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Comparison of Computerized Tomography (CT) Scan, Clinical and Para-clinical Findings in Hospitalized Vaccinated and Unvaccinated COVID-19 Patients: A Pilot Study from Babol County

Hastanede Yatan Aşılanmış ve Aşılanmamış COVID-19 Hastalarında Bilgisayarlı Tomografi (BT) Taraması, Klinik ve Para-klinik Bulguların Karşılaştırılması: Babol İlçesinden Bir Pilot Çalışma

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ABSTRACT

Objective: Vaccination plays a crucial role in preventing severe lung disease and reducing hospitalization rates among patients with coronavirus disease-2019 (COVID-19). In this study, researchers compared lung computed tomography (CT) scans of vaccinated and unvaccinated individuals with COVID-19, along with clinical and para-clinical findings.

Methods: This study was conducted at Ayatollah Rouhani Hospital in Babol, Iran, between July and November 2021. The researchers selected 106 confirmed COVID-19 patients and divided them into two groups: 53 fully vaccinated individuals who received the Sinopharm vaccine and 53 unvaccinated individuals. Demographics, laboratory, and imaging data were collected.

Results: The mean age of hospitalized patients with COVID-19 was 59.8±16.1 years. The most common CT finding in both groups was bilateral ground glass opacities, observed in 95 patients (89.6%). Significant associations were found between the vaccinated and unvaccinated groups regarding hospital stay duration, oxygen saturation, intensive care unit admission, lactate dehydrogenase levels, and erythrocyte sedimentation rate index.

ÖZ

Amaç: Aşılama, koronavirüs hastalığı-2019 (COVID-19) olanlarda ciddi akciğer hastalıklarını önlemede ve hastaneye yatış oranlarını azaltmada önemli bir rol oynar. Bu çalışmada, araştırmacılar COVID-19'lu aşılanmış ve aşılanmamış bireylerin akciğer bilgisayarlı tomografi (BT) taramalarını klinik ve para-klinik bulgularla karşılaştırmıştır.

Yöntemler: Bu çalışma, Temmuz ve Kasım 2021 arasında İran'ın Babol kentindeki Ayatollah Rouhani Hastanesi'nde yürütülmüştür. Araştırmacılar, 106 doğrulanmış COVID-19 hastasını seçerek iki gruba ayırmıştır: Sinopharm aşısı olan 53 tam aşılanmış birey ve 53 aşılanmamış birey. Demografik, laboratuvar ve görüntüleme verileri toplanmıştır.

Bulgular: COVID-19 nedeniyle hastaneye yatırılan hastaların ortalama yaşı 59,8±16,1 olarak bulunmuştur. Her iki gruptaki en yaygın BT bulgusu, 95 hastada (%89,6) gözlenen bilateral buzlu cam opasiteleri olmuştur. Aşılanmış ve aşılanmamış gruplar arasında hastanede kalış süresi, oksijen satürasyonu, yoğun bakım ünitesine yatış, laktat dehidrogenaz seviyeleri ve eritrosit sedimantasyon hızı indeksi açısından anlamlı ilişkiler bulunmuştur.

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ABSTRACT

Conclusion: This study revealed no difference in the pattern of pulmonary involvement between vaccinated and unvaccinated individuals with COVID-19, except for the peribronchovascular pattern, which was more commonly observed in unvaccinated patients. Other common patterns of pulmonary involvement were also more prevalent among unvaccinated individuals. These findings emphasize the effectiveness of COVID-19 vaccination, as the vaccinated group had a lower rate of pulmonary involvement. This highlights the need for widespread vaccination to effectively combat COVID-19.

Keywords: COVID 19, vaccines, X-ray computed tomography

ÖZ

Sonuç: Bu çalışma, aşılanmış ve aşılanmamış COVID-19'lu bireyler arasında akciğer tutulumu örüntüsünde, aşılanmamış hastalarda daha sık görülen peribronkovasküler örüntü dışında hiçbir fark olmadığını ortaya koymuştur. Ayrıca, diğer yaygın akciğer tutulumu örüntülerinin de aşılanmamış bireyler arasında daha yaygın olduğu gözlenmiştir. Bu bulgular, aşılanmış grupta akciğer tutulumu oranının daha düşük olması nedeniyle COVID-19 aşılamasının etkinliğini vurgulamaktadır. Bu, COVID-19 ile etkili bir şekilde mücadele etmek için yaygın aşılamanın gerekliliğini ortaya koymaktadır.

Anahtar Sözcükler: COVID-19, aşılar, X-ray bilgisayarlı tomografi

INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was officially declared a pandemic by the World Health Organization on March 11, 2020 (1). SARS-CoV-2 has the potential to spread rapidly among humans, currently (December 2024) infecting more than 776 million people worldwide and killing more than 7 million people (2). The virus is spread through respiratory droplets released when an infected person coughs, sneezes, breathes, or speaks. These droplets can be inhaled or land in the mouth, nose, or eyes of someone nearby. In some situations, SARS-CoV2 can be spread when a person is exposed to droplets or aerosols that stay in the air for minutes or hours as airborne transmission. Signs and symptoms may include fever, cough, fatigue, and early symptoms of loss of taste or smell. Other symptoms may comprise shortness of breath or difficulty breathing, muscle pain, sore throat, headache, chest pain, and diarrhea (3). Significant vaccination of at-risk groups and the general population is the most effective public health strategy for mitigating the COVID-19 pandemic (4). Although vaccines do not eliminate reinfection or infection, they certainly reduce the severity of symptoms and the likelihood of infection and improve patient survival(5). Sinopharm vaccine (BBIBP-CorV) is an inactivated vaccine produced in China that demonstrates 79.34% efficacy, which was available at the time of this study in Iran (6). At present (December 2024), according to information from the World Health Organization (WHO), the total number of SARS-CoV2 infections is more than 7.627.863, with 146,837 fatal cases in Iran. Moreover, more than 155 million doses of vaccine have been injected so far (December 2024), and the distribution of the vaccine in the study area is similar to that in other parts of Iran. Chest X-ray (CXR) is not a sensitive tool for detecting lung abnormalities at the onset of the disease. Computed tomography (CT) is considered the most effective method for detecting lung abnormalities, especially in the early stages of the disease, and it has a sensitivity of 97% for diagnosing COVID-19 (7). On high-resolution computed tomography (HRCT), ground-glass opacities (GGO) refer to the area of increased lung opacity in which the underlying bronchovascular markings are not obscured. GGO is the most common manifestation of pneumonia caused by COVID-19. The bilateral lower lobes are most commonly affected, and multilobar subpleural ground-glass opacities are observed in most cases (8). Lung parenchymal involvement is more common in nonvaccinated than in vaccinated patients. The vaccine also reduces the severity of the disease, as well as its symptoms (9). Several studies also found that there was a statistically significant correlation between vaccination status and lung lesions based on chest HRCT. As a result, the presence of vaccination reduces the severity of the CT severity score and improves the outcome in terms of survival of the patients (5). Other studies in India have indicated significantly lower CT severity scores in fully or partially vaccinated patients compared with nonvaccinated patients. Complete vaccination is critical for preventing severe lung disease (10). This study aimed to compare lung CT scans of vaccinated and unvaccinated individuals with COVID-19, along with clinical and para-clinical findings.

MATERIALS AND METHODS

This study was carried out at the Ayatollah Rouhani Hospital, Babol, Northern Iran, from August to December 2021 (five months). This retrospective cross-sectional study included 106 patients vaccinated with 2 doses of Sinopharm vaccine and nonvaccinated patients with reverse transcription-polymerase chain reaction (RT-PCR)-positive COVID-19, irrespective of age and sex. Patients were 53 in each group. All vaccinated patients received 2 doses of the Sinopharm vaccine. Our Sampling technique was purposive.

1) Inclusion criteria

• All hospitalized patients with positive RT-PCR results for SARS-CoV-2/Suspected for COVID-19 during the specified period

2) Exclusion criteria

• Patients who died or were discharged within the first 24 hours of hospitalization

• Pregnant patients

• Patients younger than 20 years

• Vaccinated patients who received only one vaccine dose or those who received the last vaccine dose within less than 2 weeks of admission

• Patients who have had symptoms for more than a week

This study was approved by the local ethics committee (approval number: IR.MUBABOL.HRI.REC.1400.235, date: 07.03.2022) at the Babol University of Medical Sciences, Babol, Iran, and written informed consent was collected from each patient. The data-capturing master sheet was maintained throughout the study. At enrollment of patients, demographic and baseline characteristics were recorded. CT findings were evaluated. Patient information was obtained using an information sheet that included laboratory data and radiological findings.

All scans were performed using 16 slices of SIMENS (Germany) CT scanner.

Scan Parameters**:**

1- Slice Thickness: 3.00 mm

2- Rotation Time: 0.6s

3- Scan time: 6.93 s

4- Pitch: 1.5

5- mAS: 35

6- Kvp: 110

Images were interpreted independently by two certified radiologists, blinded to the patient's names and clinical or other laboratory findings, and the abnormalities that were considered significant for the disease were recorded by them.

Statistical Analysis

Statistical analysis were performed using SPSS version 23.0 (SPSS Inc., USA). A descriptive analysis was performed on all data. The mean values were calculated for continuous variables. Quantitative observations are indicated by frequencies. A *p* value<0.05 was considered statistically significant. The intent and purpose of the study, as well as its procedures, risks, and benefits, were explained in an easy-to-understand local language, followed by oral and written consent from the Patients. All information and records are guaranteed to be treated confidentially.

RESULTS

A total of 106 RT-PCR-positive COVID-19 patients participated in our study at Ayatollah Rouhani Hospital, Babol, Northern Iran, from August to December 2021 (five months). Of these, 53 (50%) patients were vaccinated and 53 (50%) were unvaccinated. The mean age of the participants was 59.8±16.1 (age range of 21-94 years). The mean age of the vaccinated and unvaccinated participants was 59.2±14.6 (age range of 34-88 years) and in the unvaccinated group was 60.4±17.6, 6 (age range of 21-94 years). In this study, 65 (61.3%) patients were male and 41 (38.7%) were female. Regarding comorbidities, a history of smoking, hypertension, diabetes mellitus, chronic kidney disease, and obesity was not statistically significant (p>0.05). GGO were a predominant CT scan finding in our patients and were found in 95 (89.6%) of them. 52 (54.7%) were unvaccinated and 43 (45.3%) were vaccinated (p=0.004). Interlobular septal thickening was seen in 74 (69.8%) of the patients in whom 43 (58.1%) were unvaccinated and 31 (41.9%) were vaccinated (p=0.011). The next finding was rounded morphology found in 66 (62.3%) patients which were 30 (45.5%) unvaccinated and 36 (54.5%) vaccinated patients (p=0.229). Consolidation, Air bronchogram, Enlarged subsegmental vessels, Crazy paving, Linear opacities, Reverse halo sign, Pleural effusion, and Tree-in-bud were other CT scan findings that are shown in Table 1. The predominant distribution of lung parenchyma was Bilateral involvement. It was detected in 95 (89.6%) patients that 43 (45.3%) patients were vaccinated and 52 (54.7%) patients were unvaccinated (p=0.004). 90 (%84.9) patients had more than two lobes affected that 50 (55.6%) patients were unvaccinated and 40 (44.4%) patients were vaccinated (p=0.007). Peripheral involvement was the next finding that has been found in 88 (83%) patients that 49 (55.7%) patients were unvaccinated and 39 (44.3%) patients were vaccinated (p=0.010). Posterior, lower lung, peri-bronchovascular, and central were other distributions found in the CT scan that are also shown in Table 1. The mean time of hospitalization was 8 days, and vaccinated patients stayed for fewer days than unvaccinated patients (p=0.020). Also O_2 saturation percentage was higher in vaccinated patients at admission (p=0.001). Comparison of the cycle threshold value (Ct value) from the RT-PCR test, number of intensive care unit (ICU) admissions, and number of deaths during the time of hospitalization between the vaccinated and unvaccinated groups are shown in Table 2. Table 2 also shows some laboratory data of patients, including white blood cell (WBC) count, polymorphonuclear neutrophil percentage, lymphocytes percentage, lactate dehydrogenase (LDH), erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP). LDH and CRP showed a statistically significant difference in vaccinated patients. Blood O_2 saturation percentage status in vaccinated and unvaccinated patients was divided into three groups: mild (O_2>94%), moderate (90%<O_2<94%), and severe (O_2<90%). Figure 1 shows that as the O_2 saturation percentage progresses, the number of vaccinated patients increases.

DISCUSSION

Due to the critical role of vaccination in COVID-19 prevention, the current cross-sectional study compared lung involvement between vaccinated and unvaccinated patients by performing HRCT. In the present study, GGO was our patients' predominant CT finding. It was found in 95 (89.6%) of them with a significant relationship between GGOs and being vaccinated or not, which was observed less in vaccinated patients compared with unvaccinated patients. In addition, consolidation was observed in 53 (50%) participants, with a significant relationship between consolidation and being vaccinated or not, which was also found less in vaccinated people compared with unvaccinated cases. In a similar study by Verma et al (11) GGOs and consolidation were significantly less in the group receiving the vaccine compared with the unvaccinated patients were significantly less. Interlobular septal thickening, air bronchogram, and linear opacities are also our other findings that respectively seen % in 69.8, 44.3%, and 35.8% of patients that were observed significantly more in unvaccinated patients than vaccinated ones, respectively, similar to the study of Hughes et al. (12), Zhu et al. (13), and Liu et al. (14), which showed the efficacy of vaccines against the severity of this disease.

In another part of the comparison of CT scan findings in this study, the distribution of lung involvement was investigated, and the predominant distribution of lung parenchymal involvement was bilateral involvement. It was observed in 95 (89.6%) patients, which was lower in vaccinated patients than in unvaccinated patients. Other distributions of lung involvement included more than two lobes affected (84.9%), peripheral (83%), posterior (52.8%), and lower lung (35.8%). These involvements were observed less frequently in vaccinated patients compared with unvaccinated patients (15), suggesting that vaccination is possibly an effective approach to prevent the occurrence and severity of this disease. The only distribution that showed a higher incidence among vaccinated patients was peri-bronchovascular involvement (35.8%), which requires further investigation to be clarified. According to the current study, the average length of hospital stay for vaccinated patients

Table 1. Computed tomography chest findings of patients with COVID-19 infection in correlation to vaccination status

Findings	Total (n=106) median ± sig.	Unvaccinated median ± sig.	Vaccinated median ± sig.	p
Ground glass opacities	95 (89.6%)	52 (54.7%)	43 (45.3%)	0.004
Interlobular septal thickening	74 (69.8%)	43 (58.1%)	31 (41.9%)	0.011
Rounded morphology	66 (62.3%)	36 (54.5%)	30 (45.5%)	0.229
Consolidation	53 (50%)	34 (64.2%)	19 (35.8%)	0.004
Air bronchogram	47 (44.3%)	31 (66%)	16 (34%)	0.003
Enlarged subsegmental vessels	12 (11.3%)	10 (83.3%)	2 (16.7%)	0.014
Tree-in-bud	1 (0.94%)	0 (%0)	1 (100%)	0.315
Pleural effusion	3 (2.8%)	2 (66.6%)	1 (33.3%)	0.558
Linear opacities	38 (35.8%)	25 (65.8%)	13 (34.2%)	0.015
Crazy paving	52 (49.1%)	25 (48.1%)	27 (51.9%)	0.698
Reverse halo sign	9 (8.5%)	7 (77.8)	2 (22.2%)	0.081
Bilateral	95 (89.6%)	52 (54.7%)	43 (45.3%)	0.004
More than 2 lobes affected	90 (84.9%)	50 (55.6%)	40 (44.4%)	0.007
Peripheral	88 (83%)	49 (55.7%)	39 (44.3%)	0.010
Posterior	56 (52.8%)	34 (60.7%)	22 (39.3%)	0.020
Lower lung	38 (35.8%)	29 (76.3%)	9 (23.7%)	0.001
Peri-broncho vascular	38 (35.8%)	12 (31.6%)	26 (68.4%)	0.005
Central	4 (3.8%)	1 (25%)	3 (75%)	0.308

was 6.9 days compared with 8.3 days for unvaccinated patients. The Ct values measured by real-time RT-PCR were 25 for vaccinated and 26.9 for unvaccinated patients. These data are also similar to those of Verma et al study that demonstrated the mean Ct value in vaccinated patients was less than that in unvaccinated patients (11). The percentage of O_2 saturation for vaccinated patients was 93.8% but it was 90.7% for unvaccinated patients. Seo et al (16) also found that unvaccinated patients significantly needed more complementary oxygen therapy, which is similar to the data of the current study and indicates the advantage of vaccination in reducing the severity of disease. Sikora et al. (17) showed that vaccination reduces the number of ICU admissions which is also similar to the current study in which a total of 14 (13.2%) patients were admitted to ICU whom 9 of them were unvaccinated and 5 were vaccinated. Although it was not significant, it indicates the efficacy of vaccination in reducing the excessive hospital load. Regarding the laboratory data, similar to the Rzymski et al. (18) study, this study showed no significant difference between the WBC count in vaccinated and unvaccinated patients. LDH levels were significantly higher in unvaccinated patients, similar to the study of d'Arminio Monforte et al. (19) which showed that LDH level changes were higher in unvaccinated patients. CRP levels also increased in unvaccinated patients, although it was not statistically significant, but similar to the study of Wang Y et al. (20) CRP levels were higher in unvaccinated patients. These data show that LDH and CRP levels can anticipate the severity of disease in patients (21). Lastly, unvaccinated patients had significantly higher ESR levels than vaccinated patients. Samrah et al. (22) also came to this conclusion and stated that high ESR was

Table 2. Parameters of patients with COVID-19 infection correlated with vaccination status

Parameters	Total Median ± sig.	Vaccinated Median ± sig.	Unvaccinated Median ± sig.	p
Hospital stays (day)	8±5.5	6.9±3.1	8.3±2.8	0.020
O_2 Saturation (%)	92.3±4.9	93.8±3.6	90.7±5.5	0.001
Cycle threshold value	26±4.2	25±4	26.9±4.2	0.023
ICU admission (number)	14	5	9	0.251
Deaths (number)	7	1	6	0.051
WBC	7647±4722	7236±4640	7662±4722	0.521
PMN (%)	75±14.3	73.9±16.7	76.1±11.7	0.757
LYM (%)	21.1±10.8	21.2±11.3	21±10.5	0.897
LDH	696.7±244.5	631±219.6	762±252.7	0.014
ESR	39.7±22.6	34.9±21.2	44.5±23.1	0.032
CRP	83 ± 67.1	76.5 ± 66.7	89.6 ± 66.7	0.436

WBC: White blood cells, PMN: Polymorphonuclear neutrophil, LYM: Lymphocytes percentage, LDH: Lactate dehydrogenase, ESR: Erythrocyte sedimentation rate, CRP: C-reaktif protein, Sig.:

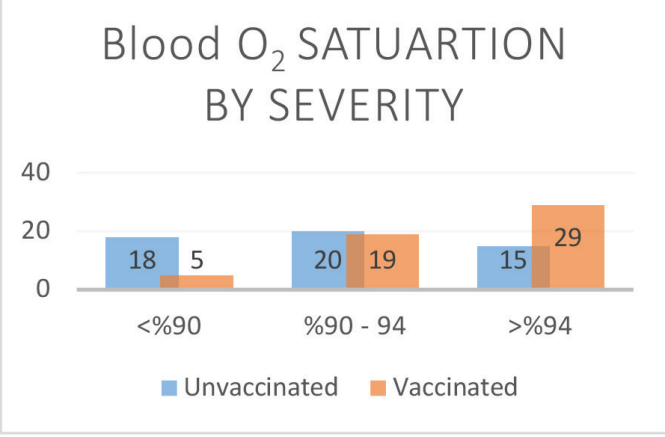

Figure 1. Distribution of O_2 saturation (%) according to severity

found to be a predictor of abnormal chest radiographs; therefore, this marker is expected to increase in patients with severe disease. One of the limitations of this study was that there was only one type of vaccine access, and vaccinated patients received only two doses, both of which can affect all the results. Therefore, other studies needed to be done in this field to compare all the existing vaccines and compare different doses.

CONCLUSION

Based on the results of this study, there was no difference between the pattern of lung involvement in the COVID-19 vaccinated and unvaccinated patients, but the pattern and severity of lung involvement in the vaccinated patients were lower than those in the unvaccinated patients. Additionally, there was a strong correlation between vaccination status and length of hospitalization, oxygen saturation, and the levels of the laboratory markers LDH and ESR levels. Those who had received vaccination had lower levels of LDH and ESR. Additionally, those who were fully vaccinated spent less time in the hospital, and vaccination reduces the number of ICU admissions and deaths; therefore, it can decrease the excess load of patients. These results indicate the effectiveness and necessity of COVID-19 vaccination.

Ethics

Ethics Committee Approval: This study was approved by the local ethics committee (approval number: IR.MUBABOL.HRI.REC.1400.235, date: 07.03.2022) at the Babol University of Medical Sciences, Babol, Iran.

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: H.A., Concept: M.B., Design: M.B., Supervision: F.S., Resources: M.B., Material: M.B., F.S., Data Collection or Processing: H.A., G.H., Analysis or Interpretation: M.T., Literature Search: M.Baz., Writing: H.A., Critical Review: F.S.

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