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Pictorial Essay of Named CT Signs in COVID-19 Pneumonia on High Resolution Computed Tomography

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In December 2019, there was an outbreak of Severe Acute Respiratory Syndrome (SARS) cases in Wuhan, Hubei Province, China which was caused by a novel Coronavirus (nCoV). Due to its high homology (~80%) to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), the novel coronavirus has been referred initially as 2019-nCoV and later as SARS-CoV-2. The disease where upon spread worldwide rapidly and on 11th March 2020 it was declared a pandemic by the World Health Organisation (WHO) [1].

The gold standard test to diagnose COVID-19 is real-time Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR). Although imaging is not considered as a primary tool to diagnose COVID-19, but it's been routinely used to screen patients to assess the extent of lung parenchyma involved and to know the progression of disease [2]. On High Resolution Computed Tomography (HRCT) COVID-19 pneumonia imaging features can be classified as classical and atypical. Classical features include peripheral ground glass opacities, with or without consolidation, crazy paving pattern, reverse halo sign and the atypical features not commonly but sometimes seen are less specific and include central distribution of ground glass opacities, nodules, tree in bud appearance, cavities [3].

When searching the internet for studies of CT imaging signs in COVID-19 published in English using PubMed and Google scholar computerised databases, we discovered the following signs in separate journal articles and were unable to find all of the signs collectively in one article. However, we found one article that mentioned a few of the named signs but did not include the "target sign, vascular tree-in bud sign and the melting sugar sign."

During the second wave of COVID-19 pneumonia, authors have noticed few frequently seen yet non specific signs, which are described below.

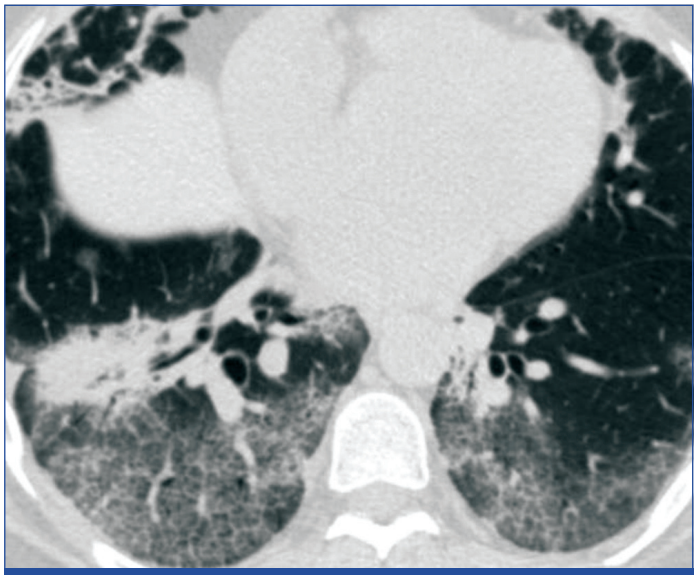
1. Crazy Paving Pattern

Ground-glass opacity with a superimposed reticular pattern, giving the appearance of interlobular septal thickening which has the appearance of irregularly arranged pavement tiles [Table/Fig-1]. This pattern was first noticed in patients with Pulmonary Alveolar Proteinosis (PAP) and is very characteristic of PAP, but it can also be seen in patients with acute lung diseases such as pneumocystis or viral pneumonia, acute eosinophilic pneumonia, Organising Pneumonia (OP), nocardia infection, oedema, haemorrhage, diffuse infiltrative lung disease and acute lung injury [4].

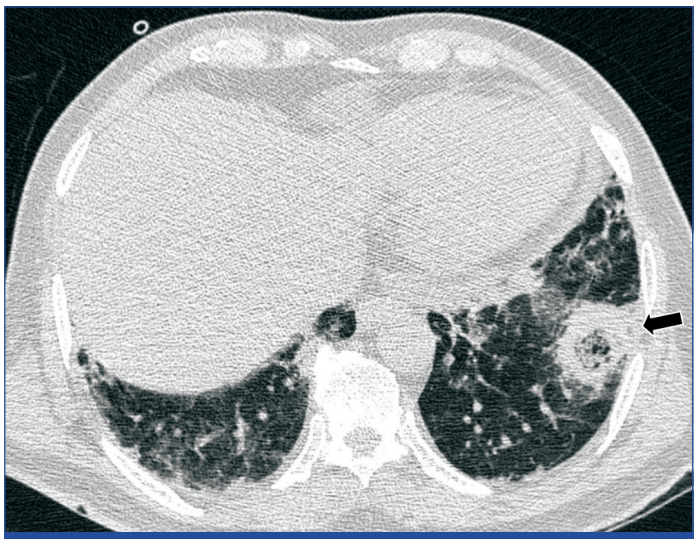
2. Reverse Halo Sign

Reverse halo sign, also known as the Atoll sign, because of its resemblance to a coral reef. On CT, the reverse halo sign can be seen as a central area of ground glass opacity with a surrounding complete or crescentic ring of consolidation [Table/Fig-2] [5].

This pattern has been identified in a multitude of COVID-19 cases. It's attributed to the advancement of the disease. The reverse halo sign was considered to be distinct to OP, but it can be seen in a variety of pathologies like polymyositis dermatomyositis, chronic eosinophilic pneumonia, drug induced reactions due to usage of amiodarone, bleomycin, buslphan, gold, interferon and methotretxate. Pulmonary infarction being the most important differential diagnosis among non infectious processes [6,7].



[Table/Fig-1]: Axial images showing ground glassing with intra and inter lobar septal thickening giving appearance of paving the marbles one after the other, crazy paving pattern, seen in bilateral lower lobes.

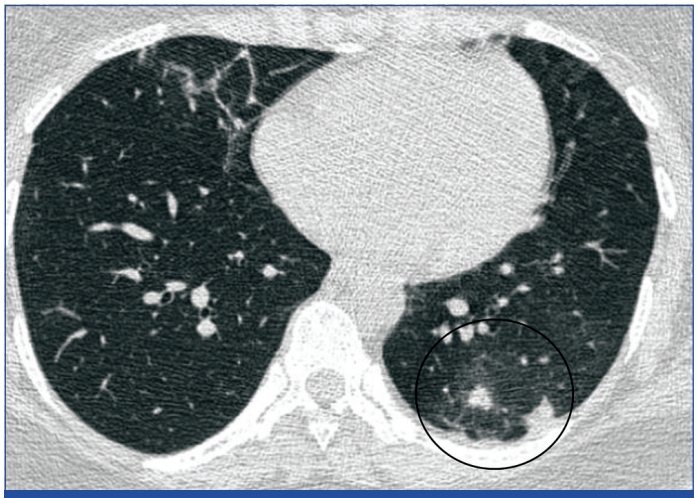


[Table/Fig-2]: Axial HRCT image showing reverse halo or atoll sign (arrow) note the central ground glass opacity surrounded by thin ring of consolidation.

3. CT Halo Sign

A halo of ground-glass opacity surrounding a nodule or mass [Table/Fig-3]. It is a non specific sign seen in conditions like invasive aspergillosis (representing haemorrhage), mucormycosis, candida,

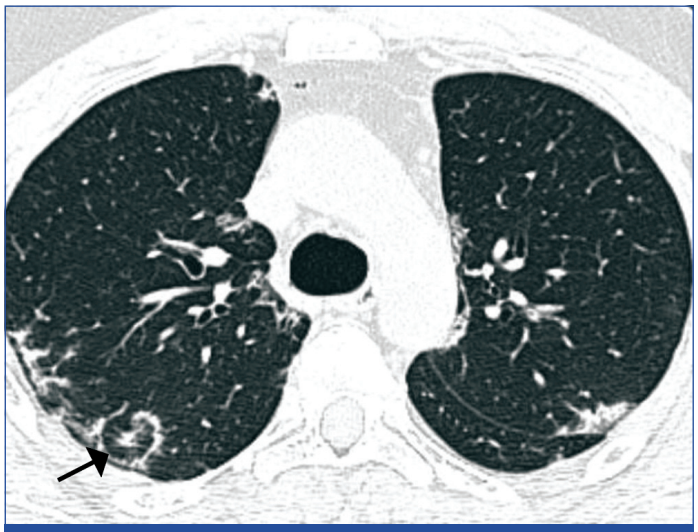
pseudomonas, herpes simplex virus, and cytomegalovirus infections, other causes, such as Wegener granulomatosis, haemorrhagic metastasis, kaposi sarcoma and neoplasms (adenocarcinoma, bronchioalveolar carcinoma) [8].



[Table/Fig-3]: Axial HRCT image showing CT halo sign seen in posterior segment of left lower lobe marked with circle (note the central consolidation and surrounding ground glass halo).

4. Target Sign

Target sign is described as a central nodular opacity with surrounding ring-like opacity. Central nodular opacity depicts perivascular inflammation or focal enlargement of the pulmonary artery [Table/Fig-4] [9].



[Table/Fig-4]: HRCT axial image showing target sign (arrow) with central dot representing vessel and surrounding thick rim hyperdensity.

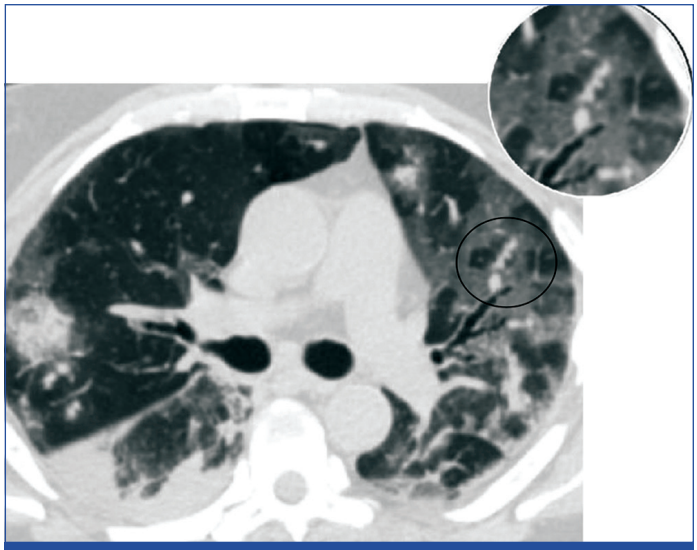
The pathogenesis of this sign is believed due to the distinctive vascular features of COVID-19, characterised by endothelial injury leading to disruption of cell membranes, widespread thrombosis with microangiopathy, and angiocentric inflammation [10].

5. Vascular Tree-in Bud Sign

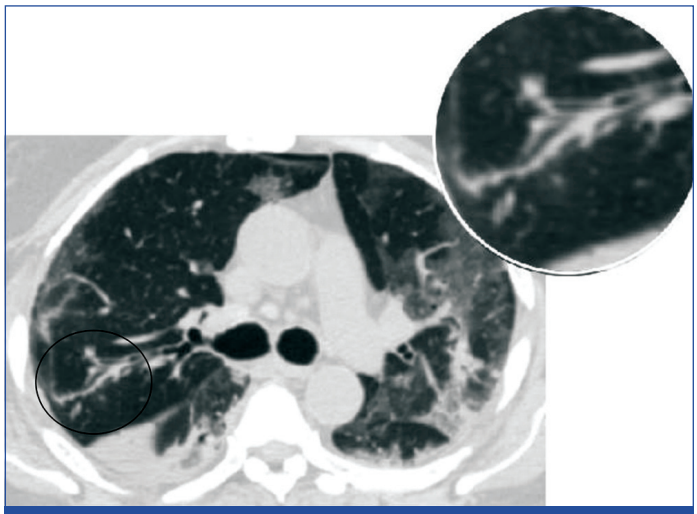
Is a pulmonary vascular abnormality causing pulmonary thrombosis due to hypercoaguability and lack of fibrinolysis that enhances the peripheral pulmonary vessels on CT imaging and can be detected by the presence of peripheral tortuous and dilated vessels with irregular branching pattern [Table/Fig-5] and acts as a marker of thrombotic vasculopathy with angiogenesis and microthrombosis. In a study done by Patel BV et al., the presence of this sign in in-patients reported poor prognosis [11].

6. Melting Sugar Sign

On serial imaging in COVID-19 patients the consolidation area of the lung begins to absorb, reducing its density and gradually becoming

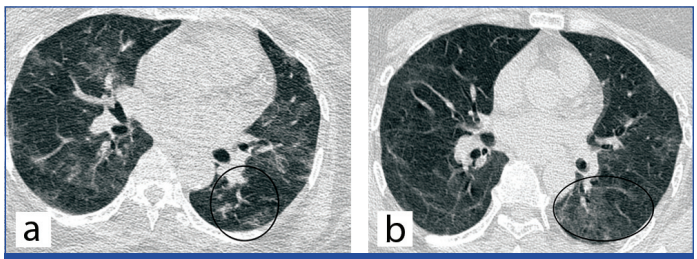


[Table/Fig-5a]: Axial HRCT image showing vascular tree in bud sign seen in COVID-19 pneumonia (marked with circle). Magnified image at the right corner of the image Note the vessel showing small vascular buding seen as irregular beaded appearance at its wall suggestive of proliferative microangiopathy.



[Table/Fig-5b]: Axial HRCT image of another patient showing vascular tree in bud sign (marked with circle). Magnified image at the right corner of the image note the beaded appearance of vessel.

a ground glass opacity, like "melted sugar or tinted sign" marked decrease in the attenuation of GGO, with a slightly increased extension of the GGO which suggest alveolar expansion [Table/Fig-6a,b] [12].



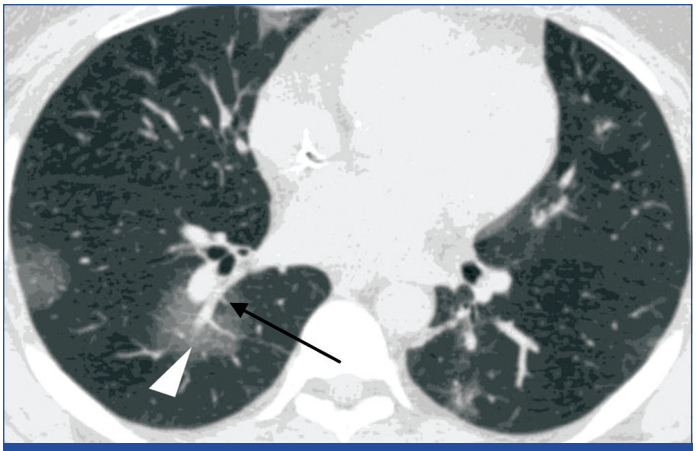
[Table/Fig-6a,b]: Melting sugar sign or tinted sign (marked with circle) in a COVID-19 patient. Left image showing multifocal peribronchial and peripheral patchy ground glass opacities scattered in both lungs note the left lower lobe patchy ground glass opacities on follow-up of 4 weeks we can see the corresponding area on the right image showing decreased attenuation of ground glass opacity with increased volume area suggesting alveolar expansion.

7. Dandelion Sign

It is characterised by the presence of patchy round ground glass opacity with prominent pulmonary vasculature [Table/Fig-7] and interlobular septal thickening due to increased vascular permeability caused the action of inflammatory mediators [13].

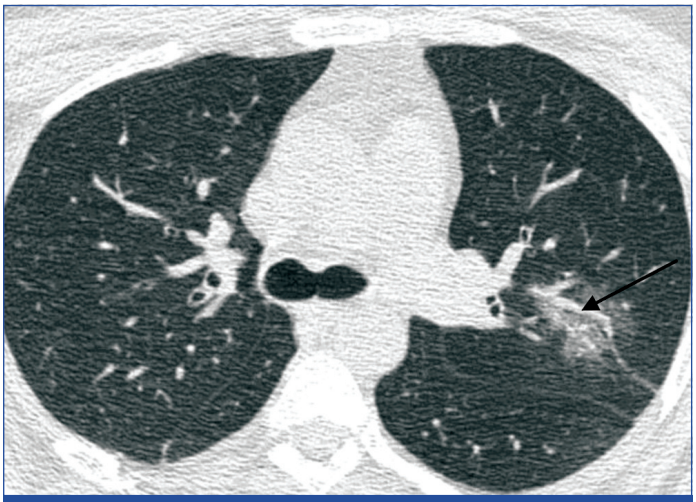
8. Feather Sign

It is identified by the presence of irregular stripe of ground glassing with pulmonary vascular thickening [Table/Fig-8] owing to increased



[Table/Fig-7]: Axial HRCT images showing dandelion flower sign. The ground glass opacity represents the flower (marked with arrow head) and the stem is represented by the central dilated vessel (arrow) as shown in the anteromedial segment of right lower lobe.

vascular permeability leading to dilatation of pulmonary capillaries and thereby causing pulmonary vascular thickening. In a study by Jin J et al., reported feather sign and dandelion sign to be typical imaging features of vasculopathy seen in COVID-19 pneumonia [14].



[Table/Fig-8]: Axial HRCT images showing feather sign. Note the central dilated vessel (arrow) with side branches and peripheral ground glass opacity along the vessel.

Few of the other named CT signs in literature include pomegranate sign and rime sign although these signs were not identified in our institute but the imaging features have been described below.

1. Pomegranate sign: It is characterised by increased range of GGO and the significant thickening of the interlobular septum, complicated with a small amount of punctate alveolar haemorrhage. It is an exudative lesion accompanied by tiny amount of bleeding, showing round and imbricates arrangement similar to a pomegranate.

2. Rime sign: Defined as multiple exudative and punctate haemorrhages in the lesion accompanied with extensive interstitial fibrosis forming large white lung, similar to white rime attached to the branches. On CT imaging diffuse GGO, vascular thickening, interlobular septal thickening, showing "rime sign" is seen in lungs [15].

These are some of the most commonly observed CT imaging findings in COVID-19 pneumonia cases at our institute. We wanted to illustrate and interpret some of the named signs to familiarise the named signs and their differential diagnosis. Though imaging findings in COVID-19 pneumonia revealed a wide spectrum, indicating a significant overlap with various infectious and non infectious aetiologies, with an exception of the feather sign, vascular tree in bud and dandelion sign which are typical imaging findings in COVID-19. However, the other signs are not pathognomonic to COVID-19, they are still commonly seen.

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