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A Discriminant Analysis of the Factors Affecting Abnormalities in Chest Computed Tomographies of 608-Group Patients with COVID-19 Pneumonia

Sitthichok Fangmongkol, M.D.[1], Vachira Posai, M.N.S.[2]

[1]Department of Radiology, Pathum Thani Hospital, Mueang, Pathum Thani 12000, Thailand.

[2]Nursing Division, Ministry of Public Health, Mueang, Nonthaburi 11000, Thailand.

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Abstract:

Objective: To study factor correlation and classification affecting abnormalities in chest computed tomographies (CTs) of 608-group patients with coronavirus disease 2019 (COVID-19) pneumonia.

Material and Methods: We retrospectively collected data of 608-group patients with COVID-19 pneumonia from medical records combined with data from chest CTs which were interpreted by a radiologist for CT abnormalities. The findings were analyzed by descriptive statistics, Fisher's Exact Test and multiple discriminant analysis (MDA) by a stepwise method.

Results: The majority of the 161 patients were female (55.9%), with an average age of 62.90 years (S.D. 16.68) and average weight of 63.07 kg (S.D. 16.18), non-smoking and non-alcohol drinking (71.4% and 61.5%, respectively) and with underlying respiratory diseases (28.6%). The important symptoms brought to a doctor were main symptoms including fever, chills, cough, nasal congestion, sore throat, difficult breathing, shortness of breath (74.5%). The average duration from onset of the symptoms to perform chest CTs was 11.18 days (S.D. 5.42). The abnormalities of CTs chest such as characteristics and locations were periphery (54.7%) with ground-glass opacity (44.7%). The CT severity score was level 2 (24.8%) from 5 levels. MDA revealed there were 5 factors affecting the abnormalities in the chest CTs of 608-group patients with COVID-19 pneumonia. CT severity score, peripheral location, body weight, age and location in the lower lungs. These factors accurately predicted abnormalities in chest CTs (60.2%).

Conclusion: Abnormalities in chest CTs, and factor correlation and classification that affect abnormalities in chest CTs of 608-group patients with COVID-19 pneumonia will benefit the medical and multidisciplinary team in helping to determine treatment method, accurately prognosing severity and reducing mortality.

Keywords: chest computed tomographies, COVID-19 pneumonia, discriminant analysis, 608-group patients

Contact: Vachira Posai, M.N.S.
Nursing Division, Ministry of Public Health, Nonthaburi 11000, Thailand.
E-mail: vachira.nurse1991@gmail.com

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Introduction

From 2020 to 2022, the world faced a major health crisis with coronavirus disease 2019 (COVID-19). During that time, the virus was aggressive resulting in severe pneumonia, especially the elderly. The viral gene mutation causes illnesses in both animals and humans, with greater severity than previous outbreaks, and continues to cause new cases and deaths. The COVID-19 disease affects all ages, particularly children (6 months to 2 years), the elderly, people with disabilities, thalassemia patients, immunocompromised patients and those with chronic diseases, which are the high-risk risk groups for infection and severe symptoms that can lead to death[1,2]. Patients with non-communicable diseases, known as the 608-group, include those with chronic respiratory diseases, cardiovascular diseases, chronic kidney disease, cerebrovascular diseases, cancers, diabetes, obesity with a body mass index (BMI) more than 35 kg/m^2, and pregnant women[3,4].

The COVID-19 disease has rapid progression and causes severe symptoms[5]. Severe cases with respiratory failure require mechanical ventilation and other life supports[6] and have a lower chance of survival, and spend several weeks in the intensive care unit. These patients cannot be weaned from the ventilator, have potentially regressive performance and a higher chance of death[7,8].

Chest computed tomographies (CTs) are currently considered to have great potential for a role in the diagnosis, detection of complications, prognosis and outcomes for COVID-19 patients[9-11]. Studies have reported that CTs found that lesions indicated to be caused by COVID-19 infection occurred with ground-glass opacity at peripheral areas and both lower lobes[12,13]. Chest CTs has been an efficient tool for COVID-19 screening, faster than laboratory tests require more time[14,15]. In addition, many institutions use chest CTs to assess the severity of pneumonia and for follow ups. Therefore, chest CTs is recommended in conjunction with the standard method for diagnosis and evaluation of COVID-19 disease. However, there have been no studies to day about the factors affecting abnormalities in chest CTs of 608-group patients with COVID-19 pneumonia in Thailand.

Therefore, this study was undertaken to examine the factors affecting abnormalities in chest CTs of 608-group patients with COVID-19 pneumonia in order to determine treatment methods and to prognose the severity in the specific circumstances and changes over the time, and as a guideline for further development of the care for COVID-19 patients.

Material and Methods

This study retrospectively collected data from the medical records of patients admitted to a tertiary care hospital combined with data from the hospital Picture Archiving and Communication System (PACS) evaluated by a radiologist who interpreted chest CTs.

Non-contrast scans had to be acquired in volumetric mode, with the scan extending from the thoracic inlet to caudally include the upper abdomen (liver and adrenals). The patients had to be imaged in the supine position in suspended deep inspiration with arms extended overhead to reduce beam hardening artefacts. For routine CECT, the iodine concentration had to be 300-350 mgI/ml. The dose of contrast administered depended on the weight of the patient and the CT scanners in use during the study period allowed 1-1.5 ml/kg for routine CECT. A scan delay of 55-70 seconds was kept following administration of the contrast to allow for optimal enhancement of the soft tissues. The acquired CT images were reconstructed into a soft tissue mediastinal window (50 window level (WL) and 350 window width) and lung window (in sharp algorithm, - 500 WL and 1500 WW in 3.0 mm section thickness) for interpretations.

The study sample was 608-group patients, as defined by over 60 years of age, patients with chronic respiratory diseases, cardiovascular diseases, chronic kidney diseases, or cerebrovascular diseases, who were

obese, had cancer, or diabetes, or were pregnant (GA 12 weeks or greater), who had been diagnosed by a doctor with COVID-19 pneumonia and had been treated in Pathum Thani Hospital from October 1, 2020 to September 30, 2022. The purposive sampling was based on the following criteria: 1) 608-group patients and 2) those who had had a chest CT. The required sample size was calculated using the G* Power program[16,17] with an effect size of 0.15, an alpha level of 0.05, and a 0.8 power value, resulting in a final sample size of 161 patients.

The research tool consisted of 2 sections including 8 questions of the first section and 3 questions of the second section as follows: 1) was demographic and clinical data: sex, age, body weight, smoking history, alcohol history, underlying diseases, important presenting symptoms brought to a doctor, as defined by main and secondary symptoms and duration from onset of the symptoms to perform chest CTs. The main symptoms included fever, chills, cough, nasal congestion, sore throat, difficulty breathing, and shortness of breath. The secondary symptoms were ageusia, anosmia, headache, nausea, vomiting, diarrhea and conjunctival injection. 2) was an assessment of the chest CTs of 608-group patients with COVID-19 pneumonia: evaluation of the location of the lesions, abnormalities in the chest CTs and CT severity scores. From the review of the relevant literature, it was found that the most common location of the lesions in COVID-19 patients were the periphery. In cases where the lesion location was greater than one, the researchers analyzed and recorded the most prominent location of the lesions. The abnormalities in chest CTs consisted of ground-glass opacity (lung appearance translucent, white, like opaque glass but the vessels that run through it can still be seen), consolidation (characteristics of the white lung tissue so the vessels or the bronchioles are not visible), crazy-paving pattern (thickened interlobular septa combined with a ground-glass opacity pattern), thickening of interlobular septum/reticulation (thickened septum between the lobules and either smooth or nodular appearance), vascular engorgement (diameter >3 mm), parenchymal band (a linear opacity, 1-3 mm thick, and less than 5 cm in length, perpendicular to the visceral pleura), honey-combing appearance (an abnormal round shape about 3-10 mm in size surrounded by thick walls clearly visible, and stacked up so they look like a honeycomb), and mixed pattern (abnormalities or lesions in the lungs in which more than 2 abnormal characteristics and those abnormalities could not be clearly distinguished from each other). The CT severity score was calculated by summing the percentages of each of the five lobes that were involved: 1 point <5% involvement, 2 points 5-25% involvement, 3 points 26-49% involvement, 4 points 50-75% involvement, and 5 points >75% involvement. The total CT score was the sum of the individual lobar scores and could range from 0 (no involvement) to 25 (maximum involvement). The researchers developed and modified the assessment form from Nokiani et al.[18]. Our CT severity scores were level 1 (0-5 points), level 2 (6-10 points), level 3 (11-15 points), level 4 (16-20 points) and level 5 (21-25 points). These record forms consisted of a checklist and "filling in the blanks" section. All research tools were examined for content validity by 3 experts with a Content Validity Index (CVI) value of 0.96.

This research was approved by the Human Research Ethics Committee Pathum Thani Hospital, EC-PTH Certification Code A001-66 at November 28, 2022 for a year. All information was kept confidential and not disclosed to others.

All data were analyzed using the Statistical Package for Social Sciences (SPSS) version 26 with frequency, percentage, average, standard deviation (S.D.) and association between clinical data, important presenting symptoms brought to a doctor, duration from onset of the symptoms to perform chest CTs, location of the lesions, abnormalities in the chest CTs and CT severity scores of 608-group patients with COVID-19 pneumonia using Fisher's exact test. The data were also analyzed for factors

affecting abnormalities in the chest CTs of 608-group patients with COVID-19 pneumonia by MDA with a stepwise method.

Results

Demographic data

There was a total of 161 608-group patients with COVID-19 pneumonia, with 55.9% female and an average age of 62.90 years (S.D. 16.68), an average weight of 63.07 kg (S.D. 16.18), and most non-smoking and non-alcohol drinking (71.4% and 61.5%). The percents of patients with chronic respiratory diseases, diabetes, cardiovascular diseases, cerebrovascular diseases, chronic kidney disease, cancer, obesity and pregnancy were 28.6%, 22.4%, 11.8%, 9.3%, 6.2%, 4.4%, 1.9% and 1.2%, respectively.

Clinical data

The important presenting symptoms brought to a doctor were main symptoms of 74.5%, such as fever, chills, cough, nasal congestion, sore throat, difficult breathing, shortness of breath. The duration of time from the first day of onset to the date of chest CTs was an average 11.18 days (S.D. 5.42). The lesions were at the periphery, both lungs, lower lungs, posterior lungs and upper lungs in 54.7%, 28.0%, 8.7%, 5.6% and 3.1% of the patients, respectively. The abnormalities in the chest CTs were ground-glass opacity, thickening of interlobular septa/reticulation, consolidation, crazy paving pattern and mixed pattern in 44.7%, 31.1%, 16.8%, 5.6% and 1.9% of the patients, respectively. The CT severity scores were in level 2, level 1, level 3, level 4 and level 5 in 24.8%, 23.6%, 18.6%, 17.4% and 15.5% of the patients, respectively.

Factors associated with abnormalities in chest CTs

Analysis by Fisher's Exact Test found that age, body weight, smoking history, duration from onset of the symptoms to perform chest CTs and CT severity score were statistically significantly associated with abnormalities in the chest CTs of 608-group patients with COVID-19 pneumonia (p-value<0.05) (χ^2 test=22.861, 37.813, 12.772, 32.143 and 93.802, respectively). However, sex, alcohol drinking history, and important presenting symptoms brought to a doctor were not significantly associated with any abnormalities (p-value>0.05), as shown in Table 1.

Factor classification of abnormalities in chest CTs of 608-group patients with COVID-19 pneumonia

MDA analysis with the stepwise method had the following results:

1. The test of differences between independent variables revealed that there were differences between age, body weight, smoking history, duration of time from the first day onset to the date of chest CTs and CT severity score with statistical significance at the level of 0.05. There were no differences between sex, important presenting symptoms brought to a doctor, and lesions at the periphery, both lungs, posterior lungs, upper lungs and lower lungs.

2. The tests of variance covariance matrix between groups with Box's Test were equal. According to preliminary agreement, the various independent variables were likely to yield a classification equation. The variance covariance matrix between groups was statistically significant at 0.076, which was greater than 0.05.

3. The factor classification that affected abnormalities in the chest CTs of the 608-group patients with COVID-19 pneumonia revealed five variables selected in the classification equation and sorted the significance (consideration of the coefficients) from a higher to lower priority (as shown in Table 2), including CT severity score, peripheral location, body weight, age, and location in the lower lungs, respectively. They were written as a group classification equation, as follows++

Table 1 Factors associated with abnormalities in chest CTs of the study 608-group patients with COVID-19 pneumonia (n=161)

Variable/factor	Frequency (%)	Abnormalities in chest CTs					χ^2	df	p-value
		1	2	3	4	5			
Sex									
Male	71 (44.1)	33 (20.5)	12 (7.5)	1 (0.6)	4 (2.5)	21 (13.0)	0.320	4	0.988
Female	90 (55.9)	39 (24.2)	15 (9.3)	2 (1.2)	5 (3.1)	29 (18.0)			
Age (years)									
15-35	17 (10.6)	12 (7.5)	0(0.0)	0 (0.0)	3 (1.9)	2 (1.2)	22.861	12	0.029*
16-45	10 (6.2)	3 (1.9)	4 (2.5)	0 (0.0)	1 (0.6)	2 (1.2)			
46-60	31 (19.3)	16 (9.9)	6 (3.7)	1(0.6)	2 (1.2)	6 (3.7)			
>60	103 (64.0)	41 (25.5)	17 (10.6)	2(1.2)	3 (1.9)	40 (24.8)			
Body weight (kg)									
<45	26 (16.1)	10 (6.2)	10 (6.2)	1 (0.6)	2 (1.2)	3 (1.9)	37.813	16	0.002*
46-60	47 (29.2)	25 (15.5)	8 (5.0)	0 (0.0)	0 (0.0)	14 (8.7)			
61-75	59 (36.6)	30 (18.6)	7 (4.3)	1 (0.6)	3 (1.9)	18 (11.2)			
76-90	19 (11.8)	7 (4.3)	2 (1.2)	1 (0.6)	2 (1.2)	7 (4.3)			
>90	10 (6.2)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.2)	8 (5.0)			
Smoking history									
Yes	46 (28.6)	30 (18.6)	7 (4.3)	1 (0.6)	1 (0.6)	7 (4.3)	12.772	4	0.013*
No	115 (71.4)	42 (26.1)	20 (12.4)	3 (1.9)	9 (5.6)	50 (31.1)			
Alcohol drinking									
Yes	62 (38.5)	33 (20.5)	12 (7.5)	2 (1.2)	4 (2.5)	11 (6.8)	8.926	4	0.063
No	99 (61.5)	39 (24.2)	15 (9.3)	3 (1.9)	9 (5.6)	50 (31.1)			
Important presenting symptoms brought to a doctor									
Main symptoms	120 (74.5)	49 (30.4)	22 (13.7)	2 (1.2)	8 (5.0)	39 (24.2)	3.670	4	0.453
Secondary symptoms	41 (25.5)	23 (14.3)	5 (3.1)	1 (0.6)	1 (0.6)	11 (6.8)			
Duration from onset of the symptoms to perform chest CTs (days)									
0-4	11 (6.8)	5 (3.1)	3 (1.9)	0 (0.0)	1 (0.6)	2 (1.4)	32.143	12	0.001*
5-8	45 (28.0)	30 (18.6)	10 (6.2)	2 (1.2)	0 (0.0)	3 (1.9)			
9-13	53 (32.9)	15 (9.3)	8 (5.0)	0 (0.0)	4 (2.5)	26 (16.2)			
≥14	52 (32.3)	22 (13.8)	6 (3.7)	1 (0.6)	4 (2.5)	19 (11.8)			
Location of the lesions									
Periphery	88 (54.7)	36 (22.4)	16 (9.9)	1 (0.6)	5 (3.1)	30 (18.6)	21.737	16	0.152
Both lungs	45 (28.0)	19 (11.8	4 (2.5)	2 (1.2)	4 (2.5)	16 (9.9)			
Posterior lungs	9 (5.6)	7 (4.3)	2 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)			
Upper lungs	5 (3.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)			
Lower lungs	14 (8.7)	5 (3.1)	0 (0.0)	0 (0.0)	0 (0.0)	4 (2.5)			
CT severity score (points)									
Level 1 (0-5)	38 (23.6)	34 (21.1)	3 (1.9)	0 (0.0)	0 (0.0)	1 (0.6)	93.802	16	<0.001*
Level 2 (6-10)	40 (24.8)	18 (11.2)	13 (8.1)	1 (0.6)	1 (0.6)	7 (4.3)			
Level 3 (11-15)	30 (18.6)	12 (7.5)	1 (0.6)	1 (0.6)	2 (1.2)	14 (8.7)			
Level 4 (16-20)	28 (17.4)	4 (2.5)	10 (6.2)	1 (0.6)	0 (0.0)	13 (8.1)			
Level 5 (21-25)	25 (15.5)	4 (2.5)	0 (0.0)	0 (0.0)	6 (3.7)	15 (9.5)			

1=Ground-glass opacity, 2=Consolidation, 3=Mixed pattern, 4=Crazy paving pattern, 5=Thickening of interlobular septa/reticulation

*Significance level p-value<0.05, CTs=computed tomographies

The equations in raw score were formed as

$$Y' = -0.646 + 1.198(X_{\text{CT severity score}}) + 1.079(X_{\text{peripheral location}}) + 0.564(X_{\text{body weight}}) + 0.429(X_{\text{age}}) + 0.651(X_{\text{lower lung location}})$$

The equations in standard score were formed as

$$Zy = 0.983(Z_{\text{CT severity score}}) + 0.542(Z_{\text{peripheral location}}) + 0.540(Z_{\text{body Weight}}) + 0.413(Z_{\text{age}}) + 0.184(Z_{\text{lower lung location}})$$

4. According to the classification equation mentioned above, the effectiveness of the correct classification equations revealed it was possible to accurately predict abnormalities in chest CTs of 608-group patients with COVID-19 pneumonia at a level of 60.2%. Ground-glass opacity, consolidation, mixed pattern, crazy paving pattern, and thickening of interlobular septa/reticulation were accurately predicted at rates of 66.7%, 37.0%, 66.7%, 44.4% and 66.0%, respectively, as shown in Table 3.

Table 2 Coefficients and Wilks's lambda values of the factors in the classification equation of abnormalities in chest CTs of the study 608-group patients with COVID-19 pneumonia

Variables in the group classification equation	Coefficient in raw score[u]	Coefficient in standard score	Wilks's lambda	p-value
CT severity score	1.198	0.983	0.657	0.000*
Peripheral location	1.079	0.542	0.587	0.000*
Body weight	0.564	0.540	0.517	0.000*
Age	0.429	0.413	0.467	0.000*
Lower lung location	0.651	0.184	0.449	0.000*
(Constant)	-0.646			

u=unstandardized coefficients, *Significance level p-value<0.05, CTs=computed tomographies

Table 3 Effectiveness of correct classification equations of the abnormalities in chest CTs of the study 608-group patients with COVID-19 pneumonia

	Abnormalities	Forecast groups				
		Ground-glass opacity (%)	Consolidation (%)	Mixed pattern (%)	Crazy paving pattern (%)	Thickening of interlobular septa/reticulation (%)
Real groups	Ground-glass opacity	48 (66.7)	8 (11.1)	6 (8.3)	5 (6.9)	5 (6.9)
	Consolidation	10 (37.0)	10 (37.0)	3 (11.1)	0 (0.0)	4 (14.8)
	Mixed pattern	0 (0.0)	1 (33.3)	2 (66.7)	0 (0.0)	0 (0.0)
	Crazy paving pattern	0 (0.0)	2 (22.2)	1 (11.1)	4 (44.4)	2 (22.2)
	Thickening of interlobular septa/reticulation	2 (4.0)	3 (6.0)	4 (8.0)	8 (16.0)	33 (66.0)

The percentage of correct predictions of the classification equation was 60.2.
CTs=computed tomographies

Discussion

The correlation between the factors and abnormalities in chest CTs of the 608-group patients with COVID-19 pneumonia showed that age, body weight, smoking history, duration from onset of the symptoms to perform chest CTs and CT severity score were statistically significantly associated with abnormalities in the chest CTs of 608-group patients with COVID-19 pneumonia, which is in line with previous studies which found that age, body weight, smoking history, duration from onset of the symptoms to perform chest CTs and CT severity score were independent variables or risk factors that could predict the prognosis or progression of COVID-19[19,20]. Old age, increased body weight, smoking history, greater duration from onset of the symptoms to perform chest CTs and higher CT severity score were associated with abnormalities in chest CTs, and greater severity and mortality rates, as well[21-24].

The factor analysis of abnormalities in chest CTs of 608-group patients with COVID-19 pneumonia consisted of five factors: CT severity score, peripheral location, body weight, age and in the lower lungs. Using these factors, it is possible to accurately predict abnormalities in chest CTs of 608-group patients with COVID-19 pneumonia, about 60.2%, which describes a sequence of factor weighting in the equation, as follows

1. The CT severity score is the highest weight in the classification equation, which is considered the most important factor. This findings was consistent with studies by Islam et al.[25], Yang et al.[26], and S. Zhou et al.[19] which found that the CT severity scores were statistically significantly associated with abnormalities in chest CTs and mortality rates of COVID-19 patients. In addition, it was found that the CT severity score was an important variable that accurately predicted the mortality rate of COVID-19 patients (p-value<0.0001). The likelihood of the greater CT severity score was more severe abnormalities in chest CTs that it was worse prognosis and increased mortality.

2. Peripheral location was the second factor. Studies by Bernheim et al.[27] and Sun et al.[28] found that the major location of lesion was at the periphery of both lungs and more than 1 lobe. Especially in the early stages of the COVID-19 infection, the patient will still have a normal chest CTs, and the abnormalities will begin at the periphery. It is an important location to help and diagnose the differentiation and prognosis of 608-group patients with COVID-19 pneumonia[24].

3. Body weight was the third factor, which indicated that overweight patients have a higher risk of severity and mortality than other groups[24]. These patients rapidly change of the symptoms and have significantly greater lung damage in chest CTs than those with normal body weight. This increases the risk of developing serious COVID-19 and can lead to a three-fold increase in hospitalization rates[29], because of reduction of immune levels and lung capacity. A study showed that increased body weight without correlation with height statistically significantly contributed to mortality, intubation and hospitalization particularly in patients younger than 65 years. In the U.S., another study of more than 900,000 patients hospitalized with COVID-19 found that 30% of overweight patients were[29,30].

4. Age was the fourth factor. Abnormalities in chest CTs among the elderly are different from those of children and younger adults. The elderly CTs showed a lower prevalence of ground-glass opacity compared to younger individuals, but they showed an increase in consolidation and pleural effusion that is considered to indicate a poor prognosis as it results in increased severity and mortality[21]. This is consistent with studies by García-Portilla et al.[22] and Ruksakulpiwat et al.[31] which found that elderly patients had the highest risk of severe infection and death. One study reported that in children, the abnormalities in chest CTs were less common and less severe than in adults[26]. In another study, the abnormalities found in most children were the same as in adults, with the exception of bronchial

wall thickening, which was statistically significantly more common in children than in adults[22].

5. Lesions in the lower lungs were the last factor. According to a relevant review, the location of the abnormalities in chest CTs of COVID-19 patients was often the periphery of both lungs and another location was in the lower lungs. This study found that a location in the lower lungs was secondary to the periphery, in line with studies by Caruso et al.[32] and Chen et al.[33] which found that the location in the lower lungs was found to be secondary. The most common location of abnormalities in chest CTs of COVID-19 patients is the lower lung, which is more common than the upper lungs or right lower lobe. A study by Suwatanapongched et al.[9] reported that ground-glass opacity or consolidation predicted the severity in patients with COVID-19 pneumonia. Similarly, a study by Anusasnee[34] found that the main locations of lesions in COVID-19 patients found by chest CTs were at the periphery and in both lower lungs.

Implications for future research

1. In the study, there were 5 factors that affected abnormalities in chest CTs of 608-group patients with COVID-19 pneumonia: CT severity score, peripheral location, body weight, age and location in the lower lungs, which can be used as a basis for prognosis, planning and selection of a treatment for 608-group patients with COVID-19 pneumonia or other COVID-19 patients, so that knowledge should be provided to relevant multidisciplinary personnel and teams.

2. The factor classification should be studied in other contexts about the abnormalities in chest CTs of COVID-19 patients in order to create a more effective classification equation.

3. The results of this study should be used to further develop healthcare systems and research into quality of the care of COVID-19 patients, comprehensive and responsive to all dimensions.

4. Studies should be conducted in other groups of patients other than 608-group patients with COVID-19 pneumonia, age range, data sources or samples, and a larger number of participants. The information obtained for further analysis will lead to more efficient and comprehensive care for COVID-19 patients.

Limitations

Data of this study may be similar or non-different because they are in a single hospital.

To minimize bias, we recommend that at least two radiologists should evaluate the imaging either by consensus or by evaluating interobserver agreement. Additionally, the radiologists should interpret the imaging blindly from the clinical data.

Conclusion

This study found that abnormalities in chest CTs, factor correlation and factors that affected abnormalities in chest CTs of 608-group patients with COVID-19 pneumonia, which will benefit the related medical and multidisciplinary teams to use as a basis for determining treatment methods and can accurately predict the severity of COVID-19 pneumonia. It also provides a basis for the development of healthcare services and research to manage the care for 608-group patients with COVID-19 pneumonia.

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