



Evaluation of Cavitory Lung Lesions with ¹⁸F-FDG PET/CT: Differentiating Benign from Malignant Lesions

¹⁸F-FDG PET/BT ile Kaviter Akciğer Lezyonlarının Değerlendirilmesi: Benign ve Malign Lezyonların Ayırt Edilmesi

✉ Nur Aydınbelge Dizdar¹, ✉ Ebru Tatçı¹, ✉ Ülkü Nur Derya², ✉ Özlem Özmen¹

¹University of Health Sciences Türkiye, Ankara Etlik City Hospital, Clinic of Nuclear Medicine, Ankara, Türkiye

²University of Health Sciences Türkiye, Ankara Atatürk Sanatorium Training and Research Hospital, Clinic of Nuclear Medicine, Ankara, Türkiye

Abstract

Objectives: This study aimed to analyze ¹⁸F-fluorodeoxyglucose positron emission tomography/computed tomography (¹⁸F-FDG PET/CT) features to differentiate benign from malignant pulmonary cavitory lesions.

Methods: A total of 76 patients with cavitory lung lesions who underwent ¹⁸F-FDG PET/CT imaging were retrospectively analyzed. Patient demographics, histopathological findings, cavitory lesion morphology, CT characteristics, and maximum standard uptake value (SUV_{max}) of lesions were recorded. Cavitory lesions were classified as benign or malignant and further subdivided by maximum wall thickness into two groups: ≤15 mm and >15 mm. Histopathological results, clinical follow-up, or both were used as the reference standard for lesion classification.

Results: Among 76 patients (mean age, 63.4 years), 31 (40.8%) had benign disease and 45 (59.2%) had malignant disease. Malignant lesions were observed at older ages and exhibited significantly greater lesion size, wall thickness, and SUV_{max} than those in benign lesions (p<0.05 for all). There were no significant differences between the malignant and benign groups regarding sex, lesion localization, air-fluid levels, or pleural effusion (p>0.05 for all). Peripheral consolidation, multiple cavitory lesions, and tree-in-bud pattern were significantly more prevalent in benign lesions than in malignant lesions (p<0.05 for all). In lesions with a maximum wall thickness ≤15 mm, SUV_{max} was significantly higher in malignant lesions than in benign lesions (mean values, 9.81 vs. 5.28; p<0.05). Malignant lesions with a maximum wall thickness >15 mm demonstrated higher SUV_{max} values (mean 18.37 vs. 10.45; p<0.05). SUV_{max} was independently associated with malignancy (odds ratio: 1.237, p=0.017) and showed the best diagnostic performance (area under the curve=0.866; cut-off 8.58, sensitivity 80%, specificity 77%).

Conclusion: The morphological characteristics of pulmonary cavitory lesions, associated parenchymal findings, and ¹⁸F-FDG uptake patterns on PET/CT provide valuable information for distinguishing between benign and malignant lesions. In this study, SUV_{max} demonstrated the highest diagnostic performance. The combined evaluation of metabolic and morphological parameters can enhance diagnostic accuracy and support the clinical decision-making process, thereby contributing to the optimal management of patients.

Keywords: ¹⁸F-FDG PET/CT, cavitory lung lesions, wall thickness, lung cancer, differential diagnosis, SUV_{max}

Address for Correspondence: Nur Aydınbelge Dizdar, University of Health Sciences Türkiye, Ankara Etlik City Hospital, Clinic of Nuclear Medicine, Ankara, Türkiye

E-mail: fnuraydinbelge@gmail.com **ORCID ID:** orcid.org/0000-0002-9657-6906

Received: 23.12.2025 **Accepted:** 29.05.2026 **Epub:** 13.07.2026 **Publication Date:** 06.10.2026

Cite this article as: Aydınbelge Dizdar N, Tatçı E, Derya ÜN, Özmen Ö. Evaluation of cavitory lung lesions with ¹⁸F-FDG PET/CT: differentiating benign from malignant lesions. Mol Imaging Radionucl Ther. 2026;35(3):157-165.



Copyright© 2026 The Author(s). Published by Galenos Publishing House on behalf of the Turkish Society of Nuclear Medicine. This is an open access article under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 (CC BY-NC-ND) International License.

Öz

Amaç: Bu çalışma, benign ve malign pulmoner kaviter akciğer lezyonlarını ayırt etmede ¹⁸F-florodeoksiglukoz pozitron emisyon tomografisi/bilgisayarlı tomografi (¹⁸F-FDG PET/BT) özelliklerini analiz etmeyi amaçladı.

Yöntem: ¹⁸F-FDG PET/BT görüntüleme yapılan toplam 76 kaviter akciğer lezyonu olan hasta retrospektif olarak analiz edildi. Hastaların demografik özellikleri, histopatolojik bulguları, kaviter lezyon morfolojisi, BT özellikleri ve lezyonların maksimum standart tutulum değeri (SUV_{max})'ı kaydedildi. Kaviter lezyonlar benign veya malign olarak sınıflandırıldı ve maksimum duvar kalınlığına göre ≤15 mm ve >15 mm olmak üzere iki gruba ayrıldı. Histopatolojik sonuçlar ve/veya klinik takip, lezyon sınıflandırması için referans standardı olarak kullanıldı.

Bulgular: Toplam 76 hastanın (ortalama yaş: 63,4), 31'i (%40,8) benign hastalık, 45'i (%59,2) malign hastalık tanısı aldı. Malign lezyonlar daha ileri yaşlarda gözlemlendi ve benign lezyonlara göre anlamlı olarak daha büyük lezyon boyutu, duvar kalınlığı ve SUV_{max} değerleri bulundu (tümü için p<0,05). Cinsiyet, lezyon lokalizasyonu, hava-sıvı seviyelerinin varlığı veya plevral efüzyon açısından gruplar arasında anlamlı bir fark bulunmadı (tümü için p>0,05). Periferik konsolidasyon, çoklu kaviter lezyonlar ve tomurcuklanmış ağaç paterni benign lezyonlarda anlamlı olarak daha sık gözlemlendi (tümü için p<0,05). Maksimum duvar kalınlığı ≤15 mm olan lezyonlarda, SUV_{max} malign lezyonlarda benign lezyonlara göre anlamlı olarak daha yüksekti (ortalama değerler, 9,81'e karşı 5,28; p<0,05). Maksimum duvar kalınlığı >15 mm olan lezyonlarda, malign lezyonlar benign lezyonlara kıyasla daha yüksek SUV_{max}'a sahipti (ortalama değerler, 18,37'ye karşı 10,45; p<0,05). SUV_{max}, malignite ile bağımsız olarak ilişkili bulundu (olasılık oranı: 1,237, p=0,017) ve en iyi tanılabilir performansı gösterdi (eğri altında kalan alan=0.866; kesim değeri 8,58, duyarlılık %80, özgüllük %77).

Sonuç: Kaviter akciğer lezyonlarının morfolojik özellikleri, eşlik eden parankimal bulgular ve PET/BT'deki ¹⁸F-FDG tutulum paternleri benign ve malign lezyonların ayırt edilmesinde önemli bilgiler sağlamaktadır. Bu çalışmada SUV_{max} en yüksek tanılabilir performansı göstermiştir. Metabolik ve morfolojik parametrelerin birlikte değerlendirilmesi tanılabilir doğruluğu artırarak klinik karar verme sürecine ve hasta yönetiminin optimize edilmesine katkı sağlayabilir.

Anahtar Kelimeler: ¹⁸F-FDG PET/BT, kaviter akciğer lezyonları, duvar kalınlığı, akciğer kanseri, ayırıcı tanı, SUV_{max}

Introduction

A cavitory lung lesion is a gas-filled space within a pulmonary consolidation, mass, or nodule. The evacuation of necrotic tissue through the bronchial tree leads to the development of cavitation (1). Cavities can develop from a variety of causes, including malignancies (such as squamous cell carcinoma, adenocarcinoma, and small cell lung cancer), infections (such as *Streptococcus pneumoniae*, *Streptococcus aureus*, typical and atypical mycobacteria, fungal infections, and parasites), autoimmune diseases (including rheumatoid arthritis or granulomatosis with polyangiitis), sarcoidosis, pulmonary embolism, and congenital abnormalities (such as bronchogenic cyst, pulmonary sequestration, congenital pulmonary airway malformation) (2).

Radiographic differentiation between malignant and benign cavitory lesions is crucial in clinical practice, as it guides management and treatment decisions. Computed tomography (CT) plays significant role in the detection and differential diagnosis of cavitory lesions. The size, shape, location, and wall characteristics of cavitory lesions can provide important clues to their underlying etiology. The thickness of the cavity wall is the most important criterion for assessing these lesions, as it often helps distinguish malignant from benign etiologies. Several studies indicate that malignant cavitory lesions have thicker walls, whereas thin-walled cavitory lesions are usually benign (3,4,5). However, there is no consensus on the CT threshold for wall thickness. Additionally, there may be considerable overlaps in wall thickness between malignant and

benign lesions. ¹⁸F-fluorodeoxyglucose positron emission tomography with CT (¹⁸F-FDG PET/CT) is an important imaging technique for differentiating benign from malignant lung lesions. Moreover, ¹⁸F-FDG PET/CT can be useful in evaluating disease severity, identifying optimal biopsy sites, and monitoring treatment response in benign lung diseases such as tuberculosis and sarcoidosis (6). Malignant lesions typically exhibit high ¹⁸F-FDG uptake due to increased glycolytic activity. However, ¹⁸F-FDG uptake can also be observed in a variety of inflammatory and infectious disorders, including tuberculosis, pneumonia, abscesses, sarcoidosis, and autoimmune diseases, due to increased metabolic activity. Accordingly, this study evaluated ¹⁸F-FDG PET/CT imaging features to differentiate benign from malignant cavitory lung lesions based on metabolic and morphological characteristics.

Materials and Methods

Clinicopathological Characteristics of the Patients

In this study, patients who had cavitory lung lesions on radiological exams and underwent ¹⁸F-FDG PET/CT for differential diagnosis between 2020 and 2021 at our department were involved. Exclusion criteria included patients with cavitory lesions who had received antibiotic, antiviral, or antifungal therapy prior to ¹⁸F-FDG PET/CT, as well as those with incomplete clinical records or suboptimal PET/CT images. Patients with a primary malignancy or a history of granulomatous, rheumatological, or congenital diseases were excluded from the study.

Cavitory lesions were classified primarily into two groups: benign and malignant. The definitive diagnosis was confirmed by sputum and blood culture results, response to treatment, and histopathological findings. Ethical approval for this retrospective study was obtained from the Local Ethics Committee of the University of Health Sciences Türkiye, Ankara Atatürk Sanatorium Training and Research Hospital, (approval no: 661, date: 06.02.2020).

^{18}F -FDG PET/CT Imaging

Prior to the imaging procedure, all patients fasted for 4-6 hours. After confirming that their blood glucose levels were under 190 mg/dL, an average ^{18}F -FDG dose of 390.8 ± 54.2 MBq (ranging from 310 to 565 MBq) was administered intravenously. Sixty minutes after ^{18}F -FDG administration, whole-body PET/CT imaging from the vertex to the proximal femur was performed for each patient using a Siemens Biograph 6 HI-REZ integrated PET/CT scanner (Siemens Medical Solutions, Knoxville, TN, USA). CT scans were first obtained at 130 kV with automatic real-time amperage modulation, a slice thickness of 0.5 cm, a rotation time of 0.6 seconds, a table speed of 1.5 cm per rotation, and a pitch of 1.5. Following CT acquisition, PET images were acquired for 3 minutes per bed position. PET images were attenuation-corrected using the CT data and reconstructed with the ordered-subsets expectation maximization algorithm, employing 4 iterations and 8 subsets. A gaussian post-filter was applied, resulting in a transaxial spatial resolution of 5 mm at full width at half maximum. Reconstructed transaxial, coronal, and sagittal PET, CT and fused PET/CT images, as well as maximum-intensity projection images, were reviewed on a dedicated workstation for visual and semi-quantitative analysis.

Visual assessment was performed to evaluate ^{18}F -FDG uptake relative to background lung activity. Semi-quantitative analysis was performed by placing a region of interest (ROI) over each cavitory lesion to measure the maximum standard uptake value (SUV_{max}). The ROI was carefully drawn to include only the cavitory lesion, excluding any adjacent parenchymal abnormalities, such as consolidation or tree-in-bud patterns. CT morphological features, including cavity wall thickness, the longest axial diameter, and adjacent parenchymal findings, were also recorded. Based on CT findings, the patients were retrospectively classified into probable benign and probable malignant groups. The presence of a tree-in-bud pattern or multiple cavitory lesions on CT imaging was accepted as a criterion for benignity. Additionally, cavitory lesions were subdivided into two groups based on maximum wall thickness: ≤ 15 mm and > 15 mm. The images were evaluated by two nuclear medicine specialists with over

10 years of experience (OO and ET). Any discrepancies between reviewers were resolved by consensus.

Statistical Analysis

Statistical analyses were conducted with SPSS version 27.0 (IBM Corp., Armonk, NY, USA). The relationships between categorical variables were analyzed using the chi-square test, and correlations were evaluated using appropriate correlation methods. The Mann-Whitney U test was used for pairwise comparisons between groups. Spearman correlation analysis was used to assess the associations among SUV_{max} , lesion diameter, and maximum wall thickness. ROC analysis was performed to evaluate the diagnostic performance of SUV_{max} , maximum wall thickness, and lesion diameter, and to determine their optimal cut-off values for differentiating malignant from benign lesions. Logistic regression analysis was used to determine factors associated with malignancy risk. A p-value less than 0.05 was considered statistically significant throughout the analysis.

Results

Clinicopathological Characteristics of the Patients

A total of 76 patients who underwent ^{18}F -FDG PET/CT scan for the assessment of cavitory lesions were enrolled in the study, comprising 10 females (13.1%) and 66 males (86.8%), with a mean age of 63.4 ± 12.7 years. The clinicopathological characteristics of the patients were presented in Table 1. Of the 76 patients, 31 (40.8%) had benign lesions and 45 (59.2%) had malignant lesions. Sex distribution did not differ significantly between the benign and malignant groups ($p=0.081$). The mean age was significantly lower in the benign group compared with the malignant group (31 ± 12.2 vs. 45 ± 11.8 years, $p<0.001$). Furthermore, the final diagnoses of benign and malignant cavitory lesions were summarized in Table 2.

^{18}F -FDG PET/CT Findings

No significant differences were detected between benign and malignant cavitory lesions with respect to lung side, presence of air-fluid levels, pleural effusion, and perilesional infiltration ($p=0.91$, $p=0.58$, $p=0.66$, $p=0.13$, respectively; Table 3). Malignant cavitory lesions had significantly greater diameters than benign cavitory lesions ($p=0.003$). Consolidation associated with the primary lesion was more common in benign lesions ($p=0.025$). The perilesional tree-in-bud pattern was observed in only 8 (25.8%) of the 31 benign lesions. The tree-in-bud appearance was not associated with malignant cavitory lesions. Additional cavitory lesions in the same or the contralateral lung were observed in 8 (25.8%) of 31 benign lesions (Figure 1),

Table 1. Demographic characteristics and the final clinical classification of patients with benign and malignant cavitory lung lesions

Definitive diagnosis	Benign (n=31, 40.8 %)	Malignant (n=45, 59.2%)	p
Demographic data			
Gender (male/female)	24/7	42/3	0.081
Age (years), mean $\pm$ SD (range)	31 $\pm$ 12.2 (31-91)	45 $\pm$ 11.8 (33-95)	<0.001

Chi-square test for categoric variables, p<0.05 level is significant, Mann-Whitney U test for continuous variable, mean $\pm$ SD, p<0.05 level is significant, SD: Standard deviation

Table 2. Diagnosis of cavitory lung lesions

Definitive diagnosis	n	%
Benign	31	
Bacterial abscesses	17	54.8
Tuberculosis	12	38.7
Bronchogenic cyst	1	3.2
Aspergillus infection	1	3.2
Malign	45	
Lymphomatoid granulomatosis	2	4.4
Squamous cell carcinoma	35	78
Carcinoid tumor	1	2.2
Adenocarcinoma	3	6.6
Adenosquamous carcinoma	3	6.6
Small cell lung cancer	1	2.2
Total	76	

whereas no additional cavitory lesions were identified in malignant cavities.

When the presence of multiple cavitory lesions or a tree-in-bud pattern on CT scans was considered a benign imaging feature and was interpreted in conjunction with clinical findings, the preliminary clinical assessment classified 16 of the 76 patients as possibly benign and 60 as possibly malignant (Table 3). All patients (n=16) in the possibly benign group were eventually diagnosed with benign disease. In the group classified as possibly malignant, malignant disease was confirmed in 45 patients (75%), whereas benign lesions were identified in 15 patients (25%).

The mean maximum wall thickness in the malignant cavitory lesions (21.2 $\pm$ 9.2 mm, range 6-50 mm) was significantly greater than that of the benign cavitory lesions (12.6 $\pm$ 6.2, range 3-27 mm), (p<0.001; Table 3). Only one cavitory lesion had a maximum wall thickness of less than 4 mm, and it was an infectious cavity. The maximum wall thickness was at least 4 mm in all 45 malignant lesions. Of the 76 patients, 36 (47.4%) had a maximum wall thickness $\leq$ 15 mm, while 40 (52.6%) had a wall thickness >15 mm

(Table 3). Of the 36 cavitory lesions with a maximum wall thickness $\leq$ 15 mm, 23 (63.88%) were benign (Figure 2). The remaining 13 lesions (36.12%) were malignant (Figure 3). Of the 40 cavitory lesions with a maximum wall thickness over 15 mm, 8 (20%) were classified as benign and 32 (80%) were classified as malignant (Figure 4). The proportion of malignant lesions was significantly higher in cavitory lesions with a maximum wall thickness >15 mm compared with those $\leq$ 15 mm (p<0.001; Table 4). Of the 76 patients, 35 (46.1%) had cavitory lesions with a maximum wall thickness of 5-15 mm. Among the 35 cavitory lesions with a maximum wall thickness of 5-15 mm, 22 (62.9%) were benign and 13 (37.1%) were malignant.

Relationship Between SUV_{max} , Maximum Wall Thickness and Lesion Size

Table 4 shows SUV_{max} by maximum wall thickness and lesion status (benign or malignant) based on the final diagnosis. The SUV_{max} of benign lesions was significantly lower than that of malignant lesions, with mean values of 6.62 $\pm$ 4.2 (range: 1.7-21.4) and 15.9 $\pm$ 7.6 (range: 4.3-30.3), respectively (p<0.001). According to maximum wall thickness, the overall mean $\pm$ standard deviation of SUV_{max} was 6.92 $\pm$ 5.15 in lesions with a wall thickness $\leq$ 15 mm and 16.78 $\pm$ 6.95 in those with a wall thickness >15 mm. A moderate positive correlation was found between SUV_{max} and the longest axial diameter of the cavitory lesions (r=0.519, p=0.0001; Figure 5). A positive correlation between the maximum wall thickness and SUV_{max} was also observed (r=0.602, p=0.0001).

Univariate and Multivariate Logistic Regression Analyses in Predicting Malign Cavitory Lesion

In univariate logistic regression analysis, increasing age [odds ratio (OR): 1.067, 95% confidence interval (CI): 1.021-1.116, p=0.004], larger lesion diameter (OR: 1.029, 95% CI: 1.007-1.051, p=0.01), greater maximum wall thickness (OR: 1.15, 95% CI: 1.066-1.246, p<0.001), and higher SUV_{max} (OR: 1.316, 95% CI: 1.153-1.502, p<0.001; Table 5) were significantly associated with increased odds of malignancy. In contrast, perilesional consolidation was inversely associated with malignancy

Table 3. The CT findings between benign and malignant cavitory lung lesions based on the final diagnosis			
CT findings	Benign (n=31, 40.8 %)	Malignant (n=45, 59.2%)	p
Localization (left/right lung)	12/19	18/27	0.911
Lesion diameter (mm), mean ± SD (range)	48.5±26 (13-120)	64.6±23.5 (20-120)	0.003
Maximum wall thickness (mm), mean ± SD (range)	12.6±6.2 (3-27)	21.2±9.7 (6-50)	<0.001
Maximum wall thickness <4 mm, n (%)	1 (1.3%)	0	
Maximum wall thickness 5-15 mm, n (%)	22 (28.9%)	13 (17.1%)	
Maximum wall thickness >15 mm, n (%)	8 (10.5%)	32 (42.1%)	
Presence of air-fluid level, n (%)	9 (11.8%)	17 (22.4%)	0.587
Presence of multiple cavitory lesions, n (%)	8 (10.5%)	0	<0.001
Presence of pleural effusion, n (%)	12 (15.8%)	14 (18.4%)	0.661
Presence of perilesional consolidation, n (%)	22 (28.9%)	19 (25%)	0.025
Presence of perilesional infiltration, n (%)	16 (21.1%)	32 (42.1%)	0.136
Presence of tree-in-bud pattern, n (%)	8 (10.5%)	0	<0.001
Preliminary diagnosis based on CT findings			
Possibly benign	16 (21.1%)	0	<0.001
Possibly malign	15 (19.7%)	45 (59.2%)	

Chi-square test for categoric variables, p<0.05 level is significant, Mann-Whitney U test for continuous variables, mean ± SD, p<0.05 level is significant, SD: Standard deviation, CT: Computed tomography

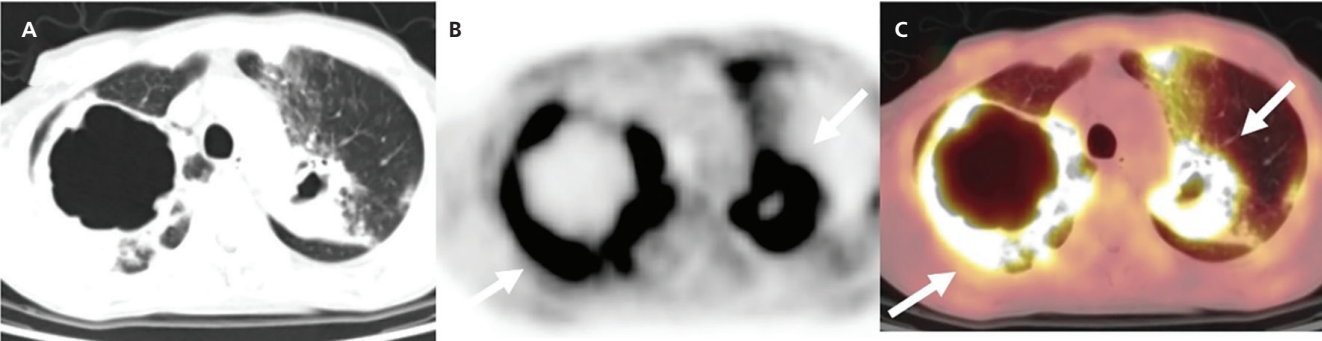


Figure 1. Tuberculosis. Axial CT (A), ¹⁸F-FDG PET (B), and fusion PET/CT (C) images show irregular, thick-walled cavitory lesions surrounded by infiltrated pulmonary parenchyma in both lungs, with the largest lesion located in the right apical region measuring approximately 85 mm (arrows). Increased metabolic activity is observed along the cavity walls (SUV_{max}: 14.34)
¹⁸F-FDG PET/CT: ¹⁸F-fluorodeoxyglucose positron emission tomography/computed tomography, SUV_{max}: Maximum standard uptake value



Figure 2. Tuberculosis. Axial CT (A), ¹⁸F-FDG PET (B), and fused PET/CT images demonstrate increased ¹⁸F-FDG uptake in a cavitory mass lesion containing fluid, measuring approximately 63 mm in diameter, with a maximum wall thickness of 15 mm and SUV_{max} of 8.52 (arrows)
¹⁸F-FDG PET/CT: ¹⁸F-fluorodeoxyglucose positron emission tomography/computed tomography, SUV_{max}: Maximum standard uptake value

(OR: 0.299, 95% CI: 0.113-0.793, $p=0.015$), indicating lower odds of malignancy. The presence of air-fluid level, pleural effusion, and perilesional infiltration was not associated with malignancy.

In multivariate analysis, increasing age (OR: 1.071, 95% CI: 1.008-1.137, $p=0.025$) and higher SUV_{max} (OR: 1.237, 95% CI: 1.039-1.473, $p=0.017$) remained independently associated with increased odds of malignancy. Conversely, the presence of perilesional consolidation remained independently associated with lower odds of malignancy (OR: 0.142, 95% CI: 0.018-0.649, $p=0.029$). Other parameters were not associated with malignancy in the multivariate model.

ROC Analysis for Diagnostic Performance

ROC analysis showed that SUV_{max} had the highest diagnostic performance [area under the curve (AUC)=0.866, 95% CI: 0.786-0.947, $p<0.001$], followed by maximum wall thickness (AUC=0.780, 95% CI: 0.676-0.884, $p<0.001$) and lesion diameter (AUC=0.701, 95% CI: 0.574-0.828, $p=0.003$; Figure 6). The optimal cut-off values to differentiate malignant from benign lesions were 53.5 mm for lesion size (66% sensitivity, 64.5% specificity), 15.5 mm for maximum wall thickness (71.1% sensitivity, 74.2% specificity), and an SUV_{max} of 8.58 (80% sensitivity, 77% specificity).

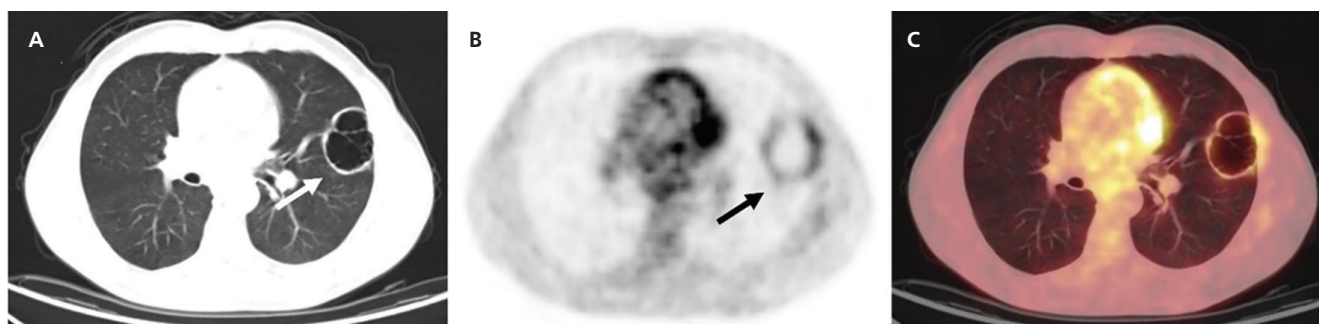


Figure 3. Squamous cell carcinoma. Axial CT (A), ^{18}F -FDG PET (B), and fused PET/CT (C) images show a cavitary mass lesion with mild ^{18}F -FDG uptake, measuring approximately 55 mm in the longest axial diameter, with a maximum wall thickness of 6 mm and an SUV_{max} of 4.22 (arrows)

^{18}F -FDG PET/CT: ^{18}F -fluorodeoxyglucose positron emission tomography/computed tomography, SUV_{max} : Maximum standard uptake value

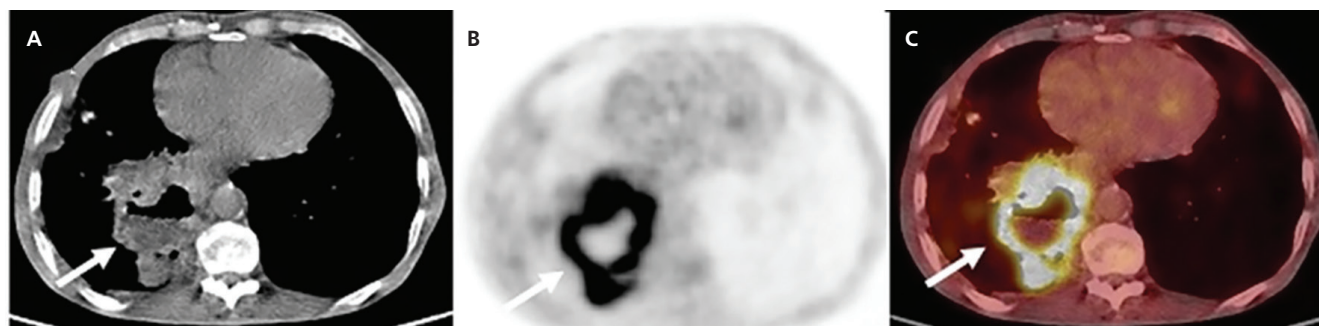


Figure 4. Squamous cell carcinoma. Axial CT (A), ^{18}F -FDG PET (B), and fusion PET/CT (C) images show high ^{18}F -FDG uptake (SUV_{max} : 15.30) on a cavitary mass measuring approximately 93 mm with thick, irregular walls and an internal air-fluid level (arrows)

^{18}F -FDG PET/CT: ^{18}F -fluorodeoxyglucose positron emission tomography/computed tomography, SUV_{max} : Maximum standard uptake value

Table 4. Comparison of SUV_{max} in benign and malignant cavitory lesions based on the maximum wall thickness

	Benign	Malign	p
Maximum wall thickness ≤ 15 mm, n (%)	23 (30.3%)	13 (17.1%)	<0.001
Maximum wall thickness >15 mm, n (%)	8 (10.5%)	32 (42.1%)	<0.001
SUV_{max} , all lesions, mean $\pm$ SD (range)	6.62 $\pm$ 4.2 (1.7-21.4)	15.9 $\pm$ 7.6 (4.3-30.3)	<0.001
SUV_{max} , maximum wall thickness ≤ 15 mm, mean $\pm$ SD (range)	5.28 $\pm$ 2.61 (1.72-11.09)	9.81 $\pm$ 7.13 (4.22-25.28)	0.013
SUV_{max} , maximum wall thickness >15 mm, mean $\pm$ SD (range)	10.45 $\pm$ 5.6 (3.71-21.4)	18.37 $\pm$ 6.38 (7.17-30.31)	0.003

Chi-square test for categoric variables, $p<0.05$ level is significant, Mann-Whitney U test for continuous variables, mean $\pm$ SD, $p<0.05$ level is significant, SD: Standard deviation, SUV_{max} : Maximum standardized uptake value

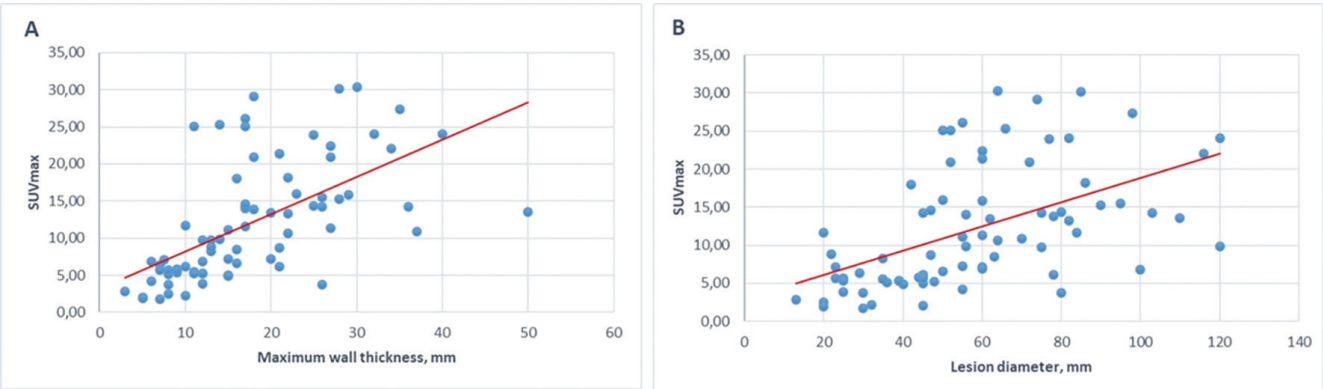


Figure 5. Correlation of SUV_{max} with morphologic parameters. (A) Moderate positive linear correlation between maximum wall thickness (mm) and SUV_{max}. (B) Moderate positive linear correlation between lesion diameter (mm) and SUV_{max}. The red lines indicate linear regression fits
SUV_{max}: Maximum standard uptake value

Table 5. Univariate and multivariate logistic regression analyses in predicting malign cavitory lesion				
Parameters	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p	OR (95% CI)	p
Age	1.067 (1.021-1.116)	0.004	1.071 (1.008-1.137)	0.025
Lesion diameter	1.029 (1.007-1.051)	0.01	1.013 (0.96-1.066)	>0.05
Maximum wall thickness	1.15 (1.066-1.246)	<0.001	1.00 (0.88-1.12)	>0.05
Presence of air–fluid level	1.48 (0.556-3.963)	0.43	1.009 (0.18-5.6)	>0.05
Presence of pleural effusion	0.715 (0.274-1.867)	0.49	1.853 (0.3-11.22)	>0.05
Presence of perilesional consolidation	0.299 (0.113-0.793)	0.015	0.142 (0.018-0.649)	0.029
Presence of perilesional infiltration	2.308 (0.888-5.996)	0.086	2.706 (0.547-13.39)	>0.05
SUV _{max}	1.316 (1.153-1.502)	<0.001	1.237 (1.039-1.473)	0.017

SUV_{max}: Maximum standardized uptake value, OR: Odds ratio, CI: Confidence interval

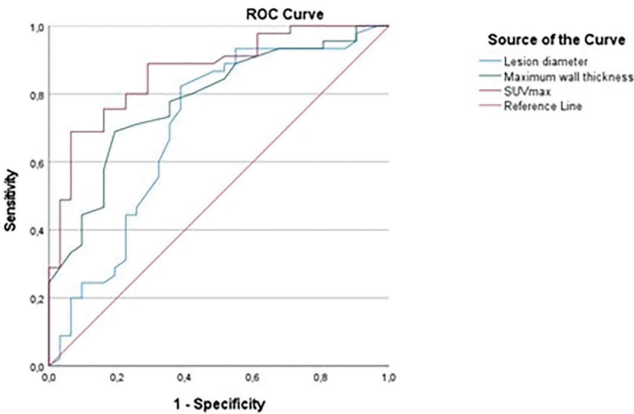


Figure 6. ROC curve analysis showing the diagnostic performance of SUV_{max} (AUC=0.866), maximum wall thickness (AUC=0.78), and lesion diameter (AUC=0.701) for distinguishing benign from malignant cavitory pulmonary lesions
SUV_{max}: Maximum standard uptake value, AUC: Area under the curve

Discussion

Cavitation is observed in approximately 2%-25% of primary lung cancers, with squamous cell carcinoma, adenocarcinoma, and large cell carcinoma being the subtypes most associated with cavitory lesions, respectively (7,8). Differentiating benign from malignant cavitory lesions using radiological imaging methods is a key factor in planning effective treatment strategies. Although CT is the leading imaging technique for detecting cavitory lesions, it can be limited in accurately distinguishing between benign and malignant lesions. CT findings such as multiple cavitory lesions or a tree-in-bud pattern may suggest a benign etiology; however, our results indicate that morphological imaging alone may be insufficient for accurate differentiation. ¹⁸F-FDG PET/CT may change preliminary diagnoses based on CT and clinical evaluation. However, some lesions may be misclassified. This situation emphasizes the need to interpret ¹⁸F-FDG PET in conjunction with other clinical and imaging information to prevent

misdiagnosis. Our findings showed that ^{18}F -FDG PET/CT imaging can offer valuable insights into the metabolic and morphological characteristics of cavitory lung lesions.

Air space surrounded by a wall less than 2 mm thick is called a cyst (9). Sometimes the cyst wall thickness can reach 4 mm. However, cysts and cavities may not always be distinguishable through radiological imaging. To differentiate, air-filled spaces with walls 4 mm or thinner are referred to as cysts, while those with walls thicker than 4 mm are classified as cavities (10). Wall thickness is one of the most important factors in distinguishing benign cavitory lesions from malignant ones. Woodring et al. (5) reported that in a cohort of 61 patients with cavitory lung lesions, 92% of cavities with a maximum wall thickness ≤ 4 mm was benign. In lesions with a wall thickness of 5-15 mm, 51% were benign and 49% were malignant, whereas 95% of cavitory lesions with a wall thickness ≥ 15 mm was malignant. In our study, among the 40 cavitory lesions with a maximum wall thickness > 15 mm, a lower rate of malignancy (80%) was observed. Of the 35 cavitory lesions with a maximum wall thickness of 5-15 mm, 13 (37.1%) were malignant. In our ROC analysis, the cut-off point for maximum wall thickness was 15.5 mm for distinguishing malignant cavitory lesions, with a sensitivity of 71.1% and a specificity of 74.2%. Differences in patient selection, underlying disease prevalence, and diagnostic confirmation methods may explain these discrepancies. Although an increase in wall thickness is strongly associated with malignancy, it is not a definitive indicator. There is considerable overlap in the maximum wall thickness between benign and malignant cavities. Thick, irregular walls are often seen in benign cavitory lesions, such as pulmonary abscess, tuberculosis, aspergillosis, and granulomatosis with polyangiitis (2). Conversely, thin walls can also be present in certain malignant cavitory lesions, including adenocarcinoma, squamous cell carcinoma, and cystic metastases from sarcoma and colon adenocarcinoma (10).

It has been shown that perilesional consolidation is more common in tuberculous cavities than in malignant cavitory lesions (3). Consistent with the literature, perilesional consolidation was significantly more common in benign cavitory lesions in our study. We also observed perilesional tree-in-bud nodularity in 25.8% (8/31) of benign cavitory lesions, whereas no perilesional tree-in-bud nodularity was detected in malignant cavitory lesions. The tree-in-bud pattern is characterized by centrilobular micronodules connected to branching linear opacities that resemble a budding tree (11). This finding usually indicates infectious diseases, including bacterial, fungal, viral, or parasitic infections, as well as inflammatory processes such as aspiration and immunologic

or connective tissue disorders (12). Primary lung malignancies and metastases—especially those from renal cell carcinoma, breast, liver, stomach, prostate, and ovarian cancers—and Ewing's sarcoma may also present with a tree-in-bud pattern (13,14). However, the presence of a perilesional tree-in-bud pattern supports the diagnosis of a benign cavitory lung lesion (4).

In our study, no significant difference in air-fluid levels was observed between benign and malignant cavitory lesions. This finding is consistent with previous reports indicating that air-fluid levels are nonspecific features and may occur in both infectious cavitory processes and cavitating malignancies due to necrosis, hemorrhage, or secondary infection (2,15).

According to our results, multiple cavitory lesions involving the same lung or the contralateral lung were present in 8 of 31 benign cases (25.8%). No additional cavitory lesions were identified within these malignant cavitory lesions. Primary lung cancer usually presents as a solitary nodule or mass. Lung adenocarcinoma rarely presents as a multiple cavitory disease (16). Multiple metastatic cystic or cavitory lung lesions are reported in colorectal cancer, gallbladder cancer, breast cancer, bladder cancer, renal cell carcinoma, and lymphoma (17,18). However, multiple cavitory lesions are more commonly associated with infectious causes (e.g., abscesses, tuberculosis, fungal or parasitic infections, septic emboli), metastatic disease, or autoimmune conditions such as granulomatosis with polyangiitis, rheumatoid nodules, and vasculitis (1,2).

In our study, a positive correlation was found between SUV_{max} and both cavity size and wall thickness. This relationship reflects the biological aggressiveness of malignant lesions in which necrosis and tumor proliferation coexist. According to our data, cavitory lesions with maximum wall thickness > 15 mm showed markedly higher SUV_{max} than those of thinner-walled lesions. Even in cavitory lesions with a maximum wall thickness ≤ 15 mm, ^{18}F -FDG uptake was higher in malignant lesions than in benign ones. Additionally, SUV_{max} demonstrated good diagnostic performance in distinguishing malignant from benign lesions in our study. At a cut-off value of 8.58, it provided moderate sensitivity (80%) and specificity (77%). Logistic regression analysis showed that higher SUV_{max} values were associated with an increased likelihood of malignancy. This result aligns with the known biological behavior of malignant tumors, which exhibit increased glucose metabolism and ^{18}F -FDG uptake. However, it should be noted that benign infectious and inflammatory cavitory lesions such as tuberculosis or abscesses, can also demonstrate intense ^{18}F -FDG accumulation, potentially leading to false-positive results. Furthermore, thin-walled

cystic or cavitory malignant lesions may show low or absent ¹⁸F-FDG uptake. In particular, cystic or cavitory lung adenocarcinomas may show low to moderate ¹⁸F-FDG uptake (19). Therefore, SUV_{max} alone cannot be considered an absolute discriminator between benign and malignant cavitory lesions; it should be interpreted in conjunction with morphological characteristics and clinical findings.

Study Limitations

The main limitations were its retrospective design and the relatively small patient cohort from a single institution. Multicenter investigations with larger sample sizes are required to validate SUV_{max} and wall-thickness criteria for the differentiation of cavitory lung lesions.

Conclusion

We concluded that ¹⁸F-FDG PET/CT provides valuable complementary information to CT in distinguishing malignant from benign cavitory lung lesions. According to the findings of our study, advanced age and elevated SUV_{max} were significantly associated with a higher likelihood of malignancy, whereas consolidation surrounding the lesion was more frequently observed in benign lesions. Although lesion diameter and maximum wall thickness tended to be greater in malignant lesions, SUV_{max} showed the best performance among quantitative variables in distinguishing malignant from benign lesions. A comprehensive assessment including cavity morphology, wall thickness, lesion size, SUV_{max}, and associated parenchymal findings on ¹⁸F-FDG PET/CT can improve diagnostic accuracy and assist clinical decision-making in patients with cavitory pulmonary lesions.

Ethics

Ethics Committee Approval: Ethical approval for this retrospective study was obtained from the Local Ethics Committee of the University of Health Sciences Türkiye, Ankara Atatürk Sanatorium Training and Research Hospital, (approval no: 661, date: 06.02.2020).

Informed Consent: This is retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Ö.Ö., E.T., Concept: N.A.D., E.T., Design: Ö.Ö., E.T., Data Collection or Processing: Ü.N.D., N.A.D., Ö.Ö., E.T., Analysis or Interpretation: E.T., N.A.D., Ö.Ö., Literature Search: Ö.Ö., E.T., Writing: N.A.D., Ö.Ö., E.T.

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

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

References

- Hansell DM, Bankier AA, MacMahon H, McCloud TC, Müller NL, Remy J. Fleischner society: glossary of terms for thoracic imaging. *Radiology*. 2008;246:697-722.
- Parkar AP, Kandiah P. Differential diagnosis of cavitory lung lesions. *J Belg Soc Radiol*. 2016;100:100.
- Nin CS, de Souza VV, Alves GR, do Amaral RH, Irion KL, Marchiori E, Hochegger B. Solitary lung cavities: CT findings in malignant and non-malignant disease. *Clin Radiol*. 2016;71:1132-1136.
- Duong TB, Ceglar S, Reaume M, Lee C. Imaging approach to cavitory lung disease. *Ann Am Thorac Soc*. 2020;17:367-371.
- Woodring JH, Fried AM, Chuang VP. Solitary cavities of the lung: diagnostic implications of cavity wall thickness. *AJR Am J Roentgenol*. 1980;135:1269-1271.
- Pinar Deniz P, Duru Çetinkaya P, Hanta İ, Arslan MS, Güney İB. Comparison of ¹⁸F-FDG-PET/CT scans in patients diagnosed with sarcoidosis and tuberculosis. *Medicine (Baltimore)*. 2025;104:e41119.
- Chaudhuri MR. Primary pulmonary cavitating carcinomas. *Thorax*. 1973;28:354-366.
- Vourtsi A, Gouliamos A, Mouloupoulos L, Papacharalampous X, Chatjiioannou A, Kehagias D, Lamki N. CT appearance of solitary and multiple cystic and cavitory lung lesions. *Eur Radiol*. 2001;11:612-622.
- Raoof S, Bondalapati P, Vydyula R, Ryu JH, Gupta N, Raoof S, Galvin J, Rosen MJ, Lynch D, Travis W, Mehta S, Lazzaro R, Naidich D. Cystic lung diseases: algorithmic approach. *Chest*. 2016;150:945-965.
- Ryu JH, Swensen SJ. Cystic and cavitory lung diseases: focal and diffuse. *Mayo Clin Proc*. 2003;78:744-752.
- Bankier AA, MacMahon H, Colby T, Gevenois PA, Goo JM, Leung ANC, Lynch DA, Schaefer-Prokop CM, Tomiyama N, Travis WD, Verschakelen JA, White CS, Naidich DP. Fleischner society: glossary of terms for thoracic imaging. *Radiology*. 2024;310:e232558.
- Miller WT Jr, Panosian JS. Causes and imaging patterns of tree-in-bud opacities. *Chest*. 2013;144:1883-1892.
- Li Q, Fan X, Huang XT, Luo TY, Chu ZG, Chen L, Zhang ZW, Li YQ, Wu JQ, Ouyang Y, Lv FJ, Ma CH. Tree-in-bud pattern in central lung cancer: CT findings and pathologic correlation. *Lung Cancer*. 2015;88:260-266.
- Bhalla N, Chang CF, Lee C. Special considerations for tree-in-bud nodules. *Ann Am Thorac Soc*. 2019;16:636-638.
- Nunes AG, Rodrigues MC, Carneiro C, Costa AC. Pulmonary cavitory lesions: a captivating visual review. *J Thorac Dis*. 2025;17:6296-6308.
- Carreto L, Alves C, Eurico J, Cavinho P. Lung adenocarcinoma presenting as a multiple cavitory disease. *Arch Bronconeumol (Engl Ed)*. 2019;55:495-496.
- Saito T, Kobayashi S, Okutomo K, Miura T, Ohori H, Yanai M. Multiple cavitory lung lesions from colorectal cancer responding to chemotherapy. *Respir Med Case Rep*. 2023;44:101865.
- Van Schoor J, Joos G, Pauwels R. Non-Hodgkin's lymphoma presenting as multiple cavitating pulmonary nodules. *Eur Respir J*. 1993;6:1229-1231.
- Murota M, Norikane T, Yamamoto Y, Ishimura M, Mitamura K, Takami Y, Fujimoto K, Satoh K, Yokota N, Ishikawa R, Nishiyama Y. Cystic and cavitory lung cancer: its characteristic features on CT and FDG-PET scans. *I J Radiol*. 2023;20:e130478.