INTERNAL MEDICINE

□ ORIGINAL ARTICLE □

Comparison of Clinical and Radiological Features of *Pneumocystis* Pneumonia Between Malignancy Cases and Acquired Immunodeficiency Syndrome Cases: A Multicenter Study

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Abstract

Background The clinical features of pneumocystis pneumonia (PCP) differ according to the predisposing factors responsible for immunosuppression. Although PCP in patients with acquired immunodeficiency syndrome (AIDS) has been extensively described, its characteristics in non-AIDS patients, such as those with malignancies, are not thoroughly documented.

Study objective To characterize and compare the clinical and imaging features of PCP in patients with malignancies with those in AIDS patients.

Design A multi-center retrospective study.

Patients and Measurements We evaluated the clinical and radiological features of PCP in 21 patients with malignancies and in 17 with AIDS. Clinical presentation, serum markers, oxygenation, CT findings, and outcome were examined.

Results The patients with malignancies showed shorter durations of symptoms before PCP was diagnosed. The levels of serum markers and the oxygenation index did not differ. CT showed diffuse or widespread ground-glass opacity (GGO) in all of the patients evaluated. None of the AIDS patients demonstrated consolidation, whereas half of the patients with malignancy showed consolidation along with GGO. The extent of GGO scored on CT images was significantly greater in the AIDS patients. No correlation was observed between the CT findings and other clinical parameters. All of the AIDS patients recovered from PCP, whereas six patients with malignancies died within a month after the onset of PCP.

Conclusion The characteristics of the CT images differed between the patient groups with different underlying disorders, although it remains to be determined whether CT findings are associated with other clinical features or are predictive of the outcome of PCP.

Key words: pneumocystis pneumonia, computed tomography, ground-glass opacity, malignancy, acquired immunodeficiency syndrome

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Introduction

Pneumocystis pneumonia (PCP) remains one of the most frequent and serious opportunistic infections in immunocompromised patients, including those infected with the human immunodeficiency virus (HIV) (1). PCP can also occur in patients with malignant disease, especially when they have been under treatment with anti-neoplasmic agents, corticosteroid and other immunosuppressive agents.

The clinical characteristics of PCP are known to vary according to the underlying disorders responsible for immunosuppression (2). In particular, the differences in the clinical course of PCP between HIV-infected and HIV-negative patients have been described (2-4). At presentation, the latter reveal a shorter duration of symptoms and more severe oxygenation impairment compared with the former (2). The prognosis of PCP also differs between HIV-negative patients, only 40-70% of whom survive, and HIV-infected patients, who have survival rates as high as 90% (2). Among HIV-negative patients, the prognosis of those with cancer was reported to be the worst (3, 4). It was previously reported that PCP in HIV-infected patients is characterized by greater numbers of organisms and fewer inflammatory cells in the bronchoalveolar lavage fluid samples than in other immunocompromised patients (5). It was hypothesized that, in HIV-negative patients, even fewer organisms were able to induce severe lung inflammation, leading to respiratory impairment, and high rates of complications and death, although other factors may account for the difference (5).

The radiographic features of pneumocystis pneumonia are typically bilateral perihilar interstitial infiltrates that become increasingly diffuse and homogeneous as the disease progresses (6). High-resolution computed tomography (HRCT), which is more sensitive than chest radiography, usually reveals extensive ground-glass opacity (GGO) and sometimes cystic lesions (7). Few studies have investigated whether or not HRCT findings differ between HIV-infected and HIV-negative patients. We previously conducted a retrospective multicenter study and compared the clinical and radiological features of PCP in patients with rheumatoid arthritis (RA) and in those with acquired immunodeficiency syndrome (AIDS) (8). We found that, in patients with RA, PCP occurred without severe immunosuppression and showed more intense inflammation than in AIDS patients (8). In radiological analysis using HRCT, patients with RA did not reveal a single predominant pattern, whereas AIDS patients with PCP predominantly showed diffuse GGO without interlobular septal boundaries (8).

The primary goal of the present study was to evaluate the clinical and radiological characteristics of PCP in patients with malignancy in comparison with those in patients with AIDS. We retrospectively evaluated the clinical presentation, serum markers, oxygenation, radiological findings using HRCT, and outcome in patients with PCP.

Methods

The study protocol was approved by the ethical committees of all of the participating centers.

Patients

Twenty-one patients, in whom PCP appeared as a complication during treatment for malignancy, were identified from August 1998 to September 2008 at 7 participating centers in Japan by practicing pulmonologists. For comparison, 17 cases of PCP in patients with AIDS were randomly selected at two AIDS centers in Tokyo from July 2003 to September 2008. All of these cases were enrolled in the study after confirming that sufficient clinical information and imaging materials had been obtained before the initiation of definitive treatment for pulmonary events.

A diagnosis of PCP was made when the patient had symptoms such as fever, cough and progressive dyspnea, associated with bilateral infiltrates on chest radiography, and when either of the following criteria was satisfied; a) detection of *P. jirovecii* by staining (Grocott-Gomori methenamine stain or Calcofluor white stain) in a respiratory specimen or b) both positive PCR for *P. jirovecii* in a respiratory specimen and elevated (1→3)-β-D-glucan (β-D-glucan) in serum. The cut-off level of (β-D-glucan was set at 31.1 pg/mL according to our previous data (9). Cytomegalovirus (CMV) infection was examined with antigenemia method or polymerase chain reaction of serum or a respiratory specimen. In cases where CMV was markedly positive, CMV pneumonia was ruled out with reference to response to anti-CMV treatment, such as ganciclovir.

The most common category of underlying malignancy of the 21 HIV-negative patients was hematological malignancy (n=16), comprising non-Hodgkin lymphoma (n=7), acute lymphoblastic leukemia (n=4), chronic myelogenous leukemia (n=1), chronic lymphoblastic leukemia (n=1), myelodysplastic syndrome (n=1), Hodgkin's lymphoma (n=1), and multiple myeloma (n=1). Other underlying diseases included lung cancer (n=3), brain tumor (n=1), and esophageal carcinoma (n=1). Most of these patients with malignancy were immunocompromised as a result of preceding antineoplastic or corticosteroid therapy. None of the patients with malignancy were under prophylaxis against PCP. Since the patients with malignancy had undergone CT, pulmonary invasion of malignant cells was ruled out by comparison of CT appearance with previous findings.

None of the patients with AIDS had been diagnosed as HIV-positive until the episode of PCP. As the underlying

pulmonary disease, pulmonary emphysema was seen in 4 patients with AIDS and in 2 with malignancy, and one patient with malignancy had unclassifiable interstitial pneumonia on HRCT.

Data collection

We reviewed the medical records of all the patients and evaluated the clinical data at the time when the PCP was first recognized, as well as the clinical course and its outcome. In the sera, the levels of albumin, immunoglobulin G (IgG), sialylated carbohydrate antigen KL-6 (KL-6), lactate dehydrogenase (LDH), C-reactive protein (CRP), and (β-D-glucan were examined. The counts of white blood cells (WBC) and lymphocytes in peripheral blood were also evaluated. The oxygenation index was determined from the arterial oxygen tension and inspiratory oxygen concentration values.

Radiological analysis

Inspiratory CT images were obtained with the patient in the supine position. The imaging technique varied between cases; however, contiguous slices of 1- to 5-mm thickness were taken from the pulmonary apex to the base, with or without contrast enhancement. In all cases, HRCT images collimated from 0.75- to 3-mm slices that were obtained at selected levels were also available. Radiological checkpoints included GGO, consolidation, thickening of the bronchial wall, centrilobular nodules, thickening of the interlobular septa, intralobular reticular opacity, subpleural curvilinear opacity, traction bronchiectasis, pleural effusion, and cyst formation (10).

The CT images of the chest were independently reviewed by two experienced radiologists (F.S, T.J.). When there were conflicting interpretations, the case was discussed and a final consensus was reached. The CT appearances were categorized into three patterns: a) diffuse GGO distributed in a panlobular manner, that is, GGO was sharply demarcated from the adjacent normal lung by interlobular septa (pattern A) (Fig. 1), b) diffuse GGO with inhomogeneous distribution unrelated to secondary lobules (pattern B) (Fig. 2A, Fig. 2B), and c) consolidation with GGO (pattern C) (Fig. 3). The occurrence of each pattern was assessed in each group.

The extent of GGO and consolidation was scored to the nearest 10% in six zones in the lungs; right upper lobe, right middle lobe, right lower lobe, upper portion of left upper lobe, lingular portion of left upper lobe, and left lower lobe (11). For the purposes of this study, the extent of GGO was calculated as the sum of the extent of GGO, as scored by two observers in each of the six zones. Interobserver variability was evaluated and determined to be satisfactory for consistency in visual scoring.

The relationship of CT features and other clinical parameters (age, sex, oxygenation impairment, blood counts, and serum markers) was analyzed subjectively.

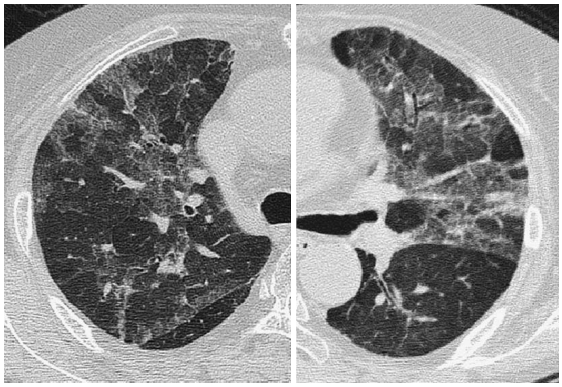

Figure 1. Ground-glass opacity (GGO) seen in a 58-year-old woman with non-Hodgkin lymphoma. She had received methotrexate for RA for 4 years. HRCT indicates GGO sharply demarcated from the adjacent normal lung by interlobular septa (type A).

Statistical methods

Data are presented as median scores with the interquartile range in parentheses. Differences in variables between the patients with malignancy and those with AIDS were compared by the non-parametric Mann-Whitney's U-test. The relationships between variables were analyzed by the Spearman rank-order correlation test. Statistical significance was defined as $p<0.05$.

Results

Patient characteristics

The background characteristics and clinical presentation of the patients evaluated are shown in Table 1. The age of the patients was not statistically different between the patients with malignancy and those with AIDS. There were no female patients in the HIV-infected group.

Clinical presentation

The predominant symptoms were dyspnea and fever regardless of the patient background. These symptoms preceded the diagnosis of the PCP by 4 days in the malignancy group, and by 14 days in the AIDS group. It was observed that PCP progressed more rapidly in the patients with malignancies ($p<0.01$).

Serum markers

We compared the levels of serum markers between the patients with malignancies and those with AIDS (Table 1). In the latter, the serum albumin level was significantly lower than in those with malignancies ($p<0.001$). Humoral immunity was evaluated in terms of the serum IgG level. The patients with malignancies showed significantly lower levels of IgG than those with AIDS ($p<0.001$). Serum levels of KL-6, LDH, CRP, and (β-D-glucan were elevated in most patients

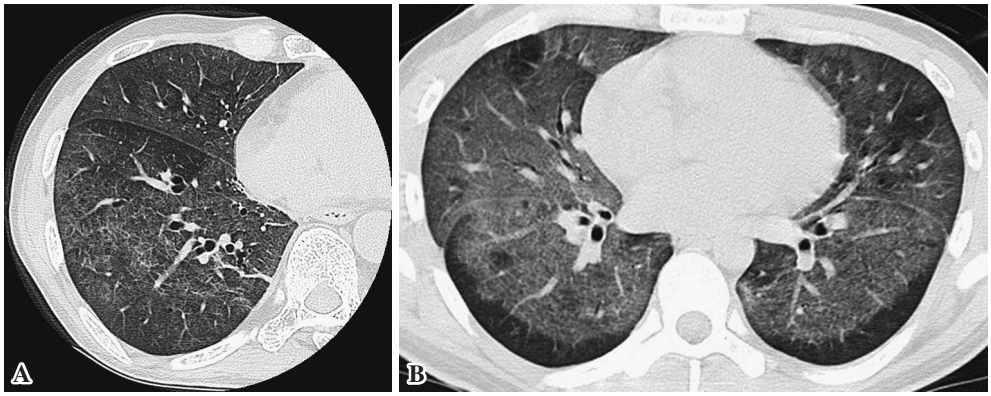

Figure 2. **(A) HRCT appearance in a 76-year-old man with esophageal cancer, revealing diffuse ground-glass opacity (GGO) with inhomogeneous distribution unrelated to secondary lobules. (B) GGO seen in a 30-year-old male patient with AIDS. HRCT shows diffuse GGO with inhomogeneous distribution unrelated to secondary lobules and with spared peripheral lung parenchyma.**

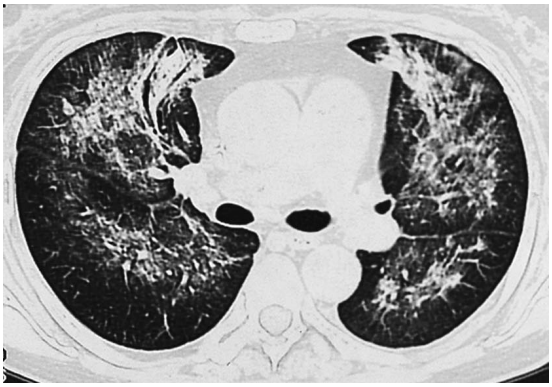

Figure 3. **HRCT images of a 60-year-old woman with non-Hodgkin lymphoma, showing consolidation along the bronchovascular bundle, structural distortion, and thickening of the interlobular septal lines.**

with PCP, but not significantly different between the patients with malignancy and those with AIDS.

Blood counts

The peripheral WBC and lymphocyte counts are shown in Table 1. WBC counts were within the normal range in most patients. No significant differences were observed in WBC and lymphocyte counts between the patients with malignancies and those with AIDS.

In patients with AIDS, $CD4^+$ lymphocyte counts were as low as 51 ± 9/mm^3, but they were not measured in the HIV negative group.

Oxygenation index

The median oxygenation index was lower than 300 mmHg in both patient groups. There was no difference in the oxygenation index between the patients with malignancies and those with AIDS. Ten patients with malignancies and 8 patients with AIDS needed oxygen supplementation. Mechanical ventilation was necessary in two patients with malignancies but in not in any of the AIDS patients.

Radiological features

All of the patients showed diffuse bilateral infiltrates on chest radiography, which, by itself, was neither specific nor pathognomonic for the background of the patients. Through the analysis of CT images, we found three patterns of opacities, as mentioned above. The occurrence rates of these three patterns in each patient group are shown in Table 2. Pattern A was observed only in a patient with non-Hodgkin lymphoma complicated by RA. This is compatible with our previous finding that pattern A was observed frequently in PCP cases with RA (8). In the patients with malignancy, patterns B (Fig. 2A) and C (Fig. 3) were observed in 10 patients each. On the other hand, all of the AIDS patients showed pattern B (Fig. 2B). In some of the patients with malignancy, sequential CT assessment was conducted, which revealed consolidation that rapidly emerged over GGO (Fig. 4A, Fig. 4B).

The extent of GGO on CT images was scored to the nearest 10% in six zones in the lungs and summed up. As shown in Fig. 5, the extent of GGO was significantly greater in the patients with AIDS than in those with malignancy ($p< 0.05$). In contrast, none of the patients with AIDS showed consolidation, whereas 8 out of 21 patients with malignancies revealed significant consolidation.

The characteristics of CT appearance are summarized in Table 2. Consolidation along the bronchovascular bundle (Fig. 3) was observed more frequently in the patients with malignancy than in those with AIDS ($p<0.02$). Transverse parenchymatous bands, which are distributed 2-3 cm from the chest wall and cross the bronchovascular bundle (Fig. 6), the centrilobular nodules (Fig. 7), and thickened interlobular septal lines (Fig. 3) were also observed more often in patients with malignancy than in those with AIDS. By contrast, the peripheral sparing of GGO occurred less often in patients with malignancy than in those with AIDS (Fig. 2B). Cyst formation occurred with similar frequencies in both pa-

Table 1. Patient Characteristics and Clinical Presentation

	Malignancy (n=21)	AIDS (n=17)	p value
Age, yr	51 (37-64)	40 (29-47)	0.062*
Male/female	13/8	17/0	0.004†
Clinical presentation			
dyspnea	18	14	
fever	18	12	
general fatigue	4	3	
cough	5	6	
abdominal pain/diarrhea	1	5	
Duration of symptoms, days	4 (2 - 8)	14 (4 - 28)	0.007*
Biochemistry			
Albumin, g/dL	3.3 (3.0-3.5)	2.5 (2.2-3.0)	<0.001
IgG, mg/dL	752 (425-988)	2,094 (1,694-2,358)	<0.001
KL-6, U/mL	889 (705-1,379)	1,060 (673-1,843)	0.749
LDH, IU/L	436 (297-598)	451 (327-620)	0.523
CRP, mg/dL	5.9 (2.8-13.2)	3.7 (1.6-8.1)	0.223
β-D-glucan, pg/mL	161 (74-254)	172 (76-301)	0.717
Blood count			
WBC, $x10^3/mm^3$	7.74 (5.10-10.0)	5.65 (4.75-8.29)	0.272
Lymphocyte, $/mm^3$	704 (180-1034)	645 (510-966)	0.438
PaO_2/FIO_2, mmHg	269 (213-290)	291 (229-338)	0.504

Data are presented as median scores with the interquartile range in parentheses.
*: Mann-Whitney's U-test, †: chi-square test

tient groups.

Correlation between CT findings and other parameters

The correlation between the extent of GGO or consolidation and other clinical parameters, including serum markers and the oxygenation index, was evaluated. No significant correlation was observed between the CT findings and other clinical parameters (data not shown).

Treatment and patient outcome

After the diagnosis of PCP was made, all patients were treated with trimethoprim-sulfamethoxazole (TMP-SMX). Side effects of TMP-SMX were observed in 5 patients with malignancies and in 11 patients with AIDS. In the patients with AIDS, drug allergy was the most frequent side effect, whereas none of the patients with malignancy had any drug allergy. In 3 patients with malignancies and 11 patients with AIDS, it was necessary to replace TMP-SMX with pentamidine isethionate. Adjunctive corticosteroids were given to all patients with malignancies and to 15 patients with AIDS. Eleven patients with malignancies and 7 patients with AIDS received pulse-steroid therapy using methylprednisolone 500-1,000 mg/day.

All of the patients with AIDS recovered from PCP, whereas 6 patients with malignancies died within a month after the onset of PCP. Among the 6 deceased patients, two showed significant improvement of PCP. The cause of death included multiple organ failure, myocardial infarction, gastrointestinal tract bleeding, enlargement of brain metastasis, and respiratory failure due to either PCP or drug-induced pneumonitis.

In the patients with malignancy, 11, including the 6 mentioned above, suffered an in-hospital death. PCP could not be ruled out as a cause of the death in one patient. In other words, at least 10 patients avoided death due to PCP once, suggesting that, even in a patient with malignancy, early diagnosis and treatment for PCP appears to be important.

Discussion

The clinical features of PCP are known to differ according to the predisposing factors responsible for immunosuppression (1, 3). For example, PCP in patients with AIDS is characterized by greater numbers of organisms but good prognosis (3). In contrast, PCP in patients with malignancy

Table 2. Occurrence of Image Patterns and Characteristic Findings on CT

	Malignancy (n=21)	AIDS (n=17)	p value†
Image patterns			
Type A	1* (5%)	0 (0%)	
Type B	10 (48%)	17 (100%)	<0.01
Type C	10 (48%)	0 (0%)	
Characteristic findings			
Consolidation along the bronchovascular bundle	9 (43%)	1 (5%)	<0.02
Transverse parenchymatous band	8 (38%)	3 (18%)	0.17
Subpleural curvilinear opacity	1 (5%)	1 (5%)	0.88
Peripheral sparing of GGO	7 (33%)	10 (59%)	0.12
Centrilobular nodules	5 (24%)	1 (5%)	0.13
Septal line thickening	8 (38%)	2 (12%)	0.07
Intralobular reticular opacity	2 (10%)	3 (18%)	0.46
Cyst formation	3 (14%)	3 (18%)	0.78

Type A: sharply demarcated panlobular/multilobular GGO

Type B: diffuse GGO with inhomogeneous distribution unrelated to secondary lobules

Type C: consolidation with GGO

†: chi-square test

∗: This case was complicated with rheumatoid arthritis.

has a poor outcome (3, 4, 12, 13). The radiological features of PCP in AIDS patients have been extensively reported (14-16), but those of PCP in HIV-negative patients have not been reported in detail. Since we previously observed that the CT patterns of PCP differ between the patients with AIDS and those with RA (8), we hypothesized that CT appearance might vary between patients with different backgrounds.

In the present study, we compared the CT appearance and other clinical parameters between patients with malignancy and those with AIDS. The major findings included differences in CT patterns between the two patient groups. In the patients with malignancy, diffuse GGO with inhomogeneous distribution unrelated to secondary lobules (pattern B) and consolidation with GGO (pattern C) were observed at similar percentages. By contrast, all of the patients with AIDS presented pattern B (i.e., GGO without consolidation) on CT, which is consistent with the result of our previous study and with features previously reported (8, 16). To the best of our knowledge, this is the first report that describes the difference in imaging features of PCP between patients with malignancy and those with AIDS.

In about one half of the patients with malignancy, we observed consolidation on CT, which could be rapidly developed over a few days as shown in Fig. 4A and Fig. 4B. Limper and colleagues reported that PCP in patients without AIDS is accompanied by greater neutrophil infiltration than in PCP secondary to AIDS (5). Although there is no pathological evidence of the difference of the CT findings, we speculated that consolidation in HIV-negative patients could be associated with severe inflammation of the lung. We considered that another possible mechanism of the development of consolidation is a mixed infection of *P. jirovecii* and another pathogen, although it was not bacteriologically proven.

PCP in patients with malignancy was likely to show less GGO but a wide range of other findings, such as consolidation along the bronchovascular bundle, centrilobular nodules, and thickening of interlobular septal lines. Transverse parenchymatous bands were seen in both patients with AIDS and those with malignancy, although it remains to be determined whether the bands have any pathological significance. Nodular lesions were observed in 5 patients with malignancy but in only 1 with AIDS. Otahbachi and colleagues reviewed 19 non-AIDS patients with granulomatous PCP who often showed nodular infiltrates on chest X-ray (17). We considered that the nodular lesions observed could represent granuloma formation during PCP especially in HIV-negative patients.

In this study, cystic lesions were observed in similar percentages for both patient groups, whereas it has been described that cyst formation is a characteristic CT finding of PCP in AIDS patients (18). In addition, the percentage of

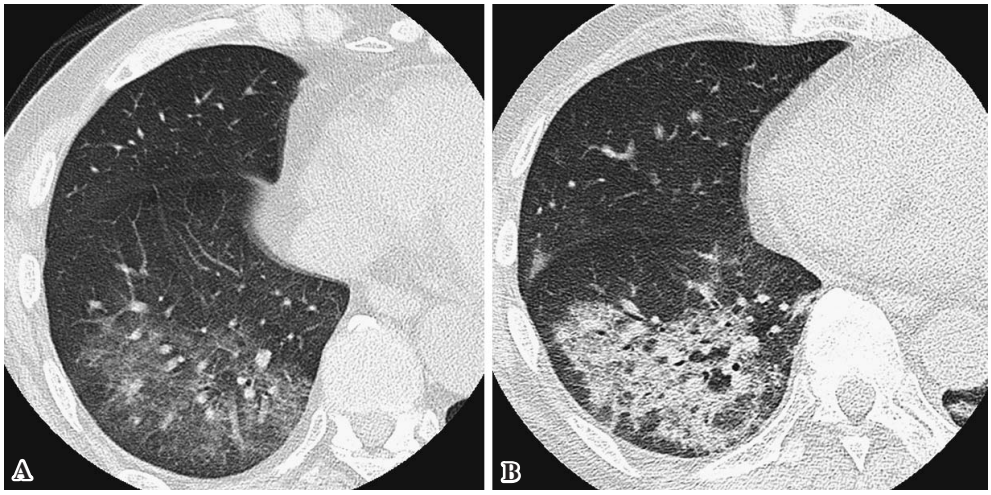

Figure 4. **HRCT images of a 64-year-old man with non-Hodgkin lymphoma. (A) On the day of onset, HRCT shows diffuse GGO with inhomogeneous distribution. PCP was diagnosed through positive PCR in induced sputum and the serum β-D-glucan level elevated as high as 64.7 pg/mL. (B) Three days later, consolidation in addition to GGO was observed.**

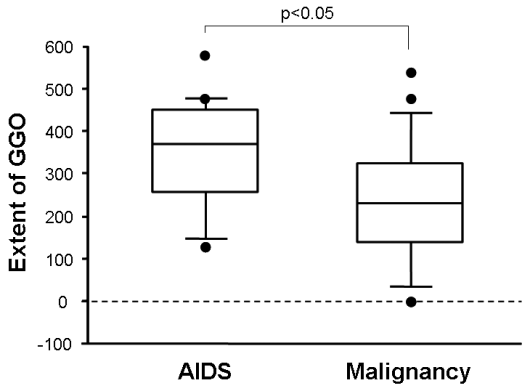

Figure 5. **Extent of GGO on HRCT images. The extent of GGO was scored to the nearest 10% in six zones in the lungs and summed up. The box-whisker plots show the 25th and 75th percentiles, the median (horizontal line within the box), and the 10th and 90th percentiles (whiskers). The extent of GGO was significantly greater in the patients with AIDS than in those with malignancy (p<0.05).**

the AIDS patients with cyst formation was lower than in previous reports (18, 19). We speculated that these discrepancies might be because HRCT was conducted at an earlier time point in our patients with AIDS. In this study, none of the patients with AIDS had been diagnosed as HIV-positive until the episode of PCP, and HRCT was performed immediately after the first visit in most cases. Fujii and colleagues reported that cyst formation was observed in 21% of the HIV-positive patients with PCP (16), which is comparable to the current observation. The earlier conduct of HRCT might be associated with the lower percentage of cyst formation, leading to the lack of difference between the two groups.

At presentation, the patients with malignancy had a shorter duration of symptoms than those with AIDS, which is compatible with a previous report (3). This difference in the disease progression might be associated with severe inflammation during PCP in HIV-negative patients. Oxygenation, however, did not differ between the two patient groups, although better oxygenation has been reported in AIDS patients with PCP (3, 5). There was no inter-group difference between the serum levels of LDH and KL-6, an indicator of pulmonary epithelial damage (9, 20). We considered that these absences of difference might have been due to the variety of the underlying disorders and concomitant treatment.

β-D-glucan is one of the major components of the yeast cell wall and its level in serum is known as a reliable indicator for detecting *P. jirovecii* infection (9). Since PCP in HIV-negative patients is reported to be characterized by a lower organism burden, a lower β-D-glucan level had been anticipated in the HIV-negative patients. However, there was no significant difference in the serum levels of β-D-glucan between the patient groups with different backgrounds. In addition, no correlation was seen between the β-D-glucan level and the CT findings. Since the number of *P. jirovecii* was not quantitatively assessed, it also remains unclear whether or not the β-D-glucan level reflects the organism burden in the lung.

With the recent advances in anti-malignancy treatment, a growing number of patients receive anti-cancer chemotherapy and other immunosuppressive agents, which may result in placing an increasing number of patients at risk of PCP (21). Even in a patient with far advanced malignancy, PCP is usually a treatable disease. The role of HRCT evaluation in early diagnosis and outcome prediction should be evaluated in future investigations with a larger number of patients.

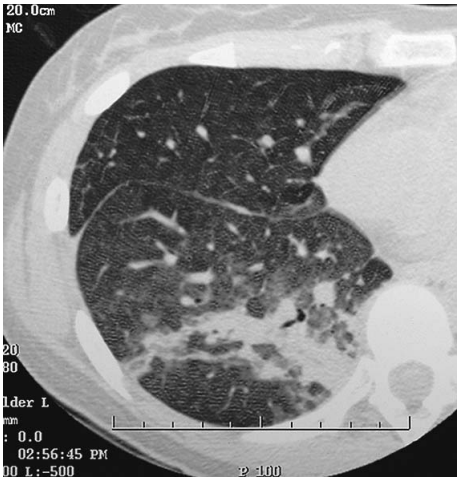

Figure 6. **HRCT appearance in a 58-year-old man with non-Hodgkin lymphoma. In addition to GGO, transverse parenchymatous bands, which cross the bronchovascular bundle, can be seen 2-3 cm from the chest wall.**

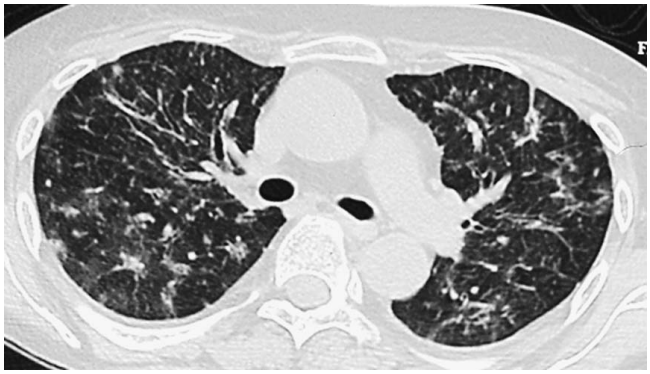

Figure 7. **HRCT appearance in a 42-year-old female patient with acute lymphoblastic leukemia, showing diffuse GGO with inhomogeneous distribution unrelated to secondary lobules and centrilobular nodules.**

Conclusions

We investigated the CT findings of 38 cases of PCP, comparing 21 with malignancy with 17 with AIDS. The patients with malignancy tended to have symptoms of shorter duration, although no significant differences were observed in oxygenation or in the levels of serum markers. In all of the PCP patients examined, chest CT showed GGO, but its extent was significantly greater in the patients with AIDS than in those with malignancy. Whereas airspace consolidation was observed in about the half of the patients with malignancy, none of those with AIDS showed significant consolidation. Despite these differences, it still remains to be determined whether CT findings are associated with other clinical indicators or are predictive of outcome in patients with PCP.

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References

1. Thomas CF Jr, Limper AH. Pneumocystis pneumonia. N Engl J Med **350**: 2487-2498, 2004.
2. Sepkowitz KA. Opportunistic infections in patients with and patients without acquired immunodeficiency syndrome. Clin Infect Dis **34**: 1098-1107, 2002.
3. Kovacs JA, Hiemenz JW, Macher AM, et al. *Pneumocystis carinii* pneumonia: a comparison between patients with the acquired immunodeficiency syndrome and patients with other immunodeficiencies. Ann Intern Med **100**: 663-671, 1984.
4. Sepkowitz KA, Brown AE, Telzak EE, Gottlieb S, Armstrong D. *Pneumocystis carinii* pneumonia among patients without AIDS at a cancer hospital. JAMA **267**: 832-837, 1992.
5. Limper AH, Offord KP, Smith TF, Martin WJ II. *Pneumocystis carinii* pneumonia: differences in lung parasite number and inflammation in patients with and without AIDS. Am Rev Respir Dis **140**: 1204-1209, 1989.
6. DeLorenzo LJ, Huang CT, Maguire GP, Stone DJ. Roentgenographic patterns of *Pneumocystis carinii* pneumonia in 104 patients with AIDS. Chest **91**: 323-327, 1987.
7. Gruden JF, Huang L, Turner J, et al. High-resolution CT in the evaluation of clinically suspected *Pneumocystis carinii* pneumonia in AIDS patients with normal, equivocal, or nonspecific radiographic findings. AJR Am J Roentgenol **169**: 967-975, 1997.
8. Tokuda H, Sakai F, Yamada H, et al. Clinical and radiological features of *Pneumocystis* pneumonia in patients with rheumatoid arthritis, in comparison with methotrexate pneumonitis and *Pneumocystis* pneumonia in acquired immunodeficiency syndrome: a multicenter study. Intern Med **47**: 915-923, 2008.
9. Tasaka S, Hasegawa N, Kobayashi S, et al. Serum indicators for the diagnosis of *Pneumocystis* pneumonia. Chest **131**: 1173-1180, 2007.
10. Sakai F, Tokuda H, Goto H, et al. Computed tomographic features of *Legionella pneumophila* pneumonia in 38 cases. J Comput Assist Tomogr **31**: 125-131, 2007.
11. Best AC, Meng J, Lynch AM, et al. Idiopathic pulmonary fibrosis: physiologic tests, quantitative CT indexes, and CT visual scores as predictors of mortality. Radiology **246**: 935-940, 2008.
12. Yale SH, Limper AH. *Pneumocystis carinii* pneumonia in patients without acquired immunodeficiency syndrome: associated illness and prior corticosteroid therapy. Mayo Clin Proc **71**: 5-13, 1996.
13. Roblot F, Godet C, Le Moal G, et al. Analysis of underlying diseases and prognosis factors associated with *Pneumocystis carinii* pneumonia in immunocompromised HIV-negative patients. Eur J Clin Microbiol Infect Dis **21**: 523-531, 2002.
14. Bergin CJ, Wirth RL, Berry GJ, Castellino RA. *Pneumocystis carinii* pneumonia: CT and HRCT observations. J Comput Assist Tomogr **14**: 756-759, 1990.
15. Hidalgo A, Falco V, Mauleon S, et al. Accuracy of high-resolution CT in distinguishing between *Pneumocystis carinii* pneumonia and non- *Pneumocystis carinii* pneumonia in AIDS patients. Eur Radiol **13**: 179-184, 2003.
16. Fujii T, Nakamura T, Iwamoto A. Pneumocystis pneumonia in pa-

tients with HIV infection: clinical manifestations, laboratory findings, and radiological features. J Inf Chemother **13**: 1-7, 2007.

17. Otahbachi M, Nugent K, Buscemi D. Granulomatous *Pneumocystis jiroveci* pneumonia in a patient with chronic lymphocytic leukemia: a literature review and hypothesis on pathogenesis. Am J Med Sci **333**: 131-135, 2007.

18. McGuinness G, Gruden JF. Viral and *Pneumocystis carinii* infections of the lung in the immunocompromised host. J Thorac Imaging **14**: 25-36, 1999.

19. Hartman TE, Primack SL, Müller NL, et al. Diagnosis of thoracic complications in AIDS: accuracy of CT. Am J Roentgenol **162**: 547-553, 1994.

20. Hamada H, Kohno N, Yokoyama A, et al. KL-6 as a serologic indicator of *Pneumocystis carinii* pneumonia in immunocompromised hosts. Intern Med **37**: 307-310, 1998.

21. Sepkowitz KA, Brown AE, Armstrong D. *Pneumocystis carinii* pneumonia without acquired immunodeficiency syndrome. More patients, same risk. Arch Intern Med **155**: 1125-1128, 1995.