Radiological findings of chest in patients with H7N9 avian influenza from a hospital

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Abstract

Objective: To analyze the chest X-ray and computed tomography (CT) findings of human infection with avian-origin influenza H7N9 virus from a hospital.

Materials and methods: Chest X-ray or CT was performed in five patients with H7N9 avian influenza within 2 weeks after onset. The chest imaging data and characteristics of five patients were analyzed retrospectively.

Results: Abnormal findings were shown on chest X-ray and CT images in all of the patients. The main abnormal findings included ground-glass opacities (GGOs) in all five cases, consolidations with air bronchograms and pleural effusion in four patients. In the early onset of four patients, the right lobe was more commonly affected (particularly in the right lower lobes). Over the course of disease, the lesions were rapidly progressed to bilateral lungs, and from focal or multifocal to diffuse. Ipsilateral pleural effusion also appeared and developed with the coexisting consolidation. Imaging findings closely reflected the overall clinical progression and severity of the disease.

Conclusion: With the right lower lobe prominence, the main abnormal findings in H7N9 pneumonia include rapidly progressive GGOs, consolidations with air bronchograms, and pleural effusion. CT imaging may provide a more accurate assessment of the lung pathology with H7N9 avian influenza, helping the early diagnosis and monitoring its progression.

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Keywords: H7N9 avian influenza; Computed tomography; X-ray; Radiography

1. Introduction

The first outbreak of human avian influenza A (H7N9) infection occurred in March 2013 in China and this novel reassortant virus was initially isolated from throat-swab specimens collected from three patients [1]. Since then, new cases of H7N9 infection were continually reported in China [2]. Infections with H7N9 influenza virus, which usually occur after recent exposure to birds or wild poultry [3], commonly present with acute onset, rapid progression, poor prognosis and high mortality rate [1]. Fever and cough with sputum production are the initial clinical manifestations [3−5]. The condition of the H7N9-infected patients deteriorates rapidly with acute respiratory distress syndrome (ARDS), multiple organ failure and even death [1,3−6]. Hence, early diagnosis and early antiviral treatment are significantly critical to improve clinical prognosis of the patients with H7N9 avian
influenza. Magnetic resonance imaging (MRI) can acquire both anatomic and functional assessments and lots of MRI techniques for tissue perfusion have been developed [7]. However, the imaging of pulmonary inflammation still mainly depends on X-ray or computed tomography (CT). Chest X-ray and CT findings, along with clinical manifestations and laboratory results provide clues for the diagnosis of the disease. In this study, we analyzed the radiologic findings of patients with avian influenza H7N9 pneumonia who admitted to our hospital.

2. Materials and methods

2.1. Clinical patients

In February 2015, five patients with positive oropharyngeal specimen for H7N9 infection tested by the local Center for Disease Control and Prevention (CDC) were treated in our hospital. The five patients were all males with age range from 29 to 59 years (mean ± SD, 41.4 ± 12.92 years). All the patients were hospitalized with 4- or 7-day history of fever with the temperature of 38.5–39.5 °C, cough and white sputum but sometimes with blood streak. One had a clear history of exposure to live poultry, whereas all others denied. One patient had coexisting medical disorders such as hypertension, gout, and type 2 diabetes, and two had none but type 2 diabetes. Laboratory testing results of all patients at admission showed the normal White blood cells (WBC) count, lymphocytopenia, and elevated levels of serum lactate dehydrogenase (LDH), high-sensitivity CRP (HS-CRP) and creatinine kinase (CK). The clinical data and laboratory results of these 5 cases are presented in Table 1.

2.2. Radiologic findings and analysis

The interval between the onset of symptoms and the initial imaging scan ranged from 4 to 8 days (mean, 4 days) for CT in four patients (case 1–4), and was 4 days for chest anteroposterior X-ray in 1 patient (case 5). Chest bedside anteroposterior radiography was then ordered every 1 or 2 days to monitor disease progression and treatment response in three severe patients (case 2, 3, and 5). The radiological characteristics, such as lesion patterns, distribution, lung lobes involved, pleural effusion, and follow-up, were investigated. Ground glass opacity was defined as hazy increased opacity of lung, with preservation of bronchial and vascular margins on CT or indistinct outline of pulmonary vessels on chest X-ray [8]. Consolidation was defined as a homogeneous increase in pulmonary parenchymal opacity that obscures the margins of vessels and airway walls [8].

3. Results

Abnormal findings were shown on chest radiological images in all patients. The chest CT or X-ray imaging within 4–7 days after the onset of symptoms could demonstrate the unilateral or bilateral multi-segment or lobar pulmonary exudative lesions. Table 2 shows the initial radiological findings of these 5 patients with H7N9 virus infection. Two patients began with just unilateral one-lobe involvement, the right lower lobe in case 2 and case 4. Moreover, the lesions mostly involved the left lower lobe in case 1 and the right upper lobe in case 3 in the initial CT results. The most common findings were ground glass opacities (GGOs) in all the five patients, consolidation with air bronchogram and ipsilateral pleural effusion in four patients (case 1–3, 5). The involvement of case 1 progressed to bilateral multi-lobe distribution within 12 days after the onset, but the extent began to decrease 7 days later during treatment. The condition of case 2 deteriorated rapidly and progressed to septic shock on day 7 after onset and acute respiratory distress syndrome (ARDS) on day 8. The series of follow-up bedside chest X-ray demonstrated bilateral diffuse pulmonary distribution and right pleural effusion on day 8 and subsequently daily increased GGOs and consolidation (Fig. 1). Case 3 began from the right upper lobe on day 4 and rapidly progressed to right-side pulmonary diffuse distribution on day 7 and the left lower lobe was involved as well on day 10. Also, right pleural effusion appeared on day 7 and developed during the course.

Table 1
Summary of clinical information for patients with H7N9 avian influenza.

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
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<tr>
<td>Age</td>
<td>29</td>
<td>33</td>
<td>59</td>
<td>35</td>
<td>51</td>
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<tr>
<td>Time of admission (days after onset)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>4</td>
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<tr>
<td>Poultry exposure</td>
<td>Yes</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
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<tr>
<td>Smoke</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Coexisting disorders</td>
<td>Type 2 diabetes</td>
<td>No</td>
<td>Hypertension, Gout, Type 2 diabetes</td>
<td>No</td>
<td>Type 2 diabetes</td>
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<tr>
<td>Temperature (°C)</td>
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<td>39.5</td>
<td>39.5</td>
<td>39.5</td>
<td>38.5</td>
</tr>
<tr>
<td>Cough</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sputum</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>WBC</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
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<tr>
<td>Lymphocytes</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Decreased</td>
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<tr>
<td>LDH</td>
<td>Increased</td>
<td>Increased</td>
<td>Increased</td>
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<td>HS-CRP</td>
<td>Increased</td>
<td>Increased</td>
<td>Increased</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>CK</td>
<td>Increased</td>
<td>Increased</td>
<td>Increased</td>
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Table 2
X-ray or CT findings of patients with H7N9 virus infection.

<table>
<thead>
<tr>
<th>Case</th>
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<th>3</th>
<th>4</th>
<th>5</th>
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<tr>
<td>GGO</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Consolidation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Pleural effusion</td>
<td>No</td>
<td>Right</td>
<td>Right</td>
<td>No</td>
<td>Bilateral</td>
</tr>
<tr>
<td>Air bronchogram</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Initial involved lung zone</td>
<td>Left lower lobe</td>
<td>Right lower lobe</td>
<td>Right upper lobe</td>
<td>Right lower lobe</td>
<td>Bilateral diffuse distribution</td>
</tr>
<tr>
<td>Predominant site</td>
<td>Left</td>
<td>Right</td>
<td>Right</td>
<td>Right</td>
<td>Bilateral</td>
</tr>
</tbody>
</table>

After 6-day hospitalized treatment, the chest CT imaging of case 4 showed the remarkable decrease in the area and opacity of the lesion in the right lower lobe with improvement of correlative clinical symptoms and negative oropharyngeal specimen, and then the patient discharged (Fig. 2). The chest X-ray of case 5 at admission showed the bilateral pulmonary involvement which presented as diffused and mixed pattern of GGOs and consolidation along with bilateral pleural effusions. The daily bedside chest X-ray were performed and demonstrated significant increase in both size and opacity of the lesions with more extensive bilateral GGOs and consolidation. The bilateral pleural effusions also progressed. Septic shock, ARDS, and multi-organ failure occurred in succession and the patient finally died.

4. Discussion

H7N9 is a novel, reassortant subtype of avian influenza A virus, with which human can be infected by direct contact with live poultry. One of our patients reported the exposure history but the rest denied. This may indicate existing another transmission route. All the five patients presented with high fever, cough, sputum with blood streak sometimes, and positive laboratory results, such as elevated CK and LDH levels, low
lymphocyte counts, but normal total white cell counts. The above presentations are similar to previous reports [3–5,9]. Moreover, diabetes and old age are two of the predisposing conditions for the infection with influenza A [10]. Three of our patients have coexisting type 2 diabetes, but the younger one had a better prognosis and discharged after treatment. Large area of pulmonary exudative lesion involving multiple segments or the whole lobe was observed on CT or X-ray in all the five cases in the early stage (within 4–7 days after the onset).

In our cases, the most common initial radiological findings of the avian influenza A (H7N9) were unilateral or bilateral GGO (5 cases) and area of consolidation with air bronchogram (4 cases). Most cases were presented with a mixed pattern of GGO and consolidation, which is consistent with those previous reports [9,11–14]. For instance, Wang QL et al. [11] reported 12 patients with H7N9 virus infection and radiological findings included GGOs (in 12 of 12 patients), consolidations (in 11 patients), air bronchograms (in 11 patients).

Previous studies stated that patients with viral pneumonias characterized with consolidations on CT have a more severe clinical prognosis than those with GGOs [15,16]. Moreover, Feng F et al. observed that the mortality patients had more extensive consolidations than the survivors [17]. In our cases, the follow-up bedside chest X-ray of two patients (case 2 and case 5) revealed the progression of increased size and opacity of bilateral diffusive consolidation along with the severe clinical course. Their clinical course deteriorated with acute respiratory distress syndrome (ARDS) and one patient (case 5) even died of multiple organ failure. However, another patient (case 4) presented with mild symptoms and a big area of GGO on CT finally discharged with negative oropharyngeal specimen after treatment. Therefore, in our view, the proportion of GGO to consolidation which was monitored by follow-up chest X-ray or CT may be closely related to the progression and severity of clinical disease. The more consolidation, the severer condition and poorer prognosis.

In addition, the initial radiological findings of our 5 patients manifested a prominent single-lobe lesion in 4 patients, right lung prominence in 3 patients. Also, a larger probability (2/3) of lower lung lobe involvement than the upper (1/3) was suggested, which was consistent with previous reports which have showed that the right lung was more commonly affected [11–13]. A previous 12-patient analysis [11] stated that all patients had involvement of three or more lobes, with predominant distribution in the right lower lung. This

![Fig. 2. Case 4. A and B: CT sectional and coronal views on day 7 after onset at admission show large area of ground glass opacity involving the right lower lobe. C and D: Follow-up CT scan after 6 days shows the decreasing pulmonary lesion.](image)
phenomenon may be contributed to the patient’s position and anatomical structure of the right bronchus which is short and straight for the causative virus to land easily.

Moreover, bilateral or unilateral pleural effusion was also reported in the previous studies [11,17–19] and stated to be associated with the severity of the disease [19,20]. We had one severe patient (case 5) who presented with progressive bilateral pleural effusion accompanied increasingly deteriorating condition. The patient was given left-sided chest drainage, but finally died of multiple organ failure. Unilateral pleural effusion appeared in another two patients (case 2, 3) as well on the progression but decreased on the mend. Although a previous study with 12 cases showed no significant connection between pleural effusion and mortality in H7N9 influenza pneumonia [11], we believe that pleural effusion still reflects the progression of the illness, which is similar to consolidation, based on our patients’ prognosis.

However, all the image findings in our patients above are nonspecific, and GGOs and consolidation are also the most common radiological findings in patients with H1N1 or H5N1 influenza pneumonia [21,23,24]. Pleural effusion was also discovered in other type of viral pneumonia [22,23,25]. However, the clinical course of human H7N9 infection was severe and progressed rapidly, with large multi-segment or lobar exudative lesions observed on the early-stage chest radiological imagings. In contrast, most H1N1 patients had mild illness and some cases showed the normal initial chest radiograph [25]. H5N1 infection also commonly could cause a rapidly progressive pneumonia and sequent ARDS or multi-organ failure [23]. Thus, the differential diagnosis must rely on virus detecting. Moreover, the exhibition of diffuse parenchymal involvement in H7N9 pneumonia might help to exclude community-acquired pneumonia [10,26].

5. Conclusion

In conclusion, the most common patterns of chest radiological findings for H7N9 influenza cases are GGOs, consolidations with air bronchograms and pleural effusion, with right lower lobe predominance. The imaging findings are related to the progression and severity of the clinical condition. They may provide a clinical evidence for assisting in the early diagnosis of avian influenza (H7N9) and monitoring its progression.

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References


