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The Pattern of COVID-19-related Pneumonitis on High-Resolution Computed Tomography Chest in Post-Vaccination Patients

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ABSTRACT

Objective: To find the changing radiological pattern of COVID-19 on HRCT chest in vaccinated patients.
Study Design: Observational, cross-sectional study.
Place and Duration of Study: Combined Military Hospital, Sialkot Pakistan, from Jan to Feb 2022.
Methodology: All patients referred for High-resolution computed tomography (HRCT) chest were included. All participants underwent HRCT chest after recording the demographic data. Computed tomography (CT) images were reviewed by an experienced radiologist for pulmonary involvement and determining the computed tomography severity score, which ranged from 0-40 points.
Results: A total of 90 patients were included in the study. The mean age was 35.8±13.2 years. The number of partially vaccinated, fully vaccinated patients, and those with booster doses were 10(11.1%), 62(68.9%) and 18(20%), respectively. Patients with normal or non-specific findings on HRCT were 74(82.2%), and those with findings suggestive of COVID-19 pneumonitis were 16 (17.8%). The mean CT severity score among positive cases was 4.69±8.01, while the most frequent pulmonary finding was ground glass opacities found in 11(68.8%) cases.
Conclusion: Vaccination reduces the frequency and severity of pulmonary involvement in cases with breakthrough COVID-19 though the presentation of the disease and pattern of the pulmonary involvement does not show much change.

Keywords: COVID-19, HRCT Chest, Vaccination.

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INTRODUCTION

The symptoms in post-vaccination COVID-19 patients are mild to moderate, and most of these patients show recovery without vigorous treatment.[1,2] However, some of them become seriously ill and might require medical attention.[3] Most people who become seriously ill and had extensive lung infiltrates are those who are not vaccinated.[4,5] In response, more than 100,463,513 Pakistanis have been fully vaccinated as of March 8, 2022, apart from 127,697,360 partially vaccinated and 4,704,755 with booster dose, according to the national command operational cell government of Pakistan (NCOC).[6,7]

Although COVID-19 vaccine is effective, some of the vaccinated people still have the disease. They are called breakthrough cases.[8] This is not unexpected as no vaccine is 100% effective. Thus the possibility of breakthrough infection is always there. However, the disease in such cases is either asymptomatic, or these patients might have mild symptoms and are usually treated as outdoor patients with low mortality.[9,10] With time, the effectiveness of the vaccine wanes because of the new variants replacing the old ones, thus increasing the number of breakthrough infections. This study has been carried out to see the pattern of COVID-19-related pneumonitis on high-resolution computed tomography (HRCT) in post-vaccination individuals to see the frequency and extent of pulmonary involvement.

METHODOLOGY

The cross-sectional study was carried out at the Radiology Department, Combined Military Hospital, Sialkot Pakistan, from January to February 2022, after the approval by the Institutional Ethical Review Board (ERC number: ERC/03/2022).Sample size was calculated using the WHO sample size calculator taking the reported prevalence of ground glass opacities (GGOs) in cases of COVID-19 at 57%.[11]

Inclusion Criteria: Patients of either gender and any age group presenting for HRCT chest were included in the study by non-probability consecutive sampling method.

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Exclusion Criteria: Patients with negative PCR for the SARS-CoV-2 virus and those not vaccinated were excluded from the study.

Informed consent was obtained from all participants. Demographic data were recorded on a previously designed proforma along with their symptoms, previous history of COVID-19 and vaccination history. All participants underwent HRCT chest on a Toshiba Asteion 4 CT scanner dedicated to evaluating patients with COVID-19. A high-resolution chest CT scan was performed with a 1 mm slice at 10 mm intervals from lung apices to bases. The CT images were reviewed by a radiologist having ten years of experience in chest radiology. A note was made of the type of lesions and their location, and every case was given a CT severity score (CSS) depending upon the extent of involvement. For calculating the CSS, both lungs were divided into 20 regions. Every region was assigned a score of 0, 1 or two depending upon the extent of involvement as described by Yang *et al*.[12] Individual scores from all 20 regions were added to get CSS which ranged from 0-40 points.

Statistical Package for Social Sciences (SPSS) version 20.0 was used for the data analysis. Quantitative variables were expressed as Mean±SD and qualitative variables were expressed as frequency and percentages. Mean CSS was calculated for partially vaccinated, fully vaccinated patients and those with booster doses and compared by One-Way ANOVA. The *p*-value lower than or up to 0.05 was considered as significant.

RESULTS

Ninety patients fulfilled the inclusion and exclusion criteria during the study period. The mean age of the patients was 35.8±13.2 years (ranging from 19-80 years). Partially vaccinated patients with a single dose of the vaccine were 10(11.1%), fully vaccinated patients with a double dose of the vaccine were 62(68.9%), and those with a booster dose were 18(20%). Most patients, 45(50%), had Sinovac followed by Sinopharm, 25(27.8%). The mean duration of symptoms was 5.33±1.84 days (ranging from 2-10 days). Patients with normal or non-specific findings on HRCT were 74(82.2%). Those with findings suggestive of COVID-19 pneumonitis were 16(17.8%), with the most frequent finding being GGOs found in 11(68.8%) cases, followed by reticulo-nodular or nodular opacities noted in 7(43.8%) cases (Table-I). Figures 1-2 show the appearance of GGOs, interlobular septal thickening, reticulo-nodular and tree in bud opacities on HRCT. Among the patients with findings suggesting COVID-19, the mean age was 43.62±16.73 years, while the mean CSS was 4.69±8.01 (ranging from 1-32). Mean CSS in partially vaccinated, fully vaccinated and those with booster doses is shown in Table-II. There was no statistically significant difference in CSS among these groups (*p*-value 0.824). Table-III depicts the detailed findings of all 16 cases positive for COVID-19 changes on HRCT chest.

Table-I: Radiological pattern of pulmonary involvement in breakthrough COVID-19 (n=90)

HRCT Findings	Nature of Opacities	n(%)
Normal or non-specific findings		74(82.2)
COVID-19 findings		16(17.8)
	GGOs	11(68.8)
	Reticulo-nodular/nodular	7(43.8)
	Tree in bud	5(31.2)
	Interlobular septal thickening	3(18.7)
	Fibrotic	2(12.5)
	Pleural effusion	1(6.2)

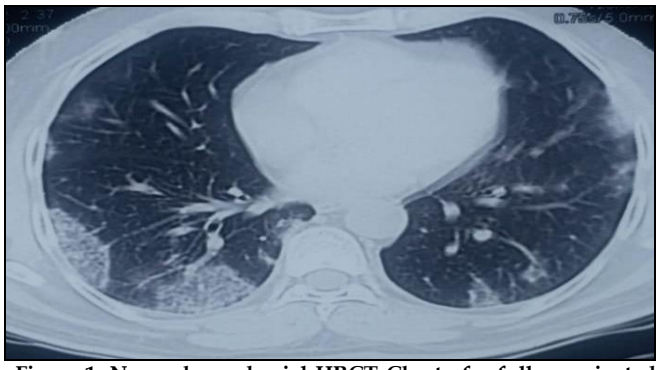

Figure-1: Non-enhanced axial HRCT Chest of a fully vaccinated 43 years old male patient shows peripheral GGOs with interlobular septal thickening (CT severity score: 7/40)

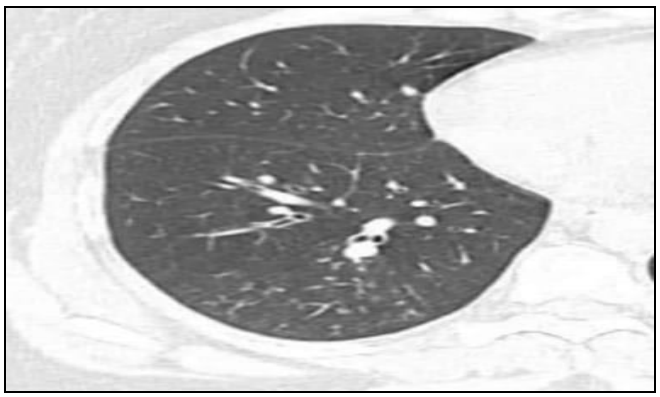

Figure-2: Non-enhanced magnified axial HRCT chest of a vaccinated 21 years old male patient showing clusters of reticulo-nodular densities and linear branching 'tree in bud nodules' involving right lower lobe (CT severity score 2/40)

Table-II: Mean CT Severity Score in different Vaccination Groups and Inter-Group Comparison (n=90)

Parameters	Mean CT severity score in different vaccination groups			
	PV(n=3)	FV(n=1)	BD(n=2)	*p*-value
Mean CT severity score out of 40	2.00±1.00	5.45 ±9.59	4.50 ±3.53	0.824

PV: Partially vaccinated; FV: Fully vaccinated; BD: Fully vaccinated with booster dose

aches (72.2%), fever (63.3%) and symptoms of flu (43.3%).

During the initial period, most patients affected by COVID-19 showed some pulmonary manifestation of the disease.[15] Our study aimed at finding the frequency and extent of pulmonary findings on HRCT in cases of breakthrough COVID-19, and it showed that the frequency of pulmonary findings in breakthrough COVID-19 was 17.8%. Apart from the infrequent pulmonary involvement, the severity of the pulmonary disease was also reduced, with the mean CT severity score of 4.69±8.01. Thus the study showed that both the frequency and extent of the pulmonary involvement, as shown on HTCT, were reduced in cases of breakthrough COVID-19. These findings were in accordance with Juthani *et al.* who showed that the number of cases with severe or critical COVID-19 was low in breakthrough COVID-19 with a reduced number of hospital admissions.[8]

Table III: CT severity score of 16 Cases with Breakthrough COVID-19

No	Age(yeas)	Vaccination status	Findings	CSS
1	41	FV	Peripheral GGOs, consolidation, ILS thickening	32
2	28	PV	Tiny nodule in superior segment of RLL	1
3	23	PV	RN & TIB in medial segment of RML and PB segment of LLL	2
4	31	FV	RN & TIB in post segment of RUL	1
5	55	FV	Peripheral GGOs	3
6	50	FV	RN bilateral upper lobes	2
7	38	FV	GGO post basal segment RLL	1
8	36	FV	GGO post segment RUL	1
9	21	FV	RN & TIB opacities in RLL	2
10	72	FV	GGO, RN & TIB opacities in RUL	2
11	34	PV	GGO, Few RN & TIB opacities Post segment of RUL and Superior segment of both LL	3
12	60	FV	Solitary GGO in superior segment of RLL	1
13	50	B	Small, subtle peripheral GGOs	2
14	80	FV	Peripheral GGOs, ILS thickening, bilateral mild pleural effusion	14
15	43	B	Peripheral areas of GGOs, ILS thickening	7
16	36	FV	Solitary GGO in superior segment of RLL, fibrotic band	1

(CSS. CT severity score; PV. Partially vaccinated; FV. Fully vaccinated; B. Booster dose; GGO. Ground glass opacity; ILS. Interlobular septal thickening; RLL. Right lower lobe; RN. Reticulo-nodular; TIB. Tree in bud; RML. Right middle lobe; PB. Posterior basal; LLL. Left lower lobe; RUL. Right upper lobe; RLL. Right lower lobe; LL. Lower lobe)

DISCUSSION

Being a systemic disease COVID-19 affects all systems of the body with predominant effect on respiratory tract leading to symptoms of flu, cough, fever, shortness of breath and generalized weakness.[13] Since then, HRCT chest has played a pivotal role in the evaluation of lungs affected by COVID-19. The pattern of lung involvement on HRCT included GGOs with or without crazy paving pattern or interlobular septal thickening, consolidations, nodularity and in later stages evidence of fibrosis in the form of reticulation or fibrotic bands.[14]

Pakistan also started a vaccination campaign in 2021, and many people have been vaccinated since then. Our study shows that 11.1% of participants were partially vaccinated among the study population, and only 20% had a booster dose. This indicates the need for accelerated effort by the concerned authorities to persuade people to complete the vaccination and have the booster dose for enhanced protection. Most of the cases in our study presented with cough (73.3%), body

The most frequent pulmonary finding on HRCT among the cases positive for pulmonary involvement in our study was GGOs in 68.8% of patients, followed by nodularity, interlobular septal thickening, consolidation or reticulation. This pattern was not different from that occurring in non-vaccinated patients, as shown by one study with the most frequent (65%) pulmonary finding in COVID-19 being ground glass opacification.[16] The same fact has been highlighted by two studies as GGO to be 68.1% and 68%, respectively.[17,18] Some other studies, however, show even a higher prevalence of GGO, reaching as high as

78% and 83.31%.[19,20] The high prevalence of GGOs implies that the pattern of pulmonary involvement in breakthrough COVID-19 has not much changed with vaccination.

LIMITATION OF STUDY

One of the limitations of the study was that it took into account vaccinated patients because of the lesser availability of the non-vaccinated participants. The inclusion of non-vaccinated patients made the comparison of pulmonary findings in the two groups possible.

CONCLUSION

Vaccination reduces the frequency and severity of pulmonary involvement in cases with breakthrough COVID-19 though the presentation of the disease and pattern of the pulmonary involvement does not show much change.

Conflict of Interest: None.

Author's Contribution

Following authors have made substantial contributions to the manuscript as under:

HU & HS: Data acquisition, data analysis, concept, drafting the manuscript, approval of the final version to be published.

RM & TA: Data acquisition, critical review, approval of the final version to be published.

RS & AM: Study design, drafting the manuscript, data interpretation, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Yuki K, Fujiogi M, Koutsogiannaki S. COVID-19 pathophysiology: A review. Clin Immunol 2020; 215(1): 108427. https://doi.org/10.1016%2Fj.clim.2020.108427
2. Bohn MK, Hall A, Sepiashvili L, Jung B, Steele S, Adeli K, et al. Pathophysiology of COVID-19: mechanisms underlying disease severity and progression. Physiology 2020; 35(5): 288-301. https://doi.org/10.1152/physiol.00019.2020
3. CDC COVID-19 Vaccine Breakthrough Case Investigations Team. COVID-19 Vaccine Breakthrough Infections Reported to CDC - United States, January 1-April 30, 2021. MMWR Morb Mortal Wkly Rep 2021; 70(21): 792-793. https://doi.org/10.15585/mmwr.mm7021e3
4. Elicker BM. Breakthrough COVID-19 Infections: What Are They and What Do They Look Like? Radiol Cardiothorac Imaging 2022;4(1): e210301. https://doi.org/10.1148/ryct.210301
5. Brogna B, Bignardi E, Brogna C, Capasso C, Gagliardi G, Martino A, et al. COVID-19 Pneumonia in Vaccinated Population: A Six Clinical and Radiological Case Series. Medicina 2021; 57(9): 891. https://doi.org/10.3390/medicina57090891
6. NCOC. National Command & Control Centre-COVID-19 Situation Reports: NCOC - Govt of Islamic Republic of Pakistan; 2022 [Internet] Available at: https://ncoc.gov.pk/Sitrep/mar22/705.%2006%20Mar%20. [Accessed on March 7, 2022]
7. Zheng Y, Wang L, Ben S. Meta-analysis of chest CT features of patients with COVID-19 pneumonia. J Med Virol 2021; 93(1): 241-249. https://doi.org/10.1002/jmv.26218
8. Juthani PV, Gupta A, Borges KA, Price CC, Lee AI, Won CH, et al. Hospitalisation among vaccine breakthrough COVID-19 infections. Lancet Infect Dis 2021; 21(11): 1485-1486. https://doi.org/10.1016/s1473-3099(21)00558-2
9. Elicker BM. Breakthrough COVID-19 Infections: What Are They and What Do They Look Like? Radiol Cardiothoracic Imaging 2022;4(1):e210301. https://doi.org/10.1148/ryct.210301
10. Latif A. Pakistan faces 5th wave of COVID-19: Anadolu Agency (Asia-Pacific); 2022. [Internet] Available at: https://www.aa.com.tr/en/asia-pacific/pakistan-faces-5th-wave-of-covid-19/2463417. [Accessed on March 7, 2022]
11. Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X, et al. CT imaging features of 2019 novel coronavirus (2019-nCoV). Radiology 2020; 295(1): 202-207. https://doi.org/10.1148/radiol.2020200230
12. Yang R, Li X, Liu H, Zhen Y, Zhang X, Xiong Q, et al. Chest CT severity score: an imaging tool for assessing severe COVID-19. Radiol Cardiothorac Imaging 2020; 2(2): e200047. https://doi.org/10.1148%2Fryct.2020200047
13. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. N Engl J Med 2020; 382(13): 1199-1207. https://doi.org/10.1056/nejmoa2001316
14. Zheng M, Gao Y, Wang G, Song G, Liu S, Sun D, et al. Functional exhaustion of antiviral lymphocytes in COVID-19 patients. Cell Mol Immunol 2020; 17(5): 533-35. https://doi.org/10.1038/s41423-020-0402-2
15. Zhang J, Litvinova M, Wang W, Wang Y, Deng X, Chen X, et al. Evolving epidemiology and transmission dynamics of coronavirus disease 2019 outside Hubei province, China: a descriptive and modelling study. Lancet Infect Dis 2020; 20(7): 793-802. https://doi.org/10.1016/s1473-3099(20)30230-9
16. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020; 395(10223): 497-506.
17. Ishfaq A, Farooq SMY, Goraya A, Yousaf M, Gilani SA, Kiran A, et al. Role of High Resolution Computed Tomography chest in the diagnosis and evaluation of COVID-19 patients-A systematic review and meta-analysis. Eur J Radiol Open 2021; 8: 100350. https://doi.org/10.1016/j.ejro.2021.100350
18. Shi H, Han X, Jiang N, Cao Y, Alwalid O, Gu J, et al. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. Lancet Infect Dis 2020; 20(4): 425-434. https://doi.org/10.1016/s1473-3099(20)30086-4
19. Kim H, Hong H, Yoon SH. Diagnostic performance of CT and reverse transcriptase polymerase chain reaction for coronavirus disease 2019: a meta-analysis. Radiology 2020; 296(3): E145-E155. https://doi.org/10.1148/radiol.2020201343
20. Bao C, Liu X, Zhang H, Li Y, Liu J. Coronavirus disease 2019 (COVID-19) CT findings: a systematic review and meta-analysis. J Am Coll Radiol 2020; 17(6): 701-709. https://doi.org/10.1016/j.jacr.2020.03.006