

# Comparative Study of HRCT Imaging Characteristics of Psittaci Pneumonia and COVID-19 Pneumonia

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## Research Article

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## Abstract

**Background:** Both Chlamydia psittaci and COVID-19 virus can cause lung inflammation, which manifests extremely similarly in clinical symptoms and imaging. Especially during the epidemic of COVID-19, psittacosis pneumonia is easily misdiagnosed as COVID-19 pneumonia. The identification of the chest imaging between the two diseases is of special significance when the epidemiological contact history is unclear, and the etiology and nucleic acid test results are not available. This study conducts to compare the imaging characteristics on chest high-resolution CTs (HRCT) between patients with psittaci pneumonia and COVID-19 pneumonia.

**Methods:** A retrospective analysis of the imaging characteristics on chest HRCTs of 10 psittaci pneumonia patients and 13 COVID-19 pneumonia patients. The similarities and differences in HRCT images of patients with psittaci pneumonia and COVID-19 pneumonia were analyzed.

**Results:** HRCT showed that among the 10 psittaci pneumonia patients, 8 cases (80.00%) had single lobe involvement, and 2 cases (20.00%) had multiple lobe involvement. Among the 13 COVID-19 pneumonia patients, 2 cases had single lobe involvement (15.38%), and 11 cases had multiple lobe involvement (84.62%). The types of lesions in 10 psittaci pneumonia patients included simple consolidation in 5 cases (50.00%), and ground-glass opacity (GGO) with consolidation in 5 cases (50.00%). The types of lesions in 13 COVID-19 pneumonia patients included simple GGO in 6 cases (46.15%), GGO with consolidation in 4 cases (30.77%), GGO with paving stone sign in 2 cases (15.38%), and simple consolidation in 1 case (7.69%). Lymphadenopathy was observed in 1 psittaci pneumonia patient (10.00%) and 1 COVID-19 pneumonia patient (7.69%). Among the 10 psittaci pneumonia patients, 8 cases (80.00%) had bronchial inflation, and 6 patients (60.00%) had pleural effusion. Among the 13 COVID-19 pneumonia patients, 5 patients (38.46%) showed signs of bronchial inflation, while no pleural effusion was observed in 13 patients.

**Conclusion:** Chest HRCTs can distinguish COVID-19 pneumonia from psittaci pneumonia, and can provide early diagnoses of these two diseases.

## Background

Psittacosis is caused by the gram-negative, obligate intracellular parasite: Chlamydia. Humans are mainly infected through direct contact with infected birds (such as parrots, poultry, etc.), inhalation of aerosols from the nasal secretions of infected birds, or dust [1, 2]. Human-to-human transmission can occasionally occur in the acute stage of psittacosis through the respiratory tract. The latency of Chlamydia psittaci infection is usually 5 to 14 days [3]. The typical clinical manifestations of psittacosis are fever, chills, headache, dry cough, and gastrointestinal symptoms. The severe pneumonia, endocarditis, jaundice, and nervous system complications can be observed in severe disease [4, 5]. At present, the diagnosis of psittacosis relies on pathogenic testing of Chlamydia psittaci [6–8]. Clinical imaging is also an important diagnosis method.

New coronavirus pneumonia is a severe acute respiratory infection (SARI) caused by the COVID-19 virus. The clinical symptoms of COVID-19 pneumonia are atypical, and the diagnosis requires viral nucleic acid testing. Both Chlamydia psittaci and COVID-19 virus can cause lung inflammation, which manifests extremely similarly in clinical symptoms and imaging. Especially during the epidemic of COVID-19, psittacosis pneumonia is easily misdiagnosed as COVID-19 pneumonia [9]. The identification of the chest imaging between the two diseases is of special significance when the epidemiological contact history is unclear, and the etiology and nucleic acid test results are not available.

This study retrospectively analyzed the high-resolution CT (HRCT) images of 10 psittaci pneumonia patients and 13 COVID-19 pneumonia patients during the COVID pandemic; this was conducted in order to provide early differential diagnoses of psittaci and COVID-19 pneumonia.

## **Materials And Methods**

### **General information**

Clinical data from 10 cases of psittaci pneumonia and 13 cases of COVID -19 pneumonia were collected from January 2020 to November 2020. All 10 psittaci pneumonia patients were diagnosed with Chlamydia psittaci through second-generation gene sequencing. COVID-19 patients were diagnosed according to the National Health and Construction Commission's "New Coronavirus Infection Pneumonia Diagnosis and Treatment Program" [10].

### **Instruments and scanning methods**

Patients were scanned using chest non-contrast HRCT, and data were collected using Siemens emotion (Siemens Medical Solutions). Scanning parameters were as followed: tube voltage 120 kV, tube current 100-200mA, slice thickness 0.625-5mm, pitch 0.75-1.5, and calibration 0.625-5mm. The lung window and the mediastinal window were reconstructed with a high-spatial-resolution algorithm. The lung window level was set to -700 HU, and the width was set to 1700 HU; the mediastinal window level was set to 40 HU, and the width level was set to 350 HU. The scanning range was from the entrance of the thorax to the level of the posterior costophrenic angle, and an end-inspiratory scan was taken. The MRP method was adopted for image post-processing to obtain multi-directional two-dimensional images of human tissues and organs from the original horizontal axis images.

### **Image analysis**

Two physicians, both with over 10 years of experience in diagnostic imaging, performed image diagnoses to determine the location and imaging characteristics of the lesion. If the diagnosis results are inconsistent between these two physicians, a consensus was reached after discussion. Consolidation was defined as an increased density of lung parenchyma with obscuration of the underlying vessels. Ground-glass opacity (GGO) was defined as an increase in lung parenchymal opacification without obscuration of the underlying vessels (opposed to consolidation). The "paving stone" sign was defined as thickened interlobular septa and intralobular lines superimposed on a background of GGO, similar to

irregular paving stones. The bronchial sign refers to the air-filled, low-density bronchial shadow in the high-density lung tissue without air.

## Results

### General information, clinical manifestations, and laboratory tests

Ten patients (7 males and 3 females) with psittaci pneumonia were between the ages of 26-68 years old, with an average age of 44.6 years. All 10 patients visited the doctor with fever as the main symptom, which was accompanied with cough in 2 cases, shortness of breath in 2 cases, and abdominal pain in one case. Thirteen COVID-19 patients (8 males and 5 females) were between the ages of 27-79 years old, with an average age of 51.4 years. Similarly, these ten patients also visited the doctor with fever as the main symptom, but 2 patients also had cough and 1 patient had fatigue. Three cases were asymptomatic patients. The laboratory results of the two groups of patients are presented in Table 1.

Table 1  
First laboratory examinations of COVID-19 pneumonia and psittaci pneumonia patients

	<b>Patients</b>	<b>WBC</b>	<b>L (%)</b>	<b>NCI</b>	<b>LC</b>	<b>PCT</b>	<b>ESR</b>	<b>CPR</b>
psittaci	1	6.22	19.05↓	4.37	2.21	0.136↑		58.01↑
	2	10.07↑	23.1	6.61↑	2.33			31.87↑
	3	10.43↑	19.60↓	7.57↑	2.04		51↑	12.17↑
	4	11.70↑	18.90↓	8.66↑	2.21	0.127↑		50.55↑
	5	4.77	4.60↓	0.22↓	0.22	>100	82↑	137↑
	6	5.05	33.8	1.55↓	0.97↓	0.173↑	81↑	19.20↑
	7	9.95↑	3.10↓	95.00↑	0.31	7.690↑	100↑	
	8	2.1	10.00↓	1.86	0.21	2.750↑	32↑	151.59↑
	9	6.43	10.90↓	5.39	0.70↓	0.430↑	78↑	165.32↑
	10	10.73↑	1.80↓	10.42↑	0.19	12.000↑	87↑	>200
COVID-19	1	4.38	39.3	1.96	1.72	0.067↑	14.78↑	6.45
	2	5.51	12.00↓	78.70↑	0.66↓	0.045	5	1.95
	3	4.7	30	54.50↑	1.41	0.072↑	7	3.24
	4	5.77	14.40↓	73.40↑	0.83↓	0.101↑	15.75↑	19.55↑
	5	4.16	17.80↓	2.63	0.74↓	0.076↑	6	19.43↑
	6	5.1	22.7	3.54	1.16	0.085↑	20↑	47.71↑
	7	10.48↑	15.00↓	8.14↑	1.57	0.020	11	1.01
	8	5.8	12.40↓	4.57	0.72↓		68↑	51.08↑
	9	4.3	12.10↓	3.48	0.52↓	0.058↑	14	26.68↑
	10	7.95	21.51	5.55	1.71	0.032	6	
	11	4.66	17.60↓	3.34	0.82↓			
	12	5.88	27.4	59.80↑	1.61	0.023	13	9.46
	13	4.99	10.40↓	4.04	0.52↓			40.53↑

PBWBC: Peripheral blood white blood cell count ( $3.50\sim9.50\times10^9$ ); L(%): Lymphocyte percentage (20.00~50.00%); NC: Neutrophil count ( $1.80\sim6.30\times10^9$ ); LC: Lymphocyte count ( $1.10\sim3.20\times10^9$ ); PCT: Procalcitonin (0~0.050ng/ml); ESR: Erythrocyte sedimentation rate (1~15mm/h); CPR(<10.00mg/L).

# HRCT imaging manifestations of psittaci pneumonia and COVID-19 pneumonia

Lesion distribution: Among the 10 cases with psittaci pneumonia, 9 cases (90.00%) had single lobe involvement and one (10.00%) had multiple lobes involvement. There are Representative images for psittacosis pneumonia in figure 1.

Among the 9 cases with single lobe involvement, lesions localized in the right or left lower lobe. Among the 13 cases with COVID-19 pneumonia, 2 cases (15.38%) had single lobe involvement, while 11 cases had multiple lobe involvement (84.62%).There are Representative images of COVID-19 pneumonia in figure 2.

Type of lesion: The images of these two kinds of atypical pneumonia mainly manifested as consolidation, GGO, or both. Among the 10 cases with psittaci pneumonia, 7 cases (70.00%) had simple consolidation lesion, and 3 cases (30.00%) had GGO with consolidation. Among the 13 patients with COVID-19 pneumonia, 1 case (7.69%) had simple consolidation, 4 cases (30.77%) had GGO with consolidation, 6 cases (46.15%) had simple GGO, and 2 cases (15.38%) had GGO with paving stone sign.

Other signs: Among the 10 cases with psittaci pneumonia, one case (10.00%) had lymphadenopathy, eight cases (80.00%) showed signs of bronchial inflation, and six cases (60.00%) had pleural effusion. Among the 13 cases with COVID-19 pneumonia, one case (7.69%) had lymphadenopathy, and five cases (38.46%) showed signs of bronchial inflation without sign of pleural effusion in all cases. The main imaging manifestations and accompanying signs of psittaci and COVID-19 pneumonia are shown in Table 2.

**Table 2**  
**The main imaging manifestations and accompanying signs of psittaci and COVID-19 pneumonia**

<b>Imaging sign</b>	<b>psittaci</b>		<b>COVID-19</b>	
	<b>Case</b>	<b>Percentage</b>	<b>Case</b>	<b>Percentage</b>
consolidation	7(7/10)	70%	1(1/13)	7.69%
GGO With consolidation	3(3/10)	30%	4(4/13)	30.77%
GGO	0(0/10)	0%	6(6/13)	61.54%
Negative	0(0/10)	0%	2(2/13)	
Single lobe	9(9/10)	90%	2,(2/13,)	15.38%
Multiple lobes	1(1/10)	10%	11(1/13)	84.62%
Pleural effusion	6(6/10)	60%	1(1/13)	7.69%
Mediastinal lymphadenopathy	1(1/10)	10%	2(2/13)	15.38%
Bronchial inflation	8(8/10)	80%	5(5/13)	38.46%
GGO with paving stone sign	0(0/10)	0%	2(2/13)	15.38%

## Discussion

Human infection of psittacosis is mainly caused by close contact with infected birds or poultry and inhalation of bird secretions or contaminated aerosols; human-to-human transmission is rare [8, 11]. Most reported psittaci pneumonia are sporadic cases. In this study, 4 cases of psittaci pneumonia were a clustered occurrence; the 4 cases were medical staff in the same ward. However, clinical epidemiological investigation revealed no similar infections among their close contacts. Therefore, the fresh air conditioning system was suspected to be the possible source of infection; after the air conditioning system was turned off and cleaned, no new cases occurred. Although its original source is still under investigation, the COVID-19 pneumonia is at least confirmed to spread between humans through droplets and close contacts. Therefore, COVID-19 pneumonia can often be traced back to close contacts of the infection or virus carriers.

Previous studies have shown that the amount and percentage of peripheral lymphocytes are usually normal in psittaci pneumonia, whereas peripheral lymphocytes are usually decreased in COVID-19 pneumonia [8, 11–14]. In this study, no significant differences in amount and percentage of peripheral lymphocytes were observed between the two groups of patients. However, erythrocyte sedimentation rate and CPR had increased in almost all patients with the psittaci pneumonia, yet they were normal in patients with COVID-19 pneumonia.

In this study, 9 of the 10 patients with psittaci pneumonia were diagnosed with unilateral lung involvement, and lesions were all located in the lower lung in the first HRCT imaging diagnosis. The lesions were mainly solid with or without pleural effusion. Our observation is consistent with a previous report that the lung lesions of psittaci pneumonia usually occurred in a single lower lung [15]. Among the 13 patients with COVID-19 pneumonia, GGO and GGO with consolidation were the main lesions [16], and the lesions were mainly emerged in the peripheral lung zone. In addition, unlike psittaci pneumonia, pleural effusion is rarely observed in COVID-19 pneumonia [17]. Therefore, these two diseases could be easily distinguished based on the distributions of the lesions, the main imaging manifestations, and accompanying signs on the first HRCT. Our dynamic observations demonstrated that the lesions in psittaci pneumonia typically changed over the course of a few days, whereas the lesions in COVID-19 pneumonia changed more rapidly, often in a few hours (Data not shown). Therefore, multiple re-examinations of lung HRCTs and dynamic observations of the lung lesion changes could benefit the differentiation of the two diseases.

After humans are infected with Chlamydia psittaci, the pathogen enters the body, and it first enters the macrophages of the liver and spleen to proliferate; then, it enters the lungs and other organs through the bloodstream [18]. A previous study shows that an inflammatory reaction in psittaci pneumonia is observed around blood vessels and spread to the surroundings, and therefore causes lobular and interstitial pneumonia [19]. In contrast, COVID-19 viruses directly invade the bronchial epithelium and mainly cause bronchiolitis and peripheral inflammation. On HRCT imaging, the consolidation is caused by perivascular inflammation, while GGO is caused by inflammation spreading to the surrounding area. The early lesions of psittaci pneumonia may form a typical "anti-halo sign" due to the central inflammatory exudation and the repair of the marginal zone. In the early stage of COVID-19 pneumonia, it is mainly inflammatory exudation in the interstitium of the lung, and GGO is the main manifestation on CT. The thickened interlobular septum and intralobular septum line shadow superimposed on the background of GGO can form a typical "paving stone-like change". In the middle and late stages of the disease, bacterial fibrous mucus exudation appeared in the alveolar cavity, and the density of the lesion increased, which forms the paving stone-like changes with consolidation on CT [21].

The images of COVID-19 pneumonia and psittaci pneumonia should also be distinguished from other atypical pneumonia, such as: SARS, avian influenza virus pneumonia, and legionella pneumonia. Psittaci pneumonia is often a single lesion localizing in the right or left lower lobe. COVID-19 pneumonia is often multiple lung lesions. Patients without underlying lung diseases generally have no mediastinal and hilar lymphadenopathy, and pleural thickening or effusion. The imaging characteristics of SARS include that the lesions change rapidly, even in hours, and the lesions are single or multiple, and more common in the middle and lower lung lobes. Some SARS patients may have inconsistency between symptoms and image performance; that is, the symptoms are mild, and the lung shadows are obvious [21]. Avian influenza virus pneumonia is characterized by lung consolidation and ground-glass shadows as the main imaging features of the lungs with multiple lobes and multiple segments involved, and the lower and posterior lesions of the lungs are more severe than the upper and anterior lesions; this indicates that the lesion has characteristics of distribution along gravity [22]. Legionella pneumonia is a widespread

multilobe distribution of fibrinous purulent bronchopneumonia. It is often manifested as multilobe and multi-segmental invasion on images, and lesions may appear in the inner segment of the lung field. In severe cases, lung cavities or lung abscesses may appear [23].

We acknowledged that this study has several limitations. First, the sample size is small for both the psittaci pneumonia and COVID-19 pneumonia patients. Thus, they were not stratified for disease severity, complications, the time from first symptom occurrence to the HRCT, sex, and age. Secondly, since our hospital is not a designated hospital for COVID-19 pneumonia, there is a lack of analysis on dynamic image changes and a follow-up study.

## Conclusion

In this study, results suggests that chest HRCT can objectively reflect the large changes in the lung lesions of psittaci pneumonia and COVID-19 pneumonia, and it can provide help for their early clinical diagnosis, early isolation, and early treatment.

## Declarations

**Ethics approval and Consent to participate:** This study was approved by the Ethics Committee of the Second Xiangya Hospital of Central South University. All methods were carried out in accordance with relevant guidelines and regulations. Written informed consent was obtained from all participants.

**Consent for publication:** Consent for publication was obtained from every individual.

**Availability of data and materials:** All data generated or analysed during this study are included in this published article

**Competing interests:** The authors declare that they have no competing interests

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**Authors' contributions:** SC, QS, QL collected General information of patients; YZ, MW, LZ, JL, TW collected data of HRCT; ZM, CT, FZ, CS, JL, HL analyzed and interpreted the patient data of Image; ZM and HL were major contributor in writing the manuscript. All authors read and approved the final manuscript

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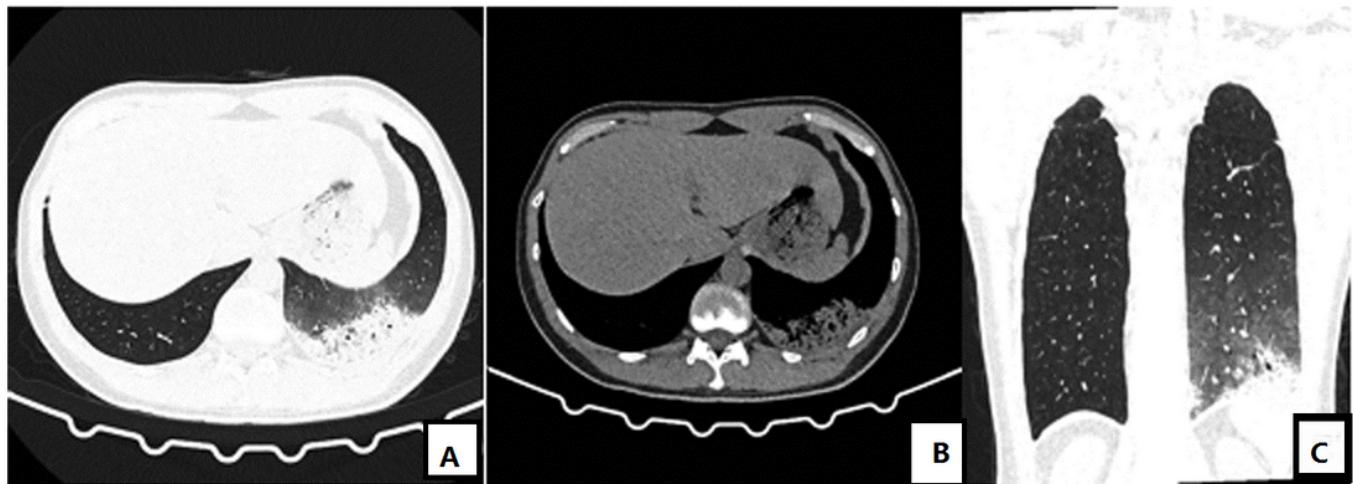
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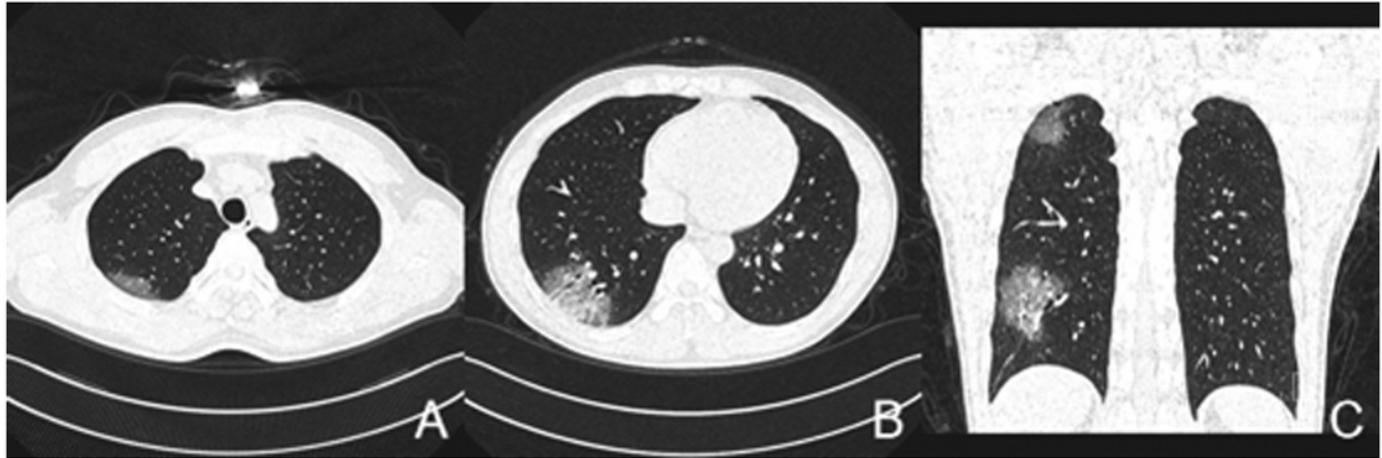
## Figures



**Figure 1**

Representative images for psittacosis pneumonia. A 48-year-old male presented with a fever. (A) The lung window in the transverse position on HRCT showed the consolidation of the posterior basal segment of the left lower lobe, with some GGO shadows around. (B) The transverse mediastinal window of HRCT

showed a small amount of fluid in the left thoracic cavity. (C) The coronal view of the lung window showed that the lesion is confined to the lower lobe of the left lung.



**Figure 2**

Representative images of COVID-19 pneumonia. A 40-year-old male with a cough. (A) The lung window in the transverse position showed the GGO in the posterior segment of the right upper lobe with a little GGO around. (B) The transverse lung window showed round GGO at the posterior basal segment of the right lower lobe. (C) The coronal view of lung window showed that the lesion involved multiple lung lobes without effusion in the bilateral pleural cavity.