Immunity due to COVID-19 vaccination and its correlation with lung involvement severity as an indicator of disease severity

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ABSTRACT

Introduction: Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic is a worldwide challenge; regarding the lack of an effective and efficient drug. It seems that the vaccine is the only modality to save the world from this pandemic

Objectives: This study was conducted to assess the effect of vaccination on preventing pulmonary involvement and the disease severity of COVID-19 patients.

Patients and Methods: This descriptive-analytical study was conducted on 247 people with coronavirus disease 2019 infection. Demographic characteristics and vaccination status information were collected. Patients' lung computed tomography scan findings were scored based on the pulmonary involvement percentage, and then according to this score, they were graded into severe, moderate, mild, and without lung involvement. The association between pulmonary involvement and vaccination status were evaluated by Fisher's exact test and logistic regression.

Results: Most participants were male, with a mean age of 53.74 ± 10.96 years. Most people (42.9%) were partial-vaccinated. Lungs in 53.3% were with lung involvement and in 46.6% were without. The correlation between pulmonary involvement and vaccination was significant (*P*<0.001).

Conclusion: Vaccination is an effective and efficient method in preventing coronavirus disease 2019 severity.

Introduction

The vaccination process and people's immunization are one of the greatest public health successes (1). The rapid production and clinical development of effective vaccines to reduce the epidemic of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has been a testimony to decades of research and successive advances in immunology, vaccinology, and auxiliary biology (2,3). During the outbreak of coronavirus disease 2019 (COVID-19), after the approval of the clinical trial phase of several vaccines, some people hesitated about injecting the vaccine and participating in the universal vaccination process. However, with time passaging and the positive effectiveness of the vaccine in reducing hospitalization and mortality rate related-COVID-19, many people showed a positive attitude and acceptance towards the vaccines approved by the World Health Organization (WHO) (4). Previous studies in different countries indicated the high safety and efficiency of vaccines. A study in England (5) demonstrated that 92% effectiveness of vaccine injection. Several studies in the United States demonstrated that the effectiveness of vaccines against SARS-CoV-2 is 80%

to 90% (6,7). Despite the high effectiveness of vaccines, reported in various studies, some vaccinated people were re-infected with SARS-CoV-2, and reports indicated that disease severity in these patients was lower compared to non-vaccinated (8-10).

Lungs are one of the most vital organs for people, and lung involvement is the main concern of patients with COVID-19 (11). Based on previous studies results, lung involvement, and its subsequent respiratory symptoms have been the most common symptoms of COVID-19 patients (12,13). Some studies reported pulmonary involvement as an indicator of the severity of COVID -19 (14), and others approved its association with kidney damage (15).

Objectives

In this study, we are going to investigate the correlation between pulmonary involvement as an indicator of COVID-19 severity and the vaccination status of COVID-19 patients.

Patients and Methods
Study design and participants

This descriptive-analytical study was conducted on 247 SARS-CoV-2 patients referred to Imam Hossein hospital in Tehran, Iran (2022). In this study, patients with a definite diagnosis of SARS-CoV-2 based on positive real-time-polymerase chain reaction (RT-PCR) were selected by continuous and accessible sampling methods. Demographic characteristics and vaccination status information were collected through clinical documents or asking patients. Chest computed tomography (CT) scan were conducted by a radiologist. Patients' lung CT scan findings were scored based on pulmonary involvement percentage. Then according to these scores, they were categorized into four levels severe, moderate, mild, and without involvement, and the correlation between vaccination status and lung CT scan findings was assessed.

Vaccination status definition

Patients were divided into three categories based on the vaccination injection status; non-vaccinated, partially vaccinated, and fully vaccinated. Patients who did not inject the vaccine at all were considered non-vaccinated, patients who injected less than three doses or more than six months had passed since their third dose were considered partial-vaccination, and patients who injected all three doses and two weeks passed and also had not passed more than six months since the last dose, were considered fully-vaccinated (8).

Chest CT scan score and lung involvement severity

For lung involvement scoring, patients without involvement were taken a score of zero, involvement less than 5% in a lobe was taken a score of one, 5% to 25% score two, 25% to 50% score three, 50% to 75% score four, and

75% to 100% score give. For lung involvement grading, patients without involvement were considered normal, a total score of 1 to 8 was considered mild, 9 to 15 moderate and a score above 15 was considered severe (10).

Statistical analysis

Data were analyzed by SPSS version 26. Quantitative variables were used to describe the data center means, and standard deviations were conducted to describe the data distribution. Analytical tests such as Fisher's exact test, Cramer's V, and binary logistic regression were conducted to explore the correlation between vaccination status and lung involvement severity. A P value less than 0.05 were considered significant.

Results

Out of 247 patients, 150 (60.7%) were male, with a mean age of 53.74 ± 10.96 years. The most common underlying disease was hypertension. Most patients were partial-vaccination. Pulmonary involvement in 24.7% was mild and moderate, 4% severe, and 46.6% were without involvement (Table 1).

Results demonstrated that the correlation between pulmonary involvement severity and vaccination status was statistically significant; considering Cramer's V, this correlation was moderate. Most of the fully-vaccinated patients were without lung involvement or had mild severity, and none had moderate or severe involvement. All of the non-vaccinated patients had pulmonary involvement. Patients with partial vaccination had various degrees of lung involvement, most were without, and the others had moderate or severe involvement. Among patients who had severe lung involvement, most of them (80%) were non-vaccinated, others were partially

Table 1. Demographic characteristics, vaccination status, and pulmonary involvement severity status (N = 247)

Variables		Max	Min
Age (y), Mean ± SD	53.74 ±10.96	80	27
		No.	Percent
Gender	Male	150	60.7
	Female	97	39.3
Underlying Disease	Diabetes	29	11.7
	Hypertension	51	20.6
	Cardiac	18	7.3
	Respiratory	15	6.1
Vaccination Status	Non-vaccination	103	41.7
	Partial-vaccination	106	42.9
	Fully-vaccination	38	15.4
Lung involvement status	Without Involvement	115	46.6
	Mild	61	24.7
	Moderate	61	24.7
	Severe	10	4

vaccinated, and none of them were full-vaccinated. All without pulmonary involvement patients had been vaccinated; most fully vaccinated (84.2%) and partially vaccinated (78.3%) were without lung involvement (Table 2).

Figure 1 demonstrates the frequency of lung involvement severity in patients based on vaccination status. Most partial and fully vaccinated patients had no lung involvement; however, non-vaccinated patients mostly had moderate and severe lung involvement severity (Figure 1).

In another classification, we allocated the patients into two groups, fully vaccinated versus partially or non-vaccinated. Furthermore, based on lung involvement, patients were allocated into two groups with and without lung involvement. The results demonstrated that partially or non-vaccinated patients had pulmonary involvement 8.09 times more than fully vaccinated patients (Table 3).

Discussion

According to the Centers for Disease Control and Prevention (CDC), vaccines are one of the 10 great achievements of the 20th century in the public health field. For almost a hundred years, most countries have been using vaccines to prevent the most common and dangerous infectious diseases (16). From the beginning of the COVID-19 pandemic, researchers from different countries sought to produce an effective vaccine with adequate efficacy and low side effects to fight the pandemic. Regarding the lack of an effective and efficient drug, the vaccine seems to be the only modality to save the world from the SARS-CoV-2 pandemic (17). This study aimed to evaluate the correlation between immunity due to COVID-19 vaccination and pulmonary involvement severity.

Our results showed that pulmonary involvement severity as an indicator of COVID-19 disease severity
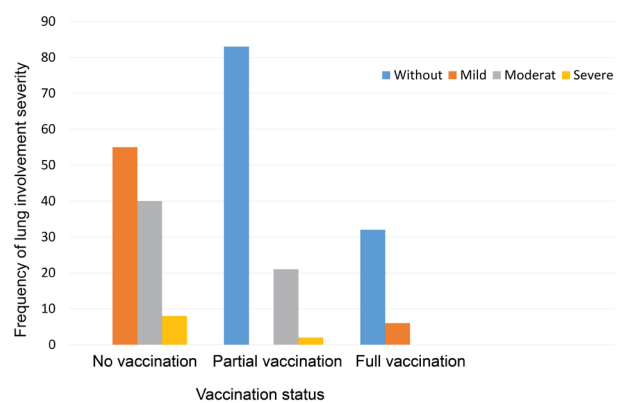

Figure 1. Frequency of lung involvement severity in patients based on vaccination status.

was associated with vaccination status, and vaccinated patients had less disease severity, therefore, full or partial vaccination could prevent critical illnesses to a large extent. In line with our study, Lakhia et al stated that pulmonary involvement severity scores in fully and partially vaccinated COVID-19 patients had been significantly lower compared to non-vaccinated, and full vaccination would be able to prevent severe pulmonary disease (8). Ravindra Naik et al stated that the correlation between lung CT severity score and vaccination status was significant, and CT severity score decreased significantly after receiving two doses (10). In their study, Modi et al demonstrated a statistically significant correlation between vaccination status and pulmonary involvement, and said that vaccine injection reduces the severity of pulmonary involvement in COVID-19 patients and improves the outcome in terms of patient survival (18). In contrast with our study, in a case-control study, Hitchings et al reported an increase in symptomatic SARS-CoV-2 infection among vaccinated healthcare staff after receiving the first vaccination dose compared to those who had

Table 2. Correlation between lung involvement severity and vaccination status

Vaccination status	Lung involvement severity				P value
	Without No. (%)	Mild No. (%)	Moderate No. (%)	Severe No. (%)	
Non-vaccination (n = 103)	0 (0)	55 (53.4)	40 (38.8)	8 (7.8)	
Partial-vaccination (n = 106)	83 (78.3)	0 (0)	21 (19.8)	2 (1.9)	< 0.001*
Fully-vaccination (n = 38)	32 (84.2)	6 (15.8)	0 (0)	0 (0)	

* Fisher's exact test, Cramer's V = 0.585.

Table 3. Comparison of full vaccination versus partial or non-vaccination in preventing lung involvement

Vaccination status	Long involvement		P value	OR	95 % CI	
	With No. (%)	Without No. (%)			Lower	Upper
Fully vaccinated (n = 38)	6 (15.8)	32 (84.2)	<0.001*	8.09	3.24	20.21
Partially or non-vaccinated (n = 209)	126 (60.3)	83 (39.7)				

CI, Confidence interval; OR, odds ratio. *Binary logistic regression.

not been vaccinated (19). Meanwhile, Bernal et al found that the risk of hospitalization, lung involvement, and mortality due to COVID-19 was lower in vaccinated patients compared to non-vaccinated (5).

Our study showed that pulmonary involvement severity in completely vaccinated people was lesser than in partially or non-vaccinated. A study in India reported that complete vaccination reduced the severity of pulmonary complications and mortality of patients with COVID-19 (20). Verma et al showed that lung involvement severity scores had been lower in people who received both SARS-CoV-2 vaccination doses versus those who received one dose or no vaccine at all (21). Another study in eastern India showed that the pulmonary involvement severity of COVID-19 patients in unvaccinated people had been significantly higher than in vaccinated (9). Joshi et al stated that the lung involvement severity of vaccinated individuals was significantly lower than in non-vaccinated, therefore, it is suggested that complete vaccination should be conducted to reduce the COVID-19 infection rate (22). The noted differences in previous studies could be due to differences in the studied populations and the used analytical approach. Our results showed that vaccination could prevent COVID-19 disease severity, and compared to unvaccinated patients, fully or partially vaccinated showed lower pulmonary involvement severity. These findings confirm the evidence that vaccines are an efficient and effective tool in preventing the development of severe stages in the SARS-CoV-2 epidemic. This finding of reduced lung involvement with full or partial vaccination could be practical in highlighting the role of vaccines as an effective tool in the fight against the COVID-19 pandemic in this time of vaccine misinformation to motivate more people to be vaccinated.

Conclusion
The results demonstrated that the immunity caused by vaccination would be able to prevent the development of severe disease in those suffering from COVID-19; therefore, we conclude that vaccination is an effective and efficient method in preventing COVID-19 infection complications in this current pandemic situation.

Limitations of the study
The sample size wasn't enough; because, with an increase in the sample size, the difference in some variables may become significant. Also, this study was conducted on a limited population; for this reason, these results may be no generalizable to all people. Individual, social, psychological, and family differences were the others uncontrollable variables of the present study that can affect the research results.

Authors' contribution
Conceptualization: RM, HS and MA.

Methodology: YKh and MM.
Validation: EGh, FGh and GA.
Formal analysis: MM and HS.
Investigation: RM and YKh.
Resources: FGh, GA and EGh.
Data curation: RM and HS.
Writing–original draft preparation: RM, FGh, EGh, MM and YKh.
Writing–review and editing: HS, GA and MA.
Visualization: YKh and MM.
Supervision: RM.
Project administration: HS.

Conflicts of interest
The authors declare that there is no conflict of interest.

Ethical issues
The research followed the tenets of the Declaration of Helsinki. The Ethics Committee of Shahid Beheshti University of Medical Sciences approved this study (ethical code #IR.SBMU.MSP.REC.1401.390). Accordingly, written informed consent was taken from all participants before any intervention. Besides, the authors have ultimately observed ethical issues (including plagiarism, data fabrication, and double publication).

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