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Review

Chest CT features and their role in COVID-19

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Abstract

Since December 2019, the novel coronavirus disease (COVID-19) has spread rapidly throughout China. This article reviews the chest CT features of COVID-19 and analyzes the role of chest CT in this health emergency.

Keywords: COVID-19; Computed tomography; Chest; Imaging features

1. Introduction

In December 2019, a novel pathogenic human coronavirus, called 2019 novel coronavirus, was identified in Wuhan, Hubei Province, China [1]. It can achieve human-to-human transmission between close contacts, and can cause serious coronavirus disease (COVID-19), especially pneumonia [2–4]. On January 30, 2020 the World Health Organization (WHO) announced that the outbreak of COVID-19 has become a Public Health Emergency of International Concern, and further declared it a pandemic on March 11, 2020. Although the Chinese government has adopted timely and effective measures to prevent and control the spread of COVID-19, the scope and effect of this outbreak is rapidly evolving [5]. As of March 20, 2020, there were 81,263 confirmed cases, 3250 deaths and 70,560 recovered cases in China. Thanks to its high-resolution and lack of the overlap of organizational structures, chest computed tomography (CT) is an important noninvasive examination for the diagnosis of lung disease. The aim of this article is to review the chest CT features and analyze its value in this COVID-19 pandemic.

2. Chest CT features of COVID-19

To date, many descriptive studies and case reports have focused on the CT manifestations of COVID-19 [6–14]. According to the literature, the typical findings of chest CT images of individuals with COVID-19 are multifocal bilateral patchy ground-glass opacities (GGOs) or consolidation with interlobular septal and vascular thickening, mostly in the peripheral fields of the lungs. The respective incidence rate of GGOs and consolidation are about 86% and 29% [15]. The most common morphology of these opacities are patchy and round ones, followed by triangular and linear ones [16,17]. The triangular or angular GGOs under the pleura with thickened internal interlobular septa is considered a new sign that one research paper has termed the “spider web” [17]. Special classic signs, including “crazy paving” or “reverse halo”, can also be seen, while cavitation, nodules, pleural effusions, and lymphadenopathy are rare.

CT findings can change as the disease progresses. In the early stage, chest CT shows small lobular and subsegmental patchy GGOs, interstitial changes, and thickening vascular lumens throughout. Notably, 20/36 (56%) of early patients (0–2 days after the onset of symptoms) had a normal CT finding in a recent study [16]. In the progressive and peak stage, the lesions gradually progress to multiple GGOs in the

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lungs, and some patients may have dense consolidation in the lobes. The interlobular septum in GGOs becomes thickened, similar to the “crazy paving” sign. In severe cases, patients may have diffuse lesions in both lungs, some showing as “white lung”. Air bronchogram and blood vessel penetration signs are common. In the absorption or remission stage, the GGOs and consolidation resolves with no “crazy paving” sign, and subpleural parenchymal fibrosis lesions can be seen. Therefore, CT can both indicate disease evolution and evaluate the clinical severity and extent of COVID-19 [17−23].

These manifestations are also compatible with other viral pneumonias, especially Severe Acute Respiratory Syndrome (SARS) coronavirus, which was first detected in China's Guangdong Province in late 2002 [24,25]. Different viral pneumonias, in fact, share many nonspecific overlapping imaging features. Given this, CT alone can often differentiate and confirm the etiology of pneumonia with difficulty. This shows the limitation of imaging. However, where the differential diagnosis is between COVID-19 and non-COVID-19 viral pneumonia, radiologists from China and the United States have had high specificity but moderate sensitivity according the most recent research [26]. This suggests that a negative diagnosis of COVID-19 may exclude patients who in fact have COVID-19. Diagnostic mistakes have often been made when the chest CT findings are either subtle in the early stage of COVID-19 or when the chest CT findings are atypical. Epidemiological factors such as contact exposure to sick individuals and clinical information should be used to support the diagnosis.

Due to then general inaccessibility of autopsy and biopsy findings, there remains a lack of research into the correlation of pathology and radiology; nevertheless, there are a small number of pathological case reports. In a report of two cases who underwent surgery for lung adenocarcinoma and were retrospectively found to have had COVID-19, the accidental histologic results revealed alveolar edema, proteinaceous exudates, focal reactive hyperplasia of pneumocytes with inflammatory cellular infiltration, and multinucleated giant cells [27]. There were no prominent formations of hyaline membranes, which may indicate that these cases were in the early stage of COVID-19. In a report of one death with biopsy, the histological examination showed bilateral diffuse alveolar damage (DAD) with cellular fibromyxoid exudations, and pulmonary edema with hyaline membrane formation [28]. From the two articles, we can speculate that the pathological findings of COVID-19 are interstitial pneumonia with edema in the early stage, and combined DAD in severe cases. These features may be the pathological basis of GGOs and consolidations in the radiological findings of COVID-19.

3. Role of chest CT in the diagnosis and follow up of COVID-19

As there are currently no specific antiviral drugs to treat COVID-19, so early detection and adherence to medical isolation becomes essential. As an etiological diagnosis, the positive result of reverse transcriptase polymerase chain reaction (RT-PCR) test in laboratory for respiratory specimens is considered the practicable gold standard for COVID-19 diagnosis [10,29]. However, the RT-PCR test itself also has limitations. First, false-negative results can occur with the RT-PCR test because of, for example, incorrect sampling location of the swab test, and insufficient viral material in the specimen or procedural error. Therefore, the RT-PCR test for COVID-19 is considered to have high specificity but sensitivity has been reported to be as low as 59 %−71% [30,31]. Second, the RT-PCR process is time-consuming. Third, at the beginning of the epidemic outbreak, shortages in test kit supplies meant the needs of the large number of people in Wuhan and Hubei Province could not be met. The result of such limitations may be the delay of medical isolation and the transmission of infection.

CT examination, however, can compensate for the above shortcomings and play an important auxiliary role in the diagnosis and subsequent management of COVID-19 patients. First, CT can decrease the chance of false-negative results in the RT-PCR assay. CT is more sensitive than initial RT-PCR (98% vs. 71%, and 88% vs. 59%) according to two recent reports, and many suspected patients with atypical CT findings but a negative RT-PCR test have been found [30−33]. Therefore, it is necessary to repeat the swab test for such patients. Second, since CT equipment is widespread in China and the CT scan process is relatively simple and quick, CT can be used as a rapid screening tool for suspected patients in the severe epidemic center when RT-PCR results are unavailable. It is suggested that in emergencies, patients whose CT findings show COVID-19 may be first medically isolated and later undergo RT-PCR testing to confirm the diagnosis. This conforms to the principle of “early detection and early isolation” for infectious diseases. In brief, a combination of RT-PCR and CT may be more helpful for the diagnosis and management of individuals with COVID-19.

CT can be used as a follow-up tool to monitor the disease evolution and evaluate the severity of COVID-19 patients for its invasiveness and objectivity. Furthermore, CT can predict the prognosis. Imaging appearance of bilateral lung involvement is regarded as an additional index and account for the highest score in MuLBSTA system (multilobular infiltration, hypo-lymphocytosis, bacterial coinfection, smoking history, hyper-tension and age) for predicting the mortality in COVID-19 patients compared to other virus pneumonia [34,35]. In the Chinese National Health Commission's recently released “Program for diagnosis and treatment of novel coronavirus pneumonia (trial version 6)”, patients with obvious lesion progression greater than 50% are to be treated as severe cases. However, how to accurately evaluate disease scope with CT imaging is a problem. This is where artificial intelligence (AI) may be a good new technique to quantitatively evaluate the disease [36].

4. Potential risk of chest CT in COVID-19

It is important to note that the wide application of CT scans may generate potential risks such as false-positives in

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cases of pneumonia not caused by the novel coronavirus. However, in the epidemic area, the positive predictive value of CT will be markedly improved. Furthermore, the high specificity of RT-PCR can compensate for the low specificity of CT. Exposure to radiation is also a potential risk in the application of CT: low dose scan mode or techniques are suggested, especially for children and pregnant women. Another risk of concern is cross-infection during the scanning process: strict protective measures during the scan process are very important, and it is best to use a dedicated CT scan machine for suspected patients. Despite the limitations above, CT still plays an important role in the detection, diagnosis, assessment of disease scope and severity, follow-up assessment and in predicting prognosis [37].

In conclusion, the CT features of COVID-19 include bilateral GGOs with crazy-paving pattern and consolidation in the lung periphery. CT plays a crucial auxiliary role in both diagnosis and follow up in this health emergency.

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