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The diagnostic performance of chest computed tomography scanning in the diagnosis of coronavirus disease 2019 compared to polymerase chain reaction: A retrospective study of 1240 cases from Tripoli University Hospital, Libya

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Abstract:

OBJECTIVE: The increasing prevalence of suspected cases of coronavirus disease 2019 (COVID-19) presenting to emergency departments (EDs) requires a rapid and reliable triaging tool. The diagnostic performance of chest computed tomography (CT) has yet to be validated for triaging cases in the ED. We aimed to assess the diagnostic performance of chest CT compared to GeneXpert Xpress Xpert severe acute respiratory syndrome coronavirus 2 test in rapidly diagnosing COVID-19 among patients with respiratory symptoms presenting to the ED.

MATERIALS AND METHODS: This was a retrospective, single-center study at Tripoli University Hospital including cases with respiratory symptoms who underwent chest CT as well as polymerase chain reaction (PCR) testing for suspected COVID-19 between May 18 and August 18, 2020.

RESULTS: A total of 1240 cases were included, among whom 570 had radiologically evident COVID-19 on chest CT (46%). Five hundred and sixty-five cases had positive PCR results (45.6%), of whom 557 had radiologically evident COVID-19 on chest CT (97.7%). The calculated accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were 98%, 98.5%, 98%, 97.7%, and 98.8%, respectively, in relation to the PCR results.

CONCLUSION: During the current pandemic, chest CT is a quick and reliable diagnostic tool for COVID-19 in the ED.

Keywords:

Chest computed tomography, coronavirus disease 2019, Libya, severe acute respiratory syndrome coronavirus 2, sensitivity, triage

Introduction

With more than 27 million cases reported globally,[1] coronavirus disease 2019 (COVID-19) continues to exact a tremendous toll, particularly on countries with already exhausted health-care systems. In Libya, COVID-19 infections had a slow rising slope initially with only 61 cases

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reported by the end of April 2020.[2] The number of cases rose dramatically since July with more than 15000 cases reported by the end of August.[1,2] Such a dramatic rise coincided with a limited availability of molecular diagnostics such as polymerase chain reaction (PCR) testing for COVID-19. It also coincided with a large influx of cases in emergency departments (EDs) requiring rapid triaging and referral of COVID-19 cases to dedicated isolation wards and centers.

In addition to the limited availability of PCR testing and its variable sensitivity in early stages of infection,[3-6] chest computed tomography (CT) has previously been reported to be a fast, convenient, and sensitive tool for the early diagnosis of COVID-19. For instance, studies from China,[5,7,8] Japan,[9] The Netherlands,[10] Belgium,[11] France,[12,13] Germany,[14] and Turkey[15] reported high sensitivity for chest CT scan in diagnosing COVID-19. However, specificity was variably reported in these studies, ranging from <60% to over 90%. In addition, many of the early studies did not report criteria for participant selection or a reference standard for diagnosis.[16]

The wide availability of CT scans in both public and private hospitals in Libya makes chest CT an important and interesting triaging tool for rapid COVID-19 diagnosis in the ED.

Tripoli University Hospital (TUH) adopted the policy of performing chest CT for all patients with clinical history, contact history, and physical examination suggestive of COVID-19 presenting to the ED, in addition to ordering a COVID-19 PCR test.

In this study, we aimed to assess the diagnostic performance of chest CT compared to GeneXpert Xpress Xpert severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) test in diagnosing COVID-19 among cases with respiratory symptoms presenting to the ED.

Materials and Methods

This was a retrospective, single-center study conducted at TUH, a tertiary referral center with a 1200-bed capacity. Between May 18 and August 18, a total of 3400 chest CT scans were performed at TUH for various indications. Of the 3400, 1240 scans were performed for cases suspected of having COVID-19 based on clinical history (e.g. contact with a diagnosed case of COVID-19, fever, shortness of breath, and dry cough) and physical examination (fever and low oxygen saturation by pulse oximetry). The remaining 2160 scans were performed for indications other than COVID-19 (e.g. lung fibrosis and pneumothorax).

Scans were performed on the Canon Aquilion Lightning 16-raw 32-slice helical CT system using a predefined protocol (noncontrast; 100 kVP tube voltage; 100–200 mAs tube current). Images were then reconstructed at a slice thickness of 0.625 mm. Scans of asymptomatic cases, pregnant women, and cases below 18 years of age were excluded from this study.

Chest CTs were reported as "radiologically evident COVID-19," "possible COVID-19," or "no radiological evidence of COVID-19" with reference to the Radiological Society of North America Expert Consensus Statement on Reporting Chest CT Findings Related to COVID-19[17] [Table 1].

Table 1: Chest computed tomography reporting classification adopted by Tripoli University Hospital during the current coronavirus disease 2019 epidemic

Reporting classification	Chest CT characteristics
Radiologically evident COVID-19	Bilateral, peripheral GGO with/without consolidation
	Multiple round patches of GGO with/without consolidation
	GGO with interlobular septal thickening (crazy paving)
	Reverse halo sign
Possible COVID-19	Absence of typical COVID-19 features
	Presence of:
	Multifocal GGO that is nonperipheral or unilateral or nonrounded
	Mixed features like GGO with fibrosis and pleural effusion
	GGO with a preexisting lung pathology
No radiological evidence of COVID-19	No CT features to suggest pneumonia

COVID-19=Coronavirus disease 2019, GGO=Ground-glass opacity, CT=Computed tomography

Combined oropharyngeal and nasopharyngeal samples underwent PCR testing for all 1240 cases with a suspicion of infection using the GeneXpert Xpert Xpress SARS-CoV-2 test (Cepheid, Sunnyvale, CA, USA) following the manufacturer's protocol. Results were reported as "Positive" vs. "Negative".

Statistical analysis

Statistical analysis was performed using R: A Language and Environment for Statistical Computing (R Foundation for Statistical Computing; version 4.0.2). Accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using the Xpert Xpress PCR test as a standard reference. Agreement between chest CT report and PCR result was measured using kappa coefficient.

Results

Table 2 summarizes the characteristics of the study

population. A total of 1240 cases were included in this study (male = 508/1240; 41%), with a mean age of 60 years (standard deviation = 3) for both males and females. Figure 1 details the study flow from selection of cases to classification based on CT and PCR results.

Table 2: Characteristics of study population

Items	Male	Female
Total number	508	732
Age (years) (SD)	60 (3)	60 (3)
Radiologically evident COVID-19 on CT scan	234	336
SARS-CoV-2-positive PCR test	231	334

COVID-19=Coronavirus disease 2019, SD=Standard deviation, CT=Computed tomography, PCR=Polymerase chain reaction, SARS-CoV-2=Severe acute respiratory syndrome coronavirus 2

Among the 1240 scanned cases, 570 had "radiologically evident COVID-19" on chest CT (46%), 27 had a "possible COVID-19" (2%), while 643 had no radiological evidence of the infection on their scans (52%). Figure 2 shows the chest CT features of radiologically evident COVID-19 observed in this study. Other radiological features of COVID-19 are presented in Figure 3.

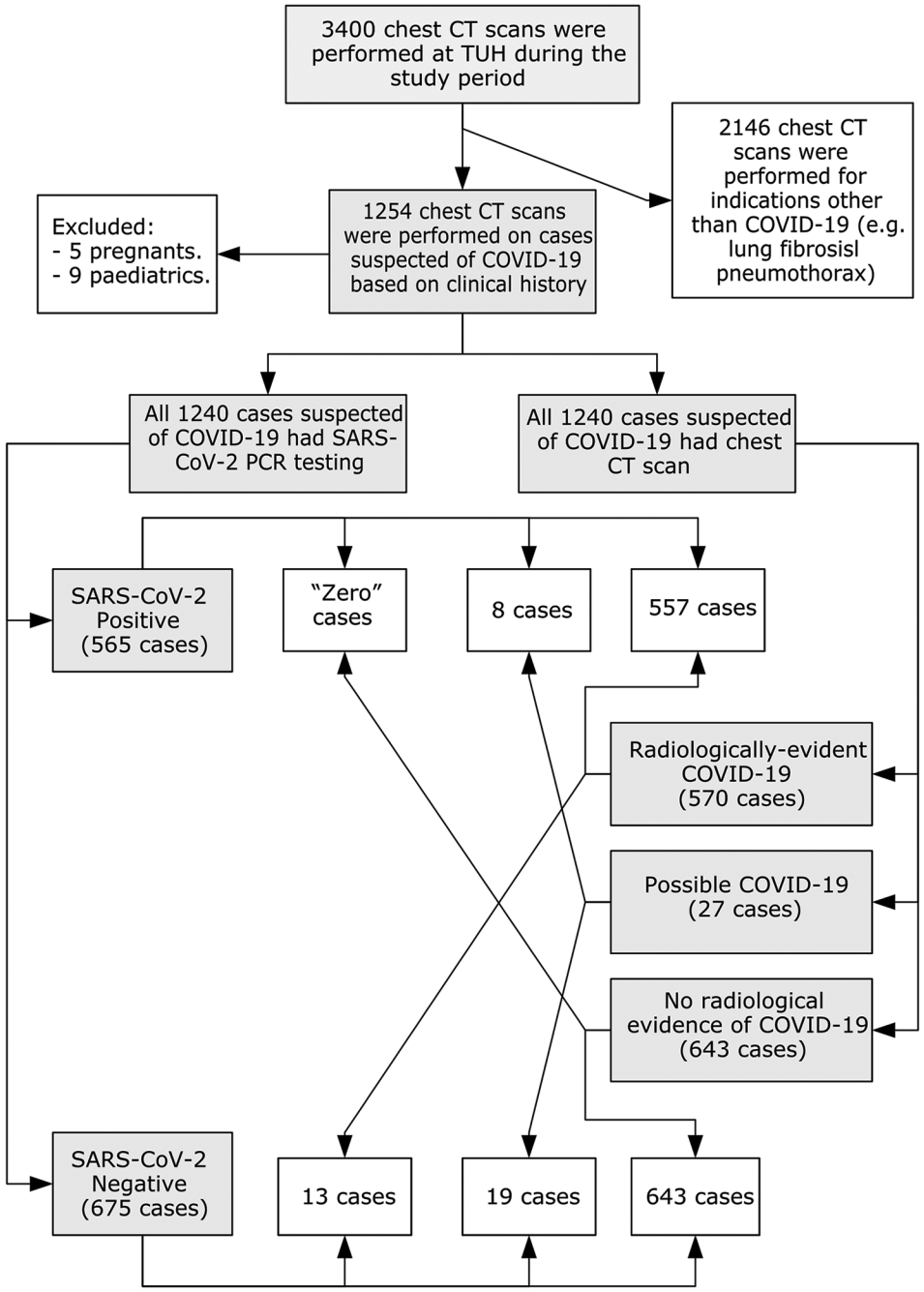

Figure 1: Study flowchart. Tripoli University Hospital

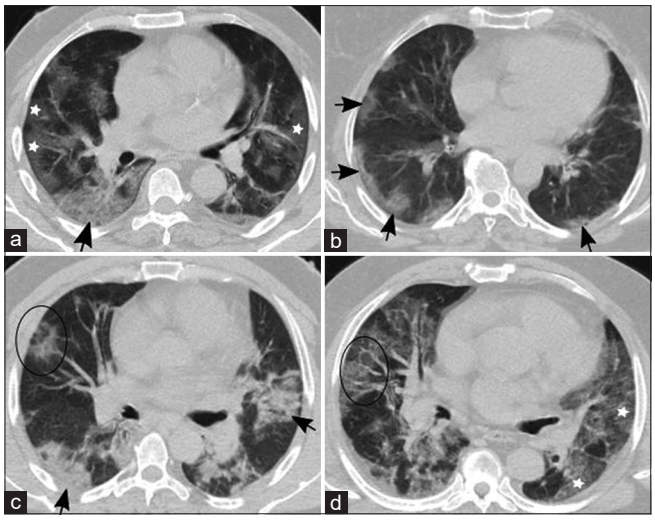

Figure 2: Axial noncontrast chest computed tomography features of radiologically evident coronavirus disease 2019 observed in this study. (a) Bilateral, peripheral patches of ground-glass opacity (stars) with consolidation (short black arrow); (b) Multiple round patches of ground-glass opacity (short black arrows); (c) Reverse halo sign (circle) with consolidation (short black arrow). (d) ground-glass opacity (stars) with interlobular septal thickening (crazy paving) (circle)

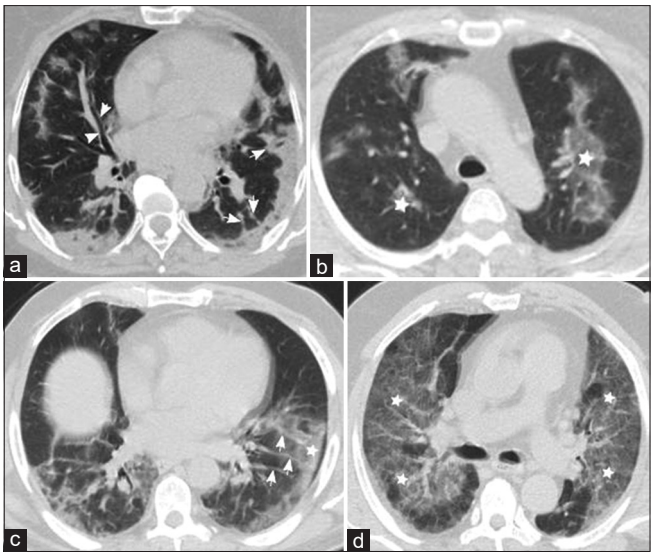

Figure 3: Axial noncontrast chest computed tomography of other features of coronavirus disease 2019 observed in this study. (a) Subpleural traction bands with architectural distortion (arrowheads), and bronchial wall thickening (arrowheads); (b) Nonperipheral patches of ground-glass opacity (stars); (c) Vessel dilatation (arrowheads) within ground-glass opacity (star); (d) Extensive ground-glass opacity and consolidation (ARDS (Acute Respiratory Distress Syndrome) like) (stars)

A total of 565 cases had positive PCR results (45.6%), of whom 557 had "radiologically evident COVID-19" on chest CT (97.7%), and the scans of 8 cases were reported as "possible COVID-19" (29.6%). All cases with "no radiological evidence of COVID-19" had negative PCR results.

To calculate accuracy, sensitivity, specificity, PPV, and NPV, CT reports were categorized as "radiologically evident" or "radiologically nonevident. "The radiologically non-evident group included cases their scans had "no radiological evidence of COVID-19" as well as cases with "possible COVID-19". Calculated accuracy, sensitivity, specificity, PPV, and NPV were 98%, 98.5%, 98%, 97.7%, and 98.8%, respectively, in relation to the PCR result [Table 3]. Agreement between chest CT and PCR was excellent with a kappa of 0.96 (95% confidence interval: 0.95–0.98).

Discussion

With a rapidly escalating course of COVID-19 in Libya,[1,2] EDs in public hospitals are crowded with patients suspected being infected. With a limited availability of PCR testing, a long time before test results can be obtained, and the chance false-negative results, reliance solely on PCR testing may result in the slow triaging of suspected cases as well as delays in referring COVID-19 cases to appropriate isolation wards.

In this study, and in agreement with previously published studies from China,[5,7,18,19] Italy,[20,21] The Netherlands,[10] and France,[12,13] we report a high level of accuracy and sensitivity of chest CT in diagnosing COVID-19 in adults with respiratory symptoms presenting to the ED. The use of the highly specific PCR testing platform Xpress Xpert SARS-CoV-2 as a standard reference further increases reliability in our findings.[22,23] Although chest CT is not currently recommended for a routine use in triage,[24,25] a recent meta-analysis by the Fleischner Society recommended chest CT for quick ED triaging of moderate-to-severe cases suspected of COVID-19.[26] The WHO also suggests using CT scan in situations where PCR testing is not available or when COVID-19 is still suspected despite a negative PCR result.[24]

Moreover, the growing knowledge and experience in COVID-19 chest CT features during the current pandemic as well as the implementation of consensus reporting guidance may reduce reporting uncertainty and decreases inter-reporter variability.[27,28]

Specificity in our study is particularly higher than previous studies conducted earlier this year.[5,12,20,21] This might be partially explained by the summer season in Libya which makes alternative diagnoses, such as viral or atypical pneumonia, relatively infrequent.

However, cases with preexisting or concomitant pulmonary pathology, such as advanced fibrosis or pulmonary edema, might pose a challenge to triaging by chest CT alone and may also reduce its specificity. In this study, only 27 cases were reported as a mixed picture (possible COVID-19), and 8 tested positive by PCR. This category of cases needs careful reporting and might need PCR testing before referral for further care.

Table 3: Performance of computed tomography scan compared to polymerase chain reaction in coronavirus disease 2019 diagnosis

Items	SARS-CoV-2 positive	SARS-CoV-2 negative	Percentage
Radiologically evident	557	13	PPV=97.7
Radiologically nonevident	8	662	NPV=98.8
Percentage	Sensitivity=98.5	Specificity=98	

SARS-CoV-2=Severe acute respiratory syndrome coronavirus 2, PPV=Positive predictive value, NPV=Negative predictive value

Previous studies have reported variable PPV and NPV for chest CT findings.[12,21,28] This may be due to variations in geographical disease prevalence, inclusion of asymptomatic cases, and the reliability of PCR testing platform used as a reference. In this study, we reported a high PPV of chest CT findings; this might be due to exclusion of asymptomatic cases, high prevalence of COVID-19 in the ED, and the very low false-negative results with Xpert PCR testing platform.[22,23]

In addition, high NPV is very important to safely address negative patients to general admission wards. The reported high NPV is similar to previous studies in France[12,13] and The Netherlands.[10] This could be explained by the nature of the cohort under study. It mostly comprised cases presenting to the ED with respiratory symptoms and thus with a low probability of having a false-negative chest CT.

Our study has limitations that need to be acknowledged. First, it is retrospective and from a single center. Second, chest CT reporters were aware of the suspicion of COVID-19 in the scanned cases which might have introduced a reporter bias; however, swabs were collected after performing the scan, and reporters were blinded to PCR results at time of reporting. Third, our study was conducted during the summer season with only a few instances of radiologically similar atypical pneumonia. Fourth, there is a concern regarding generalizing our results to geographical areas or ED settings in which COVID-19 prevalence is low. This could certainly decrease sensitivity and PPV. However, as the figures of new infections continue to rise and overload ED in Libya, our study results are applicable to similar settings. Finally, the specificity of chest CT might be lower than we reported in cases with preexisting or concomitant pulmonary pathology who might still need PCR results for triaging.

Despite its limitations, our study does have advantages. Cases were included based on clear clinical criteria for suspected COVID-19, and a highly accurate reference standard for COVID-19 diagnosis was used.

Conclusion

During the currently high prevalence of COVID-19 in Libyan EDs, and with the limited availability of PCR testing, there is a substantial evidence to support the implementation of chest CT in properly triaging and quickly referring symptomatic cases to the appropriate medical facility for further care.

Ethic statement

This study was conducted in accordance with the Declaration of Helsinki on ethical principles for medical research. The study was submitted to and approved by the local ethics review board of TUH (reference: IDD-2020-003). Written informed consent was waived by the review board as the study is retrospective with no direct harm to participants, and individually identifiable data would not be made publically available.

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Conflicts of interest

There are no conflicts of interest.

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