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Diagnostic accuracy of chest computed tomography for detecting COVID-19 pneumonia in low disease prevalence area: A local experience

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Abstract

Background: The role of computed tomography (CT) was crucial in detecting coronavirus disease 2019, their diagnostic performances were evaluated frequently in the high disease prevalence regions. In contrast, limited studies assessed the accuracy of chest CT in low disease prevalence areas.

Methods: A retrospective study was conducted at a single center from April 3 to October 16, 2020. The data were collected manually involving age, gender, symptoms, chest CT and RT-PCR results. Patients included were all suspected cases diagnosed by both chest CT and RT-PCR. The confidence intervals (95%) were estimated using the Wilson method.

Results: A total of 104 patients (mean age 59±15 years, 61 males) were included. 6/104(15%) were presented with fever, 22/104(21%) with cough, 19/104(18%) with dyspnea, 4/104(4%) with diarrhea, and 7/104(6%) with headache. Regarding reverse transcription-polymerase chain reaction (RT-PCR) tests, 34 cases were positive and 70 were negatives. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of chest CT using RT-PCR as a reference were 97% (33/34,95%CI; [85-99%]), 50% (35/70,95%CI; [38-61%]), 48% (33/68,95%CI; [37-60%]), 97% (35/36,95%CI; [85-99%]) and 65% (68/104,95%CI; [56-74%]), respectively.

Conclusion: Chest CT is an important tool that contributed to the treatment decision of the high-suspected cases, as an early intervention before the confirmation with RT-PCR.

Introduction

The first outbreak of the novel coronavirus was in Wuhan, China in December 2019 [1], its spread was very fast and widely extended across different countries in the world. For the African nations especially in Morocco, the first confirmed case of COVID-19 was declared on 2 March 2020 by the health authorities [2]. Nowadays, more than 474 966 confirmed cases were reported in Morocco (February 06, 2021) [3]. Further, during the period ranging from March 2, 2021, to May 28, 2021, the total COVID-19 related deaths were 202 cases and a mortality rate of 2.6% [4].

The diagnosis of COVID-19 infection is based on reverse transcription-polymerase chain reaction (RT-PCR) as a reference standard according to the international recommendations [5]. Therefore, three Moroccan centers were considered at the beginning of the epidemic as the national referral institutions, which were charged to perform the RT-PCR assays in the whole country. However, the big challenge was the prior detecting of the COVID-19 infection, to control the widespread of the virus among Moroccan regions. Thus, the number of laboratories was increased progressively from 3 to more than 24 over 4 months period including public and private centers.

Following the first protocol of diagnosis and treatment of the novel virus declared by the Moroccan health ministry, the chest X-ray was recommended to be performed systematically for each patient suspected of COVID-19 [6]. This procedure was considered to detect chest abnormalities that may be caused by the virus infection and to eliminate the other pulmonary diseases that could affect the health of patients. Thus, identify at an early stage any factor of comorbidity.

The period of process testing with the RT-PCR method was ranging from 2 days to 4 days, including the collection of several swabs samples for each day, transportation, and the analyzing time in the referral laboratories. This long process of detecting requires another intervention as computed tomography (CT) technique, which was necessary to confirm primarily the positivity or negativity of the high suspected patients.

On one hand, the role of chest CT was crucial in diagnosing the COVID-19 as a complementary tool of the RT-PCR technique [7, 8]. The sensitivity, specificity, and accuracy of chest CT were estimated in China by Tao *et al*, which were 97%, 25% and 68%, respectively [8]. On the other hand, another investigation concluded that in low prevalence disease regions (<10%), there is no benefit of using CT as a tool for detecting the COVID-19 [9]. The debate about the diagnostic performance of chest CT remains an open and uncompleted issue, especially with the significant differences reported in study's findings, and the lack of reports investigated from the low prevalence countries. Therefore, the purpose of the present study was to assess the diagnostic accuracy of chest CT for detecting COVID-19 pneumonia using the RT-PCR findings as a reference and taking into consideration the low disease prevalence in Morocco.

Methods

Clinical data and design study

This retrospective study was conducted at a single center from April 3 to October 16, 2020, excluding June and July months. The data were collected manually involving age, gender, symptoms, chest CT acquisition parameters, chest CT and RT-PCR results. The patients included were all suspected patients diagnosed by both chest CT and RT-PCR during the period mentioned above. While we excluded patients who were tested only by RT-PCR.

The administration permission for data collection was obtained and the informed consent of participating patients was waived due to the retrospective anonymized data collection.

CT acquisition parameters

The patients admitted in this center were scanned by using Hitachi model scanner 16-slice and the chest CT was performed without venous contrast and with the following scans parameters: tube voltage: 120kV, scan time: 0.75s, slice thickness: 3.75mm, collimation: 1.25 x 16, table pitch: 1.0625 and field of view: 350mm x 350mm.

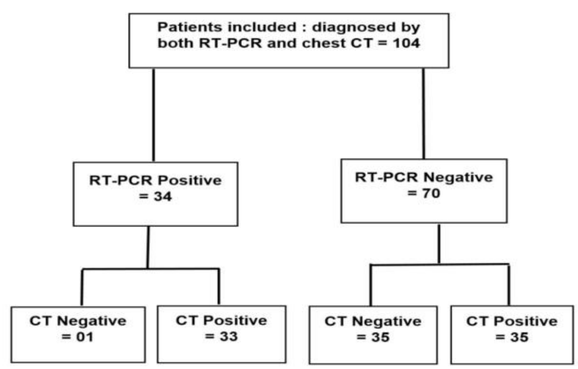

Figure 1: Study flowchart showing the inclusion criteria, results of RT-PCR tests (based on single test) and findings of chest CT regarding the detection of COVID-19.

CT image analysis

The analysis of chest CT images was performed by two radiologists with experience of more than 8 years in CT.

Statistical analysis

The statistical analysis of data was performed using SPSS Software (Version 20.0). The descriptive statistics were used to determine means, standard deviation, and ranges. The confidence intervals (95%) were estimated using the Wilson method.

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of chest CT screening were estimated by using the formulas (1), (2), (3), (4), and (5), respectively. While the disease prevalence in the included population was evaluated by the formula (6) [10, 11].

Sensitivity = True Positive / (True Positive + False Negative) (1)

Specificity = True Negative / (True Negative + False Positive) (2)

PPV= (Sensitivity ×Prevalence) / (Sensitivity × Prevalence) +[(1 – Specificity)×(1- Prevalence)] (3)

NPV= Specificity× (1- Prevalence) / Specificity× (1- Prevalence) +[(1 – Sensitivity)× Prevalence] (4)

Accuracy = (True Positive + True Negative) / Total population (5)

Prevalence= (True Positive + False Negative) / Total population (6)

Results

A total of 104 patients were included in this study, 36% (38/104) of whom were presented with different symptoms as follows: 16/104 (15%) fever, 22/104 (21%) cough, 19/104 (18%) dyspnea, 4/104 (4%) diarrhea, 7/104 (6%) headache, and the data of 64% (66/104) were unavailable. The mean age of the sample was 59± 15 years, ranging between 16 years and 90 years. While 41% (43/104) of the patients included were females and 59% (61/104) were males. Clinical and demographic data were reported in table 1 and the flowchart of the present study is summarized in figure 1.

Demographic Data	Number of patients	Percentages (%)	Total number
Mean Age (Years)± SD	59±15	-	104
Range (Years)	16-90	-	104
Female	43	41	104
Male	61	59	104
Symptoms			
Fever (>37.5©)	16	15	104
Dyspnea	19	18	104
Cough	22	21	104
Diarrhea	4	4	104
Headache	7	6	104
Results of RT-PCR			
Positive	34	33	104
Negative	70	67	104

Table 1: Demographic characteristics of the study population, clinical data, and results of RT-PCR tests performed. SD= Standard Deviation, RT-PCR= Reverse Transcription Polymerase Chain Reaction

Of the total sample included, 34 cases were positive, and 70 cases were negatives regarding the RT-PCR assays. Thus, the true and false values of chest CT were provided as follows: 33 true positive, 35 true negatives, 35 false positive, and 1 case with a false negative CT. Otherwise, of 68 cases with positive CT findings, 43 (63%) were recorded with the proportions of lungs affected. The repartitions were as follows: 16% (7/43) with <25%, 32% (14/43) with 25-50%, 37% (16/43) with 50-75%, and 14% (6/43) with >75% of lungs affected.

The performance estimation of chest CT in detecting COVID-19 was based on the sensitivity, specificity, PPV, NPV, and accuracy indicators, which were assessed by considering the RT-PCR as a reference standard or the gold standard at present in diagnosing COVID-19 pneumonia. The sensitivity, specificity, and accuracy of chest CT estimated were 97% (95%CI, [85-99%]), 50% (95%CI,[38-61%]) and 65% (95%CI,[56-74%]), respectively as shown in table 2.

The PPV and NPV were evaluated with caution and took into consideration the disease prevalence of our study population by using Bayes' theorem. The PPV, NPV and prevalence were 48% (95%CI, [37-60%]), 97% (95%CI, [85-99%]) and 32% (95%CI, [24-42%]), respectively (Table 2).

-	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	Accuracy	Prevalence
Number	33	35	35	01	33/34	35/70	33/68	35/36	68/104	34/104
Percentage (%)	-	-	-	-	97	50	48	97	65	32
95% CI	-	-	-	-	85-99	38-61	37-60	85-99	56-74	24-42

Table 2: The results of the diagnostic performances of chest CT for detecting COVID-19 including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and prevalence of disease for the study population.
TP= true positive, TN= true negative, FP= false positive, FN= false negative, PPV= positive predictive value, NPV= negative predictive value, CI = Confidence Interval.

Discussion

The diagnostic performances of chest CT in differentiating COVID-19 pneumonia have been reported by several studies, which were almost documented from the high prevalence disease countries or regions, such as China, Italy, and France [8, 12, 13]. By contrast, a few reports were published from non-high-epidemic area in terms of disease prevalence [14]. The results of a meta-analysis study published by KIM *et al* [9], were our first inspiration source to investigate more about the diagnostic performance in low prevalence region as Morocco. Therefore, the purpose of the present study was to assess the diagnostic performance of chest CT in diagnosing COVID-19 using the RT-PCR findings as a reference and taking into account the low disease prevalence in Morocco.

The sensitivity, specificity, PPV, and NPV are applicable only for the population from which they are estimated. The sensitivity and specificity are the intrinsic characteristics of a diagnostic test and they are independents of disease prevalence. In contrast, the PPV and NPV are very influenced by the disease prevalence level of the population studied [10]. Thus, in two different sites with different disease prevalence, the predictive values of CT in diagnosing COVID-19 will be different by site [10]. It is important to note that the patients included in the present study were scanned at the initial presentation as an emergency examination. Furthermore, the suspected patients who were discharged from the hospital with a negative RT-PCR were controlled at home during 14 days period to exclude complications or development of other symptoms of COVID-19 infection. The sensitivity of chest CT at the initial presentation was investigated by Fang *et al*, They reported that the sensitivity of chest CT in diagnosing COVID-19 at initial patients' presentation was higher than that of RT-PCR(98% vs 71%, $p< 0.001$) [15]. On one side, the use of RT-PCR as a reference to estimate the performance of chest CT is a universal approach considered by several studies. However, the number of RT-PCR tests used as the final reference remains an important source of differences between studies and may affect the accuracy of RT-PCR results. In our study, the sample collection for RT-PCR testing was based on the nasopharyngeal swabs uniquely without using any other swabs such as throat or sputum swabs. Thus, the presence of COVID-19 infection in the suspected swabs was confirmed or ignored by a single test of RT-PCR. In contrast, the other countries performed two(or more than 2) virological tests consecutive to declare the positivity or negativity of swabs tested. Therefore, the accuracy of RT-PCR tests may affect the assessment of the diagnostic performance of chest CT in the detection of COVID-19 pneumonia. On the other side, the time of testing the cases is an important factor that can affect the results of RT-PCR. Yu *et al* reported that after 5-6 days of onset, COVID-19 infection is detected with high probability in nasopharyngeal swabs [16]. So, if we tested the patients by two tests consecutive (or more) separated in time, we increase the probability of detecting the infection, then decrease the false negative results of RT-PCR. As reported by Ducray *et al*, the false negatives tests of RT-PCR decrease the PPV of chest CT [17]. That may explain the low PPV (48%) of chest CT obtained in our investigation, especially we used a single test of RT-PCR as a reference. The majority (70) of patients included in this study were recorded in August, September, and October months, they were presented with severe illness and symptoms. Of 68 cases with positive chest CT, 43 cases were collected with the proportions of lungs affected, the first group involved 22 cases with >50% of lungs affected, 16 were true positive CT and 6 false positive CT using RT-PCR results as the standard reference. For the second group, 21 cases with <50% of lungs affected including 13 false positive CT and 8 true positive CT using RT-PCR findings. In this context, Ducray *et al* concluded that for patients with severe illness, there is a low probability of having false negatives CT, which increases the values of NPV estimated in the sample [17]. The higher value of NPV (97%) documented in this study may be due to the reason mentioned above. Besides, it is known that the predictive values of a diagnostic test are influenced by the disease prevalence in the population tested. In Other Words, the low prevalence disease decreases the PPV and increases the NPV [18]. Thus, the low PPV (48%) and high NPV (97%) estimated in our population study were highly impacted by the low prevalence of disease assessed (32%). At present, the COVID-19 infection increases to evolve many peoples in Morocco. Thus, the request for RT-PCR analysis will be increased dramatically. Therefore, the use of CT as a diagnostic tool of COVID-19 is necessary for the suspected cases and for the confirmed positive patients under treatment to control their evolution. The limitations of the present study were the following: First, the pre-objective of this study was to conduct a multi-center investigation but the access to other centers was limited and not authorized. Second, the presence or absence of COVID-19 infection was confirmed by a single test of RT-PCR which was used as a reference. In contrast, it is recommended to perform more than two tests to assure the accuracy of RT-PCR. Third, the number of cases included was limited due to that the chest CT scan was undergone only for the high suspected patients. Fourth, the procedure of administration permission for data collection was complicated and time-consuming. Fifth, the data archiving in the center was based on handwriting papers due to that the electronic archiving system is not available. The chest CT was required for the high suspected and complicated patients who were admitted with severe illness and with abnormalities in chest X-ray images. Thus, the chest CT was an important tool that contributed to the treatment decision of the high suspected cases, as an early intervention before the confirmation with RT-PCR results. Otherwise, the findings of the present study shed light on the efficacy of chest CT in diagnosing COVID-19 pneumonia in the low prevalence area in Morocco.

Competing Interests

"We have read and understood ALS policy on declaration of interests and declare that we have no competing interests."

Author Contributions

Study concepts and design: Dadouch Ahmed, Maghnouj Abdelmajid, Benmessaoud Mounir

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Statistical analysis: Benmessaoud Mounir, Lemmassi Assiya

Drafting the manuscript: Benmessaoud Mounir, Lemmassi Assiya

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