



A WINDOW TO COVID-19: TEN TYPICAL SIGNS SEEN IN COVID-19 PNEUMONIA ON LUNG WINDOW

Radio-diagnosis

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ABSTRACT

Computed tomography (CT) plays a key role in the diagnosis and management of COVID-19 pneumonia. Although many CT findings in Coronavirus disease 2019 (COVID-19) have been reported, they vary according to the stage of the disease, disease severity, and associated comorbidities of patients. The typical appearance of COVID-19 pneumonia is bilateral peripheral, basal, patchy areas of ground glass opacification which later progress to consolidation. Black bronchus sign, air bronchogram sign, halo sign, and crazy paving are commonly seen in COVID-19 pneumonia, however, these are non-specific signs. It is essential to look out for useful typical and specific signs observed in COVID-19 which may help differentiate it from other viral pneumonia. We describe some specific signs such as vacuolar sign, pulmonary target sign, parallel pleura sign, vascular enlargement sign, subpleural transparent line, spider-web sign, and pleura retraction sign seen in the disease process along with few of the complicating signs to look out on thoracic CT of such patients in this article. Also, a typical sign seen in pulmonary mucormycosis, a secondary infection seen in rising numbers in COVID-19 patients recently, is discussed. Such signs would make CT chest a good screening tool in symptomatic patients as it is economical and easily available.

KEYWORDS

COVID-19; computed tomography; pneumonia; consolidation; GGO

BACKGROUND

Coronavirus disease 2019 (COVID-19), the global pandemic which has been a threat to mankind since its inception in 2019, continues to wreak havoc by its rapidly unfolding evolution and mutation. Radiology has played an enormous role in diagnosing, managing, and following up patients affected by this highly infectious disease which affects almost all organ systems. The respiratory system takes the major brunt of the disease due to the presence of a large number of angiotensin-converting enzyme-2 receptors, the cell receptor of COVID-19[1]. Although real-time polymerase chain reaction(RT-PCR) is the gold standard for diagnosis, computed tomography(CT) of the thorax gives the extent of involvement of lungs by the virus, and various CT-based scoring systems and reporting formats have been formulated to standardize reporting of disease severity. Besides, it helps in the detection of complications such as fibrotic lung disease and secondary infections developing in the lungs of COVID-19 patients, like the devastating pulmonary mucormycosis.

Thin section, non-contrast chest CT has good sensitivity, however, a low specificity in the diagnosis of COVID-19 pneumonia[1]. Chinese Medical Association Radiology Branch categorized the CT imaging findings in COVID-19 pneumonia into four stages[2]:

1. Early stage: characterized by enlargement of vessels, mild alveolar fluid exudation, and interstitial edema, resulting in patchy ground glass opacity (GGO), which are mostly peripheral and subpleural.
2. Second stage: lesions increase in density and size, forming varied patterns of GGO mixed with consolidation.
3. Third stage: fibrous exudation into the alveoli, visualized as wide areas of consolidation with bronchial dilatation on CT, with patchy GGO in the non-consolidated area.
4. Fourth stage: consolidation and GGO progressively resolve, with small areas of residual fibrosis in the form of interstitial bands or residual GGO.

GGO is the most prevalent and the earliest sign of COVID-19 pneumonia[1]. GGO is the hazy opacification of lung in the X-ray/CT without obliteration of bronchial or vascular markings, due to partial filling of the lung alveoli by fluid, fibrosis, or partial collapse of lung alveoli[1]. Black bronchus sign(Fig.1) is the appearance of a relatively darker bronchus in comparison to subjacent GGO and is particularly useful in early subtle GGO[3]. Consolidation reflects complete filling of the alveolar spaces and appears as increased density areas obscuring bronchial and vascular markings[1]. Air bronchogram sign(Fig.2) is air-filled bronchi within consolidation or GGO[4]. Crazy paving sign(Fig.3) represents thickened interlobular septation overlaid on GGO[4], while halo sign(Fig.4) is defined as GGO surrounding a nodule or mass[4]. All these signs are seen commonly in COVID-19 pneumonia, however, these signs are non-specific signs of pneumonia

due to any etiology. The goal of this pictorial review is to educate the residents by highlighting ten typical (although not specific) signs seen in the clinical course of COVID-19 pneumonia.



Fig.1. Black bronchus sign.

This sign is useful in detecting subtle ground glass attenuation as the bronchus appears darker (arrow) in comparison to the gray background of ground glass opacity.

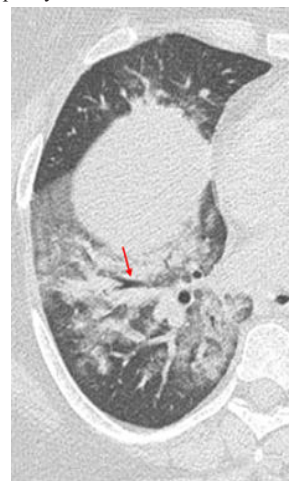


Fig.2. Air bronchogram sign.

Bronchi and bronchioles containing air (arrow), within a patch of consolidation or ground glass opacity, depicts their patency.

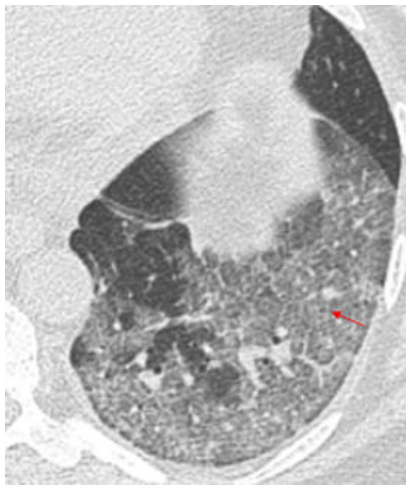


Fig.3. Crazy paving sign.

Areas of ground glass infiltration interspersed with interlobular septal thickening (arrow) gives this appearance of irregular paving stones.

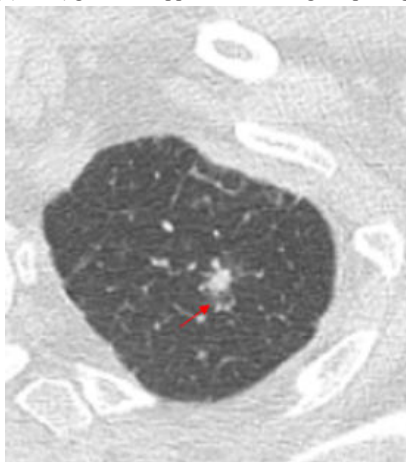


Fig 4. Halo sign.

A halo of ground glass density around a nodule or mass is called halo sign.

TYPICAL CT SIGNS OF COVID-19 PNEUMONIA

1. Air bubble sign/vacuolar sign: refers to < 5mm sized air-containing cavities within the patch of consolidation and may represent internal physiological dilated spaces or transverse bronchial section(Fig.5)[5].

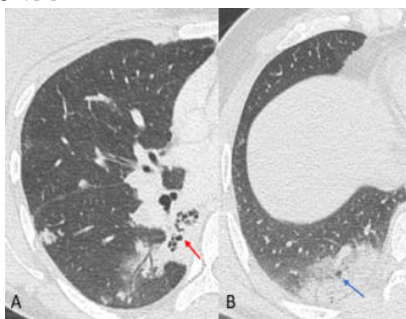


Fig 5. Vacuolar sign.

Multiple tiny air-filled spaces (red arrow) seen within an area of consolidation in superior segment of right lower lobe in a case of COVID-19 pneumonia, suggests vacuolar sign or air bubble sign(A). Another patient of COVID-19 pneumonia, with CT thorax showing patchy consolidation in posterior basal segment of right lower lobe, with subtle lucent spaces (blue arrow) or vacuolar sign(B).

2. Vascular enlargement sign: Engorgement and dilatation of vessels adjacent to or within the lesions on CT(Fig.6)[6].

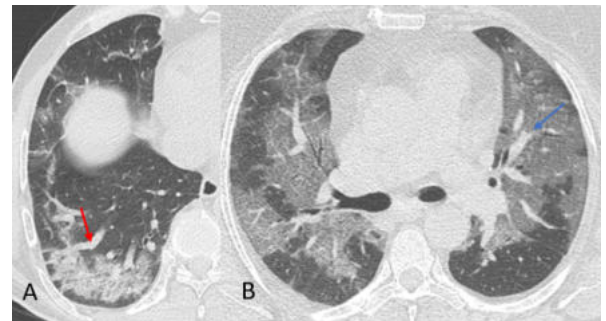


Fig.6. Vascular enlargement sign or prominent vessel sign.

Dilated pulmonary vessels seen adjacent to a consolidation patch (red arrow)(A) and within an area of ground glass attenuation (blue arrow)(B), in a case of COVID-19 pneumonia.

3. Subpleural transparent line: thin and transparent line located between the visceral pleura and areas of GGO or consolidation(Fig.7)[5].



Fig.7. Subpleural transparent line sign.

A patient with COVID pneumonia, whose CT demonstrates the thin and transparent subpleural line separating the visceral pleura from underlying ground glass opacity.

4. Parallel pleura sign: Subpleural curvilinear line or parallel pleura sign appears as a thin linear band of thickness 1-3mm, lying parallel to and within 1 cm from the pleural surface, representing fibrosis, edema or band atelectasis(Fig.8)[7].

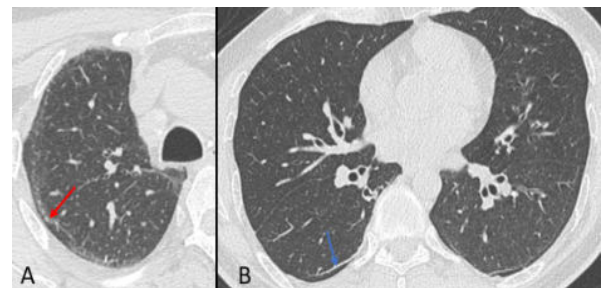


Fig.8. Subpleural curvilinear line or parallel pleura sign.

HRCT done in a follow-up case of COVID-19 pneumonia shows a thin linear band of fibrosis (red arrow) paralleling the pleura in right upper lobe(A). HRCT in another patient with COVID-19 reveals a similar smooth linear band of atelectasis (blue arrow) parallel to the pleura, involving posterobasal segments of both lower lobes(B).

5. **White lung sign:** white appearance to lung due to diffuse GGO(Fig.9)[5].



Fig.9. White lung sign.

The generalized and homogenous ground glass infiltration of almost all the lobes of right lung seen in a case of COVID-19 pneumonia, gives the classic white lung appearance or sign.

6. **Pulmonary target sign:** a specific manifestation of organizing pneumonia described in COVID-19, with central high attenuation focus (pulmonary vasculature) surrounded by complete or incomplete ring-like consolidation, forming a circle(Fig.10A)[8]. Its variant consists of multiple concentric perivascular densities(Fig.10B)[8]. Another sign representing organizing pneumonia is the atoll sign (area of GGO surrounded by a consolidation ring), also described typically in COVID pneumonia(Fig.10C)[9].

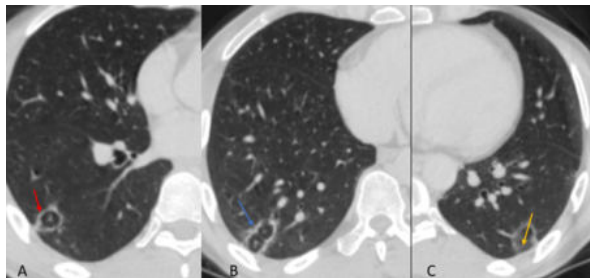


Fig.10. Pulmonary target sign, variant target sign and atoll sign.

The classic appearance of a central dense focus with surrounding consolidation (red arrow) giving a target appearance is seen in a patient with COVID pneumonia(A). Note the variant target sign(B) with two such lesions apposing each other (blue arrow) and the atoll sign(C) where the consolidation ring surrounds an area of ground glass opacity (yellow arrow) in the same patient.

7. **Spider web sign and pleura retraction sign:** thickening of the interlobular septa simulating a spider's web adjacent to a subpleural triangular area of GGO with associated pleural retraction (Fig.11A,B) [10]. Pleura retraction sign may be seen adjacent to a fibrotic band, GGO or nodule, as an early sign of fibrosis(Fig.11C)[10].

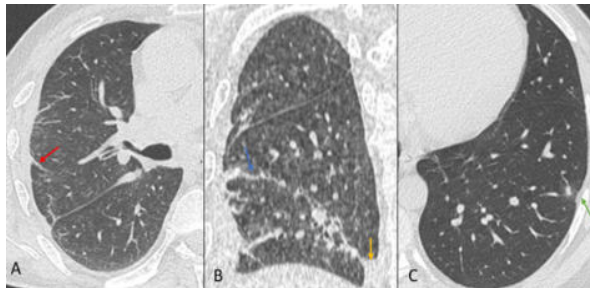


Fig.11. Spider web sign, pleura retraction sign.

Axial sections of CT thorax (A) of a subject with COVID pneumonia depicts linear bands of fibrosis which are perpendicular to the pleural surface (red arrow), simulating the web of a spider with subtle adjacent ground glass attenuation and pleural thickening in the lateral segment or right middle lobe. Similar spider-web appearance of fibrotic strands (blue arrow) is seen along with significant pleural thickening and retraction (yellow arrow) in the left lower lobe of another patient suffering from late stage COVID pneumonia as seen on coronal reformatted CT sections (B). Pleural retraction sign (green arrow) adjacent to a nodule with halo sign in the left lower lobe lateral basal segment in another patient with early stage corona virus infection on axial thoracic CT sections (C).

SIGNS SEEN IN COMPLICATIONS OF COVID-19 PNEUMONIA

8. **Honeycombing:** CT feature of usual interstitial pneumonia pattern of pulmonary fibrosis, with stacked cystic air spaces (3-10mm diameter) in subpleural location(Fig.12)[11].

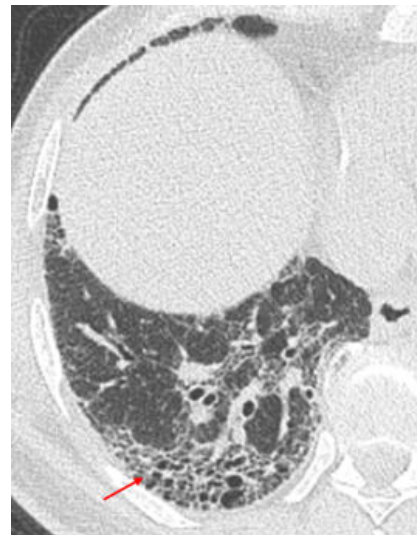


Fig.12. Honeycombing.

In a patient with end-stage interstitial fibrosis after COVID-19 pneumonia, HRCT thorax reveals multiple layers of tiny air spaces arranged one above the other (red arrow) in posterobasal segment of right lower lobe, representing macrocystic honeycombing. This suggests usual interstitial pneumonia pattern of interstitial fibrosis, a complication seen in COVID patients.

9. **Bird's nest sign:** appearance consisting of a reverse halo or atoll sign with the internal area of GGO showing multiple intersecting areas of stranding or irregular lines, giving it the appearance of a bird's nest(Fig.13)[9]. It is a specific sign seen in invasive pulmonary fungal infection, especially mucormycosis[9].

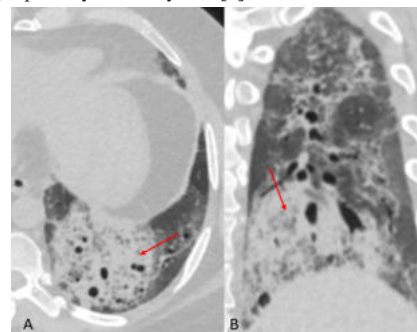


Fig.13. Bird's nest sign.

Axial (A) and coronal reformat (B) images in a patient on oral steroid treatment for COVID pneumonia reveals the classic bird's nest appearance of pulmonary mucormycosis, of a well-defined round area of ground glass attenuation, interspersed with multiple dense lines.

10. **Spontaneous pneumothorax and pneumomediastinum:** these

complications have also been reported in COVID-19 cases(Fig.14)[12].

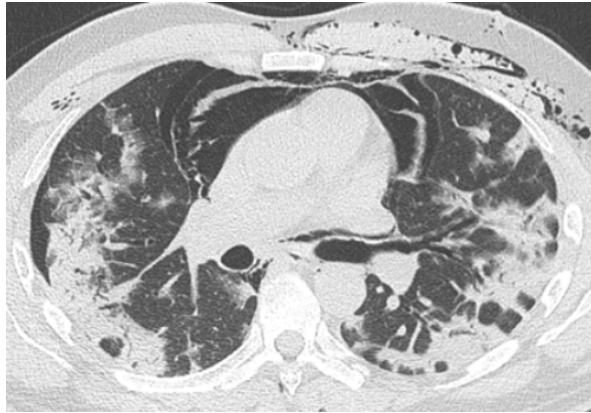


Fig.14. Spontaneous pneumothorax, spontaneous pneumomediastinum, subcutaneous emphysema.

A case of mildly symptomatic COVID pneumonia, who was under home treatment and isolation developed acute onset chest pain and breathlessness, without any history of trauma. Thoracic CT reveals extensive pneumomediastinum, right mild pneumothorax and subcutaneous emphysema in the patient.

Differential Diagnoses

The primary differential diagnosis in patients presenting clinically with fever and respiratory symptoms, with consolidation and GGO on CT, is pneumonia. The peripheral location of lesions and the typical lung CT signs described above may help distinguish COVID-19 pneumonia from other types of viral pneumonia. In a study comprising of 122 patients, the authors observed that rounded opacities in the lung periphery, in the absence of nodules and tree-in-bud sign, favors the diagnosis COVID-19[13].

Bacterial pneumonia is differentiated from COVID-19 pneumonia as consolidation follows characteristic lobar or segmental distribution with associated bronchial wall thickening and centrilobular nodules. This is quite different from COVID-19 pneumonia, which is usually not associated with pleural effusion or lymphadenopathy, unlike bacterial pneumonia[14]. The diffuse GGO in Pneumocystis jiroveci pneumonia in immunocompromised persons can be differentiated from COVID-19 pneumonia because it spares the subpleural spaces[15].

CONCLUSION

The main challenge on CT is to differentiate COVID-19 pneumonia from other cases of viral pneumonia with overlapping CT features[1]. However, in the context of the COVID-19 pandemic, one should always consider COVID-19 pneumonia as an etiology of GGO in the appropriate clinical settings. Knowledge of the typical CT signs seen in COVID-19 pneumonia and its complications, throughout its evolution from interstitial pneumonitis to end-stage fibrosis, increases the confidence of the radiologists in diagnosing the disease and hence aid in the adequate management of the patient.

LIST OF ABBREVIATIONS

COVID-19- Coronavirus disease 2019
 CT- computed tomography
 RT-PCR- Real-time polymerase chain reaction
 GGO- ground glass opacities

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