

High Resolution Computed Tomography (HRCT) Chest Assessment of Vaccinated and Non-Vaccinated COVID-19 Patients in a Tertiary Care Centre

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Abstract: ***Background:** Mass vaccination is recognized as the most effective preventive measure to halt transmission of COVID-19 infection. This study was undertaken to compare the clinical and radiological profiles of COVID-19 patients in vaccinated and non-vaccinated patients. **Materials and Methods:** This retrospective study was conducted in the Department of Radiodiagnosis, GIMS, GADAG. The clinical and chest imaging data of 150 RT-PCR positive patients who had undergone a standardized HRCT chest imaging were analyzed. CT severity scoring was given for each of the 5 lobes, and the CT severity Index (CTSI) score was calculated as the sum of each individual lobar score in both vaccinated and non-vaccinated patients. Patients were further categorized into mild, moderate and severe based on CTSI score, and were compared between the two study groups. **Results:** Majority of patients were male in both Vaccinated (58%) and non-vaccinated (55%) groups. In our study, out of 150 patients, 50 patients were vaccinated and 100 patients were non-vaccinated for COVID-19. Of 50 vaccinated patients, 42% of patients had received single dose of vaccine, while 58% had received double dose of COVID-19 vaccine. Lung involvement on HRCT was observed in 30% of vaccinated patients, and 95% of non-vaccinated patients. In Vaccinated group, mild (20%) lung involvement was observed in most of the patients, while in non-vaccinated group, majority of patients had moderate (60%) lung involvement. **Conclusion:** This study concluded that patients vaccinated against COVID-19 demonstrates less severe lung involvement than non-vaccinated patients. Thus, HRCT can be used as an accurate means for determining the severity of COVID-19-related pneumonia.*

Keywords: computed tomography severity score, COVID-19, high-resolution computed tomography, vaccine.

1. Introduction

COVID-19 has emerged as the most severe viral disease encountered in the past century. The World Health Organization (WHO) classified it as a Public Health Emergency of International Concern on January 30, 2020, and subsequently declared it a pandemic on March 11, 2020. [1, 2] India reported its first case of COVID-19 on January 30, 2020. The virus primarily spreads through the respiratory route when individuals inhale droplets and particles expelled by infected persons during activities such as breathing, talking, coughing, sneezing, or singing. [1] Mass vaccination is recognized as the most effective preventive measure to halt transmission and achieve herd immunity against this deadly disease. In late 2020, global vaccination efforts against COVID-19 began using a range of vaccines. [3] India began its vaccination campaign in January 2021, introducing two vaccines: COVISHIELD, developed by the Serum Institute of India, and COVAXIN, produced by Bharat Biotech. [4]

WHO recommends using chest high-resolution computed tomography (HRCT) as part of diagnostic process for COVID-19 when Reverse Transcription-Polymerase Chain Reaction (RT-PCR) testing is unavailable, when test results are delayed, or in suspected cases with initially negative RT-PCR results. [5] Understanding the HRCT profiles of vaccinated and non-vaccinated COVID-19 patients is crucial

for treating physicians, which helps them in guiding the course of treatment and understanding the disease prognosis. This study explored the clinical and radiological profiles of COVID-19 patients in relation to their vaccination status visiting our institute.

2. Materials and Methods

This retrospective study was conducted in the Department of Radiodiagnosis of a tertiary care centre. Study protocol was approved by the Institutional Ethical Committee. The clinical and chest imaging data of 150 RT-PCR positive patients who had undergone a standardized HRCT chest imaging between 25th April 2021 and 30th September 2021, were analysed. Patients aged 20 years and above, with completed record of COVID-19 vaccination were included, while those with negative RT-PCR and incomplete records were excluded from the study. Patients were further distributed into Vaccinated and Non-vaccinated groups, based on their vaccination status. CT images of the chest were obtained on a Philips, 16-slice multidetector CT Unit and slice section of 5 mm. CT severity scoring was given for each of the 5 lobes considering the extent of involvement [4]: Score 0 (No involvement); Score 1 (<5% involvement); Score 2 (6%-25% involvement); Score 3 (26%-50% involvement); Score 4 (51%-75% involvement); Score 5 (>75% involvement). The resulting CT severity Index (CTSI) score was calculated as the sum of each individual

Volume 13 Issue 8, August 2024

Fully Refereed | Open Access | Double Blind Peer Reviewed Journal

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lobar score, which ranged from 0 to 25. [1] HRCT image analysis was performed by single radiologists with 10 years of experience in chest radiology. Scans were categorized based on the CTSI score [6, 7]: (i) No lung Involvement (CTSI score 0) (Figure 1); (ii) Mild (CTSI score ≤ 8) (Figure 2); (iii) Moderate (CTSI score 9-18) (Figure 3); and (iv) Severe (CTSI score 19-25) (Figure 4 and 5) for both Vaccinated and Non-vaccinated groups and were compared.

3. Results

Our study included total 150 patients, of which 50 patients were vaccinated with at least one dose of COVID-19 vaccine, while 100 patients were non-vaccinated. Majority of patients with COVID-19 were in the age group of 51-60 years. (Table 1) Proportion of male patients was greater in both Vaccinated (58%) and Non-vaccinated groups (55%). Most commonly observed co-morbidity was diabetes Mellitus (DM) and hypertension (HTN) in both Vaccinated and Non-vaccinated study patients. In our study, HRCT showed lung involvement in 30% of vaccinated patients, and 95% of non-vaccinated patients, whereas in 70% of Vaccinated patients and 5% of Non-vaccinated patients, the lung appeared normal. Mild lung involvement was observed in most of the vaccinated patients, while in majority of non-vaccinated patients, moderate involvement was observed. (Table 2, Figure 6) Among the 15 vaccinated patients with lung involvement, the most common radiographical pattern observed was ground glass opacities (GGO) (46.67%), while among non-vaccinated patients, combination of both GGO and consolidation was more commonly observed (37.89%). (Figure 7) Peripheral pattern of lung involvement (53.33%) was more common in vaccinated patients, while in non-vaccinated patients, diffuse lung involvement (62.10%) was more frequently observed. (Figure 8) No involvement was observed in 47.61% of patients who had received single dose and 86.20% of patients who had received two doses of vaccination in our study. (Table 3)

4. Discussion

Chest CT scans have been the standard for COVID-19 imaging. Prior to the widespread use of RT-PCR tests for detecting COVID-19 infection, chest CT scans played a crucial role in diagnosis, showing a pooled sensitivity and specificity of 86.9% and 73.3%, respectively. [8, 9] Vaccination against COVID-19 is seen as a key strategy to mitigate the impact of COVID-19 disease. Vaccination is considered essential in reducing the severity and mortality of COVID-19, and is evidenced by chest CT findings as well. [8] This study aimed to compare lung involvement on chest CT scans between vaccinated and non-vaccinated RT-PCR positive COVID-19 patients. In our study, out of 150 RT-PCR positive COVID-19 patients, 33.33% were vaccinated with at least one dose of COVID-19 vaccine, while 66.66% were non-vaccinated. In a similar study, Shah PK [5] observed that 22.4% of the study patients were vaccinated, while 77.6% were non-vaccinated. Similar observations were made in other studies, wherein percentage of vaccinated COVID-19 patients were lower than non-vaccinated patients. [1, 3, 8]

Majority of vaccinated patients in our study were in their fifth decade of life (32%), whereas most of the non-vaccinated

patients were in 21-30 years of age group. (Table 1) This may be because in the initial vaccination drive, elderly population were given preference, owing to their old age and higher risk of disease due to old-age associated co-morbidities. Other studies have observed most of the vaccinated patients in the age group of 41-50 years and non-vaccinated patients above 60 years of age. [1, 5] In our study, majority of patient were male in both Vaccinated (58%) and Non-vaccinated (55%) groups. (Table 1) These findings are in accordance with previous studies. [3, 5, 8, 10] In our study, co-morbidities were present in 40% of patients in both Vaccinated and Non-vaccinated groups, among which the most commonly observed co-morbidity was DM, followed by HTN in both the groups. (Table 1) Similar observations were made by Mendiratta K et al [1], who observed comorbidities in 34% and 40% of their vaccinated and non-vaccinated patients, respectively. In contrast to our findings, other studies have observed HTN as the most common comorbidity, followed by DM in most of their vaccinated and non-vaccinated COVID-19 patients. [1, 3, 5, 8, 10]

Chest HRCT was done in each of the study patients which revealed that proportion of patients with lung changes were significantly lower in Vaccinated group (30%) when compared to Non-vaccinated group (95%) ($p < 0.05$). (Table 2) Similar observations were made by a study from Jaipur. [1] In our study, lung involvement was categorised based on the CTSI score in each of the study patient. We observed that lung involvement was mild in majority of Vaccinated group patients, while it was moderate in most of the Non-vaccinated group patients. (Table 2) However, other studies have observed that most of the vaccinated patients had moderate lung involvement, while most of the non-vaccinated patients had severe lung involvement based on CTSI score in their respective studies. [1, 3, 5]

Among the patients with lung involvement evident on HRCT scan, most commonly observed radiographical pattern was GGO in Vaccinated group (46.67%), while in Non-vaccinated group, combination of GGO and consolidation was most commonly observed (37.89%), followed by consolidation alone (36.84%). (Table 2) These findings are in agreement with previous studies. [5, 8] Peripheral lung involvement (53.33%) was most commonly observed in Vaccinated group, while diffuse lung involvement (62.10%) was more common in Non-vaccinated group in our study. Similar observations were made by a study from Nepal, wherein, Peripheral Lung involvement (28.7%) was more common in vaccinated group, and diffuse lung involvement (34.4%) was more common in non-vaccinated group patients. [5]

In our study, out of 50 patients in Vaccination group, 21 patients (42%) had received single dose and 29 (58%) patients had received double dose of COVID-19 vaccine. (Table 3) These findings are in accordance with study from France wherein, proportion of patients with double dose of vaccination was higher than those with single dose. [8] However, one similar study from Uttarakhand reported that percentage of patients with single dose of vaccine (65.97%) was higher than those with double dose of vaccine (34.21%). [3] Comparison of HRCT findings between patients vaccinated with single dose and double doses showed that percentage of patients with lung involvement was

significantly lower in double dose group (13.8%) when compared to single dose group (52.39%). Smaller sample size was one limitation of our study.

5. Conclusion

There was difference in the HRCT scan of Vaccinated and Non-vaccinated patients. CTSI score was mild to moderate in most of the Vaccinated group patients, when compared to Non-vaccinated group patients, who showed moderate to severe CTSI score in majority of patients. Furthermore, two doses of vaccination demonstrated superior protective effect against severe HRCT scores for lung involvement, in comparison to single dose. Thus, this study concluded that regardless of patient's demographic profile, vaccination has been proven as an effective tool against COVID-19.

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Tables

Table 1: Characteristics of Study Patients

Patients Characteristics	Vaccinated n (%)	Non-vaccinated n (%)	Total n (%)	p-value
Age				
21-30	5 (10%)	30 (30%)	35 (23.33%)	0.04 S
31-40	2 (12%)	20 (20%)	22 (14.44%)	0.12 NS
41-50	12 (24%)	15 (15%)	27 (18%)	0.11 NS
51-60	16 (32%)	18 (18%)	34 (22.66%)	0.022 S
>60	12 (24%)	18 (18%)	30 (20%)	0.29 NS
Total	50 (100%)	100 (100%)	150 (100%)	
Gender				
Male	29 (58%)	55 (55%)	84 (56%)	0.66 NS
Female	21 (42%)	45 (45%)	66 (44%)	0.66 NS
Total	50 (100%)	100 (100%)	150 (100%)	
M: F	1.27: 1			
Co-morbidity				
DM	8 (16%)	22 (22%)	30 (20%)	0.28 NS
HTN	7 (14%)	12 (12%)	19 (12.66%)	0.67 NS
COPD	3 (6%)	5 (5%)	8 (5.33%)	0.75 NS
Others	2 (2%)	1 (1%)	3 (2%)	0.56 NS
Nil	30 (60%)	60 (60%)	90 (60%)	0.99 NS

Table 2: HRCT Findings in Vaccinated and Non-vaccinated groups

HRCT findings	Vaccinated n (%)	Non-vaccinated n (%)	Total n (%)	p-value
HRCT findings based on CTSI score				
No involvement	35 (70%)	5 (5%)	40 (26.66%)	<0.0001 S
Mild	10 (20%)	30 (30%)	40 (26.66%)	0.10 NS
Moderate	3 (6%)	60 (60%)	63 (42%)	<0.0001 S
Severe	2 (4%)	5 (5%)	7 (4.66%)	0.72 NS
Total	50 (100%)	100 (100%)	150 (100%)	
Pattern on HRCT				
GGO	7 (46.67%)	24 (25.26%)	31 (28.18%)	0.0012 S
Consolidation	2 (13.33%)	35 (36.84%)	37 (33.63%)	<0.0001 S
Both	6 (40%)	36 (37.89%)	42 (38.18%)	0.77 NS
Total	15 (100%)	95 (100%)	110 (100%)	
Pattern of lung involvement				
Hilar	3 (20%)	14 (14.73%)	17 (15.45%)	0.35 NS
Peripheral	8 (53.33%)	22 (23.15%)	30 (27.27%)	<0.0001 S
Diffuse	4 (26.66%)	59 (62.10%)	63 (5.27%)	<0.0001 S
Total	15 (100%)	95 (100%)	110 (100%)	

Table 3: HRCT Findings among Vaccinated patients with Single dose and Double dose

HRCT findings based on CTSI score	Single dose n (%)	Double dose n (%)	Total n (%)	p-value
No involvement	10 (47.61%)	25 (86.20%)	35 (70%)	<0.0001 S
Mild	7 (33.33%)	3 (10.34%)	10 (20%)	<0.0001 S
Moderate	2 (9.52%)	1 (3.44%)	3 (6%)	0.044 S
Severe	2 (9.52%)	0 (0%)	2 (4%)	0.0012 S
Total	21 (100%)	29 (100%)	50 (100%)	

Figure Legends:

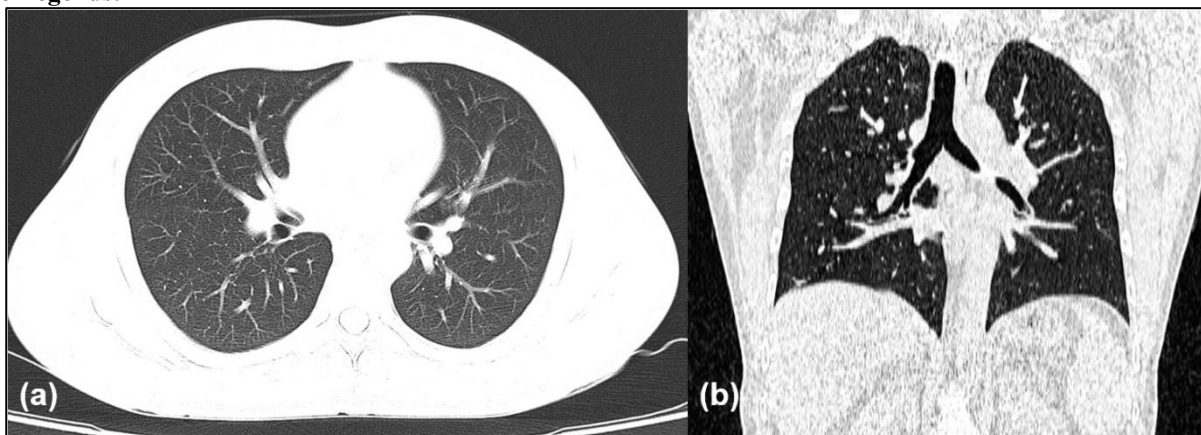


Figure 1: HRCT LUNG image of a vaccinated patient showing normal lung (a) Axial view; (b) Coronal view

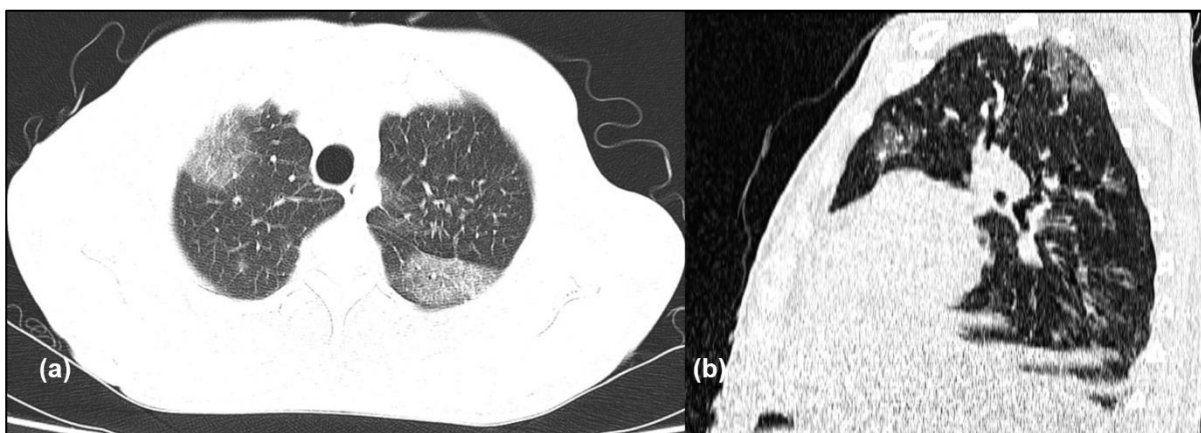


Figure 2: HRCT LUNG image of a vaccinated patient with Mild lung involvement showing patchy areas of subpleural ground glass opacities (a) Axial view; (b) Coronal view

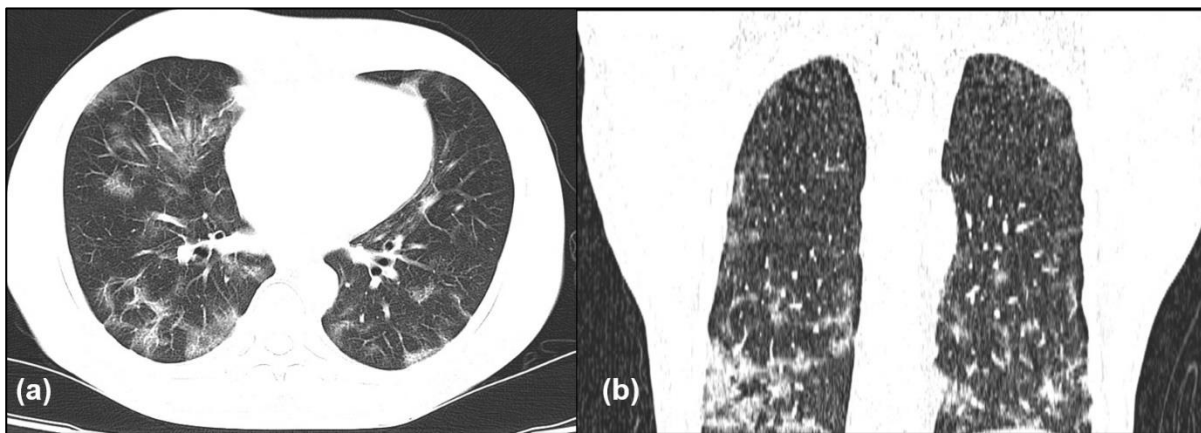


Figure 3: HRCT LUNG image of a non-vaccinated patient with Moderate lung involvement showing patchy areas of subpleural ground glass opacities with areas of consolidations in bilateral lung fields. (a) Axial view; (b) Coronal view

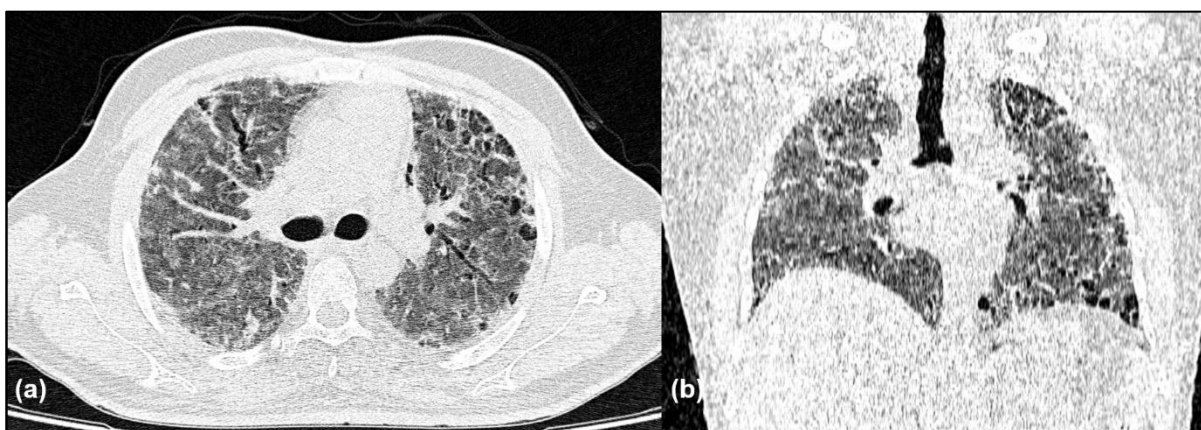


Figure 4: HRCT lung image of a non-vaccinated patient with Severe lung involvement showing diffuse ground glass opacification of bilateral lobes (a) Axial view; (b) Coronal view

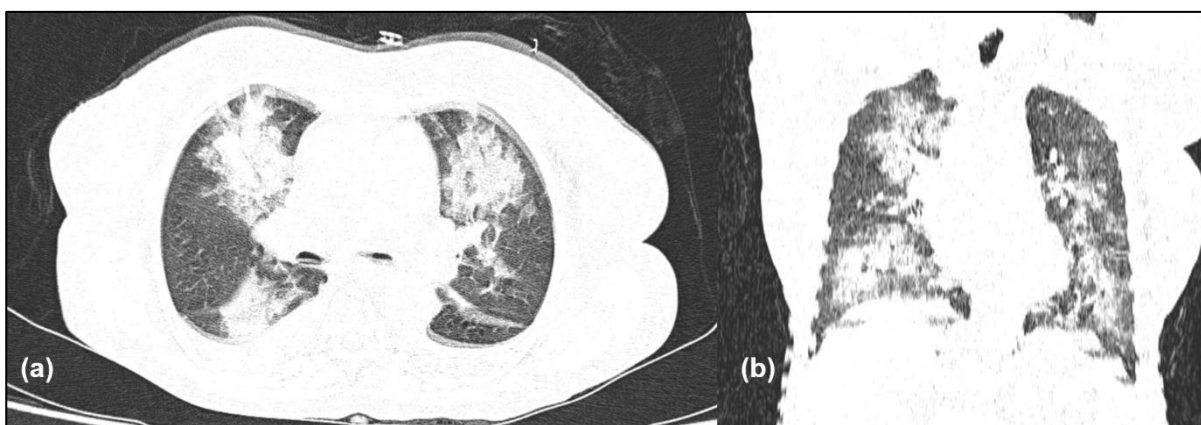


Figure 5: HRCT lung image of a non-vaccinated patient with Severe lung involvement with Subsegmental consolidation with air bronchogram in both lung fields (a) Axial view; (b) Coronal view

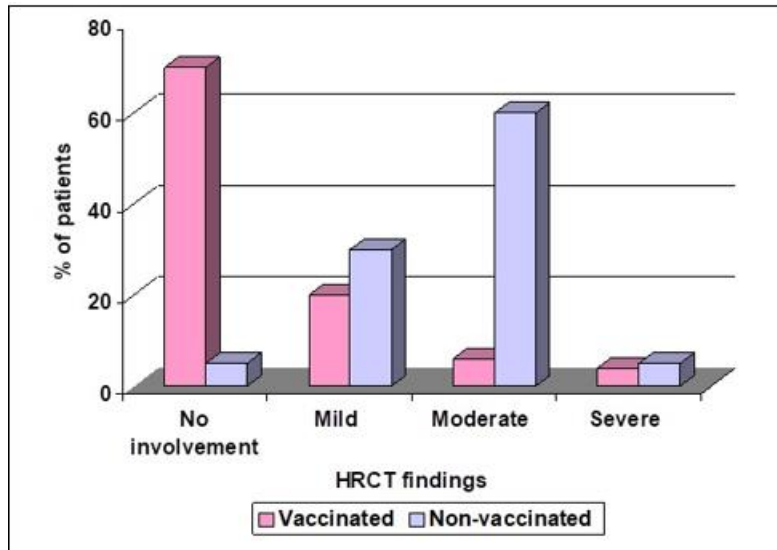


Figure 6: Graph showing HRCT findings among Vaccinated and Unvaccinated patients

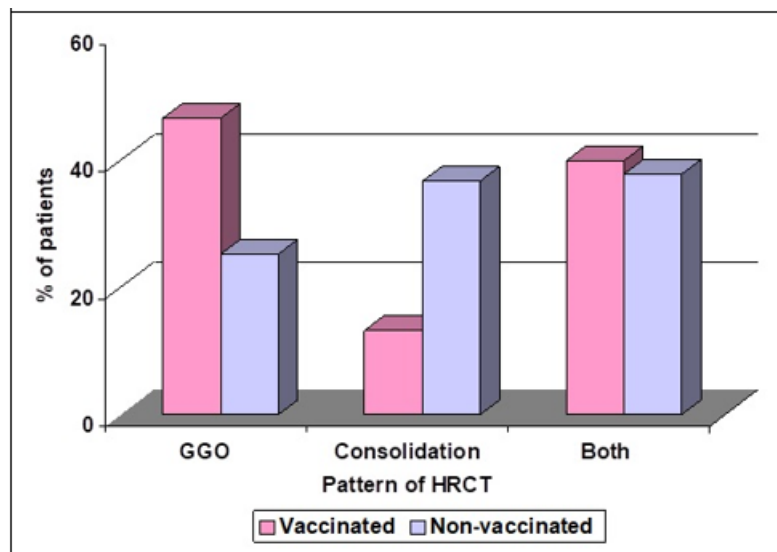


Figure 7: Graph showing Pattern of HRCT in Vaccinated and Unvaccinated patients

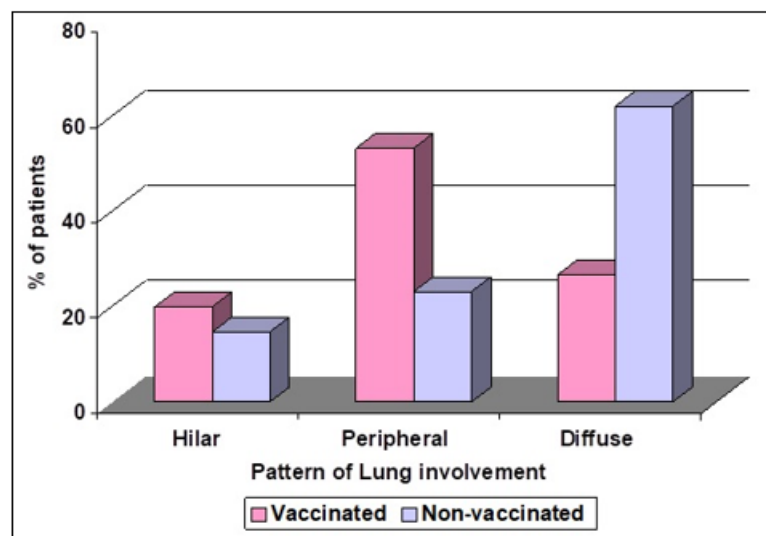


Figure 8: Graph showing Pattern of Lung involvement on HRCT in Vaccinated and Unvaccinated patients