ORIGINAL RESEARCH

Bagcilar Med Bull 2022;7(3):197-204
**DOI:** 10.4274/BMB.galenos.2022.2022-02-014

# Evaluation of the Efficacy of PET/CT in Gynecological Cancers: A Retrospective Study

## Jinekolojik Kanserlerde PET/BT'nin Etkinliğinin Retrospektif Olarak Değerlendirilmesi

Yücel Kaya[1], Nedim Tokgözoğlu[2], Gökhan Demirayak[3], Veli Mihmanlı[2], Damla Yasemin Yenliç Kaya[1], Hamit Caner Uzun[4]

[1]University of Health Sciences Turkey, Van Training and Research Hospital, Clinic of Gynecology and Obstetrics, Van, Turkey
[2]University of Health Sciences Turkey, Prof. Dr. Cemil Taşcıoğlu City Hospital, Clinic of Gynecology and Oncology, İstanbul, Turkey
[3]University of Health Sciences Turkey, Bakırköy Dr. Sadi Konuk Training and Research Hospital, Clinic of Gynecology and Oncology, İstanbul, Turkey
[4]Ceyhan State Hospital, Clinic of Gynecology and Obstetrics, Adana, Turkey

## Abstract

**Objective:** To evaluate the efficacy of preoperative positron emission tomography/computed tomography (PET/CT) to detect lymph node metastasis in gynecologic malignancies.

**Method:** This study included a total of 78 patients who underwent surgery for gynecological cancer at the Gynecology and Obstetrics Clinic, University of Health Sciences Turkey, Prof. Dr. Cemil Taşcıoğlu City Hospital between January 2016 and November 2017. Data on age, menopausal status, clinical diagnoses, definitive pathology reports and PET/CT findings were obtained from the Hospital Information Management System and the patient files. The histological type and pelvic and/or paraaortic lymph node involvement status of the tumor based on a definitive pathology report, and the maximum standardized uptake value ($SUV_{max}$) values of the primary tumor and lymph nodes with pathological involvement in the PET/CT were recorded.

**Results:** Of the 78 patients, 42 had endometrial cancer, 10 had uterine sarcoma, 14 had cervical cancer and 12 had ovarian cancer. The sensitivity, specificity, accuracy, positive predictive value and negative predictive value of PET/CT in predicting lymph node metastasis were 54.5%, 96.7%, 85.7%, 85.7%, and 85.7%, respectively, in patients with endometrial cancer; 100%, 89.9%, 90%, 50%, and 100%, respectively, in patients with uterine sarcoma; 0%, 92.3%, 85.7%, 0%, and 92.3%, respectively, in patients with cervical cancer; and 62.5%, 75%, 66.7%, 83.3%, and 50%, respectively, in patients with ovarian cancer. When all of the patients were assessed together, these values were found to be 57.1 %, 92.9%, 83.3%, 75%, and 85.4%, respectively.

## Öz

**Amaç:** Bu çalışmanın amacı, jinekolojik malignitelerde operasyon öncesi yapılan pozitron emisyon tomografi/bilgisayarlı tomografinin (PET/BT) lenf nodu metastazını saptamadaki etkinliğini değerlendirmektir.

**Yöntem:** Sağlık Bilimleri Üniversitesi, Prof. Dr. Cemil Taşcıoğlu Şehir Hastanesi, Kadın Hastalıkları ve Doğum Kliniği'nde Ocak 2016 ile Kasım 2017 yılları arasında jinekolojik kanser nedeni ile opere olan 78 hasta çalışmaya dahil edildi. Hastane veri sisteminden ve hasta dosyalarından hastaların yaşına, menopozal durumuna, klinik tanılarına, nihai patoloji raporlarına ve PET/BT bulgularına ulaşıldı. Nihai patoloji raporundaki tümörün histolojik tipi, pelvik ve/veya paraaortik lenf nodu tutulumları, PET/BT'de patolojik tutulum izlenen lenf nodlarının ve primer tümörün maksimum standart tutulum değeri ($SUV_{maks}$) kaydedildi.

**Bulgular:** Çalışmaya alınan 78 hastanın 42'si endometrium kanseri, 10 hasta uterin sarkom, 14 hasta serviks kanseri ve 12 hasta over kanseriydi. Endometrium kanser tanısı almış hasta grubunda PET/BT'nin lenf nodu metastazını tahmin etmedeki sensitivitesi, spesifitesi, doğruluğu, pozitif prediktif değeri ve negatif prediktif değeri sırasıyla %54,5, %96,7, %85,7, %85,7 ve %85,7 idi. Uterin sarkomda bu değerler sırasıyla %100, %89,9, %90, %50 ve %100'dü. Serviks kanserinde sırasıyla %0, %92,3, %85,7, %0 ve %92,3 ve son olarak over kanserinde sırasıyla %62,5, %75, %66,7, %83,3 ve %50 idi. Tüm hasta grubu incelendiğinde bu değerler sırasıyla %57,1, %92,9, %83,3, %75 ve %85,4 olarak bulundu.

**Sonuç:** PET/BT tanı testleri bakımından en iyi başarı uterin sarkomlarda elde edilmiştir. Ayrıca, çalışmamızda metabolik parametrelerden ortalama $SUV_{maks}$ değerlerinin yalnızca over kanserinde lenf nodu

**Address for Correspondence:** Yücel Kaya, University of Health Sciences Turkey, Van Training and Research Hospital, Clinic of Gynecology and Obstetrics, Van, Turkey
**E-mail:** yucelkaya0007@gmail.com **ORCID:** orcid.org/0000-0003-4597-2922 **Received:** 12.05.2022 **Accepted:** 17.06.2022

**Cite this article as:** Kaya Y, Tokgözoğlu N, Demirayak G, Mihmanlı V, Yenliç Kaya DY, Uzun HC. Evaluation of the Efficacy of PET/CT in Gynecological Cancers: A Retrospective Study. Bagcilar Med Bull 2022;7(3):197-204
©Copyright 2022 by the Health Sciences University Turkey, Bagcilar Training and Research Hospital
Bagcilar Medical Bulletin published by Galenos Publishing House.

**Conclusion:** The highest diagnostic yield of PET/CT was obtained for uterine sarcoma. Furthermore, among the metabolic parameters, the mean $SUV_{max}$ value was found to be associated with lymph node metastasis only in patients with ovarian cancer and was not predictive in other gynecologic malignancies.

**Keywords:** Gynecological neoplasms, lymphatic metastasis, $^{18}$F-FDG PET/CT

metastazı ile ilişkili olduğu, diğer jinekolojik malignitelerde anlamlı olmadığı saptanmıştır.

**Anahtar kelimeler:** Jinekolojik neoplazmlar, lenfatik metastaz, $^{18}$F-FDG PET/BT

## Introduction

Gynecological cancers are important in the female population in terms of causing morbidity and mortality. According to 2018 data reported by the American Cancer Society, it was stated that 32,120 of the estimated 110,070 patients newly diagnosed with gynecological cancer would die (1).

The most important factor determining prognosis in gynecologic cancers is disease stage. In gynecological malignancies other than cervical cancer, lymph node metastasis is among the prognostic factors owing to its inclusion in the International Federation of Gynecology and Obstetrics (FIGO) staging system. That said, although not included in the FIGO stating system, lymph node metastasis is very important when deciding upon treatment and predicting outcomes in cervical cancer (2). Lymph node dissection prolongs the operation time and increases the rates of such complications as bleeding, lymphocyte formation and lower extremity edema, and for this reason, non-invasive imaging methods are important in determining lymph node metastasis in the preoperative period (3). Imaging modalities include ultrasonography, magnetic resonance imaging, computed tomography (CT), and positron emission tomography/CT (PET/CT), and PET/CT in particular is gaining increasing importance among the imaging methods.

Our study evaluates the effectiveness of the determination of lymph node metastasis by $^{18}$F-fluoro-2-deoxy-G-glucose ($^{18}$F-FDG) PET/CT in patients with endometrial carcinoma, uterine sarcoma, cervical cancer, and ovarian cancer.

## Materials and Methods

### Study Population

The study was conducted in the Obstetrics and Gynecology Clinic of the University of Health Sciences Turkey, Prof. Dr. Cemil Tascioglu City Hospital. The patient files and records of 120 patients who underwent surgery for a gynecologic cancer between January 2016 and November 2017 were obtained from the hospital information management system and were reviewed retrospectively. Patients who were considered to have a high operation risk and so precluded from lymph node dissection and those being treated for another concurrent malignancy were excluded from the study. Of the remaining 78 patients included in the study, 42 had endometrial cancer, 10 had uterine sarcoma, 14 had cervical cancer, and 12 had ovarian cancer. Of the 12 patients with ovarian cancer, three had recurrent ovarian cancer and also had a minimum of 3 months between the time of the PET/CT scan and the last treatment. Data on age, menopausal status, clinical diagnoses, definitive pathology reports and PET/CT findings were obtained from the hospital information management system, and the patient files. The histological type and pelvic and/or paraaortic lymph node involvement status of the tumor based on a definitive pathology report, and the maximum standardized uptake value ($SUV_{max}$) values of the primary tumor and lymph nodes with pathological involvement in the PET/CT were recorded.

### Surgical Procedure

All patients were operated on by gynecologic oncology specialists of the University of Health Sciences Turkey, Prof. Dr. Cemil Taşcıoğlu City Hospital within 30 days of the PET/CT examinations. The surgical procedures included radical hysterectomy, bilateral salpingo-oophorectomy, bilateral pelvic and paraaortic lymphadenectomy, omentectomy and peritoneal cytology. Unlike in other cancer types, patients with endometrial cancer did not undergo a systematic lymphadenectomy. In these patients, the risk of metastasis was preoperatively evaluated with respect to the histological type, tumor grade and PET/CT findings, and a sentinel lymph node dissection was made to the patients having low risk for metastasis. Pelvic and paraaortic lymphadenectomies and omentectomies were performed on three patients with recurrent ovarian cancer.

### Data Analysis

In the present study, the standard protocol was applied for the histopathological evaluation of lymph nodes. Fine cuts

were performed so as not to miss any micrometastases. Pathological specimens obtained during the operations were evaluated by pathology specialists experienced in gynecologic oncology in the University of Health Sciences Turkey, Prof. Dr. Cemil Taşcıoğlu City Hospital. In the patients who underwent surgery after PET/CT imaging, the PET/CT findings were evaluated along with their definitive pathology reports. The PET/CT findings of the pelvic and paraaortic lymph nodes were compared with the corresponding findings related to these lymph nodes mentioned in the pathology report. In the PET/CT report, lesions with pathological $^{18}$F-FDG uptake and metastasis in the pathology report were considered true positives; lesions with pathological $^{18}$F-FDG uptake but no metastasis in the pathology report were considered false positives; lesions with no pathological $^{18}$F-FDG uptake but metastasis in the pathology report were considered false negatives; and lesions with no pathological $^{18}$F-FDG uptake and no metastasis in the pathology report were considered true negatives. The sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) of PET/CT for the detection of lymph node metastasis were calculated.

In order to predict the presence of nodal metastasis, the $SUV_{max}$ values of the primary tumor were recorded from the PET/CT reports. The staging was performed using the FIGO staging system in all patients.

### Statistical Analysis

The normality of the distribution of the data was tested with the Shapiro-Wilk test. A Student's t-test was used to compare data with a normal distribution between two independent groups and the Mann-Whitney U test was used to compare data with a skewed distribution between two independent groups. One-Way Analysis of Variance and least significant difference multiple comparison tests were employed to compare continuous data with a normal distribution between more than two independent groups. The Kruskal-Wallis and all-pairwise multiple comparison tests were used to compare data with a skewed distribution between more than two groups. The correlations between variables were tested with the Spearman's correlation test. A receiver operating characteristic (ROC) analysis was performed to estimate cut-off values for continuous variables. The cut-off value was determined with respect to the activity level of the area under the ROC curve (AUC). Mean ± standard deviation values were given for numerical variables, and categorical variables were expressed as numbers and frequencies. The SPSS for Windows version 24.0 package program was used for the statistical analysis, and a p-value of $<0.05$ was considered as statistically significant.

## Results

### Patient Population

There were 78 patients in our study. Of them, 42 had endometrial cancer, 10 had uterine sarcoma, 14 had cervical cancer and 12 had ovarian cancer. The age of the patients ranged from 21 to 80 years and the mean age was 55.69±11.95 years.

Histopathological data and demographic information of the patients with clinical diagnoses of endometrial cancer, uterine sarcoma, cervical cancer and ovarian cancer are presented in Tables 1 and 2, respectively.

### Histopathological Findings

The total number of pelvic lymph nodes removed from the patients was 1,221 (mean 15.65±11.13), and the total number of paraaortic lymph nodes was 586 (mean 7.51±10.25). The definitive pathological report recorded 40 (3.2%) of the 1,221 pelvic lymph nodes and 94 (16.04%) of the 586 para-aortic lymph nodes as metastatic.

### PET/CT Findings

Table 3 presents the statistical parameters of PET/CT in predicting lymph node metastasis in patients with endometrial cancer, uterine sarcoma, cervical cancer and ovarian cancer. In endometrial cancer, there was no statistically significant difference between different stages and between patients with myometrial invasion of <50% and those with ≥50% in terms of the mean $SUV_{max}$ values of the primary tumor on a PET/CT examination.

In the present study, 42 patients with endometrial cancer were categorized with respect to the risk classification system described jointly by the European Society for Medical Oncology, the European Society for Radiotherapy & Oncology and the European Society of Gynecological Oncology. Based on this system, 19 (45.2%) patients were in the low-risk group, 8 (19%) were in the middle-risk group and 15 (35.7%) were in the high-risk group. There were no patients in the high-middle risk group. The mean $SUV_{max}$ value of the primary tumor was 14.40±6.79 in the low-risk group, 18.06±7.32 in the medium-risk group, and 16.55±7.87 in the high-risk group. After evaluating all risk groups, the mean $SUV_{max}$ values were found to be statistically insignificant.

**Table 1. Descriptive characteristics and histopathological findings of endometrial cancer patients**

| Parameters | Number |
|---|---|
| Age | 58.83±10.24 (38-80) |
| **Menopausal condition** | |
| Postmenopausal | 33 (78.6%) |
| Premenopausal | 9 (21.4%) |
| **Histopathological subtype** | |
| Type 1 | 37 (88.1%) |
| Type 2 | 5 (11.9%) |
| FIGO stage | |
| IA | 19 (45.2%) |
| IB | 9 (21.4%) |
| II | 2 (4.8%) |
| IIIA | 1 (2.4%) |
| IIIC1 | 5 (11.9%) |
| IIIC2 | 6 (14.3%) |
| **Myometrial invasion** | |
| <50% | 19 (45.2%) |
| ≥50% | 23 (54.8%) |
| **Risk group** | |
| Low | 19 (45.2) |
| Intermediate | 8 (19%) |
| High | 15 (35.7%) |
| **Grading** | |
| 1 | 13 (30.9%) |
| 2 | 17 (40.4%) |
| 3 | 12 (28.5%) |
| **Lymph node metastasis** | |
| Yes | 11 (26.1%) |
| No | 31 (73.8%) |
| **CSI** | |
| Yes | 8 (19%) |
| No | 34 (81%) |
| **LVSI** | |
| Yes | 8 (19%) |
| No | 34 (81%) |

CSI: Cervical stromal involvement, LVSI: Lymphovascular space invasion

The use of the mean $SUV_{max}$ values of the primary tumor in a PET/CT examination to discriminate between patients with and without lymphatic metastasis with respect to the pathology report was evaluated by a ROC analysis (Figure 1). The 95% confidence interval of the AUC of the ROC curve was calculated as 0.697 (p=0.073). The ROC curve analysis was not statistically significant. In addition, the optimum cutoff value was determined as 19.20, which corresponds to a sensitivity of 66.7% and a specificity of 78.8%.

When we evaluated patients with endometrial cancer, there was no significant correlation between the mean $SUV_{max}$ value of the primary tumor and histological subtype, LVSI, or cervical stromal involvement (Table 4). The mean $SUV_{max}$ value of the primary tumor in patients with uterine sarcoma was 16.92±8.68 (range 5.3 to 32.4). The relationship between the mean $SUV_{max}$ value and lymphatic metastases of the primary tumor based on the definitive pathology report could not be estimated owing to the insufficient number of patients.

When the mean $SUV_{max}$ values of patients with cervical cancer were compared according to FIGO stages, an insignificant difference was found. However, nine of the 14 patients with cervical cancer had squamous cell carcinomas and five had adenocarcinomas with respect to the histopathology. The mean $SUV_{max}$ of the primary tumor was 10.25±6.065 in patients with squamous cell carcinoma and 12.25±11.01 in patients with adenocarcinoma. There was no statistically significant difference between these two groups in terms of the mean $SUV_{max}$ values of the primary tumor upon a PET/CT examination.

The lesion-based mean $SUV_{max}$ in PET/CT was 9.92±4.71 (range 2.66-15.40) in ovarian cancer. The lesion-based mean $SUV_{max}$ value of the patients who had lymph node metastases based on a pathological examination was 9.96±5.55, and the mean $SUV_{max}$ value of the patients who had no lymph node metastasis was 9.79±1.19 (Table 5). There was a statistically significant difference between these two groups (p=0.041).

## Discussion

Our study assessed the efficacy of preoperative $^{18}$F-FDG PET/CT to detect lymph node metastasis in patients who underwent surgery and lymphadenectomy for endometrial cancer, uterine sarcoma, cervical cancer or ovarian cancer, and found that the highest diagnostic yield of PET/CT was for uterine sarcomas. Furthermore, we found that the mean $SUV_{max}$ value was the only variable among the metabolic parameters of PET/CT that was used and there was an important relationship between lymph node metastasis and $SUV_{max}$ only in patients who had ovarian cancer.

In terms of determining lymph node metastasis, there have been many studies in the literature comparing the non-invasive medical imaging techniques. Some of these studies have only investigated the yield of $^{18}$F-FDG PET/CT in predicting lymph node metastasis. One such study, carried out by Crivellaro et al. (4), investigated 76 patients who had

**Table 2. Descriptive characteristics and histopathological findings of patients with uterine sarcoma, cervical cancer, and ovarian cancer**

| | | Uterine sarcoma | Cervical cancer | | Ovarian cancer | |
|---|---|---|---|---|---|---|
| **Parameters** | | **Number** | **Number** | | **Number** | |
| Age | | 56.6±14.28 (33-77) | 47.64±9.14 (37-63) | | 53.33±14.71 (21-73) | |
| Menopausal condition | Postmenopausal | 8 (80%) | 6 (42.9%) | | 10 (83.3%) | |
| | Premenopausal | 2 (20%) | 8 (57.1%) | | 2 (16.7%) | |
| Histological subtype | Leiomyosarcoma | 2 (20%) | Adenocarcinoma | 5 (35.7%) | Granulosa cell tumor | 1 (8.3%) |
| | Carcinosarcoma | 6 (60%) | SCC | 9 (64.3%) | Serous cancer | 11 (91.7%) |
| | USS | 2 (20%) | | | | |
| FIGO stage | IA | 1 (10%) | IA1 | 1 (7.1%) | IA | 2 (22.2%) |
| | IB | 6 (60%) | IA2<br>IB1 | 1 (7.1%)<br>9 (64.5%) | | |
| | IC | 2 (20%) | IB2 | 1 (7.1%) | IIIC | 7 (77.8%) |
| | IIIC2 | 1 (10%) | IIA1<br>IIA2 | 1 (7.1%)<br>1 (7.1%) | | |

USS: Undifferentiated uterine sarcoma, SCC: Squamous cell carcinoma

**Table 3. PET/CT findings**

| | | |
|---|---|---|
| **Endometrial cancer** | Sensitivity | 54.5% |
| | Specificity | 96.7% |
| | Accuracy | 85.7% |
| | PPV | 85.7% |
| | NPV | 85.7% |
| **Uterine sarcoma** | Sensitivity | 100% |
| | Specificity | 89.9% |
| | Accuracy | 90% |
| | PPV | 50% |
| | NPV | 100% |
| **Cervical cancer** | Sensitivity | 0% |
| | Specificity | 92.3% |
| | Accuracy | 85.7% |
| | PPV | 0% |
| | NPV | 92.3% |
| **Ovarian cancer** | Sensitivity | 62.5% |
| | Specificity | 75% |
| | Accuracy | 66.7% |
| | PPV | 83.3% |
| | NPV | 50% |
| **Total** | Sensitivity | 57.1% |
| | Specificity | 92.9% |
| | Accuracy | 83.3% |
| | PPV | 75% |
| | NPV | 85.4% |

PPV: Positive predictive value, NPV: Negative predictive value, PET/CT: Positron emission tomography/computed tomography

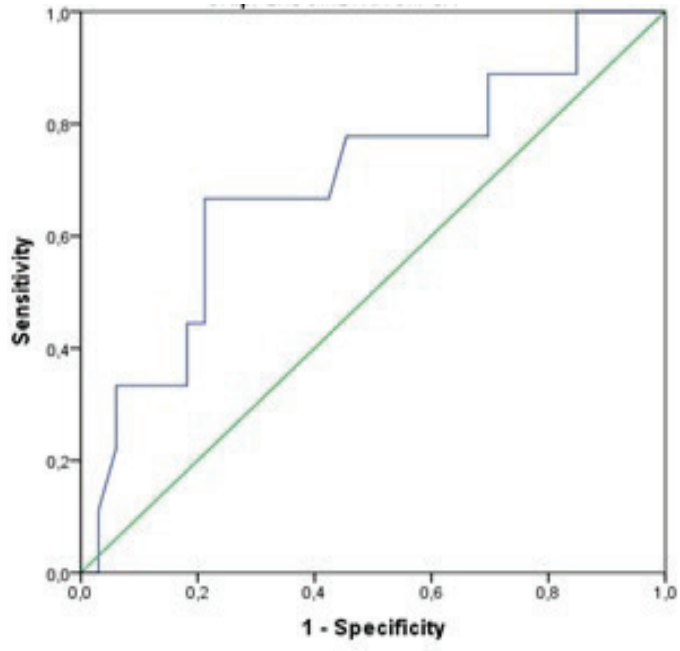



**Figure 1.** Evaluation of lymph node metastasis in endometrial cancer through a receiver operating characteristic curve analysis

high-risk endometrial cancer and found that 66 patients had endometrioid, seven patients had carcinosarcoma and the remaining patients had a non-endometrioid histology. The sensitivity, specificity, accuracy, PPV and NPV of PET/CT in detecting lymph node metastasis were 78.6%, 98%, 94.7%, 91.7%, and 95.3%, respectively. In a study by Atri et al. (5), comparing the success of PET/CT in predicting lymph node metastasis in cervical cancer with CT, the sensitivity and specificity of PET/CT were found to be 81% and 69%, respectively, and PET/CT was thus reported to be superior to CT. Jiafu et al. (6) compared the sensitivity,

specificity, and accuracy of PET/CT with CT in predicting lymph node metastasis in 28 patients (17 with cervical cancer, four with endometrial cancer and seven with ovarian cancer), and they reported sensitivity, specificity and accuracy of 100%, 61.54% and 82.14%, respectively, for PET/CT, and these values were higher than in CT. They also found no relationship between the mean $SUV_{max}$ value and lymph node metastasis.

In the present study, no comparison was made among PET/CT and other imaging techniques, as only the performance of $^{18}$F-FDG PET/CT was investigated. The statistical values of PET/CT in predicting lymph node metastasis in patients with endometrial cancer were comparable with those of similar studies, aside from the sensitivity of PET/CT in endometrial cancer. The relatively low sensitivity was attributed to the fact that most of the patients with endometrial cancer in the present study were at an early stage of the disease. We speculate that $^{18}$F-FDG PET/CT may perform better in advanced stage endometrial cancer.

Considering the statistical parameters in Table 3, the sensitivity of PET/CT in detecting lymph node metastasis in patients who had cervical cancer was found to be quite low when compared to other studies in literature, although it should not be concluded that $^{18}$F-FDG PET/CT does not achieve good success in cervical cancer, as the low number of patients with cervical cancer in the present study may have led to a type 1 error.

When we analyzed the statistical parameters in Table 3, the PET/CT examination achieved a very high success rate to predict lymph node metastasis in cases of uterine sarcoma when compared to other studies in literature. Uterine sarcoma's a very rare gynecological malignity, and there have been very few studies to date investigating PET/CT in the identification of patients with this form of cancer. The efficacy of PET/CT in uterine sarcomas has been evaluated in conjunction with endometrial cancer in previous studies, although uterine sarcomas have not been classified separately in these studies. There is little doubt that the findings of the present study of patients with uterine sarcoma will contribute significantly to literature, but it should be supported by larger scale studies.

In addition, the statistical values that were found by PET/CT in ovarian cancer are in parallel with those of other similar studies. When we consider the statistical values of the PET/CT examination in the total study population of 78 patients, there are currently insufficient data on the performance of $^{18}$F-FDG PET/CT in these four cancer types together, and so it is not possible to compare these values with those of other studies.

The $SUV_{max}$ value, which is a semi-quantitative parameter obtained from PET/CT, is a measure of $^{18}$F-FDG concentration in metabolically active tissue, and is widely used as a marker of tumor aggressiveness and prognosis in many cancers (7). Recently, measures of metabolic tumor burden, such as metabolic tumor volume (MTV) and total lesion glycolysis (TLG), have been used as important prognostic markers in many cancers (8). However, only the $SUV_{max}$ value was used in the present study, while the other metabolic parameters of MTV and TLG were not used.

**Table 4. Correlation analysis**

| | | Mean $SUV_{max}$ value of primary tumor |
|---|---|---|
| **Histological subtype** | r | -0.216 |
| | p | 0.098 |
| | n | 41 |
| **LVSI** | r | 0.168 |
| | p | 0.199 |
| | n | 41 |
| **CSI** | r | -0.034 |
| | p | 0.792 |
| | n | 41 |
| **Mean $SUV_{max}$ value of primary tumor** | r | - |
| | p | - |
| | n | - |

LVSI: Lymphovascular space invasion, CSI: Cervical stromal involvement, r: Spearman correlation coefficient, n: Number of patients

**Table 5. Comparison of lesion-based mean $SUV_{max}$ values of patients with ovarian cancer and lymph node metastasis**

| | | N | Mean ± SD | Minimum | Maximum | p |
|---|---|---|---|---|---|---|
| **Lymphatic metastasis in PET/CT** | Yes | 6 | 8.96±5.76 | 2.66 | 15.40 | 0.500[a] |
| | No | 6 | 11.52±2.30 | 8.95 | 13.40 | |
| **Lymphatic metastasis in pathology** | Yes | 8 | 9.96±5.55 | 2.66 | 15.40 | 0.041*[a] |
| | No | 4 | 9.79±1.19 | 8.95 | 10.63 | |

N: Number of patients, SD: Standard deviation, PET/CT: Positron emission tomography/computed tomography, [a]Student's t-test, *p<0.05

When we have reviewed the literature, there are many studies related to metabolic parameters. Antonsen et al. (9) reported that a high $SUV_{max}$ value in endometrial carcinoma was related to lymph node metastasis, and they observed that high $SUV_{max}$ values were significantly associated with advanced FIGO stage, deep myometrial invasion, and cervical stromal involvement. In another study conducted with 56 patients diagnosed with endometrial cancer, the study population was classified as having low or high-risk cancer, and the high-risk group had significantly higher MTV and TLG values than the low-risk group. They showed no differences in mean $SUV_{max}$ values among the groups (10).

Miccò et al. (11) reported that the $SUV_{max}$ value was not associated with lymph node metastasis in a retrospective study involving 49 patients with cervical cancer. Takagi et al. (12) reported that the use of the $SUV_{max}$ value contributed to the differentiation between benign and malign ovarian tumors, as well as between uterine myomas and uterine sarcomas.

In our study, no significant correlation was found between the mean $SUV_{max}$ values of the primary tumor and lymph node metastasis, histopathological subtype, deep myometrial invasion, LVSI or cervical stromal involvement in patients diagnosed with endometrial cancer. When evaluated according to risk groups, the mean $SUV_{max}$ values were found to be similar to each other and were not statistically significant. No significant relationship was found in the present study between the mean $SUV_{max}$ values of the primary tumor and histological type, FIGO stage or lymph node metastasis in patients with cervical cancer. Due to the small number of patients with uterine sarcoma, the relationship between the mean $SUV_{max}$ value of the primary tumor and other study parameters could not be clearly determined. Finally, in the patients with ovarian cancer in the present study, the lesion-based mean $SUV_{max}$ values were associated with lymph node metastasis.

While the $SUV_{max}$ values have been related to lymph node metastasis, FIGO stage, histological subtype, deep myometrial invasion and risk groups in some studies, no such associations have been noted in others. Relatively new metabolic parameters such as MTV and TLG have been shown to provide a better diagnostic yield than $SUV_{max}$, and their use could potentially provide better results in the present study.

In the present study, the demographic characteristics of the patients were similar to those of other studies in literature. It is well-known that physiological $^{18}$F-FDG uptake may be observed in the endometrium, which changes cyclically in the premenopausal period (13). Ovarian $^{18}$F-FDG uptake may also be physiological in the premenopausal period, but is considered abnormal in the postmenopausal period (14). The rates of postmenopausal and premenopausal patients were similar in the present study and similar studies in the literature. In the present study, $^{18}$F-FDG uptake was not evaluated separately in postmenopausal and premenopausal patients, and this limitation may have influenced the assessment of the association between the mean $SUV_{max}$ values and lymph node metastasis.

One of the strongest points of our study is that the effectiveness of PET/CT was evaluated separately for four gynecological cancer types and was specifically investigated also for uterine sarcomas.

### Study Limitations

The present study has some limitations, the first of which relates to the low number of patients, especially those with cervical cancer, uterine sarcoma, and ovarian cancer. And, the absence of a balanced distribution of some study variables among some cancer groups is another limitation. Secondly, the effect of $SUV_{max}$ values on treatment outcomes, recurrence, progression-free survival or overall survival was not investigated. Thirdly, relatively new metabolic parameters such as MTV and TLG were not evaluated in the present study. Finally, the only non-invasive imaging method utilized in the study was PET/CT.

## Conclusion

PET/CT was found to provide the best diagnostic yield in uterine sarcomas, and the mean $SUV_{max}$ values of metabolic parameters were only associated with lymph node metastasis in ovarian tumor, but not in other gynecologic malignancies.

### Ethics

**Ethics Committee Approval:** Ethics committee approval dated 19/12/2017 and numbered 785 was obtained from University of Health Sciences Turkey, Okmeydanı Training and Research Hospital Ethics Committee before the study.

**Informed Consent:** Retrospective study.

**Peer-review:** Externally peer-reviewed.

### Authorship Contributions

Surgical and Medical Practices: N.T., V.M., Concept: N.T., V.M., G.D., Design: N.T., V.M., G.D., Data Collection

or Processing: Y.K., D.Y.Y.K., H.C.U., Analysis or Interpretation: Y.K., D.Y.Y.K., H.C.U., Literature Search: Y.K., D.Y.Y.K., H.C.U., Writing: Y.K., D.Y.Y.K., G.D.

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

**Financial Disclosure:** The authors declared that this study received no financial support.

## References

1. American Cancer Society. Cancer facts & figures. Available from: https://www.cancer.org/research/cancer- facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2018.html July 2018.
2. Gien LT, Covens A. Lymph node assessment in cervical cancer: Prognostic and therapeutic implications. J Surg Oncol 2009;99(4):242-247.
3. Çetinkaya K, Ardıç F, Atalay F, Bacınoğlu A, Dervişoğlu H. What Is The Accuracy Of Frozen Section For Risk Triage In Endometrial Cancer?. Acta Oncol Turc 2016;49(2):80-85.
4. Crivellaro C, Signorelli M, Guerra L, Ponti ED, Pirovano C, Fruscio R, et al. Tailoring systematic lymphadenectomy in high-risk clinical early stage endometrial cancer: The role of 18F-FDG PET/CT. Gynecol Oncol 2014;130(2):306-311.
5. Atri M, Zhang Z, Dehdashti F, Lee SI, Ali S, Marques H, et al. Utility of PET-CT to evaluate retroperitoneal lymph node metastasis in advanced cervical cancer: Results of ACRIN6671/GOG0233 trial. Gynecol Oncol 2016;142(3):413-419.
6. Jiafu W, Linhan Z, Di W, Yong L. Diagnostic value of $^{18}$F-FDG PET/CT in detecting distant lymph node metastasis of gynecological malignancies. Biomed Res 2017;S659-662.
7. Crivellaro C, Guglielmo P, Ponti ED, Elisei F, Guerra L, Magni S, et al. 18F-FDG PET/CT in preoperative staging of vulvar cancer patients: is it really effective?. Medicine (Baltimore) 2017;96(38):e7943.
8. Nagamachi S. The Problem of Metabolic Tumor Volume in FDG/PET for Evaluating Cancers - Determination of Threshold and Use of Methionine-PET. J Radiol Radiat Ther 2014;2:1-2.
9. Antonsen SL, Loft A, Fisker R, Nielsen AL, Andersen ES, Høgdall E, et al. SUVmax of 18FDG PET/CT as a predictor of high-risk endometrial cancer patients. Gynecol Oncol 2013;129(2):298-303.
10. Kitajima K, Suenaga Y, Ueno Y, Maeda T, Ebina Y, Yamada H, et al. Preoperative risk stratification using metabolic parameters of 18F-FDG PET/CT in patients with endometrial cancer. Eur J Nucl Med Mol Imaging 2015;42(8):1268-1275.
11. Miccò M, Vargas HA, Burger IA, Kollmeier MA, Goldman DA, Park KJ, et al. Combined pre-treatment MRI and 18F-FDG PET/CT parameters as prognostic biomarkers in patients with cervical cancer. Eur J Radiol 2014;83(7):1169-1176.
12. Takagi H, Sakamoto J, Osaka Y, Shibata T, Fujita S, Sasagawa T. Utility of 18F-fluorodeoxyglucose-positron emission tomography in the differential diagnosis of benign and malignant gynaecological tumours. J Med Imaging Radiat Oncol 2018. doi: 10.1111/1754-9485.12707.
13. Kim HJ, Cho A, Yun M, Kim YT, Kang Won J. Comparison of FDG PET/CT and MRI in lymph node staging of endometrial cancer. Ann Nucl Med 2016;30(2):104-113.
14. Lerman H, Metser U, Grisaru D, Fishman A, Lievshitz G, Sapir EE. Normal and abnormal 18F-FDG endometrial and ovarian uptake in pre-and postmenopausal patients: assessment by PET/CT. J Nucl Med 2004;45(2):266-271.