EAS Journal of Radiology and Imaging Technology
Abbreviated Key Title: EAS J Radiol Imaging Technol
ISSN: 2663-1008 (Print) & ISSN: 2663-7340 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-6 | Issue-2 | Mar-Apr-2024 | DOI: 10.36349/easjrit.2024.v06i02.001

Original Research Article

Accuracy of Chest Xray in Hospitalized COVID-19 Patients

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Article History
Received: 26.01.2024
Accepted: 03.02.2024
Published: 12.03.2024

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: ***Introduction:*** At the end of the year 2019 a novel virus named SARS-CoV-2 caused Coronavirus Disease 19 (COVID-19), manifesting as lung infection which can result in severe pneumonia. The gold standard for diagnosis of the virus is the detection of viral RNA through reverse transcriptase PCR (RT-PCR). ***Materials and Methods:*** This study is a retrospective analysis of diagnostic yield of chest imaging modalities in the diagnosis of COVID-19 in patients admitted to the Imam Khomeini hospital, Tehran, Iran during march 2020 until July 2020. *Results:* 204 hospitalized patients with a mean age of 58.5 years, diagnosed with COVID-19 were enrolled in this study, who had their disease confirmed by PCR. About 20% of patients had normal O_2 Saturation (above 93%) and 80% had low O_2 Saturation. Also 70% of patients were hospitalized to the ICU. Among investigated patients, 87.6% had abnormal findings in their CXR. Also, 97.1% of patients had abnormal CT-Scan. In this study, the sensitivity of the CXR in the diagnosis of COVID-19 was 87.5% (CI 95%, 83 to 91) and the sensitivity of the chest CT-Scan was 97.1% (CI 95%, 94.8 to 99). ***Discussion:*** Utilizing CXR as a first-line imaging modality is recommended in many countries and clinical settings and chest CT-Scan is mainly reserved for other additional roles. This study reveals a CXR sensitivity of 87.5% which is in accordance with the recent literature (69-90%).

Keywords: COVID-19, CXR, CT-Scan, PCR.

INTRODUCTION

At the end of the year 2019 a novel virus, named SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2), caused Coronavirus Disease 19 (COVID-19) and expanded globally from China throughout the world. This new coronavirus causes a highly infectious disease, COVID-19, manifesting as lung infection which can result in severe pneumonia and more aggressive acute respiratory distress syndrome (ARDS) [1, 2].

The gold standard for diagnosis of the virus is the detection of viral RNA through reverse transcriptase PCR (RT-PCR) of respiratory tract samples. However, this method has several inadequacies including low sensitivity (60%–90% in different studies), relatively slow turnaround times ranging from a few hours to several days, high expense and limited capacity for testing in many countries [3, 4].

The recent literature focuses primarily on computed tomography (CT) findings in COVID-19, which is more sensitive and specific than chest X-ray (CXR). CT-Scan has shown to be more sensitive than RT-PCR for diagnosis of COVID-19, while being significantly faster and cheaper. Nonetheless, it has to be mentioned that CT-Scan is not easily accessible during this pandemic, considering not only the excessive radiation exposure especially, but also disinfection procedures for the scanners needed regularly [2, 5].

Plain film chest X-ray (CXR) is employed as the first-line method, with faster results comparing with

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those of RT-PCR, and lessening the risk of cross-infections [3, 6].

Studies have so far only evaluated imaging in those with confirmed infection; it is, therefore, not possible to calculate the specificity of these modalities. In the context of the global pandemic, infection may be widespread in the community, often with subclinical infection. A reliable and rapid method to detect infection in the general population is needed.

Despite its extensive use, the specificity and sensitivity of CXR in the general emergency population for diagnosis of COVID-19 is unknown, nor how imaging features correlate with severity [6].

This study investigates the performance of CXR and CT-Scan in diagnosing COVID-19 in patients with RT-PCR established COVID-19.

MATERIALS AND METHODS

Patient Selection

This study is a retrospective analysis of diagnostic yield of chest imaging modalities in the diagnosis of COVID-19 in patients admitted to the Imam Khomeini hospital, Tehran, Iran during march 2020 until July 2020. 321 patients presenting to emergency department with suspected COVID-19 signs and symptoms, were primarily enrolled in the study. 117 patients were excluded due to confounding issues (Underlying pulmonary diseases interfering with interpretation of imaging, negative COVID-19 PCR test results, time incongruency of performing CXR and CT-Scan and etc.)

Finally, 204 hospitalized patients diagnosed with COVID-19 in Imam Khomeini tertiary university center, Tehran, Iran, were retrospectively analyzed in this study, who had their disease confirmed by PCR. Patients underwent CXR and then chest CT-Scan simultaneously at the time of admission to the hospital or during hospitalization. Each patient's CXR and CT-Scan images were thoroughly assessed and reported by two expert radiologists independently to confirm signs and pattern of COVID-19 in the imaging of patients.

This retrospective study was approved by the institutional ethics committee review boards of Imam Khomeini hospital, Tehran university of medical sciences.

Image Acquisition and Analysis

Chest CT-Scan images were acquired with *Siemens Somatom Emotion 16 Slice*. Each patient imaging was evaluated and reported by two expert radiologists independently. Pattern of involvement, severity of involvement and time interval between imaging and the onset of symptoms were assessed for each patient individually. Patients' O_2 saturation and ICU admission status was also assessed.

Statistical Analysis

Statistical analysis was performed with SPSS (SPSS Chicago IL, USA). Statistical significance threshold was set at $p = 0.05$.

The authors declare that there is no conflict of interests and also there are no financial or non-financial competing interests.

RESULTS

204 hospitalized patients with a mean age of 58.5 years (range 20-93 years) diagnosed with COVID-19 were enrolled in this study, who had their disease confirmed by PCR.

About 41% of patients were female and 59% were male. About 20% of patients had normal O_2 Saturation (above 93%) and 80% had low O_2 Saturation. Also 70% of patients were hospitalized to the ICU.

Among investigated patients, 87.6% had abnormal findings in their CXR and in 12.4% of cases CXR were reported normal. Different radiological features seen in CXR are shown in **Table 1.**

Also, 97.1% of patients had abnormal CT-Scan and 2.9% of patients' chest CT-Scan had no abnormal findings. Radiological features of chest CT-Scan are depicted in **Table 2**.

Table 1: Radiological features of COVID-19 patients in CXR

Radiological feature	N (%)
Mixed ground glass and consolidation	120 (68.2)
Ground glass	163 (92.4)
Consolidation	132 (75)
Air Bronchogram	119 (67)
Pleural effusion	46 (26)

Table 2: Radiological features of COVID-19 patients in Chest CT-Scan

Radiological feature	N (%)
Location:	
Peripheral	**131 (66.3)**
Central	**119 (60)**
Central and peripheral	**113(57.1)**
Peribronchovascular	**47 (23.8)**
Pattern:	
Patchy to confluent	**138 (69.5)**
Ground glass	**136 (68.6)**
Consolidation	**111 (56.2)**
Wedged	**96 (48.6)**
Air bronchogram	**119 (59.7)**
Confluent	**83 (41.9)**
Elongated	**75 (38.1)**
Round	**38 (19)**
Crazy paving	**38 (19)**
Nodular	**26 (13.3)**
Reticular	**15 (7.6)**
Reverse halo	**4 (1.9)**

The severity of the disease was also calculated based on the percentage of pulmonary involvement in imaging. The results are as follows:

CXR revealed that the severity of lung involvement among 20.7% of patients was 0 to 25%, 23% had 25 to 50% involved, 28.7% had 50 to 75% while 27.6% was 75 to 100% involved.

Investigation of CT-Scan results showed that the severity of lung involvement among 21.6% of patients was 0 to 25%, 32.4% had 25 to 50% involved, 21.6% had 50 to 75% while 24.3% was 75 to 100% involved.

No significant correlation is found between age and severity of lung involvement in CXR (P Value=0.653) and severity of lung involvement in CT-Scan (P Value=0.760).

The rate of involvement found in the CXR is significantly associated with the patient's O_2 saturation and admission to the ICU (P Value<0.01).

Also, the severity of lung involvement in the CT-Scan was significantly associated with low O_2 Saturation (P Value<0.007).

Another important factor in confirming radiologic assessment, is the number of days between the time in which the person is diagnosed with COVID-19 and the time the radiologic assessment is performed (Around one week of infection). In our study, significant relationship is found between the date CXR is taken and involvement of lungs seen in CXR (P Value<0.01). Also, the same pattern is found between the date CT-Scan is taken and involvement of lungs seen in CT-Scan (P Value<0.01). In other words, the later the patient is assessed with radiologic studies, the more is possible to have positive findings in CXR or CT scan.

In this study, the sensitivity of the CXR in the diagnosis of COVID-19 was 87.5% (CI 95%, 83 to 91) and the sensitivity of the chest CT-Scan was 97.1% (CI 95%, 94.8 to 99).

DISCUSSION

Early diagnosis of 2019 novel COVID-19 is crucial for disease treatment and control. Viral nucleic acid test via RT-PCR assay plays a vital role in assessment of suspicious individuals for early diagnosis and hospitalization. However, lack of sensitivity and relatively long processing time are detrimental to the control of the disease epidemic. The reasons why RT-PCR detection rate is low may include immature technology development of nucleic acid detection; variation in detection rate from different manufacturers; low patient viral load and improper clinical sampling [7, 8].

In the era of a global pandemic of COVID-19, the aim of radiologic studies should be rapid identification and classification of the patient with suspected COVID-19. The radiology departments and staff are at the forefront of the diagnosis, quantification and in the follow-up of COVID-19 patients [9, 10].

Utilizing CXR as a first-line imaging modality is recommended in many countries and clinical settings and chest CT-Scan is mainly reserved for other additional roles, including the identification of COVID-19 pneumonia typical features in selected cases.(11, 12) Multiple studies have shown that CXR does not have the diagnostic yield of CT Scan, but it still plays role in managing the COVID-19 patients [11, 13, 14].

This study reveals a CXR sensitivity of 87.5% which is in accordance with the recent literature (69-90%) [2, 3, 7, 9, 15].

Although chest CT-Scan has shown to be a highly sensitivity (around 97–98%) modality in many studies, it has low specificity in detecting typical features of pneumonia in COVID-19 patients [2, 13, 15].

CT-Scan is often performed in specific situations: in case of clinical-radiological discordance (negative CXR negative with high clinical-epidemiological suspect), in case of acute complications (pulmonary embolism or severe respiratory failure) or after intubation. Portable CXR is very useful in the pandemic situation, as it is more difficult to perform chest CT scan, considering the disinfection procedures after each examination [11].

Our study data concludes to the following main radiologic characteristics in COVID-19 patients described in previous studies: In most cases, imaging shows patchy (69.5%), ground glass opacities (68.6%) and consolidation (56.2%). Also, the distribution of lesions tends to be in peripheral region (67.6%), then central (59%) and after that, combined central and peripheral areas (57.1%).

Balbi *et al.,* evaluated the inter-rater agreement of chest X-ray (CXR) findings in COVID-19 and to determine the value of initial CXR along with demographic, clinical, and laboratory data. Ground glass opacities admixed with consolidation (n = 235, 69%) was the most common finding in CXR of patients [6].

Chen *et al.,* also tried to explore the value of CT in the diagnosis of COVID-19 pneumonia, especially for patients who have negative initial results of reverse transcription-polymerase chain reaction (RT-PCR) testing. The main features in CT-Scan of patients were ground-glass opacity (95%) and consolidation (72%) with a subpleural distribution (100%). 33% of patients had other lesions around the bronchovascular bundle. The other CT features included air bronchogram (57%), vascular enlargement (67%), interlobular septal thickening (62%), and pleural effusions (19%). Chest CT-Scan of the group with negative initial RT-PCR results was less likely to show pulmonary consolidation Compared with that in the group with positive initial RT-PCR results [16].

Cozzi *et al.,* described the main CXR radiological features of COVID-19 and correlation with clinical outcome. They found out results as following: 135 patients with lung consolidations (57.7%), 147 (62.8%) with ground-glass opacity, 55 (23.5%) with nodules and 156 (66.6%) with reticular-nodular opacities. Patients with consolidations and ground-glass opacity coexistent in the same radiography were 35.5% of total. Peripheral (57.7%) and lower zone distribution (58.5%) were the most common predominance [17].

Ai *et al.,* concluded that the sensitivity of chest CT-Scan in COVID-19 was 97% (95% confidence interval: 95%, 98%; 580 of 601 patients) based on positive RT-PCR results. Also, With RT-PCR results as reference in 1014 patients, the sensitivity, specificity, accuracy of chest CT in indicating COVID-19 infection were 97% (580/601), 25% (105/413) and 68% (685/1014), respectively. The positive predictive value and negative predictive value were 65% (580/888) and 83% (105/126), respectively [2].

De Smet *et al.,* also confirmed that chest CT-Scan for COVID-19 had good diagnostic performance in symptomatic patients, supporting its application for triage. However, Sensitivity of chest CT-Scan in asymptomatic patients was insufficient to justify its use as a first-line screening approach [1].

Fang *et al.,* retrospectively analyzed sensitivity of chest CT-Scan compared to RT-PCR and found out that the sensitivity of chest CT was greater than that of RT-PCR (98% vs 71%, respectively, p<.001)(15)

This study has several limitations: first, the lack of a non-COVID-19 control group in the study population limit evaluation of specificity and predictive value of CXR and chest CT-Scan. Also, the low number of patients studied may affect the accuracy and generalization of the results of this study. Further evaluation with higher number of patients with control group of patients is warranted to assess diagnostic performance of chest imaging more precisely in detection of COVID-19 patients.

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Cite This Article: Nasrin Ahmadinejad *et al* (2024). Accuracy of Chest Xray in Hospitalized COVID-19 Patients. *EAS J Radiol Imaging Technol*, *6*(2), 11-15.