Diagnostic Yield of ^{18}F-FDG PET After Lung Transplantation: A Single-center, Retrospective Cohort Study

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Background. To investigate the diagnostic yield of ^{18}F-fluorodeoxyglucose positron emission tomography (^{18}F-FDG PET) in lung transplant recipients. **Methods.** A single-center, retrospective cohort study including 234 ^{18}F-FDG PET examinations in 199 lung transplant recipients. Indication for PET referral, ^{18}F-FDG PET diagnosis/findings and final clinical diagnosis were classified into 3 groups: malignancy, infection/inflammation not otherwise specified, and chronic lung allograft dysfunction with restrictive allograft syndrome phenotype. Sensitivity/specificity analysis was performed to determine accuracy of ^{18}F-FDG PET in each group. **Results.** Sensitivity of ^{18}F-FDG PET for malignancy was 91.4% (95% confidence interval, 82.5%-96.0%) and specificity was 82.3% (95% confidence interval, 74.5%-88.1%). Infection/inflammation not otherwise specified and restrictive allograft syndrome as indication for ^{18}F-FDG PET comprised relatively small groups (14 and 31 cases, respectively). In addition, ^{18}F-FDG PET revealed clinically relevant incidental findings in 15% of cases. **Conclusions.** Referral for ^{18}F-FDG PET after lung transplantation mainly occurred to confirm or rule out malignancy. In this specific setting, ^{18}F-FDG PET has a high diagnostic yield. Accuracy of 18F-FDG PET for other indications is less clear, given small sample sizes. Clinically relevant diagnoses, unrelated to the primary indication for ^{18}F-FDG PET, are found relatively often in this immunocompromised cohort.

(*Transplantation* 2021;105: 1603–1609).

INTRODUCTION

Patients who underwent lung transplantation (LTx) are at high risk for complications. Among these complications, "infection," "graft failure," and "malignancy" still remain an important source of morbidity and the leading cause of death.[1] The most common cancer types after LTx—excluding skin tumors—are lung cancer and posttransplant

Received 2 January 2020. Revision received 25 June 2020.

Accepted 21 July 2020.

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R.V. is a senior clinical research fellow of the Fund for Scientific Research Flanders. O.G. and C.M.D. are senior clinical investigators of the Fund for Scientific Research Flanders. G.M.V. is supported by the Broere Charitable Foundation.

The authors declare no conflicts of interest.

W.V.R. performed research/study, collected data, and wrote the article. O.G. collected data, critically revised the data and the study. C.M.D. collected data, critically revised the data and the study. S.E.V. collected data, critically revised the data and the study. B.M.V. collected data, critically revised the data and the study. L.J.C. collected data, critically revised the data and the study. D.E.V.R. collected data, critically revised the data and the study. A.P.N. collected data, critically revised the data and the study. G.M.V. collected data, critically revised the data and the study. R.V. designed research/study, collected data, wrote the article, critically revised the data and the study.

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions. All authors contributed in an important manner to the study design, data collection and analysis, or writing of the article according to the guidelines of the International Committee of Medical Journal Editors. All authors have read and approved the article, all authors take responsibility for the article, and the submitting author has permission from all authors to submit the article on their behalf.

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ISSN: 0041-1337/21/1057-1603

DOI: 10.1097/TP.0000000000003456

<zdoi;10.1097/TP.0000000000003456>

lymphoproliferative disorder (PTLD), both most often localized inside the thorax.[2]

^{18}F-fluorodeoxyglucose-positron emission tomography (^{18}F-FDG PET), often combined with simultaneous computed tomography (CT), is a noninvasive imaging tool increasingly used to diagnose and stage a variety of diseases. The ability of ^{18}F-FDG PET to identify inflammatory/infectious or oncological sites is mainly related to glycolytic activity of cells involved in these disorders. Ample evidence exists on the usefulness of ^{18}F-FDG PET in management of patients with lung cancer and infectious/inflammatory disorders in the general population.[3,4] In addition, there is accumulating evidence on the value of ^{18}F-FDG PET in patients with PTLD.[5]

The high level of immunosuppression after LTx and local factors after surgery, such as lymphatic remodeling and lack of bronchial artery re-anastomosis, however, may alter the LTx recipient's responses to infection or malignancy.[6] Theoretically, these changes could inversely affect local glucose metabolism, hence PET imaging results after LTx. Earlier studies have investigated the diagnostic yield of ^{18}F-FDG PET for infectious or malignant complications in solid organ transplant recipients.[7,8] However, the number of LTx recipients in these studies was relatively small (n ≤ 31% and ≤25%) and to our knowledge no large cohort study has been undertaken to determine the accuracy and clinical performance of ^{18}F-FDG PET in LTx recipients.

Therefore, we conducted a large, retrospective study in our LTx cohort with the aim to determine the diagnostic yield of ^{18}F-FDG PET for infectious/inflammatory or malignant complications in this specific population.

MATERIALS AND METHODS

Study Design and Patient Selection

We conducted a single-center, retrospective cohort study including all LTx recipients who underwent ^{18}F-FDG PET from January 2008 until December 2015, during which period instrumentation and software for ^{18}F-FDG PET remained unchanged. Repeat ^{18}F-FDG PET in the same patient within 6 months of the previous ^{18}F-FDG PET performed for the same indication ("follow-up"), for example as a follow-up for PTLD, were excluded for analysis. Each new ^{18}F-FDG PET for a new clinical indication in the same patient was considered a new event for sensitivity/specificity analysis.

All LTx recipients had life-long, 3–4 monthly post-transplant follow-up at our institution. The local Ethics Committee approved the study and all patients had provided written informed consent at time of listing for LTx to access their clinical and biobanked data for research purposes (S51577). Demographic data, including ^{18}F-FDG PET results, clinical diagnosis, lung allograft function status, and pathology reports were obtained from the patients' electronic medical records.

Positron Emission Tomography

^{18}F-FDG PET scans were performed on a PET standalone ECAT HR+ (Siemens, Knoxville, TN) or a PET/CT Biograph 40 TruePoint or Biograph 16 HiRez (both Siemens). Patients fasted for at least 6 hours, had glucose levels below 180 mg/dL at time of intravenous ^{18}F-FDG administration, and were given a nonselective beta-blocker (Propranolol 20 mg) as per protocol. Acquisition was performed 60 minutes after ^{18}F-FDG administration. Whenever possible/available, whole-body CT scan (from skull to mid-thigh, either low-dose nondiagnostic or intravenously and orally contrast-enhanced diagnostic) was performed just before ^{18}F-FDG PET acquisition. PET emission images were corrected for scatter and attenuation based on concurrent CT information, if available. Scans were analyzed using a commercial software platform (Hybrid Viewer; Hermes Medical Solutions, Stockholm, Sweden), final assessment and protocol finalization was performed by a skilled nuclear medicine physician (O.G. and C.M.D.).

^{18}F-FDG PET Interpretation and Reference Standard

All ^{18}F-FDG PET examinations were evaluated and rendered into a written report by experienced nuclear medicine physicians as part of routine clinical care. The clinical diagnosis made by the treating LTx physicians' team that was retained as the final diagnosis 6 months after ^{18}F-FDG PET was used as reference standard. The clinical diagnosis was based on all available information, including clinical examination, laboratory results, histology, microbiology, imaging including ^{18}F-FDG PET, and treatment outcome during follow-up during this 6-month period.

To allow for sensitivity/specificity analysis, primary indication for ^{18}F-FDG PET referral, PET-based diagnosis and final clinical diagnosis were coded 2 dimensionally (0 = false, 1 = true) according to 3 categories: malignancy (including PTLD and all types of solid tumors), infection and/or inflammation not otherwise specified (NOS), and chronic lung allograft dysfunction (CLAD) with restrictive allograft syndrome (RAS) phenotype. Inflammation NOS was defined as an inflammatory response on ^{18}F-FDG PET which could not be categorized into the other predefined groups (malignancy, infection, and RAS) and could either include a more specific diagnosis (eg, cryptogenic organizing pneumonia) or not. All data were collected by a trained general pulmonologist (W.V.R.) and reviewed by a LTx pulmonologist (R.V.). An incidental finding (eg, focal colonic uptake suspicious for a colon polyp) on ^{18}F-FDG PET was not used in the primary sensitivity/specificity analysis, but used in a secondary analysis of incidental findings.

Statistical Analysis

All analyses were performed using Graphpad Prism 8.0.2 (San Diego, CA). Results are expressed as absolute values (percentage of total), mean (±SD) or median (interquartile range) wherever appropriate. Fisher's Exact or Chi Square test was used to compare proportions and to calculate sensitivity/specificity. All values of P are twotailed and $P < 0.05$ was considered statistically significant.

RESULTS

^{18}F-FDG PET Cohort

During the study period (2008–2015), a total of 329 ^{18}F-FDG PET examinations were performed in 195 LTx recipients, of which 234 ^{18}F-FDG PET were included in the current analysis, after exclusion of 95 (28.8%) repeat ^{18}F-FDG PET (<6 month interval in same patient; Figure 1).

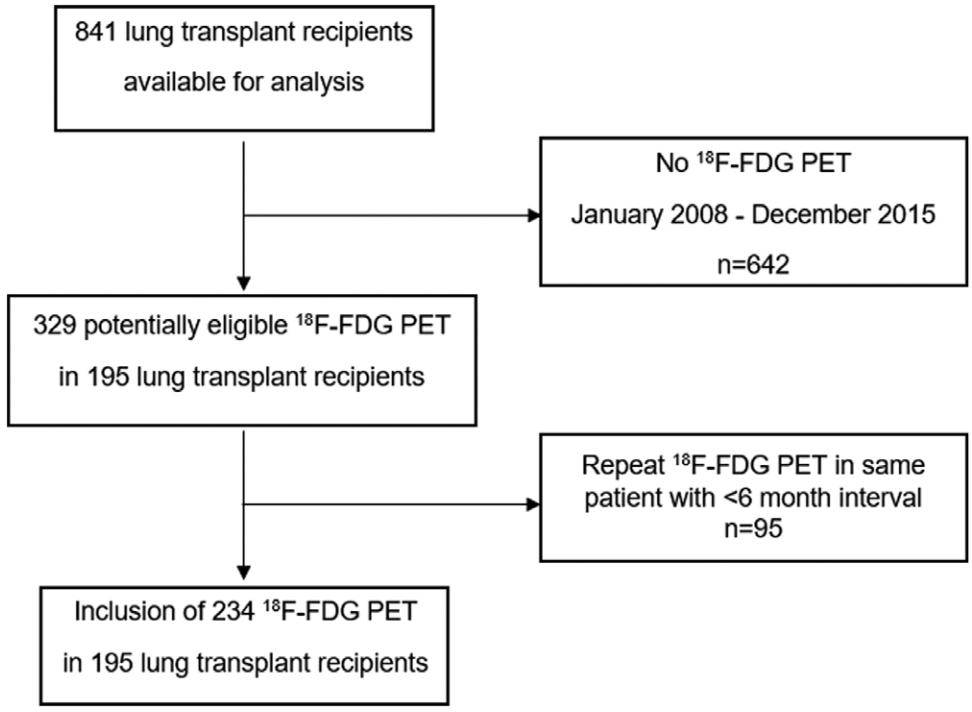

FIGURE 1. Flow chart of lung transplant recipient and ^{18}F-FDG PET inclusion. ^{18}F-FDG PET, ^{18}F-fluorodeoxyglucose positron emission tomography.

Patient characteristics of the 234 individual ^{18}F-FDG PET are summarized in Table 1. Of the 195 included patients, 31 patients (15.6%) had >1 ^{18}F-FDG PET performed, 23 patients (11.8%) had 2, and 8 patients (4.1%) had 3 ^{18}F-FDG PET examinations, respectively. The majority of ^{18}F-FDG PET examinations (178/234 or 76.1%) were performed with simultaneous CT scan, allowing for subsequent attenuation correction and morphologic information. A total of 66 of 234 (28%) ^{18}F-FDG PET examinations were performed in diabetic patients, but per our institution's PET-protocol all patients had glucose levels below 180 mg/dL at time of intravenous ^{18}F-FDG administration.

Bilateral LTx procedure (74.4%), followed by single-sided LTx (21.8%), heart-lung transplantation (2.6%), and combined lung-liver transplantation (1.3%) were included. Median age at time of transplantation was 56 (43–61) years; males (50.9%) and females (49.1%) were equally included. The most frequent indication for transplantation was emphysema (52.6%), followed by pulmonary fibrosis (23.9%), cystic fibrosis or noncystic fibrosis bronchiectasis (16.2%), pulmonary hypertension (5.1%), or other diseases (2.1%), including obliterative bronchiolitis, lymphangioleiomyomatosis, and epithelioid hemangioendothelioma.

Median time interval between ^{18}F-FDG PET and transplantation was 4.2 (1.6–7.9) years. Median follow-up time after transplantation at time of analysis was 8.3 (5.4–11.6) years. At time of analysis, 99 patients (50.7%) had died, which matches to deaths after 124 of 234 (52.9%) ^{18}F-FDG PET examinations. CLAD diagnosis was made during follow-up in 111 of 195 included patients (56.9%), with bronchiolitis obliterans syndrome (BOS) in 78 patients (70.3% of CLAD or 40.0% of all patients) and RAS in 33 patients (29.7% of CLAD or 16.9% of all patients), which equals CLAD diagnosis in 137 (BOS 96 and RAS 41) of 234 ^{18}F-FDG PET examinations (58.5%). CLAD diagnosis was made on average 8.7 months before time of ^{18}F-FDG PET examination.

The most important clinical indication for ^{18}F-FDG PET referral was malignancy (n = 189, 80.8%), including (1) new lesions on chest X-ray film or CT imaging during routine follow-up (n = 71, 38%: parenchymal lesion(s) n = 60, pleural lesion(s) n = 7, and adenopathy n = 4), (2) staging of documented malignancy (n = 67, 35%: gastro-intestinal n = 22, pulmonary n = 15 [including n = 1 in donor lung], neurologic n = 9, ear-nose-throat n = 6, hematologic n = 5, urologic n = 5, skin n = 4, gynecologic n = 1), (3) unexplained weight loss (n = 50, 26%), and screening before retransplantation (n = 1, 0.5%). ^{18}F-FDG PET was less frequently performed for infection/inflammation NOS (n = 14, 6.0%: recurrent infections n = 5, persistent inflammation n = 5, and unexplained pain n = 1) and CLAD RAS (n = 31, 13.2%). In CLAD RAS, PET was performed for study purposes. Figure 2 shows representative images in these different pathologies, with either comparable or dissimilar regional ^{18}F-FDG PET appearance.

^{18}F-FDG PET Diagnostic Performance

Results of sensitivity/specificity analysis are summarized in Table 2. Sensitivity for malignancy was 91.4% (95% confidence interval, 82.5%-96.0%) and specificity was 82.3% (74.5%-88.1%). Positive predictive value (PPV) for malignancy was 75.3% (65.2%-83.2%) and negative predictive value (NPV) 94.2% (88.0%-97.3%). Accuracy was 85.7%.

Sensitivity, specificity, PPV, NPV, and accuracy for infection/inflammation NOS were, respectively, 83.3% (55.2%-97.0%), 100% (17.8%-100%), 100% (72.3%-100%), 50% (8.9%-91.1%), and 85.7%; whereas for

TABLE 1.

Characteristics of 234 ^{18}F-FDG PET in 195 lung transplant recipients

	^{18}F-FDG PET (n = 234)	
Type of ^{18}F-FDG PET, n (%)		
with CT	178	(76.1%)
without CT	56	(23.9%)
Type of lung transplantation, n (%)		
Bilateral lung	174	(74.4%)
Single lung	51	(21.8%)
Heart-lung	6	(2.6%)
Combined lung-liver	3	(1.3%)
Sex, n (%)		
Male	119	(50.9%)
Female	115	(49.1%)
Underlying disease, n (%)		
Emphysema (including alfa 1antitrypsin deficiency)	123	(52.6%)
Pulmonary fibrosis	56	(23.9%)
CF and nonCF bronchiectasis	38	(16.2%)
Pulmonary hypertension (primary or Eisenmenger)	12	(5.1%)
Other (including OB, LAM, and EHE)	5	(2.1%)
Age at transplantation, y	56	(43–61)
CLAD at time of analysis, n (%)	137	(58.5%)
Bronchiolitis obliterans syndrome	96	(41.0%)
Restrictive allograft syndrome	41	(17.5%)
Time interval between CLAD diagnosis and PET, d	-267	(–1087 to 382)
Time interval between transplantation and PET, y	4.2	(1.6–7.7)
Time of follow up at time of analysis, y	8.3	(5.4–11.6)

CF, cystic fibrosis; CLAD, chronic lung allograft dysfunction; CT, computed tomography; EHE, epithelioid hemangioendothelioma; ^{18}F-FDG PET, ^{18}F-fluorodeoxyglucose positron emission tomography; LAM, lymphangioleiomyomatosis; OB, obliterative bronchiolitis.

CLAD RAS this was, respectively, 78.6% (60.5%-89.8%), 33.3% (17.1%-88.2%), 91.7% (74.2%-98.5%), 14.3% (0.7%-51.3%), and 74.2%.

In infection/inflammation NOS, ^{18}F-FDG PET findings can be summarized as follows: negative/noncontributing (n = 4), confirmation of known (and treated) pulmonary aspergillosis (n = 3), new findings (n = 7) including focal pneumonitis (culture negative, not treated; n = 3), aspergillus pleuritis (treatment started; n = 1), focal colitis (culture negative, not treated; n = 2), and granulomatous hepatitis *e causa ignota* (culture negative, not treated; n = 1).

Importantly, ^{18}F-FDG PET overall revealed clinically relevant incidental findings unrelated to the primary clinical indication for ^{18}F-FDG PET referral in 35 of 234 cases (14.9%). These incidental diagnoses consisted of a broad range of diseases, summarized in Table 3, of which malignancy and infection accounted for more than half of the findings.

DISCUSSION

As expected, the most important clinical indication for referral for ^{18}F-FDG PET after LTx was malignancy, consisting of >80% of all examinations in our study. The diagnostic yield of ^{18}F-FDG PET for malignancy, with a sensitivity of 91.4% and specificity of 82.4%, can be considered to be very good in this specific patient population. These results are comparable to earlier studies investigating ^{18}F-FDG PET in SOT recipients and only slightly lower compared to lung cancer staging in a more general patient cohort (with sensitivity up to 93% and specificity 96%).[7-10] Due to its high sensitivity and NPV, ^{18}F-FDG PET can essentially be used as a "rule-out" examination for malignancy in LTx recipients. However, when clinical suspicion remains very high in case of a (false) negative ^{18}F-FDG PET, other or more disease site-specific investigations should be pursued to come to a final diagnosis. In our patient cohort, for instance, of the 6 patients with a false negative ^{18}F-FDG PET 3 patients were diagnosed with PTLD (brain, colon, and epiglottis), 1 patient with nonsmall cell lung cancer, 1 patient with Ewing sarcoma (an entity which can have low ^{18}F-FDG avidity) and 1 patient with transitional cell carcinoma of the bladder (for which sensitivity is very low due to urinary ^{18}F-FDG excretion). The slightly lower PPV for malignancy (75%) is most likely caused by the relatively high prevalence of infective/inflammatory diseases that are found in this highly immunocompromised patient group.

In contrast to malignancy, infection/inflammation NOS was far less the referral indication for ^{18}F-FDG PET, resulting in low patient numbers for these conditions. Therefore, no firm conclusions can be made regarding the diagnostic accuracy of ^{18}F-FDG PET in these conditions. Nevertheless, given the high diagnostic yield of ^{18}F-FDG PET for malignancy in the current study and its usefulness for infectious/inflammatory diseases in the general population, it is reasonable to assume that ^{18}F-FDG PET has similar added value for diagnosing infectious/inflammatory disorders in this immunocompromised patient population, as demonstrated by the relatively high prevalence of inflammatory findings (pneumonitis, pleuritis, colitis, and hepatitis) in this subgroup of our study, but this warrants further investigation.[4] Interestingly, preclinical studies in an orthotopic LTx mouse model demonstrated increased glucose uptake in CD8$^+$ T-cells during acute lung graft rejection.[11] However, in a clinical study of LTx recipients, increased ^{18}F-FDG-uptake was only present in proven infection, but no abnormal uptake was observed in the absence of infection or sole presence of acute cellular rejection,[12] possibly suggesting that ^{18}F-FDG PET may discriminate between infection and acute cellular rejection after LTx. Yet, acute cellular rejection is characterized by high levels of activated T-lymphocytes, specifically binding interleukin (IL)-2 to high-affinity IL-2 receptors on the cell membrane. Therefore, nuclear imaging with ^{99m}Tc-HYNIC-IL-2 or ^{18}F-IL-2 may perhaps be more suited and specific to detect acute cellular rejection after LTx.[13]

Next to the retrospective design of the current study, our smaller sample size also prohibits to make firm conclusions regarding possible prospective utility of ^{18}F-FDG PET as diagnostic tool in CLAD RAS. In RAS patients, PET was performed for study purposes to assess discernment of RAS from BOS by specific imaging and to have an idea about the maximum standardized uptake value of the persistent parenchymal opacities. Indeed, we have previously demonstrated the value of ^{18}F-FDG PET to retrospectively distinguish CLAD phenotypes

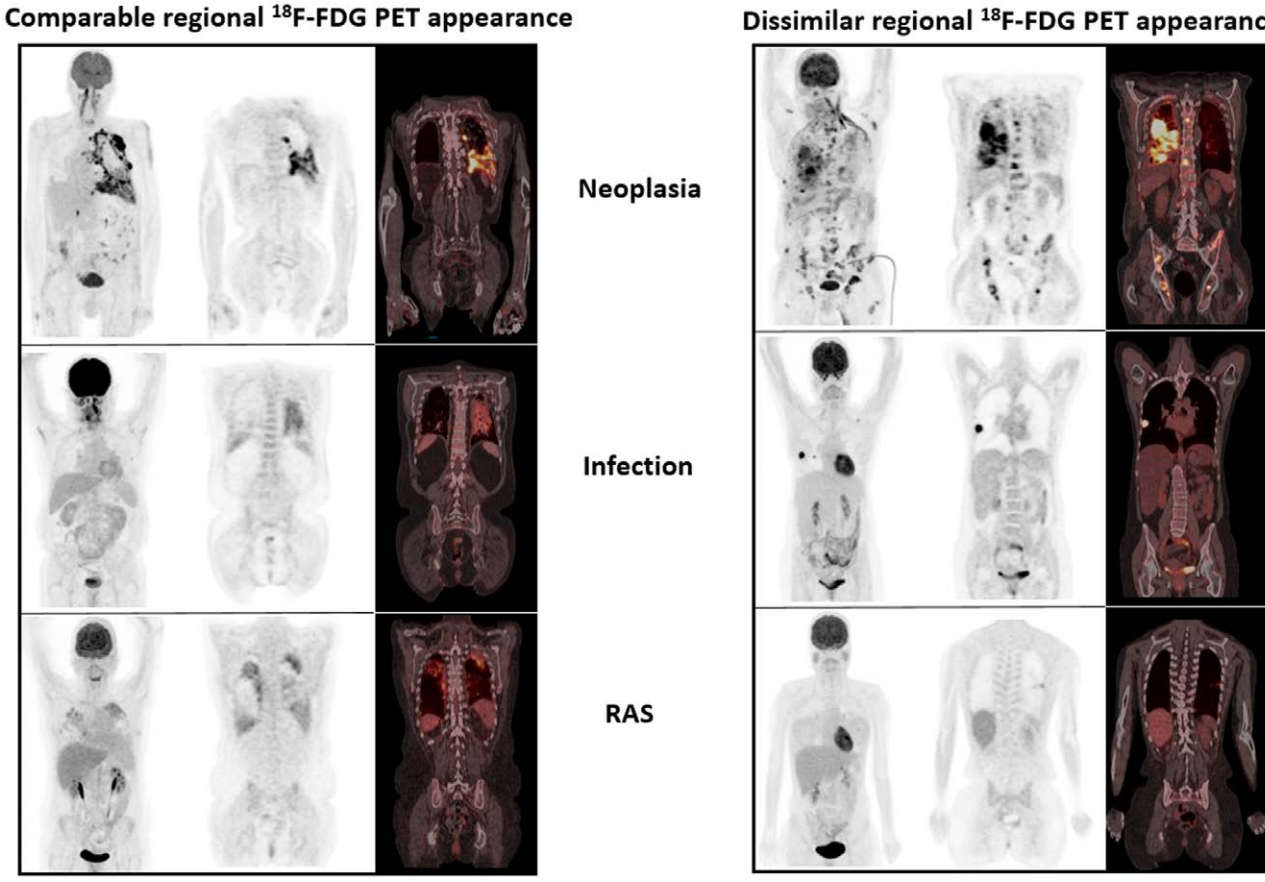

FIGURE 2. Comparison of ^{18}F-FDG PET for various indications after lung transplantation. Representative images of lung transplant recipients undergoing ^{18}F-FDG PET demonstrating comparable or dissimilar regional findings between the various indications/diagnosis (malignancy, infection, and RAS), all PET images were scaled to the same standardized uptake value (SUV 0–7). ^{18}F-FDG PET, ^{18}F-fluorodeoxyglucose positron emission tomography; RAS, restrictive allograft syndrome; SUV, standardized uptake value.

and stable LTx recipients using maximum standardized uptake value, which was mainly increased in intrapulmonary and subpleural fibrotic areas in RAS, allowing to discriminate RAS from BOS with 76% sensitivity and 87% specificity[14] and which may be of prognostic[14] and/or therapeutic[15] importance in RAS. In the current study, however, the broad confidence interval of both sensitivity and specificity indicates that ^{18}F-FDG PET alone is insufficient to discriminate RAS from malignancy or infection/inflammation, which reflects the importance of the clinical context in diagnosing each condition. Of particular note is the relatively high prevalence of incidental findings (up to 15%) on ^{18}F-FDG PET in this immunocompromised patient cohort. Therefore, as a general rule, appropriate attention for secondary findings on ^{18}F-FDG PET is advisable in this specific population.

Limitations of our study are inherent to its single-center, retrospective design, with rather limited patient numbers and a large study-period over several decades, during which different prophylactic and therapeutic strategies may have been applied. In addition, there has been a technical evolution in PET cameras and the introduction of hybrid PET-CT technology, which is known to enhance diagnostic accuracy compared to PET alone. Also, clinical differential diagnosis between different pathologies may sometimes be difficult, such as, for instance, respiratory infection, organizing pneumonia or malignancy, yet the currently used time interval of 6 months following ^{18}F-FDG PET and assessment of all medical tests and treatments during this time interval by experienced clinicians to obtain a final diagnosis for sensitivity/specificity-analyses, significantly decreases the chance of misclassification and possible bias. Moreover, no ^{18}F-FDG PET was performed during the first month after transplantation in our study, thus excluding nonspecific early postoperative inflammation or ischemia-reperfusion-injury/primary graft dysfunction as possible reasons for the observed increase in pulmonary ^{18}F-FDG uptake in our cohort.[16] Finally, specific assessment of PET-performance according to nodule size (><10 mm), number of pulmonary nodules, or composition (ground-glass, solid) in the 60 patients with documented parenchymal lesions on chest X-ray film or CT imaging during standard follow-up which instigated PET subsequent PET examination, was not possible as this was outside the initial scope of the article.

In conclusion, the current largest single-center study confirms the use of ^{18}F-FDG PET as an excellent diagnostic tool for malignancy in LTx recipients. Firm conclusions concerning other conditions could not be made from this study. However, based on previous data on ^{18}F-FDG PET in other cohorts, it is reasonable to assume that ^{18}F-FDG PET may also have added value for detecting infection, inflammation, and CLAD RAS. The high prevalence of incidental findings on ^{18}F-FDG PET warrants for extra attention when assessing ^{18}F-FDG PET in LTx recipients.

TABLE 2.

Diagnostic accuracy of ^{18}F-FDG PET after lung transplantation

Main sensitivity/specificity analysis				
	Malignancy	Infection/ inflammation NOS	RAS	
Indication for PET (n)	189	14	31	
Positive PET	85	10	24	
Positive PET + Clin	64	10	22	
Positive PET – Clin	21	0	2	
Negative PET	104	4	7	
Negative PET + Clin	6	2	6	
Negative PET – Clin	98	2	1	
PET other indication	45	220	203	
Positive PET	1	73	3	
Positive PET + Clin	0	53	3	
Positive PET – Clin	1	20	0	
Negative PET	44	147	200	
Negative PET + Clin	0	15	1	
Negative PET – Clin	44	132	199	
Total	234	234	234	
Malignancy				
Malignancy, n	**Clin positive**	**Clin negative**		
PET positive	64	21	TP + FP	85
PET negative	6	98	FN + TN	104
	TP + FN	FP + TN		
	70	119		
Effect size	**Value**	**95% CI**		
Sensitivity	0.9143	0.8253-0.9601		
Specificity	0.8235	0.7452-0.8816		
PPV	0.7529	0.6517-0.8324		
NPV	0.9423	0.8798-0.9733		
Accuracy	0.8571			
Infection/inflammation NOS				
Infection/inflammation, n	**Clin positive**	**Clin negative**		
PET positive	10	0	TP + FP	10
PET negative	2	2	FN + TN	4
	TP + FN	FP + TN		
	12	2		
Effect size	**Value**	**95% CI**		
Sensitivity	0.8333	0.5520-0.9704		
Specificity	1	0.1777-1.000		
PPV	1	0.7225-1.000		
NPV	0.5	0.08884-0.9112		
Accuracy	0.8571			
CLAD RAS				
RAS, n	**Clin positive**	**Clin negative**		
PET positive	22	2	TP + FP	24
PET negative	6	1	FN + TN	7
	TP + FN	FP + TN		
	28	3		
Effect size	**Value**	**95% CI**		
Sensitivity	0.7857	0.6046-0.8979		
Specificity	0.3333	0.01710-0.8815		
PPV	0.9167	0.7415-0.9852		
NPV	0.1429	0.007328-0.5131		
Accuracy	0.7419			

CI, confidence interval; CLAD, chronic lung allograft dysfunction; Clin, clinical diagnosis; FN, false negative; FP, false positive; ^{18}F-FDG PET, ^{18}F-fluorodeoxyglucose positron emission tomography; NPV, negative predictive value (reference standard 6 mo after ^{18}F-FDG PET); PPV, positive predictive value; RAS, restrictive allograft syndrome phenotype; TN, true negative; TP, true positive.

TABLE 3.

Clinically relevant incidental findings on 234 ^{18}F-FDG PET in 195 lung transplant recipients

Incidental finding	Number	Subtype
Hyperplastic thyroid nodule	2	END
Multinodular goiter	1	END
Oesophagitis	1	GI
Small intestine invagination	1	GI
Colon polyp	4	GI
Cholecystitis	1	GI
Ovarian cyst	1	GYN
Sinusitis	1	RESP
Pneumonia	8	RESP
Bronchiolitis/BOOP	2	RESP
Pleuritis	2	RESP
CLAD RAS	1	RESP
Pulmonary embolism with infarction	1	RESP
Warthin's tumor	3	ONC
Lung cancer	1	ONC
Metastatic colon cancer	1	ONC
Periprosthetic inflammation	1	ORT
Bursitis trochanterica	1	ORT
Avascular necrosis	2	ORT
Total	35 (14.9%)	

Incidental findings on ^{18}F-FDG PET were detected unrelated to the primary clinical indication for ^{18}F-FDG PET referral and confirmed by concurrent CT scan or other diagnostic investigations during follow-up after ^{18}F-FDG PET.

BOOP, bronchiolitis obliterans organizing pneumonia; CLAD, chronic lung allograft dysfunction; CT, computed tomography; END, endocrine; ^{18}F-FDG PET, ^{18}F-fluorodeoxyglucose positron emission tomography; GI, gastro-intestinal; GYN, gynecologic; ONC, oncologic; ORT, orthopedic; RAS, restrictive allograft syndrome; RESP, respiratory.

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