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ORIGINAL PAPERS

COVID-19 Vaccination Leads to Less Pneumonia at Chest CT

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Abstract

The study's objective was to assess, using CT scans, the impact of vaccinations and booster shots on the severity of COVID-19 pneumonia. In this retrospective analysis, 210 Covid-19 patients were included. Within six weeks of receiving a COVID-19 diagnosis, every patient who was included had at least one CT scan and had received a full, partial, or no vaccination. Patients were separated in three groups. A 6-point scale called the Pneumonia Score was used to compare the severity of pneumonia across the three groups. Hypertension, CAD, DM and CKD were the most common comorbidities among all cases. Mean CRP in group I was 94.7±15.63 mg/dl, in group II mean CRP was 96.9±11.44 mg/dl and in group III mean CRP was 97.3±5.35 mg/dl. We found that severity of pneumonia score 5 was higher in group III in 16 (22.8%) as compared to group I in 4 (5.7%) and group II in 8 (11.4%) cases with p value <0.003. Hospital stays and ICU admission was also higher in non-vaccinated case with p value <0.004. Rate of mortality in group I was 7 (10%), in group II was 13 (18.6%) cases while in group III was 15 (21.4%) cases.

Keywords: Covid-19, Vaccination, CT scan, Pneumonia, ICU

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INTRODUCTION

On March 11, 2020, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), also known as the virus that causes the 2019 coronavirus sickness (COVID-19), was given the status of a pandemic[1]. Since then, over six million people have lost their lives, and the World Health Organization has confirmed over five hundred million cases[2]. Even though there is no vaccination that can ensure full protection, the development of a COVID-19 vaccine has greatly decreased the spread of COVID-19 pneumonia[3].

Chest computed tomography (CT) has demonstrated remarkable sensitivity in identifying COVID-19 patients since the beginning of the global epidemic outbreak caused by SARS-CoV-2. This is true even if there is still work to be done on polymerase chain reaction-reverse transcriptase (RT-PCR) confirmation [5,6] and clinical problems prediction[4,5]. Furthermore, a strong prognostic predictor is the severity of pneumonia as revealed by the initial CT scan[7].

Recent studies[8,9] have reported changes in pneumonia rates and CT findings between patients who got the whole immunization cycle and those who did not. These differences were seen in individuals who had received the full vaccination cycle. Covaxin® (Bharat Biotechnology) and AZD1222 (ChAdOx1) (a quasi-replicating viral vector for vaccine) (Covishield®; AstraZeneca, University of London) [8,9] both found evidence, but only in groups that had previously been vaccinated with deactivated virus vaccines. Nevertheless, Lee et al. reported CT findings with a sample size that was considerably smaller (n = 64) for partially immunized patients and (n = 22) for fully immunized patients[10]. Additionally, there was a significant amount of variation in the degree to which COVID-19 affected the lungs across studies[11], even when the effect of vaccination status was taken into account.

Historically, pandemics have been accompanied by unusually violent cases of pneumonia brought on by the virus. In patients who have viral lung infections, the acute respiratory distress syndrome, often known as ARDS, may be deadly if they do not get prompt treatment. Case fatality rates of the Spanish flu of 1919 (also known as H1N1) were more than 2.5%[12], which led to the deaths of anywhere from 17 million to 50 million individuals worldwide. More than 329 million instances of COVID-19 have been verified; 5.6 million individuals have died, giving the worldwide mortality rate a value of 1.7%. This is despite the significant advances that have been made in medicine over the course of the previous century.

Getting vaccinated is the single most effective way to lower one's chances of becoming infected with SARS-CoV-2, a virus that can, in some instances, result in death. Skepticism over vaccinations represents an opposing force, particularly in the United States. Vaccine reluctance refers to when an individual chooses not to be vaccinated despite the availability of a vaccine[13]. Luo et al. conducted a survey of more than 6,000 Medicare users (aged 65 and older) in order to determine what factors impacted the recipients' willingness to get the COVID-19 immunization. When questioned about vaccination, 61% of respondents said that they would be willing to have it if it were made available. According to the results of a poll, forty percent of respondents said that they had avoided being vaccinated due to a lack of faith in the government. During a pandemic, mistrust may have serious repercussions for those affected. Using CT images, radiologists may be able to "see" this effect very clearly in the lungs.

After two years of the COVID-19 epidemic, the majority of radiologists have observed chest x-rays or CT scans of patients who are infected with the virus. In our practice, the rates of abnormal chest radiographs have followed a pattern that mirrors the cyclical peaks and reductions that have been seen over a number of different pandemic waves. Extracorporeal membrane oxygenation is a technique that temporarily substitutes an external machine for the function of the lungs in order to oxygenate the blood in patients who have suffered the most severe loss of lung function. As the lungs recover from SARS-CoV-2-induced acute respiratory distress syndrome, there is a possibility that the blood will be oxygenated.

Patients diagnosed with COVID-19 have not completed the healing process of their lungs by the time they are discharged from the hospital[14]. Pan et al.[15] looked at the CT scans of twenty-nine COVID-19 hospitalized patients who had received subsequent scans. It is noteworthy that after a year, 25% of patients still had aberrant chest CT findings. In addition to having pulmonary fibrosis, bronchial dilatation was seen in 12% of patients when they were followed up after 1 year. The malfunction of the lungs goes beyond their flawed anatomical structure. Grist et al.[14] investigated the process of lung air exchange in nine different individuals by using hyperpolarized xenon MRI. Even

though the chest CT findings were normal or virtually normal, the patient's alveolar capillary diffusion remained abnormal three months after the patient was discharged from the hospital.

There is a dearth of data comparing the frequency of radiologic abnormalities in individuals who have been vaccinated and those who have not been vaccinated; this is despite the fact that vaccinations have shown to be quite effective. Research was done by Lee et al.[22] to see if there was a relationship between the extent of COVID-19 pneumonia and immunization. In Korea, the overall vaccination rate is 84%, and 86% of the population has had at least one kind of vaccination. Even though everyone has been immunized against COVID-19, there are still cases of the virus breaking through. The authors of a study that was conducted across many centers in Korea conducted an investigation on the incidence of pneumonia in patients who were either fully vaccinated, partially vaccinated, or unvaccinated.

It's possible that the authors' initial discovery may cause some chest radiologists to respond with a "I told you so" remark. At the time of admission, more than two-thirds of patients in the COVID-19 study had negative chest radiographs. When patients were evaluated depending on whether or not they had received vaccinations, there were no discernible changes detected. Because of certain technological restrictions, interstitial lung disease brought on by COVID-19 is notoriously difficult to depict on chest radiographs.

The clinical variables that have been linked to the chest CT results that range from acute to chronic in individuals diagnosed with COVID-19 have been established in previous studies. According to the most recent study, patients who were immunized against COVID-19 had a much lower risk of developing severe CT pneumonia compared to unvaccinated persons. There are, however, surprisingly few reports regarding CT findings in individuals who have had a booster or extra dose of the vaccination. Due to geographical variations in vaccination tactics and varied frequency at the time the study was undertaken, the studies that have been generated have yielded inconclusive results.[18-20]

This important knowledge gap was identified during an era in which the Delta and Omicron variants predominated. The current research addresses this knowledge gap by investigating the correlation between immunization and the greatest severity of pneumonia as measured by CT scans collected during a window of six weeks surrounding the time of diagnosis (from two to four weeks after the diagnosis). We have a working hypothesis that chest CT scans done relatively close to the time of diagnosis will indicate less severe pneumonia if vaccination is complete, regardless of whether or not a booster dose or extra dose was given.

MATERIAL AND METHODS

This retrospective study was conducted at Tikrit teaching hospital and comprised of 210 patients of Covid-19. The COVID-19 diagnosis must have occurred within a 6-week interval (between +2 and 4 weeks) and at least one CT scan must have been conducted during that time. The age range of the patients was 20 to 80.

Demographic data, including age, sex, BMI, status as a smoker and vaccination history (containing product names and dates of immunization), were gathered from electronic medical records. Hospitalizations, admissions to the critical care unit, fatalities from all causes, levels of C-reactive protein and D-dimer, and underlying illnesses such as cancer, diabetes, lung disease, high blood pressure, coronary artery and chronic kidney disease were all recorded. Lung illnesses included lung cancer, thoracic surgery, ILD, COPD, and asthma.

Patients were separated in three groups. Group I had 70 fully vaccinated patients, group II had 70 partially vaccinated and group III had 70 unvaccinated cases. When performing chest CT scans at our institution, we adhered to the standard protocols, which included performing scans with or without the use of intravenous contrast. In a lung window, each and every one of the section CT images was analyzed using the following parameters: 1,000 to 2,000 Hounsfield units for the window's width; 700 to 500 Hounsfield units for the window's level.

Using a modified approach of pattern categorization, as employed by Jin et al. [16], CT scans performed between two and four weeks after the diagnosis were categorized into six severity scores (Pneumonia Scores): No Pneumonia (projected Extent, 0%), Ground-glass opacity (GGO) (10%), Consolidation (30%), GGO to Consolidation Transition (30%), and 4: When more than one CT scan was conducted throughout the course of the six-week interval, each of the scans was assigned a Pneumonia Score, and the scan with the highest score was chosen as the result. After conducting a thorough and impartial analysis of

the CT images, NW and HH, both seasoned thoracic radiologists, were able to come to a unanimous decision about the final score. When there was a disagreement between these two readers, a third, highly trained, and blinded thoracic radiologist (MN) made the decision that ultimately mattered. The three radiologists were completely clueless of the patients' pasts, both in terms of their personal lives and their medical conditions. Calculating the interobserver agreement of the Pneumonia Score was another method that was utilized in order to ascertain the level of concurrence that existed between the initial two readers of the sample of one hundred cases.

For data that was regularly distributed, the numerical variables were given as the mean together with the standard deviation. Categorical factors were given using percentages, and Fisher's exact test was used to determine whether or not there was a correlation between those variables and vaccination status. An one-way analysis of variance, or ANOVA, was utilized to compare hospital stays, D-dimer, and CRP between the three groups. The Kruskal-Wallis test was employed to evaluate age and body mass index. The corrections required for multiple comparisons were made using the Bonferroni procedure. The Wilcoxon rank-sum test was used in order to establish whether or not there were significant changes in Pneumonia Scores based on vaccination status. The analysis of each and every piece of data was performed using SPSS 24.0.

RESULTS

There were majority males 43 (61.4%) in group I, 39 (55.7%) in group II and 40 (57.1%) in group III. (figure 1).

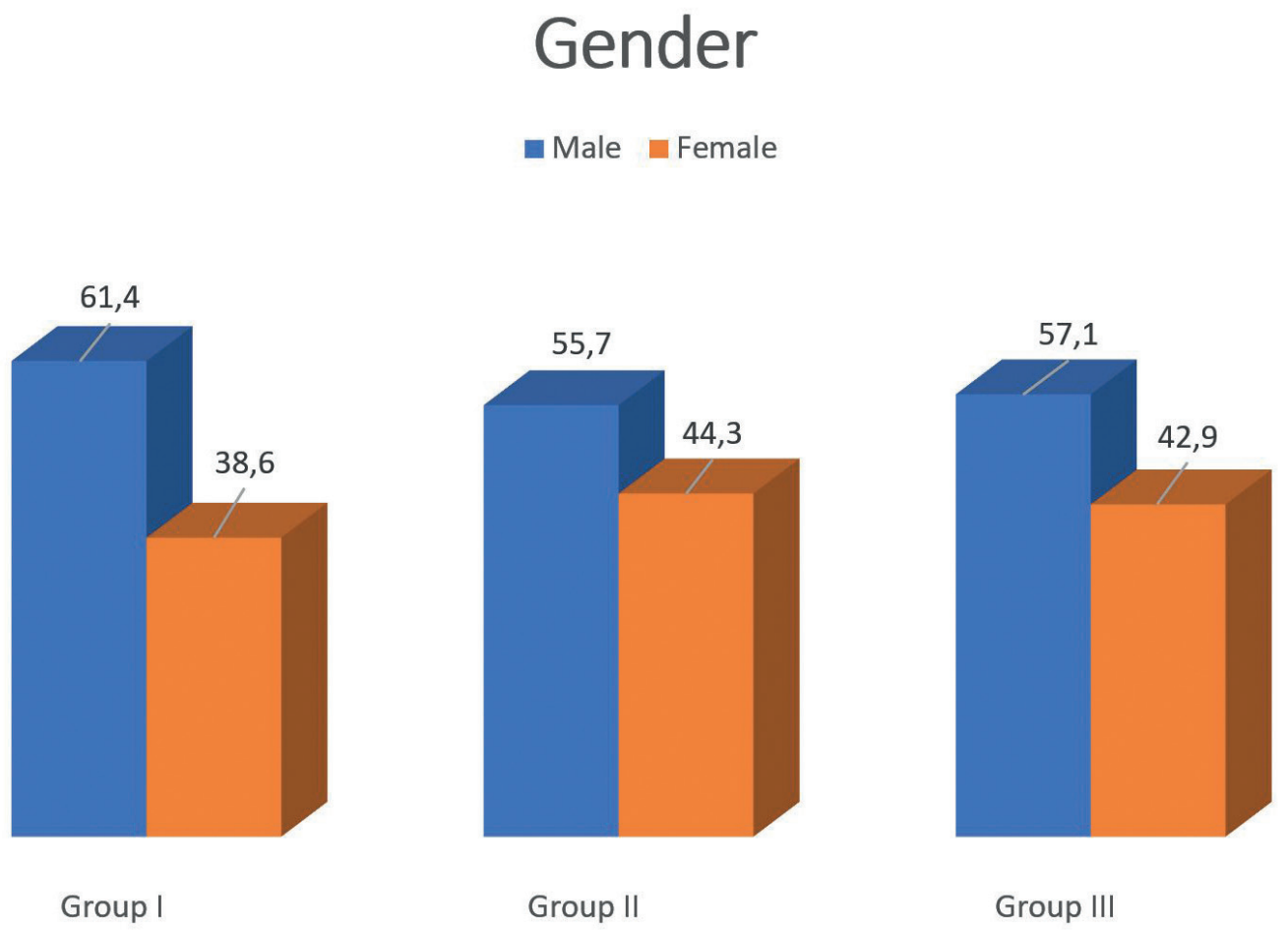

Figure 1. Gender distribution among all cases

Patients mean age in group I was 50.9±7.82 years, in group II mean age was 48.6±14.67 years and in group II mean age was 52.11±14.73 years. Mean BMI in group I was 26.5±10.28 kg/m^2, in group II mean BMI was 25.5±7.38 kg/m^2 and in group III mean BMI was 25.3±15.82 kg/m^2. Hypertension, CAD, DM and CKD were the most common comorbidities among all cases. Mean CRP in group I was 94.7±15.63 mg/dl, in group II mean CRP was 96.9±11.44 mg/dl and in group III mean CRP was 97.3±5.35 mg/dl. 34 cases in group I, 37 cases in group II and 35 cases in group III had smoking history. In group I lung disease was found in 27 cases, 25 cases in group II and 30 cases in group III. (table 1)

Table 1. Baseline characteristics of enrolled cases

Variables	**Group I (70)**	**Group II (70)**	**Group III (70)**
Mean age (years)	50.9±7.82	48.6±14.67	52.11±14.73
Mean BMI (kg/m^2)	26.5±10.28	25.5±7.38	25.3±15.82
Mean CRP (mg/dl)			
Comorbidities			
HTN	30 (42.9%)	32 (45.7%)	28 (40%)
CAD	25 (35.7%)	23 (32.9%)	26 (37.1)
DM	20 (28.6%)	19 (27.1%)	15 (21.4%)
CKD	13 (18.6%)	15 (21.4%)	10 (14.35)
Smoking History			
Yes	34 (48.6%)	37 (52.9%)	35 (50%)
No	36 (51.4%)	33 (47.1%)	35 (50%)
Lung Disease			
Yes	27 (38.6%)	25 (35.7%)	30 (42.9%)
No	43 (61.4%)	45 (64.3%)	40 (57.1%)

We found that severity of pneumonia score 5 was higher in group III in 16 (22.8%) as compared to group I in 4 (5.7%) and group II in 8 (11.4%) cases with p value <0.003 (table 2).

Table 2. Comparison of pneumonia score among all groups

Variables	**Group I**	**Group II**	**Group III**
Pneumonia Score			
5	4 (5.7%)	8 (11.4%)	16 (22.8%)
4	13 (18.6%)	15 (21.4%)	25 (35.7%)
3	15 (21.4%)	18 (25.7%)	13 (18.6%)
2	20 (28.6%)	13 (18.6%)	10 (14.3%)
1	12 (17.1%)	13 (18.6%)	8 (11.4%)
0	6 (8.6%)	3 (4.3%)	2 (2.9%)

Hospital stays and ICU admission was also higher in non-vaccinated case with p value <0.004. Rate of mortality in group I was 7 (10%), in group II was 13 (18.6%) cases while in group III was 15 (21.4%) cases (table 3).

Table 3. Comparison of ICU stay and mortality among all groups

Variables	**Group I (70)**	**Group II (70)**	**Group III (70)**
Mean Hospitalization (days)	4.6±2.15	7.4±6.19	9.5±6.23
ICU admission			
Yes	3 (4.3%)	5 (7.1%)	12 (17.1%)
No	67 (95.7%)	65 (92.9%)	58 (82.95)
Mortality			
Yes	7 (10%)	13 (18.6%)	15 (21.4%)
No	63 (90%)	57 (81.4%)	55 (78.6%)

DISCUSSION

An adult who received a booster dose of COVID-19 during a time when the virus was primarily composed of Delta and/or Omicron variants was found to have substantial protection against infection, hospitalization, severe illness, and death[17,18]. Furthermore, these investigations discovered that the degree of CT scan severity functioned as an imaging proxy for the degree of COVID-19 illness[19,20]. Consequently, the main focus of our study was the CT severity of patients who were not vaccinated as well as those who were, such as those who had received a renewal or additional dosage, throughout this time. In order to achieve this, we gathered clinical and demographic data and examined the degree of bronchitis on CT scans collected during a 6-week window surrounding the time of diagnostic (2 to +4 weeks), encompassing inpatients as well as outpatients with a COVID-19 diagnosis. Every patient received this treatment.

In currents study, 210 patients of covid diseases were presented. Majority of the patients 58.1% were males and 41.9% were females. Mean age of the included cases was 52.11±14.73 years. These findings were comparable to the previous study.[21] Patients who had received the entire course of vaccines were less likely to acquire pneumonia (classified as a CO-RADS 1 or ACR negative) than those who hadn't been vaccinated, and the effect was apparent across a broad range of demographic and clinical characteristics. Patients who hadn't been immunized were significantly more likely to get pneumonia. This was particularly noteworthy considering that the readers were previously informed that every patient had tested positive for SARS-CoV-2. In addition, this discovery was consistent with earlier studies demonstrating that having a complete vaccine against COVID-19 decreases the severity of illness, especially pneumonia rates[22]. This conclusion was also supported by the fact that it was found that the disease was prevented by the vaccination. Recent research has looked at the differences in CT results between unvaccinated patients and vaccinated individuals during the acute phase of COVID-19.[23,24]

According to the findings of Verma et al.[23], patients who were totally vaccinated had a significantly lower mean CT severity score than incompletely vaccinated patients and unvaccinated patients did. In spite of differences in study time range, prevalent COVID-19 polymorphisms, grading technique of CT severity, and the kind of vaccine, it seems that the severity of CT pneumonia in vaccinated individuals is lower than that of unvaccinated people. Tsakok et al. concluded that patients who received a booster dosage had a lower chest CT severity rating than unvaccinated patients after further comparing the computed tomography (CT) severity in booster vaccination recipients with single/double vaccinated and unvaccinated participants. This was just one instance of what they found. Furthermore, a significantly higher percentage of patients who had gotten a booster shot or a single or double vaccine were considered normal compared to those who had not received any immunisations[25]. The results of our investigation support the conclusions made by prior researchers about the effectiveness of the vaccination in protecting against the pulmonary effects of COVID-19.

Although the probability of contracting COVID-19 was the same for men and women, male sex was linked to worse illness outcomes, such as mortality and admission to a hospital's intensive care unit[26]. Moreover, we found that a higher Pneumonia Score - a measure of the severity of CT - was associated with the male gender as a separate risk factor. A second primary dosage for immunocompromised people and a booster dose for those 65 and older were adopted due to a decrease in responsiveness in immunocompromised patients, a fall in immunization effectiveness over time, and a highly transmissible Delta variant[27]. It is probable that the vaccination policy is to blame for the fact that in this study, a greater proportion of persons in the group that got additional or booster vaccinations were of a greater age and suffered from a greater number of preexisting conditions. In further studies, it would be beneficial to include subjects aged 12 and above who are moderately or severely immunocompromised. Additionally, as of the 26th of July, the CDC advises a second booster dose for people aged 50 and up.[28,29]

A significant number of people, especially medical professionals, depend largely on their sense of sight. If a chest CT does not detect pneumonia, it is likely that the lungs are healthy, and the doctor may proceed to evaluate other COVID-19-related issues. After seven months, more than ninety percent of more than three thousand and seven hundred patients diagnosed with COVID-19 disease still had chronic pulmonary problems[30]. This is due to the fact that recovering from pneumonia may be a lengthy process, which might result in a condition known as prolonged COVID.

Do we really need more evidence to demonstrate

that immunization against COVID-19 protects against lung disease? Perhaps. In the study conducted by Lee et al., the unvaccinated, partially vaccinated, and fully vaccinated groups should have all had their risk factors, ages, and genders matched up. With this information, we would be able to more precisely disentangle the effects of the pneumonia caused by COVID-19. It is possible that we are interested in finding out whether or not certain COVID-19 pneumonia vaccinations are more successful than others; matched groups may make it easier to conduct a study into this question. Unfortunately, it is not very probable that we will have this information any time soon. In spite of the remarkable effectiveness of vaccines against COVID-19, it is not possible to compare patient groups in a way that is fair and accurate owing to a lack of data. The prevalence of Omicron as well as other, less severe abnormalities has contributed to a decrease in the clinical need of chest CT.

The old proverb that "a picture is worth a thousand words" is completely accurate nowadays. As shown in Figure (Lee et al.,),[22] those who had received the COVID-19 vaccination were at a much-decreased risk of developing pneumonia caused by the COVID-19 virus. The authors have contributed to our understanding of how efficiently vaccination's function. If what you see is what you believe, then the visuals that Lee et al. have given might be helpful for public health officials who are still working hard to persuade people that vaccinations are safe and effective.

Patients with COVID-19 pneumonia showed notable variations between the vaccinated and untreated groups on their CT scans. These results could be used as an imaging surrogate to gauge the disease's severity. The severity of CT was less severe in individuals who had received vaccinations than in patients who had not, during the time when the Omicron and Delta strains were most common. Further proof of the efficacy of the COVID-19 immunization is provided by this study. The discipline of radiology provides the proof.

CONCLUSION

We came to the conclusion that vaccinated individuals, whether they had a booster vaccination or multiple shots, exhibited milder COVID-19 pneumonia on CT scans than unprotected patients. From a radiological standpoint, this study affirms the effectiveness of the COVID-19 vaccination.

Authors' Declaration Statements

Availability of the data and material

The data used in this study are available and will be provided by the corresponding author on request.

Acknowledgement:

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Conflict of interest

The author does not report any conflicts of interest.

Funding disclosure

None to declare.

Ethical Standards

The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. Informed consent was obtained from all of the patients included in this study.

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