CLINICAL ARTICLE

Radiological findings and clinical characteristics of pregnant women with COVID-19 pneumonia

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KEYWORDS: COVID-19; CT scan; Pneumonia; Pregnancy

SYNOPSIS: Clinical characteristics and radiological findings in pregnant women with COVID-19 were similar to those of nonpregnant women with COVID-19. A correlation between clinical and radiological characteristics was observed.

ABSTRACT

Objective: To study chest CT images and clinical characteristics of COVID-19 pneumonia in pregnant patients to examine any correlation.

Methods: Between December 31, 2019 and March 7, 2020, 23 hospitalized pregnant patients with confirmed COVID-19 were enrolled in the study. Clinical presentations were collected retrospectively from records, including laboratory testing, chest CT imaging, and symptoms. Descriptive analysis and correlation of patients' clinical and CT characteristics were performed. Laboratory results from time of first admission and CT absorption (defined as reduction in lesion area, decrease in density, and absorption of some solid components) were compared between symptomatic and asymptomatic patients.

Results: Fifteen (65.2%) patients were asymptomatic with patchy ground-glass opacity in a single lung lobe. Eight (34.8%) patients were symptomatic with multiple patchy ground-glass shadows, consolidation, and fibrous stripes. Differences in lymphocyte percentage and neutrophil granulocyte rate between first admission and CT absorption were significant (P<0.001). Median absorption time was shorter in the asymptomatic group compared with the symptomatic group (5 vs 10 days; P<0.001).

Median hospitalization time between asymptomatic and symptomatic patients was 14 vs 25.5 days; P>0.001. Median absorption time and length of hospitalization for all patients was 6 days (IQR 5–8) and 17 days (IQR 13–25), respectively.

Conclusion: Radiological findings and clinical characteristics in pregnant women with COVID-19 were similar to those of non-pregnant women with COVID-19. Median absorption time and length of hospitalization in asymptomatic patients were significantly shorter than in symptomatic patients. Lymphocyte percentage and neutrophil granulocyte rate may be used as laboratory indicators of CT absorption.

1 INTRODUCTION

COVID-19 pneumonia first occurred in Wuhan, China, in December 2019 and has since spread rapidly throughout the world. After severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV), COVID-19 was established as a third kind of coronavirus causing severe pneumonia [1,2]. COVID-19 is transmitted by droplets, contact, or orally and has symptoms similar to acute respiratory distress syndrome (ARDS), acute respiratory failure, and other serious complications that pose a huge threat to public health globally [3–6].

COVID-19 is highly contagious and transmits from person to person. As of April 7, 2020, 1214 466 patients worldwide have been diagnosed [7], including pregnant women. Pregnancy may trigger important changes in respiratory functions, both anatomical and physiological, making pregnant women prone to respiratory disease [8]. Pregnant women with COVID-19 pneumonia are more difficult to manage than nonpregnant patients, because drug therapy and intrapartum risk also need to be considered. Past studies have indicated that SARS/MERS infections were found to be associated with severe maternal illness, maternal death, and spontaneous abortion [9–11].

Many current studies focus on the impact of COVID-19 on the general population, with few analyzing its impact on pregnant women. The aim of the present study was to assess the radiological characteristics and clinical presentations of pregnant patients with COVID-19, as well as their correlation.

2 MATERIALS AND METHODS

The present study was approved by the Ethics Committee of the Central Hospital of Wuhan, Tongji Medical College, Huazhong University of Science and Technology. Informed patient consent was waived owing to the study's retrospective nature.

A total of 23 pregnant patients diagnosed with COVID-19 at the Central Hospital of Wuhan were identified retrospectively from the electronic medical records database between December 31, 2019 and March 7, 2020. Patients ranged in age from 21–37 years (median, 29 years). Suspected cases were excluded according to the clinical diagnosis for COVID-19 pneumonia. The study included patients who received low-dose chest CT and had clinical records and laboratory data available.

Diagnosis of COVID-19 pneumonia was based on the Guidelines for the Diagnosis and Treatment of Novel Coronavirus Infection (2019-nCoV) [12], published by the National Health Commission of China (Trial Version 5). All patients in the study had confirmed COVID-19 according to these clinical diagnostic criteria. According to the clinical criteria, four clinical classifications were defined: mild, moderate, severe, and critical [13].

Low-dose CT scanning was performed using Somatom Definition FLASH (Siemens, Erlangen, Germany) or Philips Ingenuity Core128 (Philips Medical Systems, Best, The Netherlands) CT scanners following the chest protocol, where the patient adopted a supine position with arms raised. Each patient was instructed to hold their breath during image acquisition, which included whole lung volume. The slice thickness for

reconstruction was 1.25 mm, and other parameters were set to 120 kV, 30 mA, display field of view (DFOV) 36.0 cm, and matrix 512 × 512.

CT absorption was defined as: (1) reduction in lesion area, (2) decrease in density, and (3) absorption of some solid components.

Based on previously published articles, four stages of lung involvement were defined based on CT imaging at the lung window [14]: (1) early stage, (2) progressive stage, (3) peak stage, and (4) absorption stage. All CT image analyses were performed by two experienced thoracic radiologists (YX, 20 years of experience; XW, 22 years of experience) who were blinded to the clinical information. The image findings were determined according to a consensus.

Statistical analysis was performed using SPSS version 22 (IBM, Armonk, NY, USA). Categorical variables were expressed as numbers (percentages). Continuous variables were expressed as median and interquartile range (IQR) and were compared using the Mann-Whitney *U* test. $P<0.001$ was considered statistically significant.

3 RESULTS

3.1. Clinical characteristics

Data from 23 pregnant patients diagnosed with COVID-19 were retrieved from the medical records. Nineteen (82.6%) patients had been diagnosed using real time reverse transcription–polymerase chain reaction (RT-PCR), while 4 (17.4%) patients who tested negative by RT-PCR were diagnosed as positive according to the clinical diagnostic criteria. Three (13.0%) patients had had close contact with other COVID-19 patients.

According to the classification criteria, the clinical stages of all patients were mild or moderate. The main clinical symptoms included cough (n=6, 26.1%), fever (n=4, 17.4%), and nasal congestion (n=1, 4.3%). Fifteen (65.2%) patients were clinically asymptomatic, out of whom six had threatened abortion or premature rupture of membranes.

Twenty (87.0%) patients were in late pregnancy (≥28 weeks), while three (13.0%) patients were in early pregnancy (≤12 weeks). Eighteen patients were delivered by cesarean section, while two patients had a vaginal delivery. Three patients had voluntarily terminated their pregnancies in the first trimester. Of the 21 neonates, 19 were singletons and two were twins; one neonate had neonatal jaundice. APGAR score for each newborn 5 minutes after delivery was 9–10. Four of the 21 neonates were negative for COVID-19 on RT-PCR, while 17 neonates were negative according to clinical diagnostic criteria following delivery.

All patients had been discharged from hospital, median length of hospitalization was 17 days (IQR 13–25) days, with a range of 6–31 days. Median hospitalization time between asymptomatic and symptomatic patients was 14 days (IQR12-17) vs 25.5 days (IQR 20-26.7); $P=0.055>0.001$. The relevant clinical characteristics of the 23 patients are presented in Table 1.

3.2. Radiological findings

Based on the staging definition of CT images, 15 (65.2%) patients were classified as early stage and 8 patients (34.8%) were classified progressive stage. Three (13.0%) patients demonstrated ground-glass opacity in a single lobe (Figure 1a), with the

smallest lesion diameter at approximately 5 mm. One (4.3%) patient showed ground-glass opacity embodying a symmetrical sphere (Figure 1b). Twenty (87.0%) patients presented with patchy, wedge-shaped ground-glass shadows mainly along the bronchovascular area and lung field with subpleural area (Figures 1c, 1d). One (4.3%) patient had intralobular interstitial thickening with consolidation (Figure 1e), and 2 (8.7%) patients had fibrous stripes (Figure 1f). Six (26.1%) patients had concomitant hydropericardium and/or hydrothorax. Median time to absorption was 6 days (IQR 5–8) days, including reduction in lesion area, decrease in density, and absorption of some solid components. The different characteristics of the findings observed on CT scan are classified in Table 2.

3.3. Correlation between CT manifestations and clinical characteristics

Fifteen asymptomatic patients were in the early stages of disease, with patchy/punctate ground-glass shadows and ground-glass opacity in a single lobe, while three patients demonstrated signs of air bronchus. Eight other patients had abnormal clinical symptoms such as cough, fever, and other symptoms, with consolidation and fibrous stripes in the corresponding CT images. Comparison of laboratory results at first admission and CT absorption revealed that lymphocyte percentage and neutrophil granulocyte rate were significantly different (P<0.001; Table 3). Median absorption time in the asymptomatic group was 5 days (IQR 4–6), while in the symptomatic group it was 10 days (IQR 8–12) days, which was statistically significant (P<0.001).

4 DISCUSSION

In the present study, most pregnant patients were asymptomatic but had clinically threatened or premature rupture of membranes. Three such patients were examined due to their close contact history with COVID-19 patients. The remaining patients had symptoms during pregnancy, such as cough, fever, and nasal obstruction. The clinical characteristics of the pregnant patients with COVID-19 were similar to those of nonpregnant patients with COVID-19, which was consistent with previous studies [15–17]. However, the present study had more asymptomatic patients with COVID-19. Previous reports have shown that patients with SARS tended to experience spontaneous abortion due to intrauterine hypoxia triggered by the virus [9]. In the present study, however, only one patient had fetal distress, although it was unclear whether this was associated with COVID-19 or late pregnancy. Three patients had voluntarily terminated their pregnancy during the first trimester, hence, no evidence was observed regarding COVID-19 pneumonia causing spontaneous abortion.

Studies have indicated that the newborns of pregnant patients confirmed to have SARS or MERS in both early and late pregnancy did not have COVID-19 at birth, with no cases suggesting vertical transmission of the infection from mother to child [18]. However, studies have reported that perinatal COVID-19 infection may confer adverse effects on newborns, causing fetal distress, premature labor, respiratory distress, thrombocytopenia accompanied by abnormal liver function, and even death [19]. In the present study, 21 newborns had negative results on RT-PCR or no abnormal clinical manifestations, and no vertical transmission was noted, which was consistent with Chen et al. [20].

The CT images of the patients showed that they were in early and progressive stages of the disease, illustrating its diversity. Some had intralobular interstitial thickening with consolidation and fibrous stripes, while others manifested ground-glass opacity of symmetrical spheres and concomitant hydropericardium and/or hydrothorax, which is generally similar to nonpregnant patients with COVID-19 pneumonia [14,21]. In addition, the differences in lymphocyte percentage and neutrophil granulocyte rate at admission and CT absorption were significant. Accordingly, these laboratory values could be used as indicators of the absorption time of infected lesions; median absorption time for all patients was 6 days (IQR 5-8). Median period of hospitalization was 17 days (IQR 13–25). Length of hospitalization was significantly shorter in asymptomatic patients compared with symptomatic patients (14 vs 25.5 days, P>0.001)**.** Furthermore, median absorption time was significantly shorter in asymptomatic patients compared with symptomatic patients (10 vs 5 days). Interestingly, in just 3 days, one patient with confirmed COVID-19 diagnosed by RT-PCR who had patchy ground-glass shadows on CT imaging had a significant level of absorption and was hospitalized for only 6 days. The clinical curative effect achieved in pregnant women with COVID-19 was significantly higher than in pregnant women with SARS/MERS infection.

COVID-19 pneumonia in pregnant patients warrants special consideration as CT radiation is a factor in fetal teratogenicity. Although low-dose CT noise was higher than in a conventional chest CT, its radiation dose was about one-quarter to one-third that of a conventional CT scan, which did not affect the final diagnosis of COVID-19 [22]. Therefore, we recommend low-dose CT scans for pregnant women with COVID-19 pneumonia.

In conclusion, the clinical characteristics of pregnant women with COVID-19 pneumonia were classified as mild or moderate, while radiological findings were classified as early or progressive stages, similar to nonpregnant COVID-19 patients. Median absorption time and length of hospitalization in asymptomatic patients were significantly shorter than in symptomatic patients. Lymphocyte percentage and neutrophil granulocyte rate could be used as laboratory indicators for CT absorption. The study's small sample size, as well as the stages of pregnancy for patients during the onset of COVID-19, served as limitations. These issues will continue to garner attention for research in the future.

AUTHOR CONTRIBUTIONS

XW, RS, and XW conceived and designed the study. RS, JC, and SZ contributed to the literature search. XW, XW, and YX contributed to data collection. SZ, XW, and RS contributed to data analysis and data interpretation. JC and XW contributed to the tables and figures. XW and RS contributed to writing of the report.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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FIGURE LEGEND

Figure 1. Transverse thin-section CT scans in pregnant patients with COVID-19 pneumonia. (a) 32-year-old, 38 weeks: ground-glass opacity in the right lower lobe with a diameter of about 8 mm; (b) 28-year-old, 39+1w: bilateral, circular ground-glass opacity in the lower lobes; (c) 30-year-old, 35+4 w: single peripheral ground-glass shadow with air bronchograms in the right upper lobe; (d) 29-year-old, 37+6 w: multiple patchy, wedge-shaped ground-glass shadows mainly along the bronchovascular area and lung field with subpleural area; (e) 33-year-old, 38+6 w, day 5 after onset of symptoms: focal ground-glass shadow associated with smooth interlobular and intralobular septal thickening in the right lower lobe; (f) 28-year-old, 38+5 w, day 6 after onset of symptoms: patchy consolidation and fibrous stripes in the lower lobes.

TABLE 1 Clinical characteristics of COVID-19 infection in 23 pregnant women.

Patient No.	Age, y	Gestational age, w	Primary symptom and duration	Baseline medical history	RT-PCR result	Newborn RT-PCR result (–) or clinical diagnostic criteria	Hospitalization, d
1	27	39	None	None	–	None	16
2	29	37+6	Cough 6 d; fever 3 h	None	+	None	19
3	28	39+1	Threatened abortion	None	–	–	22
4	26	38+5	Nasal obstruction 2 d	None	+	None	31
5	33	38+6	Threatened abortion	Hypothyroidism	–	None	12
6	28	38+5	Cough 2 d	Hepatitis B	+	none	26
7	34	38+3	Premature rupture of membranes	Hepatitis B	+	–	12
8	28	39+1	None	None	+	None	26
9	24	12	Threatened abortion	Pregnancy-induced hypertension	+	None	13
10	32	38	Cough 3D	None	+	None	9
11	37	6	Premature rupture of membranes	Pregnancy-induced hypertension	–	None	15
12	22	8	Fever, cough 1 w	None	+	None	6
13	30	35+4	None	Pregnancy-induced hypertension	+	None	17
14	26	37+3	Fever, cough 3 d	None	+	–	23
15	29	39	None	Contact with infected person	+	None	27
16	21	39+9	None	Contact with infected person	+	–	14
17	26	38	None	None	+	None	15
18	32	31+5	None	Contact with infected person	+	None	17
19	35	37+6	Fever 1 d	None	+	None	25
20	30	40	Fetal intrauterine hypoxia	None	+	None	27
21	36	38+1	None	Pregnancy-induced hypertension	+	None	12
22	30	31+8	None	Hypothyroidism	+	None	25
23	29	37+2	None	None	+	None	16

Abbreviation: RT-PCR, reverse transcription-polymerase chain reaction.

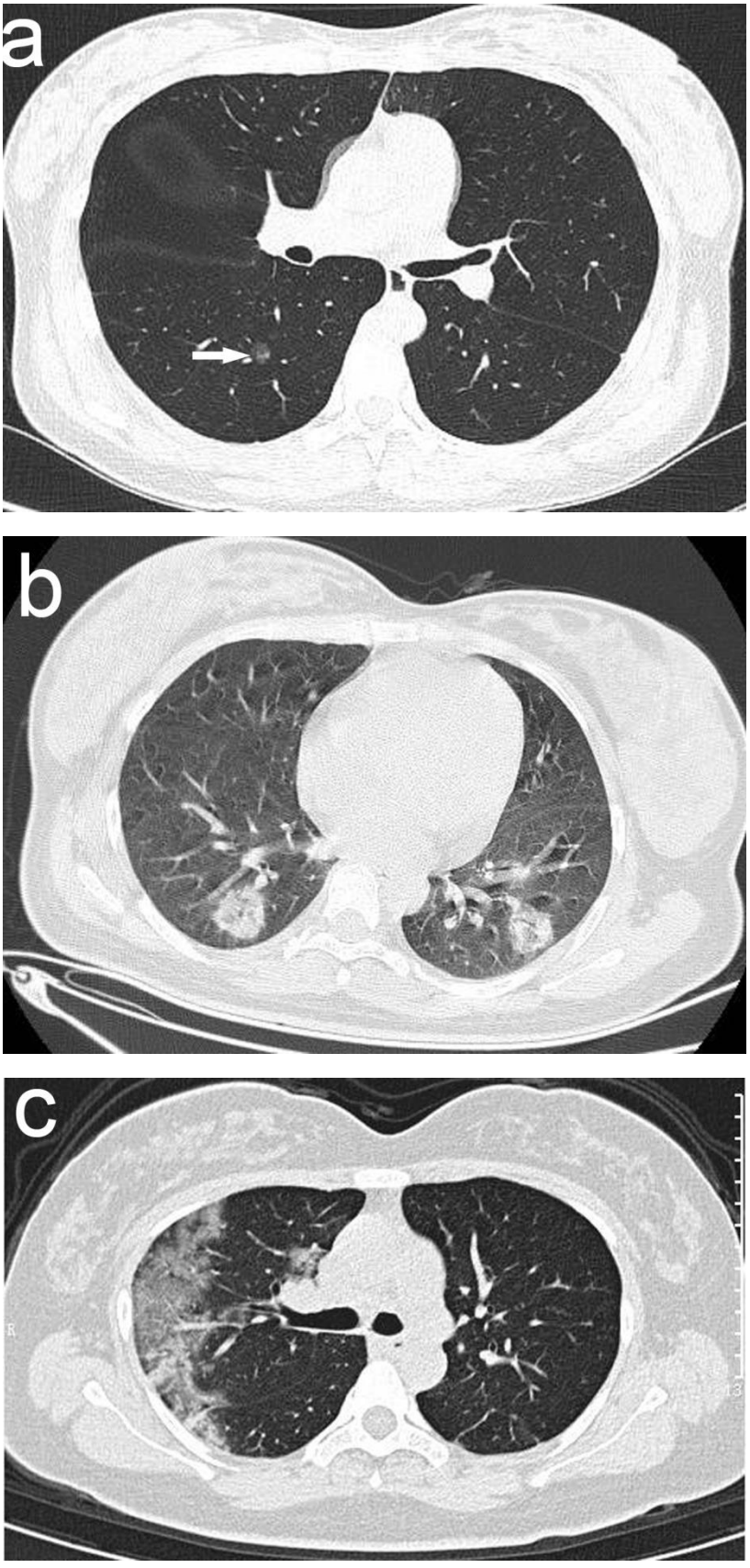
TABLE 2 Radiological characteristics observed in 23 pregnant women with COVID-19 pneumonia.

Characteristics	Number (%)
Shape	
Nodules	3 (13.9)
Patchy	18 (78.3)
Wedge	8 (34.8)
Fibrous stripes	2 (8.7)
Density	
Ground-glass	20 (87.0)
Semi-solid	8 (34.8)
Solid	5 (21.7)
Location	
Subpleural	9 (39.1)
Peripheral area	16 (69.6)
Intermediate area	5 (21.7)
Lung lobe	
Single lobe	9 (39.1)
Multiple lobes	14 (60.9)

TABLE 3 Comparison of laboratory results at two time points in pregnant patients with COVID-19 pneumonia.

Laboratory result	First admission	CT absorption	*P* value[a]
Lymphocyte percentage	77.213 ± 1.416	65.591 ± 1.493	<0.001
Neutrophil granulocyte rate	16.033 ± 0.309	26.030 ± 1.382	<0.001
C-reactive protein	2.975 ± 0.534	1.695 ± 0.310	0.052
D-dimer	4.356 ± 1.376	2.310 ± 0.450	0.128

[a]Mann-Whitney *U* test.



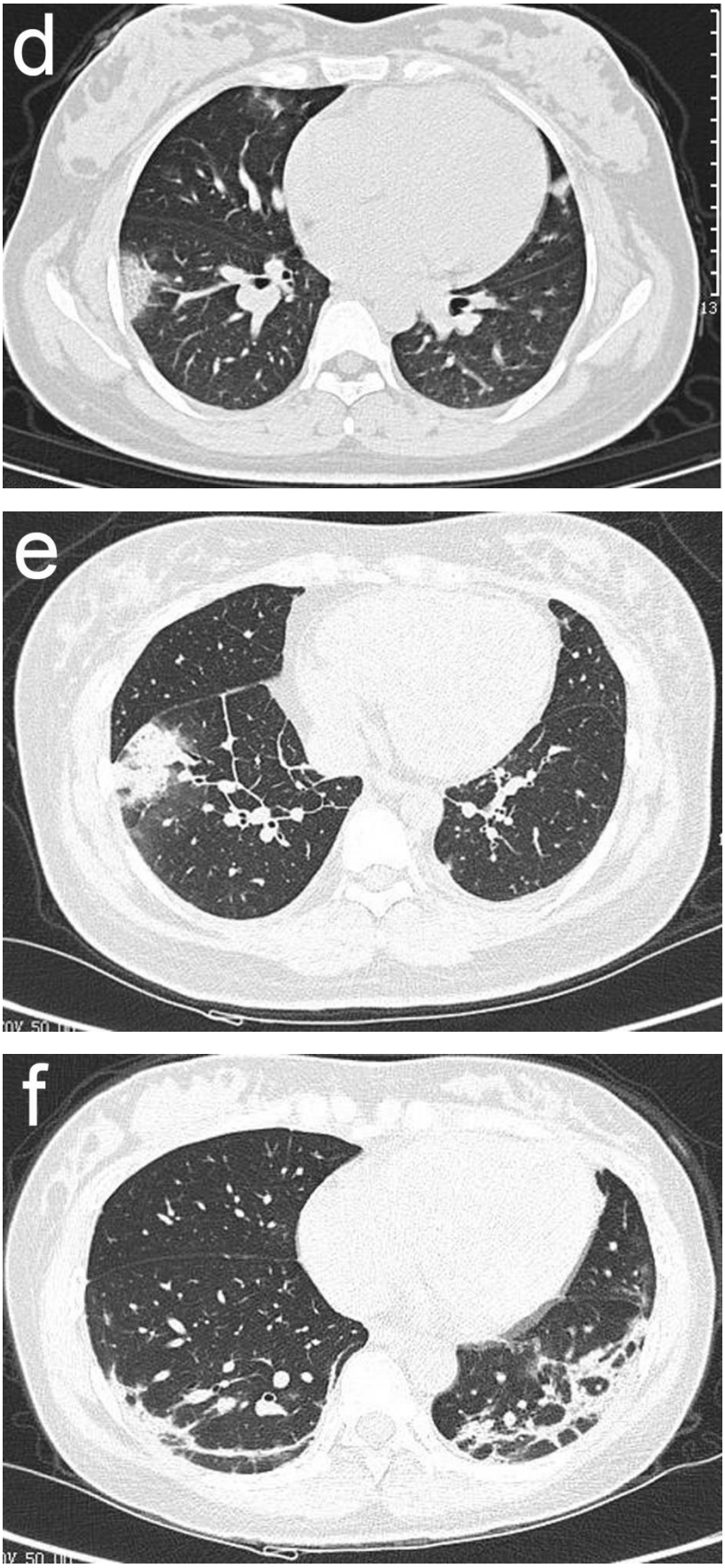


Figure 1