Received:
20 August 2015

Revised:
5 October 2015

Accepted:
2 November 2015

doi: 10.1259/bjr.20150695

Cite this article as:

Lei W, Zeng H, Zeng D-X, Zhang B, Zhu Y-H, Jiang J-H, et al. ^{18}F -FDG PET-CT: a powerful tool for the diagnosis and treatment of relapsing polychondritis. *Br J Radiol* 2016; **89**: 20150695.

FULL PAPER

^{18}F -FDG PET-CT: a powerful tool for the diagnosis and treatment of relapsing polychondritis

¹WEI LEI, MD, PhD, ¹HUI ZENG, MD, ¹DA-XIONG ZENG, MD, PhD, ²BIN ZHANG, MD, PhD, ¹YE-HAN ZHU, MD, PhD, ¹JUN-HONG JIANG, MD and ¹JIAN-AN HUANG, MD, PhD

¹Department of Respiratory Medicine, The First Affiliated Hospital of Soochow University, Suzhou, Jiangsu, China

²Department of Nuclear Medicine, The First Affiliated Hospital of Soochow University, Suzhou, Jiangsu, China

Address correspondence to: Dr Jian-an Huang

E-mail: huangjianansdfyy@163.com

W Lei and H Zeng contributed equally to this work.

Objective: This study aimed to evaluate fluorine-18 fludeoxyglucose positron emission tomography-CT (^{18}F -FDG PET-CT) for the diagnosis, targeted biopsy and therapy of relapsing polychondritis (RP).

Methods: The literature pertaining to the use of ^{18}F -FDG PET-CT in patients with RP was retrieved from the Cochrane Library, PubMed, Excerpta Medica Database (EMBASE), China National Knowledge Infrastructure (CNKI) and Wanfang databases until July 2015. Clinical characteristics, auxiliary examination results, chest CT findings, tracheoscopy and biopsy findings, high metabolic activity lesions, maximum standardized uptake values, ^{18}F -FDG PET-CT-guided biopsy site, pathologic results of biopsy samples and alteration in high ^{18}F -FDG-uptake lesions after treatment were retrospectively analysed.

Results: 18 publications with 26 cases were enrolled. The five most common symptoms of patients with RP diagnosed with ^{18}F -FDG PET-CT were cough, fever, chest tightness, sore throat and arthralgia. Of the 26 patients, 23 patients had multiple and symmetric cartilage lesions with high metabolic activity, revealed by ^{18}F -FDG PET-CT.

The disease mainly affected organs such as the bronchus, trachea, throat, costicartilage and auricle. The maximum standardized uptake values ranged from 1.93 to 13.03 (mean, 4.94). ^{18}F -FDG PET-CT revealed that patients with RP with tracheal and bronchial involvement had a close correlation with cough ($\chi^2 = 6.80$, $p = 0.006$). ^{18}F -FDG PET-CT showed a significantly higher positive biopsy rate compared with bronchoscopy ($\chi^2 = 12.91$, $p < 0.001$) for targeted lesions with high metabolic activity. Post-treatment re-examinations with ^{18}F -FDG PET-CT showed obvious subsidence or complete disappearance of high ^{18}F -FDG-uptake lesions in 13 cases, showing highly consistent symptom improvements.

Conclusion: ^{18}F -FDG PET-CT is likely to become a valuable imaging tool in the diagnosis and treatment of RP.

Advances in knowledge: The presence of symmetrically distributed high FDG-uptake lesions may be a criterion for the diagnosis of RP. ^{18}F -FDG PET-CT is useful for targeting biopsy sites, which remarkably increase the positive biopsy rate. Therefore, ^{18}F -FDG PET-CT may be of great value in the diagnosis and treatment of RP.

INTRODUCTION

Relapsing polychondritis (RP) is a multisystem inflammatory disease characterized by recurrent episodes of inflammation in the cartilage and connective tissues at multiple sites of the body. Its aetiology remains unknown; however, the disease is often associated with autoimmune disorders.^{1,2} Although RP is a rare disorder, it has various types of clinical manifestations, which involve multiple systems. In addition, there are no specific detection methods available, resulting in difficult early diagnosis of RP. With unavailable early diagnosis, timely and effective therapy is not possible, thereby leading to the development

of severe complications in late stages such as respiratory failure and subsequent death.³

Fluorine-18 fludeoxyglucose positron emission tomography-CT (^{18}F -FDG PET-CT) has been widely used in the diagnosis and therapeutic evaluation of tumours, nervous system diseases and cardiovascular disorders.⁴⁻⁶ Recently, case reports have described the use of ^{18}F -FDG PET-CT for the diagnosis and treatment of RP, making it a vital tool in RP management.⁷ This study was, therefore, designed to retrospectively analyse the literature pertaining to the use of ^{18}F -FDG PET-CT in the diagnosis and treatment of RP.

Table 1. Clinical data of patients with relapsing polychondritis

Patient's number (N)	Study	Age/sex	Symptoms ^a	ESR (mm h ⁻¹)	CRP (mg l ⁻¹)	Other examinations of the blood	Chest CT
N1	Nishiyama et al; ⁸ Japan	47/M	1, 2, 3, 4	NR	14.13	Negative	Thickening of the tracheal and bronchial walls
N2	De Geeter and Vandecasteele; ⁹ Belgium	67/M	1, 2, 3, 5	130	20	WBC, LDH and ANCA, increased; ANA, negative	NR
N3	Yokoyama et al; ¹⁰ Japan	60/M	1, 2, 3, 6	NR	11.59	WBC, IL-2 receptor and anti-CII Ab, increased; tumour marker, ANCA, negative	Thickening of the tracheal and bronchial walls
N4	Sato et al; ¹¹ Japan	59/F	1, 2, 4, 5, 7, 8	77	5.16	ANCA and other laboratory examinations of the blood, negative	Thickening of the tracheal and bronchial walls and narrowing of airway, with swelling of multiple lymph nodes
N5	Cassone et al; ¹² Italy	77/M	3, 5, 8, 9, 10, 11, 12	120	9.77	NR	Inflammatory tissue filling the tympanic cavity and left mastoid
N6	Czepczyński et al; ¹³ Poland	57/M	1, 6	118	180	Negative	Thickening of the tracheal walls
N7	Blanc-Caille et al; ¹⁴ France	55/F	1, 3	NR	200	Negative	Thickening of the tracheal and bronchial walls and narrowing of airway
N8	Honne et al; ¹⁶ Japan	50/F	2, 3, 5, 7	NR	4.29	ANA, RF and ANCA, negative; anti-CII Ab, positive	Thickening of the tracheal walls and narrowing of bronchus
N9	Yamashita et al; ¹⁸ Japan	79/F	3, 4, 8, 10, 11, 12, 13	20	4	NR	Thickening of the tracheobronchial wall
N10	Yamashita et al; ¹⁸ Japan	61/M	1, 4, 6, 10, 11, 14	93	28.2	NR	Swelling of the cervical lymph node
N11	Yamashita et al; ¹⁸ Japan	74/F	7, 8, 12	122	114	anti-CII Ab, positive	Sinusitis
N12	Yamashita et al; ¹⁸ Japan	66/M	1, 2, 3, 6	NR	91.1	NR	Thickening of the tracheobronchial wall and swelling of the mediastinal lymph node
N13	Yamashita et al; ¹⁸ Japan	44/F	2, 3, 5	NR	5	NR	Thickening of the tracheobronchial wall
N14	Deng et al ¹⁵ and Wang et al; ¹⁹ China	37/M	1, 2, 7	100	220	Negative	Thickening and narrowing of the trachea and main bronchus

(Continued)

Table 1. (Continued)

Patient's number (N)	Study	Age/sex	Symptoms ^a	ESR (mm h ⁻¹)	CRP (mg l ⁻¹)	Other examinations of the blood	Chest CT
N15	Wang et al; ¹⁹ China	38/M	2, 15	115	106.9	Negative	Thickening and narrowing of trachea and main bronchus
N16	Wang et al; ¹⁹ China	55/M	1, 2	10	0.3	Negative	Calcification of the trachea
N17	Wang et al; ¹⁹ China	66/F	2, 3	105	53.6	Negative	Normal
N18	Wang et al; ¹⁹ China	41/M	2, 3	120	264.1	Negative	Thickening and narrowing of the trachea and main bronchus
N19	Wang et al; ¹⁹ China	55/M	2	112	234.1	Negative	Thickening and narrowing of the trachea and main bronchus
N20	Mahida, et al; ²⁰ UK	39/M	2, 3, 5, 6	114	121	Plt, increased; other laboratory examinations of the blood, negative	Thickening of the tracheal wall and swelling of mediastinal lymph node
N21	Sugrue et al; ²¹ UK	51/M	7, 11	25	28	NR	Normal
N22	Bayer et al; ²² France	37/F	1, 2, 3, 7, 12, 16, 17	NR	247	NR	Normal
N23	Chen et al ¹⁷ and Lei et al; ²³ China	42/M	1, 2, 8	124	14.89	Plt and Fer, increased; other laboratory examinations of the blood, negative	Normal
N24	Lei et al; ²³ China	51/M	1, 2	57	15.06	WBC, Plt and Fer, increased; other laboratory examinations of the blood, negative	Increased lung markings and enlarged mediastinal lymph nodes
N25	Ikeda et al; ²⁴ Japan	40/F	1, 2, 8, 11, 12, 15,	Increase	Increase	anti-CII Ab, increased; ANCA, negative	Stenosis in the trachea and bilateral bronchus
N26	Hagiya et al; ²⁵ Japan	68/M	2	NR	NR	anti-CII Ab, increased	Thickening of the tracheal wall

^a1, fever; 2, cough; 3, chest tightness; 4, hoarseness; 5, sore throat; 6, weight loss; 7, arthralgia; 8, hearing loss; 9, headache; 10, conjunctivitis; 11, swelling and redness of the auricle; 12, swelling and redness of the nasal bridge; 13, dizziness; 14, shoulder pain; 15, chest pain; 16, alopecia; 17, dermatitis. ANA, antinuclear antibody; ANCA, anti-neutrophil cytoplasmic antibody; anti-CII Ab, antitype II collagen antibody; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; F, female; Fer, ferritin; IL-2, interleukin 2; LDH, lactic dehydrogenase; M, male; N, patient's number; NR, no record; Plt, platelet; RF, rheumatoid factor; WBC, white blood cell.

METHODS AND MATERIALS

Literature search and data collection

Publications regarding the use of ¹⁸F-FDG PET-CT in patients with RP were retrieved from the Cochrane Library, PubMed, Excerpta Medica Database (EMBASE), China National Knowledge Infrastructure (CNKI) and Wanfang databases, until July 2015, using the terms “relapsing polychondritis”, “RP”, “positron emission tomography-computed tomography”, “PET-CT” and “PET/CT”.

Duplicated references were excluded. Patients' age, gender, nationality, clinical characteristics, auxiliary examination results, bronchoscopic signs of airway, chest CT findings, ¹⁸F-FDG PET-CT-guided biopsy, lesions with high metabolic activity on ¹⁸F-FDG PET-CT images prior to treatment and their maximum standardized uptake values (SUV_{max}), alterations in high metabolic activity lesions on ¹⁸F-FDG PET-CT images post treatment, treatment regimen and year of publication were extracted from

Table 2. The positron emission tomography-CT (PET-CT) imaging characteristics and PET-CT-guided biopsy of patients with relapsing polychondritis

Patient's number (N)	Uptake focuses of PET-CT (before treatment) ^a	SUV _{max}	Uptake focuses of PET-CT (after treatment)	Bronchoscopy and biopsy results	PET-CT-guided biopsy sites and results
N1	18, 19, 20, 21	6.25	No	Oedema in the main bronchus and hypertrophy of the carina; positive	Tracheal mucous membrane; positive
N2	18, 19, 22, 23	NR	9 months; mostly disappeared	NR	Costicartilage; positive
N3	18, 23	NR	After therapy; eliminated	NR	Auricular cartilage; positive
N4	18, 19, 22, 23, 24	6.41	6 months; disappeared	NR	Undone
N5	24, 25, 26	NR	13 months; disappeared	NR	Undone
N6	20, 22, 23, 27, 28	4.5	No	NR	Undone
N7	18, 19, 23	4.5	1 and 8 months; disappeared in both follow-up scans	Oedema in the main bronchus; negative	Undone
N8	18, 19	NR	No	NR	Undone
N9	22, 23, 26, 30	3.38	No	NR	Undone
N10	21, 24, 26, 31	6.44	No	NR	Undone
N11	19, 20, 21, 23, 27, 32	13.03	1.5 months; disappeared	NR	Nasal cartilage; positive
N12	18, 19, 21, 23, 32	4.75	No	NR	Laryngeal cartilage; positive
N13	19	1.93	No	NR	Undone
N14	18, 19, 22, 23, 29	5.8	5 months; decreased	Oedema in the main bronchus and hypertrophy of the carina; negative	Costicartilage; positive
N15	18, 19, 22, 23, 29	4	3 months; decreased	Oedema in the main bronchus and hypertrophy of the carina; negative	Auricular cartilage; positive
N16	22, 23, 26, 29	4.8	2.5 and 9 months; decreased in both follow-up scans	Oedema in the main bronchus and hypertrophy of the carina; negative	Costicartilage; positive
N17	23	3.6	No	Oedema in the main bronchus and hypertrophy of the carina; negative	Auricular cartilage; positive
N18	18, 19, 22, 24, 26	5	3 months; decreased	Oedema in the main bronchus and hypertrophy of the carina; negative	Auricular cartilage; positive
N19	18, 19, 26	4.2	4 months; decreased	Oedema in the main bronchus and hypertrophy of the carina; negative	Auricular cartilage; positive
N20	18, 19, 23, 24	NR	No	Widespread inflammation of the bronchus and trachea with expiratory collapse; negative	Lymph node, trachea, tonsil; negative
N21	31	2.3	36 months, increased	NR	Auricular cartilage; (before PET-CT)
N22	18, 19, 22, 23	4.1	No	NR	Undone

(Continued)

Table 2. (Continued)

Patient's number (N)	Uptake focuses of PET-CT (before treatment) ^a	SUV _{max}	Uptake focuses of PET-CT (after treatment)	Bronchoscopy and biopsy results	PET-CT-guided biopsy sites and results
N23	18, 19, 22	3.73	No	Congestion and oedema in the main bronchus and trachea; (guided by PET-CT, positive)	Tracheal rings; positive
N24	18, 19, 22	5.04	No	Congestion and oedema in the main bronchus and trachea; (guided by PET-CT, positive)	Tracheal rings and lymph nodes; positive
N25	18, 19, 22	5.0	14 months; disappeared	Diffuse mucosal swelling and stenosis; (undone)	Auricular cartilage and costicartilage; positive
N26	18, 19	NR	6 months; disappeared	Stenosis; (undone)	Undone

^a18, trachea; 19, bronchus; 20, wrist joint; 21, shoulder joint; 22, costicartilage; 23, throat; 24, lymph nodes; 25, auditory canal; 25, auricle; 27, elbow joint; 28, sternum; 29, nose; 30, annular cartilage; 31, aorta; 32, sinus and paranasal sinus.

N, patient's number; NR, no record; SUV_{max}, maximum standardized uptake value.

each study for retrospective analysis. The present retrospective study was approved by the Ethics Committee of The First Affiliated Hospital of Soochow University, and the patient information was anonymized and de-identified prior to analysis.

Statistical analysis

All statistical analyses were performed using the SPSS® statistical software v. 18.0 (IBM Corp., New York, NY). Differences in proportions were assessed by χ^2 test. $p < 0.05$ was considered statistically significant.

RESULTS

Characteristics of the screened studies

A total of 18 eligible publications were retrieved,^{8–25} which involved 26 patients with RP. Four articles were published between 2007 and 2010, four articles in 2012, two articles in 2013, six articles in 2014 and two articles in 2015. Most cases reported were from Europe and Asia. The patients included 17 males and 9 females, with a male to female ratio of 17:9. Their average age was 54.5 years. The detailed clinical characteristics of these patients are summarized in Table 1.

Major clinical manifestations

The major clinical manifestations of patients with RP included cough, fever, chest tightness, sore throat, arthralgia, weight loss, hearing loss, hoarseness, conjunctivitis, swelling and redness of the auricle, swelling and redness of the nasal bridge, headache, dizziness, shoulder pain, chest pain, alopecia and dermatitis. The five most common clinical symptoms were cough (19/26), fever (14/26), chest tightness (12/26), sore throat (6/26) and arthralgia (6/26) (Table 1).

Major results of auxiliary examinations

The auxiliary examinations described in the 18 studies mainly included erythrocyte sedimentation rate detection, C-reactive protein level assessment, pulmonary function test and bronchoscopy. Elevated C-reactive protein levels were found in 76% (19/25) of patients, and increased erythrocyte sedimentation rate was detected in 94.4% (17/18) of patients. Chest CT scans

displayed thickening of the tracheal and/or bronchial wall in 64.0% (16/25) of subjects, while ventilation dysfunction was detected in 90.0% (9/10) of patients. In addition, five and two patients had elevated levels of antitype II collagen antibody and ferritin, respectively. However, no patient had systemic lupus erythematosus, antineutrophil cytoplasmic antibody, rheumatoid factor or a tumour marker (Table 1).

Major imaging characteristics of ¹⁸F-FDG PET-CT in patients with RP

Of the 26 patients with RP described in the screened studies, ¹⁸F-FDG PET-CT images displayed high FDG uptake in the following 15 sites: bronchus, trachea, throat, costicartilage, auricle, lymph nodes, shoulder joint, wrist joint, nasal cartilage, elbow joint, sinus and paranasal sinus, auditory canal, sternum, annular cartilage and aorta. The five most commonly affected sites were the bronchus (18/26), trachea (17/26), throat (14/26), costicartilage (12/26) and auricle (6/26). Among the 26 patients, 3 patients had only a single affected organ. For the remaining 23 (88.5%) patients, the cartilaginous tissue and joint in 2 or more sites were affected: 2 sites, 4 cases; 3 sites, 5 patients; 4 sites, 7 subjects; 5 sites, 6 cases; and 6 sites, 1 individual. The lesions with high metabolic activity appeared symmetrical on ¹⁸F-FDG PET-CT scans. In addition, SUV_{max} was estimated in 20 patients of the 26 patients, and a mean value of 4.94 (range, 1.93–13.03) was obtained (Table 2). The presence of symmetrically distributed high FDG-uptake lesions at 2 or more cartilages displayed by ¹⁸F-FDG PET-CT highly suggests the diagnosis of RP.

Correlation between lesions with high metabolic activity and clinical symptoms

We further analysed the frequent symptoms and lesions with high metabolic activity in patients with RP diagnosed with ¹⁸F-FDG PET-CT. Of the 19 patients with cough, 89.5% (17/19) patients had high FDG uptake at the bronchus and/or trachea, as revealed by ¹⁸F-FDG PET-CT. Conversely, among the 19 patients showing high FDG uptake at the bronchus and/or trachea on ¹⁸F-FDG PET-CT scans, 89.5% (17/19) patients

were coughing. These findings demonstrated a strong correlation between cough and high FDG-uptake lesions at the bronchus and/or trachea on ^{18}F -FDG PET-CT scans ($\chi^2 = 6.80$, $p = 0.006$) (Table 3).

^{18}F -FDG PET-CT facilitates targeted guiding to the biopsy site

Of the 26 patients with RP, 16 patients underwent biopsy; the sites mainly included the auricular cartilage, costicartilage, tracheal mucous membrane, nasal cartilage, laryngeal cartilage and tracheal rings. Among these 16 cases, 15 cases received targeted biopsy of the lesions with high metabolic activity according to the imaging findings of ^{18}F -FDG PET-CT scans. Interestingly, positive results were obtained in 14 of 15 individuals, with a success rate of 93.3%. In addition, no severe complications occurred as a result of ^{18}F -FDG PET-CT. The remaining nine patients underwent tracheoscopy-guided biopsy of the bronchial mucosa, and success was achieved only in one case, with a positive rate of 11.1%. These data indicated a significantly higher positive rate for ^{18}F -FDG PET-CT-targeted biopsy compared with tracheoscopy-guided biopsy ($\chi^2 = 12.91$, $p < 0.001$) (Table 4).

^{18}F -FDG PET-CT is useful in assessing the therapeutic efficacy in RP

Of the 26 patients with RP reported, 25 patients had described treatment protocols, and the major drugs were hormones and immunosuppressants. In addition, an airway stent and non-invasive positive pressure ventilation were employed in two cases with RP. Post-treatment re-examinations with ^{18}F -FDG PET-CT revealed a reduction in number or complete disappearance of the lesions with high metabolic activity in 13 of 14 patients compared with the situation before treatment; the SUV_{max} values of lesions with high metabolic activity all decreased remarkably or returned to normal, consistent with improved clinical symptoms and laboratory examination results. No SUV_{max} reduction was seen in one case, as revealed by post-treatment examination with ^{18}F -FDG PET-CT. However, the patient's symptoms and laboratory examination data returned to normal following treatment with an increased dose of the drug. The first re-examination with ^{18}F -FDG PET-CT was performed 1–36 months post treatment with a mean time to re-examination of 6.6 months. Three cases underwent two ^{18}F -FDG PET-CT re-examinations individually, and all showed improvements in the lesions with high metabolic activity following the integrated therapy (Table 2).

DISCUSSION

RP is a recurrent, degenerative, inflammatory disease of the cartilaginous tissue, which is characterized by the involvement of organs

such as the ears, nose, throat, trachea, eyes, joints and heart valves, and connective tissues like blood vessels. It is difficult to comprehensively assess the affected site and therapeutic efficacy in patients with RP using conventional approaches. ^{18}F -FDG PET-CT plays an important role in the diagnosis and assessment of therapeutic efficacy in tumours,⁴ and its potential diagnostic and therapeutic values have been reported for inflammatory disorders.^{26,27}

However, studies assessing ^{18}F -FDG PET-CT in the diagnosis and treatment of RP are scarce. The present study retrospectively analysed the publications describing the application of ^{18}F -FDG PET-CT in the diagnosis and therapy of patients with RP until July 2015. A total of 18 articles reporting 26 patients were screened.^{8–25} Most patients with RP (88.5%) had symmetric and multiple high FDG-uptake lesions at the cartilage and joint as shown via ^{18}F -FDG PET-CT scans. The most frequently affected sites included the bronchus (18/26), trachea (17/26), throat (14/26), costicartilage (12/26) and auricle (6/26). The mean SUV_{max} of the lesions with high metabolic activity was 4.94. Two or more symmetrically distributed cartilages or joints with high FDG-uptake lesions highly indicated the diagnosis of RP. Therefore, it is recommended to revise Damiani's diagnostic criteria²⁸ for RP. Based on our opinions, individuals who meet one of the following four criteria may be diagnosed with RP: (1) meeting three or more of the six current parameters: (a) relapsing chondritis of both ears, (b) non-invasive polychondritis, (c) chondritis of the nose, (d) inflammation of the eyes, (e) respiratory chondritis involving the throat and/or tracheal cartilage and (f) invasion of the cochlea and/or ear vestibules); (2) positive for at least one parameter, together with histological confirmation (cartilage biopsy); (3) development of chondritis at two or more anatomical sites, and effective treatment with glucocorticoid or dapsone; and (4) ^{18}F -FDG PET-CT scan displays symmetrically distributed high FDG-uptake lesions in two or more cartilages or joints. Such a revision should not only decrease the number of biopsies and biopsy-induced complications,^{29,30} but also help avoid the use of hormones and immunosuppressants for therapy and the development of treatment-associated adverse events to the utmost extent.^{31,32}

We analysed the correlation between the affected lesions displayed by ^{18}F -FDG PET-CT and patients' clinical symptoms. Of the patients with RP with cough, the bronchus and/or trachea were involved in 89.5% (17/19) patients as revealed by ^{18}F -FDG PET-CT scans, while 89.5% (17/19) of patients with RP with involvement of the bronchus and trachea on ^{18}F -FDG PET-CT images were coughing. These results demonstrated a close correlation between the bronchus and trachea involvement and cough in patients with RP. To the best of our knowledge, we did not find a case report on the increased SUV_{max} in the trachea and bronchia in the chronic cough disease,

Table 3. The correlation between PET-CT lesions and clinical symptoms

Cough	Uptake at bronchus and/or trachea		χ^2 value	p -value
	Yes	No		
Yes	17	2	6.80	0.006
No	2	5		

Table 4. PET-CT facilitates better targeted guidance to the biopsy compared with bronchoscopy

Biopsy	Positive	Negative	χ^2 value	p-value
PET-CT-guided biopsy	14	1	12.91	<0.001
Bronchoscopy biopsy	1	8		

such as chronic obstructive pulmonary disease, asthma, interstitial lung disease and tuberculosis. Our findings suggest that atypical patients with RP with cough, without involvement of the ears and/or nose, may be definitely diagnosed through biopsy of the airway and tracheal cartilages with transbronchial needle aspiration in the absence of ^{18}F -FDG PET-CT scan.²³

Of the 26 patients described in 18 studies, 14 patients received ^{18}F -FDG PET-CT scans before and after treatment. Following treatment, all clinical symptoms and some laboratory parameters improved remarkably or returned to normal, and post-treatment re-examinations with ^{18}F -FDG PET-CT revealed partial or complete disappearance of pre-treatment lesions with high metabolic activity, in agreement with improved clinical symptoms and laboratory examination data. This finding suggests that ^{18}F -FDG PET-CT may be used to evaluate the therapeutic efficacy in RP with relatively higher objectivity.

Among the 26 patients with RP, 16 patients received biopsy, including 15 patients who underwent targeted biopsy of the lesions with high metabolic activity according to the ^{18}F -FDG PET-CT data. Satisfactory biopsy specimens were obtained, with a positive rate of 93.3%, and no severe complications were observed. The remaining nine patients received tracheoscopy, and tracheal mucosa oedema was seen. Biopsy of bronchial mucosa was successful in one case, with a positive biopsy rate of 11.1%, indicating that targeted biopsy of the lesions with high metabolic activity according to ^{18}F -FDG PET-CT scan may remarkably improve the diagnosis of RP. The affected sites of patients with RP can be comprehensively assessed based on the lesions with high metabolic activity present at multiple sites displayed by ^{18}F -FDG PET-CT, which provides new insights into the diagnosis of RP. In addition, the best option for biopsy sites can be chosen according to the doctors' experience, technical conditions and patient's health status. This would not only achieve satisfactory pathologic results, but also avoid the development of severe complications to the greatest extent.

This study has some limitations. Few cases were included in this retrospective analysis, and each patient had incomplete medical records. Therefore, selection bias cannot be excluded. One study showed that PET-CT could reduce the treatment cost of patients with head and neck cancer without apparent clinical side effects.³³ It remains elusive whether PET-CT reduces the treatment cost of patients with RP. Further large-scale, prospective clinical trials are required to determine this surmise and to validate the findings presented here.

CONCLUSION

In summary, the presence of symmetrically distributed high FDG-uptake lesions, at two or more cartilages displayed by ^{18}F -FDG PET-CT, may be a criterion for the diagnosis of RP. ^{18}F -FDG PET-CT reveals that most patients with RP with cough have involvement of the airway, and there is a positive correlation between cough and airway involvement in patients with RP. In addition, ^{18}F -FDG PET-CT is useful for targeting biopsy sites, which remarkably improves the positive biopsy rate, providing a possibility for an appropriate choice of biopsy sites. The results of the present study demonstrate that ^{18}F -FDG PET-CT has the potential to become an imaging approach for objectively and comprehensively evaluating the therapeutic efficacy in RP. Therefore, ^{18}F -FDG PET-CT may be of great value in the diagnosis and therapeutic evaluation of RP.

ACKNOWLEDGMENTS

We thank Zhi-de Hu (Department of Laboratory Medicine, General Hospital of Jinan Military Command Region) for help with the statistical analysis and Hong-wei Yao (Department of Environmental Medicine, University of Rochester) for editing this article.

FUNDING

This work was supported by the youth science and technology project of Suzhou City (number: KJXW2012001), clinical key speciality project of China and National Natural Science Foundation of China (number: 81300026).

REFERENCES

- Sharma A, Gnanapandithan K, Sharma K, Sharma S. Relapsing polychondritis: a review. *Clin Rheumatol* 2013; **32**: 1575–83. doi: [10.1007/s10067-013-2328-x](https://doi.org/10.1007/s10067-013-2328-x)
- Chopra R, Chaudhary N, Kay J. Relapsing polychondritis. *Rheum Dis Clin North Am* 2013; **39**: 263–76. doi: [10.1016/j.rdc.2013.03.002](https://doi.org/10.1016/j.rdc.2013.03.002)
- Abbas O, Fares M, Jamaledine G, Arayssi T, Touma Z, Khalil PB. Endobronchial stenting for respiratory complications in relapsing polychondritis. *Clin Rheumatol* 2007; **26**: 271–3. doi: [10.1007/s10067-005-0137-6](https://doi.org/10.1007/s10067-005-0137-6)
- Shen G, Zhang W, Jia Z, Li J, Wang Q, Deng H. Meta-analysis of diagnostic value of ^{18}F -FDG PET or PET/CT for detecting lymph node and distant metastases in patients with nasopharyngeal carcinoma. *Br J Radiol* 2014; **87**: 20140296. doi: [10.1259/bjr.20140296](https://doi.org/10.1259/bjr.20140296)
- la Fougère C, Suchorska B, Bartenstein P, Kreth FW, Tonn JC. Molecular imaging of gliomas with PET: opportunities and limitations. *Neuro Oncol* 2011; **13**: 806–19. doi: [10.1093/neuonc/nor054](https://doi.org/10.1093/neuonc/nor054)
- Buscombe JR. Exploring the nature of atheroma and cardiovascular inflammation *in vivo* using positron emission tomography (PET). *Br J Radiol* 2015; **88**: 20140648. doi: [10.1259/bjr.20140648](https://doi.org/10.1259/bjr.20140648)

7. De Geeter F. Nuclear imaging in relapsing polychondritis. *J Clin Rheumatol* 2013; **19**: 55–6. doi: [10.1097/RHU.0b013e3182863651](https://doi.org/10.1097/RHU.0b013e3182863651)
8. Nishiyama Y, Yamamoto Y, Dobashi H, Kameda T, Satoh K, Ohkawa M. [18F] fluorodeoxyglucose positron emission tomography imaging in a case of relapsing polychondritis. *J Comput Assist Tomogr* 2007; **31**: 381–3. doi: [10.1097/01.rct.0000243459.46178.7d](https://doi.org/10.1097/01.rct.0000243459.46178.7d)
9. De Geeter F, Vandecasteele SJ. Fluorodeoxyglucose PET in relapsing polychondritis. *N Engl J Med* 2008; **358**: 536–7. doi: [10.1056/NEJMc072254](https://doi.org/10.1056/NEJMc072254)
10. Yokoyama T, Koyama N, Kodama K, Hagiwara K, Kanazawa M. ¹⁸F-fluorodeoxyglucose positron emission tomography for relapsing polychondritis as a diagnostic approach and evaluation of disease activity. *BMJ Case Rep* 2009; **2009**: bcr02.2009.1519. doi: [10.1136/bcr.02.2009.1591](https://doi.org/10.1136/bcr.02.2009.1591)
11. Sato M, Hiyama T, Abe T, Ito Y, Yamaguchi S, Uchiumi K, et al. F-18 FDG PET/CT in relapsing polychondritis. *Ann Nucl Med* 2010; **24**: 687–90. doi: [10.1007/s12149-010-0406-6](https://doi.org/10.1007/s12149-010-0406-6)
12. Cassone G, Lo Gullo A, Bajocchi G, Salvarani C. [18F]fluorodeoxyglucose positron emission tomography imaging in a case of relapsing polychondritis. *Rheumatology (Oxford)* 2012; **51**: 1813. doi: [10.1097/01.rct.0000243459.46178.7d](https://doi.org/10.1097/01.rct.0000243459.46178.7d)
13. Czepczyński R, Guzikowska-Ruszkowska I, Wyszomirska A. Relapsing polychondritis detected in PET/CT. *Eur J Nucl Med Mol Imaging* 2012; **39**: 1366–7. doi: [10.1007/s00259-012-2128-6](https://doi.org/10.1007/s00259-012-2128-6)
14. Blanc-Caille M, Beynat C, Blot M, Audia S, Genety C, Toubreau M, et al. Isolated tracheobronchial involvement by atrophic polychondritis: role of PET scanning. [In French.] *Rev Mal Respir* 2012; **29**: 903–7. doi: [10.1016/j.rmr.2012.05.004](https://doi.org/10.1016/j.rmr.2012.05.004)
15. Deng H, Chen P, Wang L, Li X, Yi J. Relapsing polychondritis on PET/CT. *Clin Nucl Med* 2012; **37**: 712–15. doi: [10.1097/RLU.0b013e31823eae56](https://doi.org/10.1097/RLU.0b013e31823eae56)
16. Honne K, Nagashima T, Onishi S, Nagatani K, Iwamoto M, Minota S. Fluorodeoxyglucose positron emission tomography/computed tomography for diagnostic imaging in relapsing polychondritis with atypical manifestations. *J Clin Rheumatol* 2013; **19**: 104–5. doi: [10.1097/RHU.0b013e31828635a9](https://doi.org/10.1097/RHU.0b013e31828635a9)
17. Chen T, Jiang JH, Ling CH, Ji C, Zhang B, Huang JA. Relapsing polychondritis diagnosed by transbronchial needle aspiration and (18)F-fluorodeoxyglucose positron emission tomography/computed tomography. *Chin Med J (Engl)* 2013; **126**: 3930. doi: [10.3760/cma.j.issn.0366-6999.20130807](https://doi.org/10.3760/cma.j.issn.0366-6999.20130807)
18. Yamashita H, Takahashi H, Kubota K, Ueda Y, Ozaki T, Yorifuji H, et al. Utility of fluorodeoxyglucose positron emission tomography/computed tomography for early diagnosis and evaluation of disease activity of relapsing polychondritis: a case series and literature review. *Rheumatology (Oxford)* 2014; **53**: 1482–90. doi: [10.1093/rheumatology/keu147](https://doi.org/10.1093/rheumatology/keu147)
19. Wang J, Li S, Zeng Y, Chen P, Zhang N, Zhong N. ¹⁸F-FDG PET/CT is a valuable tool for relapsing polychondritis diagnose and therapeutic response monitoring. *Ann Nucl Med* 2014; **28**: 276–84. doi: [10.1007/s12149-014-0805-1](https://doi.org/10.1007/s12149-014-0805-1)
20. Mahida RY, Bowman S, Naidu B, Thickett DR. Positron emission tomography aids diagnosis of relapsing polychondritis. *BMJ Case Rep* 2014; **2014**: bcr2013203367. doi: [10.1136/bcr-2013-203367](https://doi.org/10.1136/bcr-2013-203367)
21. Sugrue G, Durcan L, Bell L, Bolster F, Donnelly S, Kavanagh E. Unsuspected cardiovascular involvement in relapsing polychondritis: case of aortitis with critical coronary artery stenosis secondary to relapsing polychondritis. *Circ Cardiovasc Imaging* 2014; **7**: 409–11. doi: [10.1161/CIRCIMAGING.113.001290](https://doi.org/10.1161/CIRCIMAGING.113.001290)
22. Bayer G, Diot E, Erra B. Utility of 18F-FDG PET/CT in relapsing polychondritis. *QJM* 2015; **108**: 339–40. doi: [10.1093/qjmed/hcu187](https://doi.org/10.1093/qjmed/hcu187)
23. Lei W, Zeng DX, Chen T, Jiang JH, Wang CG, Zhu YH, et al. FDG PET-CT combined with TBNA for the diagnosis of atypical relapsing polychondritis: report of 2 cases and a literature review. *J Thorac Dis* 2014; **6**: 1285–92. doi: [10.3978/j.issn.2072-1439.2014.08.21](https://doi.org/10.3978/j.issn.2072-1439.2014.08.21)
24. Ikeda S, Arita M, Ikeo S, Nishiyama A, Ito A, Furuta K, et al. Chronological assessment of airway lesions in relapsing polychondritis by positron emission tomography. *Intern Med* 2015; **54**: 1099–102. doi: [10.2169/internalmedicine.54.3775](https://doi.org/10.2169/internalmedicine.54.3775)
25. Hagiya H, Waseda K, Otsuka F. Relapsing polychondritis followed up with FDG-PET. *Intern Med* 2015; **54**: 1675–6. doi: [10.2169/internalmedicine.54.3752](https://doi.org/10.2169/internalmedicine.54.3752)
26. Owada T, Maezawa R, Kurasawa K, Okada H, Arai S, Fukuda T. Detection of inflammatory lesions by F-18 fluorodeoxyglucose positron emission tomography in patients with polymyositis and dermatomyositis. *J Rheumatol* 2012; **39**: 1659–65. doi: [10.3899/jrheum.111597](https://doi.org/10.3899/jrheum.111597)
27. Glaudemans AW, de Vries EF, Galli F, Dierckx RA, Slart RH, Signore A. The use of (18)F-FDG-PET/CT for diagnosis and treatment monitoring of inflammatory and infectious diseases. *Clin Dev Immunol* 2013; **2013**: 623036. doi: [10.1155/2013/623036](https://doi.org/10.1155/2013/623036)
28. Damiani JM, Levine HL. Relapsing polychondritis—report of ten cases. *Laryngoscope* 1979; **89**: 929–46. doi: [10.1288/00005537-197906000-00009](https://doi.org/10.1288/00005537-197906000-00009)
29. Adams HJ, Kwee TC, de Keizer B, Fijnheer R, de Klerk JM, Littooi AS, et al. Systematic review and meta-analysis on the diagnostic performance of FDG-PET/CT in detecting bone marrow involvement in newly diagnosed Hodgkin lymphoma: is bone marrow biopsy still necessary? *Ann Oncol* 2014; **25**: 921–7. doi: [10.1093/annonc/mdt533](https://doi.org/10.1093/annonc/mdt533)
30. O'Connor Reina C, Garcia Iriarte MT, Barron Reyes FJ, Garcia Monge E, Luque Barona R, Gomez Angel D. When is a biopsy justified in a case of relapsing polychondritis? *J Laryngol Otol* 1999; **113**: 663–5. doi: [10.1017/S0022215100144780](https://doi.org/10.1017/S0022215100144780)
31. Dixon WG, Bansback N. Understanding the side effects of glucocorticoid therapy: shining a light on a drug everyone thinks they know. *Ann Rheum Dis* 2012; **71**: 1761–4. doi: [10.1136/annrheumdis-2012-202021](https://doi.org/10.1136/annrheumdis-2012-202021)
32. Ballonzoli L, Bourcier T. Ocular side effects of steroids and other immunosuppressive agents. [In French.] *Therapie* 2010; **65**: 115–20. doi: [10.2515/therapie/2010002](https://doi.org/10.2515/therapie/2010002)
33. Shah K, Te Marvelde L, Collins M, De Abreu Lourenco R, D'Costa I, Coleman A, et al. Safety and cost analysis of an (18)FDG-PET-CT response based follow-up strategy for head and neck cancers treated with primary radiation or chemoradiation. *Oral Oncol* 2015; **51**: 529–35. doi: [10.1016/j.oraloncology.2015.02.005](https://doi.org/10.1016/j.oraloncology.2015.02.005)