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CT Findings in COVID 19 Infection

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ABSTRACT
The computed tomography (CT) findings in COVID-19 infection exhibit characteristic patterns that aid in the assessment of lung involvement and severity. The aim of the study is to assess different CT chest findings in COVID patients. Prospective cross sectional study conducted on COVID 19 confirmed patients in the age group of 20-70 years. Lobe involvement and CT chest findings were studied. CT findings differ according to the stage of the disease and disease severity and associated co-morbidities. CT chest findings of 250 COVID-19 confirmed patients were analyzed. The most common CT findings were ground-glass opacities (GGOs) (78%), linear opacities (46%), nodular opacities (8%) and consolidation (60%). Inter Lobular Septal Thickening (55%), Pleural effusion (6%) and bronchial wall thickening (30%) were major atypical and airway findings. 22% of patients were observed with Honeycomb sign and 8% with Lymph node enlargement. GGOs with or without consolidation, reticulations and air bronchograms-which frequently involve both lungs with peripheral distribution-are the most frequent CT findings in COVID-19 cases. Clinicians should be aware that COVID-19 may appear with unusual symptoms or no abnormal findings on chest CT.

INTRODUCTION

The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, has prompted extensive research into diagnostic modalities to understand and manage the associated respiratory complications. Coronavirus disease 2019 (COVID-19) is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)[1]. The first human cases of COVID-19 were first reported by officials in Wuhan, China, in December 2019[2].

While laboratory testing remains the primary means of confirming infection, computed tomography (CT) imaging has emerged as a valuable tool in assessing the pulmonary manifestations of COVID-19. This study explores the characteristic CT findings associated with COVID-19, emphasizing their patterns, diagnostic significance and the nuanced role of CT in the overall diagnostic approach. Understanding these imaging features is crucial for healthcare professionals, aiding in the identification and stratification of cases and contributing to informed clinical decision-making. Despite the utility of CT, its limitations and considerations in the broader context of COVID-19 diagnosis underscore the necessity for a comprehensive and judicious approach to imaging in the era of this global health crisis.

Although COVID-19's chest imaging results were initially released in January 2020, the majority of hospitalized patients had bilateral lung involvement and ground-glass opacities[3]. Since then, a huge number of papers on chest CT results in COVID-19 have been released quickly. Experience and, most importantly, the growing body of scientific data that has surfaced since the disease's breakout should guide the judicious use of chest CT in COVID-19 patients.

Numerous papers detailing chest CT results in COVID-19 have been published[4]. Nevertheless, a number of studies are constrained by selection bias, possible blinding problems and the possibility of confusing chest CT results due to the co-existence of other lung disorders[4]. Almost all researchers who looked into how COVID-19 appeared on chest CT scans in symptomatic patients also looked into CT results. The histologic findings of COVID-19 in the lungs, which are marked by acute and organized diffuse damage to the alveoli, are similar to those of other coronavirus infections, such as MERS-CoV and SARS-CoV-1[5,6]. Consequently, abnormalities on chest CT that have been documented in COVID-19 are comparable to those observed in infections with SARS-CoV-1 and MERS-CoV[7]. The stage and severity of the illness determine the frequency of abnormalities on chest CT in COVID-19 (Fig. 1).

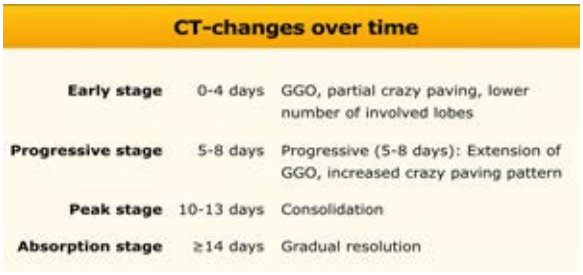

Fig. 1: How CT changes over time

Chest CT findings in COVID-19 patients can vary, but there are certain patterns that have been commonly observed. It's important to note that CT imaging is not the primary diagnostic tool for COVID-19; a definitive diagnosis is typically made through molecular tests like PCR. However, CT scans can provide valuable information in assessing the extent and severity of lung involvement in some cases.

Common CT findings in COVID-19 patients include:

- **Ground-Glass Opacities (GGOs):** GGOs are hazy areas in the lungs where the normal air-filled spaces are filled with fluid, inflammatory cells and tissue. These are one of the hallmark features of COVID-19 pneumonia.
- **Consolidation:** Consolidation refers to the solidification of lung tissue due to the accumulation of fluid, cells and debris. It often appears as white areas on the CT scan.
- **Bilateral Involvement:** COVID-19 typically affects both lungs and bilateral findings are common. The involvement is often peripheral and involves the lower lobes.
- **Crazy-Paving Pattern:** This pattern is characterized by thickened interlobular septa and intralobular lines superimposed on a background of GGOs, giving a appearance resembling irregularly arranged paving stones.
- **Vascular Enlargement:** Some studies have reported enlarged blood vessels within areas of lung opacification.
- **Reversed Halo Sign (Atoll Sign):** This is a central GGO surrounded by a more complete or partial ring of consolidation, giving the appearance of a reversed halo.

It's important to emphasize that not all COVID-19 patients will have abnormal findings on CT scans and the imaging features can overlap with other respiratory illnesses. CT imaging is typically reserved for cases where the diagnosis is uncertain, or when assessing the severity and extent of lung involvement is crucial for clinical management. In the present study, we aim to

provide a comprehensive understanding of CT chest findings in COVID-19 patients to enhance diagnosis, prognosis and treatment planning.

MATERIALS AND METHODS

Study Design: Prospective cross sectional study. The need for explicit consent from the patients had not applied to this investigation.

Sample Size: 250 patients in the age group of 20 to >70 years

Inclusion Criteria:

- Patients with suspected or confirmed COVID-19 based on clinical symptoms, epidemiological history, and/or molecular testing such as PCR.
- Individuals exhibiting symptoms such as fever, cough, shortness of breath (SOB), dependence on oxygen and non-specific patchy shadowing on a chest X-ray that indicate a strong clinical or early radiological suspicion of COVID-19.
- COVID-19 incidental abnormalities on preoperative CT scans in patients who are otherwise asymptomatic.

Exclusion Criteria:

- Patients with other known respiratory infections or co morbidities that could confound the interpretation of CT findings.
- Individuals under the age of eighteen or over the age of hundred
- Individuals who test positive for RT-PCR on the first or second try
- Individuals lacking radiological proof of COVID-19
- Individuals who may have viral or bacterial pneumonia (film array tests)

Image analysis: The distribution of the lung lesions was noted based on three dimensions: lobar, axial and anterioposterior. A dividing line drawn horizontally through the middle of the chest was used to distinguish the anterior vs. posterior and central (inner two-thirds of the lung) versus peripheral (outer one-third of the lung) axial locations of lesions. Lesions' densities were categorized as pure GGO or pure consolidation.

Three lesion shapes were identified: Wedge-shaped, nodular and amorphous. Both well-defined and ill-defined lesion margins were identified. The following additional findings were also noted: pleural effusion, bronchial wall thickening, lymph node enlargement, honey comb sign, linear opacities, intra lobular septal thickening and crazy paving.

RESULTS AND DISCUSSIONS

250 patients were considered for the study. Of these, two-thirds (66%) were female and the remaining one-third (34%) were male (Table 1).

The 250 patients considered for this study, an equal amount of patients (22%) each belonged to the age groups 41-50 years and 51-60 years. One-fifth of the patients (20%) were of the age group 61-70 years. Patients of age more than 70 years constituted 14% of the total. The age groups 31-40 years and 20-30 years had 12% and 10% patients respectively (Table 2).

In this study it was found that left lower lobe had major involvement with 82%, followed closely by left upper lobe (76%) and bilateral lung involvement (74%). The involvement of right lower lobe, right middle lobe and right upper lobe was found to be 68%, 56% and 48% respectively (Table 3).

The CT findings indicate Ground Glass Opacities in 78% of the patients from the study. Consolidation, Inter Lobular Septal Thickening and Linear Opacities were observed in 60, 54 and 46% of patients respectively. 22% patients showed Honeycomb Sign while Bronchial Wall Thickening was observed in 12% of the patients.Lymph Node Enlargement and Nodular Opacities were each observed in 8% of the patients and Pleural Effusion was visible in 6% of the patients (Table 4).

Table 1: Gender

Gender	No. of Patients (%)
Male	85 (34.0%)
Female	165 (66.0%)
Total	250 (100.0%)

Table 2: Age Group

Age Group	No. of Patients (%)
20-30 years	25 (10.0%)
31-40 years	30 (12.0%)
41-50 years	55 (22.0%)
51-60 years	55 (22.0%)
61-70 years	50 (20.0%)
>70 years	35 (14.0%)
Total	250 (100.0%)

Table 3: Lobe Involvement

Lobe Involved	No. of Patients (%)
Right Upper Lobe	120 (48.0%)
Right Middle Lobe	140 (56.0%)
Right Lower Lobe	170 (68.0%)
Left Upper Lobe	190 (76.0%)
Left Lower Lobe	205 (82.0%)
Bilateral Lung Involvement	185 (74.0%)

Table 4: CT Findings

Finding	No. of Patients (%)
Ground Glass Opacities	195 (78.0%)
Linear Opacities	115 (46.0%)
Nodular Opacities	20 (8.0%)
Consolidation	150 (60.0%)
Inter Lobular Septal Thickening	135 (54.0%)
Bronchial Wall Thickening	30 (12.0%)
Pleural Effusion	15 (6.0%)
Honeycomb Sign	55 (22.0%)
Lymph Node Enlargement	20 (8.0%)

When COVID-19 instances are identified early, medical practitioners can provide patients with appropriate clinical monitoring, essential interventions and preventive measures to stop the infection from spreading[8,11]. Lung CT is recommended as the follow-up investigation or even the preferred imaging modality in some circumstances, even though chest radiography is the initial imaging modality in the majority of patients with acute respiratory syndrome[12,13].

In the present study, Ground-Glass Opacities (GGOs) are a common early feature, often bilateral and peripheral. As the disease progresses, consolidation may occur, representing more advanced stages of lung pathology. The Crazy Paving Pattern, characterized by thickened interlobular septa superimposed on GGOs and the Reverse Halo Sign, a central ground-glass opacity surrounded by a denser ring, are observed in some cases. Vascular enlargement in affected lung areas is also noted. It is essential to recognize that these CT findings are not specific to COVID-19 and can be present in other respiratory infections. CT imaging is not the primary diagnostic tool for COVID-19, with definitive diagnosis relying on laboratory tests. CT scans are generally reserved for cases with clinical suspicion of severe disease or complications and their use should align with established guidelines, considering factors such as radiation exposure and the availability of alternative diagnostic methods. Interpretation of CT findings should be contextualized with clinical and laboratory data to inform appropriate management strategies.

We found that the vast majority (74%) of COVID-19 cases had bilateral involvement of lungs and most of the lesions were peripherally distributed. A higher percentage of patients appeared to have involvements in left lower lobe (82%). Moreover, lower lobes were more commonly involved (68%). A recent meta-analysis of 4121 patients with COVID-19 from 34 retrospective studies revealed relatively similar results, indicating predominance of bilateral (73.8%) and multilobar (67.3%) lung involvement[14].

The most common typical finding in chest CT of patients with COVID-19 was GGO with/without consolidation (78%) followed by intra lobular septal thickening (54%). Other typical findings in the order of prevalence were consolidation (60%), linear opacities (46%) and honey comb sign (22%). Bronchial wall thickening was also the most common airway finding in the patients (12%). Other relatively uncommon atypical findings were nodules (8%), pleura effusion (6%) and lymphadenopathy (8%). Relatively similar results were reported by a recent meta-analysis of 4121 patients with COVID-19. Zhu *et al*.[14] and Ahmadreza Zarifian *et al*.[15] reported the most common findings to be GGO (68.1%), air bronchogram (44.7%), crazy-paving pattern (35.6%) and consolidation (32.0%), respectively. They found pleural thickening to be present in 27.1%, while lymphadenopathy and pleural effusion were present in 5.4 and 5.3% of patients, respectively. A larger percentage (96.6%) of abnormal chest CT findings in COVID-19 patients was also identified in a different published meta-analysis of ten studies[16].

CONCLUSION

The usual chest CT findings in COVID-19 pneumonia were GGOs with or without consolidation and intralobular septal thickening. Peripheral distribution and both lungs are frequently affected by lesions. In addition to these typical results, it's important to keep in mind that a COVID-19 infection may show up on a chest CT scan with a variety of symptoms. When confronted with any of these CT symptoms, first-line clinicians should be alerted, particularly in regions where COVID-19 infection is widespread and RT-PCR is not readily available. Future research should concentrate on how CT results vary over time and how CT symptoms affect a patient's prognosis.

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