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Clinical and CT findings of adenovirus pneumonia in immunocompetent adults

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Abstract

Introduction: Adenovirus pneumonia is not uncommon in children and immunocompromised patients. However, the study of the clinical and computed tomography (CT) characteristics of Adenovirus pneumonia in immunocompetent adults is still limited.

Objective: The objective of this study was to retrospectively observe the clinical and CT characteristics as well as their dynamic change of Adenovirus pneumonia in immunocompetent adults.

Methods: Twenty patients (18 males, median age, 36 years old) with Adenovirus pneumonia were retrospectively included from January 2018 to December 2019. Clinical information and chest CT at admission of all patients were reviewed. Twelve patients underwent serial CT scans, and the temporal changes of CT findings were summarized. Pneumonia severity index (PSI) was calculated according to clinical information.

Results: The median time interval from illness onset to admission was 6 days (interquartile range [IQR], 5–7.5 days). The clinical characteristics included the high fever ($39.2 \pm 0.8^{\circ}C$) with the normal white blood cell count, the decreased lymphocyte, and elevated C-reactive protein. Ten cases complicated with mycoplasma infection at admission. Thirteen patients were mechanically ventilated, and two patients died during hospitalization. Consolidation was a predominant pattern found during the first 2 weeks and then resolved to minimal consolidation after the fourth week. There was no significant correlation between CT score and PSI score ($r = 0.15$, $p = 0.41$).

Conclusions: Predominant radiological finding of Adenovirus pneumonia was consolidation. Multilobular involvement, higher CT scores, and pleural effusion were found in more severe patients. The abnormal opacity peaked in 2 weeks of illness onset and gradually resolved after the third week. The temporal changes of radiological score are consistent with clinical findings.

KEYWORDS
adenovirus, BALF, CT, pneumonia

1 | INTRODUCTION

Since the novel coronavirus COVID-19 has rapidly evolved into a pandemic, viral pneumonia has once again attracted people's attention. Adenovirus is a non-enveloped, double-stranded DNA virus, which is one of the most common causes of respiratory infections. Adenovirus pneumonia can cause severe respiratory infections in immunocompromised hosts and children,[1] but it has also been increasingly found in immunocompetent adults.[2]

Chest imaging has been considered as part of the diagnostic workup of patients with suspected pneumonia.[3–5] In immunocompromised adults with Adenovirus pneumonia, bilateral interstitial infiltrates, ground-glass opacity (GGO) and consolidation on computed tomography (CT) were reported as the principal imaging findings.[6] However, previous studies of Adenoviral pneumonia have mostly focused on the imaging manifestations during the period of initial and rapid progression to severe pneumonia, whereas temporal changes of Adenovirus pneumonia on CT are quite limited. Moreover, to date, some researchers have focused on semiquantitative CT findings to evaluate the severity of COVID-19, Avian Influenza H7N9 Pneumonia[5,7] while semiquantitative analysis of CT findings for Adenovirus pneumonia and its correlation with pneumonia severity have not been documented. The purpose of the present study was to analyze the clinical and CT characteristics of Adenovirus pneumonia in immunocompetent adults and summarize the temporal changes of CT findings.

2 | MATERIALS AND METHODS

2.1 | Study population

The study protocol was approved by the institutional ethical review board (2020–21-K16). Informed consent was waived because this was a retrospective study. Patients with Adenovirus pneumonia at two hospitals from January 2018 to December 2019 were retrospectively included. Diagnosis of adenovirus infection was confirmed with a positive result to real-time fluorescence polymerase chain reaction (RT-PCR) assay for adenovirus nucleic acid from bronchoalveolar lavage fluid (BALF) when admission. Human adenovirus-7 (HAdV-7) was reported in two patients. Clinical information and outcome were reviewed from medical records of all patients. Pneumonia severity index (PSI) was calculated according to clinical information.[8,9] Patients who had no significant underlying disease were included. Patients who underwent chest CT scan were included. Patients who were younger than 18 years old were excluded. Patients with HIV infection or neutropenia, collagen-vascular disease, receiving immunosuppressive chemotherapy, pregnant, or breastfeeding women were excluded. Patients with organ-transplant, neoplasms were excluded. In the study, duration of disease refers to time in weeks from onset of symptoms.

2.2 | CT scan

Chest CT was performed (Canon CT, Aquilion one and Simens, SOMATOM Definition Dual Source CT, Germany) in two imaging centers using parameters as follows: calibration, 0.5 mm × 80 mm, tube voltage, 120 kVp; automatic modulation tube current; 5.0-mm slice thickness with 5.0-mm gap and 1.0-mm slice thickness with 1.0-mm gap (the latter was used for multiple planar reconstruction).

2.3 | Imaging analysis

All CT images were evaluated by two thoracic radiologists with 5- and 6-year experiences in consensus. In case of disagreement, the third senior radiologist with 20-year experiences in the chest radiology made the final decision. CT findings were evaluated for the type of radiologic pattern[4]: ① parenchymal attenuation disturbances; ② ground-glass opacity (GGO): slightly increased attenuation of the lung parenchyma that is unrelated to the obscuration of the vessels and adjacent airway walls. ③ Consolidation: increased attenuation of the lung parenchyma, resulting in the obscuration of the vascular outlines and adjacent airway walls; ④ nodules and tree-in-bud opacities; ⑤ crazy-paving pattern: defined as interlobular septal thickening superimposed on ground-glass opacities; ⑥ reticulation: thin linear opacities, which correspond to the thickened peripheral connective septa. Distribution: unilateral/bilateral, upper/middle/lower, and central/peripheral/peribronchovascular/random. In addition, the presence of pleural or pericardial effusion, mediastinal lymphadenopathy (defined as a lymph node ≥1 cm in short-axis diameter) was evaluated. For the evaluation of abnormalities distribution, the lung was divided into upper (above the carina), middle (below the carina and up to the inferior pulmonary vein), and lower (below the inferior pulmonary vein) lobes. The parenchymal opacities within each lung zone were evaluated by scoring from 0 (normal) to 4, with 4 corresponding to nearly total involvement of the lung parenchyma and total CT scores ranged from 0 to 24.[10]

2.4 | Statistical analysis

Statistical analysis was performed on SPSS (version 20.0, IBM Corp., Armonk, NY, USA). Continuous variables were expressed as median with interquartile range (IQR) and compared by Mann–Whitney *U* test and categorical variables as number (proportion) and compared by chi-square test or Fisher's exact test. All of those were two-sided test; $P < 0.05$ was considered statistically significant difference.

3 | RESULT

3.1 | Clinical characteristics

A total of 20 patients who were consisted of 18 men and 2 women with a median age of 36 (range, 18–48) years were retrospectively included. The median time from illness onset to admission was 6 days (IQR, 5–7.5 days). Clinical characteristics and laboratory findings of patients on admission were summarized in Table 1. A total of 14 patients took oral antibiotics before admission. Ten cases complicated with mycoplasma infection and *Staphylococcus epidermidis* were found in blood culture of two patients after admission. Thirteen patients underwent mechanical ventilation among whom 11 patients were mechanically ventilated on admission and 2 patients were mechanically ventilated within 2 days due to the rapidly decreased partial oxygen pressure after admission. The other seven patients had no mechanical ventilation during hospitalization. The median length of hospital stay was 17 days (IQR, 12–33 days), while two patients, respectively, died in 7 and 11 days after admission. The season of Adenovirus pneumonia onset mainly was in August and then February (supporting information S1). The median total white blood cell (WBC) count, platelet count, and cholinesterase were in normal levels; the median lymphocyte percentage, lymphocyte count, and PO_2 decreased, while the median neutrophil percentage, C reaction protein (CRP), procalcitonin (PCT), LDH, and CK levels elevated.

TABLE 1 Clinical characteristics of patients with adenovirus pneumonia

Characteristics	Cases
Basic patient characteristics	
Age, median (range), year	36 (18–48)
Sex, M/F	18/2
Symptoms, *n* (%)	
Fever (>37.5°C)	20 (100%)
High fever (>39°C)	11 (55%)
Dry cough	16 (80%)
Myalgia	20 (100%)
Pharyngeal congestion	6 (30%)
Dyspnea	6 (30%)
Diarrhea	6 (30%)
Sore throat	4 (20%)
Dry rales	12 (60%)
Moist	1 (5%)
Combined mycoplasma infection	10 (50%)
Staphylococcus epidermidis infection	2 (10%)
Death	2 (10%)
Underlying conditions, *n* (%)	
Hypertension	2 (10%)
Gallstone	1 (5%)
Kidney stone	1 (5%)
Gout	1 (5%)
Smoking	12 (60%)
Oral antibiotic history before admission	14 (70%)
Laboratory findings (median,IQR)	
Total WBC count ($\times 10^9$ cells/L)	6.47 (5.25–8.13)
Lymphocyte count ($\times 10^9$ cells/L)	0.77 (0.49–1.14)
Neutrophil percentage (%)	80 (71.55–89.25)
Lymphocyte percentage (%)	17.0 (14.0–22.0)
Platelet count ($\times 10^9$ cells/L)	144 (102–166.5)
C reaction protein (mg/L)	54.04 (27.4–103.2)
PCT (ng/ml)	1.63 (0.31–7.71)
LDH (U/L)	387 (273–933)
CK (U/L)	313 (113–880)
Cholinesterase (U/L)	4347 (3799–4642)
PO_2 (mmHg)	75.3 (59.0–89.8)

Abbreviations: CK, creatine kinase; IQR, interquartile range; LDH, lactate dehydrogenase; PCT, procalcitonin; WBC, white blood cell.

3.2 | CT findings of adenovirus pneumonia

All patients underwent chest CT scan on admission, and they had abnormal findings on CT. The initial CT scans were performed after median 5 days (IQR, 3.75–5 days) from the onset of disease. The initial CT findings of Adenovirus pneumonia were indicated in Table 2. The predominant CT finding was consolidation with GGO in 13 patients and consolidation in 7 patients (Figure 1). Parenchymal abnormalities were distributed bilaterally in 10 patients (Figure 1), whereas unilateral involvement was also seen in 10 patients (Figure 1). All patients

TABLE 2 Initial CT findings in adenovirus pneumonia patients

CT findings	Total ($n = 20$)	Group1 ($n = 13$)	Group2 ($n = 7$)	*P*
Parenchymal opacities				
Consolidation	7 (35%)	3 (23%)	4 (57%)	0.174
GGO	0	0	0	
Consolidation with GGO	13 (65%)	10 (77%)	3 (43%)	0.174
Laterality				0.350
Bilateral	10 (50%)	8 (62%)	2 (29%)	
Unilateral	10 (50%)	5 (38%)	5 (71%)	
Zone				0.003*
Multilobular	12 (60%)	11 (85%)	1 (14%)	
Upper	3 (15%)	0	3 (43%)	
Middle	0	0	0	
Lower	5 (25%)	2 (15%)	3 (43%)	
Distribution				N/A
Central	20 (100%)	13 (100%)	7 (100%)	
Peripheral	0	0	0	
Peribronchovascular	20 (100%)	13 (100%)	7 (100%)	
CT scores (median, IQR)	4.5 (2–10.8)	8.5 (3.5–15)	2 (1.8–5)	0.051
Pleural effusion	12 (60%)	11 (92%)	1 (8%)	0.004*
Bilateral	4 (33%)	3 (27%)	1 (100%)	
Unilateral	8 (67%)	8 (73%)	0	
Pericardial effusion	4 (20%)	4 (100%)	0	0.249

Note: *P* values were calculated using the chi-square test.

Abbreviations: CT, computed tomography; GGO, ground-glass opacity. Group1, patients with mechanical ventilation; Group2, patients without mechanical ventilation.

*The difference was statistically significant $p < 0.05$.

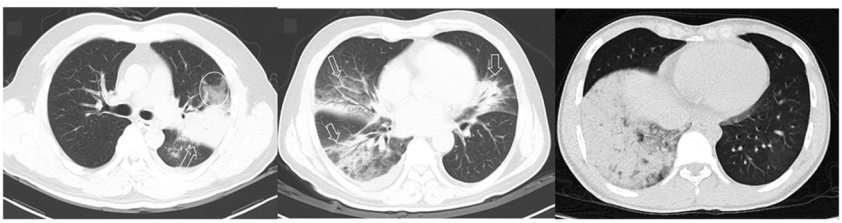

FIGURE 1 CT findings of adenovirus pneumonia. (A) A 48-year-old man with adenovirus pneumonia, multilobular consolidation (arrows) was found in both lungs, and CT score was 13. (B) A 46-year-old man with adenovirus pneumonia combined with mycoplasma infection, lobular consolidation (arrow) with surrounding ground-glass opacity (GGO) (circle) was shown in the left lower lobe, and total CT score was 3. (C) An 18-year-old man with adenovirus pneumonia. Lobular consolidation was shown in the right lower lobe (arrows), and total CT score was 4

showed peribronchovascular and central distribution. Multilobular involvement was found in 12 patients, while upper and lower lung zone predominance were found in 3 and 5 patients, respectively. Pleural effusion was presented in 12 patients, and pericardial effusion was presented in 4 patients (Figure 2). However, neither interlobular septal thickening, honeycombing sign nor crazy-paving sign was found in Adenovirus pneumonia.

Serial CT findings of 12 patients were summarized in Table 3. The predominant patterns on CT changed over time. The median CT score was 21.5 (IQR, 11.5–52.8) in the first week after symptoms onset and then increased

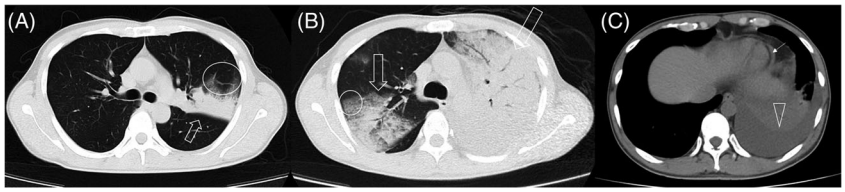

FIGURE 2 CT scans of a 41-year-old man with adenovirus pneumonia combined with mycoplasma infection, and mechanical ventilation was performed in the patient. (A) Initial CT scan showed focal consolidation (arrows) with adjacent ground-glass opacity (GGO) (circles) in the left lower lobe; total CT score was 2. (B) Rapid progression of consolidation in both lung zones (arrows) with surrounding GGO (circles) after 5 days. (C) Left pleural effusion (arrow) and pericardial effusion (thin arrow) was also observed

TABLE 3 Serial CT findings in patients with adenovirus pneumonia

CT findings	Week 1	Week 2	Week 3	Week 4	More than 4 weeks
Consolidation	5 (42%)	3 (33%)	4 (67%)	3 (75%)	5 (71%)
Pure GGO	0	0	0	0	0
Consolidation and GGO	7 (58%)	6 (67%)	2 (33%)	1 (25%)	2 (29%)
Upper lobes	1 (8%)	0	0	0	2 (29%)
Middle lobes	0	0	0	0	0
Lower lobes	5 (42%)	2 (22%)	1 (17%)	0	3 (42%)
Multiple lobes	6 (50%)	7 (78%)	5 (83%)	4 (100%)	2 (29%)
Bilateral/unilateral	7 (58%)/5 (42%)	7 (78%)/2 (22%)	5 (83%)/1 (17%)	4 (100%)/0	2 (29%)/5 (71%)
Pleural effusion	7 (58%)	7 (78%)	5 (83%)	3 (75%)	1 (14%)
Bilateral/L/R	4 (33%)/3 (25%)/0	2 (22%)/4 (44%)/1 (11%)	1 (17%)/3 (50%)/1 (16%)	1 (25%)/2 (50%)/0	0/1 (14%)/0
Pericardial effusion	2 (17%)	1 (11%)	1 (17%)	1 (25%)	0
CT score (median, [IQR])	21.5, [11.5–52.8]	36, [34–48]	21.5, [17.3–37]	19, [12–25]	2, [2–7]

Abbreviations: CT, computed tomography; GGO, ground-glass opacity; IQR, interquartile range; L, left; R, right.

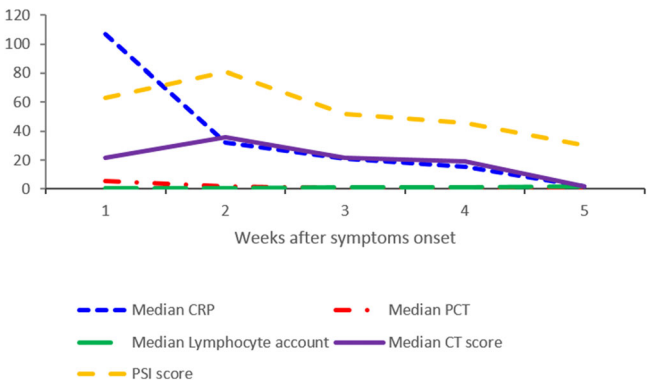

FIGURE 3 Line graph shows median CT scores, pneumonia severity index (PSI) scores, and laboratory findings at various time points in weeks after onset of symptoms. Scores peaked at second week of illness, with a gradual decline in the subsequent weeks

in the second week (Figure 3). Opacity gradually decreased to a median CT score of 2 (IQR, 1.5–7) after 4 weeks. CT scores fluctuated to another peak during the fifth week and then decreased in one patient.

3.3 | Correlation of clinical and CT findings

Neutrophil percentage, lymphocyte, PCT, CRP, PO2 in patients with and without mycoplasma infection, in patients with and without mechanical ventilation were shown in Table 4. There was no significant difference in neutrophil percentage, lymphocyte count, PCT, CRP, and PO_2 between patients with and without mycoplasma infection. Moreover, patients with mechanical ventilation

TABLE 4 Comparison of laboratory findings of patients with adenovirus pneumonia

Laboratory findings	Group1	Group2	U(p)	Group3	Group4	U(p)2
Neutrophil percentage, %	78.1% (IQR, 67.9–89.8%)	80.1% (IQR, 76.8–89.1%)	45.0 (0.74)	89.1% (IQR, 79.9–91.5%)	71.1% (IQR, 67.1–73.9)	11.0 (0.007)
Lymphocyte count ($x10^9$ cells/L)	0.84 (IQR, 0.58–1.13 L)	0.65 (IQR, 0.42–1.19)	31.0 (0.46)	0.58 (IQR, 0.47–0.81)	1.27 (IQR, 1.13–1.79)	13.0 (0.032)
PCT (ng/ml)	1.6 (IQR, 0.45–3.52)	1.65 (IQR, 0.27–12.62)	35.0 (0.67)	4.78 (IQR, 1.45–10.50)	0.11 (IQR, 0.08–0.37)	13.0 (0.045)
CRP (mg/L)	53.9 (IQR, 25.5–93.5)	66.09 (IQR, 27.4–112.4)	35.5 (0.71)	90.6 (IQR, 51.2–129)	30 (IQR, 14.5–51.0)	10.0 (0.008)
PO_2 (mmHg)	75.3 (IQR, 49.8–87.3)	75.2 (IQR, 63.4–93.4)	46.0 (0.78)	63.5 (IQR, 50.0–88.2)	82.3 (IQR, 72.3–94.3)	27.0 (0.16)

Note: Group1, patients with mycoplasma infection; Group2, patients without mycoplasma infection; Group3, patients with mechanical ventilation; Group4, patients without mechanical ventilation; *P* values were calculated using the Mann–Whitney U test, $p < 0.05$, the difference was statistically significant.
Abbreviations: CRP, C reaction protein; IQR, interquartile range; PCT, procalcitonin.

had higher neutrophil percentage, PCT, CRP, and lymphocyte count than patients without mechanical ventilation (Table 4) and there was no significant difference in PO_2 between patients with and without mechanical ventilation (Table 4). Regarding the CT findings, the presence of pleural effusion and involvement of lung zones differed significantly ($X^2 = 9.377$, $p = 0.004$ and $X^2 = 10.70$, $p = 0.003$, respectively) between the two groups (Table 2). Other CT features, such as presence of pure consolidation ($X^2 = 2.32$, $p = 0.174$), consolidation with GGO ($X^2 = 2.32$, $p = 0.174$), laterality ($X^2 = 1.98$, $p = 0.350$), CT scores ($t = 2.06$, $p = 0.054$), and presence of pericardial effusion ($X^2 = 2.69$, $p = 0.249$) did not differ significantly between patients with and without mechanical ventilation (Table 2).

Serial laboratory findings and PSI of 12 patients were indicated in Table 5. Figure 3 showed that there was a decline in CRP, PCT, and PSI, which was consistent with CT scores, while lymphocyte count was increased in contrast. However, there was no significant correlation between CT scores and laboratory findings, including WBC count ($r = -0.31$, $p = 0.33$), lymphocyte count ($r = 0.005$, $p = 0.99$), CRP ($r = -0.09$, $p = 0.80$), and PCT ($r = 0.116$, $p = 0.72$). Moreover, there was no significant correlation between CT score and PSI score ($r = 0.15$, $p = 0.41$).

4 | DISCUSSION

In the present study, we observed the clinical and CT findings of Adenovirus pneumonia in immunocompetent adults and observed the longitudinal changes of Adenovirus pneumonia in the initial and convalescent periods. The most common symptoms and signs of our immunocompetent cases were fever, myalgia, and dry cough, which were consistent with previous reports.[11,12] Most patients had the high fever. The patients also indicated some other symptoms as other studies reported,[2] including dyspnea, diarrhea, pharyngeal congestion, and sore throat. It is generally known that bacterial co-infection is associated with up to 40% of viral respiratory infections and is an important contributor to morbidity in pneumonia.[13] However, Tristan et al. revealed that significant comorbidity was uncommon among patients with Adenovirus pneumonia.[2] In the current study, 10 patients with Adenovirus pneumonia were found to be co-infected with mycoplasma which was similar with a previous study as it reported that co-infection of mycoplasma pneumonia was common in patients with Adenovirus pneumonia.[14] Bacterial co-infections in two cases were lower than the reported 28.5% (47/165) of immunocompetent military trainees with Adenovirus pneumonia.[15]

TABLE 5 Serial laboratory findings in patients with adenovirus pneumonia

Laboratory findings	Week 1	Week 2	Week 3	Week 4	More than 4 weeks
Total WBC count ($\times 10^9$ cells/L)	6.8 (5.2–8.1)	7 (5.5–9.6)	6.9 (5.8–8.6)	7 (6–8.7)	6.5 (5.2–8.3)
Lymphocyte count ($\times 10^9$ cells/L)	0.58 (0.47–0.81)	0.66 (0.43–1.21)	0.93 (0.86–1.23)	1.14 (1.12–1.24)	1.51 (1.28–1.52)
C reaction protein (mg/L)	90.6 (107.0–129.0)	31.9 (18.8–105.5)	21 (13–29)	15.6 (8.8–22.3)	2 (1.5–2.5)
PCT (ng/ml)	4.78 (1.45–10.50)	2.05 (1.21–8.29)	0.44 (0.35–0.77)	0.36 (0.32–4.19)	0.34 (0.211–1.08)
PSI score	63 (47–74)	81 (68–91)	52 (49.25–59.25)	45.5 (37.25–55.75)	30.5 (19.75–45.75)

Abbreviations: PCT, procalcitonin; PSI, pneumonia severity index; WBC, white blood cell.

We speculated that mycoplasma may be the common pathogen of co-infection in Adenovirus pneumonia. Previous studies of pediatric patients in northern and eastern China showed that a peak positive rate of adenovirus infections occurred during winter or spring.[16,17] Yao et al.[18] reported that Human adenovirus among hospitalized children in Beijing was detected in every month throughout the study period from April 2017 to March 2018, peaking in summer. In the current study, summer and winter were peak seasons of immunocompetent adult with Adenovirus pneumonia, which was partially similar with another study that reported seasonal peak for adenovirus infections in winter and spring in immunocompetent patients in Hebei province and Beijing.[19] However, due to the different climatic conditions in different regions, there will be a further observation in multiregion and multicenter.

Consistent with previous studies,[14,20] the baseline laboratory findings include a normal total white cell count, decreased lymphocyte, and increased C reaction protein which suggest virus infection. There were the elevated LDH and CK levels in patients with Adenovirus pneumonia which was similar to a study on an adenovirus-associated outbreak in a Military Training Facility.[11] Furthermore, neutrophil percentage, PCT, CRP, and lymphocyte count in patients with mycoplasma infection were comparable to patients without mycoplasma infection. We think that this is related to a small number of enrolled cases. Another finding is that patients with mechanical ventilation had a higher neutrophil percentage, PCT, CRP, and lymphocyte count than patients without mechanical ventilation, suggesting that the patients who need mechanical ventilation might suffer from the more severe inflammatory reaction.

Different viral pneumonitis sometimes has similar clinical symptoms and laboratory findings, but the imaging patterns have distinguishable characteristics. In immunocompetent adults, the CT findings of respiratory syncytial virus pneumonia, human parainfluenza viruspneumonia, and human metapneumovirus pneumonia usually appeared as multifocal patchy consolidation with GGO, and centrilobular nodules with bronchial wall thickening were also indicated.[3] Influenza pneumonia usually showed confluent consolidation and represent diffuse alveolar damage.[7] In the current study, the most frequent finding on initial CT is bilateral consolidation with GGO, which showed multilobular or peribronchovascular distribution. Consolidation without GGO was the other common CT finding. In immunocompetent military trainees,[15,21] consolidation was more commonly found than GGO in Adenovirus pneumonia patients and the study of community-acquired Adenovirus pneumonia revealed that consolidation, GGOs, and pleural effusions were the most common findings in severe cases.[1,22] A research of Adenovirus pneumonia of five immunocompromised patients showed that the extensive ground-glass opacities with or without consolidation were the main findings on HRCT.[6] In contrast, hyperinflation and lobar atelectasis were reported commonly in infants and children.[3] These suggest that consolidation with GGO in the early stage may be a key clue to suspect Adenovirus pneumonia for immunocompetent patients, although they resemble bacterial pneumonia. A case report and review of the literature reported bilateral interstitial infiltrates were the most common radiographic appearance in Adenovirus pneumonia of immunocompetent adults.[2] However, interstitial abnormalities were not found in the present study, which probably because it was masked by consolidation that appeared early.[23] The presence of pleural effusion and involvement of lung zones differed significantly between patients with mechanical ventilation and patients without mechanical

ventilation. This result is consistent with previous reports regarding prognosis of Adenovirus pneumonia,[19,24] which may be related to more serious respiratory symptoms.

The extent of parenchymal abnormalities in the total 12 immunocompetent patients with Adenovirus pneumonia increased markedly in scores between the first and second weeks after the onset of symptoms, and it was followed by an obvious decline in scores in the third week, but the variation in scores between the third and fourth weeks was not very obvious. These findings were partially consistent with previous studies,[10,19] suggesting that 2 weeks may be a key turning point in Adenovirus pneumonia. However, this was not completely consistent with laboratory findings, which were gradually increased or decreased over time. Moreover, in the current study, there was no significant correlation between the initial CT scores and initial laboratory findings. Taking the above into consideration, it may suggest that the radiographic changes are not synchronized with changes in laboratory indicators. In the current study, the temporal changes of PSI score and CT score were consistent; however, there was no obvious correlation between them. It was reported that PSI score usually paid more attention to the complications of patients and was not strongly correlated with the severity of pneumonia.[25] Most of the patients in this study were immunocompetent without obvious complications, and the CT score mainly reflected the severity of pneumonia, so this may be one of the reasons for the lack of obvious correlation between the CT score and PSI score.

The strength of our research is that all patients with Adenovirus pneumonia were confirmed with a positive finding of adenovirus in BALF; however, there are several limitations. The number of cases is small, which may partly be explained by the low incidence of Adenovirus pneumonia in immunocompetent adults, but we may miss a number of patients with mild Adenovirus pneumonia who were not tested with BALF. Due to the retrospective observation, laboratory tests and the scanning intervals of CT of patients were irregular and not all patients had serial chest CT scans. Another limitation is that no adenovirus serotype was performed at the time of sampling; thus, correlation of radiological findings with adenovirus serotype remains unknown. In further study, a multicenter study to compare the dynamic imaging changes of Adenovirus pneumonia patients with different severity needs to be performed. Because other viral pneumonia tested with BALF in immunocompetent adults were less than adenovirus in our two centers, the difference between Adenovirus pneumonia and other viral pneumonia needs a further study.

5 | CONCLUSION

Adenovirus pneumonia in immunocompetent adults mainly manifested as bilateral significant consolidation with or without ground-glass opacities on CT. Although these findings are not specific for Adenovirus pneumonia, adult patients with high fever, normal WBC count, decreased lymphocyte count, and consolidation with/without GGO on CT may be suspected Adenovirus pneumonia. The abnormal opacity on CT peaked in 2 weeks of illness onset and gradually resolved after the third week. Long-term follow-up with imaging methods was helpful to determine the temporal pulmonary changes of Adenovirus pneumonia.

ACKNOWLEDGMENT

Not applicable.

ETHICS STATEMENT

All procedures were approved by the institutional ethical review board of China-Japan Friendship Hospital (2020–21-K16).

FUNDING INFORMATION

No funding is applicable.

CONFLICT OF INTEREST

We have no any conflict of interests, and we acknowledge an understanding that copyright is being signed over to your journal.

AUTHOR CONTRIBUTIONS

Conception and design (LM and ZPY); analysis and interpretation (ZPY, LM, GXJ, ZL, LBH, WYM, and ZQY); drafting the manuscript (ZPY); reviewing and editing the manuscript (LM). All authors read and approved the final manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

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