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ORIGINAL ARTICLE

Diagnostic Accuracy of CT-Scan Chest in Distinguishing Ground-Glass Opacities from Covid-19 Causes and Other Causes of Ground-Glass Opacities

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ABSTRACT

Introduction: Evaluation of the effectiveness of diagnostic computed tomography of the chest in differentiating between coronavirus 2019 (COVID-19) ground glass opacities and other reasons of ground glass opacities (GGO) not related to COVID-19.

Place and Duration: In the department of Radiology, Miangul Abdul Haq Jahenzeb Kidney Hospital Swat for six-months duration from March 2021 to August 2021.

Methods: 90 total covid-19 confirmed patients by RT-PCR having GGO (53 males and 37 females, with 47.20 ± 15.10 years mean age) and 110 patients (63 males and 47 males) who were confirmed GGO on chest CT but not due to Covid-19 were selected for the study. The experienced radiologists studied all chest CT scans after removing all descriptive information from the images. They tested negative or positive for COVID-19 and noted other features of CT of the lungs, including laterality, distribution pattern and lobe involvement. The laboratory results and clinical data were documented.

Results: This study consisted of 90 COVID19 patients and 100 non-COVID-19 with ground glass opacities on CT chest. In terms of age; no statistically significant alteration was noted amid the 2 groups (p-value = 0.129). Non-COVID-19 cases with GGO; 6 patients have atypical bacterial pneumonia, 42 patients have GGO after viral pneumonia, 14 patients have interstitial pneumonia, 5 patients have PJP, eosinophilic pneumonia in 3 patients, 9 patients have hypersensitivity pneumonia, 6 patients have drug-induced lung injury, 5 patients have pulmonary alveolar hemorrhage and pulmonary edema in 11 patients (cardiogenic and noncardiogenic).

Conclusion: Chest CT is rational for distinguishing ground glass opacities form COVID-19 and non-COVID-19 reasons, with less specificity for distinguishing COVID-19 from viral pneumonia and intermediate specificity for distinguishing COVID-19 from other reasons of ground glass opacities.

Keywords: SARS-COV2, COVID-19, Diagnosis, Computed tomography and ground glass opacities.

INTRODUCTION

The outbreak of covid-19 has been recorded in a total of > 1.5 billion positive cases and above six-lac deaths in 214 countries and regions affected as stated by the World Health Organization in July 2020[1-2]. Although it started in China, the United States has recorded > 50 percent of these cases with covid-19[3-4]. COVID-19 affected subjects experience cough, fever, muscle aches and shortness of breath. The PCR is gold standard in detection by nasopharyngeal or oropharyngeal swabs, tracheal aspiration or bronchoalveolar lavage[5]. Recently, RT-PCR test showed a relatively less sensitivity of 65-75% for the detection of COVID-19. This can be clarified by the laboratory error or lower viral load. Chest CT, on the other hand, showed a sensitivity of about 56 to 98% in the diagnosis of COVID-19 in the initial disease stages[6-7]. However, as reported in recent studies, CT chest displays less specificity (23%) in the analysis of COVID-19. Typical chest CT scan results are characteristic of COVID-19 pneumonia are crazy-paving patterns, GGO and consolidation. Traction bronchiectasis and Vascular dilatation are also common symptoms in GGO, which have been identified in COVID-19 patients. In few patients, at the disease peak, architectural deterioration has been reported with the formation of subpleural bands[8-9]. Indeterminate COVID-19 features comprise diffuse, multifocal, unilateral or perihilar GGO with or deprived of consolidation, non-rounded GGO and nonspecific distribution[10]. Other common symptoms of infection are the bronchial wall thickening, centrilobular nodules (tree in bud), mucosal obstruction while pleural effusion and lymphadenopathy are rare[11].

The chest CT low specificity can be accredited to the existence of extensive variety of lung diseases that can hide the COVID-19 appearance on computed tomography, particularly those related with ground glass opacities[12-13]. The most common reasons of ground glass opacities, which may resemble Covid-19, are bacterial pneumonia, viral pneumonia, interstitial pneumonia, pneumocystis jiroveci pneumoniae (PJP), eosinophilic pneumonia, allergic pneumonia, drug-induced lung injury, diffuse alveolar injury, and diffuse alveolar and pulmonary edema (Cardiac and non-cardiac)[14]. So, the aim of this analysis was to evaluate the diagnostic accuracy of chest CT scan to differentiate between COVID-19 and other reasons of ground glass opacities.

MATERIALS AND METHODS

This retrospective study was conducted in the Department of Radiology, Miangul Abdul Haq Jahenzeb Kidney Hospital Swat for six-months duration from March 2021 to August 2021. 200 patients who endured non-contrast chest computed tomography during the study period were participated. 90 total covid-19 confirmed patients by RT-PCR having GGO (53 males and 37 females, with 47.20 ± 15.10 years mean age) and 110 patients (63 males and 47 males) who were confirmed GGO on chest CT but not due to Covid-19 were selected for the study. Patients' clinical information was taken from the medical record. One of the authors reviewed radiological, bronchoscopic and pathological reports to identify the pathological causes of the second group. The patients were included confirmed by bronchoalveolar lavage, PCR, sputum culture, blood test, or with appropriate post-treatment follow-up. Spiral computed tomography with a thickness of 1 mm was performed in all patients in one breath from the base of the neck to the upper pole of the kidney. Images were assembled in coronal, sagittal and axial formats with a standard pulmonary filter.

Consensus attributed chest CT results to COVID-19 in 4 classes: (i) typical COVID-19 with peripheral, bilateral and multifocal ground glass opacity of rounded structure with and deprived of consolidation, non-rounded GGO and nonspecific distribution (ii) COVID-19 with atypical features on CT chest like segmental or lobar consolidation deprived of GGO, smooth interlobular septal thickening, pulmonary cavitation, pulmonary nodules ("tree in-bud" or centrilobular), pleural effusion and lymphadenopathy. (iii) indeterminate COVID-19 that demonstrates as diffuse, multifocal, unilateral or perihilar GGO with or lacking consolidation, non-rounded GGO or nonspecific distribution and (IV) is negative for pneumonia. In addition, they were asked to evaluate for the presence of unusual COVID-19 features, such as pulmonary as well as other COVID-19-related CT findings, such as consolidations, vascular dilatation, subpleural bands, crazy-paving and reverse halo sign, also atypical COVID-19 features like mediastinal lymphadenopathy, pulmonary nodules (tree-in-bud or centrilobular), pleural effusion and mediastinal lymphadenopathy associated with lateralization, lobe involvement (up or down), and pattern of distribution (central, diffuse or peripheral).

Continuous variables are articulated as ranges and mean and variables which are categorical are stated as percentages and numbers. To assess the analytic performance of radiologists, criteria such as specificity, sensitivity, NPV, PPV and accurateness were evaluated. COVID-19 was measured positive result finding, while pneumonia was another cause and was not considered negative. 95% binomial confidence intervals for specificity, sensitivity, NPV, PPV and accuracy were calculated using the SPSS 20. P <0.05 value taken as statistically significant.

RESULTS

This study consisted of 90 COVID19 patients and 100 non-COVID-19 with ground glass opacities on CT chest. In terms of age; no statistically significant alteration was noted amid the 2 groups (p-value = 0.129).

Non-COVID-19 cases with GGO; 6 patients have atypical bacterial pneumonia, 42 patients have GGO after viral pneumonia, 14 patients have interstitial pneumonia, 5 patients have PJP, eosinophilic pneumonia in 3 patients, 9 patients have hypersensitivity pneumonia, 6 patients have drug-induced lung injury, 5 patients have pulmonary alveolar hemorrhage and pulmonary edema in 11 patients (cardiogenic and noncardiogenic). Table 1 displays the cause, various bacterial and viral pathogens, and ground glass opacities types of interstitial pneumonia other than COVID-19.

Table 1: Causes of ground-glass opacities in studied population

Non-COVID-19	90
Viral pneumonia	42
Influenza A (H1N1)	16
SARS	5
MERS	3
RSV	2
HSV	5
Adenovirus	3
Rhinovirus	7
Atypical bacterial pneumonias	6
Mycoplasma	5
Chlamydia	2
Klebsiella	2
PJP	5
Interstitial pneumonias	14
NSIP	7
DIP	4
COP	5
HP	9
EP	3
DAH	5
Drug-induced lung injury	6
Pulmonary edema (cardiogenic and non-cardiogenic)	11

Compared with patients without corona, COVID-19 patients had high fever (76.7% vs. 51.8%), p <0.001) and GIT symptoms such as nausea, vomiting and diarrhea (13.3% vs 2.7%), P < 0.001). There was no substantial difference in symptoms of respiratory system (shortness of breath and cough) amid the two groups (p = 0.29). Lymphopenia was much communal in patients with COVID-19 (55% vs. 22%, p <0.001), leucocytosis was much communal in patients without COVID-19 (44.4% vs. 18.2%, p <0.001).

COVID-19 patients had subpleural bands (22.2% vs. 12.7%, p = 0.05), isolated GGO (21.1% vs. 14.5%, p = 0.042), thickening of the vascular bed (27.8% vs. 13.6%, p = 0.012) and reverse halo sign (11.1% vs. 3.6%, p = 0.004), but less probable have traction bronchiectasis (11.1 vs. 32.7%, p = 0.006), lymphadenopathy (0% vs. 13.6%, p < 0.001) and pleural effusion (6.7 vs. 26.4%, p < 0.001). Compared with patients without COVID-19, patients with COVID-19 have the lower lobes lesions (85.6% vs. 54.5%, p = 0.004) and in the peripheral distribution (74.4% vs. 48.2%, p <0.001). There was no substantial difference between the crazy paving pattern, consolidation and lateral pattern in both groups. Demographic, laboratory, imaging and clinical information of patients in both groups are presented in Table 2.

Table 2: Patients' clinical characteristics, demographics, imaging features and laboratory data of both groups

	COVID-19 (n = 90)	Non-COVID-19 (n = 110)	P value
Age	47.20 ± 15.10	49.01 ± 19.10	0.129
Sex Male	53 (58.9%)	63 (57.8%)	0.11
Female	37 (41.1%)	47 (42.7%)	0.097
Clinical data Fever	69 (76.7%)	57 (51.8%)	< 0.001
Cough and dyspnea	60 (66.7%)	78 (70.9%)	0.29
GIT manifestations	12 (13.3%)	3 (2.7%)	< 0.001
Laboratory findings Leukocytosis	15 (16.7%)	60 (54.5%)	< 0.001
Lymphopenia	40 (44.4%)	20 (18.2%)	< 0.001
CT features Isolated GGO	19 (21.1%)	16 (14.5%)	0.042
Consolidation	51 (56.7%)	76 (69.1%)	0.27
Crazy-paving	18 (20%)	25 (22.7%)	0.37
Reversed halo	10 (11.1%)	4 (3.6%)	0.004
Subpleural bands	20 (22.2%)	14 (12.7%)	0.05
Vascular thickening	25 (27.8%)	15 (13.6%)	0.012
Traction bronchiectasis	10 (11.1%)	36 (32.7%)	0.006
Pulmonary nodules	14 (15.6%)	40 (36.4%)	< 0.001
Lymphadenopathy	0 (0%)	15 (13.6%)	< 0.001
Pleural effusion	6 (6.7%)	29 (26.4%)	< 0.001
Laterality Unilateral	15 (16.7%)	26 (23.6%)	0.31
Bilateral	75 (83.3%)	84 (76.4%)	0.28
Lobar affection Upper	38 (42.2%)	50 (45.5%)	0.040
Lower	77 (85.6%)	60 (54.5%)	0.004
Distribution Peripheral	67 (74.4%)	53 (48.2%)	< 0.001
Central	9 (10%)	14 (12.7%)	< 0.001
Diffuse	14 (15.6%)	43 (39.1%)	< 0.001

DISCUSSION

The abrupt onset of the new coronavirus (COVID-19) in late 2019 posed grave public healthiness apprehensions because of the fast human-to-human transmission that could lead to deadly ARDS. The RT-PCR was the 1st typical diagnostic technique using a throat swab, which has specificity (60-70%) but a high sensitivity for the detection of viral RNA, which leads to several false-negative results that need to be tested[12-13]. The chest HRCT has been proposed as an additional diagnostic method that enables rapid diagnosis of the disease and helps to quarantine suspected COVID-19 cases and contact them. In our analysis, chest CT showed rational sensitivity from 76.25% to 90% in distinguishing COVID-19 GGO form non-COVID-19, with analytical results from 60% to 75%. However, due to the resemblance among the radiographic image of viral infections and COVID-19 pneumonia, CT has low to moderate specificity and ranged from 46% to 68%. Bai et al encompassed 425 CT scans of the chest from the United States and China and related the analytical accurateness of two dissimilar radiology teams from both countries[14-15]. Artificial intelligence technology demonstrates that the AI system assists radiologists with moderate analytical accurateness (85% vs. 90%, p <0.001)[16].

Chest findings has not been previously reported. Other viruses of the respiratory system, such as the influenza virus, display lower prevalence of round GGO and nodular density, interstitial thickening with additional widespread GGO, tree-like appearance in buds, and pleural effusion[17-18]. GGO is realized in additional coronavirus diseases, counting severe unifocal lung involvement, ARDS and syndromes such as air bronchogram pattern, pulmonary consolidation, and thickening of the pulmonary septum without pulmonary nodules and reverse halo sign[19-20].

In the final stages of viral infections like CMV, HPV and HIV, integration with pleural effusion results in irregular, multifocal, widespread GGO and ARDS, especially in the elderly, after organ transplantation, and in immunocompromised patients[21-22]. Other reasons of ground glass opacities include a heterogeneous diseases group that are less similar to COVID-19. Unlike COVID-19, bacterial pneumonia causes partial opacity in the lungs without specific site dominance. Most interstitial pneumonia, unlike the acute manifestations of COVID-19, has an insidious onset[23-24]. Nonspecific interstitial pneumonia (NSIP) is often prone to disorders of the connective tissues and is accessible by CT scan with basal peripheral vascular fibrosis, traction bronchiectasis, and honeycomb architectural distortion. In the history of drug-induced lung injury, certain drugs (especially chemotherapeutic agents) have been used, and diffuse manifestations without distinct location or imaging features are distinct[25]. Pulmonary edema is a comprehensive term that describes fluid accumulation in the spaces of extravascular systems of the lungs due to overload of volume caused by heart or non-heart disease. Radiological observations of GGO are performed in the area of the hilum, interstitial thickening, and pleural effusion. Hypersensitivity pneumonia is caused by prolonged inhalation of an external allergen that enhances the immune response of the lungs at various stages[26].

In acute stage there is a bilateral non-uniform pattern of GGO, in the stage with subacute disease, there is GGO with internal nodules and mosaic pattern, and in the chronic stage there is a fibrosis seen bilaterally[27]. Much research has been focused on the diagnosis of fever, as this is one of the first and foremost symptoms that may be associated with the progression and severity of lung involvement in COVID-19 infection as well as the adverse outcomes of the disease. This can be explained by the fact that although GITl symptoms (including nausea, vomiting and diarrhea) were lower in both groups, they were higher statistically in the COVID-19 group than in the non-Covid-19 group (p <0.001). The new coronavirus has the exceptional capability to bind to ACE-II receptors that are distributed throughout the gastric mucosa and then cause nonspecific gastroenteritis with electrolyte disturbances[28]. In the present study, one of the most significant differences between the two groups was lymphopenia (44.4%) in COVID-19 patients, which was statistically much communal than the other group (p <0.001).

CONCLUSION

In this study, chest CT showed low specificity for the detection of COVID-19 from other viral pneumonias and moderate specificity for the detection of COVID-19 GGO from other GGO causes provided a reasonable diagnosis. Thus, accurate radiological evaluations, laboratory data and accurate clinical scenarios can aid to achieve a precise diagnosis and decrease the numeral of false positives, particularly during an epidemic.

REFERENCES

1. Parekh M, Donuru A, Balasubramanya R, Kapur S. Review of the chest CT differential diagnosis of ground-glass opacities in the COVID era. Radiology. 2020 Dec;297(3):E289-302.
2. Elmokadem AH, Bayoumi D, Abo-Hedibah SA, El-Morsy A. Diagnostic performance of chest CT in differentiating COVID-19 from other causes of ground-glass opacities. Egyptian Journal of Radiology and Nuclear Medicine. 2021 Dec;52(1):1-0.
3. Xie C, Ng MY, Ding J, Leung ST, Lo CS, Wong HY, Vardhanabhuti V. Discrimination of pulmonary ground-glass opacity changes in COVID-19 and non-COVID-19 patients using CT radiomics analysis. European journal of radiology open. 2020 Jan 1;7:100271.
4. Cozzi D, Cavigli E, Moroni C, Smorchkova O, Zantonelli G, Pradella S, Miele V. Ground-glass opacity (GGO): A review of the differential diagnosis in the era of COVID-19. Japanese journal of radiology. 2021 Aug;39(8):721-32.
5. Delli Pizzi A, Chiarelli AM, Chiacchiaretta P, Valdesi C, Croce P, Mastrodicasa D, Villani M, Trebeschi S, Serafini FL, Rosa C, Cocco G. Radiomics-based machine learning differentiates “ground-glass” opacities due to COVID-19 from acute non-COVID-19 lung disease. Scientific Reports. 2021 Aug 26;11(1):1-9.
6. Himoto Y, Sakata A, Kirita M, Hiroi T, Kobayashi KI, Kubo K, Kim H, Nishimoto A, Maeda C, Kawamura A, Komiya N. Diagnostic performance of chest CT to differentiate COVID-19 pneumonia in non-high-epidemic area in Japan. Japanese journal of radiology. 2020 May;38(5):400-6.
7. Bai HX, Hsieh B, Xiong Z, Halsey K, Choi JW, Tran TM, Pan I, Shi LB, Wang DC, Mei J, Jiang XL. Performance of radiologists in differentiating COVID-19 from non-COVID-19 viral pneumonia at chest CT. Radiology. 2020 Aug;296(2):E46-54.
8. Liu M, Zeng W, Wen Y, Zheng Y, Lv F, Xiao K. COVID-19 pneumonia: CT findings of 122 patients and differentiation from influenza pneumonia. European radiology. 2020 Oct;30(10):5463-9.
9. Chen D, Jiang X, Hong Y, Wen Z, Wei S, Peng G, Wei X. Can chest CT features distinguish patients with negative from those with positive initial RT-PCR results for coronavirus disease (COVID-19). AJR Am J Roentgenol. 2020 May 5;5:1-5.
10. Raptis CA, Hammer MM, Short RG, Shah A, Bhalla S, Bierhals AJ, Filev PD, Hope MD, Jeudy J, Kligerman SJ, Henry TS. Chest CT and coronavirus disease (COVID-19): a critical review of the literature to date. AJR Am J Roentgenol. 2020 Apr 16;215(4):839-42.
11. Wang H, Wei R, Rao G, Zhu J, Song B. Characteristic CT findings distinguishing 2019 novel coronavirus disease (COVID-19) from influenza pneumonia. European radiology. 2020 Sep;30(9):4910-7.
12. Wu Z, Liu X, Liu J, Zhu F, Liu Y, Liu Y, Peng H. Correlation between ground-glass opacity on pulmonary CT and the levels of inflammatory cytokines in patients with moderate-to-severe COVID-19 pneumonia. International journal of medical sciences. 2021;18(11):2394.
13. Abbasian Ardakani A, Acharya UR, Habibollahi S, Mohammadi A. COVIDiag: a clinical CAD system to diagnose COVID-19 pneumonia based on CT findings. European radiology. 2021 Jan;31(1):121-30.
14. Müller C, Müller NL. Chest CT target sign in a couple with COVID-19 pneumonia. Radiologia Brasileira. 2020 Aug 14;53:252-4.
15. Chrzan R, Bociąga-Jasik M, Bryll A, Grochowska A, Popiela T. Differences among COVID-19, bronchopneumonia and atypical pneumonia in chest high resolution computed tomography assessed by artificial intelligence technology. Journal of Personalized Medicine. 2021 May;11(5):391.
16. Jafari R, Maghsoudi H, Saburi A. A unique feature of COVID-19 infection in chest CT;“pulmonary target” appearance. Academic Radiology. 2021 Jan;28(1):146.
17. Li Y, Wang H, Wang F, Du H, Liu X, Chen P, Wang Y, Lu X. Comparison of hospitalized patients with pneumonia caused by COVID-19 and influenza A in children under 5 years. International Journal of Infectious Diseases. 2020 Sep 1;98:80-3.
18. Li Z, Zeng B, Lei P, Liu J, Fan B, Shen Q, Pang P, Xu R. Differentiating pneumonia with and without COVID-19 using chest CT images: from qualitative to quantitative. Journal of X-ray Science and Technology. 2020 Jan 1;28(4):583-9.
19. Zhang YJ, Yang WJ, Liu D, Cao YQ, Zheng YY, Han YC, Jin RS, Han Y, Wang XY, Pan AS, Dai JY. COVID-19 and early-stage lung cancer both featuring ground-glass opacities: a propensity score-matched study. Translational Lung Cancer Research. 2020 Aug;9(4):1516.
20. Altmayer S, Zanon M, Pacini GS, Watte G, Barros MC, Mohammed TL, Verma N, Marchiori E, Hochhegger B. Comparison of the computed tomography findings in COVID-19 and other viral pneumonia in immunocompetent adults: a systematic review and meta-analysis. European radiology. 2020 Dec;30(12):6485-96.
21. Sharma S. Drawing insights from COVID-19-infected patients using CT scan images and machine learning techniques: a study on 200 patients. Environmental Science and Pollution Research. 2020 Oct;27(29):37155-63.

22. Rouhezamin MR, Paydar S, Haseli S. COVID-19 or pulmonary contusion? A diagnostic dilemma. Academic Radiology. 2020 Jun;27(6):894.
23. 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 May;10(5):1058.
24. Ardakani AA, Kanafi AR, Acharya UR, Khadem N, Mohammadi A. Application of deep learning technique to manage COVID-19 in routine clinical practice using CT images: Results of 10 convolutional neural networks. Computers in biology and medicine. 2020 Jun 1;121:103795.
25. Xia W, Shao J, Guo Y, Peng X, Li Z, Hu D. Clinical and CT features in pediatric patients with COVID-19 infection: different points from adults. Pediatric pulmonology. 2020 May;55(5):1169-74.
26. Eslambolchi A, Maliglig A, Gupta A, Gholamrezanezhad A. COVID-19 or non-COVID viral pneumonia: How to differentiate based on the radiologic findings?. World Journal of Radiology. 2020 Dec 28;12(12):289.
27. Li X, Zeng W, Li X, Chen H, Shi L, Li X, Xiang H, Cao Y, Chen H, Liu C, Wang J. CT imaging changes of corona virus disease 2019 (COVID-19): a multi-center study in Southwest China. Journal of translational medicine. 2020 Dec;18(1):1-8.
28. Cui N, Zou X, Xu L. Preliminary CT findings of coronavirus disease 2019 (COVID-19). Clinical imaging. 2020 Sep 1;65:124-32.