

Review Article

Common imaging patterns of COVID-19 on spiral chest CT scan: a diagnostic approach for pulmonary involvement in ICU patients

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Abstract

Coronavirus disease 2019 (COVID-19) is a newly emerged pandemic with great worldwide challenges. Radiologic features are one of the most important aspects of the disease, both for screening, diagnosis, treatment assessment and follow-up. Here we review the radiologic aspects of COVID-19 with special focus on critical care patients.

Keywords: COVID-19, Coronavirus; Radiologic features

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Introduction

The new respiratory infection by 2019 novel coronavirus which is now known as coronavirus disease 2019 (COVID-19), was detected first in late December 2019 in Wuhan, China. Because of its great contagiousity, it spread rapidly and was announced as a pandemic by world health organization (WHO) (1-3). Due to a number of reasons, imaging is one of the first diagnostic tools in most places for COVID-19: lack of full access to diagnostic kits, false negative probability of molecular kits especially in early stages of the disease and typical imaging patterns especially on chest spiral CT scan for COVID-19 (4-6).

In this review, we would summarize the most common lung imaging patterns in COVID-19 patients admitted in intensive care unit (ICU). Before describing the imaging patterns, it is worth to point that these patterns in lungs can be single or multiple, unilateral or bilateral, peripheral or central, with or without involvement of peribronchovascular regions and may involve any region of lungs but it has predilection for peripheral regions, lower and posterior

zones (4-6). Since spiral chest CT scan is more accurate than chest X ray (CXR) for COVID-19 related imaging patterns, the CT patterns are described first (4, 5, 7). The study proposal was assessed and approved by Research Ethics Committee, Shahid Beheshti University of Medical Sciences, Tehran, Iran; coded: IR.SBMU.RETECH.REC.1399.022.

Computed Axial Tomography (CT) scanning

The most common features in CT scanning in COVID-19 are the following, which are discussed in detail in the next paragraphs:

- 1- Patchy ground glass opacities
- 2- Patchy ground glass opacities or consolidations with vacuolar sign
- 3- Ground glass opacities associated with interlobular septal thickening (crazy paving appearance)
- 4- Patchy consolidations
- 5- Patchy consolidations with air-bronchogram in them
- 6- Patchy consolidations with surrounding ground glass halo
- 7- Fibrotic streaks and strip like opacities mostly in



Figure 1. Single faint ground glass opacity in posterior basal segment of the right lower lobe in COVID-19



Figure 2. Multiple bilateral patchy ground glass infiltration in COVID-19

peripheral parts.

1. Patchy ground glass opacities (Figure 1-3)

Figure 1 demonstrates a 32 years old COVID-19 patient presenting with two days of fever. On low dose spiral chest CT scan shows single faint ground glass opacity in posterior basal segment of RLL (red box).

Figure 2 shows a 51 years old COVID-19 patient presenting with a week of fever and cough. Low dose spiral chest CT scan shows multiple bilateral patchy areas of ground glass infiltration.

Figure 3 demonstrates a 32 years old COVID-19 patient with a week of fever. Low dose spiral chest CT scan shows single patch of ground glass infiltration in lateral aspect of RUL (red box).

2. Patchy ground glass opacities or consolidations with vacuolar sign (Figure 4) demonstrates a 29 years old COVID-19 patient presenting with fever and chills. On low dose spiral chest CT scan shows patchy areas of ground glass infiltration and consolidations with small round hypodense foci in these infiltrated regions indicative of vacuolar sign (red box).

3. Ground glass opacities associated with interlobular septal thickening (crazy paving appearance) (Figure 5)

Figure 5 demonstrates a COVID-19 patient presented with respiratory distress. On low dose

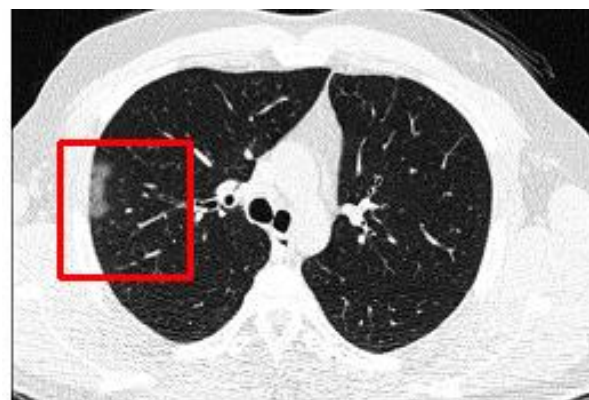


Figure 3. Single ground glass infiltration in the lateral aspect of right upper lobe in COVID-19

spiral chest CT scan shows, diffuse bilateral ground glass infiltration and interlobular septal thickening indicative of crazy paving appearance.

4. Patchy consolidations (Figures 6 &7)

Figure 6 demonstrates a 38 years old COVID-19 patient presented with 3 days of fever. On low dose spiral chest CT scan shows peripheral patchy areas of consolidation (red box).

Figure 7 demonstrates a 36 years old COVID-19 patient presented with 7 days fever and then 6 days of dry cough. On low dose spiral chest CT scan shows patchy areas of consolidation may be due to evolving of ground glass infiltrations to peripheral consolidations (organizing pneumonia) (red box).

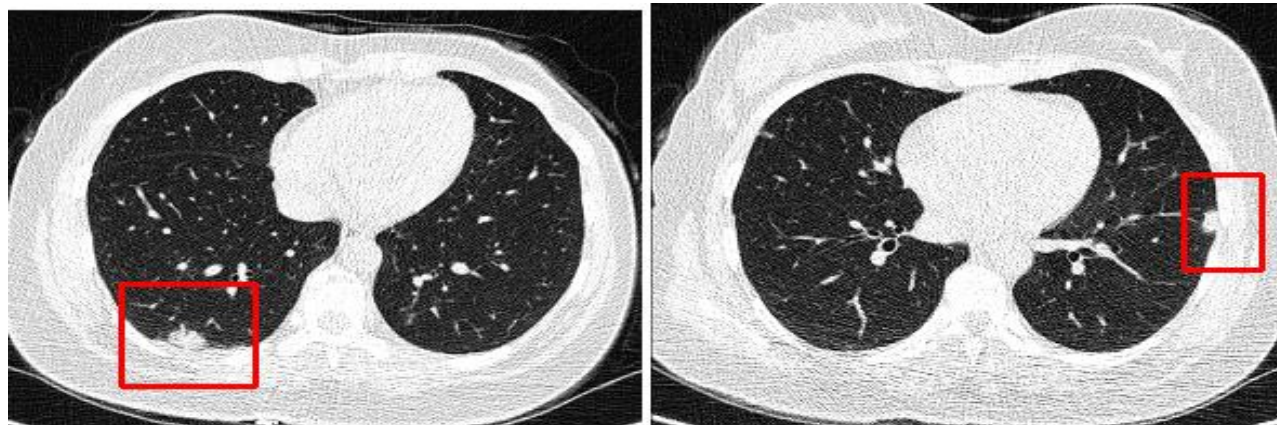


Figure 6. Peripheral patchy areas of consolidation (red box) in COVID-19

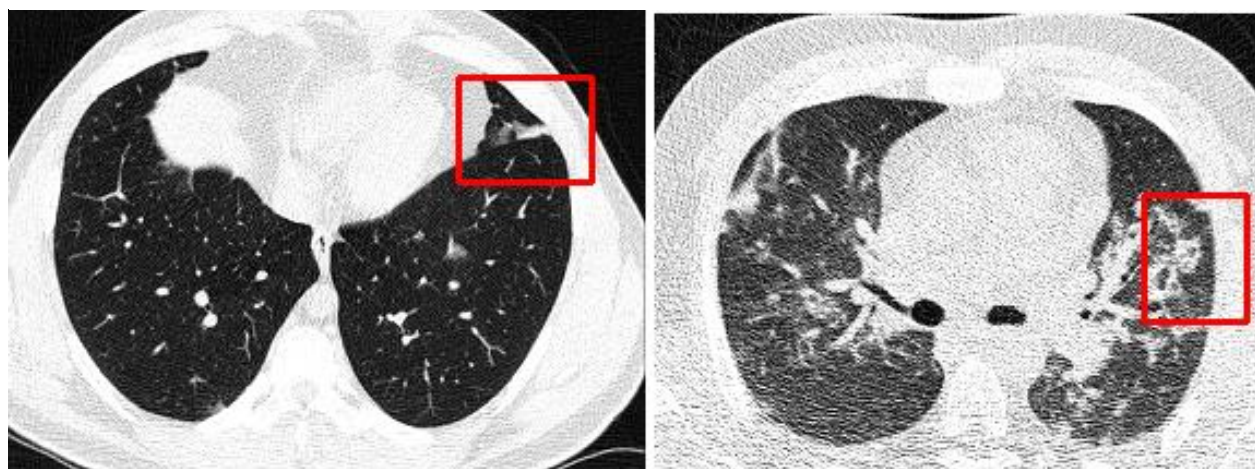


Figure 4. Vacuolar sign in COVID-19 (red box)

5. Patchy consolidations with air-bronchogram in them (Figure 8)

Figure 8 demonstrates a 50 years old COVID-19 patient with 5 days of fever. On low dose spiral chest

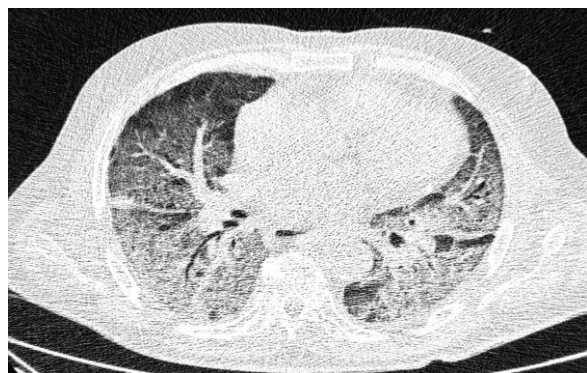


Figure 5. crazy paving appearance in COVID-19:

CT scan shows patchy areas of consolidation with air-bronchogram (red box).

6. Patchy consolidations with surrounding ground glass halo (Figure 9)

Figure 9. demonstrates a 35 years old COVID-19 patient with 5 days of fever. On low dose spiral chest CT scan shows two patch of consolidation with surrounding ground glass halo in RML and RLL (red box).

7. Fibrotic streaks and strip like opacities mostly in peripheral parts (Figure 10)

Figure 10 demonstrates a 45 years old COVID-19 patient with 10 days of fever who now has dry cough and shortness of breathing. On low dose spiral chest CT scan shows strip like opacity in lateral aspect of right lung (red box).

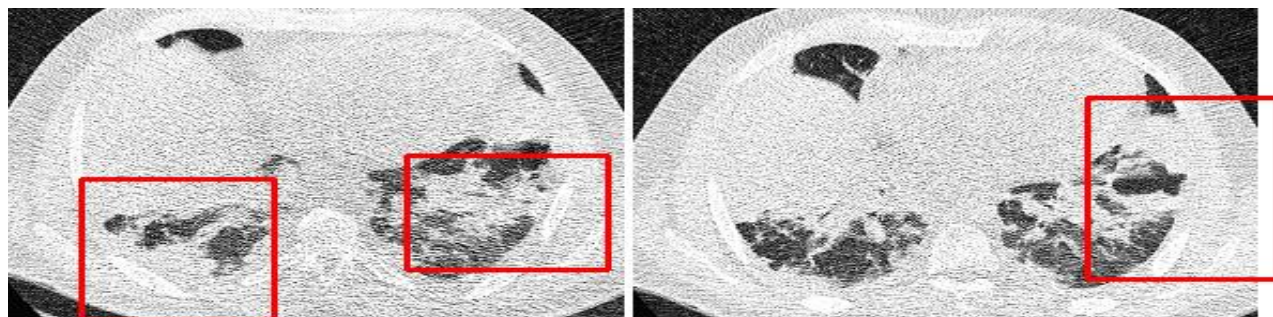


Figure 7. Evolving ground glass infiltrations to peripheral consolidations (organizing pneumonia; red box) in COVID-19

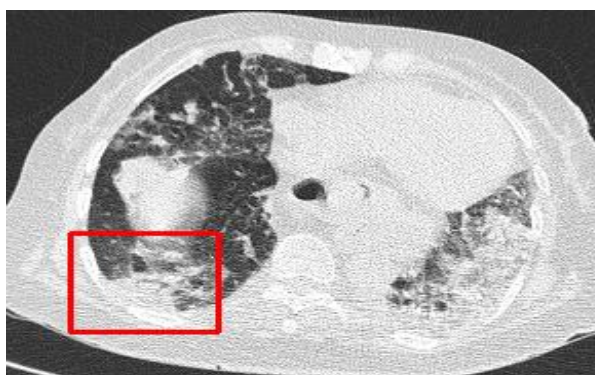


Figure 8. Patchy areas of consolidation with air-bronchogram (red box) in COVID-19

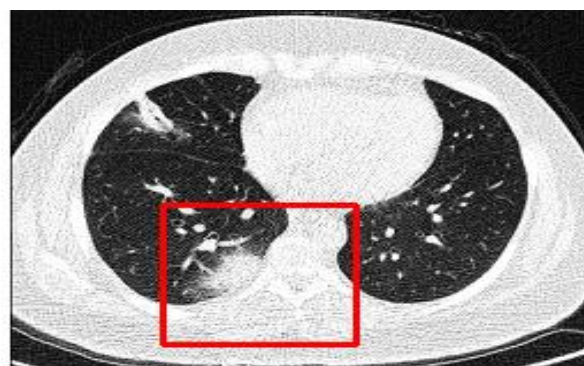


Figure 9. Consolidation with surrounding ground glass halo in COVID-19

Most of the patients who need ICU care, show diffuse, bilateral and extensive lung involvement with ground glass infiltration or consolidation. The pattern which is indicative of ARDS (1).

Figure 11 demonstrates a 36 years old COVID-19 patient presenting with fever, malaise, dry cough and respiratory distress, who admitted to ICU. (A) Chest radiography shows diffuse ground glass appearance in lower zones. (B) Low dose spiral chest CT shows areas of diffuse ground glass infiltration associated with areas of crazy paving appearance (red box). (C) Low dose spiral chest CT shows areas of consolidation in lower part of lower lobes with airbronchogram (red box).

Figure 12 demonstrates a 50 years old COVID-19 patient with past history of heart failure presenting fever and respiratory distress, who admitted to ICU. Low dose chest CT shows cardiomegaly, bilateral moderate pleural effusion (possibly in the basis of heart failure) and patchy areas of ground glass infiltration (red box).

Figure 13 demonstrates a 66 years old COVID-19 patient presenting fever, dry cough and



Figure 10. Strip like opacity in the right lung in COVID-19

respiratory distress, who admitted to ICU. On chest radiography showed diffuse patchy areas of ground glass infiltration and consolidations

Figure 14 demonstrates a 67 years old COVID-19 patient with fever, headache, dry cough and respiratory distress, admitted to ICU. (A) CXR showed diffuse areas of ground glass appearance

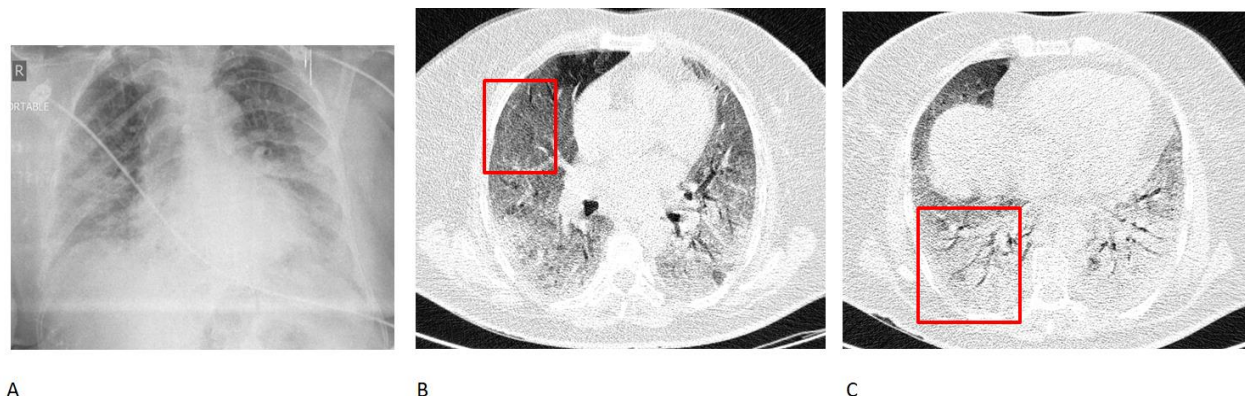


Figure 11. (A) CXR with diffuse ground glass appearance in lower zones; (B) Crazy paving appearance; (C) Consolidation in lower part of lower lobes with airbronchogram

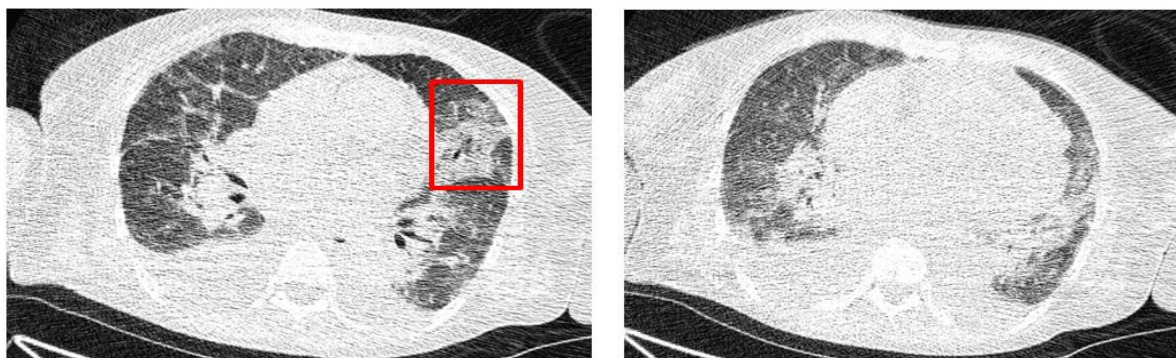


Figure 12. Cardiomegaly, bilateral moderate pleural effusion and patchy areas of ground glass infiltration in COVID-19

especially in lower zones with some small patchy areas of consolidation. (B) Areas of ground glass infiltration in both lungs and patchy areas of consolidation with surrounding ground glass halo (red box). (C) Dilatation of main pulmonary artery (35mm in diameter) which can be indicative of pulmonary hypertension

Figure 15 shows a 77 years old COVID-19 patient with history of CHF first admitted in hospital because of fever, malaise and anorexia. (A) On low dose spiral chest CT scan, no definite infiltration was seen in pulmonary parenchyma. (B) On mediastinal window of chest CT scan global cardiomegaly and minimal right side pleural effusion is noted. (C) After 10 days, dry cough and respiratory distress started and the patient transferred to ICU. On chest radiography patchy areas of ground glass infiltration and consolidations

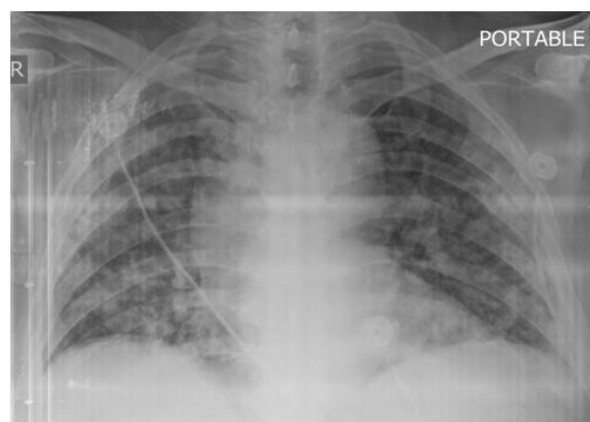


Figure 13. Diffuse patchy areas of ground glass infiltration and consolidations on CXR

appeared. (D) After 10 days, low dose spiral chest CT shows peripheral consolidations in right lower lobe and areas of ground glass infiltration in left lower lobe.

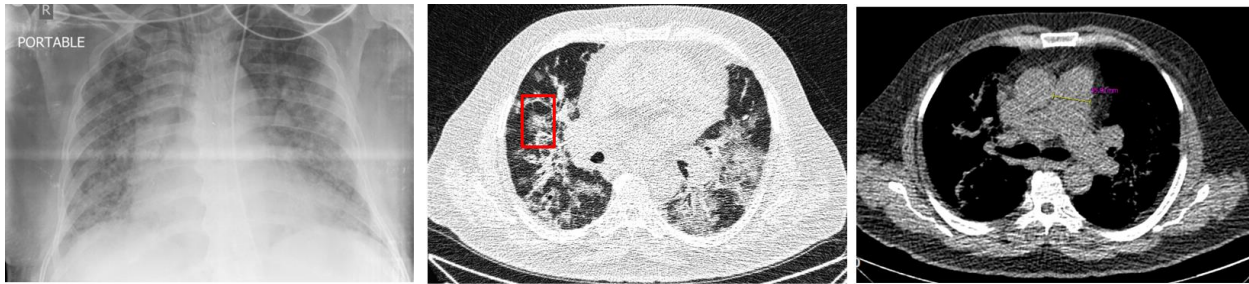


Figure 14. (A) Chest radiography with diffuse areas of ground glass appearance especially in lower zones with some small patchy areas of consolidation. (b) Areas of ground glass infiltration in both lungs and patchy areas of consolidation with surrounding ground glass halo (red box). (c) Dilatation of main pulmonary artery indicative of pulmonary hypertension.

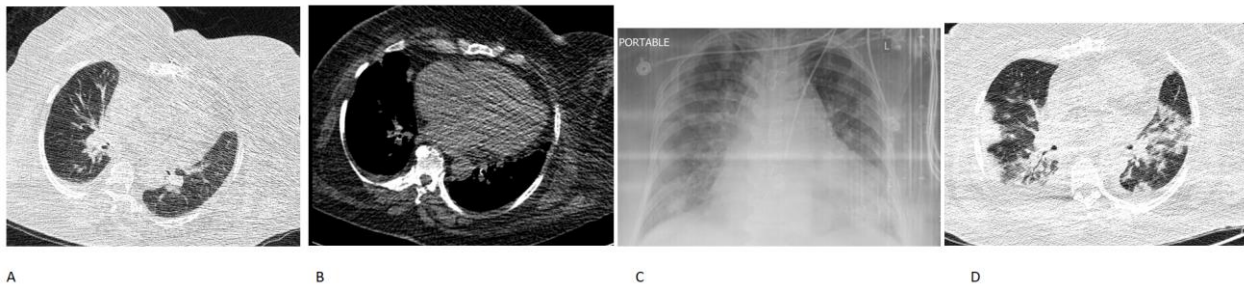


Figure 15. (A) no definite infiltration in pulmonary parenchyma (B) global cardiomegaly and minimal right side pleural effusion (C) Chest radiography with areas of ground glass infiltration and consolidations (D) Chest CT with peripheral consolidations in right lower lobe and areas of ground glass infiltration in left lower lobe.



Figure 16. Patchy areas of consolidation in lower zones in CXR (A) and chest CT scan (B)

Figure 16 shows a 78 years old COVID-19 patient with history of coronary artery disease presenting fever, dry cough, respiratory distress and decreased O₂ saturation, who admitted to ICU.

Patchy areas of consolidation are seen in lower zones in chest radiography and low dose spiral chest CT scan (red box).

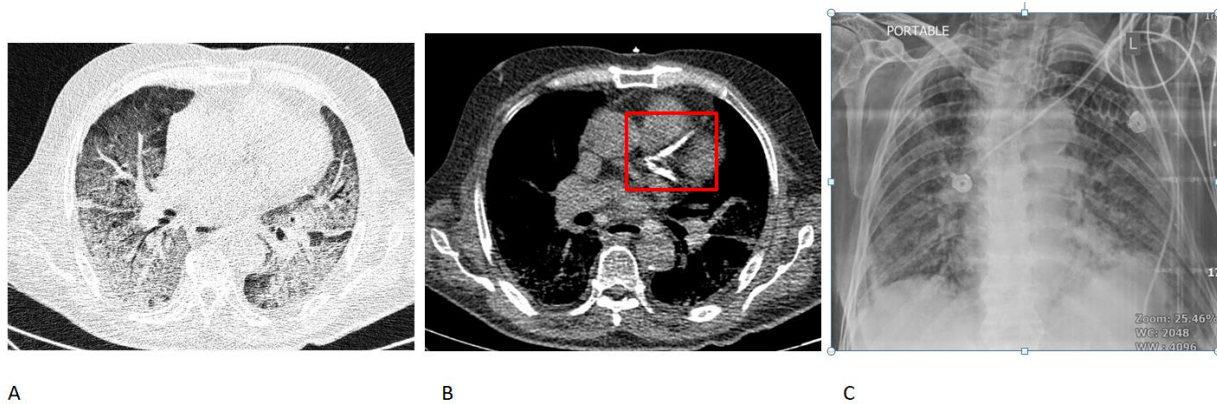


Figure 17. (A) Areas of ground glass infiltration and crazy paving appearance are seen in both lungs (B) Coronary calcified plaques are seen in LAD and LCX coronary arteries (red box). (c) Ground glass appearance in CXR in lower zones.

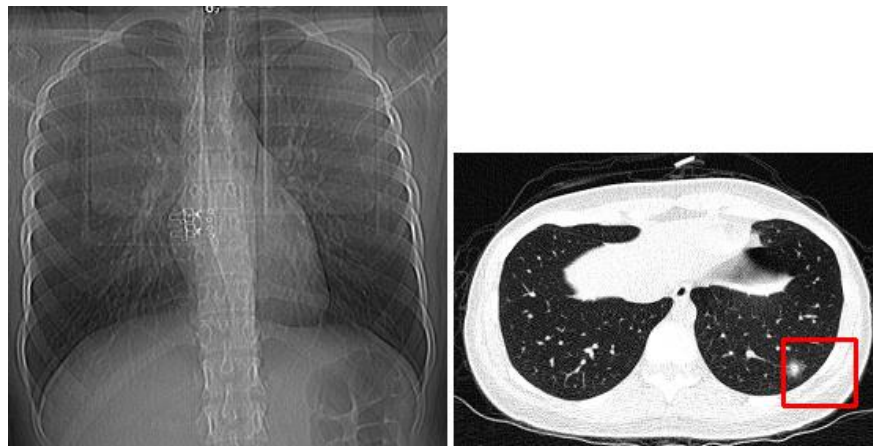


Figure 18. Totally normal CXR (Left); while there is a small patch of ground glass infiltration in posterior basal segment of left lower lung (LLL; red box) in spiral chest CT scan of the same patient (Right)

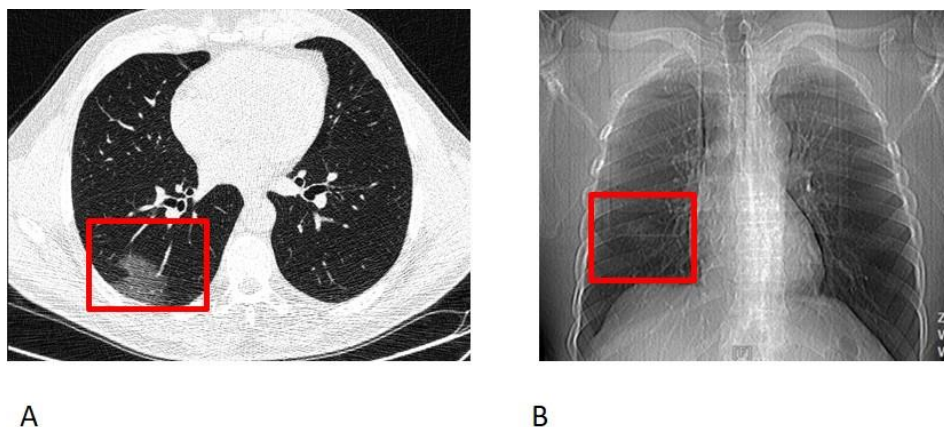


Figure 19. Ground glass infiltration in posterior basal segment of RLL (A). Very faint opacity in lower zone of right lung on CXR (B).

Figure 17 demonstrates an 81 years old COVID-19 patient with a history of coronary artery

disease presenting fever, dry cough, respiratory distress and decreased O₂ saturation, who admitted



Figure 20. Diffuse bilateral ground glass infiltration on CXR indicative of ARDS (left) and confirmed on CT scan (Right)

to ICU. (A) Areas of ground glass infiltration and crazy paving appearance are seen in both lungs on low dose spiral chest CT scan. (B) Coronary calcified plaques are seen in LAD and LCX coronary arteries (red box). (c) On chest radiography ground glass appearance is seen in lower zones

CXR presentations

About CXR, it should be mentioned that in mild involvement of lungs especially in faint ground glass infiltration CXR could not show any diagnostic clue, however, in more extensive forms it can show infiltrations corresponding to those chest CT patterns described above. Maybe we can say that normal chest X-ray cannot rule out COVID infection but observation of related findings in CXR can be helpful in diagnosis (Figure 18-20).

Figure 18 demonstrates a 26 years old COVID-19 patient with one week of fever. On low dose spiral chest CT scan showed a small patch of ground glass infiltration in posterior basal segment of left lower lung (LLL; red box) but shows totally normal CXR.

Figure 19 demonstrates a 48 years old COVID-19 patient with 5 days of fever. (A) On low

dose spiral chest CT scan shows a patch of ground glass infiltration in posterior basal segment of RLL but (B) showed very faint opacity in lower zone of right lung on CXR, which can hardly be seen (red box)

Figure 20 demonstrates a 70 years old COVID-19 patient with a week of fever and cough admitted to ICU because of respiratory distress and shows diffuse bilateral ground glass infiltration on CXR which can be indicative of ARDS and was confirmed on CT scan

Discussion

According to our experience, it may be worth to imply that over time ground glass opacities may evolve to peripheral consolidations (the same as organizing pneumonia). Also, over time and in the process of healing fibrotic streaks and strip like opacities may appear in the sites of involvement especially in peripheral regions and it is a delayed imaging pattern of disease.

Something valuable to point is that tree-in-bud appearance of infiltrations, cavitation of lesions and mucus plug in bronchi, LAP, pleural effusion and pneumothorax are very rare in these patients except for situations with comorbidities (1).

Although we have limitations in short term

CT follow up of these patients and in recovered patients, it seems possible to have focal fibrotic changes and fractional bronchiectasis in location of healed lesions and it needs next studies on follow up imaging of these patients.

According to clinical symptoms, most of these patients do not need hospital admission however, some of them need this care and among them, some need ICU admission. There is a reasonable correlation between extent of lung involvement and presence of comorbidities (especially cardiovascular disease) and need for ICU care. Although it is not true in very rare patients. Most of the patients who need ICU care show diffuse, bilateral and extensive lung involvement with ground glass infiltration or consolidation. The pattern which is indicative of ARDS (1) (Figure 11-17).

Conclusion

Imaging is one of the first diagnostic tools in most COVID-19 patients due to lack of full access to diagnostic kits, false negative probability of molecular kits especially in early stages of the disease and typical imaging patterns especially on chest spiral CT scan for COVID-19

Chest CT scan is more accurate than CXR for COVID-19 related imaging patterns.

There are seven most common features in CT scanning in COVID-19 are discussed fully in this article; each of these pattern has its own specifications.

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

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