020/10.

Informed Consent: Written informed consent was obtained from all patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: M.İ.E.K., Concept: M.E., H.Ö., Design: M.E., H.Ö., Data Collection or Processing: M.E., H.Ö., M.İ.E.K., Analysis or Interpretation: M.E., Literature Search: M.E., Writing: M.E.

Conflict of Interest: No conflict of interest was declared by the authors.

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