European Review for Medical and Pharmacological Sciences 2022; 26: 5971-5977

Total Severity Score (TSS) comparison in vaccinated and unvaccinated patients during the fourth wave (December 2021 - January 2022) of COVID-19 in Italy

G.M. RUSSO[1], M.L. MANGONI DI SANTO STEFANO[2], M.P. BELFIORE[1], G. ANNUNZIATA[2], E. ZOI[2], L. GALLO[1], G. CIANI[1], F. URRARO[1], V. NARDONE[1], A. REGINELLI[1], S. CAPPABIANCA[1]

[1]Department of Precision Medicine, University of Campania "Luigi Vanvitelli", Naples, Italy
[2]Department of Radiology, "S. Maria della Pietà Hospital", Nola, Italy

G.M. Russo and M.L. Mangoni di Santo Stefano are both first author
B. Reginelli and S. Cappabianca are both last authors

Abstract. – OBJECTIVE: This study aims at comparing the severity score assessed using high-resolution computed tomography (HRCT) in vaccinated and unvaccinated COVID-19 patients.

PATIENTS AND METHODS: From the first of December 2021 to first of February 2022, we conducted a single-center retrospective analysis on COVID-19 patients who accessed ED services. The hospital in question is a level II facility with a catchment area of around 200,000 people. According to the Italian recommendations, patients were divided into four groups based on the CT score of Micheal Chung. The sum of acute inflammatory lung lesions involving each lobe was scored as 1 (0-25%), 2 (26-50%), 3 (51-75%) or 4 (76-100%) on a visual quantitative assessment of CT. The total severity score (TSS) was determined by summing the five lobe scores.

RESULTS: The study included 134 patients divided into two groups: 67 vaccinated and 67 unvaccinated people. 53 people had incomplete (single dose/double dose) immunization, while 14 people completed the vaccination cycle. It was discovered that the mean CT severity score was lower in fully vaccinated patients compared to partially vaccinated or unvaccinated patients. The mean CT score was significantly lower in fully vaccinated patients aged 60 compared to older patients. The mean CT score was higher in unvaccinated patients compared to fully vaccinated patients.

CONCLUSIONS: Individuals who received three doses of COVID-19 vaccination had lower CT severity scores than patients who received only one dose of vaccine or no vaccines at all.

Key Words:
COVID-19, Total severity score, Vaccine COVID-19, Acute inflammatory lung lesions, Single dose/double dose.

Introduction

The first patient with COVID-19 disease was diagnosed at the end of 2019 and now the total number of confirmed cases has already exceeded 270 million with a high mortality rate of around 2.0 percent. COVID-19 vaccinations are effective and vital strategies to contain the spread of the epidemic. At present, at least one dose of the COVID-19 vaccination has been administered to 56% of the world's population. However, vaccines are still not 100% effective at preventing infection. The discovery of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) ribonucleic acid (RNA) or antigen in a respiratory specimen obtained 14 days after the administration of all prescribed doses of COVID-19 vaccinations is considered a breakthrough infection[1].

Most of the early cases were connected to the Huanan Sea food market, a live animal and seafood market. The essential and favored approach for the diagnosis, supported by the WHO interval guide, is the collection of upper respiratory samples through nasopharyngeal and oropharyngeal swabs, followed by RT-PCR identification of SARS-CoV-2 RNA. The efficacy of RT-PCR in the diagnosis of COVID-19 infection like other molecular tests, is highly dependent on the pre-analytical phase, which includes patient selection and material collection, as well as RNA extraction method and RT-PCR test performance. Starting with the Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV) in 2002, the Middle East Respiratory Syndrome Coronavirus

Corresponding Author: Gaetano Maria Russo, MD; e-mail: dott.gaetanomariarusso@gmail.com

(MERS-CoV) spread afterwards in 2012; finally, the Severe Acute respiratory Syndrome Coronavirus 2 (SARS-CoV2) is presently underway: nowadays three significant Covid variants have caused infection flare-ups.

The World Health Organization (WHO) classified Omicron as an original Severe Acute respiratory Syndrome Coronavirus 2 (SARS-CoV-2) variant of concern (VOC) on November 26, 2021. The spike (S) protein, which is the principal antigenic target of antibodies generated by infections or immunization, has 32 mutations in this variation, which is an exceptionally high number. The deadly Delta variant, however, has only 5 S protein mutations, posing a significant global threat and spreading internationally. As a result, the "panic button" has been pressed in numerous cases around the world and many nations have instituted travel restrictions to prevent the Omicron variant from spreading rapidly.

Scientists discovered that three doses of the vaccination not only neutralized the Omicron variant[2], but also raised neutralizing antibody levels by a factor of 25 when compared to two doses[3].

The efficacy of existing COVID-19 vaccines in use against the Omicron variant has been evaluated in several preliminary investigations. One- or two-dose vaccines tend to provide significantly less protection than booster vaccines, although they still appear to protect against serious disease. Studies have shown that a full immunization plus a booster dose provides better protection against Omicron infection both in the lab and the real world.

Vaccine effectiveness against symptomatic Omicron infection is much lower than in the case of the Delta variant[4]. According to a paper from Imperial College London[3], the probability of reinfection with Omicron was 5.4 times higher than with the Delta variant. Having COVID-19 previously provided minimal protection against Omicron reinfection.

The Omicron VOC has a lot of mutations, some of which are problematic since they could lead to immune evasion and enhanced infectivity. The Omicron variant effectively shares a few transformations with the C.1.2 (an exceptionally changed genealogy recently recognized in Beta and Delta variants) and it has 22 extra replacements as well (counting inclusions and cancellations), which have not been found in some other VOC or variation of interest (VOI) until now. SGTF on the TaqPath COVID-19 PCR test is known to be caused by a 69-70 amino acid deletion in the spike gene, which was previously found in the Alpha variant.

The role of HRCT scan in the COVID-19 diagnosis is crucial, especially in patients with comorbidities, diagnostic issues, and poor treatment response, being a problem-solving technique[5]. Furthermore, measuring the volume of lung implicated in a verified patient and associating disease severity with a CT scan severity score may have a more practical role[6]. According to the Italian recommendations, patients were divided into four groups based on the CT score of Micheal Chung[7].

The sum of acute inflammatory lung lesions involving each lobe was scored as 1 (0-25%), 2 (26-50%), 3 (51-75%) or 4 (76-100%) on a visual quantitative assessment of CT. The total severity score (TSS) was determined by summing the five lobe scores[8].

The goal of this study was to evaluate the severity scores determined from high-resolution computed tomography (HRCT) in COVID-19 patients between vaccinated and unvaccinated people.

Literature Review

The International Committee on Taxonomy of Viruses (ICTV) announced "severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2)" as the name of the new virus after founding it from lower respiratory testing. Moreover, WHO declared "COVID-19" as the name of this new disease on 11 February 2020. SARS-CoV-2 is an RNA infection belonging to Betacoronavirus subgroup B. Under the electron microscope, the virus appears spherical with a diameter that ranges from 60 to 140 nm. Its outer membrane exhibits distinct spikes which are 9-12 nm long, similar to those found in the solar corona. SARS-CoV-2 shows 92 percent homology with Bat Coronavirus RaTG3, proposing a zoonotic beginning for this flare-up, as per the review. COVID-19 has been declared as a global pandemic by the WHO, given its contagiousness. Fever, myalgia, dyspnea and fatigue are normal clinical characteristics of COVID-19 patients, which are similar to those of SARS-CoV and MERS-CoV.

Due to its contagiousness and vaccine escape mutations, the latest variant Omicron (B.1.1.529) ignited global fear. Its critical infectivity and antibody resistance are determined by mutations on the spike (S) protein receptor-binding region (RBD)[9]. A complete investigation on the Omicron variant could require weeks or even months. In COVID-19 patients, the total severity score (TSS) could be used to quickly evaluate the degree of pneumonic involvement in an objective way[10-12].

Patients and Methods

Study Design and Setting

From the first of December 2021 to first of February 2022, we conducted a single-center retrospective analysis on COVID-19 patients who accessed ED services. The hospital in question is a level II facility with a catchment area of around 200,000 people.

All patients had their clinical data collected, including their age, gender, exposure history, clinical complaint and laboratory values. All patients underwent RT-PCR laboratory testing before or after a chest CT scan. When RT-PCR results were delayed or initial RT-PCR results were negative but there was a high suspicion of COVID-19 infection, HRCT was used for diagnostic purposes.

CT scan was used to determine CT severity score and guide treatment care in RT-PCR-positive patients. Scans that revealed severe pre-existing/chronic pulmonary parenchymal disorders were excluded. The inactivated virus vaccine or the non-replicating viral vector vaccines were administered to immunized individuals.

HRCT

Non-contrast CT scans were taken from the lung apices to the lateral costophrenic sulci in a craniocaudal orientation and in a single breath-hold. A helical scan was obtained in supine position. The scanning rooms and equipment were disinfected and sanitized according to standard procedures.

All patients' chest CT images showed the following characteristics.

Distribution of Lesions

Dorsal and ventral (or both dorsal and ventral) lung involvement; lobar pneumonia (right upper lobe (RUL), right center lobe (RML), right lower lobe (RLL), left upper lobe (LUL), and left lower lobe (LLL)) and the entire lung; pain in the lung area; involvement of the peribronchovascular (focal) region of the lung; Ground glass opacity (GGO); vascular thickening; crazy-paving pattern; air-bronchogram; septal thickening; pleural thickening; subpleural bands; vacuolization; bronchial septal thickening; centrilobular nodules; other negative discoveries included lymphadenopathy, pleural effusion, pericardial effusion.

Image Analysis

A CT scoring system was employed based on the area involved in order to objectively quantify the pulmonary involvement in all these anomalies[13,14]. A visual, quantitative assessment of CT was based on the sum of acute inflammatory lung lesions involving each lobe, which was scored as 1 (0-25%), 2 (26-50%), 3 (51-75%), or 4 (76-100%), respectively. The total severity score (TSS) was achieved by summing the scores of the five lobes and was also divided in 4 ratings, as follows: score 0-5: low grade; score 6-10: intermediate grade; score 11-15: high score; score 16-20 very high score[15-18].

Statistical Analysis

Mann-Whitney U test and Kruskal-Wallis' test were used in order to correlate clinical features (age, CT score, lung lesions) with vaccination status and number of vaccine injections. The Chi-Square test was used for nominal data. A 0.05 *p*-value was judged significant. Multivariate analysis investigating the effects of age, gender, vaccination and CT characteristics with the CT score was performed using binary logistic regression analysis. In order to conduct the aforementioned analyses, CT score was dichotomized in low and intermediate score ($TSS \leq 10$) *vs.* high and very high score ($TSS > 10$). ROC curve was also calculated from binary logistic regression analysis. All the statistics were performed with SPSS®, version 22.0 (IBM Corp., Armonk, NY, USA).

Results

Demographic, Disease Severity and Clinical Characteristics

This study involved 134 patients, including 80 male (60%) and 54 females (40%), belonging to age ranging from 24 to 94 years (average age: 59 years). Half of the population was not vaccinated (67 patients, 50%).

Among the 67 vaccinated patients, our results show: 5 patients with 1 vaccine dose (3.73%); 48 patients with 2 vaccine dose (35.8%), one of which with second dose administered less than 4 months after the first dose; 14 patients with 3 vaccine dose (10.4%), one of which with lymphatic system dysfunction and two with vaccination cycle completed in more than 4 months.

In the fully vaccinated group (14 patients) the results are: 10 patients with score 1 (71.4% green); 1 patient with score 2 (7.1%, this patient completed the vaccination cycle in more than 4 months); 2 patients with score 3 (14%, one of these patients completed the vaccination cycle in more than 4 months); 1 patient with score 4 (7.1% red, this patient suffered from chronic lymphocytic leukemia – CLL). In the fully vaccinated group, 90.9% of patients without comorbidities and with a vaccination cycle completed in less than 3 months obtained score 1 (Figure 1).

In the two doses group (48 patients) the obtained results were: 22 patients with score 1 (45.8%); 8 patients with score 2 (16.6%); 8 patients with score 3 (16.6%) and 10 patients with score 4 (20.8%).

In the one-dose group (5 patients) the obtained results were: 1 patient with score 1 (20%); 0 patient with score 2 (0%); 2 patients with score 3 (40%) and 2 patients with score 4 (40%).

In total, there were 57 patients with score 1 (42.5%), 16 patients with score 2 (11.9%), 28 patients with score 3 (20.89%) and 33 patients with score 4 (24.62%). Disease severity was significantly correlated with lower respiratory symptoms, in particular cough, and the presence of chronic diseases.

Statistical analysis showed a significant correlation between global CT score and vaccination status (p=0.020) and vaccine injections (p=0.011).

Comparison of CTSS

The CT scores of the left upper and lower lobes did not differ significantly between the two groups (all p> 0.05). Also the number of affected lobes did not differ significantly between the two groups (all p> 0.05), except for Right Upper Lobe (RIL), which was remarkably correlated with both vaccination status (p=0.028) and the number of vaccine injections (p=0.012), affecting more unvaccinated patients (70.1% *vs.* 51.5%) or those with a lower number of doses (70.1% of unvaccinated patients, 60% of patients with single dose, 55.3% of patients with two doses and 35.7% of fully vaccinated patients).

The Findings of CT Characteristics in the Two Groups

GGO (95%), pleural thickening (52%), crazy-paving pattern (52%), interstitial inflammation defined by consolidations (43%), fibrosis (28%), discrete nodules (8%), bronchiectasis (7%), thoracic lymphadenopathy (3%), pleural effusion (0%), and cavitation (3%) were found in 134 patients (Table I). There was no critical contrast between the two groups in the event pace of every one of the ten CT characteristics in the underlying CT (all p > 0.05).

Multivariate Analysis

Binary logistic regression analysis showed that vaccination status (p=0.020, OR 0.34, 95% CI OR: 0.14-0.84), GGO (p<0.001, OR 14.4, 95% CI OR: 3.9-40.1) and consolidation (p<0.001, OR 6.15, 95% CI OR: 2.4-15.4) were the only significantly correlated parameters with the prediction of TSS score (low and intermediate *vs.* high and very high score).

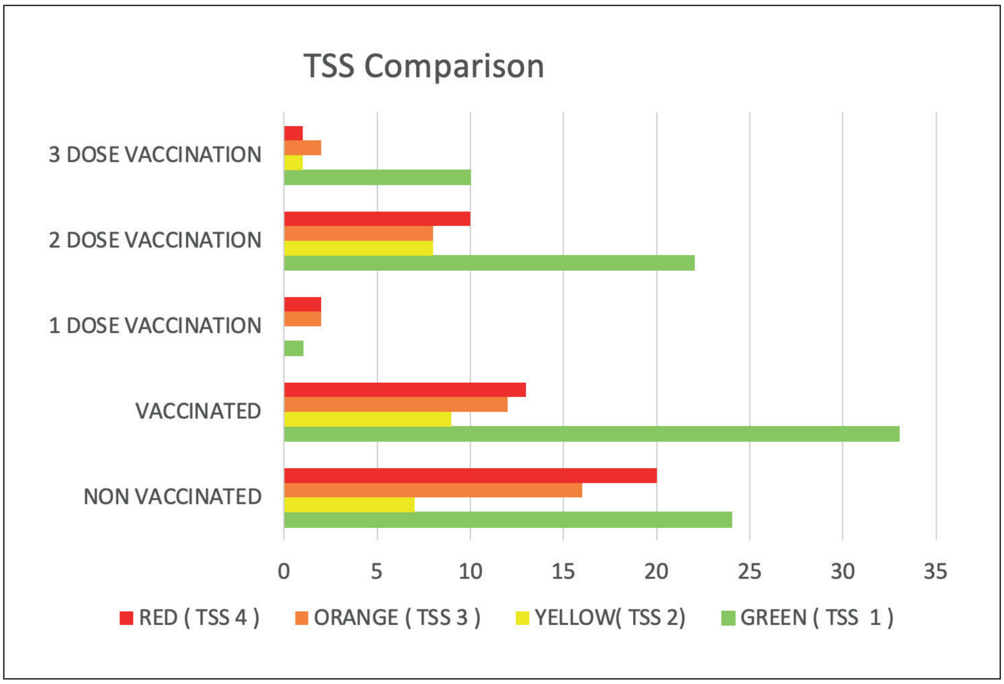

Figure 1. TSS graphical representation.

Table I. Findings of CT images between two groups.

	Unvaccinated n=67	Vaccinated n=67	*p*-value
CT characteristics			
GGO	95%	78%	0.075
Consolidation	43%	60%	0.237
Crazy-paving pattern	52%	55%	1.000
Pleural thickening	52%	49%	0.767
Fibrosis	28%	39%	0.746
Discrete nodules	8%	7%	1.000
Bronchiectasis	7%	6%	1.000
Thoracic lymphadenopathy	3%	6%	0.542
Pleural effusion	0%	14%	0.098
Cavitation	3%	0%	1.000
Involved lobes			
Right upper lobe	70.1%	51.5%	0.028
Right middle lobe	39%	68%	0.069
Right lower lobe	92%	95%	1.000
Left upper lobe	75%	78%	0.5333
Left lower lobe	70%	96%	0.080
CT score in each lobe			
Right upper lobe	0-1	0-4	0.017
Right middle lobe	0-1	0-4	0.007
Right lower lobe	0-4	0-4	0.047
Left upper lobe	0-2	0-4	0.057
Left lower lobe	0-3	0-4	0.123
TSS	0-11	0-20	0.008

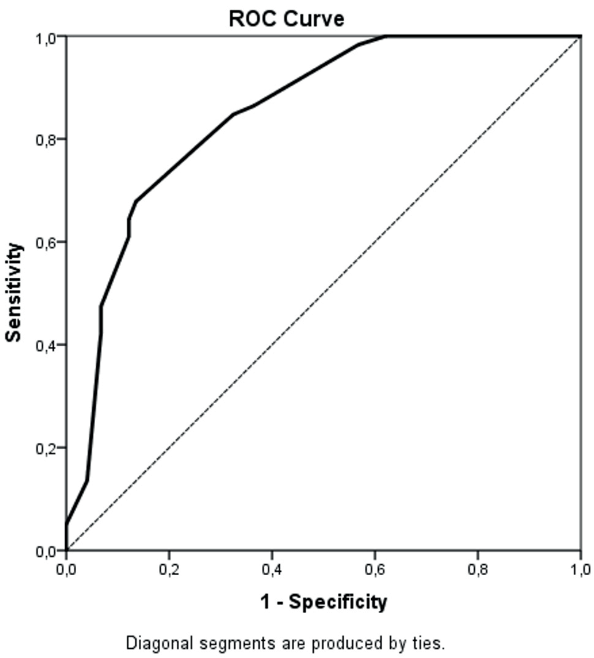

Figure 2. ROC Curve extrapolated from binary logistic regression analysis.

ROC Curve for the prediction of TSS Score showed an AUC of 0.85 (95% CI: 0.78-0.91), with a sensitivity of 67.8% and a specificity of 86.5% (Figure 2).

Discussion

In this study, we compared vaccinated COVID-19 patients with unvaccinated patients scanned in the same period in order to evaluate the effect of vaccines on CT severity score. The key conclusions of this study were twofold: firstly, vaccinated patients had a lower mean CT score than unvaccinated patients; secondly, fully vaccinated patients had a lower CT score than unvaccinated patients.

Some scholars[19] evaluated the safety and efficacy of different currently used vaccinations, finding that vaccine administration reduces lung involvement in COVID-19 patients and has an influence on systemic inflammatory and coagulopathy responses. Our findings show that COVID-19 vaccines are effective against severe disease with

CT severity score serving as an imaging surrogate of the virus' biological activity. In our investigation, the time interval between the second dose and clinical sickness was a significant factor, leading to lower CT severity scores, obtaining a similar result of earlier studies which only considered the clinic-pathological factors.

Imaging was used to assess the severity of the patients. We included the scans performed in our study since including CT scans from earlier phases could have had a confounding influence on interpretation[20-22]. Females' immunological responses to both internal and external antigens were superior to males'. This physiological advantage affected disease recovery as well as the ineffectiveness of vaccinations against numerous infections. In the current dataset, however, vaccinated patients have had an insignificantly greater CT severity score than unvaccinated patients.

Elderly people are known to have a worse prognosis, with numerous reasons for more severe pulmonary parenchyma affection[23,24]. CT scan correlated to this clinical assertion has also corroborated the hypothesis with weaker and more unusual signs reported at younger ages[25]. A comparison of mean CT severity score at various age groups between vaccinated and unvaccinated individuals in the current dataset was in agreement with past research[26,27], with a lower mean score reported in patients younger than 45 years. In the fully vaccinated group, there was a stronger inverse relationship between age and CT score.

In addition, the fully vaccinated group had considerably less acute airspace and interstitial inflammation defined by consolidations and ground-glass opacities than unvaccinated and incompletely vaccinated patients. As a result, a severe score (CT score of 20) was observed in only one fully vaccinated patient, whereas it was shared by a larger number of unvaccinated and partially vaccinated patients. Other morphological (subacute and chronic) traits did not alter significantly between the groups. Consolidation, on the other hand, was the least prevalent radiological pattern in the fully vaccinated group, whereas it was the most common feature in the unvaccinated group. This is a regular occurrence among severely ill people.

Conclusions

According to this retrospective analysis, patients who completed the vaccination cycle had lower CT severity scores than incompletely vaccinated or unvaccinated patients. The period between vaccination and the onset of clinical symptoms has an impact on pulmonary alterations visible on HRCT of the lungs, with individuals with symptoms two weeks or more after the second dose of vaccine having lower CT severity scores. The key difference is that unvaccinated patients have a medium-severe lung CT score, whereas patients with two doses which have had the last dose by more than four weeks have a 36% of chance of having a medium-severe lung CT score.

Conflict of Interests

The authors declare no conflict of interest.

Authors' Contributions

Conceptualization: G.M.R. and M.L.M.S.S.; methodology: G.M.R.; software: G.M.R, V.N. and G.C.; validation: M.P.B., A.R. and S.C.; formal analysis: MP.B., G.M.R. and V.N.; investigation: E.Z., G.A. and G.M.R.; resources: V.N.; data curation: V.N.; writing original draft preparation: M.P.B. and G.M.R.; writing review and editing: G.M.R.; visualization: M.P.B.; supervision: A.R., F.U. and S.C.; project administration: M.P.B. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Informed Consent

Informed consent was obtained from all subjects involved in the study, according to the guidelines of the SIRM.

Ethics Approval

Given the retrospective nature of this analysis, performed with data collected in an anonymous manner, and in accordance with the current legislation, the need for ethical approval was waived.

References

1) Dhar Chowdhury S, Oommen AM.Epidemiology of COVID-19. J Dig Endosc 2020; 11: 3-7.
2) Popowicz GM, Pyrc K, Hadian K. Vaccination versus SARS-CoV-2 Omicron: three vaccine doses win the battle. Signal Transduct Target Ther 2022; 7: 140.
3) Sakay YN, By the Numbers: COVID-19 Vaccines and Omicron. Healthline; 2022. Available at: https://www.healthline.com/health-news/by-the-numbers-covid-19-vaccines-and-omicron#Johnson-Johnson-vaccine-vs.-Omicron.

4) Andrews N, Stowe J, Kirsebom F, Toffa S, Rickeard T, Gallagher E, Gower C, Kall M, Groves N, O'Connell AM, Simons D, Blomquist PB, Zaidi A, Nash S, Iwani Binti Abdul Aziz N, Thelwall S, Dabrera G, Myers R, Amirthalingam G, Gharbia S, Barrett JC, Elson R, Ladhani SN, Ferguson N, Zambon M, Campbell CNJ, Brown K, Hopkins S, Chand M, Ramsay M, Lopez Bernal J. Covid-19 Vaccine Effectiveness against the Omicron (B.1.1.529) Variant. N Engl J Med 2022; 386: 1532-1546.
5) Yazdi NA, Ghadery AH, Seyedalinaghi SA, Jafari F, Jafari S, Hasannezad M, Koochak HE, Salehi M, Manshadi SA, Meidani M, Hajiabdolbaghi M. Predictors of the chest CT score in COVID-19 patients: a cross-sectional study. Virol J 2021; 18: 1-8.
6) Lee JE, Hwang M, Kim YH, Chung MJ, Sim BH, Chae KJ, Yoo JY, Jeong YJ. Imaging and Clinical Features of COVID-19 Breakthrough Infections: A Multicenter Study. Radiology 2022; 303: 682-692.
7) Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X, Cui J, Xu W, Yang Y, Fayad ZA, Jacobi A, Li K, Li S, Shan H. CT Imaging Features of 2019 Novel Coronavirus (2019-nCoV). Radiology 2020; 295: 202-207.
8) Francone M, Iafrate F, Masci GM, Coco S, Cilia F, Manganaro L, Panebianco V, Andreoli C, Colaiacomo MC, Zingaropoli MA, Ciardi MR, Mastroianni CM, Pugliese F, Alessandri F, Turriziani O, Ricci P, Catalano C. Chest CT score in COVID-19 patients: correlation with disease severity and short-term prognosis. Eur Radiol 2020; 30: 6808-6817.
9) Jiahui C, Rui W, Nancy BG, Guo-WW. Omicron Variant (B.1.1.529): Infectivity, Vaccine Breakthrough, and Antibody Resistance. J Chem Inf Model 2022; 62: 412-422.
10) Yang R, Li X, Liu H, Zhen Y, Zhang X, Xiong Q, Luo Y, Gao C, Zeng W. Chest CT severity score: an imaging tool for assessing severe COVID-19. Radiol Cardiothorac Imaging 2020; 2: e200047.
11) Sun D, Li X, Guo D, Wu L, Chen T, Fang Z, Chen L, Zeng W, Yang R. CT quantitative analysis and its relationship with clinical features for assessing the severity of patients with COVID-19. Korean J Radiol 2020; 21: 859.
12) Palwa AR, Slehria AU, Nayyar B, Aquil H, Riaz S, Nisar U, Malik ZI. Chest CT Severity Score as an Auxiliary Grading Tool to COVID-19. Pneumonia Imaging Classification: A Tertiary Care Experience in Pakistan. J Coll Physicians Surg Pak 2021; 31: 14-20.
13) Borghesi A, Maroldi R. COVID-19 outbreak in Italy: experimental chest X-ray scoring system for quantifying and monitoring disease progression. Radiol Med 2020; 125: 509-513.
14) Feng Z, Yu Q, Yao S, Luo L, Zhou W, Mao X, Li J, Duan J, Yan Z, Yang M, Tan H. Early prediction of disease progression in COVID-19 pneumonia patients with chest CT and clinical characteristics. Nat Commun 2020; 11: 1-9.
15) Pan F, Ye T, Sun P, Gui S, Liang B, Li L, Zheng D, Wang J, Hesketh RL, Yang L, Zheng C. Time course of lung changes on chest CT during recovery from Coronavirus Disease 2019 (COVID-19). Radiology 2020; 295: 715-721.
16) Li K, Wu J, Wu F, Guo D, Chen L, Fang Z, Li C. The clinical and chest CT features associated with severe and critical COVID-19 pneumonia. Invest Radiol 2020; 55: 327-331.
17) Wang X, Hu X, Tan W, Mazzone P, Mireles-Cabodevila E, Han X, Huang P, Hu W, Dweik R, Cheng Z. Multicenter study of temporal changes and prognostic value of a CT visual severity score in hospitalized patients with coronavirus disease (COVID-19). Am J Roentgenol 2021; 217: 83-92.
18) Ding X, Xu J, Zhou J, Long Q. Chest CT findings of COVID-19 pneumonia by duration of symptoms. Eur J Radiol 2020; 127: 109009.
19) Xing K, Tu XY, Liu M, Liang ZW, Chen JN, Li JJ, Jiang LG, Xing FQ, Jiang Y. Efficacy and safety of COVID-19 vaccines: a systematic review. Zhongguo Dang Dai Er Ke Za Zhi. 2021; 23: 221-228.
20) Lu Y, Zhou J, Mo Y, Song S, Wei X, Ding K. Characteristics of chest high resolution computed tomography images of COVID-19: A retrospective study of 46 patients. Pak J Med Sci 2021; 37: 840.
21) Tabatabaei SM, Rajebi H, Moghaddas F, Ghasemiadl M, Talari H. Chest CT in COVID-19 pneumonia: what are the findings in mid-term follow-up? Emerg Radiol 2020; 27: 711-719.
22) Caruso D, Guido G, Zerunian M, Polidori T, Lucertini E, Pucciarelli F, Polici M, Rucci C, Bracci B, Nicolai M, Cremona A. Post-Acute sequelae of COVID-19 pneumonia: six-month Chest CT follow-up. Radiology 2021; 301: E396-E405.
23) 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. Investig Radiol 2020; 55: 412-421.
24) Saeed GA, Gaba W, Shah A, Al Helali AA, Raidullah E, Al Ali AB, Elghazali M, Ahmed DY, Al Kaabi SG, Almazrouei S. Correlation between chest CT severity scores and the clinical parameters of adult patients with COVID-19 pneumonia. Radiol Res Pract 2021; 2021: 6697677.
25) Li K, Wu J, Wu F, Guo D, Chen L, Fang Z, Li C. The clinical and chest CT features associated with severe and critical COVID-19 pneumonia. Invest Radiol 2020; 55: 327-331.
26) Sayeed S, Faiz BY, Aslam S, Masood L, Saeed R. CT Chest Severity Score for COVID 19 Pneumonia: A Quantitative Imaging Tool for Severity Assessment of Disease. J Coll Physicians Surg Pak 2021; 30: 388-392.
27) Liu N, He G, Yang X, Chen J, Wu J, Ma M, Lu W, Li Q, Cheng T, Huang X. Dynamic changes of chest CT follow-up in coronavirus disease-19 (COVID-19) pneumonia: relationship to clinical typing. BMC Med Imaging 2020; 20: 1-8.