Research Article

Comparison of Lung CT Scan Findings in Immunodeficient and Immunocompetent Patients During COVID-19

Hermin Mokrian [1], Maryam Rostami [1], Sohrab Kolivand [2], *

[1] Radiologist Specialist, Hamadan University of Medical Sciences, Hamadan, Iran
[2] Hamadan University of Medical Sciences, Hamadan, Iran

*Corresponding Author: Hamadan University of Medical Sciences, Hamadan, Iran. Email: m_rabbaniha@yahoo.com ; skulivand222@gmail.com

Abstract

Background: Concerns asuppbout the consequences of COVID-19 in immunocompromised patients arose during the pandemic due to their higher risk of superinfection and complications. Computed Tomography (CT) scans play a confirmatory role in determining the severity of the disease.

Objectives: Given the controversial evidence in this field, we conducted a study to compare lung CT scan findings in immunodeficient and immunocompetent patients with COVID-19.

Methods: This cross-sectional study was performed on 1,246 immunodeficient and immunocompetent patients with COVID-19 from 2019 to 2022. During hospitalization and upon arrival at the hospital, all patients underwent lung CT scans, which were evaluated both quantitatively and qualitatively. The severity of lung involvement was graded as minimal, mild, moderate, or severe. All statistical analyses were performed using SPSS software version 22 and STATA version 15.1.

Results: In this study, 50% of the patients were female. The mean age was 51 ± 15.4 years, and the mean length of hospitalization was 8.8 ± 5.8 days. Immune system defects were more common in patients over 50 years of age with diabetes, hypertension, malignancy, and renal dysfunction ($P < 0.05$). There was no significant difference in lung CT scan findings between immunodeficient and immunocompetent patients ($P > 0.05$).

Conclusions: Based on our findings, there is no difference between these two groups of patients in terms of lung CT scan findings. Therefore, it would be beneficial to perform a meta-analysis for more accurate results in the future.

Keywords: Coronavirus Disease 2019, Immunosuppression, Computed Tomography, Immune System

1. Background

Acute respiratory diseases are among the most common human illnesses and a significant cause of disability. Respiratory infections also account for a high proportion of hospitalizations and deaths ([1]). Various microorganisms can cause such infections, including coronaviruses ([2]). At the end of December 2019, the first outbreak of coronavirus disease 2019 (COVID-19) was reported in Wuhan, China ([3]). In Iran, more than 97,424 people were infected with this virus, with a mortality rate of 6.83% ([4]).

Most affected patients initially presented with symptoms such as fever and mild to moderate respiratory manifestations, and varying degrees of pulmonary involvement were subsequently identified on lung computed tomography (CT) scans ([5]). Computed tomography scans play a confirmatory role in determining the severity of the disease ([6]). The most common patterns on CT scans include diffuse, typically bilateral, patchy ground-glass opacities, consolidation, and/or interstitial opacities ([7-9]).

Older males with underlying comorbidities, particularly diabetes, hypertension, obesity, and cardiopulmonary diseases, are at a higher risk of severe complications. Concerns about the consequences of COVID-19 in immunocompromised patients arose early in the pandemic, with conflicting data observed regarding COVID-19 complications in these patients ([10], [11]). Individuals with immunodeficiency are at a higher risk of superinfection with bacterial and fungal microorganisms compared to those with a healthy

immune system. This increased risk is due to underlying conditions such as malignancy and other causes of immunodeficiency, including HIV, organ transplantation, and the use of immunosuppressant drugs (12, 13).

Most studies in this field have been conducted on the general population with normal immune systems, and few have examined CT scan findings in immunodeficient patients with COVID-19.

2. Objectives

Given the importance of this issue and the conflicting findings in recent studies, we evaluated lung CT scan findings in this group of patients with COVID-19 compared to immunocompetent patients.

3. Methods

3.1. Participants

In this cross-sectional study, 1,246 patients infected with COVID-19, both with healthy immune systems and immunodeficiencies, who were referred to Shahid Beheshti Hospital in Hamadan Province, Iran, between 2019 and 2022, were investigated through simple random sampling. Patients with a confirmed diagnosis of COVID-19 based on a positive real-time polymerase chain reaction (PCR) test and aged at least 18 years were included in the study. Exclusion criteria included lack of access to patients' medical records due to missing information or any other reason, and having chronic parenchymal lung diseases.

3.2. Data Collection

Demographic characteristics, clinical symptoms (dyspnea, cough, headache, and fever), and history of underlying diseases were recorded. For all patients with a confirmed diagnosis of COVID-19 (PCR positive) based on the definitions of the national guidelines, lung CT scans were performed during hospitalization and upon arrival at the hospital. The images were evaluated both quantitatively and qualitatively. Types of lung involvement were categorized as airway abnormality, ground-glass opacity (GGO), consolidation, crazy-paving pattern, mixed GGO, tree-in-bud, pure GGO, patchy consolidation, adenopathy, cavitation, pleural effusion, and subpleural reticular band.

For the quantitative evaluation of lung involvement and to compare the extent of involvement, the lung was divided into three parts: Upper (above the carina), mid (between the carina and the inferior pulmonary vein), and lower (below the inferior pulmonary vein). The

severity of lung involvement was graded as minimal (< 25%), mild (25 - 50%), moderate (50 - 75%), and severe (> 75%). All these evaluations were conducted by a radiologist. Finally, all the studied variables were compared between patients with immune system deficiencies and those without.

3.3. Statistical Analysis

Qualitative variables were expressed as frequency (percentage), and quantitative variables were expressed as mean ± standard deviation. ANOVA, chi-square, or exact tests were used for statistical comparisons. Additionally, logistic regression analyses were conducted to assess the associations between the study parameters and the immune system status in the two groups. All statistical analyses were performed using SPSS software version 22 and STATA software (StataCorp LLC, Texas, USA), version 15.1.

4. Results

A total of 1,246 patients participated in this study, of which 623 (50%) were women. The mean age of the participants was 51 ± 15.4 years, and the mean duration of hospitalization was 8.8 ± 5.8 days. Table 1 shows that the prevalence of a history of diabetes, hypertension (HTN), malignancy, and kidney dysfunction was higher in patients with immune system deficiency ($P < 0.05$) and in patients over 50 years old. Among clinical manifestations, dyspnea, cough, and fever were more frequent; however, there was no significant difference among them ($P > 0.05$).

Based on chi-square test results, the groups compared showed no significant difference in terms of spiral lung CT scan findings ($P > 0.05$). Additionally, the severity of lung involvement was minimal in most patients. Further details are provided in Table 2.

Moreover, we evaluated CT scan findings between male and female patients, and the results showed no significant difference between the two genders, except for mixed ground-glass opacity (GGO) ($P < 0.05$), which was more common in women. A comparison between patients under and over 50 years of age using the chi-square test indicated no significant difference between these two age groups ($P > 0.05$).

5. Discussion

Since concerns about the consequences of COVID-19 in immunocompromised patients were raised early in the pandemic (10, 11), and because people with immunodeficiency were at a higher risk of superinfection compared to patients with a healthy

Table 1. Demographic and Clinical Information of Patients [a]

Variables	Immune System Deficiency		P-Value
	Yes	No	
Gender			0.37
Male	298 (47.8)	325 (52.2)	
Female	379 (60.9)	244 (39.1)	
Age			0.002 [b]
< 50 years	246 (40.3)	460 (59.7)	
> 50 years	433 (56.6)	107 (43.4)	
CVDs	27 (100)	0 (0)	1
DM	162 (100)	0 (0)	0.02 [b]
HTN	216 (100)	0 (0)	0.005 [b]
Malignancy	325 (100)	0 (0)	0.001 [b]
Past medical history			
Autoimmune diseases	27 (100)	0 (0)	1
Infectious diseases	27 (100)	0 (0)	1
Kidney dysfunction	298 (100)	0 (0)	0.001 [b]
Asthma	27 (100)	0 (0)	1
Immunosuppresor use	433 (100)	0 (0)	0.001 [b]
Clinical symptoms			0.92
Dyspnea	27 (50)	27 (50)	
Cough	81 (75)	27 (25)	
Headache	27 (50)	27 (50)	
Fever	27 (50)	27 (50)	
Dyspnea,cough	162 (66.7)	81 (33.3)	
Dyspnea,cough ,fever	81 (42.9)	108 (57.1)	

Abbreviations: DM, diabetes mellitus; CVDs, cardiovascular diseases; HTN, hypertension.

[a] Values are expressed as No. (%).

[b] Statistically significant.

immune system ([12], [13]), this study compared lung CT scan findings between immunocompromised and immunocompetent COVID-19 patients.

Based on our findings, there were no differences in spiral lung CT scan findings between patients with immune system deficiency and those without. Zhu et al. conducted a study in China and revealed that the severity of pneumonia in immunocompromised COVID-19 patients was higher than in patients with normal immunity, with a mortality rate of 10% in immunocompromised patients with severe pulmonary involvement ([14]). Conversely, Baek et al. showed that immune system deficiency was associated with a higher risk of death in patients with COVID-19 ([15]). The different results in these studies may be due to the use of different definitions and classifications for immunosuppression ([16]). It should be noted that in most studies conducted in this field, only a very small number of patients with immune system defects have participated. One systematic review showed that immunosuppression may not be related to the severity of COVID-19 but is related to the outcomes associated with other diseases in people with COVID-19 ([17]). The findings of Denis et al.'s study demonstrated the necessity of providing the same care for patients with immunodeficiency as for those without it during this pandemic ([18]).

In this study, no difference in lung CT scan findings, except for mixed GGO, was observed between male and female patients. In contrast, another study found that peripheral distribution of opacities was more common in men, and women under 60 years had lower total lung score involvement ([19]). It should be noted that using CT scans as the sole method for diagnosing COVID-19 may lead to errors due to similarities with the radiological findings of other lung infections and may not be able to diagnose the disease in its early stages ([20]).

Table 2. Comparison of the Studied Groups in Terms of Spiral Lung CT Scan Findings [a]

Variables	Immune System Deficiency		P-Value
	Yes	No	
Lung involvement site			0.30
Left	81 (12)	0 (0)	
Right	27 (4)	27 (4.8)	
Both	568 (84)	541 (95.2)	
Multisegmental	0 (0)	27 (5.9)	
Consolidation patches			0.97
Atelectasis	189 (30.4)	162 (35.3)	
Multisegmental and Bilateral	270 (43.5)	216 (47.1)	
More than two patches	108 (17.3)	54 (11.8)	
Consolidation distribution			0.99
Peripheral	27 (25)	27 (37.5)	
Peripheral and Central	81 (75)	135 (62.5)	
GGO patches			0.99
Multisegmental and Bilateral	569 (84)	514 (90.5)	
Multisegmental and Unilateral	27 (4)	27 (4.8)	
GGO distribution			0.69
Peripheral	433 (64)	406 (71.4)	
Peripheral and Central	243 (36)	162 (28.6)	
Mixed GGO			1.0
Yes	514 (76)	433 (76.2)	
Crazy paving			0.51
Unilateral	54 (40)	27 (12.5)	
Bilateral	81 (60)	190 (87.5)	
Reverse hallo			1.0
Yes	54 (8)	54 (9.5)	
Pleural effusion			0.23
Bilateral	27 (4)	0 (0)	
Unilateral	81 (12)	0 (0)	
Emphysematous changes			0.49
Yes	54 (8)	0 (0)	
Lymphadenopathy			0.49
Mediastinal	54 (8)	0 (0)	
Location			0.47
Axillary	27 (4)	0 (0)	
Mid zone and Lower zone	190 (28)	216 (38.1)	
Upper zone, Mid zone and Lower zone	406 (60)	325 (57.1)	
Total lung involvement score			0.51
Minimal	298 (44)	298 (52.4)	
Middle	190 (28)	81 (14.3)	
Moderate	81 (12)	135 (23.8)	
Severe	108 (16)	54 (9.5)	
Atelectasis			0.76
Yes	243 (36)	243 (42.9)	

Abbreviations: GGO, ground-glass opacity.

[a] Values are expressed as No. (%).

There are a number of important limitations to consider in this study. First, due to the geographical area and time frame of the study, there was limited access to data and a smaller sample size. Second, since the

information was gathered from patients' medical records, we were unable to access background variables, which would have allowed us to investigate their effect on the comparison of CT scan findings.

5.1. Conclusions

This paper aimed to compare lung CT scan findings in immunocompromised and immunocompetent COVID-19 patients. The findings suggest that these two groups do not differ in terms of spiral lung CT scan findings. Based on the results of the present study, conducting a meta-analysis in the future would be beneficial for obtaining more accurate results.

Footnotes

Authors' Contribution: Study concept and design, and analysis and interpretation of data: M. R. and S. K.; acquisition of data, and drafting of the manuscript: H. M.; critical revision of the manuscript for important intellectual content: M. R.; statistical analysis, and administrative, technical, and material support: S. K.; study supervision: H. M. and M. R.

Conflict of Interests Statement: The authors declared no conflict of interest.

Data Availability: The data are not publicly available due to privacy.

Ethical Approval: The ethical necessities of the study were reviewed and approved by the Institutional Review Board (IRB) of the Hamedan University of Medical Sciences with the number IR.UMSHA.REC.1400.026 .

Funding/Support: No fund was received in this study.

Informed Consent: Informed consent was obtained from participants

References

1. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) Outbreak in china: summary of a report of 72314 cases from the chinese center for disease control and prevention. *JAMA*. 2020;**323**(13):1239-42. [PubMed ID: 32091533]. https://doi.org/10.1001/jama.2020.2648.

2. Jung SM, Kinoshita R, Thompson RN, Linton NM, Yang Y, Akhmetzhanov AR, et al. Epidemiological identification of a novel pathogen in real time: Analysis of the atypical pneumonia outbreak in Wuhan, China, 2019-2020. *J Clin Med*. 2020;**9**(3). [PubMed ID: 32120913]. [PubMed Central ID: PMC7141128]. https://doi.org/10.3390/jcm9030637.

3. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect Dis*. 2020;**20**(5):533-4. [PubMed ID: 32087114]. [PubMed Central ID: PMC7159018]. https://doi.org/10.1016/S1473-3099(20)30120-1.

4. Abasian L, Jafari F, SeyedAlinaghi S, Ayoobi Yazdi N, Daraei M, Ahmadinejad N, et al. The comparison of clinical, laboratory, and radiological findings in immunocompromised and immunocompetent patients with COVID-19: A case-control study. *Immun Inflamm Dis*. 2023;**11**(4). e806. [PubMed ID: 37102662]. [PubMed Central ID: PMC10091368]. https://doi.org/10.1002/iid3.806.

5. Mehta P, McAuley DF, Brown M, Sanchez E, Tattersall RS, Manson JJ, et al. COVID-19: Consider cytokine storm syndromes and immunosuppression. *Lancet*. 2020;**395**(10229):1033-4. [PubMed ID: 32192578]. [PubMed Central ID: PMC7270045]. https://doi.org/10.1016/S0140-6736(20)30628-0.

6. Xia Y, Jin R, Zhao J, Li W, Shen H. Risk of COVID-19 for patients with cancer. *Lancet Oncol*. 2020;**21**(4). e180. [PubMed ID: 32142622]. [PubMed Central ID: PMC7130057]. https://doi.org/10.1016/S1470-2045(20)30150-9.

7. Argenziano MG, Bruce SL, Slater CL, Tiao JR, Baldwin MR, Barr RG, et al. Characterization and clinical course of 1000 patients with coronavirus disease 2019 in New York: retrospective case series. *Bmj*. 2020;**369**:m1996. [PubMed ID: 32471884]. [PubMed Central ID: PMC7256651]. https://doi.org/10.1136/bmj.m1996.

8. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med*. 2020;**382**(18):1708-20. [PubMed ID: 32109013]. [PubMed Central ID: PMC7092819]. https://doi.org/10.1056/NEJMoa2002032.

9. Martins-Chaves RR, Gomes CC, Gomez RS. Immunocompromised patients and coronavirus disease 2019: A review and recommendations for dental health care. *Braz Oral Res*. 2020;**34**. e048. [PubMed ID: 32428085]. https://doi.org/10.1590/1807-3107bor-2020.vol34.0048.

10. Fishman JA. The immunocompromised transplant recipient and SARS-CoV-2 Infection. *J Am Soc Nephrol*. 2020;**31**(6):1147-9. [PubMed ID: 32345701]. [PubMed Central ID: PMC7269357]. https://doi.org/10.1681/ASN.2020040416.

11. Liang W, Guan W, Chen R, Wang W, Li J, Xu K, et al. Cancer patients in SARS-CoV-2 infection: A nationwide analysis in China. *Lancet Oncol*. 2020;**21**(3):335-7. [PubMed ID: 32066541]. [PubMed Central ID: PMC7159000]. https://doi.org/10.1016/S1470-2045(20)30096-6.

12. Ueda M, Martins R, Hendrie PC, McDonnell T, Crews JR, Wong TL, et al. Managing cancer care during the COVID-19 pandemic: Agility and collaboration toward a common goal. *J Natl Compr Canc Netw*. 2020:1-4. [PubMed ID: 32197238]. https://doi.org/10.6004/jnccn.2020.7560.

13. Liu BL, Ma F, Wang JN, Fan Y, Mo HN, Xu BH. [Health management of breast cancer patients outside the hospital during the outbreak of 2019 novel coronavirus disease]. *Zhonghua Zhong Liu Za Zhi*. 2020;**42**(4):288-91. Chinese. [PubMed ID: 32100979]. https://doi.org/10.3760/cma.j.cn112152-20200221-00110.

14. Zhu L, Gong N, Liu B, Lu X, Chen D, Chen S, et al. Coronavirus disease 2019 pneumonia in immunosuppressed renal transplant recipients: A summary of 10 confirmed Cases in Wuhan, China. *Eur Urol*. 2020;**77**(6):748-54. [PubMed ID: 32317180]. [PubMed Central ID: PMC7166037]. https://doi.org/10.1016/j.eururo.2020.03.039.

15. Baek MS, Lee MT, Kim WY, Choi JC, Jung SY. COVID-19-related outcomes in immunocompromised patients: A nationwide study in Korea. *PLoS One*. 2021;**16**(10). e0257641. [PubMed ID: 34597325]. [PubMed Central ID: PMC8486114]. https://doi.org/10.1371/journal.pone.0257641.

16. Vishnevetsky A, Levy M. Rethinking high-risk groups in COVID-19. *Mult Scler Relat Disord*. 2020;**42**:102139. [PubMed ID: 32388461]. [PubMed Central ID: PMC7175875]. https://doi.org/10.1016/j.msard.2020.102139.

17. Monti S, Balduzzi S, Delvino P, Bellis E, Quadrelli VS, Montecucco C. Clinical course of COVID-19 in a series of patients with chronic

arthritis treated with immunosuppressive targeted therapies. *Ann Rheum Dis*. 2020;**79**(5):667-8. [PubMed ID: 32241793]. [PubMed Central ID: PMC7211079]. https://doi.org/10.1136/annrheumdis-2020-217424.

18. Denis C, Baldacini M, Schenck M, Artzner T, Grimaud Y, Lavigne T, et al. Equal critical care consideration for both immunocompromised and immunocompetent patients during the COVID-19 surge. *Res Square*. 2020. https://doi.org/10.21203/rs.3.rs-57911/v1.

19. Moradi B, Ghanaati H, Kazemi MA, Gity M, Hashemi H, Davari-Tanha F, et al. Implications of sex difference in CT scan findings and outcome of patients with COVID-19 Pneumonia. *Radiol Cardiothorac Imaging*. 2020;**2**(4). e200248. [PubMed ID: 33778607]. [PubMed Central ID: PMC7370352]. https://doi.org/10.1148/ryct.2020200248.

20. Li L, Qin L, Xu Z, Yin Y, Wang X, Kong B, et al. Using artificial intelligence to detect COVID-19 and community-acquired pneumonia based on pulmonary CT: Evaluation of the diagnostic accuracy. *Radiology*. 2020;**296**(2):E65-e71. [PubMed ID: 32191588]. [PubMed Central ID: PMC7233473]. https://doi.org/10.1148/radiol.2020200905.