eISSN 2255-0569

ORIGINAL

Relationship of severity of COVID -19 disease with lung-CT-scan imaging

Relación de la gravedad de la enfermedad COVID-19 con la tomografía computarizada de pulmón

Yaser Ghelmani[1], Mohammad Hossein Ahrar Yazdi[2], Farimah Shamsi[3], Tahereh Fallah[4]

1. Clinical Research Development Center of Shahid Sadoughi Hospital, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
2. Department of Radiology, School of Medicine, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
3. Center for Healthcare Data Modeling, Department of Biostatistics and Epidemiology, School of Pulic Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
4. Clinical Research Development Center of Shahid Sadoughi Hospital, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

Corresponding author
Mohammad Hossein Ahrar Yazdi
E-mail: mohammadhosseinahraryazdi@gmail.com, hdahrar@gmail.com

Received: 12 - IX - 2022
Accepted: 13 - X - 2022

doi: 10.3306/AJHS.2023.38.01.18

Abstract

Objectives: Lung-CT-scan imaging is known as important diagnostic technique for evaluation of the effectiveness and infectious involvement of the lungs. In this study, we evaluated and analyzed lung CT images in patients with Coronavirus Disease 2019 (COVID-19) and its relationship with some important clinical and laboratory factors as well as the patient's condition in the worst disease conditions.
Methods: In this retrospective descriptive-analytical study, 375 patients with complete information have been considered. Among these patients, CT scans of patients' lungs was carefully reevaluated. Other radiologist reviewed the images and recorded the final score of the patients' lung involvement.
Results: Data showed that lung and cardiac involvement have high prevalence among studies patients. Among demographic variables, there was significant relationship between age and recovery. Evaluating the relationship of recovery with CT variables showed that CT score, bilateral lung involvement, and Crazy paving had significant effect on recovery rate.
Conclusion: According to this study, evaluation of CT variables can be used as potent factors for evaluation of disease status and design of suitable treatment strategy.

Keywords: CT-scan imaging, Lung, COVID-19, Involvement, Recovery.

Resumen

Objetivos: La tomografía computarizada de pulmón es conocida como una técnica de diagnóstico importante para la evaluación de la efectividad y el compromiso infeccioso de los pulmones. En este estudio, evaluamos y analizamos imágenes de TC de pulmón en pacientes con enfermedad por coronavirus 2019 (COVID-19) y su relación con algunos factores clínicos y de laboratorio importantes, así como la condición del paciente en las peores condiciones de la enfermedad.
Métodos: En este estudio descriptivo-analítico retrospectivo se han considerado 375 pacientes con información completa. Entre estos pacientes, se reevaluaron cuidadosamente las tomografías computarizadas de los pulmones de los pacientes. Otro radiólogo revisó las imágenes y registró la puntuación final de la afectación pulmonar de los pacientes.
Resultados: Los datos mostraron que la afectación pulmonar y cardíaca tiene una alta prevalencia entre los pacientes del estudio. Entre las variables demográficas, hubo relación significativa entre la edad y la recuperación. La evaluación de la relación de la recuperación con las variables de la TC mostró que la puntuación de la TC, la afectación pulmonar bilateral y el pavimento loco tuvieron un efecto significativo en la tasa de recuperación.
Conclusión: Según este estudio, la evaluación de las variables de TC se puede utilizar como factores potentes para la evaluación del estado de la enfermedad y el diseño de una estrategia de tratamiento adecuada.

Palabras clave: Tomografía computarizada, pulmón, COVID-19, participación, recuperación.

Introduction

Since December 2019, a new coronavirus, named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was discovered in China[1]. This novel virus lead to moderate to severe pulmonary involvement, Coronavirus Disease 2019 (COVID-19). Based on epidemiological studies, the main symptoms of COVID-19 include fever, dry cough and fatigue are. Other related clinical features of this disease include aches and pains, sore throat Diarrhea, conjunctivitis, headache, loss of taste or smell, and diarrhea[2]. Due to the highly contagious nature of COVID-19 and the lack of specific proven therapeutic drugs, early detection of this disease is of particular importance. There are two main diagnosis tools for COVID-19: RT-PCR and CT scan of the lungs[3]. The incidence of false-negative RT-PCR is high due to insufficient cellular material or incorrect nucleic acid extraction[4]. According to current experience, CT imaging of the lung may show the diagnosis of pulmonary involvement earlier than RT-PCR test. At present, high-resolution CT is listed as one of the main tools for screening, early diagnosis and assessment of disease severity[5,6]. So, chest CT imaging as a non-invasive imaging technique can be useful and a tool with high accuracy for early detection[7,8]. Thus, the aim of this study was to evaluate and analyze lung CT images in patients with COVID-19 and its relationship with some important clinical and laboratory factors as well as the patient's condition in the worst disease conditions (death or recovery).

Materials and Methods

In this retrospective descriptive-analytical study, 1000 patients with at least one CT imaging were selected. All selected patients has been performed pharyngeal test for PCR and laboratory diagnosis. Among these patients, 375 patients with complete information have been considered as the final statistical population. CT scans of patients' lungs was carefully reevaluated and recorded in designed questionnaires. Two independent researchers, without information about results of CT scan, recorded the clinical and laboratory information of the patients in the questionnaire. Then, the CT scan data was entered into the questionnaires by one of experienced radiologist. Other radiologist reviewed the images and recorded the final score of the patients' lung involvement. Acquired data were analyzed by SPSS-20.

Results

Totally, 375 patients were entered in this study. Based on data, Most of the studied patients were women (54.9%). In terms of age, most patients were over sixty years old (39.5%). The clinical features of disease including fever, cough, Shortness of breath, and other related symptoms were recorded in **table I**. Cough had the highest frequency among evaluated patients (64.4%). Frequency of underlying variables in patients were summarized in **table II**. Based on this table, lung and cardiac involvement have high prevalence among studies patients. Lung CT scan findings were summarized in **table III**. This table showed that highest CT score was 25-50. Bilateral lung involvement, Ground-glass opacification, Crazy paving, linear atelectasis, bronchies, and pleural was seen in 78.5, 84, 53.7, 21.7, 2.1, and 9.1%, respectively. Results showed that 42.8% of patients had involvement of five lobe. The relationship of recovery with

Table I: The frequency of clinical features of disease (fever, cough, Shortness of breath, Plt, WBC, and other related symptoms.

Variable		Frequency	Percent
Fever	No	161	43.0
	Yes	209	55.9
	Total	370	98.9
Cough	No	129	34.5
	Yes	241	64.4
	Total	370	98.9
Shortness of breath	No	158	42.2
	Yes	210	56.1
	Total	368	98.4
Plt	< 50	1	0.3
	51-99	25	6.7
	100-149	100	26.7
	150-450	241	64.4
WBC	<4	57	15.2
	4.1-12	297	79.4
	>12.1	15	4.0
Other related symptoms	No	105	28.1
	Yes	265	70.9
	Total	370	98.9

Table II: The frequency of underlying variables in evaluated patients.

Variable		Frequency	Percent
HTN	No	217	58.0
	Yes	115	30.7
DM	No	238	63.6
	Yes	94	25.1
Cardio disease	No	307	82.1
	Yes	25	6.7
Lung disease	No	297	79.4
	Yes	35	9.4
Cancer	No	329	88.0
	Yes	3	.8
Kidney disease	No	317	84.8
	Yes	15	4.0
Infection	No	332	88.8
	Yes	42	11.2
Smoking	No	256	68.4
	Yes	20	5.3
Opium consumption	No	275	73.5
	Yes	2	.5
Hookah consumption	No	250	66.8
	Yes	27	7.2
Alcohol consumption	No	275	73.5
	Yes	2	.5

demographic variables was analyzed (**Table IV**). There was significant relationship between age and recovery. Other demographic variables had no significant effect on recovery rate. The relationship of recovery with clinical features of disease was also analyzed (**Table V**). This table showed that there is significant relationship between recovery and shortness of breath, Platelet (Plt), and White blood cells (WBCs). The relationship of recovery with underlying variables was also analyzed (**Table VI**). Among these underlying variables, cardio and lung diseases had significant correlation with recovery rate. Evaluating the relationship of recovery with CT variables showed that CT score, bilateral lung involvement, and Crazy paving had significant effect on recovery rate (**Table VII**).

Table III: The frequency of variables related to lung CT scan findings.

Variable		n	%
CT score	0	35	9.4
	< 25	98	26.2
	25-50	150	40.1
	50-75	66	17.6
	>75	25	6.7
Total involvement	Involvement of a lobe	51	13.6
	Involvement of two lobe	48	12.8
	Involvement of three lobe	39	10.4
	Involvement of four lobe	28	7.5
	Involvement of five lobe	160	42.8
Bilateral lung involvement		256	78.5
Ground-glass opacification		314	84
Crazy paving		119	31.8
Linear atelectasis		81	21.7
Air bronchogram		92	24.6
Bronchiectasia		8	2.1
Pleural effusion	No	336	89.8
	Right involvement	34	9.1
	Left involvement	1	0.3
	Bilateral involvement	3	0.8
Other involvements		6	1.6

Table V: The relationship between clinical features of disease and recovery rate.

Variable		Recovery			P value
		complete	moderate	dead	
Fever	No	4	129	13	0.348
		2.7%	88.4%	8.9%	
	Yes	2	166	23	
		1.0%	86.9%	12.0%	
Cough	No	1	103	15	0.456
		.8%	86.6%	12.6%	
	Yes	5	192	21	
		2.3%	88.1%	9.6%	
Shortness of breath	No	3	134	6	0.005
		2.1%	93.7%	4.2%	
	Yes	3	160	29	
		1.6%	83.3%	15.1%	
Plt	<50	0	0	1	0.014
		.0%	.0%	100.0%	
	51-99	0	21	3	
		.0%	87.5%	12.5%	
	100-149	0	76	15	
		.0%	83.5%	16.5%	
	150-450	7	193	18	
		3.2%	88.5%	8.3%	
WBC	<4	0	49	3	0.008
	4.1-12	.0%	94.2%	5.8%	
	>12.1	6	235	29	
	<4	2.2%	87.0%	10.7%	
	4.1-12	1	8	5	
		7.1%	57.1%	35.7%	

Table IV: The relationship between and recovery rate.

		Recovery			P value
		complete	moderate	dead	
age	18-40	1	88	1	0.0000
		1.1%	97.8%	1.1%	
	41-60	3	105	5	
		2.7%	92.9%	4.4%	
	>=61	3	101	29	
		2.3%	75.9%	21.8%	
Male	Female	6	174	24	0.197
		2.9%	85.3%	11.8%	
	Male	1	123	11	
		.7%	91.1%	8.1%	
Marital status	Married	7	274	33	0.292
		2.2%	87.3%	10.5%	
	Single	0	17	0	
		.0%	100.0%	.0%	

Table VI: The relationship between underlying variables and recovery rate.

Variables			Recovery			P value
			complete	moderate	dead	
HTN	No	Count	4	176	17	0.150
		% within HTN	2.0%	89.3%	8.6%	
	Yes	Count	2	87	17	
		% within HTN	1.9%	82.1%	16.0%	
DM	No	Count	3	196	19	0.067
		% within DM	1.4%	89.9%	8.7%	
	Yes	Count	3	68	14	
		% within DM	3.5%	80.0%	16.5%	
Cardio	No	Count	4	245	29	0.049
		% within Cardio	1.4%	88.1%	10.4%	
	Yes	Count	2	19	4	
		% within Cardio	8.0%	76.0%	16.0%	
Lung	No	Count	6	236	29	0.041
		% within lung	2.2%	87.1%	10.7%	
	Yes	Count	0	28	4	
		% within lung	.0%	87.5%	12.5%	
Cancer	No	Count	6	262	32	0.448
		% within cancer	2.0%	87.3%	10.7%	
	Yes	Count	0	2	1	
		% within cancer	.0%	66.7%	33.3%	
Kidney disease	No	Count	6	253	31	0.767
		% within kolyavi	2.1%	87.2%	10.7%	
	Yes	Count	0	11	2	
		% within kolyavi	.0%	84.6%	15.4%	
Infection	No	Count	6	264	33	1.000
		% within ofoni	2.0%	87.1%	10.9%	
Smoking	No	Count	5	213	20	0.416
		% within smoking	2.1%	89.5%	8.4%	
	Yes	Count	1	16	3	
		% within smoking	5.0%	80.0%	15.0%	
Opium consumption	No	Count	6	227	23	0.880
		% within opiom	2.3%	88.7%	9.0%	
	Yes	Count	0	2	0	
		% within opiom	.0%	100.0%	.0%	
Alcohol consumption	No	Count	6	228	23	0.938
		% within alcohol	2.3%	88.7%	8.9%	
	Yes	Count	0	1	0	
		% within alcohol	.0%	100.0%	.0%	

Table VII: The relationship between CT variables and recovery rate.

Variable		Recovery			P value
		complete	moderate	dead	
CT score	< 25	1	83	4	0.001
	25-50	4	125	11	
	50-75	2	45	12	
	>75	0	17	8	
Total involvement	Involvement of a lobe	0	44	1	0.063
	Involvement of two lobe	1	41	3	
	Involvement of three lobe	0	30	4	
	Involvement of four lobe	0	26	1	
	Involvement of five lobe	5	119	25	
Bilateral lung involvement		6	198	33	0.008
Ground-glass opacification		6	250	34	0.462
Crazy paving		4	87	20	0.004
Linear atelectasis		2	61	11	0.400

Discussion

Coronaviruses are RNA viruses with broad distribution in mammals, especially in humans[9]. A new member of these family, e.g. SARS-Cov2, similar to other related coronaviruses, lead to severe acute respiratory syndrome[10]. This new virus was assessed based on clinical records, laboratory tests, and lung CT test. Fever, cough, fatigue, sputum production and diarrhea are known as important clinical signs of SARS-Cov2 infection[11]. Shortness of breath has been also shown as sign of disease[12]. The imaging evaluation showed that patients had chest CT scans abnormalities[13]. The severity of abnormalities can related to disease severity[14]. So, it's suggested that chest CT scans can predict the severity of disease and after schedule of disease management. In this study, we evaluated the relationship between CT finding and disease outcome.

We also evaluation of relationship between demographic and clinical finding with disease outcome. Based on our results, among all evaluated demographic data, only age had significant effects on disease outcome. This result is similar to other published articles[15-18]. Our study, along with other related articles, showed that increased age can be considered as strong risk factor for COVID-19 severe outcomes. Mortality rates were significantly higher in the age group over sixty years. Among clinical data, Shortness of breath, Plt, and WBC had significant relationship with recovery rate. Blood clot formation has been occurred in some patients with COVID-19. This situation lead to artery dysfunction and enhancement of heart attack risk. All these situation can alter the recovery rate of patients[19]. Similar to these data, our data also showed the related variables, especially Plt, cane significantly alter the recovery rate. Our results showed that some finding of CT imaging had significant effect on recovery rate. Based on results, CT score, bilateral lung involvement, and Crazy paving had significant effect on recovery rate. Pneumonic changes was seen in radiological evidence of most patients. Based on literature review, bilateral lung involvement and Small unilateral peripheral opacification are two main abnormality in radiological evidence of patients[20-23]. In our study, bilateral lung involvement and Ground-glass opacification had highest prevalence among all radiological symptoms. Similar to other studies, in our study, the most common symptoms is ground-glass opacification. The highest CT score belonged to 25-50 involvement. In involvement more than 75%, that was no complete recovery among patients. The recovery rate decreased with increasing lung involvement. This relationship was statistically significant. Peijie et al indicated that in patient with severe disease, involvement of lung segments and lobes, crazy-paving pattern and air bronchogram increased[24]. Similar to Peijie et al study, crazy paving had high prevalence in our study. On the other hand, bronchogram had lower incidence in our study. In our study, similar to other related studies, the prevalence of crazy-paving pattern and air bronchogram had more incident in patients with moderate recovery or dead patients[25-28]. This data showed that there severity of these CT variable can predicted the severity of disease as well as recovery rate. Xiong et al acknowledged that COVID-19 infection usually lead to typical glass opacities and other related CT features. These variables had significant correlations with various clinical factors[29]. So, most studies suggested that follow-up CT images can help the scientists for evaluation of disease outcome, recovery rate as well as treatment procedures. Among all related variables, lung evolvement score, ground-glass opacification, crazy paving, and linear atelectasis had significant effects on disease outcome, recovery rate, and treatment procedures in most studies[25-28]. Our data showed that lung evolvement score and crazy paving had significant effects on disease outcome and recovery rate. So, our study is consistent with other reported data to some extent. The severity of lung evolvement can predict the disease outcome. Although not all CT-related variables had a significant effect on recovery rates, the data showed that for all variables, the incidence of more severe disease increased with increasing frequency of variables. But, pay attention to the lung evolvement score and crazy paving is more important to evaluate the outcome of the disease.

Conclusions

According to this study, lung and cardiac involvement have high prevalence among patients with COVD-19. Evaluation of the relationship between recovery and CT variables showed that CT score, bilateral lung involvement, and crazy paving had significant effect on recovery rate. So, evaluation of CT variables can be used as potent factors for evaluation of disease status and design of suitable treatment strategy.

List of abbreviations

COVD-19: Coronavirus disease 2019
CT: Computerized Tomography
WBCs: White blood cells
Plt: Platelet
Ethics approval and consent to participate
This study was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences.

Consent to publish

Not applicable

Availability of data and materials

The original contributions presented in the study are included in the article.

Competing interests

Not applicable

Funding

Not applicable

Acknowledgements

Not applicable

References

1. Zare-Zardini H, Ferdosian F, Soltaninejad H, Zahedi M, Memarpoor-Yazdi M, Hamidieh AA, et al. Antimicrobial peptides as potent compounds for reduction of COVID-19 infection. Bulletin of Pharmaceutical Sciences Assiut. 2021;44(1):243-52.

2. Zare-Zardini H, Soltaninejad H, Ferdosian F, Hamidieh AA, Memarpoor-Yazdi M. Coronavirus disease 2019 (COVID-19) in children: prevalence, diagnosis, clinical symptoms, and treatment. International Journal of General Medicine. 2020;13:477.

3. Rongqing Z, Li M, Song H, Chen J, Ren W, Feng Y, et al. Early Detection of Severe Acute Respiratory Syndrome Coronavirus 2 Antibodies as a Serologic Marker of Infection in Patients With Coronavirus Disease 2019. Clin Infect Dis. 2020;71(16):2066-72.

4. Arevalo-Rodriguez I, Buitrago-Garcia D, Simancas-Racines D, Zambrano-Achig P, Del Campo R, Ciapponi A, et al. False-negative results of initial RT-PCR assays for COVID-19: a systematic review. PloS one. 2020;15(12):e0242958.

5. Al-Tawfiq JA, Memish ZA. Diagnosis of SARS-CoV-2 infection based on CT scan vs RT-PCR: reflecting on experience from MERS-CoV. J Hosp Infect. 2020;105(2):154-5.

6. Zhang R, Ouyang H, Fu L, Wang S, Han J, Huang K, et al. CT features of SARS-CoV-2 pneumonia according to clinical presentation: a retrospective analysis of 120 consecutive patients from Wuhan city. Eur Radiol. 2020;30(8):4417-26.

7. Li B, Li X, Wang Y, Han Y, Wang Y, Wang C, et al. Diagnostic value and key features of computed tomography in Coronavirus Disease 2019. Emerg Microbes Infect. 2020;9(1):787-93.

8. Awulachew E, Diriba K, Anja A, Getu E, Belayneh F. Computed Tomography (CT) Imaging Features of Patients with COVID-19: Systematic Review and Meta-Analysis. Radiol Res Pract. 2020;2020:1023506-.

9. Fauci AS, Lane HC, Redfield RR. Covid-19—navigating the uncharted. Mass Medical Soc; 2020.

10. Yuki K, Fujiogi M, Koutsogiannaki S. COVID-19 pathophysiology: A review. Clinical immunology. 2020:108427.

11. Alimohamadi Y, Sepandi M, Taghdir M, Hosamirudsari H. Determine the most common clinical symptoms in COVID-19 patients: a systematic review and meta-analysis. J Prev Med Hyg. 2020;61(3):E304-E12.

12. Shi L, Wang Y, Wang Y, Duan G, Yang H. Dyspnea rather than fever is a risk factor for predicting mortality in patients with COVID-19. J Infect. 2020;81(4):647-79.

13. Adams HJ, Kwee TC, Yakar D, Hope MD, Kwee RM. Chest CT imaging signature of coronavirus disease 2019 infection: in pursuit of the scientific evidence. Chest. 2020;158(5):1885-95.

14. Shan F, Gao Y, Wang J, Shi W, Shi N, Han M, et al. Abnormal lung quantification in chest CT images of COVID-19 patients with deep learning and its application to severity prediction. Medical physics. 2021;48(4):1633-45.

15. Chen Y, Klein SL, Garibaldi BT, Li H, Wu C, Osevala NM, et al. Aging in COVID-19: Vulnerability, immunity and intervention. Ageing Res Rev. 2021;65:101205-.

16. Romero Starke K, Petereit-Haack G, Schubert M, Kämpf D, Schliebner A, Hegewald J, et al. The Age-Related Risk of Severe Outcomes Due to COVID-19 Infection: A Rapid Review, Meta-Analysis, and Meta-Regression. Int J Environ Res Public Health. 2020;17(16):5974.

17. Bajaj V, Gadi N, Spihlman AP, Wu SC, Choi CH, Moulton VR. Aging, Immunity, and COVID-19: How Age Influences the Host Immune Response to Coronavirus Infections? Front Physiol. 2021;11:571416-.

18. Levin AT, Hanage WP, Owusu-Boaitey N, Cochran KB, Walsh SP, Meyerowitz-Katz G. Assessing the age specificity of infection fatality rates for COVID-19: systematic review, meta-analysis, and public policy implications. Eur J Epidemiol. 2020;35(12):1123-38.

19. Biswas S, Thakur V, Kaur P, Khan A, Kulshrestha S, Kumar P. Blood clots in COVID-19 patients: Simplifying the curious mystery. Med Hypotheses. 2021;146:110371-.

20. Martínez Chamorro E, Díez Tascón A, Ibáñez Sanz L, Ossaba Vélez S, Borruel Nacenta S. Radiologic diagnosis of patients with COVID-19. Radiología. 2021;63(1):56-73.

21. Sun Z, Zhang N, Li Y, Xu X. A systematic review of chest imaging findings in COVID-19. Quantitative imaging in medicine and surgery. 2020;10(5):1058-79.

22. Cui N, Zou X, Xu L. Preliminary CT findings of coronavirus disease 2019 (COVID-19). Clin Imaging. 2020;65:124-32.

23. Meng H, Xiong R, He R, Lin W, Hao B, Zhang L, et al. CT imaging and clinical course of asymptomatic cases with COVID-19 pneumonia at admission in Wuhan, China. J Infect. 2020;81(1):e33-e9.

24. Lyu P, Liu X, Zhang R, Shi L, Gao J. The performance of chest CT in evaluating the clinical severity of COVID-19 pneumonia: identifying critical cases based on CT characteristics. Investigative radiology. 2020;55(7):412-21.

25. Quispe-Cholan A, Anticona-De-La-Cruz Y, Cornejo-Cruz M, Quispe-Chirinos O, Moreno-Lazaro V, Chavez-Cruzado E. Tomographic findings in patients with COVID-19 according to evolution of the disease. The Egyptian Journal of Radiology and Nuclear Medicine. 2020;51(1):215.

26. Kumar H, Fernandez CJ, Kolpattil S, Munavvar M, Pappachan JM. Discrepancies in the clinical and radiological profiles of COVID-19: A case-based discussion and review of literature. World J Radiol. 2021;13(4):75-93.

27. Jacobi A, Chung M, Bernheim A, Eber C. Portable chest X-ray in coronavirus disease-19 (COVID-19): A pictorial review. Clin Imaging. 2020;64:35-42.

28. McFee RB. COVID-19 - A Brief Review of Radiology Testing. Dis Mon. 2020;66(9):101059-.

29. Xiong Y, Sun D, Liu Y, Fan Y, Zhao L, Li X, et al. Clinical and High-Resolution CT Features of the COVID-19 Infection: Comparison of the Initial and Follow-up Changes. Investigative radiology. 2020;55(6):332-9.