Review Article

An Overview on X-Ray Diagnostic Findings in Covid-19 Patients

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Abstract

Coronavirus has widely spread around the world in a short time. The disease is caused by the novel SARS-COV-2 virus that targets mainly the respiratory system, with manifestations ranging from asymptomatic or mild symptoms to severe bronchopneumonia and impaired respiratory system. The definitive diagnosis is reverse-transcriptase polymerase-chain-reaction assay (RT-PCR). Imaging aids in the evaluation and assessment of the disease progression, with CT scan being superior to other modalities. Chest X-ray has lower efficiency than CT scan, particularly in the early stage of the disease. However, it can be useful in the emergency setting and high influx of patients, and limited resources. We aimed to review the literature for the role of chest imaging in the diagnosis and assessment of disease severity of COVID-19, in comparison with CT imaging. PubMed database was utilized for articles selection, and selected papers had undergone a thorough review. Chest imaging plays an important role in the evaluation assessment of the disease severity of COVID-19 individuals. CT scan is superiorly effective to other radiological tools in assessing the disease progression. While CXR is lower than CT in this aspect, it is still appropriate to use when CT is not applicable in an emergency, or high load of patients, or when it is unavailable.

Keywords: COVID-19, SARS-COV-2, Coronavirus, X-Ray findings

Introduction

Coronavirus has become a terrifying and challenging disease for the world over the past few years [1, 2]. It is caused by severe acute respiratory syndrome coronavirus-2 (SARS-COV-2), inflicting high morbidity and mortality globally [3, 4]. This has made the World Health Organization (WHO), on March 11, 2020, declare it as a pandemic that needs to be urgently dealt with internationally [5]. The number of confirmed cases has surpassed 170 million cases, including over 3 million deaths globally. In Saudi Arabia, there have been 450,436 confirmed cases, including 7,362 deaths reported [5]. The disease is highly contagious and it can even transmit from an asymptomatic patient during the incubation period, causing severe bronchopneumonia and ultimately respiratory failure [6, 7]. Due to the severity of the disease, social distancing and quarantine for affected individuals have been imposed to break the chain of transmission. In this paper

Materials and Methods

We utilized the PubMed database for the selection process of relevant articles, and the following keys were used in the mesh ((“COVID-19"[Mesh]) AND (“Chest X-ray"[Mesh] OR "Diagnosis"[Mesh] OR "Evaluation"[Mesh])). For the inclusion criteria, the articles were selected based on including one of the following: COVID-19 or COVID-19 chest X-ray imaging, evaluation, and diagnosis. Exclusion criteria were all other articles that did not meet the criteria by not having any of the inclusion criteria results in their topic.

Results and Discussion

To make a definitive diagnosis of COVID-19 infection, the standard diagnostic technique is the reverse-transcriptase polymerase-chain-reaction assay (RT-PCR). Although it is the standard test, it has many drawbacks. The limited capacity of the specimens, the need to develop and mass-produce the specimens, and the distribution around the world make the test hindered to be used effectively on clinical grounds [8]. The RT-PCR has high sensitivity and specificity to detect the virus and differentiate it from other common respiratory

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viruses that mimic it, however, it is affected inversely by many factors when applied clinically. These include the availability of the specimens, the handling process, and the stage of the infection in which the specimens were obtained at [8, 9]. Moreover, false-negative results can come out even if the test was carried out perfectly because it is still not a perfect test. Patients with milder symptoms can get false-negative results when the test is taken in an early stage of the disease [10].

Imaging Modalities

Radiological investigations help enormously in the diagnosis and management of COVID-19 individuals. The most effective modality in the detection of lung abnormalities associated with the virus is Computed tomography (CT) imaging. Interestingly, it can detect the pulmonary pathologies superiorly to other imaging techniques, especially in the early stage of the infection. Furthermore, it gives an excellent assessment of the disease progression [11, 12]. The pathologies detected by the CT scan include consolidation and ground-glass opacities that are usually bilateral, extension to the lower lobes, central and peripheral distribution. Moreover, it can detect pleural effusions and thickenings, and lymphadenopathy [13, 14]. Notably, the repetitive use of CT scans for the assessment of progression, from the time of diagnosis to the time of discharge, is hard to afford over time. This is attributed to the increasing number of hospitalized patients, and the requirement for strict adherence to the infection control protocols [15].

On the other hand, chest X-ray (CXR) is only second to CT scan in the detection of lung pathologies, particularly in the early stage of the infection. Nevertheless, in the emergency setting, it can be helpful in the constant assessment of the disease progression in critical cases like those in the intensive care units [8, 16]. The use of CXR is advantageous in that it is portable and can be used at the bedside. In emergency settings and increase load of patients and resource constraints, it can be utilized to establish the diagnosis and set up a management plan. Also, portable CXR can be used against glass walls to reduce the spread of infection [8, 15]. Pulmonary pathologies detected by CXR are similar to CT scan and include consolidation and ground-glass opacities that can be bilateral and peripheral, pleural effusions and pulmonary infiltrates [16].

Lung ultrasound (US) is another modality that aids in the triage and management of COVID-19 patients. It is below CXR in the terms of sensitivity, however, it is similar to CXR when it comes to portability and reduces the chance of spread of infection. Lung abnormalities that the US comprise of subpleural and alveolar consolidations, thickened pleural lines, and localized pleural effusions. Furthermore, it addresses organ involvement and complications. Cardiac ultrasound detects cardiac abnormalities attributed to COVID and includes abnormal wall motion, LV dilation and dysfunction, RV changes, thickened pericardium, and pericardial effusion, and IVC changes associated with pulmonary embolism. Vascular ultrasound describes congestion and thrombosis status. For congestion, it identifies congestion in the hepatic, portal, and intra-renal veins. For the thrombosis, it detects vein thrombosis in multiple locations, such as the common femoral, superficial femoral, and popliteal veins [17, 18].

Role of Chest X-ray Imaging

Although CXR imaging has a diminished sensitivity when it comes to detecting the early stage of the infection, it is still can be used to keep an eye on the disease progression. Few scoring systems have been developed and implemented to define the severity of the disease. SARI chest X-ray severity scoring system was developed by *Taylor*. in 2015. The goal was to come up with a scoring system that can be utilized by non-radiological physicians to monitor individuals with acute pulmonary diseases. The system is comprised of five clinical grades. It is categorized as 1. No abnormality, 2. Manifest patchy atelectasis and/or hyperinflation and/or bronchial wall thickening; 3. manifest focal consolidation; 4. manifest multifocal consolidation; and 5. manifest diffuse alveolar changes [19]. Another scoring system was described by *Wong*. in March 2020, named as RALE classification. The goal of the system is to correlate the severity of CXR findings with the RT-PCR test results. The system has four score points based on the extension of consolidation or ground-glass opacity in both lungs. The score points are (0: no extension; 1: less than 25%; 2: from 25% to 50%; 3: from 50% to 75%; 4: more than 75% extension) [20, 21]. The only system to date for assessing the CXR findings of COVID-19 severity is the scoring system described by *Borghesi* and *Maroldi* in March 2020. They divided the lungs into three zones: upper zone, middle zone, and lower zones based on anatomical positions. Then, the score is assigned to each zone based on the lung pathology of interstitial infiltrates, interstitial predominance, or alveolar predominance [22].

Clinical Scenarios of COVID-19 Patients

One study has described three clinical scenarios that explained imaging-related predicaments that arise in clinical presentations of COVID-19 patients, with regards to risk factors and availability of resources [5]. The first scenario describes patients with mild symptoms. If the COVID-19 test status is unavailable, they are treated as positive cases if they have a high pre-test probability, or negative if they have a low pre-test probability. Imaging is decided for those who have risk factors for developing a severe state of the disease, whether they are confirmed positive on the test or have a high pre-probability test. Chest Imaging is not recommended for patients who are positive and do not carry risk factors, or patients with mild symptoms with negative COVID-19 status. Chest imaging gives a baseline status of the patient's condition, aids in monitoring the disease progression, and directs the management plan. The risk factors that may promptly progress the infection are old age (above 60), medical comorbidities such as diabetes mellitus,

hypertension, chronic pulmonary disease, cardiovascular disease, and compromised immunity [5].

The second scenario describes patients presenting with moderate to the high degree of clinical symptoms. Imaging is recommended in this situation, whether the patient has a positive or negative COVID-19 test result, due to the gravity of this clinical state. Chest imaging is important to determine the disease progression and to identify risk factors and underlying abnormalities that facilitate the clinical worsening. Moreover, imaging helps to identify alternative diagnosis that explains the clinical features of negative COVID-19 patients. If no alternative diagnosis is identified, the patient is evaluated based on the pre-test probability. If they have a high pre-test probability, there is a chance that it could be a false-negative result, which necessitates the repeat of the COVID-19 test [5].

The third scenario describes patients with moderate to high clinical symptoms in an environment with a high community burden and limited resources. In these situations, imaging is recommended based on the rapid point-of-care (PoC) COVID-19 tests. Furthermore, the patient's clinical condition is investigated radiologically the same as in the second scenario. Based on the imaging results, the patients are thereafter managed with a level of care appropriate with clinical symptoms. Imaging also helps in prompt triage of the clinical cases, and aids in the identification of false-negative results [5].

The study also presented recommendations for the use of imaging, see **Table 1**. It states that imaging is not routinely recommended as a screening measure for asymptomatic patients or if they have mild symptoms unless they have risk factors for clinical worsening. On the other hand, imaging is advised for patients with moderate to severe disease despite the COVID-19 status. Also, in these cases, imaging is advised when there is a worsening of the clinical condition. In a limited resource environment with no access to CT scans, CXR imaging is adequate for patients with moderate to severe disease, unless the respiratory status necessitates the use of a CT scan. Imaging is not routinely recommended for stable intubated COVID-19 patients. For those who recover from the infection and develop hypoxemia or functional impairment, a CT scan is indicated. Also, in individuals who are found to have abnormalities on CT associated with COVID-19 by chance, COVID-19 testing is recommended [5].

Table 1. Recommendations for Chest Imaging

- Chest imaging is not routinely recommended as a screening measure for asymptomatic individuals
- Chest imaging is not recommended for individuals with mild presentation unless they have risk factors for clinical worsening
- Chest imaging is advised for individuals with moderate to severe disease despite the COVID-19 status.
- Chest imaging is advised for individuals with worsening respiratory conditions.
- In a limited resource environment with no access to CT scans, CXR imaging is adequate for patients with moderate to severe disease, unless the respiratory status necessitates the use of a CT scan.
- Serial (daily) Imaging is not routinely recommended for stable intubated COVID-19 patients.
- CT scan is indicated for patients who recover from the infection and develop hypoxemia or functional impairment
- COVID-19 testing is recommended for individuals who are found to have abnormalities on CT associated with COVID-19 by chance

Conclusion

Chest imaging plays a crucial role in monitoring the progression of COVID-19 disease and guides in establishing the management plan. CT scan is considered superior to other modalities in terms of sensitivity and specificity. It has an excellent detection for lung abnormalities in the early stage of the disease. However, it has some downfalls regarding the availability, portability, and preparedness with adherence to the infection control protocols during this pandemic. Furthermore, it is difficult to apply during emergency settings, with the high influx of patients to the hospitals. CXR imaging is only second to CT scan in terms of sensitivity and specificity. It detects similar findings as that of CT, such as consolidations and ground-glass opacities, pleural effusions, and pulmonary infiltrates. Nevertheless, it is poor when it comes to the early stage of the disease. Interestingly, it is effective when applied in emergency settings and with a high number of hospitalized patients due to its portability. It offers an overall assessment of the disease status and adds up in the clinical decision. Unlike CT scans, there are only a few scoring systems for severity stratification. This sheds the light on the need to produce a clear scoring system. there are several clinical dilemmas regarding the use of radiological imaging. Chest imaging is advised according to the disease severity, presence of risk factors, and the status of the COVID-19 test.

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