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Review Article

Chest imaging's diagnostic and prognostic relevance in COVID-19; a review article

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Abstract

Early diagnosis of coronavirus disease of 2019 (COVID-19) can help restrict the disease by allowing infection control measures to be implemented quickly, limiting the disease's spread. Although nasopharyngeal swab nucleic acid testing is the gold standard for diagnosis, proper sampling and collecting methods are critical for improving diagnostic sensitivity. A number of thoracic imaging modalities with a characteristic feature have been recorded since the first occurrence of the disease in Wuhan, China in December 2019. The goal of this review paper is to provide insight into the diagnostic and prognostic features of chest X-ray, chest computed tomography, and lung ultrasonography in COVID-19 patients

Keywords: COVID-19; chest imaging; prognosis; diagnosis

Introduction

Coronavirus disease is caused by the severe acute respiratory syndrome coronavirus 2 (SARS CoV-2) (COVID-19) (1). On March 12, 2020, the World Health Organization (WHO) declared the sickness a pandemic after it quickly spread over the globe. (2)

After binding to the angiotensin converting enzyme 2 (ACE2) cell membrane receptor, SARS-CoV-2 can theoretically infect a variety of organs, although due to the infective agent's airborne nature, the respiratory system is still the most commonly afflicted. Because inflammatory processes causing airway, alveolar, and vascular dysfunction and damage can lead to rapidly progressive acute hypoxaemic respiratory failure, lung injury in adults has the potential to induce significant life-threatening disorders. (3)

The gold standard for diagnosis is a reverse transcription polymerase chain reaction (RT-PCR) on a throat swab; however, the results of this test take time to come back, and some patients may show false-negative results at the onset of symptoms depending on the quality of the sample and the rate of viral replication in the upper respiratory tract. (4)

Chest imaging can help in the diagnosis and treatment of COVID-19 confirmed and suspected cases. Depending on local resources, clinical conditions, and national recommendations, the type of imaging employed in patients with suspected or confirmed COVID-19 pneumonia varies greatly. (5)

The purpose of this review is to show the characteristics of COVID-19 pneumonia using all available imaging modalities, such as chest X-rays, computed tomography (CT), and chest ultrasonography (US). Furthermore, the findings' prognostic implications are assessed.

1-**Chest X ray (CXR)**

The chest radiograph may be normal in up to 63 percent of those with covid-19 pneumonia, especially in the early stages (however this estimate is ambiguous, ranging from 0% to 63 percent) [6]

Changes include ground glass (68.5%), coarse horizontal linear opacities, and consolidation. These tend to develop on the periphery and in the lower zones, but they might affect the entire lung. Overall, 10% of the chest radiographs showed the usual COVID-19 appearance, 57 percent had a nonspecific appearance that may be confused with other viral or atypical pneumonias, and 33% showed no pulmonary abnormalities. When paired with clinical features, the authors discovered that, despite its low sensitivity, chest radiography can be a powerful indicator of COVID-19 in those who had classic COVID-19 results on their chest radiograph. [7]

Portable CXR is usually the first-line imaging modality, which is useful for critically ill patients who are immobile. A daily portable CXR is recommended for severely unwell ICU patients. [4] The Cochrane review found that chest radiography had a pooled sensitivity and specificity of 80.6 percent (95 percent CI 69.1–88.6 percent) and 71.5 percent (95 percent CI 59.8–80.8 percent) for detecting COVID-19, respectively. [8]

A chest x-ray can aid with alternate diagnoses, assessing the severity of COVID-19 pneumonia, tracking its progression, and finding potential complications such bacterial superinfection and pneumothorax. [9] According to several studies, a chest X-ray severity score based on the amount of lung anomalies should be used. Warren and colleagues presented the radiographic Assessment of Lung Edema score as one of them. [10]

Each lung was assigned a score ranging from 0 to 4 based on the degree of consolidation or ground-glass opacities involved (0, no involvement; 1, 25% involvement; 2, 25%–50% involvement; 3, 50%–75% involvement; 4, >75 percent involvement). By summing the ratings for each lung, the total severity score was determined. (Fig.1).

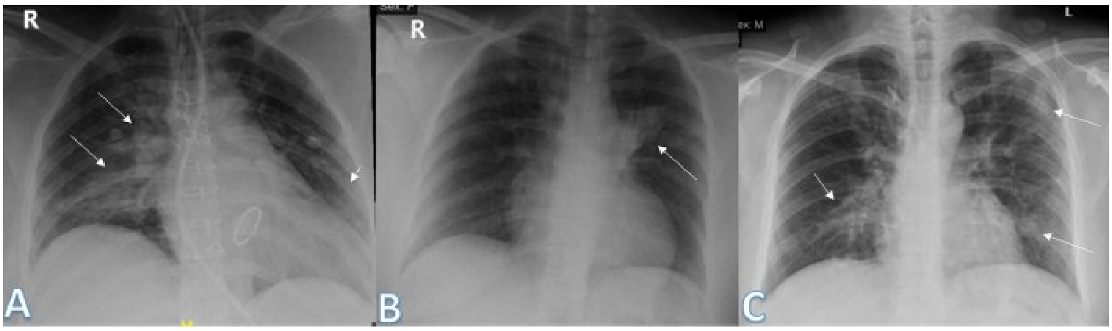

Fig. (1) Three patients that tested positive for COVID-19. (A) A right perihilar air space consolidation opacity extending to the right paracardial region was seen on a chest X-ray (long arrows). Another left lower zonal air space consolidation opacity was seen (short arrow); the severity score for the right lung was 2 and the severity score for the left lung was 1, resulting in a total severity score (TSS) of 3.

(B) Chest X-ray revealed opacity in the left perihilar air space (arrow). There was a total severity score of one.

(C) Chest X-ray revealed opacity in the right perihilar air area (short arrow). Other left lower zonal air space consolidation opacities with reticular thickening may be noted (long arrows); the severity score for each lung was 1, hence TSS was 2. Adapted from Yasin and Gouda (11)

A recent study described the application of deep-learning artificial intelligence (AI) systems for chest radiograph assessment in COVID-19 patients. In two publications from the northwest United States and one from the Netherlands, three different deep-learning AI systems produced promising results in terms of their area under the receiver operating characteristic curve (AUC). Deep COVID-XR had an AUC of 0.88, which was similar to the consensus of five radiologists (AUC=0.85) in properly classifying 300 random test pictures (134 of which were positive for COVID-19). [12]

CV19-Net surpassed three radiologists who didn't employ continuous scoring by properly identifying 500 random test images (250 of which were positive for COVID-19) with an AUC of 0.94. [13]

Finally, with an AUC of 0.81, CAD4COVID-XRay successfully recognised 454 patient images (223 of which were COVID-19 positive), yielding results that were highly consistent with radiologists' interpretations at various cut-off levels. [14]

10–12 days following the onset of symptoms, the severity of chest radiography results worsened. On the other hand, the use of chest radiography in clinical surveillance of non-severe cases is less clear. CXR is essential for monitoring severely ill and ICU-admitted patients, as well as for detecting superimposed problems [15]

2- High resolution computed tomography (HRCT)

In one study, the positive percentage of RT-PCR at the presentation was reported to range between 30 and 60%. [16] A chest CT scan is a common, non-invasive diagnostic tool for pneumonia that is reasonably straightforward to administer and can offer an accurate diagnosis quickly. When the viral load is insufficient and RT-PCR is mistakenly negative in the early stages of COVID-19, chest CT plays an important role in the early diagnosis of lung infection abnormalities. [17]

Patients with suspected COVID-19 pneumonia are often given a non-contrast material-enhanced chest CT, which is performed with a high-resolution technique (using thin 1.5 mm slices) and a high-spatial-resolution kernel to improve lung parenchyma architecture visualization. [18]

The various investigations have revealed a wide range of CT results in COVID-19. According to all investigations, the presence of ground glass opacities (GGO), often with a peripheral and subpleural distribution, is the most common CT feature in COVID-19 pneumonia (Fig.2). Most COVID-19 cases have multiple lobe involvement, particularly in the lower lobes. These GGO zones may be coupled with focal consolidation areas and/or overlaid intralobular reticulations, creating a crazy paving pattern. Patients who present many days after the commencement of the disease are more likely to have linear consolidations and other indications of organizing pneumonia, such as the reverse halo sign (ground-glass areas surrounded by peripheral consolidation). (Fig.3). [19,20]. In some cases, with COVID-19, pulmonary vascular enlargement has also been reported. [21]

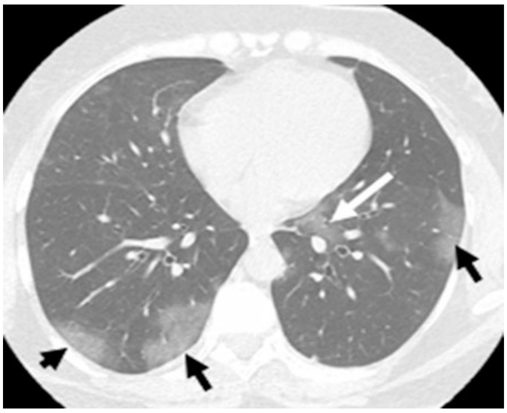

Fig. (2): CT scan of the axis of the chest with a lung window. A COVID-19 patient had multiple ground-glass pulmonary opacities. The majority of the lesions are subpleural (black arrows), although there is one central lesion (white arrow). Adapted from Sotoudeh and Git (22).

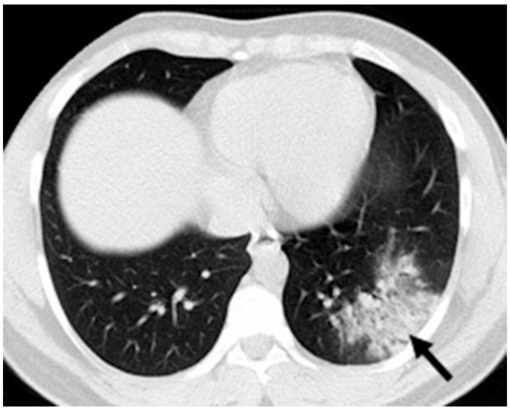

Fig. (3): CT scan of the axis of the chest. A single patchy subpleural consolidation obscures the vascular structures in the left lung. Adapted from Sotoudeh and Git (22).

Even if COVID-19 patients are clinically asymptomatic or have a mild form of the disease, the findings of the initial chest CT will aid clinicians in triaging this specific group of COVID-19 pneumonia patients, and if they have a higher degree of lung parenchymal involvement, they may benefit from more intensive care. [23]

The Radiology Society of North America (RSNA) has created a structured reporting approach for COVID-19 patients. In this method, pulmonary lesions are divided into four categories:

-COVID-19 has a typical appearance: peripheral bilateral GGO with(out) consolidations or a crazy-paving pattern.

-Multifocal, perihilar, diffuse, or unilateral GGO with indeterminate appearance: absence of usual findings and presence of multifocal, perihilar, diffuse, or unilateral GGO

-Atypical appearance: lobar or segmental consolidation without GGO, pulmonary nodule, cavities, pleural effusions, and smooth interlobular septal thickening in the absence of typical and ambiguous features.

-Negative appearance: no features of pneumonia. [24]

There are several CT grading scores that can be used to determine the severity of lung involvement. Francone and colleagues suggest a severity scoring system (CT-SS) for quick pulmonary affection assessment that is based on the degree of lung affection in chest CT. Depending on the extent of opacities, it is done in each lobe (including GGOs, and consolidation). The following factors were used for calculating the scores: 0 (none), 1 (affecting less than 5% of the lobe), 2 (affecting 5%–25% of the lobe), 3 (affecting 26%–49% of the lobe), 4 (affecting 50%–75 percent of the lobe), and 5 (affecting >75 percent of the lobe). As a result, each lobe's CT score might be as high as 5. The overall CT score was determined by sum of the scores from each of the five lobes (range from 0 to 25). [25].

In March 2020, the Dutch Radiological Society launched a new scoring system based on chest CT and patient data called COVID-19 Reporting and Data System (CO-RADS), which included clinical findings, laboratory test results, and CT records in addition to CT records. The level of suspicion ranged from very low to very high (CO-RADS categories 1–5), with category 0 indicating no infection and category 6 suggesting SARS-Cov-2 infection based on RT-PCR results at the time of assessment. [26].

CO-RADS diagnostic performance is influenced by the presence of symptoms and the pre-test likelihood, which is essentially the overall prevalence of a positive PCR. In symptomatic patients from a population with a high prevalence (42 percent) of RT-PCR-positive COVID-19, COVID-19 was detected in 89 percent of patients classified as CO-RADS 5, compared to 9 percent of patients classified as CO-RADS 1 [27].

In the Cochrane review, CT was found to be superior to chest radiography and lung ultrasound for the initial assessment of patients with suspected COVID-19, with pooled sensitivity and specificity of 87.9%

(95 percent CI 84.6–90.6 percent) and 80.0 percent (95 percent CI74.9–84.3 percent) respectively)

A greater understanding of the predictive value of a baseline CT in determining the prognosis of a disease in its early stages could lead to improved resource allocation. The time of the scan has been found to be a crucial element in determining the patient's risk level. When a CT scan is performed within the first two to three weeks after the onset of symptoms, it has the most sensitivity. [28]

According to one study, there is no significant difference in CT findings between severe and non-severe patients during the first 5 days (first period), however CT pictures begin to have more prognostic markers after the second period (6–10 days): Non-survivors show a constant increase in intensity up to 20 days from the onset of symptoms, whereas survivors see a peak in severity after 10 days. [29]

3-Lung Ultrasound (LUS)

Because of its ability to give real-time information and portability as well as its safety particularly for specialist patient populations like pregnant women, and its general availability; (LUS) is gaining popularity as an alternative imaging technique in the present pandemic setting. [30].

In COVID-19 patients, B-lines coming from a normal visceral pleural line were found, indicating an increased density of the lung parenchyma linked with the development of early inflammation and edema. With increasing severity, an increased number of or confluent B-lines will be present, and the visceral pleural line may thicken and fragment; this arises with rising prevalence, which is linked to higher disease severity and the potential development of ARDS. Ground-glass opacities (GGOs) are commonly related with the presence of B-lines on CT. As the lungs become more involved, frank lung tissue consolidation occurs, which first appears as small subpleural consolidations when viewed with LUS (Fig.4). [31]

Because lung involvement in early or moderate COVID-19 instances may be limited to the posterobasal parts of the lungs, procedures that include assessment of these areas are crucial for evaluating patients with COVID-19. [32]

According to a Cochrane study [8]. The overall sensitivity and specificity of LUS for detecting COVID-19 were 86.4 percent (95% CI 72.7–93.9) and 54.6 percent (95% CI 35.3–72.6), respectively,

LUS can be used to monitor illness progression and identify complications such pneumothorax, bacterial pneumonia, and pulmonary embolism. [33]. Moreover, LUS is simple to repeat at the bedside and does not necessitate transporting the patient to a different department for more advanced imaging. [34]

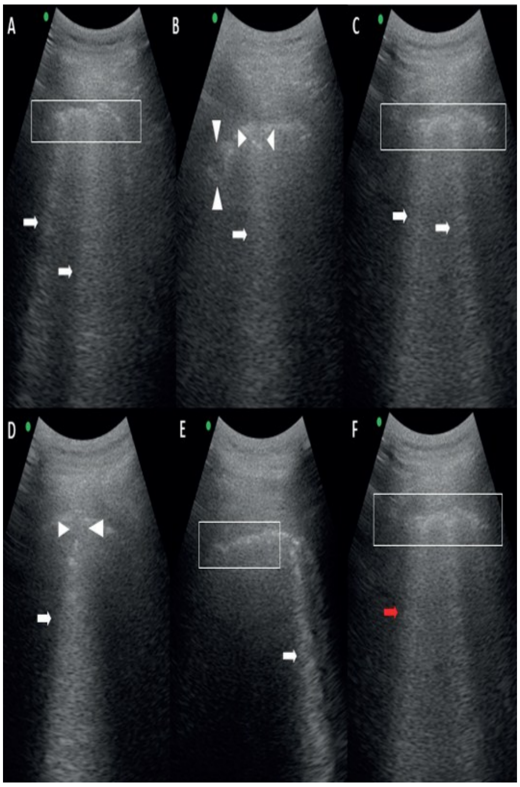

Figure 4 shows the results of a lung ultrasonography in a patient who has been diagnosed with nCoV-19 infection. Pleural line irregularities (white boxes, figures A-C-E-F), thick irregular vertical artefacts (white arrows, figures A-B-C-D-E), subpleural consolidations (white arrowheads, figures B-D), and regions of white lung are all seen on lung ultrasonography (red arrow, figure F). Adapted from Buonsenso et al (35)

Despite being a sensitive tool for detecting progressive pulmonary involvement, there is significant overlap between the typical LUS findings seen in COVID-19 and the typical LUS patterns of important differential diagnoses such pulmonary oedema, bacterial pneumonia, and pulmonary embolism. (36,37). As a result, persistent LUS findings in COVID-19 patients should be carefully examined in conjunction with other clinical and laboratory markers. [(33).]
Because aerated lung inhibits ultrasound transmission, LUS cannot detect lesions deep within the lung; as a result, the abnormality must extend to the pleural surface in order to be noticed on an ultrasonography test. [(38).]

Conclusion:

Although nasopharyngeal swab RT-PCR is the gold standard for COVID-19 diagnosis, chest imaging plays an essential role in the diagnosis, prognosis, and follow-up of COVID-19 patients. When evaluating the clinical data, chest X-ray, chest CT, and lung ultrasound have a high sensitivity for diagnosing SARS-COV2 infection. Different scores have been created to objectively quantify the severity of lesions, which aids in triaging patients on admission to an inpatient or intensive care unit (ICU) for better care and management.

Conflict of interest: There were no conflicts of interest declared by any of the authors.

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