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Review Article

The Diagnostic Value of CT scans in the Process of Diagnosing COVID-19 in medical Centers

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Abstract

Background: Coronavirus disease (COVID-19) has spread around the world since the beginning of 2020. The definitive diagnosis of COVID-19 is the RT-PCR laboratory test. However, because of low sensitivity, the chest CT scan has become important for the rapid diagnosis and clinical decision-making.

Objectives: This study aims to define CT scan' diagnostic value in diagnosing COVID-19 in medical centers.

Methods: This study is a rapid health technology assessment (HTA) and had two major phases. In phase 1, a rapid review was done for defining the sensitivity and specificity rate of CT. During this phase, studies related to the diagnostic and technical data on the use of CT in the diagnosis of COVID-19 were reviewed, and the sensitivity and specificity of CT in these studies were extracted. In phase 2, sequential testing was run to evaluate the diagnostic value of chest CT to diagnose COVID-19 according to two scenarios before and after adding RT-PCR test results.

Results: CT scan has a high sensitivity for diagnosing cases of COVID-19. Due to its low specificity, relying on CT scans to diagnose COVID-19 alone in medical centers can lead to a significant proportion of false-positive cases. This study showed that if the probability of COVID-19 before the CT scan were about 50%, with a positive CT scan, this probability would be between 60 and 70% depending on the CT specificity.

Conclusions: With the available evidence, the use of a CT scan alone is not sufficient for diagnosis. The RT-PCR test is also necessary to improve the diagnosis and continue the treatment and isolation of patients.

Keywords: COVID-19; CT Scan; Health Technology Assessment (HTA); RT-PCR Test; Sensitivity; Specificity

1. Background

Coronavirus disease (COVID-19) has spread around the world since the beginning of 2020 (1). In January 2020, this global pandemic was declared by the World Health Organization as a public health emergency (2). It is a highly contagious virus, which in severe cases, can lead to pulmonary dysfunction and acute respiratory or organ failure (3). In Iran, the first case of this virus was identified on February 20, 2020. Since then, there have been 123,000 definite infections in the country (4).

The definite diagnosis of COVID-19 is the RT-PCR laboratory test. However, because of low sensitivity, possible errors in sampling (5, 6), and a long time required for diagnosis, the use of the chest CT scan has become important for the rapid diagnosis and clinical decision-making (7). The predominant imaging features with CT scan in pulmonary infection caused by COVID-19 have been reported as double-sided ground-glass opacities, multifocal patchy consolidation, and intermediate changes with environmental distribution. However, the manifestations of pulmonary CT scans in different patients and stages may be different. The use of CT scans as the only way to diagnose COVID-19 may be associated with some errors due to the similarities between the radiological findings of COVID-19 and other lung infections and the fact that the early stages of COVID-19 are not diagnosable by CT (3).

In Iran, according to the protocol of the Ministry of Health and Medical Education, entitled "Instructions on how to care and diagnose COVID-19 in selected comprehensive health care centers (16 or 24 hours)", the patients are categorized into two groups: those who need to be hospitalized and those who are outpatient and have serious conditions. In the first group, the diagnostic imaging services are performed in the hospital, mainly according to the routine care of the disease and the patient's physical condition. In the outpatient group, the chest CT scan is conducted for people with a competent immune system,

and chest x-rays are performed for people with a disease background. These diagnostic services are performed while all of these patients are sampled at the RT-PCR laboratory test upon entering the medical centers (8).

There has been much debate about the diagnostic value of chest CT scans for the diagnosis of COVID-19 disease. Some clinicians prefer it to RT-PCR testing, while others see it as a misleading option if used alone.

2. Objectives

The present study collects, analyzes, and summarizes scientific evidence published in the world regarding the sensitivity and specificity of CT scans in the diagnosis of COVID-19. It also demonstrates the diagnostic value of CT according to different scenarios by combining symptoms and using sequential testing and also adding the RT-PCR test to provide scientific evidence for an effective diagnostic method for the diagnosis of COVID-19.

3. Methods

This study is a rapid health technology assessment (HTA) and had two major phases.

3.1. Phase 1: Rapid Review and Defining Sensitivity and Specificity Rate in Previous Studies

First, a search was conducted to identify studies related to the diagnostic and technical data on the use of CT in the diagnosis of COVID-19. For this, the most important scientific medical databases (including EMBASE, PubMed, Cochrane, and Google Scholar) were searched, and after screening the evidence considering eligibility criteria, data was extracted. Four diagnostic studies were finally entered into the final phase.

The inclusion criteria were as follows:

Study population: Suspected patients with COVID-19;

Index Test: Chest CT scan;

Control: Other diagnostic methods such as laboratory tests;

Outcome: Sensitivity, specificity, positive and negative predictive value, and accuracy.

3.2. Phase 2: Sequential Testing

This assessment was conducted in two steps. In the first step, we evaluated the diagnostic value of the chest CT for the diagnosis of COVID-19, and in the second, we investigated the effect of adding the RT-PCR test result to it.

3.2.1. First Step: Evaluation of the Diagnostic Value of Chest CT for Diagnosing COVID-19

To assess the diagnostic value of CT scans in the clinical diagnosis of COVID-19, the diagnostic process in the hospital has been considered. Based on this process, the person shows up with flu-like clinical symptoms. In the triage phase, the emergency physician hospitalizes the person for further evaluation based on the matching of the symptoms with COVID-19.

At the symptoms matching stage, other tests, such as blood cell counts, inflammatory markers, and other tests were done, which are simply referred to as "symptoms package", and their net sensitivity and specificity is assumed to be 80% and 25%, respectively. Therefore, the "symptoms package" refers to a set of diagnostic procedures that lead to a decision to perform a CT scan. Although the diagnostic value of this package can vary greatly depending on the patient's location, referral level, physicians' performance, and experience, this difference has little effect on showing the diagnostic value of the CT scan, which is the main purpose of this study.

This assessment was performed for areas with high levels of epidemics. In these cases, the disease's prevalence in patients with symptoms who referred to medical centers is 50%.

In three studies, the sensitivity of CT scans in detecting COVID-19 was estimated to be 97%, and in one study, 98%. Considering the similarity of the results of 3 out of 4 studies and the small effect of increasing the sensitivity by 1% on the overall results in the following scenarios, the sensitivity of CT scans has been considered to be 97%. However, due to the significant difference in the results of the two studies that reported the specificity (25% vs. 56%), the effect of these two features will be examined in two separate scenarios (Tables 1 and 2).

Table 1. Sensitivity and Specificity Table

Name of the Author	Name of the Study	Sensitivity, %	Minimum, %	Maximum, %
Yicheng, et al. (5)	Sensitivity of chest CT for COVID-19: comparison to RT-PCR	98	90	100
Chunqin, et al. (7)	Diagnosis of the coronavirus disease (COVID-19): rRT-PCR or CT?	97.2	-	-
Tao, et al. (6)	Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases	97	95	98
Damiano, et al. (9)	Chest CT features of COVID-19 in Rome, Italy	97	88	99

Table 2. Specificity Table

Name of the Author	Name of the study	Specificity, %	Minimum, %	Maximum, %
Tao, et al. (6)	Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases	25	22	30
Damiano, et al. (9)	Chest CT features of COVID-19 in Rome, Italy	56	45	66

3.2.2. Step 2: Evaluating the Diagnostic Value of Adding RT-PCR Test Results to CT Results

In this step, the RT-PCR test result was added to the result obtained from the CT scan test for the diagnosis of COVID-19 consecutively. Based on the results of recent studies, the sensitivity and specificity of the RT-PCR test are 60% and 100%, respectively.

4. Results

Four of the reviewed articles assessed the sensitivity. The results are shown in the sensitivity table (Table 1). As the table shows, the highest sensitivity of the CT scan has been reported as (98%; CI: 90 - 100) (5). In another study comparing RT-PCR and CT methods, CT sensitivity was reported to be 97.2% (7). The results of the two studies show the lowest sensitivity of CT (97%; CI: 95 - 98) and (97%; CI: 88 - 99). Two papers also evaluated the CT specificity. As the table of specificity shows, the lowest figure of CT (25%; CI: 22 - 30) (6) and the highest figure (56%; CI: 45 - 66) have been reported (Table 2) (9).

In the first scenario, the prevalence, CT sensitivity, and CT specificity are considered 50%, 97%, and 25%, respectively. Table 3 shows the findings of the first scenario.

Table 3. Scenario 1: The Result of Sequential Testing of Symptoms and CT Scan in the Diagnosis of COVID-19 in Medical Centersa

	Symptom			
	Disease +	**Disease -**		Sensitivity = 0.8
Test +	4000	3750	7750	Specificity = 0.25
Test -	1000	1250	2250	Prevalence = 0.5
	5000	5000	10000	
	CT SCAN			
	Disease +	**Disease -**		Sensitivity = 0.97
Test +	4850	3750	8600	Specificity = 0.25
Test -	150	1250	1400	Prevalence = 0.5
	5000	5000	10000	
	Sequential			
	Disease +	**Disease -**		Net sensitivity = 0.78
Test +	3880	2813	6693	Net specificity = 0.44
Test -	120	938	1058	Net positive predictive value = 0.58
	4000	3750	7750	Net negative predictive value = 0.66
				Net false positive rate = 0.56
				Net false negative rate = 0.22
	Net 1			Net Likelihood ratio + = 1.38
	Disease +	**Disease -**		Net likelihood ratio - = 0.51
Test +	3880	2813	6693	Net post-test prevalence = 0.67
Test -	1120	2188	3308	
	5000	5000	10000	

[a]Scenario 1 prevalence: 50%; CT sensitivity: 97%; CT specificity: 25%.

The result of sequential testing of symptoms and CT scans in the diagnosis of COVID-19 throughout the first scenario show:

Net sensitivity is estimated to be 78%. In other words, with this combination of tests, 22% of patients with symptoms who have COVID-19 are not diagnosed and are treated or discharged with diagnoses other than COVID-19.

Net specificity is estimated to be 44%. In other words, with this combination of tests, 56% of patients with symptoms, who do not have COVID-19, are considered and treated with COVID-19 diagnosis.

Net positive predictive value is estimated at 58%. In other words, 42% of people with symptoms who were recognized as COVID-19 do not have the disease.

Finally, in this scenario, the final prevalence of the disease in patients who go to medical centers is estimated at 67%, which is 17% higher than the actual prevalence.

In the second scenario, the prevalence, CT sensitivity, and CT specificity are considered 50%, 97%, and 56%, respectively. Table 4 shows the findings of the second scenario.

Table 4. Scenario 2: The Result of Sequential Testing of Symptoms and CT Scan in the Diagnosis of COVID-19 in Medical Centersa

	Symptom			
	Disease +	**Disease -**		Sensitivity = 0.8
Test +	4000	3750	7750	Specificity = 0.25
Test -	1000	1250	2250	Prevalence = 0.5
	5000	5000	10000	
	CT SCAN			
	Disease +	**Disease -**		Sensitivity = 0.97
Test +	4850	2200	7050	Specificity = 0.56
Test -	150	2800	2950	Prevalence = 0.5
	5000	5000	10000	
	Sequential			
	Disease +	**Disease -**		Net sensitivity = 0.78
Test +	3880	1650	5530	Net specificity = 0.67
Test -	120	2100	2220	Net positive predictive value = 0.70
	4000	3750	7750	Net negative predictive value = 0.75
				Net false positive rate = 0.33
				Net false negative rate = 0.22
	Net 2			Net likelihood ratio + = 2.35
	Disease +	**Disease -**		Net likelihood ratio - = 0.33
Test +	3880	1650	5530	Net post-test prevalence = 0.55
Test -	1120	3350	4470	
	5000	5000	10000	

[a]Scenario 2: Prevalence: 50%; CT sensitivity: 97%; CT specificity: 56%.

The result of the sequential testing of symptoms and CT scans in the diagnosis of COVID-19 throughout scenario 2 show:

Net sensitivity is estimated to be 78%. In other words, with this combination of tests, 22% of patients with symptoms that do not have COVID-19 have not been recognized and treated or discharged with diagnoses other than COVID-19.

Net specificity is estimated at 67%. In other words, with this combination of tests, 33% of patients with symptoms who do not have COVID-19 are considered and treated as COVID-19.

In this scenario, the net positive predictive value is estimated to be 70%. In other words, 30% of cases with symptoms that are diagnosed as COVID-19 do not have this disease.

Finally, according to scenario 2, the final prevalence of the disease in patients referred to medical centers is estimated to be 55%, which is 5% higher than the actual prevalence.

In the next step of this evaluation, we examined the effect of using the RT-PCR test on test results as scenario 3. Table 5 shows the findings of the third scenario.

Table 5. Scenario 3: The Result of the Sequential Testing of the RT-PCR test to the Evaluation of Symptoms and CT Scan in the Diagnosis of COVID-19 in Medical Centersa

Scenario 3					
	RT-PCR				
	Disease +	**Disease -**		Sensitivity = 0.60	
Test +	**3000**	**5**	3005	Specificity = 1.00	
Test -	2000	4995	6995	Prevalence = 0.50	
	5000	5000	10000		
	Sequential			Spec = 25%	Spec = 56%
	Disease +	**Disease -**		Net sensitivity = 0.47	0.47
Test +	2328	2	2330	Net specificity = 1.00	1.00
Test -	1552	1648	3200	Net positive predictive value = 1.00	1.00
	3880	1650	5530	Net negative predictive value = 0.65	0.65
				Net false positive rate = 0.00	0.00
				Net false negative rate = 0.53	0.53
	Net 3			Net likelihood ratio + = 828	1411
	Disease +	**Disease -**		Net likelihood ratio - = 0.53	0.53
Test +	2328	2	2330	Net post-test prevalence = 0.23	0.23
Test -	2672	4998	7670		
	5000	5000	10000		

The result of adding the RT-PCR test to sequential testing of CT scan assessment and the symptoms throughout both scenarios 1 and 2 shows:

Net sensitivity is estimated at 47%. In other words, with this combination of tests, 53% of the disease cases are not identified and treated with other diagnoses except COVID-19.

Net specificity is estimated to be approximately 100%. With this combination of tests, very few patients with symptoms who do not have COVID-19 are considered and treated with a COVID-19 diagnosis.

Net positive predictive value is estimated at approximately 100%. In other words, very few patients with symptoms identified as COVID-19 do not have the disease (approximately 0%).

Finally, according to scenario 3, the ultimate prevalence of the disease in patients referred to medical centers is estimated at 23%, which is 27% lower than the actual prevalence.

5. Discussion

The CT scan has a high sensitivity in detecting cases of COVID-19, but due to its low specificity, relying solely on a CT scan to diagnose COVID-19 in medical centers can lead to a significant proportion of false-positive cases. As studies showed, the presence of a high false-positive ratio in addition to estimating more than the actual number of cases of the disease (6, 10) can be lead to more hospitalization and treatment of people without the disease in the special wards of patients with COVID-19. This leads to increasing costs and also puts people at risk of COVID disease and cross-infection in the community (11). Also, large-scale use of CT will increase radiation exposure of the population, which increases the probability of uncertain biological effects in the long term (12).

In order to improve diagnostic evaluation and continue the process of treatment and isolation of patients, RT-PCR testing should be performed for all the suspected COVID-19 patients, and studies show the same results (13).

Although clinical decision-making for the treatment of patients with acute respiratory syndrome in medical centers may not be significantly different from the patients with COVID-19, the use of CT scan lonely is not sufficient for diagnosis. The RT-PCR test is also necessary to improve the diagnosis and continue the process of treatment and isolation of patients.

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